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Welcome Message

Welcome—Willkommen—Velkommen

We warmly welcome you to the Collaborative European Research Conference (CERC) hosted this year by our many campuses here at Cork Institute of Technology (CIT) and of course the Rebel County. Continuing in the tradition of CERC, we aim this year to continue to provide a platform for the dissemination of research as well as the development of social and research collaborations for future advances.

CERC 2013 features a series of talks by internationally recognised Researchers and Industrial leaders. In particular we are delighted to welcome the new CEO Dr Kieran Drain of our nearby partner and National Centre for Physics Research, Tyndall National Institute.

Over the duration of this year's 2-day conference 21 graduate and post graduate researchers will present full research papers, and a further 8 early-stage researchers and authors of proposal papers will present. On day two of the conference a poster exhibition will further showcase the research of graduates at all stages of their research journey. Researchers chosen to present have been peer-reviewed by a panel of international researchers.

As part of CERC 2013 there are a number of organised social events which we hope will foster friendships and future collaborations. Each element of the social programme will be hosted by a CIT campus. For those who wish to stay longer or further sample Cork's culture, history, attractions, sports fixtures, and great food *'Rebel Week'* (14—20th October) holds a wealth of possibilities.

We would like to express our gratitude to the invited speakers, students and researchers for their participation and contributions. We would also like to take the opportunity to acknowledge the generosity of our sponsors and CIT colleagues who have given of their time and expertise to ensure CERC 2013 is a success.

Finally, we look forward to meeting you in Cork this year and hope you thoroughly enjoy both the social and technical sides of the conference programme.

Table of Contents

A Framework for Categorising Similar Technical Support Requests using Distributed 'Big Data' Analytics

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Abstract

Technical Support call centres frequently receive several thousand customer queries daily. Traditionally, such organisations discard this data within a relatively short duration due to limited storage capacity. However, in recent years, the value of retaining and analysing this information has become evident, enabling call centres to identify customer patterns, improve first call resolution and maximise daily closure rates. This paper proposes an end to end architecture for conducting large scale analysis of technical support data. The implemented framework categorises similar support calls using the Apache Hadoop programming model, extended ecosystem and the Mahout Big Data Analytics library. This solution allows technical support staff to quickly identify previously logged similar calls and their resolutions in order to expedite case closure, and as a result, improve staff performance and customer satisfaction. Finally, it is evaluated on a VMware technical support data set with a particular emphasis on the performance and accuracy of big data clustering algorithms to optimise search techniques.

Keywords

Big Data, Distributed clustering, Parallelised programming, Hadoop, HBase, Hive, Mahout,

1. Introduction

In recent years, there has been an unprecedented increase in the volume and variety of data generated worldwide, driven by the proliferation of social media along with an increase in mobile and networked devices (the Internet of Things), finance and online retail as well as advances in the physical and life sciences sectors. Cisco IBSG predicts that there will be 50 billion devices connected to the Internet by 2020 (Cisco Internet Business Solutions Group Corporation Web Site, 2011). Such vast datasets are commonly referred to as "*Big Data*", characterised not only by its volume, but by a rich mix of data types and formats (variety) and it is time sensitive nature which marks a deviation from traditional batch processing (velocity).

Traditional distributed systems and relational databases are no longer suitable to effectively capture, store and analyse this data, exhibiting limited scalability. As a result, alternative big data processing and management solutions have gained significant attention with technologies such as the Map Reduce paradigm proving popular. However it is now recognised that it is necessary to further advance platforms that can harness these technologies in order to gain meaningful insight and to make more informed business decisions i.e. 'big data analytics'. In the current marketplace, big data analytics has become a business necessity for many organisations looking to gain a competitive advantage. This has further been recognised in the technical support space of leading technology multinationals, as

call centres have begun to explore the application of data analytics as a way to streamline the business and gain insight regarding customer's expectations. (Aberdeen Group Corporation Web Site, 2010).

This paper outlines how the open source Apache Hadoop project along with big data clustering can be applied to call center operations in order to categorise similar support calls, thereby potentially expediting case resolution and accuracy to maximise daily closure rates and improve staff performance. The rest of this paper is organised as follows: Section 2 describes the algorithms and technologies underpinning the proposed framework along with related work in this space. Section 3 outlines the implementation of the proposed technical support analytics framework with Section 4 detailing the performance evaluation and analysis of the implemented solution. Finally, Section 5 concludes the paper.

2. Constituent Technologies and Related Work

In the early 2000s, motivated by challenges in processing large data sets in a timely manner, Google developed the *Google File System (GFS)* (Ghemawat *et al*. 2003) and the *MapReduce* paradigm (Dean and Ghemawat, 2004). The underlying premise is to distribute the data across commodity hardware so that the processing of data is performed where the data is stored. GFS and MapReduce form the basis for the *Apache Hadoop* project, comprised of the *Hadoop Distributed File System (HDFS)* and *Hadoop MapReduce* (Apache Hadoop Corporation Web Site, 2012). HDFS (Shvachko *et al.* 2010) is the distributed storage component of Hadoop with participating nodes following a master/slave architecture. Files are split into blocks which are replicated and distributed across slave nodes in the cluster known as *data nodes*. The master node, called the *name node*, maintains a global file index. MapReduce (Bhandarkar, 2010) is the distributed compute component of Hadoop and also follows a master/slave architecture. It is controlled by a software daemon known as the *JobTracker*, which assigns *Map* and *Reduce* tasks to the slave nodes in the cluster (*TaskTracker)* whom are responsible for actually instantiating the Map or Reduce tasks and reporting the progress back to the JobTracker.

The extended Hadoop ecosystem includes a growing list of solutions that advance Hadoop's capabilities. *Mahout* is an open source machine learning library built on top of Hadoop. *HBase* is a distributed column-oriented database, providing real-time read/write random-access to large datasets. *Hive* defines a simple SQL-like query language, to abstract the complexity of writing complex Java MapReduce jobs. The framework described in this paper makes use of five clustering algorithms in the Mahout library. *K-means* partitions data into *k* clusters with cluster associated with a *centroid*, each data point then assigned to the nearest centroid, and each collection of points assigned to a centroid considered a cluster (Owen *et al.* 2012). *Canopy clustering* is an algorithm used to divide the input data into overlapping clusters (canopies). *Fuzzy k-means* is a soft clustering algorithm, allowing each point to belong to more than one cluster with a certain probability. *Dirichlet clustering* assumes that the input data follows a predefined probabilistic distribution e.g. normal distribution, and tries to describe the data as a mixture of models (Witten *et al.* 2005). Finally, *Latent Dirichlet Allocation (LDA)* is also a probabilistic clustering algorithm used for topic modelling.

While research associated with machine learning and data mining algorithms is well established, research on big data analytics and large scale distributed machine learning is very much in its infancy with libraries such as Mahout still undergoing considerable development. The application of Mahout k-means clustering on a 1.1GB data set of TCP dumps was studied, while examining clustering scalability and quality (Esteves *et al.* 2011). An application of k-means and fuzzy c-means clustering on an 11GB Wikipedia dataset with respect to clustering algorithm and system performance was next evaluated (Esteves and Ron, 2011). In contrast to this work, the authors of this paper consider a 32GB dataset, five clustering algorithms and provide an entire solution including data pre-processing, daily upload of new data, real-time access and a user interface by using the extended Hadoop ecosystem. The Reuters dataset was evaluated using clustering algorithms over Hadoop but also over a runtime environment, Granules (Ericson and Palliekara, 2011). While the performance of four clustering algorithms was evaluated, the primary evaluation concentrated on the underlying runtime environment and unlike the proposed architecture, a complete end to end solution was not provided as a clean data set was used.

In contrast to the state of the art literature, the distributed analytics architecture presented in this paper successfully integrates Hadoop and Mahout to provide a fully functional end to end solution that enables the streamlining of call centre operations and evaluates multiple clustering algorithms in terms of performance and accuracy.

3. Analytics Framework – Design and Implementation

The open source Hadoop platform, HBase, Hive and Mahout clustering form the main components of the proposed analytics solution as shown in Figure 1. The implemented framework is evaluated using a real-world VMware technical support data set of approximately 32 GB. The 4 node cluster is based on commodity hardware with 8GB RAM, 2 TB hard-drive, 1 CPU Intel Core i7, 2 cores at 2.20 GHz, onboard 100Mbps LAN, Linux CentOS with Hadoop v0.20 and Mahout v0.5.

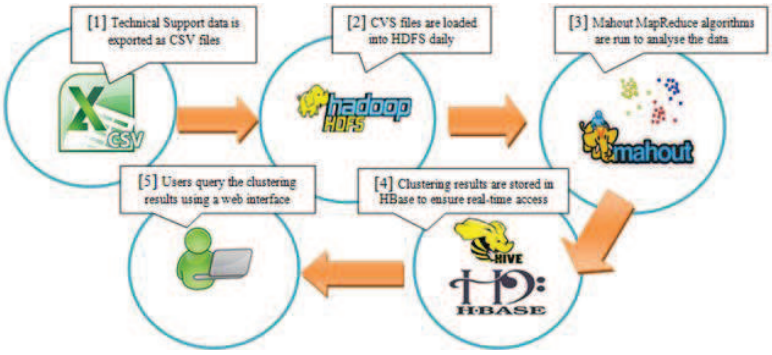


Figure 1: Proposed end-to-end Solution of the Technical Support Analytics Framework

The implementation of the proposed framework comprised five phases, as now described.

3.1. Data Pre Processing

VMware technical support data is currently stored in a SaaS platform. Therefore it is firstly necessary to export this data into HDFS in a format to be further analysed within Mahout by devising a Hadoop job to convert the data in CSV format into Hadoop *SequenceFile* format. Hadoop mappers employ an *InputReader* to parse input keys and values, with the default Hadoop *InputReader* (*TextInputFormat),* considering every line to represent a record. This is not applicable for CSV format as support calls may span multiple lines and thus the authors devised a custom *input record reader* and *partitioner* to accumulate text from the input file until it reaches a specified end of record marker. As the *mapper* requires a key and value, the *value* is the resultant text from the *input record reader*, including the support call identifier and support call description. The *key* is set to the position in the file of that record. The *mapper* extracts the support call identifier (passed to the *reducer* as the key) and associated description (passed to *reducer* as the value). Finally, the *reducer* writes these key/value pairs into a Hadoop *SequenceFile* format. Figure 2 illustrates this process by displaying the anatomy of the MapReduce job.

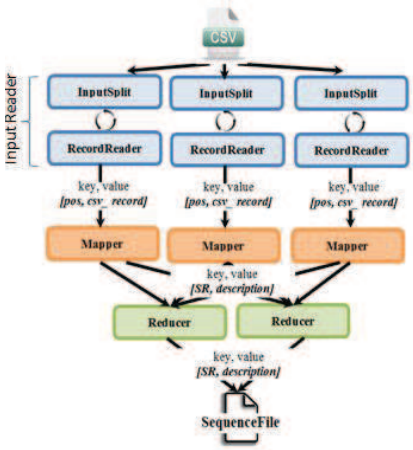


Figure 2: Design of a MapReduce job to import CSV files into HDFS for processing with Mahout

3.2 Daily Upload of New Technical Support Data

As technical support data will be updated daily and new solutions derived, a mechanism to automatically update the support data set to ensure accurate results is required. Given the nature of the data, it is sufficient to perform such a procedure on a daily basis. To avoid uploading the entire data set daily, a cron job can be scheduled to automatically backup the changes. A separate Hadoop job is responsible for uploading the CSV files containing the details of the support requests received that day into HDFS.

3.3 Mahout Clustering

In order for data to be processed using the Mahout clustering algorithms, it must first be in vector format. Data stored in HDFS is converted into vectors using Mahout's

command line for subsequent clustering analysis. TF-IDF weighting was used during this process to purge commonly occurring stop words. The specific details of the clustering are discussed further in Section 4.

3.4 Real-time Platform Access

Once the analysis phase is completed, a MapReduce job stores the clustering results in HBase for real-time access. When an engineer requests the support calls related to a particular case, the cluster to which such a case should belong is identified in HBase. An ordered list containing the support call identifier and its associated cluster membership probability is returned to the operator. The support calls at the top of this list are more likely to contain similar problems to the case specified by the user, and thus are more likely to share the same resolution.

3.5 User Query of Results

As directly querying HBase is not user friendly and technically complex, necessitating the development of a MapReduce job, HBase has been integrated with Hive. Such an approach allows users to obtain similar support calls from a web-based interface that uses HiveQL to query the clustering results derived from Mahout. This could be further developed to provide BI tools and dashboards.

4 Framework Performance and Clustering Evaluation

The technical support dataset is analysed using five distributed clustering algorithms. The output from each of these algorithms discussing the impact of the nuances of each clustering algorithm is now discussed in Section 4.1. Section 4.2 provides a comparative analysis and Section 4.3 discusses the quality and accuracy of the derived clusters.

4.1 Distributed Clustering Algorithms

Five clustering algorithms are considered: k-means, k-means with canopy clustering, fuzzy k-means, Dirichlet allocation and latent Dirichlet allocation.

4.1.1 K-means Clustering:

The number of required clusters, k, was estimated by dividing the number of total support calls in the sample, approximately 10,000, by the target cluster size of 250 support calls. This provided an approximate estimate of 40 clusters. With respect to the election of the distance measure, the cosine distance was used as it generally works well when clustering text documents. Figure 3(a) provides a subsection of the output generated after executing the clusterdump command on the generated clusters.

4.1.2. Kmeans with Canopy Clustering:

Canopy clustering was explored as an alternative method of creating the initial centroids. Since canopy clustering is a fast approximate method, the Euclidean distance was used. One of the challenges of running canopy clustering is finding a suitable value for the distance thresholds *T1* and *T2*. A variety of values for the

distance thresholds *T1* and *T2* were considered until the number of generated canopies reached a meaningful value i.e. between 20 and 50. *T1=1.0* and *T2=1.4* were found to be a good fit for the technical support data, with a total of 50 canopies generated. The resultant canopy centroids were then used as an input for the k-means algorithm with Figure 3(b) providing a subsection of the output.

4.1.3 Fuzzy KMeans:

The Technical Support data was then analysed using Mahout's implementation of fuzzy k-means. This algorithm includes a parameter known as a fuzziness factor that determines the degree of overlap between the generated clusters. Fuzzy kmeans is very sensitive to this parameter. Testing found that setting the fuzziness factor to 1.05 generated well-defined and differentiated clusters. Figure 3(c) provides a subsection of the output generated after executing the fuzzy k-means algorithm.

4.1.4 Dirichlet Allocation:

Dirichlet clustering was also evaluated with an objective of 50 clusters. The cosine distance was used as the distance measure with the default normal distribution chosen. Figure 3(d) illustrates the results of the algorithm. Using the above parameters, all supports calls are placed in the same cluster, indicating that the chosen distribution model does not fit the data. As suggested in (Eastman, 2011), the *DistanceMeasureClusterDistribution* model and the *DenseVector* model prototype were used to analyse the data instead. Such an approach provided slightly more significant results as differentiated clusters were identified. However, as illustrated in Figure 3(e), the top terms in such clusters are not very descriptive with nearly 20% of the total calls still placed in the same cluster. In order to further improve the cluster quality it may be required to develop a new model prototype and model distribution that better fits the data. Such an approach is considered out of the scope of this paper.

4.1.5 Latent Dirichlet Allocation:

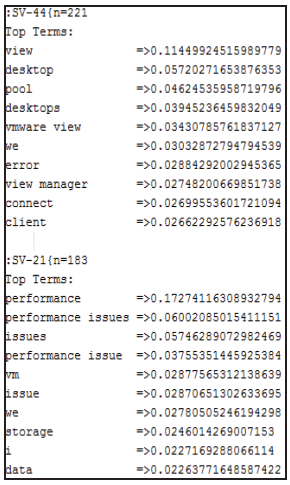
Finally, data was analysed using the latent Dirichlet allocation clustering algorithm. The number of topics was set to 50 and the number of words in the document corpus to 12886. 30 iterations were required to generate significant topics. Figure 3(f) illustrates a sample topic generated after running LDA.

```
:VL-7349{n=179
Top Terms:
performance         =>0.16844324012612083
status              =>0.05233291567181598
performance issues  =>0.05223082575207844
performance issue   =>0.04865442929400976
issues              =>0.04222222521811343
working             =>0.03624865168318950
storage             =>0.03184350181620286
vcenter             =>0.03095994554291732
hardware status     =>0.02885616307866605
issue               =>0.02829715903314257
```

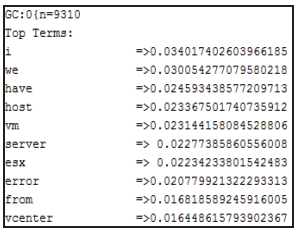
(a): kmeans clustering output

```
:VL-44{n=31
Top Terms:
view           =>0.137629097895982
desktop        =>0.0534997280159561
vmware view    =>0.0421243964616689
pool           =>0.0419625123424200
desktops       =>0.035576705223673
client         =>0.0333715957885216
we             =>0.0309680926829560
view client    =>0.0305794443710187
vmware         =>0.0295958132133564
connect        =>0.0264728306431218
:VL-21{n=161
Top Terms:
performance         =>0.228151081608485
issues              =>0.0784008160758059
performance issues  =>0.0770977025986678
performance issue   =>0.0453287041142049
data                =>0.03355438861191034
performance data    =>0.03089009123879688
issue               =>0.02885882326789462
storage             =>0.02865171568348986
we                  =>0.02829616413226657
vm                  =>0.0263984749200549
```

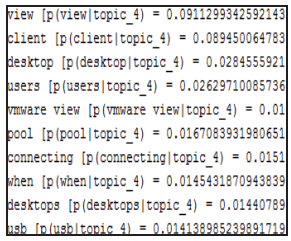
(b): kmeans with canopy clustering output

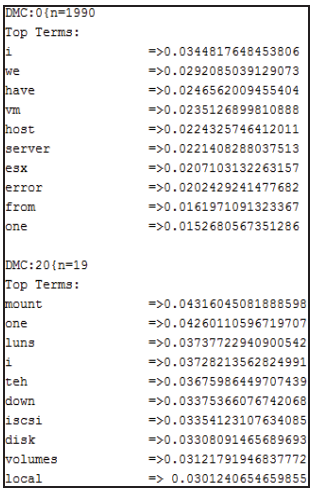


(c): sample clustering output for fuzzy k-means



(d): sample clustering output for Dirichlet clustering algorithm using a normal distribution





(e): sample clustering output for Dirichlet clustering algorithm using DistanceMeasureCluster distribution model

(f): sample clustering output for LDA

Figure 3: Clusterdump output for each clustering algorithm

4.2 Comparative Clustering Output Performance

This section provides a comparative discussion of the output from the five clustering algorithms considered. Figure 3(a) compares the top terms in a k-means cluster related to performance issues to the top terms in a similar cluster created by k-means with canopy clustering as a pre-processing step, Figure 3(b). It can be noted that the results are quite similar and the number of calls included in the cluster is comparable using both techniques. The clusters identified by the fuzzy k-means algorithm, as shown in Figure 3(c), are quite similar to those generated by the k-means algorithm using the canopy initial centroids, Figure 3(b). In both cases, the generated clusters include significant terms that describe VMware View components. The output of the LDA can be also observed in Figure 3(f). It can be concluded that the LDA was able to successfully identify the most relevant topics, matching problems frequently encountered by customers. Moreover, the topics were also consistent with the clusters identified when analysing the data with k-means and fuzzy k-means. Table 1 summarises the characteristics of the Mahout clustering algorithms and their observed execution times.

Algorithm	*Mahout command*	*Fixed clusters*	*Partial membership*	*Execution time*
K-means	kmeans	Y	N	61096 ms
Canopy K-means	canopy kmeans	Y	N	121178 ms
Fuzzy k-means	fkmeans	Y	Y	644471 ms
Dirichlet	dirichlet	N	Y	15011080 ms
LDA	lda	Y	Y	3373535 ms

Table 1: Mahout Algorithms and their execution times

Aside from the accuracy of the clustering results, the timeliness of the solution is also important to consider. The k-means algorithm is scalable and completed within minutes, but requires the specification of the number of clusters. To resolve this problem, canopy clustering was introduced as a method to calculate the initial centroids. Such technique provided good clustering results, as it successfully discovered relevant topics within the data. After this, more complex clustering techniques such as fuzzy k-means, Dirichlet clustering and LDA were explored. As fuzzy k-means calculations are more complex, it took longer to complete than the k-means algorithm, but still offered a good overall performance. The Dirichlet clustering algorithm took in excess of four hours to complete on average and as this clustering process needs to be repeated on a daily basis to incorporate new support calls, it is not a suitable solution. Finally, as the performance of the LDA clustering algorithm depends on the number of words in the corpus, it took nearly 57 minutes for LDA to execute, showing an average CPU utilisation of 99.2% in the slave nodes. Thus it is determined that k-means or fuzzy k-means offer better scalability with comparable results.

4.3 Clustering accuracy

The clustering results are next evaluated in terms of cluster accuracy, with respect to the following metrics:

Inter-cluster distance: The *inter-cluster distance* measure is the sum of the square distance between cluster centroids and provides a measure of how well the data is separated. Good clusters tend to have centroids that are not too close to each other.

Intra-cluster density: The *intra-cluster density* is the sum of the square distance from the items of each cluster to its centroid. It provides a measure of how close the points are within a particular cluster. In a good cluster, there should only be a small distance between similar objects.

The results of Dirichlet clustering and LDA were not considered due to prohibitive execution performance. Table 2 displays the average inter-cluster and intra-cluster distances of the clusters obtained when analysing the target data using the three remaining algorithms.

K-means	K-means and canopy clustering	Fuzzy k-means
Inter-Cluster Distance = 0.6266557038155763	**Inter-Cluster Distance =** 0.7189579535905156	**Inter-Cluster Distance =** 0.51809323848957046
Intra-Cluster Distance = 0.7327555471390841	**Intra-Cluster Distance =** 0.6628596750612086	**Intra-Cluster Distance =** 0.661006793309346

Table 2: Inter-cluster and Intra-cluster distances comparison for k-means, k-means and canopy clustering and fuzzy k-means

It can be noted when comparing the clustering results obtained using k-means and k-means with canopy clustering in Table 2, that the second technique provides a better cluster quality as the inter-cluster distance is higher. Additionally, the intra-cluster distance for k-means with canopy clustering was less than for k-means, indicating closer objects within the clusters. The inter-cluster distance for fuzzy k-means was the lowest of all three algorithms. However this does not indicate that the quality of the generated clusters was poor as such a result can be attributed to the overlapping nature of fuzzy k-means. It should be noted that the intra-cluster distance for fuzzy k-means

was the lowest of all three algorithms, indicating that on average the objects within the generated clusters were closer to each other. Having compared the average inter-cluster and intra-cluster distances, the intra-cluster density for specific clusters was next investigated. Table 3 compares the intra-cluster distance for the "performance" related cluster generated by k-means, k-means with canopy clustering and fuzzy k-means.

K-means	K-means and canopy clustering	Fuzzy k-means
Intra-Cluster Distance = 0.7736539259386663	**Intra-Cluster Distance =** 0.6747847465314317	**Intra-Cluster Distance =** 0.5985633435773404

Table 3: Intra-cluster distance comparison for a sample cluster generated using k-means, k-means and canopy clustering and fuzzy k-means.

For this particular data set, fuzzy k-means presents the lowest intra-cluster distance, providing a better cluster and can therefore be determined that it is the most suitable algorithm to implement the solution as it provides a good compromise between performance in terms of delay and accuracy. It generates meaningful clustering results while executing in approximately 10 minutes, fitting the requirements of the solution. Finally, as fuzzy k-means returns the cluster membership probability for each support call, it also provides a mechanism to rank the support calls within a particular cluster.

However, such an approach presents some limitations. As illustrated in Figure 6, the top terms for the clusters originated by fuzzy k-means include commonly occurring words such as *we* and *I*. This problem is related to the method used to generate the text vectors. Given the vast datasets to be processed, an automatic procedure is required to vectorize the data. At present, Mahout only supports TF or TF-IDF weighting. Although TD-IDF weighting was used to convert the calls descriptions into vectors with a maximum document frequency percentage set to 90 to aggressively prune high-frequency words, some stop words were still present. While not currently supported in Mahout, more advanced techniques such as supervised weighting methods e.g. *Gain Ratio* based on statistical confidence intervals could be used (Soucy and Mineau, 2005) to improve the quality of the text vectors and, as a consequence, the clustering output.

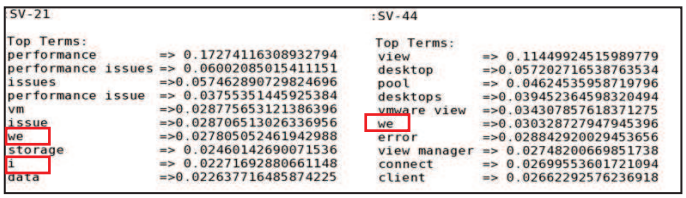


Figure 6: TD-IDF limitations

5 Conclusions and Future Work

This paper provides a framework for identifying similar technical support calls using open source Big Data analytics and was evaluated using a subset of VMware technical support data. An evaluation of the performance of the proposed solution as well as the accuracy of the applied clustering algorithms was outlined. Specifically the quality of the distributed clustering algorithms was considered. Although, this

paper discusses the analysis of VMware support data in particular, the described techniques and procedures are generally applicable to other organisations providing similar services, thereby providing a proof of concept Industry framework. Future work will examine alternative text vectorization methods to TD and TD-IDF to further improve the quality of the clustering results. Additionally, orchestration tools such as Oozie will be considered to automate the process.

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Link Adaptation Feedback Interval for Narrowband Mobile Ad-hoc Networks in Disaster Search and Rescue Scenarios

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Abstract

Mobile ad-hoc networks (MANETs) enable operation without fixed infrastructure, making them attractive for disaster search and rescue (SAR) and tactical applications. Reliability is an issue in such applications and increasing MANET communication reliability is critical for the acceptance of these systems. In this paper we investigate the impact of feedback delay on adaptive modulation and coding (AMC) in VHF narrowband MANETs. We analyse communication reliability and quality of service (QoS) under realistic conditions and study user net throughput for various AMC feedback delays. Results from Monte Carlo computer simulation show that a global maximum for the throughput with respect to interval exists. The achievable throughput, however, strongly depends on the user mobility pattern.

Keywords

Wireless communication, mobile ad-hoc networks, narrowband, adaptive coding

1. Introduction

The vision of infrastructure-less communications with mobile ad-hoc networks (MANETs), which are able to provide communication services in a constantly changing network topology, has motivated considerable research effort over the past two decades. The advent of small, portable communication devices like personal digital assistants (PDAs), smartphones and tablets, and wearable computers is offering the potential to make this vision come true for application areas where

1. only sparse or no infrastructure is provided,

2. nodes join, leave, and re-join the network by intention, due to mobility, or due to adverse effects of the radio channel,

3. and/or nodes are both concentrated at one location and sparsely distributed in other regions.

Applications such as disaster search and rescue (SAR) missions and tactical communications can use MANETs to establish and maintain connections between nodes as MANETs can operate in such conditions by adapting transmission parameters according to the changing network topology. However, while adaptation mechanisms such as adaptive modulation and coding (AMC) can significantly improve network performance, the deployment of these techniques is relatively complex in networks with completely distributed management. Especially in networks with strong bandwidth limitations as investigated here, the difficulty of increasing overhead emerges, requiring effective parameter adaptation in MANETs.

The subject of this paper is the investigation of the impact of feedback interval on AMC in time division multiple access (TDMA)-based single-carrier very high frequency (VHF) narrowband (bandwidth of 25 kHz) MANETs. For the link adaptation mechanism adaptive modulation and coding (AMC) is utilised where channel state feedback packets are transmitted from a receiver back to a transmitter. AMC is investigated at system level using an abstract model for the radio channel, with a delay spread of 14.5 μs. Since the MANET studied in this paper targets applications where bandwidth is strongly limited to enable large single-hop coverage (e.g. military communications or disaster search and rescue operations) minimisation of signalling overhead (used for link adaptation) is of major importance and is one of the most challenging issues to date. In this context, previous work (Helmle et al., 2013) focusing on the characterisation of link adaptation feedback has shown that the phenomenon of a constant AMC feedback delay (e.g. due to queuing issues) of up to ten cycles remains more a theoretical issue rather than a practical challenge. Hence, limited feedback remains beneficial for link adaptation. Despite the fact that only single-hop transmissions are analysed, our findings can also be beneficial for quality of service (QoS) provisioning in (TDMA-based) multi-hop wireless radio communication systems employing AMC.

The remainder of this paper is organised as follows: Section 2 presents related work. The system model used in our study is described in Section 3. In Section 4 the simulation model and parameters as well as the results are presented. Finally, Section 5 concludes the paper.

2. Related work

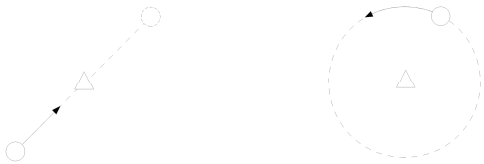
To mitigate multi-path fading impairments in two-hop MANET scenarios, adaptive modulation and coding can be applied as shown in (Müller and Hong, 2010). The combination of AMC and multi-hop transmission can achieve a trade-off between network coverage and throughput. The authors of (Müller and Hong, 2010) provide a mathematical performance evaluation for two-hop connections (source - relay - destination). In 2008, Cho et al. investigated multi-hop networks for multicast broadcast services in mobile WiMAX systems (Cho et al., 2008). For the optimisation of throughput, an AMC scheme was adopted in order to perform appropriate selection of modulation and coding schemes (MCS) between base station and relay station. As shown from computer simulations, the application of AMC to multi-hop networks with (fixed) infrastructure can yield significant performance improvements. In (Helmle et al., 2012) the impact of link adaptation in frequency-

selective wireless multi-hop ad-hoc networks was investigated with respect to the average end-to-end throughput and delay. Here, only scenarios without mobility were considered. The benefits of using AMC were shown for both AWGN and DAB channel conditions. The results confirmed the suitability of AMC in trading throughput for coverage in multi-hop networks. However, the performance of a closed loop AMC system significantly depends on the thresholds for the modulation and coding schemes applied. Zheng et al. analysed the impact of AMC adjustment period in mobile satellite communications environments (Zheng et al., 2012) and found that the application of AMC can improve the performance. However, they showed that for longer AMC adjustment periods the performance improvement will be less obvious. (Döttling et al., 2004) evaluated the performance of channel quality feedback (CQF) schemes for High-Speed Downlink Packet Access (HSDPA) using FDD. Overall, they found that CQF schemes, considering data packets which are transmitted as bursts, enable notably higher efficiency compared to a cyclic AMC feedback. Furthermore, they mentioned that reducing the overhead caused by CQF saves power and mitigates interference.

As shown here, studies investigating link adaptation feedback exist. However, the majority of the related work does not deal explicitly with QoS from the AMC point of view, i.e. how the specific operation of resource reservation and assignment, etc. affect AMC performance. In most cases the underlying system models differ from the boundary conditions we consider here, e.g. narrowband channel, VHF radio, etc. For example, in satellite communication high propagation delays and low SNR at the receiver need to be considered whereas shadow fading is in general not a major impact factor except in cities with dense and high buildings. Mobile radio networks like UMTS achieve coverage by employing a cellular system with frequency reuse that leads to substantially higher user bandwidths (multiple MHz) compared to our narrowband VHF system. Since they are centrally organised (using base stations) only single-hop transmissions occur. This paper contributes results from performance evaluation of AMC feedback delay in narrowband MANETs operating in the VHF frequency band and QoS requirements to guarantee an AMC based on feedback information achieves reliably good performance.

3. System model

The system model is based on a single-carrier VHF narrowband MANET consisting of two nodes. One is the transmitter, which emits data packets and the other is the receiver receiving data packets. Fig. 1 shows the two scenarios covered by this study reflecting typical mobility pattern during SAR missions. A constant bit rate multicast voice service capable of reaching the majority of mobile receivers within a single hop is the primary service. The secondary service is a variable bit rate background data service. At the application layer traffic is generated continuously at the maximum achievable data rate. For low data rates at least the multicast voice service is transmitted. Whenever the data rate available is sufficient, the background data service will be transmitted in addition to the multicast voice service via piggybacking.



(a) Pass (b) Circular

Figure 1: Overview of simulation scenarios. (O, Δ) denote transmitter and receiver, respectively.

The present system model does not consider re-transmissions at the link layer, therefore, the calculated throughput is the net amount of data rate available for a transparent data service. The system uses TDMA with a superframe structure as per Fig. 2 to manage channel access. A superframe consists of M+1 frames whereby M depends on the feedback interval. Since the ability to establish either three quasi-parallel single-hop channels or at least one multi-hop (up to three hops) channel is required, each frame consists of three slots. The slot duration is designed to accommodate multicast voice packets even when the most robust modulation and coding scheme (MCS) is applied. To avoid asynchrony between application layer and link layer, the TDMA frame duration is equal to the inter-departure rate of the multicast voice service as in other voice-driven systems like GSM.

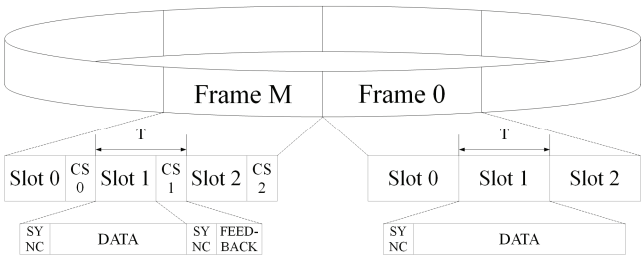


Figure 2: TDMA superframe structure consisting of M+1 frames. Frames 0 to M-1 accommodate data slots only while frame M consists of both data slots and control mini-slots (CS) for AMC feedback.

Only once within a superframe, i.e. in frame M each slot is followed by a short control minislot to enable a transmission of AMC feedback as well as other control data. A short AMC feedback packet will be transmitted by the receiver for a data packet received in frame M of which at least the header has been received correctly. Upon receipt of the AMC feedback, the transmitter is able to determine which MCS is the best for the next superframe period. While the MCS for the data transmitted in regular slots is variable, AMC feedback is always transmitted using the most robust MCS.

In order to select respective MCSs, a link adaptation algorithm based on signal-to-noise ratio (SNR) measurements is applied. Thresholds for the MCSs are selected in order to achieve a packet error rate (PER) of less than 0.01, which is required for real

time applications such as voice services where retransmissions cannot be applied. The SNR may be obtained either by a channel estimation via the SYNC sequence or by computing the error vector magnitude (EVM) subsequent to the equalisation process. The MCSs considered in this work are presented in Table 1. It should be noted that the bit rate for each MCS represents the user net bit rate (i.e. with regard to the case where a frame consists of data slots only) offered to the application layer.

ID	MCS	Bit rate/kbit/s	ID	MCS	Bit rate/kbit/s
0	BPSK 1/2	2.89	7	16-QAM 1/2	12.43
1	BPSK 2/3	3.94	8	16-QAM 2/3	16.65
2	BPSK 3/4	4.46	9	16-QAM 3/4	18.76
3	QPSK 1/2	6.09	10	16-QAM 5/6	20.87
4	QPSK 2/3	8.21	11	64-QAM 2/3	25.09
5	QPSK 3/4	9.26	12	64-QAM 3/4	28.26
6	QPSK 5/6	10.32	13	64-QAM 5/6	31.43

Table 1: Modulation and coding schemes used in link adaptation algorithm

The physical layer is simulated in a detailed link level simulation where look-up tables are generated that associate SNR with PER. The link layer simulation is able to consider effects such as Doppler spread, multipath propagation, synchronisation, frequency offset, channel estimation and equalisation as well as filtering and oversampling aspects (Dehm et al., 2012). A channel with an exponential delay power profile and a propagation delay of 100 µs (i.e. a delay spread of 14.5 µs) applies as it was found that multipaths up to 100 µs may occur in the VHF band. Signals are affected by both a distance-dependent path loss as presented in the work of (Li and Kunz, 2009)

$$\gamma\left(d\left(t\right)\right)=\alpha\left(d_0\right)+\eta\log\left(\frac{d\left(t\right)}{d_0}\right)+\theta\,,$$

where $d\left(t\right)$ represents the separation of the source and destination node at time t, $\alpha\left(d_0\right)$ is the mean path loss at a given reference distance d_0 in the far-field of the transmitting node antenna, and η denotes the path loss exponent. The path loss also consists of fading due to shadowing and is represented by θ (Helmle et al., 2013). Shadowing is modelled as a zero mean spatially correlated log-normal process to consider influences from buildings, hills, etc. which are exploited by the link

4. Numerical results

The most important parameters used in the Monte Carlo simulation are presented in Table 2. Hereby, several parameters relating to the radio channel and the physical layer have been taken from (Li and Kunz, 2009) as they are results from field measurements.

Parameter	Setting	Parameter	Setting
Path loss exponent	4.25	System bandwidth	25 kHz
Reference distance	100 m	Noise figure	6 dB
Atten. at reference distance	71.3 dB	Frame duration	180 ms
Std. dev. shadowing	5.12 dB	Slot duration	{60,52} ms
Decorrelation distance	20 m	Minislot duration	8 ms
Transmission power	30 dBm	Voice coder bit rate	2.4 kbit/s
Carrier frequency	57.0 MHz	Inter-departure time	180 ms

Table 2: Simulation parameters

The results presented for average user net throughput at the application layer consider both, the bits transmitted for the multicast voice service and for the background data service. Fig. 3 presents the average user net throughput versus AMC feedback interval for the scenario where the transmitter is passing the receiver (cf. Fig. 1a). Hereby the abscissa represents the period in terms of TDMA frames after which an AMC feedback packet is transmitted by the receiver. In this scenario the MCS applied initially is MCS number *0* (cf. Table 1) which is the most robust MCS. For an AMC feedback interval of one frame an average user net throughput of about 20.17 kbit/s is achieved for the entire range of the transmitters' velocity. Since the structure of the TDMA superframe enables the opportunity to establish three quasi-parallel single-hop data streams (cf. Fig. 2), the transmitter emits its signals only in slot number *0*.

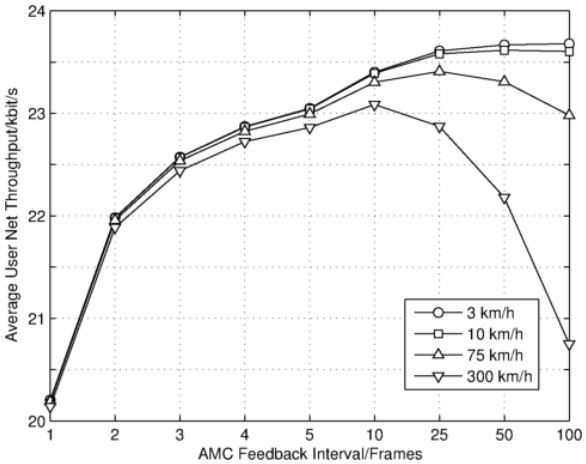


Figure 3: Average user net throughput versus AMC feedback interval for pass scenario.

Therefore, the user net throughput corresponds to about one third of the system net throughput depending on the AMC feedback interval. As the AMC feedback interval increases the average user net throughput increases, too. However, for each value of the transmitter's velocity a global maximum exists. As the feedback interval is increased beyond this maximum throughput drops. This behaviour can be explained as follows: Increasing the AMC feedback interval is leading to a reduction in accuracy of MCS selection on one hand but also a reduction of signalling overhead

and hence, a reduction in signalling overhead resulting in additional user data rate on the other hand. However, as the inaccuracy exceeds a certain value (which depends on the transmitter's velocity) the probability that an inappropriate MCSs is selected increases significantly, which in turn leads to an increasing probability of packet errors and therefore a decreasing user net throughput. At this point it should be noted that an increasing AMC feedback interval also increases the probability that the current MCS is used for a longer period as the link adaptation algorithm is able to change the MCS only when an AMC feedback packet has been received or a timeout has occurred. As MCS number *0* is used initially the probability that a more robust MCS applies for a longer period also increases.

The graph in Fig. 4 shows the average user net throughput versus AMC feedback interval for the circular scenario (cf. Fig. 1b). Here, the distance-dependent path loss is constant and therefore the link adaptation algorithm adapts according to the spatially correlated shadowing loss only.

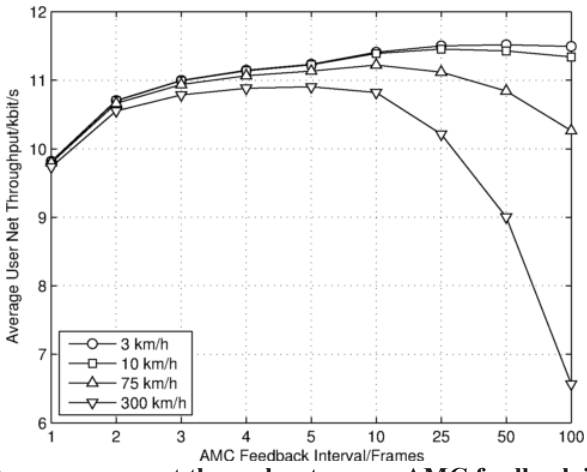


Figure 4: Average user net throughput versus AMC feedback interval for circular scenario.

As evident from Fig. 4, the qualitative behaviour is similar to the passing scenario as here the most robust MCS is chosen in the initial state. However, the average user net throughput is decreased to about 50 per cent compared to the passing scenario (cf. Fig. 3). This is due to the fact that the distance-dependent path loss remains constant (i.e. the transmitter and receiver are separated by the reference distance of 100 m) and very good channel conditions do not exists in order to select a higher order MCS.

5. Conclusions

This paper has studied the impact of link adaptation feedback interval on throughput in TDMA-based narrowband VHF mobile ad-hoc networks. The main finding is that the optimum value for feedback interval strongly depends on the nodes' velocity as well as mobility pattern. It has been shown, in case adaptive modulation and coding

is employed for link adaptation, a global optimum for user net throughput may be achieved by adjusting the feedback interval, i.e. by trading accuracy of channel state feedback against a reduction of signalling overhead. For systems with the same design but different numerical parameter values, an identical qualitative behaviour may be expected. These insights may be beneficial specifically for the provisioning of narrowband systems as the trade-off between overhead and system throughput is one of the most challenging issues. Finally, in order to limit system complexity, the number of modulation and coding schemes supported by a real system is expected to be substantial lower.

6. References

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The Reduction of Unregulated Plug Loads: The Next Obstacle in Achieving True Net Zero Energy Buildings

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Abstract

As industry pushes for further reductions in the energy consumption of buildings the era of net zero energy, zero carbon buildings has been realised. However, this frontier of highly efficient architecture has unveiled the considerably large problem of plug loads. In a typical office building plug load alone can account for 15% of total energy consumption. In a Net Zero Energy building that percentage can increase to 50+%. This paper discusses the reasons for this increasingly significant building energy load and the importance of reducing it. A methodological approach and results of monitoring the kWh consumption at plug level and room level within the main building of Cork Institute of Technology are presented. This achieved a benchmark of typical office energy usage that is then compared with the monitoring of kWh consumption at plug and room levels within the CIT Net Zero Energy Test-Bed. Calculations of true energy usage are made and potential savings identified. Finally methods of evaluation and emerging technologies are discussed, offering potential solutions to reduce plug load energy use.

Keywords

Plug loads, Net zero energy, Building performance, Operational energy loads, Unregulated energy loads, Post occupancy evaluation.

1. Introduction

The growing concern by building owners and operators of the unregulated energy loads, particularly in low energy buildings, is pushing research globally to address this issue. Given that net zero energy buildings are quickly becoming the benchmark in many countries, achieving a true net zero energy building should not even be considered without reducing unregulated operational loads. Subsequently, there is a global reassertion of focused research in this area.

The term "unregulated" energy loads refers to a building's energy demands outside of the "regulated" heating, ventilation and air conditioning (HVAC) and lighting loads (Whyte and Gann, 2001). These unregulated energy loads are primarily produced by the equipment and activities of those who work in the building, as opposed to the energy that maintains basic building comfort. This paper refers to the

key constituent of broader research that aims to deeper investigate the area of unregulated energy loads to inform existing design theories and practices of low energy building design – plug loads. By gaining a concise understanding of how users interact with low energy buildings affords the opportunity to highlight possible ways the relationship can become more harmonious and subsequently result in improved operational energy efficiency.

Typically, an architect severs all ties with a building upon completion. The lack of a developed and maintained feedback loop between the building occupiers and management and the designer is resulting in poor operational building performance. According to many studies lighting, HVAC, and office equipment consume the most energy in a typical commercial building. Plug loads consume roughly 10-15% of commercial electricity use (Sheppy et al., 2011). In a net zero energy building the proportion of energy consumption represented by unregulated plug load can increase to over 50% (Sheppy et al., 2011) of total end-use load. Simulation design forecasting has been shown to underestimate real energy use (Carbonbuzz, 2012).

The European Union (EU) has targeted 20% reduction in primary energy by 2020 (based on 1990 levels). However both by its own and external analysis it is more than 55% off target (EU Parliament, 2012) and (ECOFYS and Fraunhofer, 2012). The key directive is the Energy Performance in Buildings Directive (EPBD). The EPBD guides national legislation for buildings' energy, and in Ireland this is framed by Part L of the Technical Guidance Documents. The directive and national guidance is framed primarily around fabric driven solutions: heating, cooling and lighting services (regulated loads). Therefore these are the areas design teams typically target for reduction. However, due to the decentralised nature of plug loads it is often cheaper to make incremental modifications rather than large-scale upgrades to HVAC and lighting systems. As the percentage of energy loads attributed to plug loads balloons and becomes the predominant energy draw in low energy buildings, it can no longer be ignored.

2. Summary of Energy Use Analysis within CIT

An analysis of existing readings taken from electrical meters in 2010 and 2011 to establish a benchmark in terms of Cork Institute of Technologies total electrical consumption was the first step in undertaking this study. An analysis of CIT's electrical use was then coupled with plug load metering within certain office spaces in CIT. The unoccupied or 'phantom' electrical load quickly became evident. 29% of all electricity consumed within the main building of the CIT campus was consumed when the building was unoccupied. This percentage was cross referenced against existing research that was conducted in this area and it was found that typically the phantom load percentage within commercial buildings tends to be between 30% - 35% (Way and Brodass, 2005). This reaffirmed that these results were on par with

international results of similar research. According to Berkeley Labs in the University of California, of this, it is estimated that 75% can be saved using inexpensive incremental improvements.

3. Case Studies of Plug Loads

3.1. Case Study: Analysis of Energy Use within CIT in 2011

At the time of undertaking these case studies the only campus-wide energy use data available to the researcher was 2011 data. Fortunately, daily readings were taking from electrical meters throughout 2011. This data was painstakingly analysed to establish the usage that was attributed to the unoccupied period of 10pm – 8am. This is actually a lenient unoccupied period as it is estimated that three quarters of the total staff and student body have vacated the campus by 7pm. 10pm is the official closing time. The aim was to establish the total amount of energy consumption attributed to phantom loads over a period of a year and calculate the percentage that could potentially be saved.

To put CIT's electrical energy use in perspective, the CIBSE (Chartered Institute of Building Service Engineers) benchmark for electrical usage for a college campus is 80 kWh per square meter. CIT is using 127 kWh per square meter. The financial cost was calculated using the rate per kWh that CIT paid during the year of 2011. The financial implications of these loads are the best asset in driving reform. Applying the Berkeley Labs of the University of California estimate, a minimum of 75% saving can be made on all phantom loads using incremental, non-infrastructural improvements. This would result in a saving of €106,918 per annum for CIT.

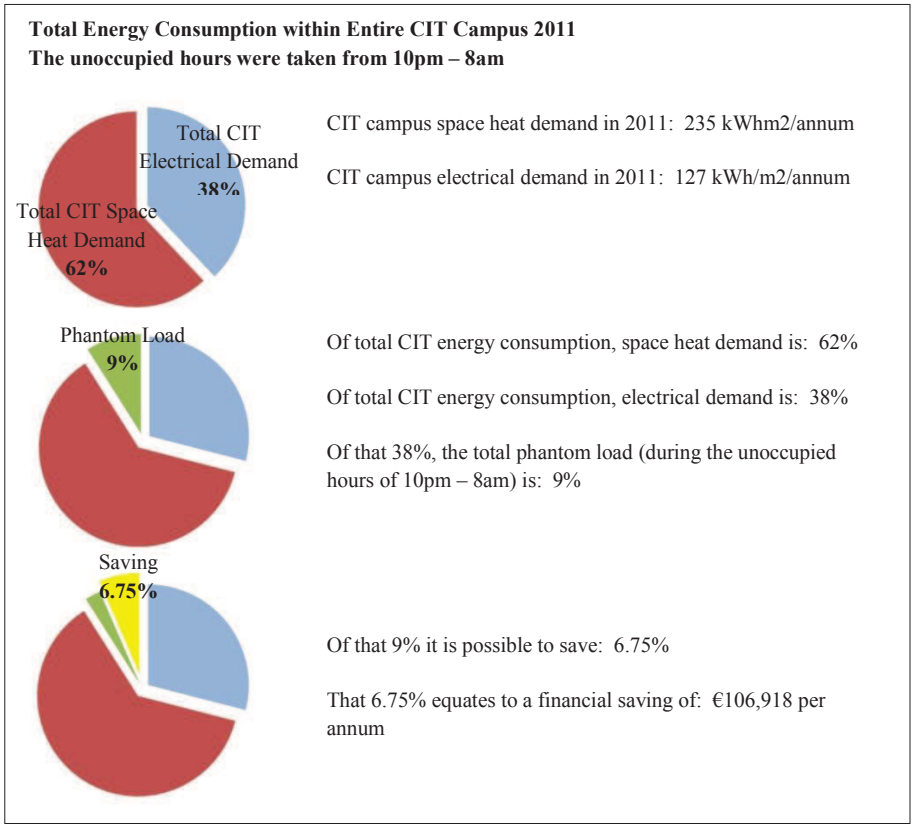

Figure 3.1 Entire CIT campus usage

3.2. Case Study: Research Office

A 24 hour monitoring of the plug loads of one of CIT's many post graduate research offices was conducted to test the plug meters, establish typical daily office device usage and identify any out of office or phantom usage. The office plug loads were monitored over a period of 30 days in December 2012 and an average 24 hour usage was established from this. Given this is a study conducted in a winter month, devices such as a space heater were prevalent within the overall usage. Currently a similar study is being conducted to establish a summer 24 hour usage. Below are the results of the winter case study.

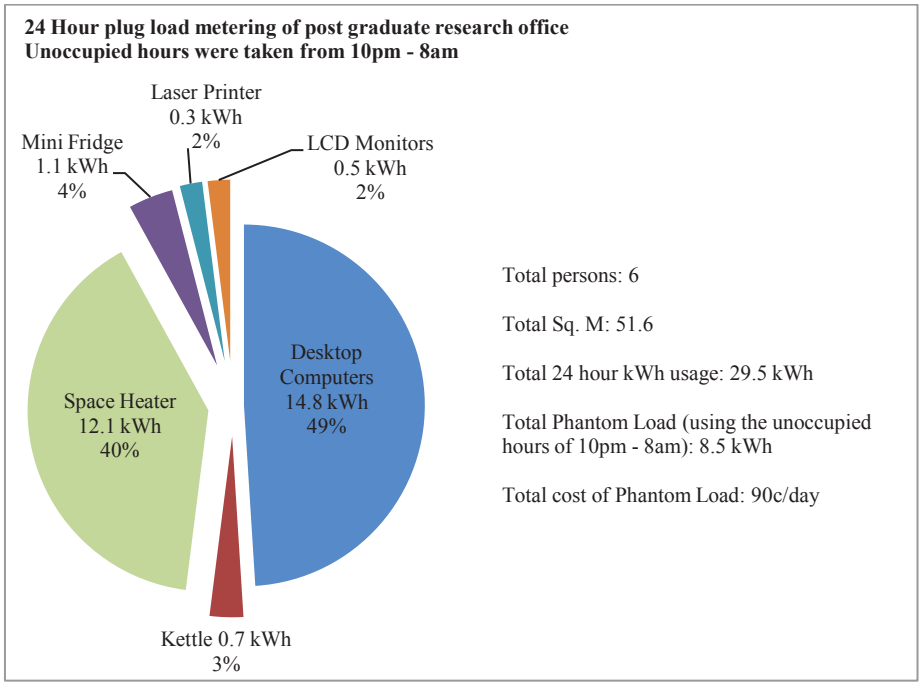

Figure 3.2 Post graduate office results

3.3. Case Study: 30 day metering of post graduate and purchasing offices

A 30 day period from 12/12/2012 to the 11/01/2013 was chosen for the second study, as this period would include the Christmas break. This allowed for the metering of plug loads during a prolonged period without occupancy. The two offices were chosen as they were similar in size, occupancy and use. Readings were taken daily over the 30 day period and this was monitored against office hours and out-of-office hours. The 14 day Christmas break was monitored separately and all staff were surveyed on their use of their relevant offices over this period: no members of staff occupied either office during this 14 day period. Some of the post graduate research staff members used remote access to access and use their computers from their homes. This is typical in many offices within Cork Institute of Technology and many other educational and commercial offices. The loads calculated during this 14 day period are still constituted as an unoccupied energy load. Of the total kWh usage monitored during this 30 day period the combined percentage of unoccupied/phantom plug load was a staggering 50%.

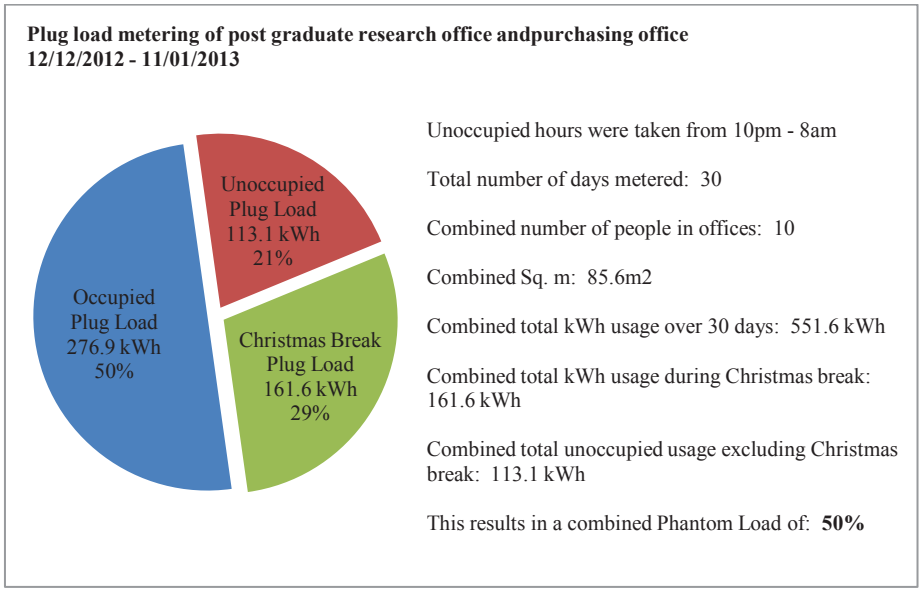

Figure 3.3 Post graduate office and purchasing office results

3.4. Case Study: Ongoing plug load analysis of CIT Zero Energy Test-Bed

The current phase of the case study is the undertaking of post occupancy evaluation of the Net Zero 20/20 Energy Test-Bed in CIT. Within this evaluation is the key component of the plug load analysis. The Net Zero Energy Retrofit 2020 Test-Bed project has upgraded approximately 290 sq. metres of the existing building with a view to achieving net zero energy by 2020. A net zero energy building produces as much energy as it uses in a year. The methodology is based on minimising consumption and supplementing the balance with renewable energy. Analysis of the unregulated energy loads is being undertaken as well as the establishment of a concise feedback loop to learn from the occupants themselves. This evaluation is fundamental to the collective aim of achieving a true low energy retro-fitted building. The plug load metering of the Zero Energy Test-Bed began on April 10 2013. This was the first stage in the post occupancy evaluation of the Test-Bed which utilises the established Probe Building Evaluation Method (Leaman and Bordass, 2001).

Having analysed plug loads in a standard building (CIT campus buildings), analysing the same loads in a Net Zero Energy building offers a comparative insight into any differences that may be evident. Do people behave differently in a Net Zero Energy building? Gaining an understanding of how much the human factor is responsible for poor operational energy performance in any building is vitally important, but given that plug loads can account for 50%+ of a Net Zero Energy building's energy load,

in this case it is imperative. The metering of occupant electrical consumption at plug level will give hard data on actual electrical consumption at each electrical outlet twenty four hours a day. This is to be continued for a period of one year, providing data throughout each season. In identifying any problems or inefficiencies that exist within the interface, a clarification of whether design, the building management or other factors are at fault will emerge. In terms of energy use the plug is often the secondary interface between the occupants and the building - lighting being the often first. By metering plug loads together with monitoring space heat demand and lighting demand, performance patterns that are directly attributed to the plug interface will become evident.

Currently the results show almost identical patterns of usage and levels of kWh consumption to that of the existing non-retrofitted buildings of CIT. It shows high occupied usage and high levels of unoccupied loads. By conducting an initial survey it became evident that the occupants were uninformed of the objectives of the other ongoing research of the Test-Bed. They were not aware of the overall objectives and aims of the Test-Bed. This undoubtedly contributes to the occupants' behaviour in treating the building as they would any other. Below is the first set of results displaying a weekly average in a Net Zero Energy Building. The weekly average was calculated from a four month period of monitoring.

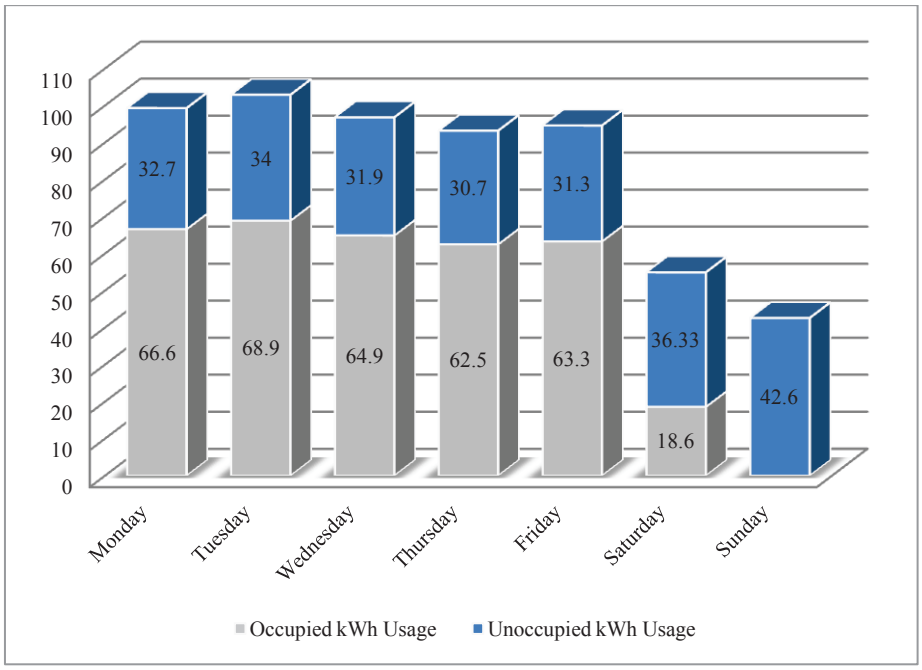

Figure 3.4 Occupied and unoccupied kWh usage with Zero Energy Test-Bed

4. Taking the next step

4.1. Evaluation

As large gaps exist between a building's pre-occupancy projected energy usage and post-occupancy actual energy usage, this has now seen the post occupancy evaluation (POE) methods that once focused primarily on health, comfort and productivity to evolve into evaluations that consider operational energy consumption. Today building performance evaluation (BPE) allows for making direct correlations between the occupants and the energy being consumed and emphasises that the evaluation should be constructed so that the returning data best informs the design process equally as much as it informs the building management (Mallory-Hill et al., 2012).

Architects, engineers, building managers and occupants must all be included in the operational performance of their buildings. Establishing an appropriately thorough POE, together with establishing a strong feedback-loop is an intrinsic part of good briefing and good building design (Mercier and Moorefield, 2011). POE is a way of providing feedback throughout a building's lifecycle from concept stage through to occupation. The information from established feedback-loops can inform future projects, whether it is information on the process of delivery or the technical performance data of the building. It serves a vital purpose. Coupled with this is the vital need to articulate to all stakeholders the potential to yield significant savings from reducing plug loads.

4.2. Managing operational energy loads

The proliferation of user appliances and poor user awareness of energy consumption is leading to increased daily electrical loads and increases in vampire loads. Vampire loads refer to the electrical loads of devices and appliances when they are on standby or in sleep modes. Within a work environment people care less about the energy they use. Including employees in the collective ethos of providing a low energy building is crucial. The monitoring and metering of electrical consumption must not be intrusive and must allow for variations, as people can change habits, increase or decrease the number of plugged-in appliances they use daily resulting in higher or lower energy consumption.

The choice of desktop computers, for example, within office or other commercial buildings can have a considerable bearing on the unregulated energy load of that building. Typical office desktops are of a higher performance level than needed for the computer's use. Incorporating desktops that are fit for purpose, for example low performance level computers for simple administrative programs, can substantially reduce the plug load from these devices.

The developments in occupancy sensors at outlet and circuit level, such as the Sensor Plug and the WattStopper DLM, respectively, hold potential to reduce plug energy load considerably. In dealing with Uninterrupted Power Supply (UPS) typically associated with server rooms, server Virtualisation is an emerging technology that will prove invaluable in the reduction of building energy load. Furthermore, the growing area of DC Microgrids, although costly, is direct response to high occupancy electrical use.

5. Conclusion

As the Energy Performance in Buildings Directive (EPBD 2010) is calling for all buildings to be Near-Zero Energy Buildings by the end of 2020 the building industry will need to position itself to achieve this standard of building. Understanding the considerable problem and the financial cost attributed to unregulated plug load energy demands in low energy buildings is necessary for designers to achieve true Zero Energy Buildings. The results of the case studies conducted for the purpose of this research reaffirm the considerable problem of unoccupied energy loads that exist within our buildings. Implementing this gained knowledge and applying proven energy saving solutions can contribute to the growing sector of low energy building design. In the case of a Net Zero Energy building, or any low energy building, it is vital to include the occupants in the overall ethos of low energy buildings. Educating the users is of upmost importance if a true low energy building is to be achieved, particularly in the commercial sector. Understanding the importance of the building's design interface with its users in terms of spatial and fit-for-use design is essential at design brief stage. It is key for building designers and managers to recognise that most of the problems associated with high operational energy use of buildings are behavioural rather than technical.

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A Procedure for a Standard Testing Method to Determine the Methane Potential of Organic Waste Streams

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Abstract

Organic waste streams represent a large potential energy resource within Ireland. A wide range of organic material found in municipal, industrial and agricultural waste streams can be used as substrates for Anaerobic Digestion (AD). The composition and characteristics of these waste streams vary widely and this can significantly affect its potential biogas yield. The method described can be used to evaluate the anaerobic biodegradability of organic wastes which may be used as a substrate in an AD facility. Current worldwide interest in utilising different organic materials for producing biogas through the AD process is growing due to decreasing energy supplies and the environmental impacts associated with the use of fossil energy forms. However there is a lack of clear references and comparability, notably in Ireland, of organic materials that could be used as potential substrates. A laboratory procedure based on biochemical methane potential (BMP) testing is described for measuring the methane (CH_4) potentials of organic waste. This testing method allows for the screening of organic wastes under identical operating parameters allowing for reliable comparability between potential substrates. The testing method is applicable to all organic materials once they can be accurately dosed based on their volatile solids content. The purpose of this laboratory work is to develop a database of potential CH_4 yields for the various organic waste streams from Irish Industry through the use of standardised testing.

1. Keywords

Biochemical methane potential, Anaerobic digestion, Biogas, Methane yields, Organic waste, Biodegradation

2. Terminology

Biodegradation potential: the ability of an organic material to undergo partial or complete biodegradation. With reference to this testing procedure the biodegradation potential of the organic material is demonstrated by the destruction of VS determined from the VS content of the reactors before and after the digestion period.

Innoculant: or digester sludge is material which contains the bacterial consortium necessary for AD to occur. Typical sources for innoculant include sludge from

wastewater treatment plants, rumen content, animal manure and sludge from biogas facilities.

Substrate: otherwise known as the feedstock, is the material which is fed into the reactor to be degraded by the bacterial consortium present in the innoculant.

3. Introduction

Anaerobic digestion (AD) is a biochemical technological process in which organic material is degraded in the absence of oxygen, via enzymatic and bacterial activities, resulting in the production of energy-rich biogas which can be utilised as a renewable energy resource. AD may be carried out in batch or continuous mode. Batch digestion is simple in terms of manufacture and operation with regards to laboratory installations (Liu et al., 2009). Where as continuous AD is more complex with a larger number of variables. Therefore batch testing is typically used when assessing the viability of an organic material as a substrate. Several batch methods exist for measuring the CH_4 potential of organic materials. The BMP assay has proved to be a relatively simple and reliable method for comparing the extent and the rate of conversion to CH_4. It may be used in lieu of more expensive and time consuming techniques such as semi-continuous feed bench-scale digester studies (Chynoweth et al., 1993). The method utilised in this paper has been adapted and modified from existing procedures, in particular (Raposo et al., 2011, Hansen et al., 2004), to an easily operable and replicable method of determining the CH_4 potential of organic material. The CH_4 potential of the organic waste streams is determined in terms of ml of CH_4 per gram of organic material which is expressed in terms of Volatile Solids (VS). The organic waste is tested under the same operating conditions to allow for comparability between the CH_4 yields. Undertaking each round of testing with the same operational parameters addresses issues such as repeatability and reproducibility which are inherent problems in the determination of CH_4 potentials of organic materials. This method will be used to determine the potential of multiple waste streams from Irish industries such as agriculture, agriculture related industries, food and beverage processing, organic waste collection etc. This will allow for a clear and reliable reference point for individuals or companies interested in developing a biogas facility within Ireland.

4. Significance and Use

Biodegradation of organic wastes through AD is an important process for the removal of many chemicals and pathogens, allowing the digested material to be disposed of safely and with negligible effects on the environment. The process also involves the production of biogas which can be used as a renewable source of energy. This test method has been developed to screen organic wastes for CH_4 potential based on their anaerobic biodegradation. A high CH_4 yield is evidence that

the test substrate is highly biodegradable and has the potential to be used for biogas production in an AD facility. Conversely, a low CH_4 yield may have causes other than poor biodegradability of the test substrate. Inhibition of the bacterial population may have occurred, or operational conditions in the test may not have been conducive for the development and growth of the bacterial population resulting in poor CH_4 production. The primary use of this method allows for direct comparisons between wastes thus decisions can be made on the viability of different organic wastes as substrates for AD. It can also be used within an operational biogas facility to determine the quality of new substrates prior to addition to the reactor.

5. Summary of Test Method

The BMP test procedure presented here is mainly based on DIN 38418 (S8) and is simplified in accordance with (Raposo et al., 2011, Hansen et al., 2004, Braun, 2007).Triplicate reactors containing 400g of innoculant, from an active anaerobic digester, and an accurately dosed quantity of substrate based on a 5:1 Innoculant:Substate (I:S) ratio, on a VS content basis, are incubated at 39^{o}C+/-1 ^{o}C within a sealed system. The CH_4 production is monitored over a period of 30 days by regular measurement of gas production using a liquid displacement system. The procedure also involves the use of a control batch containing solely 400g of innoculant to determine the levels of background gas being produced. The net amount of CH_4 produced by each substrate can then be determined by comparing the total CH_4 produced from the test reactors and the controls. The procedure has been evaluated regarding practicality, workload, gas detection limits and repeatability as well as quality control procedures through a series of preliminary testing.

6. Materials and Methods

6.1. Apparatus

The following equipment and supplies were used;

- *Incubator,* two shaking water baths thermostatically controlled at 39^{o}C ± 1^{o}C, capable of holding six reactors each.
- *Pressure resistant glass vessels,* 48 one litre GL45 Duran glass bottles, each fitted with gas tight GL45 two port caps, capable of withstanding 1.5bar. 12 bottles to act as reactors, 12 to hold gas washing solution, 12 to collect gas produced and 12 water collection bottles.
- *Temperature probe,* electronic probe capable of reading temperature within 0.1^{o}C.
- *Silicone tubing,* of 8mm internal diameter and a wall thickness of 3mm.
- *Clamps,* metal clamps suitable for sealing silicone tubing.

- *Gas washing solution,* 12 litres of a 0.5M Sodium Hydroxide (NaOH) solution.
- *Innoculant,* sourced from a mesophilic anaerobic digestion treatment plant.
- *Weighing scales,* electronic scale capable of reading weight to 0.1g.

6.2. **Innoculant and Substrate Preparation**

Active innoculant from the same source is utilised for all tests to allow for comparability of the substrates. The innoculant is pre-incubated for a period of 7 days. Once the gas production from the innoculant reaches a plateau it is suitable for use in the batch testing (Raposo et al., 2011, ISO-11734, 1995). Pre-incubation of the innoculant before the addition of the substrate reduces the volume of background gas produced by the innoculant in the active reactors and the controls resulting in more precise measurement of the net CH_4 production due to the substrate. The degassed innoculant must be stored in a manner that preserves its bacterial integrity (above freezing temperature).

Significant heterogeneity and a wide range of particle sizes characterise most organic wastes. Therefore the homogenization of the substrate/waste is extremely important to ensure representative sampling of the organic wastes being tested. To ensure representative sampling of the substrates it must undergo some form of pre-treatment. The organic waste sample must first be broken down to reduce the particle size and allow for homogeneous mixing. The reduction in particle size also increases the surface area available to the bacterial population resulting in an increased rate of biodegradation. The relationship between particle size and biodegradability has not been extensively researched to date. Raposo et al., 2011, recommends a particle size of $\leq$ 10mm to allow the results to be comparable. The particle size is reduced by passing the substrate through a mechanical grinder with an 8mm grinding disc.

6.3. **Volatile Solids Testing**

In order to characterise the prepared innoculant and substrate being tested their VS content must be determined. The VS testing carried out in this method is based on Method 1684 (U.S.-EPA, 2001). Triplicate sample aliquots of 25-50g are dried at 103^{o}C-105 ^{o}C to drive off any water in the sample and to determine the TS content of the sample. Once the TS content has been determined the dried residue is ignited at a temperature of 550 ^{o}C to burn off any volatile organic matter to establish the VS content of the sample. The TS and VS content of the samples are determined by comparing the mass of the sample before and after each drying step. The VS content of the substrates and innoculant are used to determine the concentrations that are to be added to the reactors. Triplicate samples must be used for the innoculant and each substrate. The triplicate samples validate that the results obtained are correct. In order for the values attained to be accepted they should agree within +/-10% of the

average. If one of the results is outside this % then it should be omitted and if two results are outside this % then the test should be run again. Once the gVS/kg of substrate is determined the weight of substrate required for each reactor can be decided based on the I:S ratio being used.

6.4. **Innoculant: Substrate Ratio**

The I:S ratio is an extremely important factor to consider as it significantly affects the performance of the batch testing. The I:S ratio must provide a substantial amount of bacteria within the innoculant to biodegrade the organic matter present in the substrate. A minimum I:S ratio of 2:1on a VS basis should be employed to allow for a sufficient bacterial population within the innoculant so as the reactor is not overloaded when the substrate is added (Chynoweth et al., 1993). However for this test procedure the I:S ratio chosen is 5:1 on a VS basis. This ratio is chosen based on preliminary testing which determined that this I:S ratio allows the use of a representative sample of the substrate which provides a high easy to measure level of gas production, while also avoiding large reactor volumes and impractical levels of gas production. It also ensures a high level of biodegradation of the substrate due to the larger bacterial population relative to a 2:1 ratio.

6.5. Procedure

6.5.1. Reactor Preparation

As the procedure described is a biological approach for the determination of the CH_4 yield of organic waste at least three reactors should be prepared for each substrate being tested. Biological procedures can produce varied results if the samples are not prepared and dosed correctly and the use of triplicates ensures that the results obtained are reliable based on their variance. An acceptable variance between results is 10% and as mentioned previously if one of the triplicates is outside this % it should be discounted from the analysis. In addition at least three control reactors should also be prepared for each round of batch testing. The control reactors contain 400g of degassed innoculant with the innoculant being mixed in between pours to ensure a homogenous mix of innoculant. Based on the I:S ratio of 5:1 (on a VS basis) the required weight of the substrate is determined. The substrate is then added to the reactor and vigorously mixed with the innoculant.

The addition of the substrate and innoculant needs to be carried out carefully in order to ensure the same amount of VS in each reactor. To reduce the headspace within the reactors distilled water is added to the 900ml mark on the 1L reactors. The addition of water allows for a better mix between the substrate and the innoculant while also allowing the gas produced within the reactor to escape through the medium easier. The prepared reactor prior to mixing is shown in Figure 6.1. Once the water is added

to the reactors they are sealed and the reactor is inverted several times to ensure the innoculant and the substrate is adequately mixed together. Once inoculated and dosed with substrate the reactor is connected to a gas measurement systems.

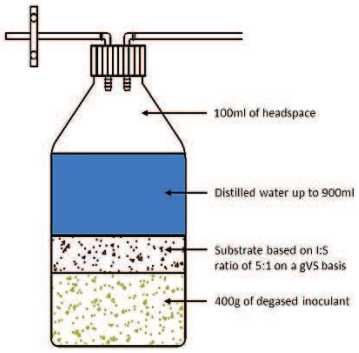

Figure 6.1: Prepared reactor prior to mixing.

6.5.2. Incubation

The sealed reactors are then incubated within the water baths at a temperature of 39^{o}C ± 1^{o}C (i.e. mesophilic temperature range) for a period of 30 days. The mesophilic temperature range is utilised as the temperature required can be maintained much more accurately than if a thermophilic range (45-65^{o}C) is used and it is also more resilient to temperature changes allowing for a more stable process. The reactors are incubated with continual gentle agitation provided by the shaking racks in the water baths. The reactors are also gently swirled and mixed daily prior to the measurement of the gas production. The mixing and agitation re suspends the innoculant and substrate mix and releases any gas trapped within the medium. It also compensates for any minor temperature variations within the reactor and the incubator.

6.5.3. Gas Measurement/Monitoring

Each reactor is fitted with an individual gas measurement system as shown in Figure 6.2. The parameters that are monitored during the batch testing are; the volume of CH_4 produced and the temperature of the incubator. In order to solely measure the CH_4 production, the biogas produced (a mix of CH_4, CO_2 and other trace gasses) must be passed through a washing solution to remove the CO_2. The washing solution used is a 0.5M NaOH (sodium hydroxide) solution. The removal of the CO_2 is achieved through chemical scrubbing where the biogas is passed through the NaOH solution and the CO_2 is extracted by forming sodium carbonate.

The remaining gas is predominantly CH_4 with some trace gases which are negligible for the purpose of these tests. CH_4 production is measured based on the weight of the water displaced from the liquid displacement system. The measurements should be

taken on a daily basis during the incubation period to allow the kinetics of the process to be followed and to provide an insight as to the progress of the process. It is critical that the incubation temperature is maintained throughout the testing and the measurement process. The temperature on the display of the water baths and the actual temperature of the water baths should be recorded before any other measurements are taken.

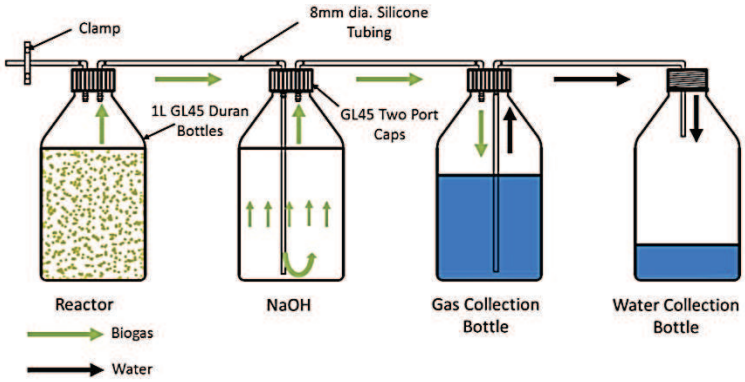

Figure 6.2: Reactor connected to gas measurement system.

6.6. Report

The following data and information is reported for each of the tests carried out:

- Information on the innoculant including information on the source, operating conditions of the digester, date of collection, TS content and VS content.
- Detailed information on the substrate which includes the source, the characterization of the waste, and any other information that may affect the contents of the waste. The TS and VS of the substrate should be recorded also.
- The TS and VS of the substrate and innoculant mix in each reactor before and after the incubation period.
- Cumulative CH_4 production for each test reactor and control, as well as daily production rates.

6.7. Data Treatment and Presentation

The daily measurements taken for CH_4 production are converted to cumulative CH_4 as a function of incubated time. The CH_4 production from the innoculant control is subtracted from the CH_4 production of the active reactors. The results therefore represent the CH_4 produced from the substrate added and not from the innoculant. At extremely low CH_4 production the uncertainty of the results increases, as the difference between the active reactor and the control gas production may not be

significant. This may occur if the substrate contains complex organic matter which is difficult to degrade. If this occurs the I:S ratio may be increased and the test runtests run again to achieve a reliable result. The increase in the I:S ratio introduces a larger amount of innoculant into the reactor thus increasing the bacterial population allowing for complete biodegradation of the complex substrate.

The amount of CH_4 produced per gram of VS is calculated by dividing the cumulative CH_4 production by the gVS of substrate added during reactor preparation. The rate of biodegradation can be calculated based on the direct measurement of the reactors VS content before and after the incubation period.

7. Results and Discussions

The results from the testing assesses the CH_4 potential of the organic waste streams being tested and can indicate those that are suitable for large scale digestion within a biogas facility. The method described here is a simple and cost effective way of screening organic wastes for their biogas potential.

7.1. Examples of Results

Figure 7.1 shows examples of triplicate curves measured for pig and chicken manure and their respective controls containing degassed innoculant and water. The triplicate curves presented for both substrates are much the same and each reactor produced similar volumes of CH_4 (variance less than 10% indicating consistency of triplicate results). The CH_4 production started once the reactors reached the incubation temperature. The high I:S ratio used results in fast CH_4 production with approximately 80-85% of the CH_4 produced within the first 10 days. After day 10 the production rate significantly decreases due to the decrease in acetate, CO_2 and H_2 which are required by the methanogenic bacteria to form CH_4. The triplicate curves shown in Figure 7.1 can be expected for most organic substrates, i.e. a high rate of production in the first 5-10days of the testing period with a steep decline after 8-10days. However the curve representing cumulative CH4 production can deviate from this typical profile due to the presence of fast and slowly digestible components and inhibitors see Hansen et al., 2004 for examples.

A significant point is that even though each reactor should be dosed with the same amount of substrate and innoculant in terms of VS the CH_4 production can vary between reactors. This can be attributed to many things including inaccurate dosing of substrate and/or innoculant, poor preparation of substrate, use of inactive innoculant, volatile fatty acid or ammonia inhibition etc. The use of the triplicate reactors and control reactors allow for the cause of the variances to be determined and to establish if they are significant enough to skew the results obtained. For example if process inhibition has occurred in one of the reactors it will be obvious as the CH_4 production in one of the reactors will be significantly lower, or, if inactive

innoculant was used, i.e. bacterial population killed off due to poor storage conditions, the CH_4 production from the reactors containing the substrate will be similar to that of the controls. Typically if the variance between the results is less than 10% they can be accepted as viable and accurate data and that no inhibition or dosing inaccuracies have occurred. The effect of the pre-incubation of the innoculant can be seen in the graphs presented in Figure 7.1. The CH_4 production in the controls is minimal in comparison to the active reactors indicating that the levels of background gas being produced within the active reactors is marginal, allowing for the precise measurement of the net CH_4 production from the substrate.

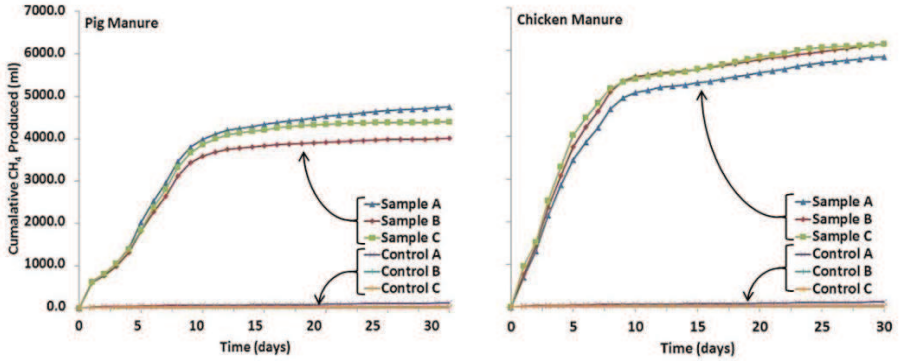

Figure 7.1: Examples of triplicate CH_4 production curves for pig and chicken manure.

The summarised results of the substrates presented in Table 7.1. The CH_4 produced is presented in two forms LCH_4/kgVS and LCH_4/kg of substrate. It is important that both these figures are taken into consideration when evaluating the waste stream as a substrate, as the CH_4 yield of the waste is significantly altered when the VS content is taken into account as can be seen with the chicken manure. If solely LCH_4/kgVS were taken into account chicken manure would present as a much more viable substrate however once the VS content of the substrate is taken into account both wastes show equal viability as a substrate for AD.

Substrate	Cumulative CH_4 Production (ml)	VS Content (gVS/kg)	LCH_4/kgVS	LCH_4/kg of Substrate
Pig Manure	4320.33	807.65	67.48	54.50
Chicken Manure	5994.80	590.11	93.68	55.28

Table 7.1: Summarised results of pig and chicken manure.

7.2. Discussions

This laboratory procedure allows for the determination of the CH_4 potential of any organic material that can be accurately dosed to the reactors. The I:S ratio of 5:1 chosen for the testing allows for maximum degradation of the substrate and consequently accurate representation of the CH_4 potential of the wastes. A minimum of triplicates must be used in order to obtain reliable and accurate results, due to the fact that the procedure presented is a biological approach to determine the CH_4

potentials. The variable nature of the substrates being tested makes it important to use control procedures such as mixing and triplicate testing to ensure reproducibility and repeatability. Although the majority of the CH_4 production takes place within the first 10 days of the incubation period it is important to allow for the full 30 day incubation period to obtain the maximum gas production from slowly degrading organic matter. The reactors should be monitored daily in order to obtain an accurate representation of the CH_4 production. The procedure described is simple and cost-effective and has the potential of being repeatedly used for both the determination of CH_4 potential and for further studies on the enhancement of the CH_4 potential through alterations of the operating parameters or pre-treatment of the substrate.

8. Acknowledgements

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Cataloguing and Energy Modelling Large Scale Retrofit Opportunities for Local Authority Housing in Cork City

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Abstract

Large scale, non-invasive and largely off site modular building retro-fit solutions offer scalable opportunities to assist in climate change adaptation for existing residential built stock. In Ireland, local authority housing (LAH) hosts a large proportion of the existing domestic built stock. This paper outlines the basis for development of a methodology to catalogue and analyze existing LAH developments in Cork City based on their thermal energy performance. This process informs location, elevation, orientation, superstructure and current energy rating. Firstly LAH existing typologies are statistically analyzed to produce a generalized house type representation of a mean terrace typology. Climate data is measured at a number of site specific locations; variations within the data are identified and comparisons are analyzed. Weather files generated for various locations are inputted into the statistical energy model and pre-retrofit findings are analyzed. This tests the efficacy of the climatic data files theoretical foundation, looking at the extent to which it generates an effective support to real time sustainable retro-fit modelling. A detailed systematic retro-fit application can then be designed and modelled using a dynamic thermal model based on the typologies identified following the statistical study. Findings from building simulation modelling will further inform the design methodology. Initial energy modelling is done using PHPP (Passive House Planning Package) and DEAP (Dwelling Energy Assessment Procedure) for preliminary findings. Cork City is used as the case study as it hosts such a large topographical variation; illustrating the effect of micro climate on building energy performance. This paper outlines a proposed research methodology to achieve the objectives set out above and identifies some initial findings which support the research hypothesis presumptions. Variations are found in site specific climate files in close proximity to each other. Trends and patterns are also established within the building typologies.

Keywords

Local Authority Housing, retrofit, Energy efficiency, Climate data, Scalability

1. Introduction

The EU adopted the Directive 2012/27EU on energy efficiency to achieving the target of 20% improvement in energy efficiency for 2020; this was done on the 25th of October 2012 (Directive, 2012/27/EU). To deliver this target existing domestic stock will need to play a role, with 40% of energy being consumed by buildings in Europe (IEA, 2010). A key area for substantial energy savings is in refurbishment of existing stock; this is identified by the National Energy Efficiency Action Plan 2009-2020. There is huge potential for energy saving measures in residential built stock. The recasting of the EPBD in 2010 by the EU outlined the roadmap to reaching nearly zero energy buildings by 2020. New tougher challenges are now faced by EU member states; new build and retro-fit must be nearly-zero energy buildings by 2020, 2018 for public buildings (Directive2010/31EU).

1.1 Local authority housing

Housing has been provided by Local Authorities for the last 100 Years. Irish social housing improved living conditions in Ireland and acted to boost home ownership through the tenant purchase agreement (Regan and Paxton, 2001). The basis for social housing was built under British rule in the late nineteenth century. Initially inspired by concerns about public health and social order as well as providing shelter to the poor (Pooley, 1992). The provision of this housing was intended to tackle a housing shortage in the first half of the 20th century; and in the second half of the century to provide basic housing to low income families (Fahey, 1999). Social housing was seen by government not just as a means to provide housing but also as a mechanism for stimulating employment during times of recession (O'Connell, 2007). For the past 90 years, since late 20's early 30's the state has been generating the nation building phase. Central to this initiative has been the generation of the housing stock for the citizen. The stock and its design through time have been premised on the concept of the pattern book. The pattern book is the base design for the building stock generated through the achievement of a mean or an average, to generate a standard superstructure (Gaskell, 1989). This pattern is evident through the design and build of Social housing throughout Ireland; which offers an opportunity to design large scale solutions to improve comfort within these poorly performing buildings.

1.2 Climate data

Currently many Building Performance Simulation (BPS) tools still use very limited sources of climate data. Using accurate local climate data in BPS becomes increasingly more important with low energy retro-fit design. In the case of ultra low energy design the need for accurate climate is increased as solar gains can compensate up to one third of the total losses (Feist, 1993). In a study carried out by John Morehead, a comparison was made between using long term measured in-situ regional TRY data (Dublin) and interpolated Meteonorm data on a Passive House project near Carrigaline, Cork; Morehead recorded that a 30% variation in predicting space heating demand was possible depending on the source of data (Morehead, 2010). Morehead also measured a 41% variation in climate data across Cork County (Morehead, 2012). This further informs us of the importance of using site specific climate data in building simulation modelling at the retro-fit design phase. If there is discomfort due to cold surfaces caused by inaccurate building design stemming from imprecise climate data, heat load is increased to compensate for the discomfort. This leads to inaccuracies in actual pre-build energy consumption forecasting (Fanger, 1970)

Local climate influences both annual energy consumption and internal environment in buildings. The buildings thermo-physical properties and geometry influence how the building responds to its micro climate. This research intends to increase accuracy in simulation output through the application of site specific climate data generation.

1.3 Retrofit

This research is complimenting pre-existing frameworks for domestic retrofit such as for example Tabula (Tabula, 2012). Tabula is a building typology brochure and web tool (www.building-typologies.eu) which was funded by Intelligent Energy Europe, Dublin City Council, Electric Ireland and Sustainable Energy Authority of Ireland. Tabula identifies the most common residential building typologies nationally; it provides relevant building energy information. It catalogues them and provides a tabulated set of retro-fit guidelines. Tabula is based on the BER (Building Energy Rating) database, which uses the DEAP method (Tabula, 2012). DEAP calculations are based on IS EN 13790 (2008) and use a similar calculation procedure as the Standard Assessment Procedure (SAP) which is used for energy ratings in the UK (SEAI, 2013). DEAP is used to show compliance with the Energy Performance of Buildings Directive (EPBD) in Ireland and includes parts of Irish

Building Regulations (SEAI, 2013). The work proposed in this paper is intended to compliment efforts like the Tabula platform; concentrating on large scale LAH terraced built stock. Dynamic thermal modelling of terraced units using TRNSYS (Transient system simulation tool) (www.trnsys.com), PHPP (passiv.de) and DEAP analysis will give sufficiently accurate data for energy consumption estimations pre retro-fit design.

2. Methodology

Cork City was chosen as the case study for this research based on its topographical variation and number of terraced LAH typologies. The Methodology is then broken up into three steps. Step one is cataloguing existing LAH. Step two is to generate site specific climate data and analyze and finally step three is to develop an optimum retro-fit solution.

2.1 Cataloguing existing case study LAH

The cataloguing process firstly involved the identification of all LAH developments in Cork City. Maps from Cork City Council helped to identify developments. Once identified, developments are broken up into new ongoing developments and older traditional developments. The following steps are taken for the analysis of each development: (i) identify number of typologies in development, (ii) photograph and document typologies, (iii) survey buildings to establish variations, (iv) count all units from maps, (v) determine percentage orientation using color referencing on maps, (vi) calculate initial building energy rating (BER) of each building type, (vii) determine variations in site elevations, (viii) vertical sectional study to determine superstructure. An example of this analysis method is graphically communicated in figure 1.0

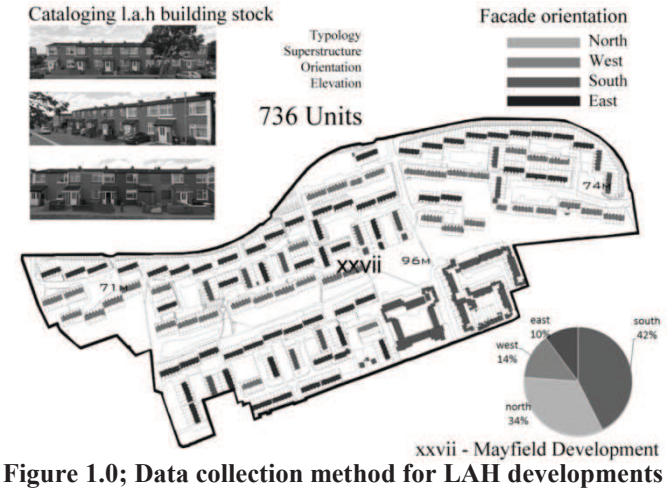

Figure 1.0; Data collection method for LAH developments

From the cataloguing of LAH building stock a spreadsheet has been generated to record and list findings based on the cataloguing criteria. Following analysis of each LAH development, data is then analyzed using a proprietary statistical computing package namely SPSS (Statistical Package for the Social Sciences) to generate a statistically significant model. This is done by converting re-occurring building elements into numerical data to generate a representative model which represents the mean. A number of re-occurring problematic areas will also be identified and addressed through statistical analysis.

2.2 Site specific climate data – importance to quantifying large scale retrofit solutions

Site specific climate data is generated at a number of LAH developments using Meteonorm software (www.meteonorm.com). The effect of local climate on building energy consumption will be assessed. Future weather files will also be generated using Meteonorm to future proof the final retro-fit design. In simulating the climate data at the chosen sites in Cork City the dynamic model of Perez et al. (1991) was used. Meteonorm software uses a method of interpolation to develop site specific weather data (Remund, 2010). Generally measured data can only be used close to a weather station, however Meteonorm software is able to interpolate between different weather stations which allows for site specific micro climate data to be produced at any geographical location in the world (Schneiders, 2009). The three nearest weather stations used by Meteonorm in these simulations are Cork Airport, Valencia and Shannon. This allows for an accurate calculation of many meteorological parameters at any site. This software is able to generate input data in text format which feeds into building simulation software packages (Remund, 2010). The primary inputs are mean ambient temperature, slope beam irradiation, horizontal irradiation, precipitation, wind, sky and ground temperatures (Remund, 2010).

HORIcatcher version 1.23 (www.meteonorm.com) is also used in addition to Meteonorm to account for local horizon obstacles affecting incident solar radiation. HORIcather is used to take a 360 degree picture of the horizon; to establish precise solar energy input. HORIcather software then transforms the picture to allow input into Meteonorm software (Meteonorm, 2013). This practice becomes increasingly more important in an urban setting as there are many obstacles most importantly effecting winter solar irradiance which become increasingly important in low energy retrofit. The combination of simulated climate data and measured horizon obstacles from HORIcather are inputted into the building simulation software. The results outputted from the dynamic thermal model will further inform the design and through a process of iterative design, the optimum Retrofit application should be obtained.

2.3 A proposed methodology for selection of optimum retrofit solutions

By studying LAH typologies and variations within superstructure it is envisaged that this will guide the study into potential retro-fit applications. The advantage of basing this study on repeated building typologies is it offers a systemised modular retro-fit methodology which can be constructed largely off-site. Figure 1.1 describes methodology overview for the execution of this research.

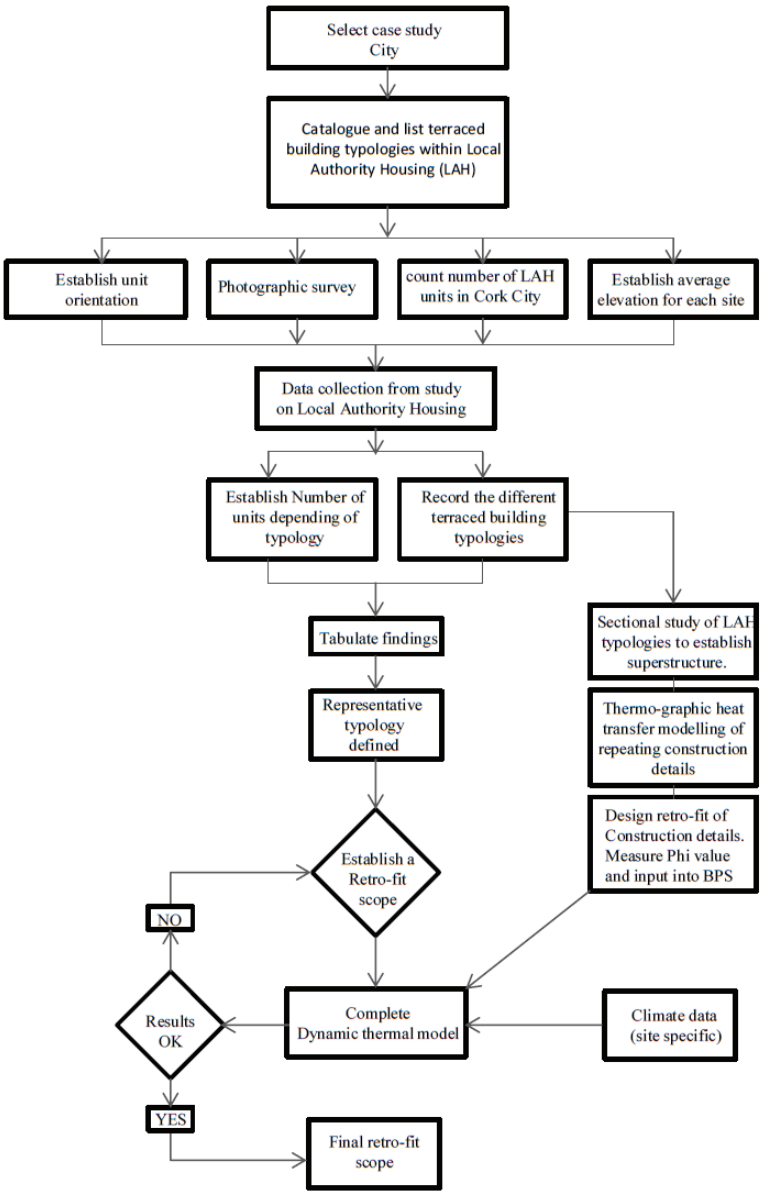

Figure 1.1; breakdown of methodology

3. Preliminary investigations

3.1 Initial results from cataloguing LAH in Cork City

The total numbers of units within the older traditional schemes are counted and color coded depending on orientation. Figure 1.2 describes the total number of units depending on orientation and percentage orientation. Orientation is based on façade orientation as front façade generally has a larger proportion of glazing. Retrofit challenge is increased due to limited solar gain to the 3,286 north facing units (Cork City Council maps, 2013)

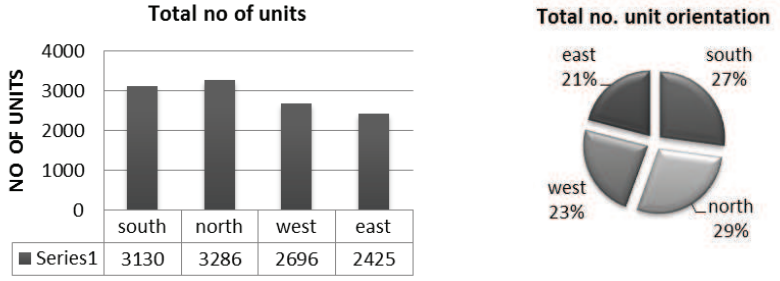

Figure 1.2; Total number of units and percentage unit orientation

The total numbers of units counted within the older traditional schemes are 11,537 units (Cork City Council maps, 2013). This number of units are in Cork City; the same typologies exist nationally. Once the retro-fit application is designed the intension is to apply this nationally to test the efficacy of findings. These tests will be carried out using site specific weather files for each location nationally

3.2 Initial analysis of climate variations within cork city

Ten LAH developments are chosen across Cork city, weather files are produced for the ten LAH traditional developments using Meteonorm software. Maximum distance between weather files generated is 7km, with a minimum distance of 500m. Figure 1.3 shows the variations in elevation for the ten weather files produced.

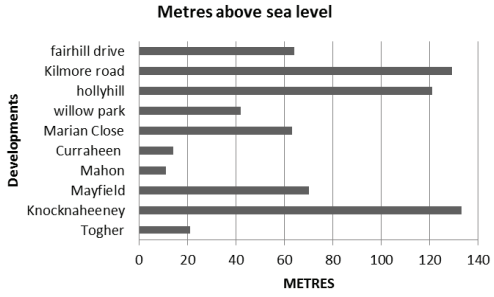

Figure 1.3; meters above sea level

The ten weather files are broken up in Figure 1.4, to analyze variations; average ambient temperatures, average sky temperatures, average ground temperatures and vertical solar irradiance are graphed. Variations are found through extrapolation of data from weather files. Figure 1.4 A-J illustrates variations in climate data generated at the 10 chosen LAH developments.

Ambient temperature: the temperature of the air around you, inside or outside. Sky temperature: the equivalent temperature of the clouds, water vapor, and other atmospheric elements that make up the sky to which a surface can radiate heat. Ground temperature: the temperature of the ground near the surface. Solar irradiance: the total frequency spectrum of electromagnetic radiation given off by the sun. Global radiation: included both radiation reaching the ground directly from the sun, and that received indirectly. Diffuse radiation: radiation received from the sun after reflection and scattering by the atmosphere and ground. Direct normal radiation: solar irradiance measured at a given location on Earth with a surface element perpendicular to the suns rays.

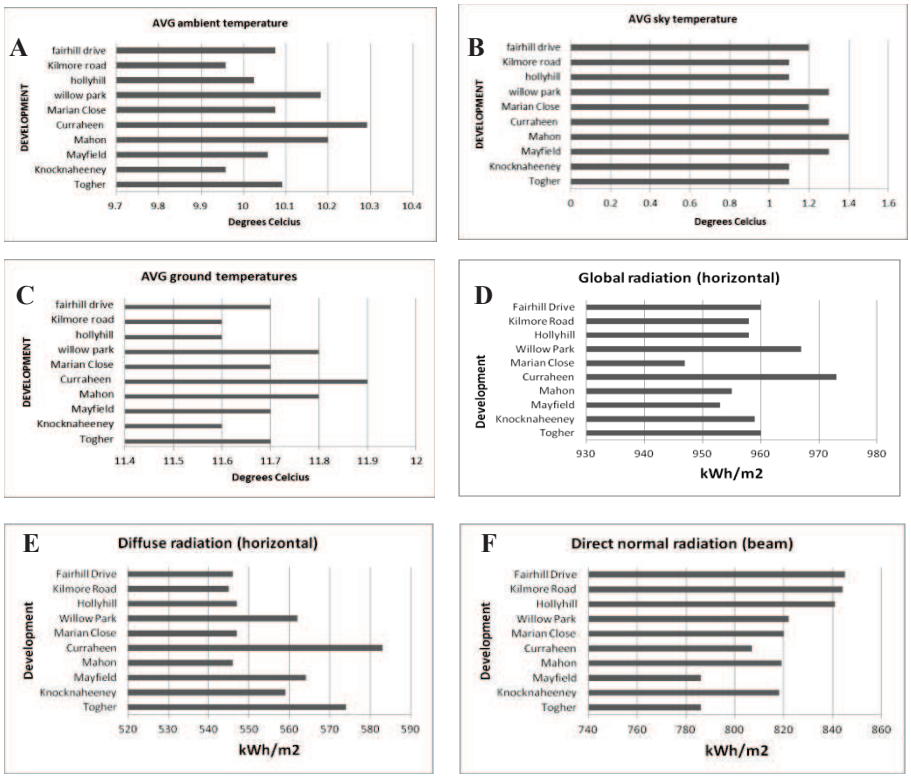

Figure 1.4; Variations within weather data for the 10 chosen locations. The 3 weather stations used by Meteonorn to interpolate weather data are Cork Airport, Valencia and Shannon.

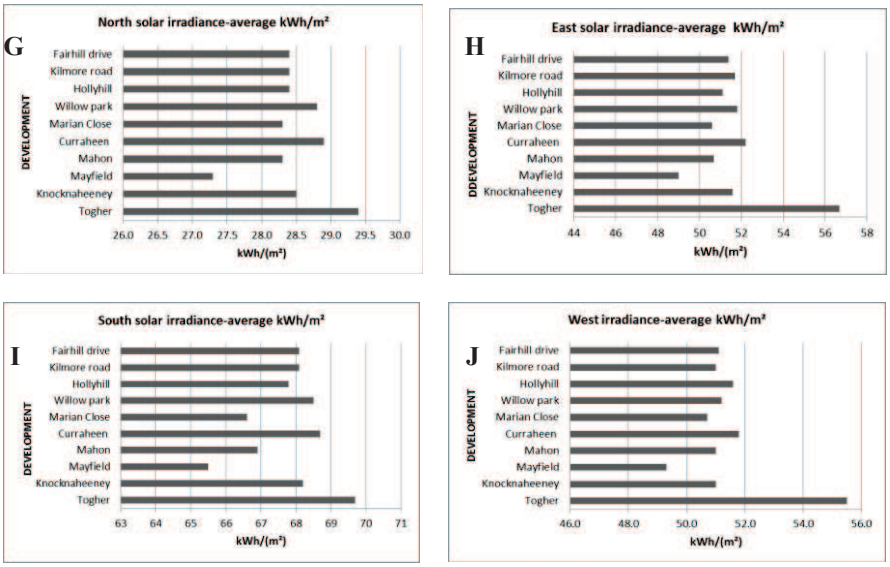

Figure 1.4; Variations within weather data for the 10 chosen locations. The 3 weather stations used by Meteonorn to interpolate weather data are Cork Airport, Valencia and Shannon.

4. Conclusion

From initial cataloguing of LAH it has become evident that patterns exist between different building typologies. Results from sectional study conclude that there is little variation in structure between traditional LAH. Most common structures are block on flat, block on flat with Cork lining and cavity wall with 60mm cavity. These initial findings support the need for a systematic retro-fit methodology as patterns in structure support a modular application. There are challenges faced in reducing typical cold bridging elements, these areas will require further design solutions.

Through extrapolation of elements in the 10 weather files generated, variations were found between locations. Variations in solar irradiance suggest further study in this area as this will have an important influence on glazing specifications, overheating and passive solar gains. Average ground and sky temperatures were minor; it is probable that one opaque retro-fit solution be adequate. Further research in this area is necessary. This would however support the focus of this research, which is to design a large scale modular retro-fit application for terraced LAH. The maximum distance between any 2 weather files produced is 7km. The variations found at such small topographical distances and elevations prove the importance to support this method for use in retro-fit nationally. The current work is not definitive and is subject to further analysis.

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Congestion Control Algorithm and Performance Analysis of Voice and Video Call over Skype

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Abstract

Video call has gained more momentum in recent Voice/Video over Internet Protocol (VoIP) applications. However, due to its large bandwidth requirement, it is challenging to develop efficient congestion control mechanisms for better perceived video quality when compared with voice call. In this paper, we investigate the congestion control mechanism of Skype, one of the most popular VoIP tools, for voice and video calls in terms of Quality of Service (QoS) and Quality of Experience (QoE). Preliminary results show that Skype uses different category-based congestion control mechanisms for voice and video calls in order to react to adverse network conditions. The congestion control mechanism only takes video contents into consideration when available bandwidth significantly changes. Nevertheless, the congestion control mechanism does not consider video contents when packet loss rate changes. The category-based congestion control mechanism can recover the QoE of voice calls more effectively than video calls under adverse network conditions.

Keywords

Skype, VoIP, Congestion Control Mechanism, QoS, QoE

1. Introduction

In recent years, VoIP communication has become more popular. There are many VoIP applications such as Skype, Google Talk and Yahoo Messenger (Sat *et al.* 2007). Skype is a Peer-to-Peer (P2P) VoIP application and it is one of the most popular and successful VoIP applications in the world with the largest amount of users reaching a peak of 45,469,977 concurrent users online in 2012 (Skype, 2013). Due to Skype's proprietary nature, its advanced congestion control mechanisms are unknown in the public domain. Therefore, understanding the congestion control mechanisms of Skype's voice and video quality may help to develop efficient congestion control mechanisms in the future. Thus this has attracted many researchers to investigate Skype's built-in congestion control mechanism and Forward Error Correction (FEC) algorithm in order to better understand the inherent problems of VoIP and the nature of Skype. This paper aims to investigate the Skype's proprietary congestion control mechanisms and the performance of Skype's voice and video call in terms of QoS and QoE. The QoS will be investigated depending on the payload size, interarrival time and throughput. The QoE is defined by ITU (International Telecommunication Union) as "*The overall acceptability of an application or service, as perceived subjectively by the end-user*" (Huang *et al.*

2010). Mean Opinion Score (MOS), from 1 to 5, is used to represent the QoE from bad to excellent. Currently Skype applies SILK codec to encode speech and uses multiple versions of video codecs to encode video such as VP6, VP7 and VP8 (Zhang *et al.* 2012 and Goudarzi *et al.* 2011).

The contribution of this paper includes three main features of Skype congestion control mechanism: (1) Skype applies category-based congestion control mechanism for voice calls and video calls to react adverse network conditions. (2) The category-based congestion control mechanism only takes video content into account when the available bandwidth changes in the network. The category-based congestion control mechanism will increase the payload size of fast motion video quicker than slow motion video, when available bandwidth significantly increases. Nevertheless video contents would not be considered by the congestion control mechanism when packet loss rate changes. (3) The category-based congestion control mechanism recovers the QoE of voice calls more effectively than video calls. The rest of this paper is organized as follows. The related work is summarized in Section 2, and Section 3 introduces the testbed and experiments carried out. Results analysis is discussed in Section 4. In Section 5, the conclusion and future work are presented.

2. Related work

Several researchers have investigated the congestion control mechanisms of Skype. Huang *et al.* investigated Skype's FEC mechanism which is used to effectively recover quality through encapsulating several data into one FEC block (Huang *et al.* 2010). Zhang *et al.* indicated that Skype reduced sending rate and video bit rate with the increase of packet loss rate (Zhang *et al.* 2012). They also found out that Skype applied two models for FEC mechanisms based on the threshold of packet loss rate (10%). De Cicco *et al.* proposed a model of congestion control mechanism for Skype voice calls in terms of packet loss rate and available bandwidth (De Cicco *et al.* 2010). Furthermore, De Cicco *et al.* also found out that Skype was TCP-friendly (De Cicco *et al*. 2011). Zhu investigated the traffic characteristics and user experience of Skype under different kinds of network such as Local Area Network (LAN), Wireless Local Area Network (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX) (Zhu, 2011). Exarchakos *et al*. found that Skype could recover lost packet efficiently when packet loss rate was lower than 10% (Exarchakos *et al*. 2011). Liotta *et al*. investigated the QoE management for Skype video stream and found out that the QoE management should consider more human-centric (Liotta *et al*.2012). Xu *et al*. investigate and compare the performance and design choices of Google+, iChat and Skype (Xu *et al*. 2011). However, most of the previous researches on Skype voice and video calls only focused on packet loss rates less than 10%. Furthermore, the investigation on Skype video congestion control mechanisms under different video contents has been ignored. Hence this paper aims to investigate congestion control mechanism based on the packet loss rate from 0% to 20% and the available bandwidth between 100 Kbps and 1700 Kbps. Additionally, this paper also investigates how Skype congestion control mechanism reacts to different video contents under different network conditions. Furthermore, the QoE of voice and video calls under adverse network conditions will be investigated based on human-listened.

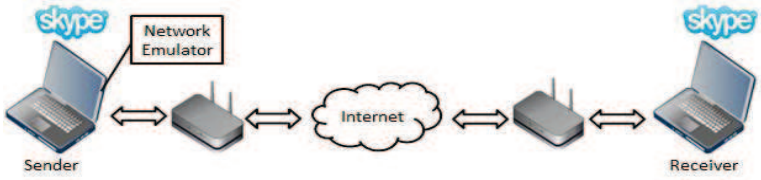


Figure 1: Testbed

3. Testbed and experiments

3.1. Testbed setup

In order to conduct Skype voice and video calls under different network conditions via wireless network, a testbed is set up which consists of two Laptops installed with Windows 7 and two wireless routers (Netgear WGR614v8) connecting to the Internet as shown in Figure 1. Network Emulator for Windows Toolkit (NEWT) is used to emulate different network conditions (NEWT, 2013). It is installed on the 'Sender' laptop. Standard voice samples and video clips are injected into the Skype Sender machine by using Virtual Audio Cable and ManyCam respectively (Virtual Audio Cable, 2013 and ManyCam, 2013). Voice and video traffic are captured by Wireshark. The voice is recorded on the receiver side by Audacity, whereas, the video is recorded by SuperTintin.

3.2. Experiments carried out

Due to low bandwidth requirements of Skype voice calls, the experiments on congestion control mechanism and performance of Skype voice calls were only conducted under different packet loss rates. The packet loss rate is incremented at an interval of 2% after every 1 minute from 0% to 20% in order to investigate how Skype adjusts the sending bit rate, interarrival time and throughput. After reaching 20%, the packet loss will be directly reduced from 20% to 0% in order to investigate whether Skype would immediately readjust its parameters under significant change of network conditions. In this experiment the sample voices 'BRITISH_ENGLISH' from ITU-T P.50 are used in the voice call test and each test lasted for 12 minutes (720 seconds) (ITU-T, 2013).

Similarly, the experiments on Skype video calls under different packet loss rates were conducted as in voice call experiments described above. Considering high bandwidth requirements for video call, we also carried out Skype video call experiments under different available bandwidth conditions. In this experiment, the available bandwidth was decremented by 200 Kbps after every 1 minute from 1700 Kbps to 100 Kbps. After reaching 100 Kbps and waited for 1 minute, the available bandwidth was suddenly increased to 1700 Kbps. This change, known as "square waves", was repeated for three times at the interval of 1 minute. This experiment used three video clips with different motion ('hall', 'foreman' and 'stefan') in order to investigate whether Skype congestion control mechanism took video motion into consideration to adjust its parameters.

Furthermore, in order to investigate the QoE of Skype voice and video calls under adverse network conditions, subjective tests were conducted which involved 20 volunteers to listen to and watch the recorded voice and video calls. They were 10 males and 10 females aged between 18 and 30 years old. Then depending on the average MOS, the QoE of Skype voice calls and video calls under different packet loss rates and available bandwidth was analysed.

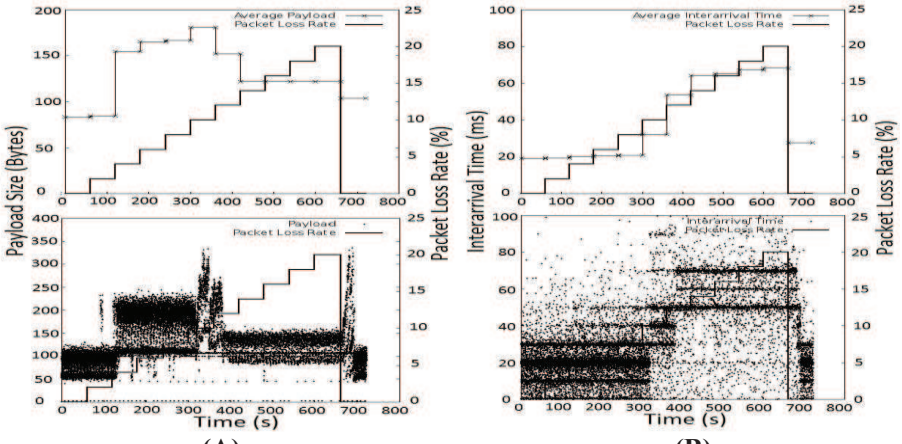
4. Results analysis

4.1. Skype voice call

4.1.1. Congestion control mechanism

This subsection will describe the results and analysis of congestion control algorithms for packet loss. The average (the top half) and detail (the bottom half) results are shown as Figure 2 and 3. As shown in Figure 2 (A), Skype adopted different method to adjust payload size based on four categories of packet loss rate from 0% to 20%.

- **Category 1: [0%, 2%]**. Skype kept payload size unchanged between 50 Bytes and 110 Bytes, and the average payload size was as about 80 Bytes.
- **Category 2: [2%, 10%]**. Skype used larger range of payload size than the one in Category 1 and kept it unchanged. It is clear that there are two bands of payload size with majority at high band around 200 Bytes and minority at low band around 100 Bytes. This indicates that Skype applied FEC to recover lost packets. The average payload size slightly increased from about 150 Bytes to 175 Bytes.
- **Category 3: [10%, 14%]**. Overall trend of average payload size was significantly decreasing with packet loss increasing. However when packet loss rate was unchanging, the payload size increased significantly.



(A) **(B)**

Figure 2: Payload sizes (A) and interarrival time (B) under different packet loss rates

- **Category 4: [14%, 20%]**. Two bands of payload sizes were higher than the bands in the category 1. This indicated that the FEC was still applied but the ratio of redundancy was low than the ratio in Category 2.

As shown in Figure 2 (B), Skype adjusted interarrival time based on the four categories of packet loss rates as shown below.

- **Category 1: [0%, 2%]**. The average interarrival time was about 20ms. Skype used three interarrival times (10ms, 20ms and 30ms) to send packets.
- **Category 2: [2%, 10%]**. The average interarrival time was still about 20ms. Skype started to use other two large interarrival times (40ms and 50ms) to send packets at the same time. Hence, Skype uses five interarrival times at the same time.
- **Category 3: [10%, 14%]**. The average interarrival time was about 30ms. Skype used interarrival times of 30ms, 40ms and 50ms to send most packets at the same time.
- **Category 4: [14%, 20%]**. The average interarrival time was about 60ms. Skype used interarrival times of 50ms, 60ms and 70ms to send packets.

As shown in Figure 3, it is obvious that Skype adjusted throughput based on four categories of packet loss rates. The main thresholds were 2%, 10% and 14%.

- **Category 1: [0%, 2%]**. Skype kept throughput unchanged between around 10 Kbps and 50 Kbps. The average throughput was about 50 Kbps.
- **Category 2: [2%, 10%]**. The average throughput was about 60 Kbps. Skype used larger range of throughput than the one in Category 1 which was around 30 Kbps and 90 Kbps.
- **Category 3: [10%, 14%]**. Skype kept throughput at lower values compared to Category 2. The average throughput decreased to about 45 Kbps.
- **Category 4: [14%, 20%]**. Skype kept throughputs unchanged between about 10 Kbps and 20 Kbps, which was lower than that of Category 1.

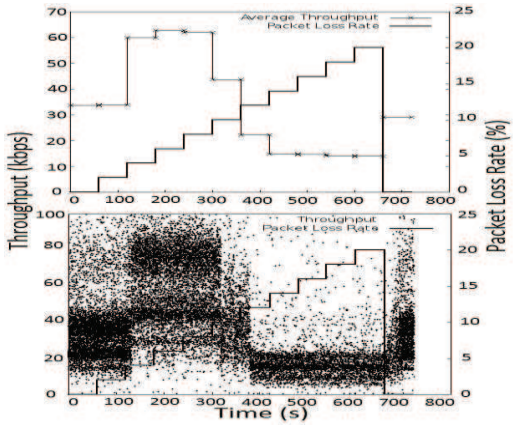


Figure 3: Throughputs under different packet loss rates

Packet loss rate	0%	2%	4%	6%	8%	10%
Average MOS	4.8	4.5	4.25	4.1	3.75	3.5
Packet loss rate	12%	14%	16%	18%	20%	20%-0%
Average MOS	3.35	3.15	2.9	2.3	1.65	3.95

Table 1: The average MOS of Skype voice call under different packet loss rates

4.1.2. QoE analysis of Skype voice call

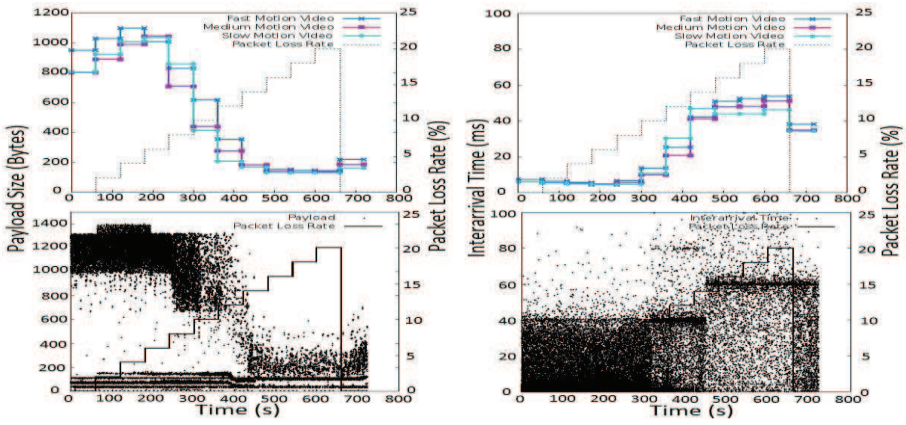
As shown in Table 1, the QoE of Skype voice calls under packet loss rates from 0% to 10% are good (higher than 3.5). Then MOS decreased with the increase of packet loss rate. However, when packet loss rate directly reduced to 0% from 20%, the QoE of Skype voice call immediately became good. In general, Skype congestion control mechanism could effectively recover the quality of voice calls when packet loss rate is between 0% and 10%. However, when packet loss rate is higher than 10%, the quality of Skype voice calls is significantly degraded.

4.2. Skype video call

4.2.1. Congestion control mechanism for packet loss

The results are shown in the Figure 4 and 5. As shown in Figure 4 (A), the payload size adjustments of Skype video calls with three different motion types were similar. Skype adjusted payload size based on different categories of packet loss rates, especially for the packets containing I frame.

- **Category 1: [0%, 8%]**. Skype increased average payload size from about 800 Bytes to 1000 Bytes. Skype kept the range of payload sizes unchanged. However when packet loss rate was between 2% and 8%, payload sizes of some I frame packets were between 1300 Bytes and 1400 Bytes.



(A) **(B)**

Figure 4: Payload size (A) and interarrival time (B) of Skype video calls under different packet loss rates

- **Category 2: [8%, 14%]**. The average payload size was around 1100 Bytes, then significantly reduced to about 200 Bytes. Skype applied the payload sizes of I Frame packets within the larger range of [600 Bytes, 1300 Bytes]. Furthermore, when packet loss rate reached 14%, the range of payload sizes of I frame packets were significantly reduced to [100 Bytes, 300 Bytes].
- **Category 3: [14%, 20%]**. Skype kept payload size unchanged in the range of 100 Bytes to 300 Bytes and the average throughput was about 180 Bytes.

As shown in Figure 4 (B), Skype adjusted interarrival time similarly for three video contents that was based on three categories of packet loss rates.

- **Category 1: [0%, 8%]**. Skype kept the interarrival times unchanged which were less than 40ms. The average was slightly reduced to about 7ms.
- **Category 2: [8%, 14%]**. Skype sent most packets by using the interarrival time of around 40ms. The average interarrival time was significantly increased from about 10ms to 40ms.
- **Category 3: [14%, 20%]**. Skype used the interarrival time of around 60ms to send most of packets. The average interarrival time was around 45ms.

As shown in Figure 5, Skype followed the similar trend to adjust the throughput of Skype video calls with different motions. It is obvious that Skype adjusted the throughput based on three categories.

- **Category 1: [0%, 8%]**. The average throughput was significantly increased from about 1000 Kbps to 1600 Kbps as packet loss rate increased. Skype used the wide range of throughput, but the dominant throughput was between 250 Kbps and 500 Kbps.
- **Category 2: [8%, 14%]**. The average throughput was significantly reduced from about 1700 Kbps to 200 Kbps. Most of the packets were sent by using throughputs of around 200 Kbps.
- **Category 3: [14%, 20%]**. The throughput of most packets was around 100 Kbps. However, the average throughput was about 50 Kbps.

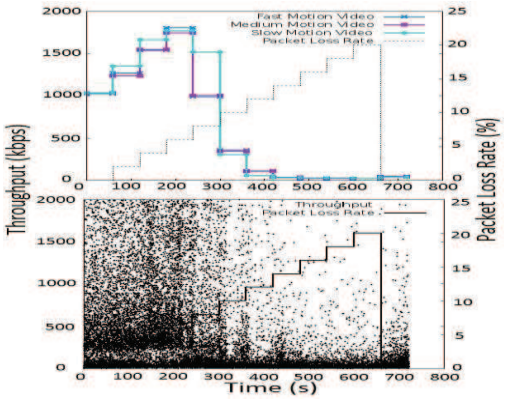


Figure 5: Throughput of Skype video calls under different packet loss rates

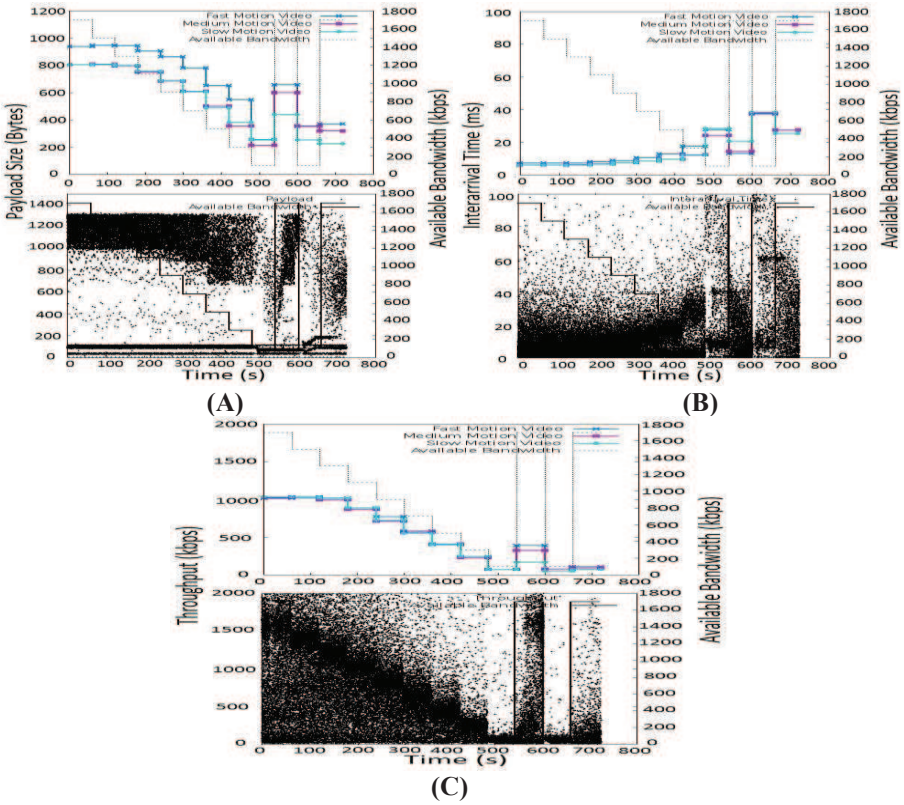


Figure 6: Payload size (A), interarrival time (B) and throughput (C) of Skype video call under different available bandwidth

4.2.2. Congestion control mechanism for available bandwidth

The average (the top half) and detail (the bottom half) results are shown as Figure 6. As shown in Figure 6 (A), when available bandwidth was decreased from 1700 Bytes to 100 Bytes, Skype followed the similar trend to decrease the payload sizes for three different video motions. Skype enlarged the scope of payload size of I frame packets from [1000, 1300] to [700, 1300] with available bandwidth decreasing from 1400 Kbps to 100 Kbps. During the wave changes of available bandwidth, the payload size was recovered immediately when the available bandwidth suddenly increased. Furthermore the payload size of fast motion video increased quicker than the slow motion video. However the second recovery was slower than the first one. As shown in Figure 6 (B), the trends of interarrival time adjustments of Skype video calls with different video motions were similar. When available bandwidth was reduced from 1700 Kbps to 500 Kbps, the average interarrival times were about 10ms. Then Skype increased average interarrival time from about 10ms to 20ms with available bandwidth decreasing. During the square wave change, the first increase of the interarrival time was higher than that in the second increase. As shown in Figure 6 (C), the trends of adjustment of throughput of three video motions were similar. Skype reduced average throughput with available bandwidth decreasing.

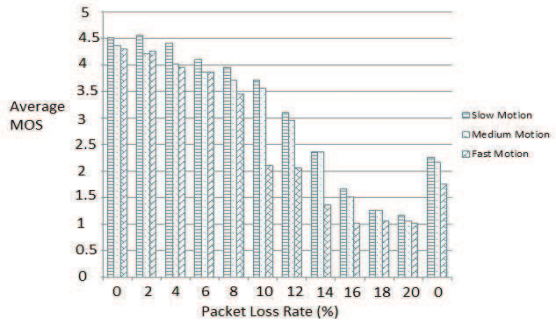


Figure 7: Average MOS of Skype video calls under different packet loss rates

Furthermore, Skype never consumed all available bandwidth. In the first square wave change, Skype significantly increased the throughput from about 90 Kbps to 400 Kbps. Nevertheless, during the second square wave change Skype slightly increased the throughput.

4.2.3. QoE analysis of Skype video call

As shown in Figure 7, the QoE of Skype video calls were degraded with the increase of packet loss rate. When packet loss rate was between 0% and 8%, the QoE was acceptable. The trend of QoE degradation of three Skype video calls was similar, but the Skype video call with fast motion was more affected than the rest. When packet loss rate was directly reduced to 0%, the QoE was slowly recovered.

5. Conclusion

In this paper, we found out that Skype applied category control mechanisms to effectively react to adverse network conditions for voice and video calls. For the Skype voice calls, the category-based congestion control mechanism is based on four categories to adjust the three main parameters under packet loss rate from 0% to 20%: [0%, 2%], [2%, 10%], [10%, 14%] and [14%, 20%]. However, for the Skype video calls, the category-based congestion control mechanism divided three categories of packet loss rate from 0% to 20%: [0%, 8%], [8%, 14%] and [14%, 20%]. The category-based congestion control mechanism only considers video contents when available bandwidth changes. The payload size of fast motion video will be increased quicker than slow motion video, when available bandwidth significantly increases. Nevertheless video contents would not be considered by the congestion control mechanism when packet loss rate changes. The category-based congestion mechanism could recover the QoE of Skype voice calls more efficiently than Skype video calls. We also found that the packet loss rate of 8% was the acceptable threshold service for Skype voice and video calls in terms of QoE.

6. Acknowledgement

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Unidirectional Narrowband Physical Layer Demonstration System

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Abstract

This paper concentrates on the physical layer of a single-carrier narrowband mobile ad-hoc network. All aspects of parameter estimation and synchronization are considered and the full transmission chain has been implemented on a software defined radio (SDR) board to provide a proof of concept. The paper shows the system performance with respect to carrier frequency offset and transmitting power. Previous investigations have shown that the detection probability of the transmitted bursts has a significant impact on the overall system performance. Therefore, different training sequences are compared to detect the bursts, i.e. a maximum length sequence (m-sequence) and a constant amplitude zero autocorrelation sequence (CAZAC-sequence). The paper discusses the results obtained from our hardware demonstration system.

Keywords

Narrowband, prototypes, physical layer

1. Introduction

Multiple services as data, voice, video, broadcast messaging, etc. are requested to be transmitted over digital communication systems. In general, demand on data rate for these services is growing continuously.

It is a major concern to have required information at the right time at the right place. Besides civil communications, these requirements also apply for disaster search and rescue (SAR) missions and tactical communications. For such applications, major interests are on mobile ad-hoc networks (MANETs) where each node may not only act as a transmitter or receiver, but also as a relay station for other nodes. With these functionalities, MANETs provide a flexible, resilient and infrastructure-less communication.

In order to increase the flexibility in MANETs, software defined radios (SDRs) can be utilised as nodes (Peacock, 2007). SDRs are a collection of hardware and software

technologies to enable reconfigurable system architectures for wireless networks and user terminals which are controlled by software.

Particularly in SAR and tactical missions, wireless networks have to cope with connectivity over long distances (Alberts et al., 2000). Therefore, narrowband systems in the VHF band are utilised.

The development process of a communication system typically consists of multiple cycles. One of the first cycles considers the design and simulation of algorithms. Algorithms and components are then initially verified via simulations. However, the effects of hardware platforms are mainly reproduced by statistical models in computer simulations. Nevertheless, the considered statistical behaviour can differ from real hardware platforms available. In order to ensure that all major effects are considered and the assumed statistical models comply with the real behaviour, in a next step the designed system should be verified on a hardware prototype.

In this paper, aspects of parameter estimation and synchronization are investigated according to the proposed adaptive narrowband physical layer in (Dehm et al., 2012). Thus, the transmission chain has been implemented on a SDR board and the results obtained are presented. The paper discusses the influence of carrier frequency offset and transmission power under consideration of two different synchronization sequences with respect to bit error rate (BER) and packet error rate (PER).

2. Related Work

Communication systems for public safety and SAR missions mainly rely on narrow channel bandwidth. For these applications, popular systems are terrestrial trunked radio (TETRA) with a bandwidth of 25 kHz and TETRAPOL having a bandwidth of 10 or 12.5 kHz. However, these systems provide only low data rates (Jondral, F. K. 2005, TETRAPOL Forum, 1999). The need of a narrowband communication system is shown by the current endeavour of the NATO to standardise a narrowband waveform (NBWF) applying a 25 kHz channel bandwidth with a maximum peak rate of 96 kbit/s.

In the context of narrowband communication, Dehm et al. presented in 2012 a transmission chain to increase further the data rates with 25 kHz channel bandwidth for SAR missions. This transmission chain applies algorithms for frame synchronization, frequency offset estimation and correction as well as channel estimation.

Related work shows that a proof of concept for the considered narrowband transmission chain (Dehm et al., 2012) is still required. Hence, this paper investigates the performance of the transmission chain on a hardware platform.

3. Reference Model

In this section, the reference transmission chain (see Dehm et al., 2012) and the considered algorithms for synchronization, frequency offset estimation/correction as well as channel estimation is described.

3.1. Transmission Chain

The considered narrowband system relies on time division multiple access (TDMA). The TDMA structure contains slots with duration T_S of 60 ms as illustrated in Figure 1. The slot duration as well as the utilised modulation and coding scheme define the maximum number of payloads bits in the physical layer service data unit (PSDU). The physical protocol data unit (PPDU) is completed with training sequences for synchronization and header information prior to the PSDU.

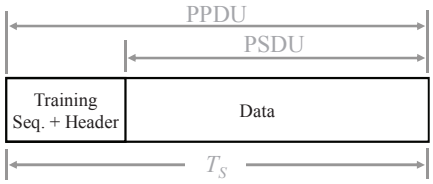

Figure 1: TDMA slot structure

Figure 2 illustrates the components of the narrowband transmission chain for transmitter and receiver operating in $B = 25\text{kHz}$ bandwidth.

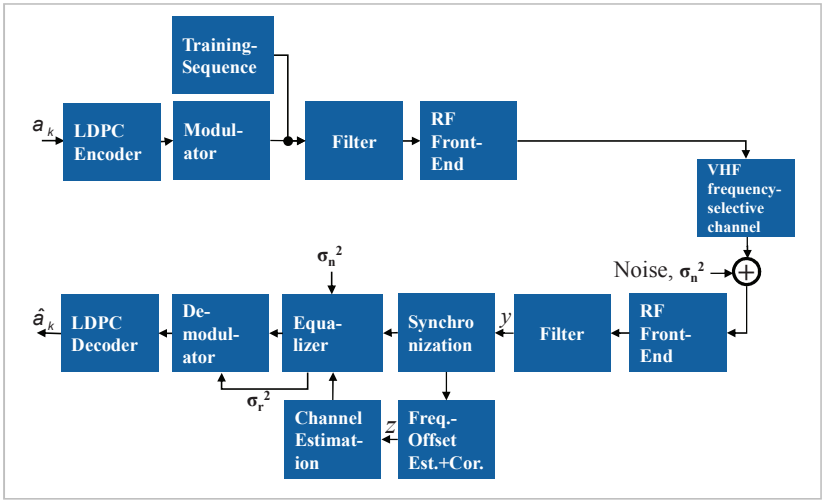

Figure 2: Narrowband physical layer transmission chain - a_k : information bit sequence, σ_n^2 : noise variance, σ_r^2 : estimated residual noise, $\hat{a}_k$: received bit sequence.

On the transmitting end, the upper layer generates a bit stream a_k which passes the irregular quasi-cyclic low-density parity-check (LDPC) encoder. Subsequently, the encoded bit stream is mapped onto symbols by the M-PSK/M-QAM modulator and a training sequence (two binary m-sequences or two complex CAZAC-sequences with equal lengths) is added. Bandwidth limitations are considered by root raised cosine (RRC) filtering prior to mixing the signal onto the carrier frequency.

The coherent receiver mixes the received signal back into the baseband domain where matched filtering is applied. Frame synchronization (detection of frames) and symbol synchronisation (determination of the position of the symbols) is achieved by exploiting the training symbols preceding the PSDU (data-aided synchronization). Additionally, the channel impulse response (CIR) is estimated using the training sequence. Based on the estimated CIR, the frequency offset between the local oscillators of transmitter and receiver is estimated and corrected. Afterwards the signal is equalized with a finite-impulse-response (FIR)-minimum mean-square error (MMSE) decision-feedback equalizer (DFE), whose coefficients are adjusted according to the estimated CIR.

For the decoding process, soft information is determined by the demodulator with respect to the equalized signal and the residual noise σ_r^2. Based on soft information, the LDPC decoder estimates the received bit stream $\hat{a}_k$.

3.2. Synchronization and Frequency Offset Estimation and Correction

One important task of receivers is to detect the beginning of data bursts (frame synchronisation). A simple method for frame synchronisation is to perform a cross-correlation of a well-known training sequence and the received signal. Once a fixed threshold is exceeded, detection of a frame is assumed. However, defining this threshold is crucial: Defining the threshold to high results in missed bursts, defining it too low, however, leads to a large number of false detections which will also cause missed or erroneous bursts since the receiver is blocked. Additionally, fading, multipath propagation, and free space loss cause a high variation of the correlation result which further impacts the synchronisation accuracy.

In communication systems, signals experience propagation delays and frequency offsets caused by oscillator instabilities and/or Doppler shifts from transmitters to the receivers. While a propagation delay can be interpreted as a constant phase shift of the data symbols, a frequency offset produces an increasing/decreasing phase shift on the signal.

In general, the propagation delay as well as the frequency offset is unknown in the receiver. To estimate the frequency offset, two consecutive m-sequences (or CAZAC-sequences) can be applied. Based on the phase shift between these two sequences, the frequency offset can be estimated.

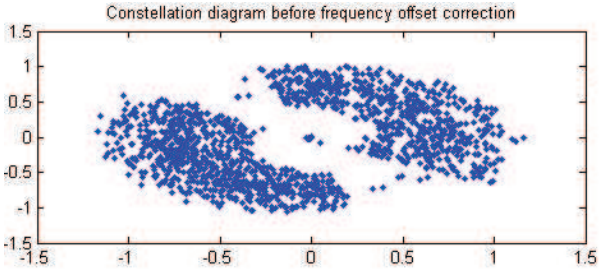

Figure 3: BPSK constellation diagram without frequency offset correction

For the estimation of the frequency offset, two cross-correlations are performed independently, each using only one of the two consecutive sequences. The vector h_1 contains M samples of the correlation result over the first training sequence which contains the maximum power in a predefined window. The same procedure is applied also for the second training sequence. The windowed correlation result is stored in h_2.

The frequency offset causes a continuous phase shift per symbol $\Delta\varphi$ determined by:

$$\Delta\varphi = \frac{\arg\left(h_1 \cdot h_2^H\right)}{N},$$

where N is the length of one training sequence.

According to the determined phase shift per symbol $\Delta\varphi$, the phase offset of the received signal y is corrected for each sample/symbol:

$$z = y \cdot e^{-j \cdot \Delta\varphi \cdot k} \quad .$$

4. Demonstration System

This section describes the SDR demonstration platform utilised to verify the algorithms and components on the hardware.

4.1. Software Defined Radio Board

The considered communication system operates in the VHF band. Analogue signals are received on a carrier frequency of $f_c = 70\text{MHz}$. The SDR-board uses an SAW (surface acoustic wave) filter to filter the received signal. After amplification using a programmable gain amplifier the signal is sampled by an analog-to-digital converter running with a sampling frequency of 92.16 MHz (sub-sampling). The SDR board is also assembled with a field-programmable gate array (FPGA). The FPGA mixes the signal into the baseband using a coordinate rotation digital computer (CORDIC) -

algorithm. Additional filtering using finite impulse response (FIR) filters as well as cascaded integrator-comb (CIC) filters is applied to reduce the sampling rate to 50 kHz which corresponds to two samples per symbol. A digital signal processor (DSP) on the SDR board processes algorithms for synchronization and frequency offset estimation.

4.2. Setup of the Demonstration System

This investigation focuses on algorithms of the coherent receiver. Hence, the transmitter is represented by a vector signal generator (VSG) (Rohde & Schwarz 1GP60, 2012). The VSG translates the modulated signal to the carrier frequency f_c and transmits it to the SDR board over a BNC cable. The BNC cable is applied to achieve reproducible results. However, wireless transmissions have also been tested applying $\lambda/2$ dipole antennas. Furthermore, a computer is connected to the SDR board via Ethernet to analyse the processed results (Wavecom Elektronik, 2010).

Figure 4 shows the schematic measurement setup and Table 1 lists the important parameters.

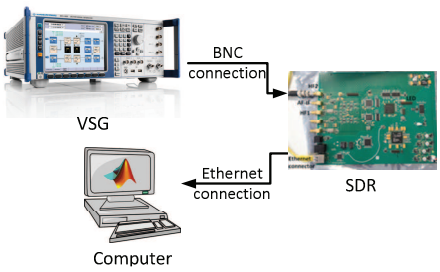

Figure 4: Schematic setup of the demonstration system

Parameter	Value
Carrier frequency (f_c)	70 MHz
Bandwidth (B)	25 kHz
TDMA slot duration (T_S)	60 ms
Length of one synchronization sequence (N)	31 symbols
Number of correlation samples (M)	7
Modulation	BPSK
Code rate	1/2

Table 1: Parameters

5. Numerical Results and Discussion

The performance of the demonstration system is investigated with respect to the packet error rate (PER) as well as the bit error rate (BER) for different carrier frequency offsets and transmit power levels. The results are compared for two types of training-sequences, binary m-sequences and complex-valued CAZAC-sequences.

5.1. Impact of Carrier Frequency Offsets on Error Rate

Local oscillators (LO) in transmitters and receivers show inaccuracies resulting in frequency offsets. Additionally, Doppler shifts contribute to frequency differences in mobile communication systems. The impact of frequency and phase offset on the constellation diagram has already been shown in Figure 3.

Frequency offset estimation and correction algorithms enable mitigation of signal distortion at the receiving end of a communication link. Remaining phase shifts can be further corrected by the equalizer, as illustrated in Figure 5.

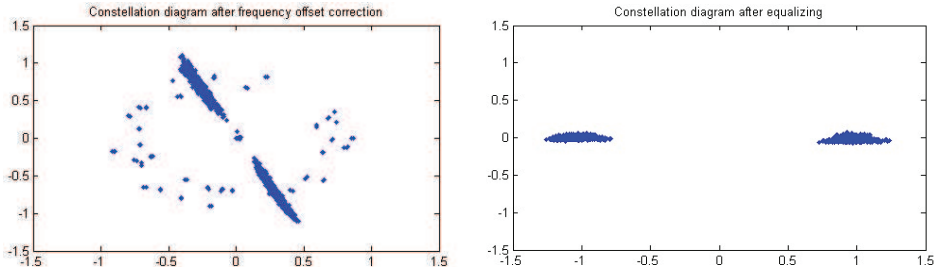

Figure 5: BPSK constellation diagram after frequency offset correction (left) and equalization (right)

In this investigation, the carrier frequency offset varies within a range of ±300 Hz. The resulting BER and PER are shown in Figure 6 for two training sequences, m- and CAZAC-sequences, respectively.

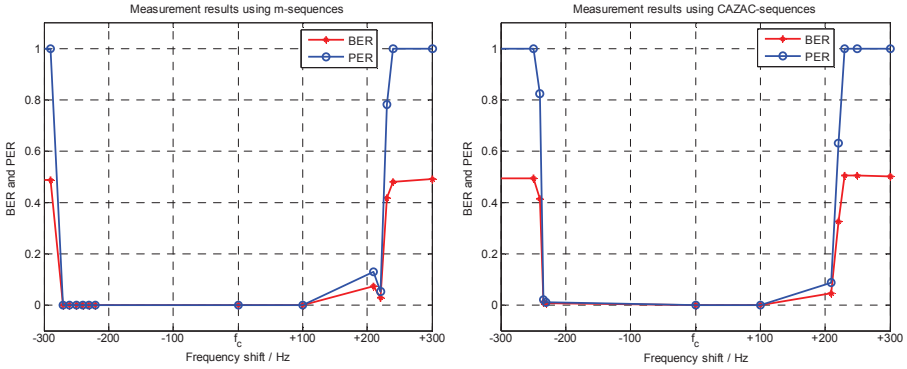

Figure 6: Carrier frequency offset versus BER/PER, left: m-sequence, right: CAZAC-sequence

The results show a strong relation between the frequency offset and the BER/PER. Both sequences provide similar performance according to the frequency offset. Although the system is designed to estimate as well as to correct frequency offsets up to ±400Hz, for both training sequences, the system achieves a low BER/PER only for frequency offsets within ±220 Hz from the carrier frequency (red and blue line). Besides this frequency operating range, the BER and PER significantly increase. A major influence on the frequency operating range has the applied frame detection algorithm. Detecting a frame according to a fixed threshold suffers from false detections resulting into high error rates in case of large frequency offsets.

According to the impact of frame detection on overall system performance, an improved synchronization algorithm with adaptive thresholds is designed and simulated.

The algorithm consists of mainly four phases:

- Phase 1: The algorithm computes the absolute value of the complex cross correlation with the synchronization sequence and the received signal.

- Phase 2: The absolute correlation results are compared to an adaptive threshold. The adaptive threshold is determined by a sliding window over the amplitudes of the received signal scaled by a predetermined factor. The first position of the correlation result exceeding the threshold is marked.

- Phase 3: From the marked position, the maximum value in a window of the length of the synchronisation sequence is determined.

- Phase 4: The detected position is verified if *N* symbols from the detected position the correlation peak from the second sequence is determined. The beginning of the information in the frame is defined according to the first detected position.

Simulations results show a gain in performance of this frame detection algorithm compared to a fixed threshold. For this synchronization algorithm, CAZAC-sequences are able to outperform m-sequences by their zero autocorrelation characteristic. In future work, this algorithm will be implemented on the SDR system and the performance of this synchronization algorithm will be investigated.

5.2. Impact of the Transmitting Power on the Error Rate

In our second measurement, the influences of different transmission power levels on the BER/PER are investigated at a carrier frequency of 70 MHz.

Figure 7 presents the degradation in the BER/PER with an increase of the transmitting power. The SNR is estimated in the receiver. As expected, SNR rises linearly according to an increase of the transmitting power. The results show that CAZAC-sequences improve the system performance slightly. A PER below 1% is reached at a transmission power of about -25.7 dBm applying CAZAC-sequences and -25 dBm applying m-sequences. The advantage of CAZAC-sequences can be explained by their good correlation properties which achieve an accurate frequency offset and CIR estimation.

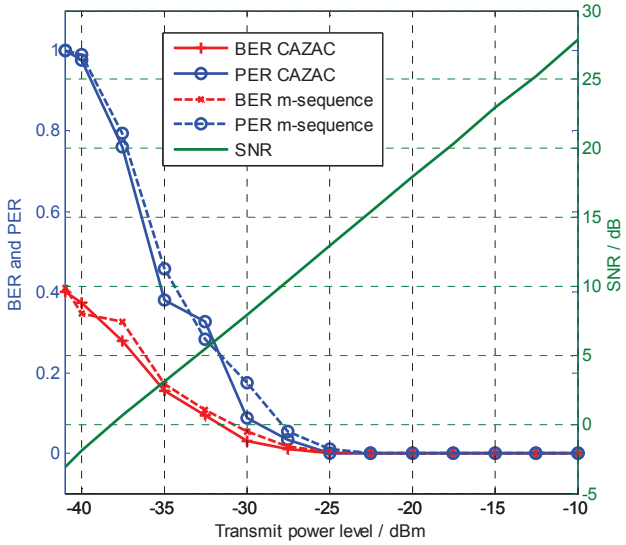

Figure 7: Transmitting power versus PER and BER

6. Conclusions

This paper has described the implementation of a narrowband transmission chain for mobile ad-hoc networks on a software defined radio platform. The impact of carrier frequency offset and transmission power on the BER and PER have been investigated. Furthermore, two types of training sequences, binary m-sequences and complex-valued CAZAC-sequences have been compared. CAZAC-sequences provide slightly better BER and PER performance compared to m-sequences. The investigation has shown that a SNR of about 7.6 dB results in a PER below 10%.

The proposed physical layer considering algorithms for symbol synchronization as well as frequency offset estimation and correction achieves also satisfactory results on a software defined radio (SDR) platform. However, the demonstration system will be further extended, e.g. with an improved frame synchronization algorithm. Thus, the demonstration system can be used for field measurements in mobile wireless scenarios.

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Rotating-Angle Estimation with help of Shaping Filter based on Kalman Filter

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Abstract

This paper presents rotating-angle estimation using a low-cost gyroscope with help of shaping filter for industry applications. This algorithm is a part of controller module, which will be implemented in an intelligent fastening tool for automotive manufacturing. The rotating-angle is estimated primarily by the signals of a low-cost pinpoint gyroscope. With the help of an error model based on Shaping filter method, the optimal rotating angle of an object is determined by compensating the estimated orientation with the estimated error. As the results from experiments, the accuracy of this attitude estimation is less than 1 degree within 90 second.

Keywords

Attitude estimation, Low-cost gyroscope, Shaping filter, Tracking, Error model

1. Introduction

Currently, quality control is one of the major focuses in manufacturing. Most of processes in production lines have been carefully observed and re-checked to ensure the quality of the end products. However, there are still many assembly processes in production lines that some parts are assembled without any quality control at that process. For example, all bolts of the assembled parts should be fastened with the right torque. Because the operators are the one who check the part assembling, it might be that they might make some mistakes by improperly fastening a bolt. To prevent this kind of problems and improve the quality of manufacturing, this system which is able to measure applied torque and rotating angle of a fastening tool, such as a wrench, is required.

A low-cost pinpoint gyroscope, CRM100 is applied for low-cost rotating-angle estimation of a fastening tool. Instead of detecting the rotating angle of a fastened bolt, the intelligent fastening tool detects its own orientation which is the same angle as the rotating angle of the bolt. However, the challenge of this orientation estimation with a low-cost gyroscope is sensor drift problem that generated the accumulated error over time (Haid *et al.*, 2003). Moreover, it is difficult to integrate magnetometers as observation sensors, since production line are a source of magnetic

field distortions and magnetic interferences that affect this type of sensors. (Won *et al.*, 2009).

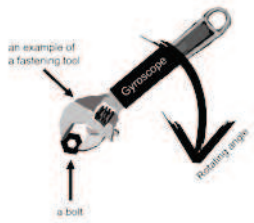

Figure 1: Demonstration of an example application of rotating-angle estimation using a low-cost gyroscope

Theoretically, the one-axis-rotating angle of an object attached with a gyroscope, is able to be numerically estimated by integrating of the angular velocity signal. But, in real world applications, there is always stochastic noise corrupting the measurement signal from a low-cost gyroscope (Haid, 2004). Therefore, the error in attitude estimation using low-cost gyroscopes increases over time dramatically. This is the result of the accumulated error from integrating a noise-corrupted signal.

To compensate the effect of sensor drift from attitude estimation, Kalman filter (KF) and variants of Kalman filter are well-known techniques to find the optimal attitude from the signals of a low-cost inertial measurement unit (IMU). Foxlin (Foxlin, 1996) applied extended Kalman Filter (EKF) based on the separated bias Kalman filter method from Friedland in (Friedland, 1969). However, the yaw estimation of this method depends on the signals from magnetometers as many other studies in (Zhu and Zhou, 2009), (Xiaoping *et al.*, 2008), (Zhao *et al*., 2007), (Romanovas *et al*., 2009), (Martin and Salaun, 2007) and (Marins *et al*., 2001). In and around production lines, there are many metallic objects that distort the magnetic field. Therefore, using magnetometers for attitude estimation might lead to the inaccuracy of the system. Another problem of EKF, it is well-known that the behaviour of EKF is unpredictable, although it can be used often successfully (Rehbinder and Hu, 2004).

Instead of EKF, other studies, such as in (Kong, 2004), successfully developed attitude estimation algorithms based on unscented Kalman Filter (UKF). The mathematic model of UKF is simpler than EKF's one, because it is not necessary to calculate Jacobian matrices in UKF (Julier *et al*., 1995). However, the computation time of UKF is greater than EKF, and it is not suitable for real-time applications. Interestingly, Rehbinder and Hu successfully developed the attitude estimation based on switching Kalman Filter (Rehbinder and Hu, 2007). Importantly, the mathematic model of their work is simple and based on complementary Kalman filter and the switching algorithm in (Daywansa and Martin, 1999). There is the switching algorithm for selecting between static mode and dynamic mode. This technique is really practical for eliminating the effect of lateral acceleration while the object is moving. However, this technique requires a full inertial measurement unit (IMU)

which composes of tri-axial accelerometers and tri-axial gyroscopes. For low-cost applications, using only a one-axis gyroscope is considered as a challenge in this study.

This paper presents the rotating-angle estimation using a low-cost gyroscope based on error model technique with help of shaping filter for estimating rotating angle in environment that is not able to use magnetometers.

2. Algorithm Structure of Orientation Estimation

There are 4 modules to estimate the rotating of a fastening tool, such as Pre-processing module, Movement detection module, Orientation estimation module and Error model module. The overview structure of this orientation estimation is shown in Figure 2.

The Pre-processing module helps the system to reduce noise of the measurement signal, ω_{mea}, from a CRM100 pin-point gyroscope (from PinPoint), and decreases the data amount used for rotating-angle estimation. This pre-processing module contains algorithms that re-sample the measurement signal from 1 kHz to 50 Hz sampling frequency, and filter the signals with low-pass Butterworth filter.

To observe the movement of the fastening tool, the Movement-detection module detects the change from static state to dynamic state. Since there is stochastic noise corrupting the measurement signal, the error from attitude estimation is dramatically reduced when processing the data in short time (Haid, 2004). Therefore, it is necessary to use the measurement signal only within dynamic state (while rotating a tool to fasten a bolt).

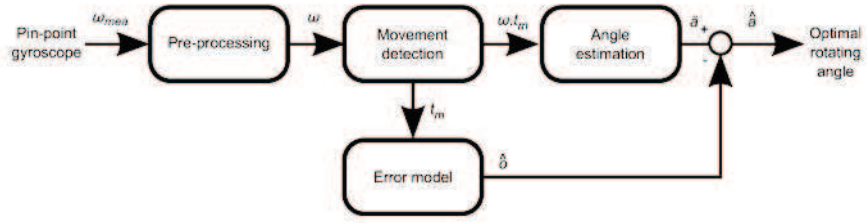

Figure 2: Algorithm structure of the orientation estimation

With the angular velocity signal ω and the movement time t_m, the one-dimensional rotating-angle of the tool is determined by the Angle-estimation module. In brief, the algorithm in this module is based on Newton's laws of motion.

The Error-model module generates the optimal misalignment, ô, to compensate the estimated orientation, ä. This Error-model module is heuristically designed based-on Shaping filter technique and optimized with the Nelder-Mead Simplex Method in Low Dimensions (Lagarias *et al*., 1998).

As the output of this rotating-angle estimation, the optimal rotating angle, â is determined by compensating the estimated orientation ä with the optimal misalignment ô. This information is sent as a protocol to the intelligent tool's controller to make a decision whether the fastening is acceptable.

3. Error Model

In many cases, the white Gaussian noise model may not be adequate to predict all noises in a real system. Practically, an error model is developed based on a mathematic model to generate empirical autocorrelation or power spectral density data as the same as the data from noises of an observed system. A linear time-invariant system, or shaping filter, provides a model driven by stationary white Gaussian noise which is determined by the power spectral density or autocorrelation of observed data. In other words, if the first and second order statistics of a wide-sense stationary are known, then a Gaussian process with the same first and second order statistics can always be generated via shaping filter (Maybeck, 1979).

In this paper, the error model for the rotating-angle estimation is heuristically constructed based on the first order Markov model (Loffeld, 1990). This error model generates an exponentially time-correlated error signal which is statistically similar to the drift error from the gyroscope. This model is described as Eq(1), where x is the state of the model, T is the time correlation, and w is a Gaussian noise with zero mean.

$$x'(t) = -(1/T)\, x(t) + w(t) \tag{1}$$

As proofed in (Maybeck, 1979), the output from this model has autocorrelation Ψ_{xx} as Eq(2) where δ is a standard deviation and τ is a time constant.

$$\Psi_{xx}(\tau) = \delta^{2}\, e^{(-|\tau|/T)} \tag{2}$$

To initialize model parameter, the stationary signals from the pin-point gyroscope are acquired to determine empirical autocorrelation and power spectral density of the signals. By curve-fitting, the initial parameter of τ is defined. This initial parameter will be used as an initial value for optimizing the error model parameters.

The bias b and misalignment o of the pin-point gyroscope is defined as the state of this error model. The behaviour of the misalignment is assumed to be an exponentially time-correlated state as the first order Markov model. Therefore, the dynamic equation of the model is constructed as in Eq(3), where $\beta = 1/\tau$.

$$\begin{bmatrix} b' \\ o' \end{bmatrix} = \begin{bmatrix} -\beta & 1 \\ 1 & 0 \end{bmatrix} \bullet \begin{bmatrix} b \\ o \end{bmatrix} \tag{3}$$

This error model is driven by initial bias and misalignment, b_0 and o_0 respectively. Both of the initial bias and misalignment will be heuristically optimized with the Nelder-Mead Simplex Method.

To optimize the error-model parameters, the optimized parameters, β, b_0 and $o_{0,}$ have been heuristically optimized with acquired data from 10 tests. In this paper, the Nelder-Mead Simplex method is applied for optimizing the error model parameters, since this method is commonly used in non-linear optimization.

4. Experiments

The accuracy of this rotating-angle estimation is tested by a test bench and its measurement data results. The results from this estimation are compared with the rotating angles measured by the encoder of the test bench. In order to test the estimation's accuracy, the data from 20 tests are acquired from a CRM100 pin-point gyroscope.

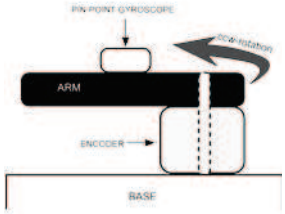

Figure 3: Test bench for testing the performance of the estimation

The test bench consists of a base, an arm and an encoder as shown in Figure 3. The length of the wooden arm is 80 centimetres, and is fixed with the shaft that connects to the encoder. The gyroscope is mounted at the centre of the top side of the arm.

The measurement data are acquired while the arm is manually rotated at different speeds by 90° clockwise and counter-clockwise. Therefore, the measurement data are not uniform and the results from the orientation estimation are independent from the rotating velocity of the arm.

5. Results

To achieve the target accuracy, the parameters of EM have been optimized by the Nelder-Mead Simplex method. The target of the optimization is to minimize the root-mean-square of the rotating-angle estimation error at the stop moving point from the previous acquired data. Then, the optimized parameters, β, b_0 and $o_{0,}$ have been applied to the EM for testing its performance.

As in Figure 4(b), the results show that the rotating-angle estimation with help of error model (EM) is significantly more accurate than one without error model's support, as Figure 4(a). The maximum absolute error of the attitude estimation

without EM is more than 1.8° within 90 second. With the help of EM, the maximum absolute error is less than 0.8° within 90 second.

The results still shows that the orientation estimation with EM has lower standard deviation than the one without EM. The mean of the maximum absolute error from the estimation without EM is 0.8628° with the standard deviation 0.5493°. And the mean of the maximum absolute error from the estimation with EM is 0.2765° with the standard deviation 0.2445°.

The EM reduces the error from sensor drift that accumulates over time. As shown in Figure 5(b), the error from the estimation without EM increases over time. But the error from the estimation with EM is suppressed and increases over time slower than one without EM. It shows that the implementation of the error model module is successfully improved the performance of the rotating-angle estimation.

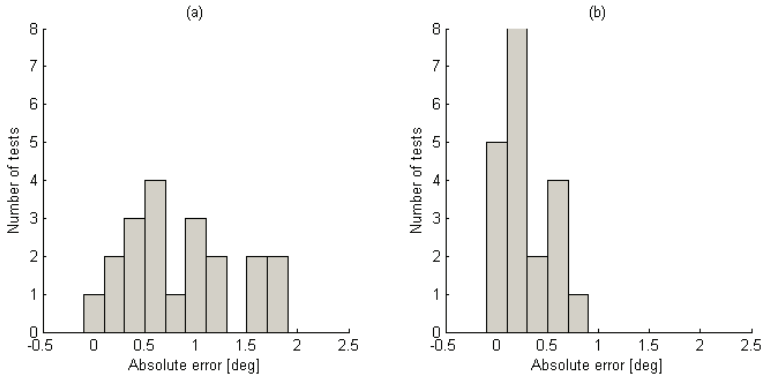

Figure 4: Histograms of the maximum absolute error from the orientation estimation (a) without EM, (b) with EM

6. Conclusion and Outlook

The error model based on Shaping filter technique significantly improves the accuracy of rotating-angle estimation with the measurement data from the test bench. With parameter optimization, the error from the estimation with the error model is less than 1° within 90 second.

This rotating-angle estimation could be implemented in other low-cost applications to determine the rotating-angle of an object in an environment which its magnetic field is distorted or not static. For examples, a pedestrian indoor-navigation and a man-machine interface device for rotating a 3D object in a personal computer (PC) are the applications that could be applied this estimation to improve their performance.

For further improvement, the inertial measurement unit (IMU) will be applied for this application. With the help of IMU, it is possible to determine the 3D-orientation of an object. Therefore, the flexibility and reliability of the orientation estimation for a fastening tool will be increased.

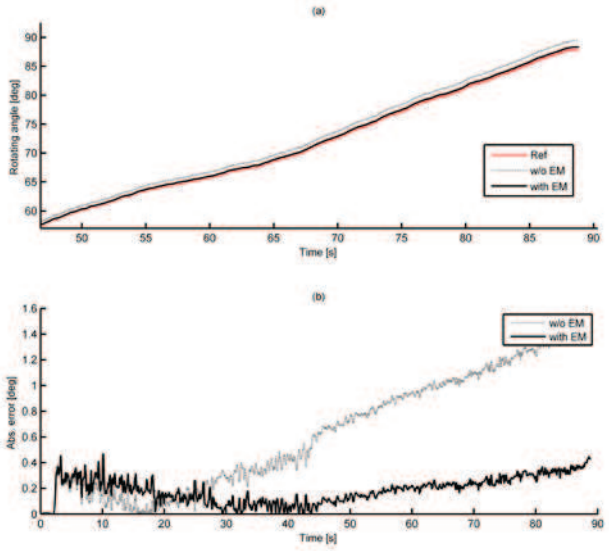

Figure 5: (a) Orientation estimation of the measurement No. 20, (b) Absolute error of the estimation from measurement No. 20

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Findings from the Expansion of Shared Services using Cloud Computing in Irish Public Service Organisations

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Abstract

Cloud computing presents an opportunity for considerable cost savings in the public sector, providing streamlined and shared public services. However, ensuring that Public Service Organisations (PSOs) can maintain their data confidentiality, privacy mandates, and functional autonomy, whilst leveraging multi-tenancy infrastructure is key to success. This paper identifies the main barriers to the adoption of cloud computing within the public sector and proposes a state-wide community cloud framework, interconnected by the existing government VPN network, which may be managed centrally as a resource for government agencies. This framework is derived from the design and implementation of a small scale private pilot cloud, providing a "cloud-in-a-box" template that can be replicated and extended to other PSOs. In order to preserve information accountability, a classification of data types by confidentiality, sensitivity and jurisdiction is provided, to enable users to evaluate whether information may be shared within the government cloud or must be kept completely confidential. Furthermore, an evaluation of methods for the migration of this data to the cloud, with Value-For-Money (VFM) analysis, is subsequently outlined.

Keywords: Cloud Computing, Public Sector, Multi-Tenancy, Privacy, Confidentiality

1. Introduction

In 2008, the Irish Government established the "Task Force on the Public Service" to create a three year plan for launching improved Public Sector services(Task Force on the Public Service, 2008). A key recommendation is the enhancement of shared services in Information and Communications Technology (ICT) with the report seeking outsourced, insourced and co-sourced shared service opportunities, effectively translating into the now familiar concept of "Cloud Computing". Prevailing economic factors have already dictated this change, not only domestically, but for Governments worldwide. Ireland, as a small and open economy, cannot afford to maintain pace using only silo-based scale-up systems.

However, five years later, negligible cloud migration has occurred, despite significant thought-leadership within the public sector and from partner vendors. Furthermore, despite considerable cutbacks in public spending, demand for Public Services has not decreased, and in many cases, such as Social Services, demand has

increased significantly. This means that PSOs impacted by economic compression must increase cost effectiveness. Brendan Howlin, the Irish Minister for Public Expenditure and Reform, noted that Cloud Computing has the ability to radically change how public services are delivered.(CMOD, Department of Public Expenditure and Reform (Ireland), 2012). The Irish Public Service already has a number of pre-existing advantages to avail of Cloud Computing models, such as the dedicated Government VPN, established frameworks of shared ICT services and Centralized Procurement Models. These provide significant potential to build "As-A-Service" applications and on-demand elasticity at scale.

However, barriers still exist to cloud adoption. Much uncertainty remains within PSOs on how to best leverage cloud services. A reference cloud model and rollout action plan is required for PSOs providing prescriptive guidelines. Furthermore, it is vital to maintain their data confidentiality, security and privacy mandates. Thus this paper describes a framework for individual PSO migration to shared cloud computing services, addressing the challenges from the "bottom up" micro level, designed to meet the "top-down" macro initiative from Government-Industry Cloud Provision partnerships. The following contributions are provided:

- A qualitative analysis of the adoption barriers to cloud computing in PSOs based on interviews with senior PSO managerial and technical staff.

- The design and implementation of a pilot private Proof of Concept (PoC) cloud. This design serves as a template to enable small PSOs to commence migration to the cloud by providing a cost effective, staged migration path. The results and key learning from this pilot provides an "on ramp" design, and also provides a starting point for PSOs to evaluate their cloud options.

- A common reference model is proposed by which workload data held by PSOs can be categorised and managed according to sensitivity. Additionally, auditable guidelines for how sensitive data can be protected on shared-service data stores throughout the data life-cycle are provided.

- An evaluation of methodologies for data migration while preserving data sensitivity and autonomy on multi-tenant cloud infrastructure is outlined.

- Finally, salient results of a detailed Value For Money (VFM) analysis of the pilot PoC cloud are shared in order to help stakeholders evaluate the economic viability of cloud computing for their organisation.

2. Requirements Gathering and Challenges facing the Adoption of Cloud computing in the Public Sector:

The authors conducted a series of interviews with PSO staff as part of Requirements Gathering. For the purposes of this research, PSOs are considered from within both the Irish Civil Service and the Public Service. The Civil Service comprises of sixteen constituent Departments and the Public Service comprises of organisational bodies ranging from the Irish Defence Forces through to the Health Service Executive

(HSE). Specifically, interviews were conducted with staff members in senior management and technical roles from the following organisations:

- The Board of Management at the Sea-Fisheries Protection Authority (SFPA)
- The Department of Public Expenditure and Reform
- The Government Chief Information Officer (CIO)council
- The Centre for Management and Organisation Development (CMOD)
- Department of Agriculture, Food and the Marine
- Bord Iascaigh Mhara (BIM)
- Irish Naval Service (INS)

Semi-structured interviews were conducted. to provide the flexibility to allow interviewees to express their thoughts in free form, and iteratively over sa prolonged period. Interviewees were selected based on their familiarity with data-sharing from/to the Pilot PSO, as well as their experience and expertise in previous outsourcing and co-sourcing initiatives with questions to determine their opinion on Cloud Computing in general, and how it might be applied to the Public Sector. More specifically, interviewees were asked about their willingness to migrate to Cloud, and what differences they foresaw between Community Cloud offerings and the more traditional outsourcing/co-sourcing frameworks already in place. While many interviewees welcomed such an initiative, a theme that successful adoption required more than "providing the service" became clear in compilation of findings. Ultimately, the over-riding common causes of concern can be summarised as follows:

1. **Lack of guidance to commence migration**
   While many Public Service staff appreciate the value proposition of cloud computing, there was a competing desire to be on the "right" cloud. Managers understood that maximum benefit would be extracted from having services migrate "at scale" and to a uniform standard. Therefore, many PSOs await prescriptive guidance on the available platforms rather than risk migrations that further isolate them from economies of scale.
2. **Ability to sustain services while migrating**
   It is a stated Irish Government Objective to reduce ICT costs by reducing contractor hours and consultancy services (ICT Control, Department of Finance (Ireland), 2009).While this has been effective, it has removed much of the discretionary workforce which facilitated peak-period resourcing during systems migrations. As maintenance of existing services is a priority, migrations run the risk of not having sufficient predictable resource allocations to succeed.
3. **Data Protection, Privacy and Tenancy**
   Traditionally, classic data centres have used a "protect everything in an isolated environment" philosophy to meet data protection and privacy requirements. There are clear perimeters for data sets in single-tenant environments mapped to classic data security measures. Cloud Computing and multi-tenant dynamic environments introduce new threats not mitigated through classic data security measures, as it changes the perimeters of the datasets to be safeguarded. Additionally, the mobility of the data in clouds presents new challenges around jurisdiction and Sovereign Law(Jared Carstensen, 2012).

4. **Accountability**
   By design, PSOs are set up to democratically distribute power into separate stand-alone silos, with separate accountability standards and standalone remits. In fact some PSOs may be legally obliged not to share information with other Government Departments. Therefore, while the benefits of Cloud Computing are obvious, recession has never diluted accountability requirements. As stated by Senator Byron Dorgan, "*You can delegate authority, but you cannot delegate responsibility*". Accountability-without-control concerns about migration to cloud services remain prevalent.
5. **Who do we trust and how do we trust them?**
   Many PSOs have data sharing arrangements with other PSOs and formalised trusts in the form of Service Level Agreements (SLAs). However, trusts are neither absolute nor transferrable. To fully benefit from shared storage and community cloud, a more dynamic (but safe) form of trust must be supported.

3. Proof of Concept (PoC) Private Cloud for the Public Service – Design and Implementation

To address migration concerns, the authors deployed a usable Proof of Concept (PoC) private cloud, leveraging pre-existing physical infrastructure at a PSO, subsequently migrating workloads into this cloud. The purpose of this was twofold. Firstly, to determine the degree of difficulty that PSOs might encounter when converting legacy physical workloads to virtual workloads. Secondly, it provided an effective staging platform where workloads could be classified by the staff, and made ready for migration to the larger Government cloud when available.

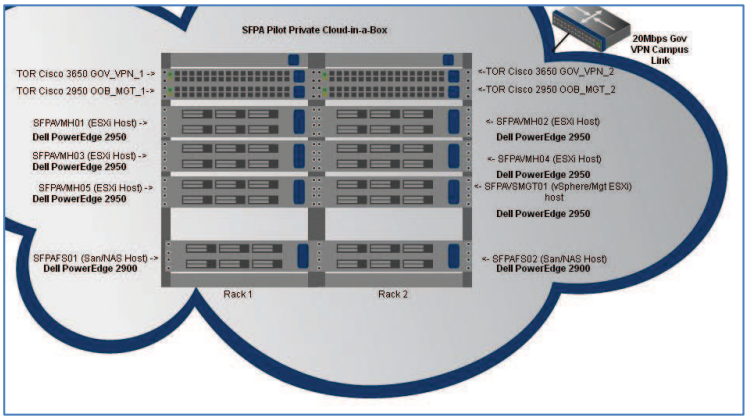

Figure 1 SFPA PoC Private Cloud Topology

The pilot PoC cloud was architected across two racks providing a redundant design, as shown in Fig. 1. In the case where PSOs have two or more data centres, the design can be geo-dispersed to provide additional Disaster Recovery. However, very small PSOs with only one data centre and a small number of servers may also scale-down. This pilot leveraged as much of the pre-existing infrastructure and current facilities (Government VPN and shared services frameworks) as possible. While common

subnets/VLANs were used between switches, the design allows routable scalability. The pod was connected to the Government VPN on a 20Mbps campus link for extensibility.

Numerous cloud computing technologies were evaluated including Citrix, Microsoft, OpenStack (Eucalyptus) and VMware. VMware was selected, but findings were kept platform agnostic. VMware provided proven reliability in the virtualization phase, and due to longevity, it has already solved a number of issues in physical-to-virtual (p2v) transformations. Also the first virtualization step of the migration, on ESXi hosts and the Standalone VMware p2v converter, incurs no licensing costs.

By following the proscribed low-risk phased approach of **Standalone Host virtualisation ->Clustered Virtualisation with shared storage ->Cloud**, PSOs can incrementally harvest efficiencies from existing investment, whilst pacing their progression at each step. Classifying data within these virtual workloads and segmenting the workloads according to confidentiality enables subsequent migration to appropriate CSP offerings.

4. Data Sensitivity Classification and Data Privacy

Historically, single-criteria, paper based filing systems have favoured "retrievability" over security. Classification was secondary, and in cases where a filing cabinet contained Top Secret information, the entire cabinet (or file-room) would be designated Top Secret. Early electronic document storage would use the same single-criteria filing systems. Whereas PSO staff would be very familiar with Data Protection obligations and classic filing systems responsibilities, a new classification model had to be designed by the authors to enable staff to map existing classifications of data to appropriate Cloud Categories.

In order to capture findings to produce a common reference framework, it was necessary for the authors to select a model that would be well-understood, underpinning existing standardisation initiatives. Where a number of Frameworks have incorporated cloud components in their models, the Information Technology Infrastructure Library (ITIL) was chosen as it is compatible with existing Project Management Office (PMO) initiatives in Ireland and across the EU. Also ITIL focuses on Service Management, so compliments the 'As-A-Service' emphasis of cloud computing. Specific to cloud computing adoption lifecycle, the ITIL PMO model comprehensively captures the work streams required to classify data. Lastly, the ITIL PMO work stream approach enabled structured, coordinated and reproducible engagement of all personnel within the PSO, without extensive process reinvention.

4.1 Designing a Common Reference Model template for Data Classification and PoC application of the template results

Because categorisation of data is not exclusively an ICT responsibility, the authors created a categorisation template to engage the skills, expertise and corporate memory of the organisation. This common reference model effectively "bridged the

knowledge gap" between legacy data and new technologies, enabling uniform and consistent classification.

To determine the sensitivity distribution of PSO data, the electronic data set from the Sea Fisheries Protection Agency (SFPA) is considered. De-duplicated data of 985 Gigabytes (GB) was categorised according to the categorization template provided in Table 1. Approximately one quarter of the dataset (223 GB) can be categorised as private data. Private data may be confidential to an individual within the organization (e.g. HR Records or Payroll information), or commercially/legally sensitive information (including Personally Identifiable information, PII). 227 GB of data was classified as Departmental (Semi-Private or Restricted) data. Much of this data resided in shared File Server Folders and databases. These were "working datasets" and contained embedded commercially sensitive information. Data was categorised to a folder or database level of granularity. Over 236GB of data was classified as community data. Much of this is intranet information, made available to stakeholders in the parent department and compliance partner authorities in Ireland and the EU. This data has been sanitised to a level where it can exist on a community cloud but may have Access Controls governed by the PSO, and may be subject to bit masking/obfuscation. Finally 289GB of the considered data was classified as public information. This was a combination of reports and statistics that the PSO is obliged to publish as part of its remit. The framework for data classification also realised consistency of new data classifications over time.

Category	Definition	Pilot PSO % of Data and classification
Private	Information that was private to the PSO itself. This included individual payroll, work records, HR Records and operational information (including PII).This information is Private not only to the PSO, but to individuals *within* the PSO.	23% ***Top Secret*** or ***Secret***
Departmental	Information that could be shared within the PSO and potentially the parent department. Much of this information was transactional or "draft" in nature and comprised a lot of work-in-progress data. Whereas this data may be *transformed* into data that feeds Community or Public workloads, it can be politically and/or commercially too sensitive for dissemination in *unprocessed form*. In keeping with the Data Protection Principles discussed further down, some additional processing (such as *Bit-Masking, Agglomeration* and *Anonymization*) may be necessary on this data.	23% ***Confidential*** or ***Restricted***
Community	Community Information includes data that is available for consumption by PSOs and interested stakeholders. It may include workloads and data sets that may be used to compile "Bigger Picture" assessments of overall public service benchmarks and the state of National and EU compliance with targets and metrics.	24.5% ***Controlled Unclassified Information (CUI)***
Public	Public information Globally Published data that is available to all interested parties on demand. In the case of Public Information, it is "*For General Distribution*" and is the elastic nature of Cloud Capacity for workloads is of interest here.	29.5% ***Unclassified***

Table 1: Data Classification Definitions for Cloud Mappings

4.2 Protecting data privacy throughout the data life-cycle

In *Cloud Security and Privacy* (Tim Mather, 2009), an important distinction is made in the quote "*You can have security and not have privacy, but you cannot have privacy without security.*" The history of data management described above explains why security and privacy are often commingled in traditional silo-based data centres.

PII may be interspersed with less sensitive information, and thus far protected through classic data centre security methods i.e. a protect everything approach.

In Cloud, the threat of Insider attacks now extends to the Cloud Service Provider employees and contractors. Without formal control processes, (usually matured in larger organisations over time), it may be more difficult for clients to detect attacks.

Whereas *liability* for Confidentiality, Integrity and Availability (CIA) can be shared with a Cloud Service Provider via strong contractual clauses, many jurisdictions and regulators assign *accountability* to the client for any data breaches. In the most recent cloud guidance issued by the Irish Data Protection Commissioner (Data Protection Commissioner of Ireland, 2012), the client retains the *Data Controller* responsibility. Cloud service providers and subcontractors are *Data Processors* which "*have a very limited set of responsibilities under the Data Protection Act*". This is echoed EU-wide in the Opinion 05/2012 on Cloud Computing (Article 29 Data Protection Working Party, 2012), ratified by the Independent European Advisory body on data protection and privacy.

To examine and address issues of compliance with Data Protection and Privacy responsibilities for long-lived data sets, this research employed the industry-recognised KPMG Data Life-cycle, applied to cloud in *Cloud Security and Privacy* (Tim Mather, 2009) to ensure compliance of the pilot PoC cloud data with Life-Cycle best practices.

5. Data Migration Framework Findings

The research findings confirm both feasibility and *plausibility* of Public Service Cloud within an appropriate framework. However, it is more complicated than recruitment of suitably scalable Cloud Service Providers (CSPs). The trust placed in PSOs cannot be transitive, even to other PSOs of a similar or higher sensitivity. For most PSOs, the information that lives within their computer systems is the gemstone. The assurances that data can be protected as well or better is central to acceptance and adoption. Increased data and machine mobility means the potential movement of contained data from one sovereign or jurisdiction to another, and custody of the data remains far less clear-cut (Moyse, 2012).

The authors offer the following key findings from the Proof of Concept to address these concerns:

1. **Start Private and phase outward**: The initial migration of workloads to the private cloud created the benefit of making workloads *mobile*. By allowing the pilot data to be classified and migrated accordingly, mapping workloads to appropriate cloud offerings became easier. Migrating physical resources to a safe private cloud also proved an efficient starting point with predictable, phased progression. Phasing alleviates pressure on the PSO, as data classification in workloads can be refined in the safety and privacy of the existing data centre. The private cloud also provides a secure "roll-back" location, if an oversight was detected and a workload had to be re-designated from community/public to private.

2. **Community trust must be dynamic and flexible:** When migrating from the private pilot cloud, community cloud workloads (leveraging synergy to get the most value for the state by scale and controlled multi-tenancy) require special consideration. Proposed solutions used well understood concepts, e.g. ITIL PMO for adoption and migration to cloud, and inline-media encryption techniques to create "safe-deposit boxes" for community workloads. Individual PSOs thus retain custody and accountability on shared multi-tenant storage.

3. **Encryption is the new perimeter:** It is recommended that clients encrypt sensitive data at source, at time of creation and the data remain encrypted blobs throughout life-cycle. PSOs should hold both the encryption keys as well as details of the encryption algorithms. Rather than the Cloud being a "Black Box" to the client, the client should encrypt-at-source, creating a white box with "Black Data". CSPs do not need to know the content of "Black Data" in order to manage the storage. Commercially available devices enable both encryption and de-duplication of data, and abstracting encryption from storage preserves storage mobility and secure maintenance of underlying technologies.

4. **Security auditing cannot be outsourced:** Auditing of access and changes is a necessary PSO responsibility. Commercial offerings now exist that provide extensive tamper proof audit logging capability. However, clients must factor in the work that goes into monitoring these logs, and assign the task to an appropriate role in the new service model. With appropriately formatted "plain-speak" AAA reporting, auditing need no longer be exclusively an ICT task.

5. **Access Controls (ACLs) haven't gone away:** Access Controls form a layer of protection that functions best **within** the encrypted data set. Whereas the encryption obfuscates the data from the external attackers, Access Controls enable granular permissions to data. Having well structured Access Controls and good auditing capabilities are critical to preventing both external threats as well as segmenting the data appropriately to minimise the risks of internal attacks.

6. **Data Mask Test and Development Data**: For completeness of data security life-cycles, it is also necessary to protect data sets used in troubleshooting and development, especially in cloud computing environments when many parties may be involved in dealing with the data. The client may still be held legally liable for data "escaping into the wild", and can suffer significant reputational damage in any case. The net delta is that clients need to ensure that their data is not given to subcontractors without first being masked.

6. Value For Money (VFM) Analysis

As a Public Sector Initiative, a Value For Money (VFM) analysis, the government equivalent of a Return on Investment (RoI), was used for evaluation. The VFM analysis process is detailed in the "Value for Money and Policy Review Initiative Guidance Manual" (Central Expenditure Evaluation Unit, Department of Finance (Ireland), 2007). Using the VFM Programme Logic Model Evaluation Framework, a significant, immediate benefit was 20% increase in available capacity by leveraging underutilized physical machine compute cycles. By pooling physical resources of 5

physical servers, it was possible to get the effective value of 6. This enabled growth of workloads, without additional capital expenditure. Capital Spend Savings of €10,000 were achieved in the first fiscal year of operation, including savings from introducing new workloads with no additional hardware procurement cost. In the pilot PSO, this represents a 20% savings on annual Hardware Capital Expenditure. Hardware-Abstracted maintenance also created new flexibilities for work windows (achieving 6x9s availability). Cloud significantly reduced procurement time (by approximately 6 weeks) as the "cushion" of 20% resources meant that new workloads could be introduced immediately. This also saved several days of administrative effort required by staff to make mid-year amendments to budgets and to solicit approval for additional spend when new unanticipated workloads were introduced. The blended rate cost of a single budgetary amendment is estimated to be €3000-4000 in time alone. New hardware could be "back-loaded" to the cluster seamlessly and "hardware-in-arrears" purchasing made procurement more strategic in the next fiscal year. As part of the pilot, certain workloads were moved to infrastructure in other PSO Comms rooms to simulate movement to a community cloud when available. Other than updates to IP addresses and Static DNS A records, these test migrations were seamless to administer. In PoC testing, the migration was performance-transparent to users. Cloud also provides business process benefits. Through agglomeration of services into a single "highest common standard", both the efficiency and the quality of the offering are improved for all. Data analysis required to migrate workloads introduced new efficiencies into the information held and prepared PSOs for fuller participation in coming global initiatives such as OpenData (Open Knowledge Foundation, 2012) and community data warehousing. As the future value of these efficiencies is difficult to quantify, the VFM treats the benefit spill-over as *externalities* (benefits not transmitted through prices).

7. Conclusion

This paper demonstrates a practical starting point for PSOs to address key concerns to the adoption of cloud computing, describes an "on-ramp" cloud pilot implementation as well as methods to designate, migrate and protect information according to sensitivity and prevailing data protection obligations. Additionally, the Value for Money Analysis of the pilot cloud gives other PSOs a benchmark by which to measure their potential cost efficiencies and additional compute flexibilities in cloud environments. Feedback from all stages of the cloud implementation and evaluation were fed back into the CMOD working group for Cloud Computing.

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Isolation and Molecular Characterization of Bovine Coronavirus in Irish cattle

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Abstract

Bovine Coronavirus (BCoV) is a pathogen implicated in bovine disease, causing either respiratory or enteric symptoms; in calves it is associated with chronic, often bloody diarrhoea, while in adult bovines, it causes winter dysentery. In Ireland, BCoV represents the third most commonly diagnosed agent of calf morbidity and death. In this study, 11 neonatal calf BCoV isolates (mean age 9 days) from the south of Ireland were characterized using molecular methods. The aim of the study was to identify if there are signatures of substitution in the spike gene that is unique to the Irish isolates when compared to global isolates. Phylogenetic analyses revealed that the Irish isolates clustered with novel BCoV isolates from Europe (Italy, Sweden and Denmark), while direct analyses of alignments and likelihood-based selective pressure variation analyses identified amino acid changes in these proteins that are unique to the Irish clade. In summary, we identify 11 sites that show signatures of positive selection in the dataset; 4 of these residues were located in the hyper-variable region of the spike protein. Eight residue changes described herein have not been reported previously - five of these sites were identified through direct analysis of sequence alignment profiles, and the remaining three were identified as under adaptive evolution following analysis using codon based models of evolution. The data has implications regarding the evolution of BCoV, as well as future vaccine design.

Keywords

Bovine Coronavirus, spike protein, codon substitution models

Introduction

Cornaviruses (CoV, family *Coronaviridae*) are large enveloped viral particles containing a positive sense single stranded RNA molecule. The CoV genome is approximately 26-30kb and is the largest known RNA viral genome, coding for polymerase (Pol), nucleocapsid (N), membrane (M), hemagglutinin-esterase

(HE), spike (S) proteins and several Non-structural proteins (NSPs). Coronaviruses are diverse and have been associated with respiratory and enteric infections in humans, turkeys, cats, dogs, cows and other ruminants. The Coronaviridae family is classified into three groups based on antigenic data; these groups were recently re-named as: Alphacoronavirus, Betacoronavirus and Gammacoronavirus (de Groot et al., 2012). Bovine coronaviruses (BCoV) are classified as Betacoronavirus as distinct from Alphacoronaviruses as they are hemagglutninating viruses (Lai et al., 2007).

The BCoV capsid forms a helical virion surrounded by a lipid envelope obtained through host budding (Lai et al., 2007). The capsid of BCoV is covered with projections of hemagglutinin esterase and spike (S) proteins, which are thought to be necessary for viral entry and infectivity (Clark, 1993). As with other virus particles, the spike proteins of BCoV play an important role in immune response, these proteins elicit both cellular immune responses and neutralizing antibodies. Therefore the spike proteins are likely to be under selective pressure from the host immune response due to their direct interaction. Positive selection is driven by mutation, a common process in viruses particularly RNA viruses, resulting advantageous mutations which persist in a population can give rise to new lineages of viruses. Diversification of proteins can cause functional shift, in viral proteins mutation can result in altered function e.g. antibody resistance or alteration in tissue/host tropism e.g. canine respiratory coronavirus. Coronaviruses have one of the largest RNA genomes and so rapidly accumulate mutations through poor RNA polymerase proof reading (Jarvis and Kirkegaard, 1991), they also have an ability to undergo homologous recombination via copy-choice mechanism (Makino et al., 1986), these features of the virus lead to high background mutation rates.

Bovine coronavirus (BCoV) replicates in the epithelial cells of the gut, destroying villi, resulting in severe, often bloody diarrhoea in calves, which can be life threatening from loss of electrolytes and malnutrition (Clark, 1993). As well as being isolated in the gut, BCoV can also be isolated from the respiratory tract, however, there are contradictory reports on whether the virus particles implicated in these conditions are different strains or the one strain with dual tropism (Chouljenko et al., 2001; Decaro et al., 2008; Hasoksuz et al., 2002; Jeong et al., 2005; Park et al., 2007). The spike protein is the largest capsid structure and is the main protein involved in virus infection. The S protein consists of 1363 amino acid residues, it undergoes post-translational proteolytic cleavage into two units (S1 and S2) to become functional; the shorter fragment (S2) anchors the main body of the protein to the virus membrane. The S2 region is highly conserved, whereas the S1 region contains several antibody binding domains, one of which has been identified as a polymorphic region (corresponding to amino acid residues 456-592 of whole protein) (Rekik and Dea, 1994), variations in host/ tissue tropism and resistance to antibody neutralisation can be attributed to variation within the S1 subunit spike protein (Gallagher and Buchmeier, 2001; Yoo and Deregt, 2001).

In this study we aimed to: (i) characterize bovine coronavirus in South of Ireland, (ii) compare Irish BCoV to global isolates, and (iii) identify any

variations in the spike gene. Initial characterization involved focusing on the hypervariable region of the spike gene, phylogenetic analyses revealed that the Irish isolates formed a distinct clade with novel European isolates. More comprehensive analysis of the whole spike gene was performed via examination of the heterogeneity in selective pressures of the spike protein across global isolates using codon models of evolution (Yang et al., 2000). These models offer a statistical framework to estimate the ratio (ω) of silent substitutions per silent site (Ds) and replacement substitutions per replacement site (Dn), across sites and lineages/isolates. Using this approach we investigated site-specific heterogeneity and branch/lineage-site specific heterogeneity in selective pressures of the BCoV spike protein. The ω value provides an estimate of the type and strength of selection in different sites and lineages, the likelihood of purifying selection ($\omega < 1$), neutral evolution ($\omega = 1$) or positive selection ($\omega > 1$) can be estimated. We identified 11 residues under positive selective pressure in the BCoV spike protein; three of these residues have not been reported previously.

Materials and methods

Samples

Faecal samples were collected from Cork Regional Veterinary Laboratory after they had tested positive for coronavirus using a immunochromatographic commercial kit, Corona Vet (Serosep, Ireland), faecal samples were also tested for rotavirus, cryptosporidium, coronavirus and *Salmonella*. A total of 11 coronavirus positive samples were collected from various locations in the South of Ireland between 2010 and 2011, from neonatal calves, mean age 9 days, presenting with diarrhoea. Samples were stored at -80°C prior to analysis.

RNA preparation

Prior to extraction, faecal samples were homogenized in an equal volume of 0.89% NaCl, centrifuged and filtered using a 0.20μm pore size. The RNA was then extracted from the cell free fluid using Qiagen Viral RNA mini kit (Qiagen), following manufacturers' instructions. Extracted RNA was stored at -20°C prior to analysis.

PCR analysis

Extracted RNA was tested for the presence of Coronavirus using degenerate oligonucleotide primers described previously (Stephensen et al., 1999) to amplify a highly conserved region within the polymerase gene, positive samples were then used in selected one step reverse transcriptase-PCR (RT-PCR). A nested PCR was used to amplify the spike (S) gene (Brandão et al., 2003), specifically the hypervariable region as described by Rekik and Dea, 1994. Following analysis of this region, one isolate was selected for the complete characterisation of the S gene using primers previously described (Hasoksuz et al., 2002; Martínez et al., 2012). Reactions were carried out using Enhanced Avian Reverse Transcriptase kit (Sigma-Aldrich), following manufacturers'

instructions, all reactions were carried out using a Biometra T3000 thermocycler. Amplified products were run on 1.5% agarose gels, stained with ethidium bromide and visualized using a UV light transilluminator.

Sequencing and Data analysis

Positive samples were cleaned using Roche High Pure PCR clean kit (Roche) and sequenced using a commercial service (MWG Eurofins, Germany). Resulting sequence data was then analysed and edited using Bioedit v7.0.9.0 (Hall, 1999) and online BLAST tool (http://blast.ncbi.nlm.nih.gov/Blast.cgi). For analysis of the complete S gene, contigs were assembled using DNAstar program Seqman, a phylogenetic tree was constructed Clustal W alignment tool and Maximum likelihood method (MEGA5.1) (Tamura et al., 2011) with GTR model including gamma distribution with invariant sites, 1000 bootstrap replicates were used to test branch strength, values less than 70 were collapsed. Maximum Likelihood tree construction is a sequence evolution model based on probability, GTR model allows for variable substitutions across all sites determined by gamma distribution in this analysis.

Selection analysis of spike protein

We applied the codon substitution models implemented in CodeML from the PAML 4.7 package (Yang, 2007). The input data for these models included the nucleotide alignment for the whole spike protein and the reconstructed phylogeny. The data was studied using eight site-specific models of evolution (m0, m1, m2, m3k2, m3k3, m7, m8 and m8a) and three branch specific models for lineage partitioning within the tree (modelA, modelAnull and modelB) (Yang and Nielsen, 2002). Null models that do not allow for positive selection were included to test the significance of the results, and the appropriate likelihood ratio tests were performed as published previously (Loughran et al., 2008; Morgan et al., 2010). All models where omega is estimated from the data were with independent starting omega values to ensure that we were sampling across the likelihood plane. The best log likelihood score was selected in each case.

Results

Phylogenetic and molecular analysis

Specimens were collected from neonatal calves (mean age 9 days), presenting with diarrhoea, from farms across southern Ireland and sent to the Regional Veterinary Laboratory in Cork. Coronavirus positive specimens were then subjected to further analysis at the Virology Unit, Department of Biological Sciences, CIT. Of the 11 positive faecal samples tested using an immunochromatographic test kit, 8/11 (72.7%) were positive for coronavirus using molecular techniques. Polymerase RT-PCR and sequence analysis were used to confirm coronavirus presence. The emphasis of this study was on the spike protein, initially a partial sequence representing the HVR of the spike was characterized, from this analysis one isolate was selected for characterization of

the whole gene. Sequence analysis of these regions was carried out using the online BLAST tool, Bioedit (Hall, 1999) and using MEGA5.1 (Tamura et al., 2011) for phylogenetic analysis.

Sequence alignment profile

Sequence alignment profiles of the translated protein of the HVR revealed novel residue changes not previously reported, isolate RVLC7 was selected for complete sequence analysis due to the novel polymorphism identified in position 60 of the HVR (S to F, corresponding to position 501 in complete protein). The complete spike protein contained a total of 14 residue changes in comparison to the Mebus strain (Table 1), 9 of these changes where shared with other isolates found globally (light grey regions), while 5 where unique to Irish isolate RVLC7 (dark grey regions). Many residues were shared with novel isolates such as Italian strains 339/06, Bubalus 179/07 and 438/06-TN, Dutch isolates SWE/C/92, SWE/M/06-4, DEN/03-2, Human coronavirus 4408 and in one instance with virulent strain LY-138.

Selection analysis

Selective pressure analysis of the complete spike protein was carried out using the CodeML program within the PAML package (Yang, 2007; Yang et al., 2005), Positively selected sites were detected using Bayes Empirical Bayes (BEB) and Native Empirical Bayes (NEB) (Yang et al., 2005) (Table 2). We used these codon models of evolution to detect heterogeneous selective pressures across the isolates for the spike protein. Specifically we wished to determine whether European isolates are subjected to lineage specific selective pressure. Likelihood ratio tests (LRTs) revealed models m2, m3k2, m3k3 and m8 were significant ($p<0.05$) for our data. Model m8 detected 11 sites under positive selection (Table 2), four of these residues are in the hyper-variable region of the spike protein (499, 501, 525 and 531), two of these residues have been reported previously as being susceptible to change. Out of a total of eleven sites identified by CodeML as being under positive selection, only two were identified in Irish isolate RVLC7 (115 and 501) from the profile analysis of the alignment with the Mebus strain (Table 1). The three ancestral branches leading to the clades that contains the novel European isolates were labeled for analysis using Branch specific models (Figure 1), LRTs revealed no significant signatures of positive selection in a lineage specific manner ($p < 0.05$).

Discussion

In this study we aimed to characterise bovine coronavirus found in Ireland using phylogenetic analysis and sequence alignment profiles to determine if there were unique features in the Irish strains, in comparison to global isolates. Here, we describe our analysis of eleven coronavirus positive fecal samples that were collected from the Regional Veterinary Laboratory in 2010 and 2011.

Initially we performed an analysis of sequence alignment of the translated protein to identify unique polymorphisms in Irish isolates; data was compared

against sequences from wild type isolates obtained globally using strain Mebus as a reference. It was found that Irish isolates had unique substitutions in the HVR of the spike protein, from this analysis one isolate was selected for analysis of complete spike protein sequence (RVLC7). Fourteen alterations in protein residues were detected: 5 were unique while 9 were shared with novel isolates (Table 1). There are two residues of particular interest, 115 and 501, these residues appear to have great variability between strains, at position 115 there are 4 different residues among the isolates, in a previous study (Gélinas et al., 2001) a change from D to K was associated with virulent strains while another study reports it as being an indicator for respiratory tropism (Chouljenko et al., 1998), in our strains there is a substitution to N , which is shared by isolates 336/06, Bubalus 179/07, 438/06-TN, SWE/C/92, SWE/M/06-4, DEN/03-2 LY-138 and HCoV 4408, all of which are virulent enteric strains. Substitutions at position 501 have been proposed to have significance in the secondary structure of the spike protein (Hasoksuz et al., 2002), commonly only two types of amino acids have been identified here (serine or proline) in RVLC7 there is a phenylalanine residue, this change was first identified in strain DBA (not available on-line) (Benfield and Saif, 1990; Hasoksuz et al., 2002) and is linked to reduced hydrophobicity and loss of an antigenic site, this change has also been recently observed in Dutch isolates. Positions 141, 897 and 1278 are unique substitutions to Irish isolates and may affect polarity (increased hydrophobicity) of the protein. The proteolytic cleavage site motif KRRSRR remains conserved in RVLC7.

Phylogenetic analysis of the whole spike gene (4092bp including s1 and s2 subunits), the taxa can be seen to group into distinct clades that can be roughly broken up into two major groups, which may represent differences antigenicity (Kanno et al., 2013) and possibly different lineages. In the tree displayed here (Figure 1) the first group consists of European isolates from Sweden, Denmark and Italy including Irish isolate RVLC7 and novel enteric HCoV 4408. The second group contains isolates from the Americas, Canada and Korea, including Irish vaccine strain Mebus. Irish vaccine for bovine coronavirus is currently based on inactiviated Mebus strain, as seen in the phylogeny there is a good deal of diverence in circulating Irish strains from vaccine strain. This phylogenetic difference between wild type and vaccine strains has been seen previously (Fulton et al., 2013).

From the sequence and phylogenetic analysis it is clear that Irish and European isolates are distinct from described global BCoV isolates, codon substitution models were used to investigate the selective pressures on Irish CoV spike protein in comparison to all other isolates. As seen in the sequence alignment profile of the whole spike protein, 14 substitutions were identified in comparison to the vaccine strain. The aim of this analysis was to determine whether these sites could be undergoing positive, neutral or purifying selection, additionally whether these changes could be leading to lineage partitioning of CoV. From the LRT analyses, m8 was determined to be the best model for our dataset, with a $p < 0.05$. Positively selected sites were determined using BEB and NEB, with a posterior probability of >95% (Yang et al., 2005). Model m8 indicates eleven residues in the whole spike protein as sites subject to selective pressure (Table 2): 11, 35, 115, 179, 499, 501, 525, 531, 716, 769 and 1352.

Four of these residues are within the hyper-variable region of the protein (499, 501, 525 and 531), while the remainder are dispersed across the protein, some of these residues and their alterations have been reported and described in previous publications. Branch specific models did not detect lineage divergence within the tree from this study, three branches supporting the clade containing isolates from Europe (Figure 1), all were insignificant ($p<0.05$). The root used in this tree results in insertions and deletions within the alignment used for this analysis, but the effect of such artifacts in branch specific models has been shown to be minimal (Fletcher and Yang, 2010). Only 2 of the 14 residues described in the Irish isolate RVLC7 were identified as selected sites (115 and 501), when using through sequence alignment only.

Overall the Irish and European isolates described in this study are relatively distinct from other global isolates as seen in the phylogeny displayed here (Figure 1). The Irish isolates group together clustering with European isolates in a separate clade. Sequence analysis of the complete spike protein reveals unique amino acid substitutions and alterations that have been identified previously, which have been associated protein structure, virulence and immunogenicity, as well as unique alterations which have not been previously described. Currently, the Irish bovine coronavirus vaccine is based on the Mebus strain, the data displayed here suggests that it may not be effective against new emerging isolates. In one year only 11 samples were collected in the south of Ireland, reflecting the relative low level of current infection with coronavirus in Ireland. However, monitoring of this pathogen is still important as, is evident from the data, the current isolates in circulation in the south of Ireland are diverging from the available vaccine strain.

	Amino acid positions													
Strain	**3**	**4**	**23**	**115**	**141**	**257**	**501**	**590**	**608**	**897**	**909**	**927**	**1260**	**1278**
MEBUS	L	I	T	K	Q	T	P	D	D	S	K	S	D	N
RVLC7	F	L	S	N	H	N	F	E	G	F	R	A	N	I
BCoV 339/06	L	I	T	N	Q	N	S	D	G	S	R	A	N	N
Bubalus	L	I	T	N	Q	N	S	D	G	S	R	A	N	N
438/06-TN	L	I	S	K	Q	N	S	D	G	S	R	A	N	N
468/06-TN-50	L	I	S	K	Q	N	S	D	G	S	R	A	N	N
SWE/C/92	L	I	T	D	Q	T	P	E	G	S	R	A	D	N
SWE/M/06-4	L	I	S	N	Q	N	F	E	G	S	R	A	N	N
DEN/03-2	L	I	S	D	Q	N	S	D	G	S	R	A	N	N
HCoV 4408	L	I	T	N	Q	T	P	E	G	S	R	A	D	N
LY-138	L	I	T	N	Q	T	S	D	D	S	K	S	D	N

Table 1: Alignment of the complete spike gene, list of all 14 substitutions within Irish isolate RVLC7 in comparison to vaccine strain Mebus. Light grey regions are shared residue alterations, while dark grey regions are unique to RCLC7

Model	p	ℓ	Estimates of parameters	Positively Selected sites
M0 (one ratio)	1	-14,549.081666	$\omega = 0.16752$	Not Allowed
M1 (neutral)	2	-14,248.621989	$p_0 = 0.87348$ $\omega_0 = 0.05329$	Not Allowed
M2 (Selection)	4	-14,218.784057	$p_0 = 0.87177$ $p_1 = 0.11944$ $p_2 = 0.00879$ $\omega_0 < 1$, $\omega = 1$, $\omega_2 = 4.32961$	11, 179, 499, 501, 525, 1352
M3K2 (discrete, k=2)	3	-14,244.399095	$p_0 = 0.89704$ ($p_1 = 0.10296$) $\omega_0 = 0.06482$ $\omega_1 = 1.31068$	11, 23, 35, 88, 113, 115, 143, 151, 157, 179, 181, 188, 244, 294, 412, 425, 447, 455, 465, 484, 499, 501, 503, 509, 510, 525, 531, 543, 546, 576, 590, 716, 718, 744, 769, 805, 881, 906,1206, 1237, 1260, 1341, 1350, 1352
M3K3 (discrete, k=3)	5	-14,216.474229	$p_0 = 0.84095$ $p_1 = 0.14501$ $p_2 = 0.01404$ $\omega_0 = 0.04695$ $\omega_1 = 0.74472$ $\omega_2 = 3.54991$	11, 179, 499, 501, 525, 1352
M7 (beta)	2	-14265.050236	$p = 0.13184$ $q = 0.62432$	Not Allowed
M8 (beta and ω>1)	4	-14,220.246273	$p_0 = 0.98318$ $p= 0.20105$ $q= 1.18023$ (p_1=0.01682), ω=3.30722	11, 35, 115, 179, 499 501 525, 531, 718, 769, 1352,
M8a (beta and ω=1)	3	-14,246.209009	p_0= 0.98249 p=0.65242 q= 9.20408 (p_1=0.10751), ω=1	Not Allowed

Table 2: CodeML parameter estimates for site specific models of the complete spike gene. Positively selected sites displayed are estimated using BEB and NEB with a posterior probability >95% and are numbered as per protein position.

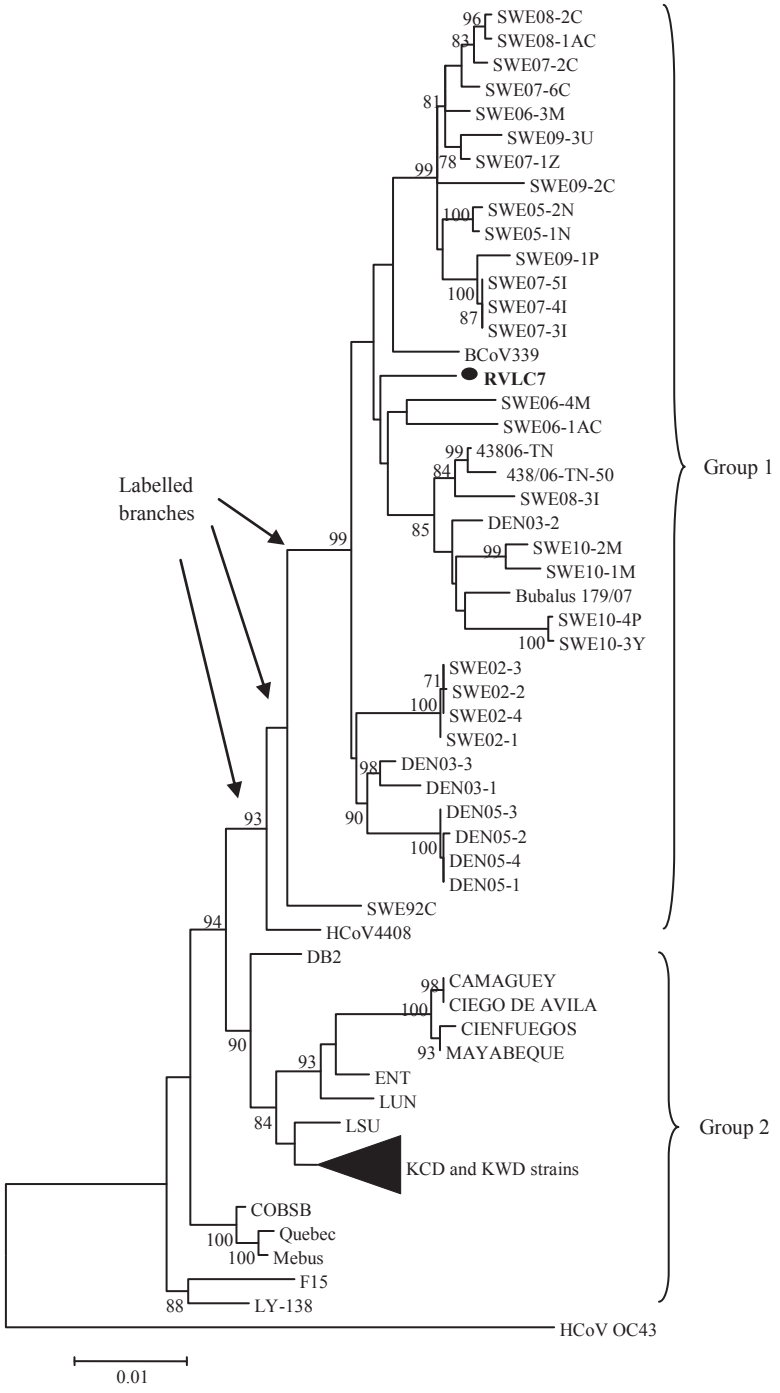

Figure 1: Maximum parsimony tree based on the complete spike gene (4092bp) including the s1 and s2 subunits. The Irish isolate from this study is in bold.

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Complete genomic sequence of a group A giraffe rotavirus: comparison with mammalian rotaviruses and evidence of interspecies transmission.

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Abstract

Group A Rotaviruses (RVA) have been established as significant contributory agents of acute gastroenteritis in young children and animal species. In 2008, we described the first RVA strain detected in a giraffe calf (RVA/Giraffe-wt/IRL/GirRV/2008/G10P[11]), presenting with acute diarrhoea. Molecular characterisation of the VP7 and VP4 genes revealed the bovine-like genotypes G10 and P[11], respectively. To further investigate the origin of this giraffe RVA strain, the 9 remaining gene segments were sequenced and analysed using the Rotavirus Classification Working Group (RCWG) guidelines, revealing the following genotype constellation: G10-P[11]-I2-R2-C2-M2-A3-N2-T6-E2-H3. This genotype constellation is very similar to RVA strains isolated from cattle or other members of the artiodactyls. Phylogenetic analyses confirmed the close relationship between GirRV and RVA strains with a bovine-like genotype constellation detected from several host species, including humans. These results suggest that RVA strain GirRV was the result of an interspecies transmission from a bovine-like rotavirus to the giraffe calf. However, we cannot rule out completely that this bovine-like RVA genotype constellation may be endemic in giraffes. Future RVA surveillance in giraffes may answer this intriguing question.

Keywords Group A Rotavirus, Giraffe, Zoo

Introduction

RVA belong to the family of *Reoviridae,* and is the leading cause of viral gastroenteritis in young children and a large variety of mammals worldwide (Nakagomi et al., 1989; Rodgers and Baldwin, 1990). The RVA genome consists of 11 segments of double-stranded RNA (dsRNA), encoding six structural viral proteins (VP1-4, VP6-7) and six non-structural proteins (NSP1-6), enclosed in a triple layered protein capsid (Estes, 2004). Rotaviruses are classified into eight antigenically or genetically distinct groups (RVA to RVH), on the basis of the common group antigen, the inner capsid protein VP6.

The two outer capsid proteins, VP7 and VP4, independently elicit neutralizing antibodies, induce protective immunity, and are used to classify RVA strains into G (for **G**lycoprotein) and P (for **P**rotease-sensitive) types, respectively (Matthijnssens et al., 2008a). Recently, a novel sequence-based classification system has been proposed, based on nucleotide identity cut-off percentages, and different genotypes have been defined for each genome segment (Matthijnssens et al., 2008b). To date, 27 G types and 37 P types have been identified in humans and animals (Matthijnssens et al., 2011; Papp et al., 2012).

A recent review of the origins of major human infectious diseases by Wolfe et al (Wolfe et al., 2007) placed RVA in a list of the 25 diseases which have had a global impact on human health. Additionally, this study also concluded that RVA possibly (and most probably) reached humans from domestic animals. The antigenic variation observed for RVA appears to have evolved in a similar fashion to that of the hemagglutinin and neuraminidase genes of influenza A viruses: antigenic shift (resulting from gene reassortment) and antigenic drift (resulting from the successive accumulation of mutations) (Gentsch et al., 2005).

Historically, host specific G- and P-types were thought to predominate in natural infections of animal and human species (Gerna et al., 1992). Moreover, it was previously believed that animal RVA strains did not infect humans under natural conditions. However, in recent years, a large number of animal-like RVA strains have been detected in humans and animals as either sporadic or non-sporadic infections providing evidence of interspecies or zoonotic transmission (Matthijnssens et al., 2009).

RVA strains belonging to genotypes G6, G8 and G10, in association with P[1], P[5] or P[11], are commonly found in cattle (Kaplon et al., 2013). G6 is the most predominant bovine RVA genotype, followed by G10 and G8 (Malik et al., 2012). G10 is the second most common bovine rotavirus genotype, and has been isolated from many countries worldwide, including Ireland (Cashman et al., 2010). In the majority of epidemiological studies, bovine G10 is found associated with P[11], and to a lesser extent with P[5]. G10 strains have also been isolated from pigs, lambs and buffalos, from Thailand/US, China/UK, India and Italy (Halahiel et al., 2010; Fitzgerald et al., 1995).

The molecular characterisation of RVA strains is important for determining the extent of diversity in circulating strains. With recent advances in sequencing technologies, subsequent phylogenetic analysis has greatly expanded our understanding of RVA evolution. However, there is still a paucity of sequencing data for whole animal RVA genomes.

RVA strain RVA/Giraffe-wt/IRL/GirRV/2008/G10P[11] was originally detected in a 14-day-old Giraffe (*Giraffa camelopardalis*), presenting with acute diarrhoea. This strain was characterised molecularly as G10P[11], features typically associated with bovine RVA strains (Iturriza-Gomara et al., 2004). Detailed sequence analysis of the VP4 and VP7 genes revealed significant identity at the amino acid sequence level to bovine RVA strains. In the present study we sequenced the remaining 9 gene segments of GirRV in order to find out its genetic relationship with other known animal RVA strains.

Materials and Methods

RNA extraction

Viral RNA was extracted from faecal material using the QIAamp Viral RNA minikit (Qiagen, Hilden, Germany) according to the manufacturers' instructions.

Reverse transcription Polymerase Chain Reaction, cloning and sequencing

Purified dsRNA was denatured at 97^{0}C for 10 min, and reverse transcriptase-PCR (RT-PCR) was carried out using a Qiagen OneStep RT-PCR kit (Qiagen). RT-PCR was carried out with an initial reverse transcription step of 30 min at 45^{0}C, followed by a denaturation step at 95 ^{0}C for 15 min, and thermal cycling for 35 cycles (45 s at 94 ^{0}C, 45 s at 45 ^{0}C, and 2.5 min at 70 ^{0}C for VP6, NSP1- NSP5, 30 s at 94 ^{0}C, 30 s at 50 ^{0}C, and 6 min at 70 ^{0}C, for VP1-VP3 genes).

Amplicons for NSP1-NSP5 and VP6 were directly ligated into pCR2.1, a cloning vector (Invitrogen, Bv, Amsterdam, The Netherlands), according to the manufacturers' instructions. The corresponding constructs were screened for the correct insert prior to purification with the Wizard Plus SV Minipreps DNA Purification system (Promega, Madison, WI, USA). Correct clones were sequenced with M13 forward and reverse sequencing primers (Qiagen). Partial nucleotide sequences were assembled and analyzed using DNAstar software (Lasergene, Madison, WI). Amplicons for VP1-VP3 were purified using the USB ExoSAP-IT PCR Product Cleanup (Affymetrix, Santa Clara, California, USA) and sequenced with an ABI Prism BigDye terminator cycle sequencing reaction kit (ABI Prism 3130xl00) using forward or reverse primer, followed by primerwalking. All sequences were compared against those available in the current GenBank database (http://www.ncbi.nlm.nih.gov/GenBank/index.html).

Analysis of the deduced amino acid sequences and phylogenetic analysis

Phylogenetic analyses based on the nucleic acid alignments (VP1 through VP3, VP6 and NSP1-NSP5) of the GirRV strain and selected global RV gene segments available in GenBank) were performed using the neighbour-joining method of MEGA4 analysis. The statistical significance of the phylogenies inferred was estimated by bootstrap analysis with 1,000 replicate data sets.

Nucleotide sequence accession numbers

The complete nucleotide sequence data of the outstanding 9 gene segments of strain UCD/GirRV were deposited in GenBank under the accession numbers GQ428136 (NSP1), GQ428137 (NSP2), GQ428138 (NSP3), GQ428139 (NSP4), GQ428140 (NSP5), GQ428141 (VP1), GQ428142 (VP2), KF438030 (VP3) and GQ428143 (VP6).

Results

Genotype constellation of GirRV

The full-length sequences of the VP7 and partial sequence of the VP4 genes of UCD/GirRV, were determined previously (Mulherin et al., 2008). To further investigate the origin of this GirRV, the near complete sequence of the remaining 9 genes were determined, in the University College of Dublin (NSP1-NSP5, VP6) and the University of Leuven (VP1-VP3). Using the RotaC online classification tool (http://rotac.regatools.be/), the complete genotype constellation of RVA/Giraffe-wt/IRL/GirRV/2008/G10P[11] was determined as: G10-P[11]-I2-R2-C2-M2-A3-N2-T6-E2-H3.

The Chinese bovine RVA strain RVA/Cow-xx/CHN/DQ-75/2008/G10P[11] was found to possess an identical genotype constellation as GirRV. In addition, the Buffalo RVA strain RVA/Buffalo-xx/ZAF/Buf1442-07SA/2007/G10P[11] and the bovine RVA strains RVA/Cow-wt/SVN/SI-B17/2004/G6P[11] only differed in a single genotype (A3 vs. A13, and G11 vs G6, respectively) with GirRV. Furthermore a range of “bovine-like” RVA strains isolated from cattle, humans, simians, goats, sheep or antelope were found to share 8 or 9 gene segments with GirRV. Most of these “bovine-like” RVA strains possessed G and P-genotype distinct from that of GirRV (G10 vs. G6 or G8, and P[11] vs. P[1], P[5] or P[14]).

Phylogenetic analyses

Structural viral proteins (VP)

The central core is mainly composed of VP2, which surrounds viral genomic dsRNA. Minor components of the central core, VP1 and VP3, include the putative

RNA-dependent RNA polymerase and the guanylyltransferase, respectively. The most abundant protein, VP6 (inner capsid), possesses the group and subgroup antigens that are used as markers for RV classification.

The VP1 gene segment of GirRV was most closely related (96.8% at the nt level) to the human bovine-like RVA strains RVA/Human-wt/AUS/V585/2011/G10P[14] isolated in Australia, and further clustered in a large subcluster of the R2 genotype possessing RVA strains from a wide range of animal species, but almost all possessing an entirely bovine-like genotype constellation.

Phylogenetic analysis of the VP2 gene revealed that GirRV clustered in a distinct subcluster of the C2 genotype, only possessing a few other RVA strains with a bovine-like genotype constellation, originating from a cow, humans, a buffalo and a rabbit. The VP2 of GirRv was most closely related to the Slovenian human bovine-like RVA strain RVA/Human-wt/SVN/Si-R56/2007/G6P[11] (97.1% at the nt level).

The VP3 gene segment of GirRV was found in a large subcluster of the M2 genotype possessing mainly RVA strains with a bovine-like genotype constellation from a variety of host species. GirRV was found to be relatively distantly related (92.5% - 93.0%) to RVA strains RVA/Rabbit-tc/NLD/K1130027/2011/G6P[11], RVA/Human-tc/GBR/A64/1987/G10P[11], Buf1442-07SA, RVA/Antelope-wt/ZAF/RC-18-08/G6P[14] and RVA/Human-tc/IND/69M/1980/G8P[10].

The VP6 gene segment of GirRV was found to be most closely related to RVA/Cow-tc/IND/CR231-39/1994-1997/G6P[1] and RVA.Cow-tc/USA/NCDV/1967/G6P[1] (97.1%), and clustered closely together with several bovine and bovine-like RVA strains isolated from all over the world in the I2-genotype.

Although VP1, VP2, VP3 and VP6 of GirRV all clustered inside genotype 2, which is shared with the typical human DS-1-like RVA strains, none of these gene segments were actually closely related to typical human DS-1-like RVA strains.

Non-structural viral proteins (NSP1-NSP5) of UCD/GirRV strain

Non-structural proteins are only found in cells following viral infection and are essential for RVA non-specific RNA binding, virion morphogenesis, translation, replication and packaging activities.

Phylogenetic analyses placed the NSP1 gene segment of GirRv in a subcluster of the A3 NSP1-genotype, containing only RVA strains with a bovine-like genotype constellation, distinct from the AU-1/feline-like subcluster of A3. GirRV only showed 94.0% nt similarity with the Thai bovine RVA strain RVA/cow-tc/THA/A44/XXXX/G10P[11].

The NSP2 gene segment of GirRV clusterd in one of the many subclusters of the N2 NSP2-genotype possessing bovine-like RVA strains. The P[14] antelope RVA strain RC-18-08 was found to be most closely related to GirRV (95.9%), and several other bovine-like human RVA strains with the P[14] genotype were also found to cluster near GirRV.

The T6 NSP3-genotype contains almost exclusively bovine and bovine-like RVA strains, and the NSP3 gene segment of GirRV clusters in this T6 genotype closely together with G10P[14] reference strain A64 (97.3%) and two South African bovine RVA strains RVA/Cow-wt/ZAF/1603/2007/G6P[5] and RVA/Cow-wt/ZAF/1605/2007/G6P[5] (96.0-96.4%).

The NSP4 gene segment of GirRV was found to cluster in the E2 NSP4-genotype distantly related from human DS-1-like RVA strains, but closely related to the unusual human bovine-like RVA strains A64, M69 and RVA/human-tc/KEN/B12/1987/G8P[1] (95.2-95.4%), all isolated in the 1980s.

The NSP5 gene segment of GirRV belonged to the H3 NSP5-genotype and was very closely related (98.7 to 99.1%) to typical bovine RVA strains from Japan (1603, 1604, 1605) and Slovenia (SI-B17), and buffalo RVA strains Buf1442-07SA. Interestingly GirRV also showed 97.1-97.3% similarity with the two unusual feline-like RVA strains RVA/Cat-wt/ITA/BA222/2005/G3P[9] and RVA/human-wt/ITA/PAH136/1996/G3P[9].

Conclusions

GARVs are important etiological agents of acute gastroenteritis in humans and animals. Currently, there is limited information on the prevalence of RV in zoo environments and among exotic species. In our earlier study (Mulherin et al., 2008), molecular characterisation of the VP7 and VP4 genes revealed bovine-like genotypes, G10P[11]. G10P[11] strain types are common infectious agents in cattle in several parts of the world, including Ireland (Cashman et al., 2010; Halahiel et al., 2010; Fitzgerald et al., 1995).

To further investigate the genomic relationship between GirRV and other known RVAs, the complete genome of GirRV was determined. The GirRV was classified as G10-P[11]-I2-R2-C2-M2-A3-N2-T6-E2-H3, which is highly reminiscent to that of bovine RVA strains, and a wide range of bovine-like RVA strains from different host species. Also the phylogenetic analyses of the 11 individual gene segments revealed a close relationship (93.0 – 99.1%) between GirRV and various RVA strains with a bovine-like genotype constellation, providing compelling evidence that giraffes are yet another member of the even toed ungulates susceptible to infection with bovine-like RVA strains in addition to cattle, goats, sheep, antelope, buffalo, llama and guanacos.

Overall, the VP1 sequence of the giraffe isolate (R2) was similar to human and bovine strains; VP2 (C2) was closely related to strains isolated from humans and

buffalo. VP3 (M2) was contained in a cluster containing mainly RVA strains with a typical bovine like genotype constellation isolated from human, antelope and buffalo, and cow. The VP6 gene segment clustered closely with several bovine and bovine-like RVA starins isolated from all over the world in the I2-genotype. NSP1 (A3) and NSP3 (T6) were contained in a cluster with human and bovine isolates. NSP2 (N2) is closely related to antelope RVA strain, RC-18-08. NSP4 (E2) belonged to a cluster containing mainly human RVA strains, but with a typical bovine like genotype constellation, while NSP5 (H3) was contained in a cluster containing mainly RVA strains with a typical bovine like genotype constellation.

The molecular basis of RV natural cross-species infectivity is not clear, but several genome segments including VP3, VP4, VP7, NSP2 and NSP4, have been implicated in host range restriction and/or virulence. It has been suggested that the control of virulence and host species specificities may reside in the complex interactions of multiple genes (Matthijnssens et al., 2006a). In spite of the bovine nature of GirRV, it caused severe diarrhoea in a giraffe host with a fatal outcome, indicating that direct cross-species bovine-to-giraffe transmission may occur in nature and that the virulence of the bovine strains may be retained in the giraffe host. It would be interesting to experimentally determine whether the bovine-like UCD/GirRV is able to efficiently infect and spread horizontally in bovine hosts.

To our knowledge, this is the first study to report the (near) complete genome sequence for a RVA strain from a giraffe species in a zoo environment. Furthermore only a handful of G10P[11] RVA strains have been sequenced completely to date. G10 genotypes have been associated with infections in children in Brazil, Thailand, and India (Santos et al., 1998; Urasawa et al., 1992). report describing the Indian bovine-like human RV (hRV) I321 strain (G10P[11]) showed that all of the gene segments were very closely related to those derived from bovine strains, whereas the NSP1 and NSP3 genes were of human origin (Rao et al., 1995; Varghese et al., 2004).

Husbandry issues were considered originally (Mulherin et al., 2008) to assess the potential route of RV infection. The giraffe calf had been fed using bovine milk, and it was suspected that this was the source of infection. Interestingly, the giraffe calf had not been in contact with any other ruminants' prior to admission to the University Veterinary Hospital. However, indirect contact with other animals could not be ruled out. Other issues for consideration were the movements of the zoo keepers and others such as veterinarians between different animal enclosures, the feeding equipment used and the apparatus used to clean the housing areas

Data presented in this study highlights events that may support the hypothesis that a bovine-reassortant virion caused infection in the giraffe calf as the amino acid similarities and dendograms clearly indicated identity between bovine RV and the UCD/GirRV deduced amino acid sequences. In certain countries interspecies transmission of bovine rotaviruses to humans by genetic reassortment appears to be taking place more frequently than previously surmised (Matthijnssens et al., 2006b).

Therefore, mapping the precise distribution of rotavirus G and P types in various animal species is vital to readily identify sources of atypical GARV infections in humans. In addition, the acquisition of this data from the various animal species is important to comprehend rotavirus ecology, and the mechanisms by which rotaviruses cross species barriers, exchange their genes during reassortment, and mutate via accumulation of single-point substitutions and/or via genetic rearrangements.

Complete genome sequences are available from only a few strains throughout the world (Matthijnssens et al., 2008b; Ghosh and Kobayashi, 2011; Delogu et al., 2013) and there is a lack of information on mixed animal rotaviruses. Further comparative studies of mammalian rotaviruses investigating the amino acids for corresponding genes, along with their role in structure and function will help with assessment of virulence determinants. Additionally, extending the sampling populations of wild-type RV and incorporating complete genome characterisation by sequence analysis will contribute to our understanding of the natural mechanisms that drive RV evolution and host range restriction.

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Review of Reality Mining Techniques Applied To Telecommunications Data

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Abstract

The majority of humans today carry mobile phones. These mobile phones have the capability to continuously sense human activity and especially human interactions. The data captured from billions of mobile phone subscribers around the world can reveal significant clues about human behaviour. These behavioural clues revealed from mobile phones about human being can have deep profound social impacts. Reality Mining is a data mining technique that is applied on mobile phone and sensor data to identify patterns in social behaviours which provides new opportunities with respect to health care, disease propagation, energy consumption, home and land security and social networking. Nathan Eagle and Alex Pentland, pioneers of Reality Mining and researchers at Massachusetts Institute of Technology (MIT), defined the term as "the collection of machine-sensed environmental data pertaining to human social behaviour".

This research is concerned with the application of state of the art data mining techniques applied to mobile phone datasets. The intention for this research is to develop expertise in Reality Mining and to further the research area by using alternative analysis techniques. These new techniques will be verified by application to real data sets such as those in the telecommunications field with a view to providing tools that provide commercial benefits to partner companies.

Keywords

Reality Mining, Context aware Computing, Modelling Human Behaviour, Social Network Analysis

1. Introduction

Mobile phones have become gradually ubiquitous reaching urban and rural populations across the large portions of the world. In the year 1982, there were 4.6 billion people living in the world, and not a single person was subscribed to mobile phones. Today, there are seven billion people in the world and over six billion of them are subscribed with mobile phones, providing mobile access for more than three-quarters (75%) of the world's population, according to a report by the World Bank [13]. The Geneva-based United Nations telecommunications agency

(International Telecommunication Union) says “The number of mobile phones worldwide is set to catch up to the world’s population next year”.

In recent years, the vast development of mobile technology has provided people with immense benefit and power to do almost all of the things that they normally do online but with the flexibility of doing it almost anywhere. The purpose of mobile phones today has reached beyond a simple communication device. Most modern mobile phones come with GPS enabled services, built-in location based services, and integrated sensors such as Bluetooth, Infrared, Wi-Fi, built-in cameras, and various applications which help people to check their emails, share files, take pictures, record videos, browse web services, listen to music, as well as connect them with their social network. All of these forms of data can be collected and analysed which allows the measurement of human and social activity. This can reveal details about human behaviour including movement, communication, and proximity to others [12, 16].

Research using mobile phone data has recently motivated lots of interest focusing on location-driven data analysis. Every time a mobile phone subscriber makes a call, it pings the nearest tower revealing its location. Built-in GPS enabled services and location based services in mobile phones can also be used to track the location at a given time, which informs where the user is, where the user goes, and even who the user is with. In addition, wireless proximity data can be gathered by using built-in Bluetooth technologies to find repeated patterns in daily life activities and individual behaviour. This type of information can provide patterns relating to people’s regional movements as well as the shape and dynamics of their social networks.

Nathan Eagle and Alex Pentland were able to determine which students were friends based solely on mobile phone location records in one of their experiments conducted at MIT [15]. They also revealed that data collected from mobile phones could shed light on workplace dynamics as well as on the well-being of whole communities. By logging and time stamping user activity, location and proximity to others, it has been proved possible to measure the underlying dynamics of a group of people working in an organization [2].

This research attempts to find the predictable patterns of human social behaviour and infer relationships by combining and analysing the data collected from sensor systems and mobile phones by applying Reality Mining techniques on local mobile data. Reality Mining is defined as the study of human social behaviour based on wireless mobile phone sensed data [12]. By leveraging recent advances in statistical methods and machine learning algorithms, computational models can be built to find the hidden patterns of human interactions and behaviour [2, 14]. Active analysis of such interactions and behaviour can be used to identify the relationships. These revealed patterns and relationships can then be used on the broader population to offer information to various applications that can be built for the advancement of business organizations and individuals.

Recently, MIT Technology Review has listed "Big Data from Cheap phones" as one of the Top 10 Breakthrough Technologies of 2013 while in the review of 2008; Reality Mining was also close to the top of the list [7].

2. Related Work

Reality Mining is an area where research is currently very active. To date, there has been numerous research studies carried out on Reality Mining. Relevant research is outlined in this paper.

The Reality Mining project performed at MIT Media Laboratory by Nathan Eagle and Alex Pentland was the largest mobile phone project ever attempted in academia. They introduced a system that sensed the complex social systems with data collected from 100 subjects at MIT over the course of the 2004-2005 academic years. The data collected represents approximately 450,000 hours of data on user's location, communication, and device usage behaviour. The data was analysed to reveal regular and predictable rules and structure in the behaviour of individuals, dyads (a tribe in Reality Mining speak), teams and organizations. By leveraging statistical analysis and machine learning methods, Eagle and his team developed discriminative and generative probabilistic graphical models as well as models based on Eigen decomposition to classify and predict an individual's behaviour, relationship with others and association with particular groups [15,16].

They demonstrated the ability to use standard Bluetooth-enabled mobile phones to measure information access and use in different contexts, recognize social patterns in daily activities of users, infer social relationships, identify significant social locations and model organizational rhythms. Behaviour prediction, relationship inference and computational social science were among the major findings of this research [15].

Alex Pentland showed that it is possible to obtain impressive information on user's group membership and social relationship characteristics by using statistical and machine learning techniques on user's behaviour and their physical situation. For example, it is possible to find out who a person is working for or who is working for them and whether they are interested in what they are doing or bored. By extending such analysis it is possible to examine user's current behaviour to classify their relationships as workgroup, friends, and their interests and so on [2].

A report presented by Christian Nordqvist shows how mobile phone records have been used in sub-Saharan Africa to help control and eliminate the malaria diseases. Caroline Buckee, a Harvard University epidemiologist and her research team from Kenya and USA have demonstrated how mobile phone records can be used to identify the regions to be targeted in order to control and eliminate malaria related diseases in Kenya. The data used was gathered from 14816521 mobile phone users, and contained their movement over the course of a 12 month period. These users were linked to 11, 920 mobile towers located in 692 different settlements. Each time a subscriber travelled from their location base, the distance travelled and the destination was recorded. This data is then applied to a malaria transmission model that foretells infection risks using mathematical probabilities. This generates a new

map that displays the likely predicted malaria movement between different areas in Kenya. The researchers were able to discover that a large part of malaria in Kenya comes from the Lake Victoria region and spreads eastwards, mainly towards Nairobi, the country's capital [5, 7].

The field of Reality Mining has been explored by many researchers for various social network analysis purposes. In one of the important papers by Xu Yang, Yapeng Wang et al [21] show how data mining techniques can be used for social network analysis. They analysed the MIT Reality Mining dataset to present a classification model that provides a new approach to infer relationship between proximity users (regularly close by) , based on the frequencies of registration to specific cellular tower associated to their place of work. They applied the K-means algorithm for clustering to show that the higher proximity occurs at work for intra-class subjects at MIT.

Similarly, Farrahi, K, Gatica-Perez, D. et al [8] proposed that the proximity data collected by Bluetooth enabled mobile phones can be integrated with human location data obtained from mobile tower connections to gain meaningful details about human activities from large and noisy datasets. In their paper, a multimodal behaviour model was proposed which aims to integrate the modelling of variations of location over multiple time scales, and the modelling of interaction types from proximity.

Another theory proposed by Huiqi Zhang, Dantu, R., Cangussu, and J.W. et al [9] presents a socioscope model for social-network and human-behaviour analysis based on mobile phone call records. Human social behaviour is very much diverse and complex. It is not possible to use a single technique to detect every attribute that arises when humans engage in social behaviour. So, Huiqi Zhang et al proposed to use multiple probability and statistical methods for quantifying such social groups, their relationships, their communication patterns and for detecting human-behaviour change. They suggested a new index to measure the level of reciprocity between users and their communication partners. This reciprocity index has application in homeland security, detection of unwanted calls (e.g., spam), telecommunication presence, and product marketing. The datasets from MIT Reality Mining experiment and University of North Texas (UNT) Network security team dataset were used for validating their experimental results.

Seong Wook Chae, Min Hee Hahn et al. [19] also explored cell phone usage patterns among the MIT students based on the data collected from the Reality Mining research project conducted by Nathan Eagle in 2004. They proposed to derive various Bayesian Network approaches that most strongly affect cell phone usage. They then chose the Bayesian Network with the highest frequency by investigating the classification accuracy of the Bayesian Network family. Later, they analysed cell phone usage through what-if/goal-seeking simulations with the selected Bayesian Network.

3. Applications of Reality Mining

A large number of commercial applications have been already developed using Reality Mining Techniques. The following section of this paper identifies some of these applications.

3.1. Serendipity

Serendipity is a mobile phone application built by Nathan Eagle and his colleagues during the year 2004. This application is a social proximity sensing software that utilizes the Bluetooth of a mobile phone to facilitate interactions between physically proximate people. So, this app helps people to make introductions with others who can benefit them in their work [14].

3.2. Outbreaks of Malaria Infections

Reality Mining could even help predict the course of a disease outbreak and provide clues about individual's health. Caroline Buckee, a Harvard epidemiologist is using detailed data on population movements gathered from mobile phone records to build precise new tools for fighting the spread of malaria [5]. Based on records from 15 million Kenyan phones, this is a result of collaboration with her husband, Nathan Eagle, who has been working to make sense of mobile-phone data for more than a decade. They have developed a new set of predictive models to help control and eliminate malaria [7].

3.3. City Sense

City Sense is a mobile application built by Sense Networks which utilizes GPS and Wi-Fi data to review the overall activity level of a city, top activity hotspots and places with unexpectedly high activity, all in real time which can then be used to make recommendation to people on their interest [18].

3.4. Urban Transport Networks

Analysis of automobile traffic congestion can be one of the simplest examples of Reality Mining. By using built-in GPS system of mobile phones, data is collected from the drivers. This data provides each and every minute updates on traffic movement allowing for more accurate prediction of journey time. This analysis also helps to predict congestion patterns and detect traffic jams before it becomes serious [2].

4. Data Ownership and privacy

Reality Mining experiments have raised lots of arguable privacy issues among people. The idea of collecting large amount of personal information naturally raises many questions about privacy [2]. One of the examples of such issues is the recent news on PRISM, a national security electronic surveillance program operated by the

United States National Security Agency. The program collects communication data on a large scale from people around the world. However, the collection of such data raises a potential threat to an individual's privacy; it may however also offer significant value to individuals and society. PRISM is said to be for the protection of people and communities against terrorism but some question people around the world have different opinions on this [20].

Alex Pentland [2] suggests that anonymous data should be used for data analysis purposes and analysis at group level should be put at a higher priority than the individual level. Development of collaborative and data sharing models should focus on guarding both the privacy of consumers as well as corporation's legitimate competitive interests. To address some of the problems of privacy issues the following measures have been suggested so far.

1. You (an individual) should have the right to possess your data. You should have the right to remove or open your account whenever you like.

2. You should have a full right of control over how your data can be used. If you're not happy with how it is being used, then you should have the option to opt out.

3. You should have the right to distribute your data elsewhere depending on your interest or destroy it completely if you like.

5. Research Project

This research is motivated by the MIT Reality Mining experiment conducted by Nathan Eagle and Alex Pentland during 2004-2005 [16]. This research intends to extend the results of the MIT Reality Mining experiment by applying new machine learning algorithms and statistical methods on the MIT dataset. This dataset has been anonymized and made available to the general academic community for research and experimental purposes and we will examine the performance of machine learning algorithms and novel statistical analysis methods to determine the best performing algorithm or algorithms.

The best performing algorithm(s) will then be applied to an anonymized dataset that has been provided by a telecommunications industry partner of IMaR (Industry Dataset). The objective of this analysis is to search for predictable patterns and infer relationships hidden within the data. Once these patterns and relationships are discovered, it will be possible to develop real-world applications which can be of immense benefit for the telecommunications industries.

5.1. Data collection

The anonymized version of the collected data provided by MIT researchers on the initial Reality Mining Team is undertaken for this research. The dataset can be downloaded from the MIT Media Lab website, http://realitycommons.media.mit.edu.

The Industry Dataset will also be anonymized before it is analysed. The dataset includes SMS logs, call logs, and Location Base Stations (tower IDs). This dataset will be pre-processed to have similar structure and shape to that of MIT dataset before applying the selected machine learning algorithms and statistical methods.

5.2. Techniques

In this research, it is proposed that more advanced algorithms developed within the machine learning tradition such as Artificial Neural Networks, Genetic Algorithms can be applied to the MIT Reality Mining dataset. The purpose of this research is to compare and contrast the performance and improvements in the results achieved using these new approaches versus the techniques used in the MIT Reality Mining experiments. However, it is expected that the algorithms selected as part of this study may need modification or may be combined with each other to achieve the best possible results.

Currently, this research is having difficulty in reproducing the MIT Reality Mining experiment. The users defined in the MIT experiment appear not to tally with the results being produced. It is likely that the anonymized MIT datasets have been further modified to keep the strong state of anonymity or while unlikely the problem may be with the techniques being applied in replicating the MIT experiment. The next step is to use Artificial Neural Networks (ANN) and Genetic Algorithms (GA) as alternative analysis techniques on the MIT Reality Mining dataset. ANN and GA are rapid growing areas of Artificial Intelligence that demonstrate powerful problem solving ability. An Artificial Neural Network is an information processing paradigm that is inspired by the way biological nervous systems process information and is remarkably able to derive meaning from complicated or unclear data that can be used to extract patterns and detect trends that are too complex to be noticed by either human or other computer techniques. ANNs have the capability of learning complex non-linear input/output relationships, using sequential training procedures and adapting themselves to the dataset. Feed Forward Network is one of the most commonly used Neural Networks for pattern classification tasks that includes Multilayer Perceptron (MLP) and Radial-Basis Function (RBF) which this project considers to apply on Reality Mining dataset for pattern recognition purposes. Neural Nets are however slow learners as they have to be trained to output the desired data [3, 11].

Another popular algorithm is Genetic Algorithm which is a search method based on principles of natural selection and the mechanisms of population genetics that can be used to find true or approximate solutions to optimization and search problems. GA is a robust search method requiring little information to search effectively in large or poorly understood search space. This research may also combine both of these algorithms into a hybrid Artificial Intelligence system if necessary to achieve an overall improved performance. Several such hybrid systems have been developed that combine neural networks with genetic algorithms in various ways such as, using GA to determine the structure of neural network; using GA to calculate the weights of a neural network and using GA to determine both structure and the weights of a neural network [6].

Furthermore, the research studies using different computational models by leveraging statistical methods and other machine learning techniques such as Bayesian Networks, Clustering, Shannon entropy etc. to predict and analyse the patterns of human movement and human behaviour.

Bayesian Network is one of the strong machine learning algorithms that can be used to demonstrate how decision can be made under uncertainty. Based on probability theory, a Bayesian Network is composed of nodes, links and a conditional probability table. Bayes rule is applied in the Bayesian Network and states how existing beliefs are modified mathematically with the input of new evidence [19].

Bayesian Neural Networks may also be used as a hybrid system to come up with the probability distribution over the network weights, given the training data. Bayesian methods allow us to consider an entire distribution of results. This approach can be used to address issues such as regularization (over fitting or not) and model selection/comparison without the need for a separate cross validation dataset [1].

5.3. Tools

This research project requires the computational Software "The R project" for statistical computing. R is a software environment for statistical computing and graphics. This software will be used to work on data manipulation, calculation and graphical display. This software includes a large, coherent, integrated collection of intermediate tools for data analysis, graphical facilities for data analysis and a well-developed, simple and effective programming language which includes conditionals, loops, user-defined recursive functions and input/output facilities [17].

In addition, knowledge of MySQL is helpful to do query and fetch required data from the different tables of Reality Mining dataset. MySQL is the world's most popular open source database system that runs on a server.

6. Conclusions

This research touches on a number of embryonic research areas such as Big Data, Deep Learning (Neural Networks) and Reality Mining. The 21st century is being termed the era of so called "Big Data". A large amount of data has been exploding around the world and a large portion of this is being created using mobile devices. These large datasets can be analysed using Artificial Intelligence techniques which will soon become a key basis of commercial competition that will support new waves of productivity, innovation and business models. The vision for big data is that organizations will be able to harness relevant data and use it to make the best decisions which will help organizations to run more efficiently and profitably [10].

This era of Big Data has now led researchers to actively undertake various research on Reality Mining techniques among which this research can be seen as one. The main goal of this research is apply these new techniques to large telecommunication

datasets with a vision to deliver business solutions and commercial benefits to the telecommunication industry.

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Multimodal Biometrics Authentication Framework for Banking Systems

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Abstract

With the deeper penetration of internet in the society and increase in mobile internet user base, banking services are being catered to the users on mobile devices; however security of such services remains a matter of concern for the users as well as for the financial institutions. The authentication system employed by most of the banks across the globe is dependent upon traditional authentication mechanisms like passwords/PIN and OTP, however such an authentication system could be attacked and biometrics technology can play a vital role in providing secured online banking services. This paper presents a multimodal biometric authentication framework for online banking and Automated Teller Machines (ATM). In light of use of multiple biometric features and increase in system complexity due to this, the proposed framework is best suited for high-net worth individuals and corporate account holders. The proposed architecture uses soft biometric features to filter the database of primary biometric features i.e. fingerprints, face and voice. The architecture also has some backup features for many of the biometric traits to help a genuine user in case of false rejections. The proposed multimodal biometric authentication framework overcomes many of the limitations of unimodal biometric system, by improving the performance of the system and restricting fraudulent access.

Keywords

Multimodal Biometrics, Soft Biometrics, Authentication, Banking

1. Introduction

In the ever changing world of technology, the banking and financial services sector has seen a tremendous shift in the way these services are now being catered to retail and corporate customers. Banking and Financial services sector has a profound impact on the society and the economic development of a country and with the deeper penetration of internet and increase in use of electronic devices such as smartphones, PDA, Tablets, etc., banking and financial companies are providing many services over the internet to their customers. Further, with an increase in reach of e-commerce and e-services across the globe, the online banking plays a key role in support and development of businesses over the internet, like online shopping, online trading (auctions), etc. (Lee, 2009).

Online banking is no longer considered a service to gain competitive advantage by the banking and financial services organizations indeed it has now become a standard

requirement in the industry (Yiu et al. 2007). Banking and Financial services industry is promoting online services due to various reasons including but not limited to cost-effectiveness, efficiency in services, providing anytime and anywhere services to customers (Cheng et al. 2006). With the millions of dollars being spent by organizations on online services, the online banking and financial services sector becomes a critical infrastructure for the economy, which needs to be protected from unauthorized access and cyber-attacks because this could lead to deficiency in services provided, leakage of customer data, etc. Thus, despite of all the benefits of online banking, customers are found to be reluctant in using online banking services (Wang et al. 2003b) due to issues of security (Lee, 2009) (Cheng et al. 2006), and financials and time related (Lee, 2009).

There is another factor associated with security and liability issues with services provided to a retail user and to a corporate customer. Banks have to bear the cost of losses from online banking frauds in case of a retail customer; however this is not the case with corporate accounts (CSO Australia Website, 2013). As reported in (CSO Australia Website, 2013), two banking Trojans namely SpyEye and Zeus, broke two-factor authentication mechanism of business accounts in Europe. The attacks broke the authentication of 5000 business accounts across two banks in The Netherlands and since business (corporate) accounts have higher transaction limits there was no suspicion on the transactions from the accounts and these attacks led to transfer of Euro 35 Million to money mules.

An attack on banking and financial institutions not only poses financial risks for the companies and users but it also has reputational risk for the organizations. As quoted in (Williamson, 2006), "E-commerce sites represent a multi-million dollar investment as well as a key revenue generating infrastructure for many businesses, especially those in the financial, retail, online auction and Internet Service Provider (ISP) markets". Thus, when an organization is attacked, the users lose confidence in it and the business of company is lost leading to overall economic losses.

In such a scenario, where security and authentication of users for online banking services is vital for growth and business of banking and financial organizations and for overall economy in turn; the biometric based authentication systems provide a much effective and secure way to provide online banking services.

In this paper, a novel multimodal biometric authentication framework for online banking and ATM systems is proposed and the proposed system would be of immense importance for High Net-worth Individuals and for corporate account holders, where high value transactions are involved..

2. Literature Review

A system using only one biometric trait is known as unimodal biometric system and a system using two or more biometric traits is called as multimodal biometric system. Unimodal systems often have lower recognition rates for various reasons like noise in the captured data, lack of distinctiveness and non-universality of the biometric trait in use. Multimodal biometric system uses information obtained from multiple

sources and is thus considered better than unimodal systems. Multimodal biometric systems can be used to overcome the limitations of unimodal biometric systems. Multimodal systems are considered more reliable due to the use of independent and multiple pieces of information (Kuncheva et al. 2001). Further, the multimodal biometric systems are capable of meeting the stringent performance requirements for high security applications (Jain et al. 2004c). Since, it is extremely difficult to copy multiple traits of a genuine user and as the multimodal biometric system often tests for a "live" user, thus limiting the success of a spoof attack on the system. Therefore, a multimodal system incorporating challenge-response feature is of immense relevance for high security applications.

The information collected from multiple biometric traits for multimodal biometric system needs to be integrated at some stage before a final decision can be taken on the authenticity of the user. The information obtained from two or more biometric features can be combined at three different levels: (a) feature extraction level, (b) matching score level, also known as rank or confidence level, and (c) decision level, also known as abstract level. Noise in raw data is a major problem in fusion at feature level and as this noise gets suppressed at further levels; noise is not a big problem in fusion at matching score and decision level fusion. Also, since the raw biometric data contains more information at feature level, a fusion at this level is expected to yield better results however consolidation and integration of information obtained from different biometric traits is a huge challenge for feature level fusion. As reported in (Ross and Govindarajan, 2005), fusion at features level is difficult for several reasons like the features obtained from multiple traits might not be compatible with each other; for example, minutiae obtained from fingerprints cannot be fused with the eigen-coefficients of features of face. Another difficulty in features level fusion is that the feature spaces of various biometric systems might not be related or the relationship is unknown. Thirdly, fusion of two feature vectors may lead to a larger feature vector leading to the problem of dimensionality and lastly, to operate on fused feature set, a more complex matcher might be required. In such a scenario, fusion at match score or decision level appears to be the only option. Hong et al. (1999) demonstrated an enhancement in accuracy of verification process based on the fusion of multiple biometric traits at confidence and abstract level. A summary of some of the multimodal biometric systems and respective fusion technique is presented in table-1, below:

Author & Year	Biometric Traits	Level of Fusion
Brunelli and Falavigna, 1995	Face and Voice	Match Score
Kittler et al. 1997	Face and Voice	Match Score
Bigun et al. 1997	Face and Voice	Match Score
Hong and Jain, 1998	Face and Finger	Match Score
Ben-Yacoub, 1999	Face and Voice	Match Score
Frischholz and Dieckmann, 2000	Face, Voice and Lip	Match Score
Ross et al., 2001	Face, Hand and Finger	Match Score
Shakhnarovich et al. 2002	Face and Gait	Match Score
Chang et al. 2003	Face and Ear	Feature Level
Wang et al. 2003a	Face and Iris	Match Score
Kumar et al. 2003	Palm and Hand	Match Score, Feature

Kumar and Zhang, 2003	Face and Palm	Match Score
Lu et al. 2003	Face (PCA. LDA, ICA)	Match Score
Ross et al. 2002	Finger (Miniutiae & Texture Features)	Match Score
Kittler and Sadeghi, 2004	RGB Channels for Face	Match Score
Ross and Govindarajan, 2005	RGB Channels for Face	Feature, Match Score
Snelick et al. 2005	Face and Fingerprint	Match Score

Table 1: Some of the Multimodal Biometric Systems in Literature

Most of the primary biometric features are found to perform well on a small database; however for a large user database a multimodal system using several primary biometric features will fail to perform well. Thus, if the ancillary user information can be used to filter the database of primary biometric features then the performance of the system can be significantly improved (Jain et al. 2004a). However, ancillary user information which includes gender, eye color, hair color, ethnicity, weight, height, etc. is not sufficient enough to distinguish users, as these parameters are not distinctive and permanent and are thus called as soft biometric features.

Heckathorn et al. (2001) proved that soft biometric features have limitations in identifying an individual accurately. Thus, a combination of ancillary information such as eye color, race, height, gender and other visible marks such as scars and tattoos are not sufficient enough to recognize an individual; however soft biometric features if used in conjunction with primary biometric features will improve the performance of the primary biometric systems. Soft biometric features when used with primary biometric system can be used for several reasons such as a supplementary feature in existing system, to improve retrievability and to provide retrievability from a partial face image with ancillary features (Jain and Kumar, 2010).

Wayman (1997) proposed filtering of a large database using soft biometric features like gender and age. Jain et al. (2004b) in their experiment used soft biometric features like height, ethnicity and gender together with a primary biometric system based on fingerprint matching and the use of soft biometric feature was found to have improved the performance of primary biometric feature by almost 5%. Jain and Park (2009) demonstrated an enhancement in performance of a face recognition system, using micro-level facial marks such as scars, moles, freckles, etc. Among the various soft biometric features like scars, marks and tattoos (SMT) have been found to provide better discriminative information over features like gender, age, race and height.

Gutta et al. (2000) proposed a method to classify users on the basis of pose of face, ethnicity, and gender. Their method had an average accuracy rate of 96% in classifying users as male or female. Their ethnicity classifier demonstrated an accuracy rate of 92% in classifying users as African, East Asian, South Asian and Caucasian. Shakhnarovich et al. (2002) proposed a demographic classification method; they classified the users on the basis of ethnicity and gender using the faces from unconstrained video sequences. Their model classified the users as either Asian

or non-Asian. Balci and Atalay (2002) proposed a gender classification mechanism where they used PCA for extraction of features and the classification was based on multi-layer perceptron and their model had an accuracy of over 86%. Buchann et al. (1996) studied the chemical composition of fingerprints of adults and children and they proposed to use this difference in chemical composition of fingerprint to classify users as adults and children. Kwon and lobo (1994) developed an algorithm to classify users based on their age and they classified users as "babies", "young adults" or "senior adults", based on facial images. They used cranio-facial changes in feature positive ratios and skin wrinkle analysis, for the purpose.

Jain et al. (2004b) proposed a framework to integrate soft biometric features with the output of the primary biometric system. They used soft biometric features, namely gender, height and ethnicity, in conjunction with fingerprint biometric systems and they reported very promising results for the system. As reported in (Jain et al. 2004b), computational requirements for soft biometrics are not expensive and the soft biometric features can be sensed at a distance and in a crowded environment, that too without requiring the cooperation of the user. These soft biometric features are extremely useful in filtering the search for a primary biometric feature. Dantcheva (2010) developed a tool to reduce the complexity associated with reliability of authentication systems. To achieve this, they used simple and robust biometric features, such as eye color, hair color and skin color along with the identification of presence of beard, glasses and moustaches.

3. Proposed Architecture

In the proposed model, when the user inserts his/her ATM card in the ATM or enters his/her User ID for online banking, after recognizing the card/user-id the user is prompted to provide his/her soft-biometric features. For the user at ATM kiosk his/her picture is taken through an integrated camera of the machine and for an user who wants to use his/her online banking account through his/her computer or handheld smart device s/he is asked to input his/her facial image through the camera integrated with the user device. The image is then pre-processed at the user end (at ATM/Smart Device) and then it is sent to the server in an encrypted form. At the server end the user provided image is processed for feature extraction and the results are matched against the server database. Soft biometrics features like Gender, Ethnicity, Age, Color of Eye, Scars and Marks, are used for the identification of the user and to filter the database of primary biometric features like fingerprint, face and voice. These particular soft-biometric features can easily be extracted from image taken from camera of handheld devices and thus the user has flexibility of full mobility. Commercially available 'OKAO Vision' product of OMRON Global provides processing, feature extraction and face matching and recognition service on machines and smart hand-held devices (Omron Website, 2013). Another commercially available product BioID is available as an API which can be integrated with other systems to verify the users based on their voice, lip motion and facial features (Frischholz and Dieckmann, 2000).

If the user identification through soft-biometrics fails then an alpha-numeric OTP is generated at the server and is send to the user as SMS to his/her registered mobile

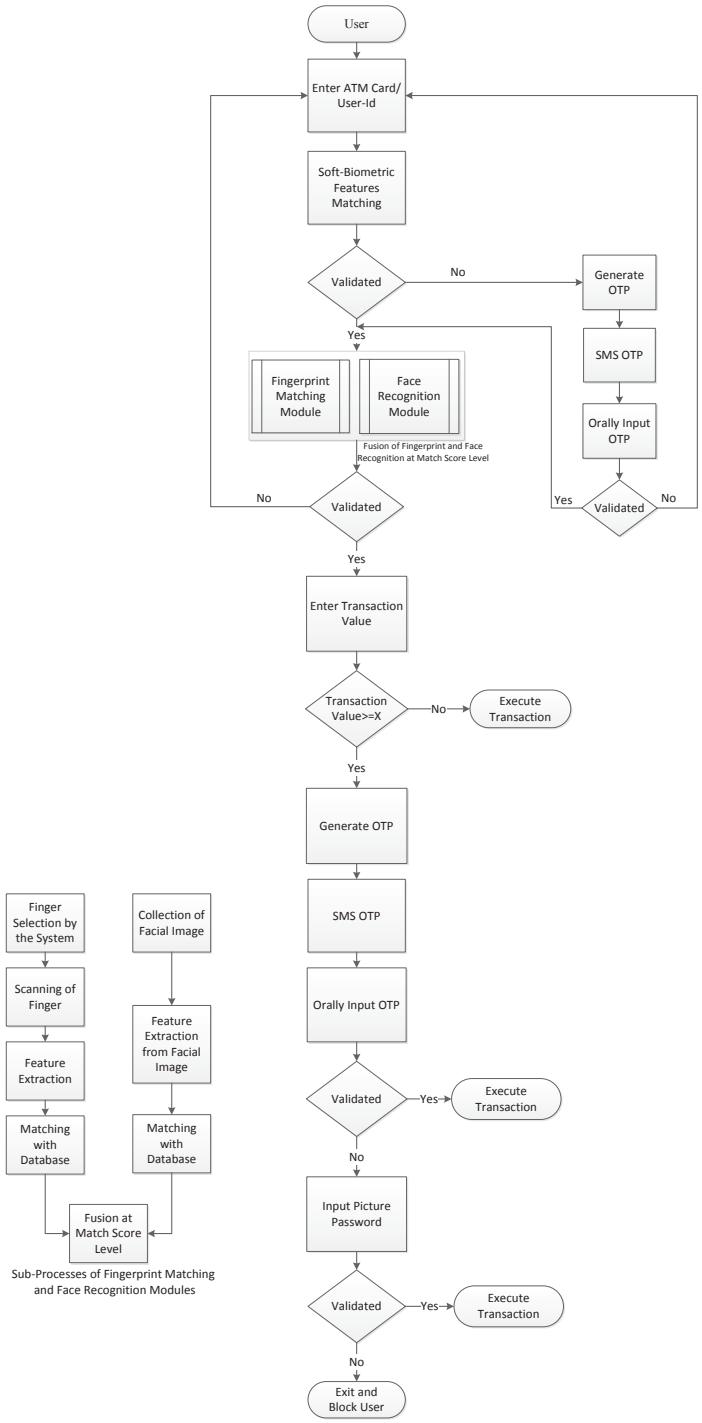

Fig-1: Proposed Multimodal Biometric Authentication Framework

number. The OTP is valid for three minutes, within which the user has to input the OTP through his/her mobile by reading it out (oral input) and the input is then verified for the correctness of OTP and the recognition of voice of the user. The voice of the user is pre-processed at the client side and then the encrypted pre-processed template is sent to server for feature extraction and recognition. The result of matching of input against the database at server side is sent to the client in an encrypted form. If the user is verified then the system takes him/her to the next stage else the user has to start the whole verification process. After the failure of three consecutive attempts to identify the user, the account is blocked for next twenty-four hours. This OTP facility is included in the system to avoid any inconvenience to a genuine user due to failure of identification through soft-biometric parameters, which could happen for several reasons.

In the next step the user enters his/her fingerprint through an integrated sensor on ATM/Handheld device. An external USB based fingerprint sensor can be used for client device if the client device has no integrated fingerprint sensor. Also, for every new session the system randomly selects a finger and asks the user to provide print of that particular finger. The fingerprint image is pre-processed at the client side before being sent to server in encrypted form for feature extraction. The facial features which will be matched at this stage are overall facial structure, distance between eyes, nose, mouth, and jaw edges and these features are extracted from the image which was taken for the extraction of soft-biometric features. The system follows a match score level method for the fusion of face and fingerprint modules; this is because in practice it is extremely difficult to integrate eigen-coefficients of face with minutiae sets of fingerprints at the feature extraction level (Ross and Govindarajan, 2005).

The result obtained from fusion module is sent to the decision module and the output from decision module is sent to client device in an encrypted form. If the verification is successful, the user is asked to enter the transaction amount else the user is asked to start the whole process again. After three consecutive attempts, if the user fails to authenticate him/her-self then the session is aborted and the account is blocked for twenty four hours. Higher value transactions are provided an additional level of security check. If the transaction value is less than ‘X amount’, a predefined value set by user or the bank, then the transaction is executed else an alpha-numeric OTP is generated at server and sent to user through SMS on his/her registered mobile number and then the user inputs the OTP in verbal form through his/her mobile and the OTP and voice of user is verified before permitting the transaction and if the OTP verification process fails then the user is taken to an option of approving the transaction by providing an image-based password else the session is aborted.

4. Conclusion

The proposed method overcomes the limitations of unimodal biometric systems and many multimodal biometric methods. If the user identification from soft-biometric features fails then the user can be identified via OTP input. However, if the soft biometric based identification fails and the user has cold or due to some other reason the OTP process also fails then the user will be unable to get into the system. If the

user has an injury in one finger then the user can be authenticated via another finger. Also, due to the involvement of multiple biometric features in the authentication process, the complexity of the proposed model will be high. Therefore, the system is less suited for retail users but for corporate users. Further, due to multiple biometric features in the proposed model there will be some ethical, privacy and legal concerns on the management and security of biometric data.

5. Future Direction of Research

The proposed framework has been conceptualized based on the results reported in various studies of biometric features and authentication systems for features like soft biometrics, fingerprints, face and voice. Thus, there is a need to evaluate the performance of the proposed framework on a large database to find out the various parameters like system complexity, cost of implementation, cost of per user authentication, false acceptance rate, false rejection rate, etc. which are key factors behind a decision to adopt an authentication model.

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Continuous Authentication using Behavioural Biometrics

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Abstract

In this paper, we will present a multimodal architecture for continuous authentication using behavioural biometrics. We will point out common shortcomings in current research on continuous authentication and present a model where the system changes the trust in the genuineness of the current user with every action this user makes. We use a multimodal architecture to ensure both performance optimizations as well as providing a higher security due to the increased difficulty for spoofing multiple behavioural biometrics simultaneously.

Keywords

Continuous Authentication, Behavioural Biometrics, Multimodal Biometrics, Keystroke Dynamics, Mouse Dynamics, Software Interaction

1. Introduction

Almost every aspect of the human life computer system and networks has become an important gadget. Now these days communication services, aviation and financial services, has been controlled by computer systems. People entrust vital information to these systems, such as medical and criminal records, financial transactions, and personal emails. However, this increasing dependency on computer systems coupled with a growing emphasis on global accessibility in cyberspace, has unveiled new threats to computer system security (Eltahir *et al.* 2008). In addition, crimes and impostors in the cyberspace appear almost everywhere. Crimes on the computer networks may cause serious damages, including communication blocking, perusal of classified files, and commerce information destruction (Lin, 1997).

Attacks on a computer system can happen on the network level, system level or user level or any combination of these three levels. Network-level attacks include network denial of service and probing. System-level attacks include privilege escalation, such as buffer overflow, program modification, perhaps caused by a Trojan horse or virus, and denial of service (Al Solami *et al.* 2010). User-level attacks include masquerade and imposter attacks. *In our research, we are mainly concentrating on user level attack that is masquerade attacks or imposter attacks.*

For most existing computer systems, once the user identity has been verified at login, the system resources are available to the user until the user exits the system or the session will be locked. This may be appropriate for low-security environments, but can lead to session hijacking in which an attacker targets a post-authenticated session. In high risk environments or where the cost of unauthorized use of a computer is high, continuous verification or authentication of the user is extremely important. A Continuous Biometric Authentication Schemes (CBAS) was built with the biometric data supplied by a user's behavioural characteristics and it continuously checks the identity of the user throughout the session. However, a single biometric may be inadequate for passive verification either because of noise in the data sample, unavailability of a sample at a given time or the uniqueness issues of that biometric modality. To overcome this limitation, researchers have proposed the use of multiple biometric modalities and have demonstrated increased accuracy of verification (Jain *et al.* 2004). *In our research, we are going to integrate three different behavioural biometric modalities (Keystroke dynamics, Mouse Dynamics, Software Interaction) with their different characteristics in a multimodal architecture to offer the user level passive continuous authentication.*

Application areas of Continuous Authentication: Continuous Authentication can be applied in any environment where unauthorized access is highly unwanted or potentially dangerous. Some examples are: Online banking; E-learning and online exams; Defence computer control system; Computers for airline cockpit and marine controls; Cyber-criminal profiling; Mobile devices (smart phones and tablet PC).

The remainder of this paper will be as follows. In Section 2, we will discuss some background knowledge for better understand this paper. We will discuss the state of the art techniques in Section 3. Section 4 will discuss our proposed scheme and ideas on continuous authentication. Finally, we will conclude this paper with future work in Section 5.

2. Background Knowledge

In this section, we will briefly describe some background material which is required for a better understanding of this research area.
In computer security domain, there are two types of systems that can enable the link to a person and his/her identity:

a. ***Identity Identification:*** When the system establishes the identity of a subject (i.e. without any prior claim of identity);
b. ***Identity Authentication (or Verification):*** When the user claims an identity and the system accept (or declines) this claim. Authentication can be further divided into two groups:
   i) ***Static Authentication:*** The system will authenticate the user only one time that is at the start of a session;
   ii) ***Continuous (or Active) Authentication:*** The system will monitor the user throughout a full session to detect any change of identity within that session.

In any secure system the Authentication or Identification can be done with any one of

the factors given below or any combination of these factors. These factors are:

i) ***A knowledge factor ("Something the user knows"):*** like password, passphrase, PIN code or the answer of a number of security questions;

ii) ***A possession factor ("Something the user owns"):*** like smart card, SIM card, phone, security token, software token or navigator cookie.

iii) ***An inherence factor ("Something the user is"):*** This refers to biometric systems. The definition of biometrics is "Application of statistical analysis to biological data", according to the online Oxford Dictionary (http://oxforddictionaries.com/). There are two types of biometrics:

- ***Biological Biometrics:*** People are recognized through their physical characteristics, like face, fingerprint, palm print, retina, iris, hand or finger vein, or ear. (Jain *et al.* 2004).
- ***Behavioural Biometrics:*** People are recognized through tasks performed in a standard manner, like gait, keystroke or mouse dynamics, signature, or voice. (Yampolskiy *et al.* 2008).

There are some standard measures to describe the performance of a biometric system. The probability that an impostor user is falsely accepted into the system is called *False Acceptance Rate (FAR)*. On the other side, the probability that a genuine user is falsely rejected by the system is termed *False Rejection Rate (FRR)*. Both these error rates depend on some system settings, and if these settings are chosen such that the FAR equals the FRR, then this error rate is defined as the *Equal Error Rate (EER)* (Mansfield *et al.* 2002).

2.1. Keystroke Dynamics

In Keystroke Dynamics (KD), users are identified or authenticated based on the way they type on a keyboard. When a password is typed not only the correctness of the password itself is checked, but also if the typing rhythm when entering the password is correct. This process is called password hardening. The use of KD as a method of identification is not new. During the early days, the telegraph operators were able to identify each other by their *Morse code* typing pattern. This identification method, known as "The Fist of the Sender", was used as a verification or identification method during World War II. Nowadays software is available for password hardening, for example, the software from *BioPassword* (see http://www.biopassword.com).

A KD based authentication or identification system is a low cost and easy to implement security solution because, this system is software based. In such a system, the keystroke timing information has to be captured, and features for authentication or identification are extracted.

Features for Keystroke Dynamics: The raw data that are captured in KD is the timing information on when a key is pressed down and when it is released. Features for identification or authentication are calculated from this raw timing information. A limited number of features are used for Keystroke Dynamics (Karnana *et al.* 2011):

1) *Key Code:* Key code is the ASCII code that represents each key on a keyboard.
2) *Down-Up (DU) Time:* The DU time is defined as the time interval between a key

remains pressed. This is also referred to as the duration of that key press.

3) *Up-Down (UD) Time:* The UD time is the time between releasing one key and pressing the next key. This feature is also referred to as the keystroke latency between two keys. The latency value is generally positive, but it can be negative. In case the next key is pressed already before the previous key was released, then the latency is negative. This can happen if the user types very fast, or if he uses special keys, like the shift key.
4) *Down-Down (DD) Time:* The DD time is often used as an alternative for the UD time because it is always positive. The DD time is the elapsed time between pressing one key and pressing the next key.

2.2. Mouse Dynamics

Mouse Dynamics (MD) has been defined as the way users are interacting with their system through the mouse. Similar to KD, MD does not require any special hardware for data capture. From 2003, the MD has become an interesting topic in the area of behavioural biometrics due to its non-intrusiveness and convenience (Gamboa *et al.* 2004).

For MD based biometric authentication, we need to capture the mouse interaction data for users while interacting with their system. The primary assumption of MD is that every mouse user has some unique mouse usage patterns which are different from other users. According to the literature (Gamboa *et al.* 2004) the MD features can be divided into two parts:

a) ***Schematic features:*** These features characterize the constituents of mouse actions during GUI interactions such as the statistical distribution of mouse action types or mouse pointer positions. There are five different schematic features we can generate from the raw data, i.e.:

1) Histogram statistics of occurrences of various mouse action types;
2) Percentage of idle time of a mouse;
3) Distribution of cursor positions on the screen;
4) Distribution of movement distances/directions;
5) Histograms of individual mouse actions (Feher *et al.* 2012).

b) ***Motor-skill features:*** These features characterize the efficiency, agility and motion habits of individual mouse actions such as the acceleration pattern or the speed of a double click. There are five relevant motor-skill features, i.e.:

1) Elapsed time of a single click;
2) Elapsed time of a double click;
3) Average movement speed for 8 different directions;
4) Average movement speed and acceleration relative to travelled distance;
5) Transition time between consecutive mouse actions.

2.3. Software Interaction

Software Interaction (SI) is a relatively new behavioural biometric modality, where users can be authenticated based on how they interact with particular software. As an example, there are many ways in which a document can be printed in Microsoft Word. Some people will use the mouse to click on the *File* menu and then on the *Print* option. Others might use the keyboard by pressing *Ctrl*+P. Another option would be to use the keyboard to the first type *Alt*+F, to activate the *File* menu and then type P to select the *Print* option. Users will generally exhibit a single of a very limited number of ways to perform this particular task.

Research in SI was started when Vel *et al.* 2001 propose an idea to identify the user based on their e-mail message. They considered amongst others particular use of greeting, farewell acknowledgment, signature, and position of re-quoted text within the message body. Research on SI based user identification or authentication has been done in four different areas (Yampolskiy *et al.* 2008):

1. ***E-mail behaviour:*** A user can be identified based on their email sending behaviour. (Vel *et al.* 2001 and Stolfo *et al.* 2003);
2. ***Game strategy:*** Users are identified based on their game playing style;
3. ***GUI interaction:*** Graphical User Interface (GUI) interaction based data is used to model the user behaviour;
4. ***Web browser interaction:*** Different types of web browser interaction are used for user identification and authentication.

2.4. Multimodal Biometrics

Most biometric systems deployed in real-world applications are unimodal. Such systems deal with the evidence of a single source of biometric information for identification and authentication. These systems have a variety of problems such as (a) noise in the sensed data; (b) intra-class variations; (c) inter-class similarities; (d) non-universality; and (e) spoof attacks (Ross *et al.* 2004).

Some limitations of a unimodal biometric system can be overcome by including multiple sources of biometric information. Such systems are called Multimodal Biometric systems. These systems are expected to be more reliable due to the fusion of multiple independent pieces of evidence or information than the conventional unimodal biometric systems (Kuncheva *et al.* 2000).

A biometric based user identification and authentication system has to be a pattern recognition system that performs four tasks: (a) data capture; (b) extract features; (c) match the extracted features with a reference template stored in a database, and (d) decide, based on the quality of the match, to accept or reject the user. With multimodal biometric system, information fusion can be possible in any of these four stages.

A variety of factors should be considered when designing a multimodal biometric system. These includes, (a) choice and number of biometric traits; (b) the level in the biometric system at which information provided by multiple traits should be fused;

(c) the method to fuse the information; and (d) the cost versus matching performance trade off (Kuncheva *et al.* 2000).

3. State of the Art

In this section, we will discuss some of the previous research conducted in continuous authentication with or without multimodal behavioural biometrics. Montalvao Filho *et al.* 2006 showed user identity verification through fusion of features from KD and speech. They collected data of 10 users in a lab environment. They have achieved a 5% EER with their best techniques.

Traore *et al.* 2012 combined MD and KD data in a multimodal architecture for web interaction based continuous authentication. They have tested their system with 24 users and achieved an EER of 8.21%. Muncaster *et al.* 2006 fused KD with face biometric data for continuous authentication in a multimodal architecture. They used score level and decision level fusion in their research. They only used a small dataset with 10 users. One of the possible limitations of this work is that face recognition biometrics requires a working environment that should be very controlled. Furthermore is the analysis of faces for recognition purposes a computationally complex issue.

Bours, 2012 proposed a new scheme, called trust model, for the analysis of a continuous authentication system. He used duration and latency as a feature for continuous authentication using KD. A distance based classifier was employed as a classification tool. This research showed that it was possible to detect an imposter with, on average, 182 keystrokes. On the other hand were genuine users have never locked out of the system given the settings used in the analysis. In this research, the data of 25 users (20 male and 5 female) were used. The analysis method of Bours has been slightly adapted by BehavioSec (http://www.behaviosec.com). In their research related to the DARPA Active Authentication project (DARPA Active Authentication, 2012). The method is simple in terms of implementation and computational cost, and it works well in continuous authentication systems.

Mondal *et al.* 2013 used a publically available mouse dynamics data and evaluated the performance of 6 different machine learning algorithms (Bishop, 2006) using a modified version of the trust model (Bours, 2012). This dataset contains MD data of 49 users (Nakkabi *et al.* 2010), and it was shown that on average 94 mouse events were required to detect an imposter. In the analysis the settings were chosen in such a way that a genuine user was never identified as an impostor, so a genuine user would never being locked out by this system.

3.1 Flaws in Current Research

During the literature survey, we have found that most of the research literature reported the results in terms of FAR and FRR or in terms of EER. Therefore, the performance of the systems was analysed over a fixed number of events or even over the data of the whole session. This implies that the results do not represent the per-

formance in continuous authentication, but at best represent periodic authentication. Also, we have found in some literature, that the behavioural biometrics data was collected from a limited set of applications, e.g. only web browsers, or Microsoft Word.

In our research, we are going to solve these problems by verifying the genuineness of the user for each and every event that occurs on the computer. We do not limit ourselves to a particular set of applications but consider all activities done by the user on his system. We will not report the performance in terms of EER or FAR and FRR, but in the average number of actions that a user can do before the system decides that it is not the genuine user. For more details on this see Section 4.2.

A continuous authentication system should satisfy the following properties:

- *Security:* Detect an imposter user as fast as possible. This means that the number of actions of an impostor before detection should be as low as possible;
- *User-friendliness:* Never, or very infrequently, lock out a genuine user. This means that the number of actions of a genuine user should be as high as possible before he/she is incorrectly locked out.

4. Proposed Scheme

Based on the literature survey, we propose a continuous authentication system using three behavioural biometric modalities named Keystroke Dynamics (KD), Mouse Dynamics (MD) and Software Interaction (SI) in a multimodal architecture to overcome the drawbacks of current continuous authentication systems. The questions we have to answer for this new system are:

- What is the motivation to choose behavioural biometrics?
  - In our research, we are going to use three behavioural biometric modalities i.e. KD, MD, and SI. These three modalities do not require any special hardware to capture the user data;
  - We expect that these modalities do not computationally complex compared to other biological biometric modalities;
  - We can collect user data without interrupting the regular working activity of the user.

- Why these three biometric modalities?
  - As we know, mouse and keyboard are the most common input devices for computers. We used both KD and MD to avoid the situation where an attacker avoids detection by restricting to one input device because the continuous authentication system only checks the other input device;
  - SI could be used to improve the system performance, although an attacker can able to mimic the behaviour of a victim if he/she had the chance to observe the victim in their daily activity.

- What is the motivation to choose a multimodal architecture?

- Multimodal architecture was chosen to improve the overall system performance and to overcome some of the drawbacks found in behavioural biometrics and in the state of the art research on continuous authentication;
- It is very difficult to spoof more than one behavioural biometric modality simultaneously.

4.1 Methodology

Figure 1 shows a simplified representation of the comparator module of our system. We will use different comparators for the different biometric modalities used in this research. The comparator matching score is forwarded to the fusion unit, and the fused information goes to the upper layer, where the trust module decides if the user can continue his/her activity or if he/she will be locked out from the system.

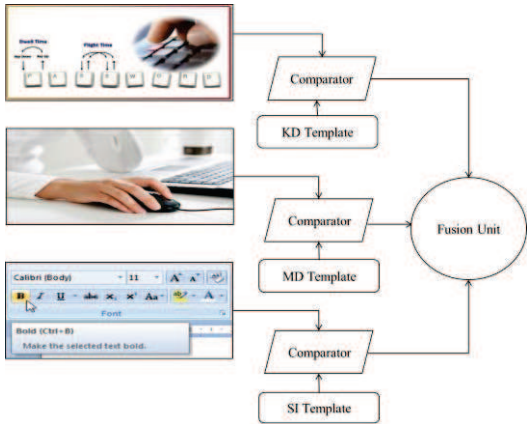

Figure 1: Comparator Module.

4.2 Performance Measure

In the testing phase, the performance of the system can be measured in terms of the average number of actions that can be performed by the users. To be precise, we will report the *Average Number of Genuine Actions (ANGA)* and the *Average Number of Impostor Actions (ANIA)*. This is done by counting the number of test data samples of the genuine or an impostor user that can be used in the trust model (Bours, 2012 and Mondal *et al.* 2013) before a user is locked out. A user will start a session at the trust value C=100, representing full (or 100%) trust in the genuineness of the user. In case, a data sample corresponds to what is expected according to the template of the genuine user, then the trust level will go up (with a maximum of 100); while in the other case, the trust level will go down. Generally speaking, most of the data samples of a genuine user will lead to an increase of the trust level, but some data samples will lead to a decrease of the trust level. Overall the trust level will stay a high value for a genuine user. For an impostor, this will be the opposite. Most data samples will

lead to a decrease of the trust level while some will increase the trust level. This means that the trust level of an impostor will generally drop to a low value.

Once the trust value drops below a system threshold value, then the user will be locked out of the system. In a real system, this would mean that the user needs to log on to the system again. When measuring the performance of the system we count the number of actions that were performed before the lockout and then continue with trust level C=100 again. This represents a successful log on after the lockout. The average number of actions an impostor can do before being locked out will be the ANIA value while the average number of actions for the genuine user will be denoted by ANGA. The goal of any continuous authentication system is obviously to have ANGA as high as possible (in fact we try to set the system threshold such that a genuine user is never locked out) while, at the same time the ANIA value must be as low as possible. The last is obviously to assure that an impostor user can do as little as possible; hence he/she is detected as quickly as possible.

5. Conclusion

In this paper, we have given an overview of continuous authentication. We have described new multimodal behavioural biometrics architecture for continuous authentication. In this architecture, the concept of the trust model is going to be used to detect the genuineness of the claimed user. Furthermore, the way to do a performance analysis for continuous authentication was described. The concepts of ANGA (Average Number of Genuine Actions) and ANIA (Average Number of Impostor Actions) were used to express the performance of the system. The reason to use ANGA and ANAI instead of what is commonly seen in literature, FAR and FRR, or EER, is that it is necessary to know how many actions a genuine user can do and how few actions an impostor can do before being locked out. This information is much more significant than the mere fact that an impostor is detected.

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The Impact Of Government Policy On Economic Growth

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Abstract

Government policy has always had a significant influence on economic growth and new business formation. During the past two decades, policy uncertainty has grown in the United States as the polarization of the electorate has intensified. The stark political differences are increasingly on display by elected officials in Washington. The recent political brinksmanship surrounding the so-called "Fiscal Cliff" is one example of the costly policy uncertainty facing U.S. businesses that is now endemic in Washington. While much of the focus of the Fiscal Cliff debate was on the constituents who would lose benefits or see their taxes increase, there was less attention to the debilitating impact of poorly fashioned policies, and policy uncertainty, on the nation's businesses and the impact on the economy. Those issues were most significant for small businesses and entrepreneurship, which account for more than fifty percent of U.S. private sector economic activity. Through a review of the literature, this paper examined the consequences of government policy uncertainly and sought to identify gaps in the related literature, especially those arising from the application of new policy tools. The research found that contemporaneous monetary policy may be having a greater impact upon business activity than previously identified and is an area in need of further study. While the policy uncertainty and its impact on business expansion discussed in this paper are principally associated with the U.S., the implications can be readily applied across borders. The results of this analysis will be helpful in enhancing the understanding of these important policy issues, which are commonly excluded from policy debate and often given insufficient treatment in post secondary institutions of management practice.

Keywords

Policy uncertainty, Economic growth, Entrepreneurship, Quantitative easing

1. Introduction

Conditions of uncertainty have always been a part of the economic environment of free enterprise. Entrepreneurs and business strategists commonly seek opportunity in that arena. In the past two decades, however, policy uncertainty has risen to a level that makes forward economic planning and the search for opportunity more inscrutable for even the most adept in business challenges. In both United States and the European Union, the lack of new business formation, partly attributable to rising uncertainty, has contributed to stubbornly high levels of unemployment and underemployment.

The jobs that are being created in the U.S. are typically not of the quality of past economic recoveries, leaving many newly-employed workers in the unenviable position of remaining on various modes of government assistance, even after acquiring their new employment. As reported by Rampell (2012), "lower-wage occupations, with median hourly wages of $7.69 to $13.83, accounted for 21% of job losses during the retraction. Since employment started expanding, they have accounted for 58% of all job growth."

The policy uncertainty and related decline in small business startups is taking a toll not only on the traditional lower wage occupations, but on college graduates as well. According to Sum (2013) of the Center for Labor Market Studies at Northeastern University, 36% of college graduates were working in jobs that did not require a college degree (Figure 1). That rate was less than 28% in the year 2000. Such underemployment can impact future earnings, as college skills dwindle. It also increases the difficulty for them to pay their student loans, purchase a home, or become married, since their wages are typically 40% below their peers working in traditional college graduate careers (Luhby, 2013).

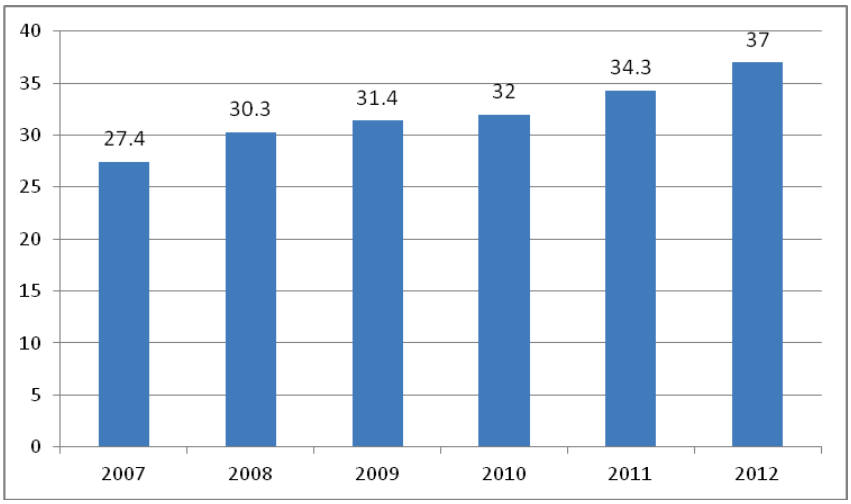

Figure 1. Recent College Graduate Underemployment Rate (%) – (Source: Northeastern University – Center for Labor Market Studies, 2013)

In addition to the lower skills and wages in many of the post 2008 recession jobs, uncertainty has contributed to a significant increase in the number of temporary employees. In "Is the U.S. Turning into a Nation of Temps," Fastenberg (2013) notes that the "hiring rate of temp workers is five times that of hiring overall in the past year… and the number of temp workers has been rising steadily since the recession-impacted year of 2009.

Supporting Fastenberg's research, Dhanya and Wohl (2013) reported that the largest retailer in the U.S. has embarked upon a strategy has in recent months been only hiring temporary workers at many of its U.S. stores, the first time the world's largest retailer has done so outside of the holiday shopping season. Internally, Wal-Mart calls these temporary employees flexible associates. According to Fastenberg (2013), the number of part-time workers at Wal-Mart has risen from just 1% of its 1.3 million employee workforce to 10% in just one year. Given the employer's size, that has had a chilling impact on the already tepid market for full-time employment, and the trend has been adopted by many other large employers as well.

These difficult economic conditions have contributed to a decline in middle-class aspirations in America. While the question of policy uncertainty has received broad study, it is likely that the new and artful strategies of important policy making institutions, such as the U.S. Federal Reserve, have produced gaps in the literature.

This paper will review the work of researchers in this area, seek to identify gaps, and attempt to find new methods for understanding the implications of rising policy uncertainty. The paper focuses on the negative implications of policy uncertainty due to the current climate of lethargic GDP and job growth, while recognizing that there are positive components of uncertainty that many businesses have and will continue to successfully exploit (Sawyerr *et al.*, 2003).

2. Prior research on policy uncertainty

The most recent and robust study on the implications of government policy uncertainty for the U.S. economy was conducted by Baker *et al*. (2013) in their seminal *Measuring Policy Uncertainty*. The authors found that businesses delay investment and hiring in times of uncertainty. The authors identified several factors that were influencing the uncertainty, including debt and spending problems associated with the so-called "Fiscal Cliff" that was looming in Washington, the continuing problems in Europe, and the lingering impact of the housing crisis.

The authors created an index of policy uncertainty through an intensive study that sampled 5,000 newspaper articles to assess whether they actually discuss policy uncertainty. They also compared the index against the frequency of the word "uncertainty" in the Federal Open Market Committee (FOMC) Beige Book. They also analyzed stock market movement that was initiated by policy news (Baker *et al*., 2013).

The authors concluded that, in times of high uncertainty, businesses delay investment and hiring. They determined that the rise in uncertainty from 2006 to 2011 cut employment by as many as 2.3 million jobs and industrial production by up to 4%. They found that taxes, government spending, and fiscal policy accounted for 40% of policy-related economic uncertainty in the period from 1985 to 2011percent. Monetary policy accounted for 33% of that diminution (Baker *et al*, 2013).

Following the research of Baker *et al*. (2013), Gulen and Mihai (2013) investigated how corporate capital investment at the firm and industry level is affected by policy uncertainly. Their research found that policy related uncertainty is negatively related to firm and industry level investment, and the economic effect is substantial. They found that approximately two thirds of the 32% drop in corporate investments observed during the 2007-2009 crisis period can be attributed to policy related uncertainty.

Interestingly, they also found the relation between policy uncertainty and capital investment is not uniform in the cross-section of U.S. firms. It is significantly stronger for firms with a higher degree of investment irreversibility, for firms that are more financially constrained, and for firms operating in less competitive industries. Policy uncertainty is also associated with higher cash holdings and lower net debt issuance. They noted that "overall, these results lend empirical support to the notion that policy-related uncertainty can depress economic growth through a decrease in corporate investment. This decrease is related to precautionary delays induced by investment irreversibility and to increases in the cost of external borrowing" (Gulen and Mihai, 2013). Their research added an important component to the topic, by quantifying the drop in corporate investment related to policy uncertainty. Further, they found

that these basic effects maintained their relationship cross border, specifically citing countries such as Canada, the United Kingdom, France, Germany, and Italy.

In his paper *Economic policy uncertainty in the U.S. and Europe: A cointegration test*, Sum (2012) also examines policy uncertainty in and its trans border applicability. Sum concludes that heightened policy uncertainty in a major nation can have a direct or indirect effect on the world economy. His study focused on the relationship between economic policy uncertainty between the United States and Europe. The results reveal a long-run equilibrium relationship (cointegration) in economic policy uncertainty between the United States and Europe. Sum indicated that the results "provide evidence of the interconnectedness of economic conditions between the United State and Europe in line with the international transmission and spill-over literature" (2012).

Johannsen (2012), in *When are the effects of fiscal policy uncertainty large?,* found that uncertainty about short-run and long-run fiscal policy can cause large falls in consumption, investment, and output, and have depressed economies across the globe. He also noted that the fiscal impact on the economy is small when the monetary authority is not constrained by the zero lower bound (ZLB). He presents empirical evidence indicating that shocks to policy uncertainty had larger effects on the U.S. economy during the Great Recession, a period in which the Federal Reserve's policy rate has been at its effective lower bound, than in the preceding years. Johannsen postulates that relatively high real interest rate continue to encourage households to forego consumption in order to save, which decreases demand and causes the economy to contract. Importantly, his work concluded prior to the launch of the Fed's massive and unlimited $85 billion per month program of quantitative easing known as "QE3."

Giertz and Feldman (2012), in *The Economic Costs of Tax Policy Uncertainty: Implications for Fundamental Tax Reform*, argue that uncertainty fosters rent-seeking, which represents a shift between productive and unproductive or destructive entrepreneurship. They found that "with little policy uncertainty, higher returns may be sought from investing in productive activities. However, when government is receptive to policy changes, the returns from rent-seeking (through lobbying, political action committees, etc.) may be more appealing. When policy uncertainty does not otherwise exist, politicians sometimes manufacture it."

They concluded that enduring reform of the tax code would produce efficiency and higher productivity, with the effects widely distributed. However, as they noted, that wide distribution of benefits creates an environment among policy makers that becomes ripe for "carve outs" by influence-seeking lobbyists willing to pay rent to effect their goals. Giertz and Feldman (2012) agreed that societies relying heavily on "institutions that reward rent-seeking tend to stagnate; societies that rely on institutions whose wealth is achieved through private competitive markets tend to prosper."

Dunkelberg (2013), chief economist for the National Federation of Independent Business (NFIB) noted the counterproductive implications of Fed policy, stating that "uncertainty probably increases with the size of the Fed's portfolio. He hypothesized that Fed policies made no contribution to the improvement of the economy, or even slowed it down, by creating uncertainty and fear among investors. Dunkelberg, in the NFIB's April 2013 "Small business economic trends" indicated that over 60% of small business owners, a record number, had no interest in further borrowing because the funds did not have a high probability of generating a return. With more than 50% of jobs in the U.S. created by small businesses and entrepreneurs, Dunkelberg's findings cast a sobering view of the stimulative impact of the Fed's quantitative easing programs.

3. The impact of quantitative easing

A review of the seminal work for Baker *et al*. (2013), *Measuring Policy Uncertainty*, demonstrated the exhaustive efforts of those authors in identifying indications of public policy uncertainty in the public domain. The authors distinguished between the level of policy uncertainty derived from fiscal issues and monetary issues. They concluded that, between 1985 and 2011, taxes, government spending, and fiscal policy accounting for about 40 percent of the policy uncertainty, with 33% precipitated by Fed policy. They determined that the uncertainty led to a postponement of business investment in hiring.

While this author found it unnecessary to further examine their rigorous work surrounding fiscal policy, it was apparent that the authors' work concluded prior to the imposition the largest tranche of the Fed's quantitative easing, known as "QE3." Further, it appeared that the authors' method of analysis might not fully capture the policy uncertainty implications of any of the Fed's quantitative easing programs, given that media articles reporting on the QE programs would focus on the enhancement in economic prospects to flow from the programs, rather than policy uncertainty. That is especially true with the Fed's latest, and, by far, the most robust program of QE3, which provides for a continuing flow of $85 billion per month as long as the Fed determines that the economy is sufficiently weak. Thus, media articles following QE3 would, once again, focus on the certainty, or predictability, of Fed policy, which would have likely lowered the authors' 33% calculation. That reduction in the robustness of the monetary component would have given the Fed a higher level of policy credence than warranted, a theory supported by the data reported by Dunkelberg (2013).

In the research by Dunkelberg of the NFIB, businesses surely look at a different policy scenario when contemplating the later, more voluminous states of quantitative easing, such as at QE3. First, the massive amounts of monetary intervention by the Fed were, in large part, precipitated by a stunning failure of fiscal policy, or lack thereof. The use of the Fed to intervene in the salvation of the economy, to the near exclusion of Congressional and Executive Branch action, is unique at current levels and indicative of the dysfunction in the political system. More importantly, small businesses realize that, despite the announced duration of the Fed's QE3, it is a poor substitute for enduring tax and investment policies and will someday come to an end. They appear to comprehend that the unwinding of perhaps more than $4 trillion from the Fed's balance sheet could cause significant GDP shrinkage and calamitous conditions in the economy. From the NFIB research, those businesses clearly question whether the incipient recovery in the economy will be able to survive the removal of Fed stimulus, and thus, as shown in the data, are unwilling to borrow and expand under these conditions of uncertainty.

Due to its time frame, the Baker *et al*. (2013) work does not appear to identify this component of uncertainty. From the NFIB "Small business trends" report of April, 2013, it is clear that this QE uncertainty is extant for small business and impacting their expansion and job creation. Further research, with in depth quantitative and qualitative surveys of businesses, both large and small, will be necessary to better determine the impact on the economy from this component of Fed policy.

4. Fiscal policy and entrepreneurship

Entrepreneurs and small businesses have a lesser incentive to develop and grow in an environment shrouded in policy uncertainty, such as the current, highly-contentious climate that remains deeply impacted by the 2008 financial crisis (Patterson, 2011 and Barnes, 2012). Governments around the world were faced with extraordinary challenges following the failure of Lehman Brothers and the near-collapse of the global financial system. In the United States, the federal government increased spending from 21.4% of gross domestic product (GDP) in 2007, to a high of 27.3% in 2009, including the historic budgetary legislation in the Troubled Asset Relief Program (TARP), an expenditure of $860 billion. With TARP and additional measures, U.S. government "stimulus spending over the past five years totalled more than $4 trillion" (Laffer, 2012), but has not achieved a significant growth in jobs and output. In fact, the recovery from the recession that ended in 2009 has been the weakest since World War II (Wiseman, 2012). The growth of nonfarm employment in the U.S. has been the most muted of any post-recessionary period since 1981, despite the record federal spending and stimulus programs.

This has been the first recession in the post-war period that combined U.S. federal, state, and local government employment has fallen. Most of that employment loss is at the state and local level, where budgets must be in balance and deficits are not allowed. As a result of the myriad headwinds in the current cycle, such as falling housing prices and weak tax revenues, states and local governments have been a significant drag on the U.S. economy.

The rise in bankruptcies of U.S. cities, despite the public sector budget cuts and layoffs, has reduced small business investment and an increased economic uncertainty. With 706,000 jobs lost by state and local governments from May 2009 through June of 2012 (Dewan and Rich, 2012), those important sectors of the economy are creating another large obstacle to economic recovery and a deterrent to new business creation. According to Nayab (2011), such unstable political conditions and uncertain government policies suppress entrepreneurship. The historic financial problems of the public sector in the U.S. economy exemplify the instability and its impact on the economy. According to Haltiwanger *et al*. (2012), the start-up rate of firms has declined from "as high as 12 percent to 13 percent, as a percentage of all firms, in the 1980s to 7 percent or 8 percent in recent years."

5. Uncertainty in trade policy

According to the U.S. House of Representatives Committee on Small Business, entrepreneurs and small businesses face a variety of barriers that significantly inhibit their ability to compete in the export market. Those barriers include higher tariffs, and anti-competitive technical standards. Adding to the global issues, some nations, including the U.S. create complex domestic rules regulating international trade. Entrepreneurs must navigate multiple federal agencies to obtain that license. With their limited resources, entrepreneurs and small businesses rely on free trade agreements to navigate the complexities of international trade (2012).

Despite the agreements in place, their complexity and uncertain, or disparate, enforcement have deterred entrepreneurial activity in international markets. Unfair trade practices, especially the theft of intellectual property (IP), deter small business engagement in that arena. According to the U.S. House of Representatives, China is the preeminent offender, including dumping, intellectual property theft, and market access. In total, domestic firms lost an estimated $48 billion from this theft. Notably, only one percent of the 27 million small businesses are engaged in export (2012).

The U.S. Government has been a failure in consistently ensuring that trade agreements with nations like China have been "fair" as well as "free." Large enterprises have the scale and clout – for the present – to better monitor and limit intellectual property theft. The U.S. could impose more significant penalties on certain Chinese manufacturers and products where IP theft is known. The lack of strong action by the U.S., as some allege, may be due to fear of losing the nation's key source for its debt-fuelled economy. To stimulate entrepreneurial development and to restore manufacturing jobs in the U.S., the nation must take a stronger stance against global IP theft.

In a positive signal for entrepreneurs and a possible shift toward a tougher posture on violators, on February 29 of this year the Obama administration signed an executive order to target the unfair trade practices of nations such as China. Commerce Secretary John Bryson, who will appoint the deputy director, said his department "is committed to making it as easy as possible for U.S. businesses to build things here and sell them everywhere." (Barklay and Favole, 2012).

6. Lobbying and its impact on entrepreneurship

Increased lobbying and the rapidly growing outside influence on lawmakers in Washington and other political circles of power have an outsized negative impact on entrepreneurship (Figure 2). Small businesses and entrepreneurs do not have the financial resources or infrastructure available to larger entities, leaving them relatively unable to mount a viable defense when they are confronted by regulatory issues. As derived from Baumol (1990), when the need for lobbying increases, more of an entrepreneurs time and resources must be utilized in non-innovative rent seeking activities, such as lobbying government officers instead of productive activities.

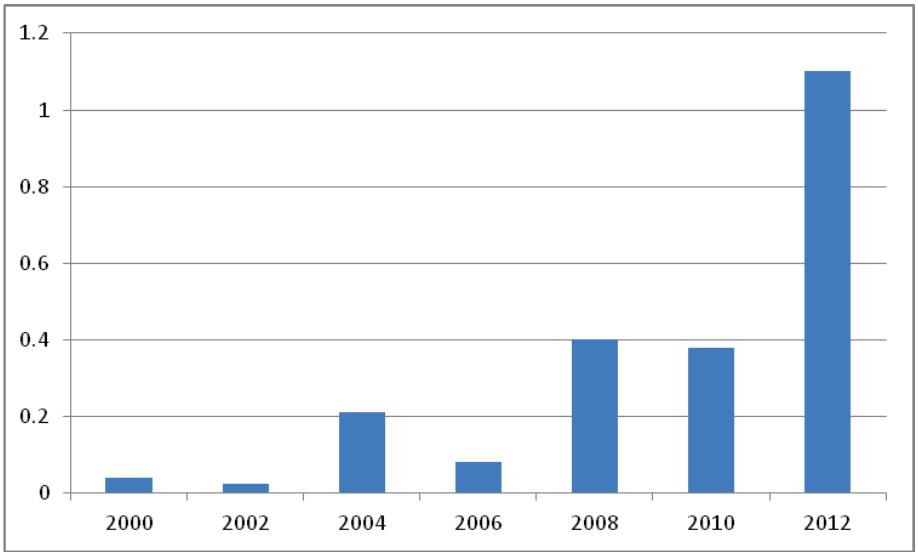

Figure 2. Outside Spending in U.S. Federal Election Cycles (Billions of Dollars) (Source: U.S. Federal Elections Commission)

The increase in outside monetary influence in recent years has been historic, with $1.1 billion spent in the 2012 cycle. Given that more than 50% of all new jobs created in the U.S. are from small businesses, the growing and outsized influence of larger firms could explain some of the sluggish job growth that America has experienced. Significantly, entrepreneurship is fundamental to a society's long term growth, due to its ability to transfer new knowledge into commercial applications (Audretsch *et al*., 2006).

The implications of the increases in non-productive rent seeking are not unique for small business, though more profound due to their resource limitations. The cost to an economy of rising rent seeking, typified by Figure 2, adds a debilitating dimension to any free market economy that increases uncertainty and reduces opportunity for ascension of the middle class.

7. Conclusion

The role of governments can be helpful in fostering entrepreneurship and economic growth. Most efforts to stimulate business creation and expansion have been in the form of tax incentives. While preferential taxation, such targeted capital gains reductions and investment tax credits can be helpful, other, sometimes more subtle policy factors of predictability that are noted in this paper, can be more enticing. Chief among them is an environment in which a medium- to long-term assessment of government policy is possible. In the U.S., for example, the lack of policy visibility in a politically divided nation, and fear of new regulations, taxes, and rent seeking by lobbying groups, is having a chilling effect on new business creation.

Some Western nations are recognizing the value of providing a more positive viewpoint from government, and one that can diminish policy fears harboured by entrepreneurs. The U.K.'s Department of Business, Innovation, and Skills recently announced the elimination or modification of 3,000 rules that impacted small companies. The U.K.'s Business Secretary noted that "in these tough times, businesses need to focus all their energies on creating jobs and growth not being tied up in unnecessary red tape" (Vina, 2012).

Entrepreneurs and small businesses realize a nation that has incurred more debt in just four years than in its entire 200 year history, increased the rent seeking in its bastions of political power, and effectively printed nearly $4 trillion, as is the case for the U.S., is on an unsustainable trajectory. As a result, the government's job creating and GDP enhancing efforts have produced modest, and arguably unsustainable, results. Some of these same issues are an impediment to business formation elsewhere, such as the European Union. Until a more stable environment, built upon policies that engender private sector growth and investment is visible to the job creating cadre, we can expect sub-par economic growth and missed opportunity.

Further study is needed to quantify the impact of contemporaneous issues in policy uncertainty, such as quantitative easing. Research that would include a broad sampling of small business leaders would assist in closing the gaps in the literature and enhance the understanding of effective policy. The benefits of such an enhanced understanding would be beneficial on a global basis.

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THE INCREASING IMPORTANCE OF STRATEGIC PLANNING AND OBJECTIVES IN IRISH HIGHER EDUCATION

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Abstract

Currently, there are mulitple factors in the national and global environment that are impacting Irish higher education institutions such as, internationalisation and massification. Coupled with this, Irish higher education institutions are operating in a challenging economic and political environment. In this context, the need to develop strategic plans and strategic objectives that are ambitious, robust and sustainable has, therefore, come into sharp focus for Irish higher education institutions.

Keywords

Strategic planning, strategic management, strategic objectives, higher education, public sector, private sector

Introduction

Higher education systems around the world are experiencing significant levels of change and academic senior managers are challenged to set and implement strategic objectives that allow their institutions to compete in the very competitive higher education environment. Throughout the last decade, there have been particular factors that have contributed towards the existing higher education environment that Irish higher education institutions (HEI) currently operate in. These factors include: globalisation and internationalisation, massification (the increase and expansion of higher education), and commercialisation. These particular forces, alongside others such as technological advances, have contributed to a more complex and dynamic environment in which senior management have to evaluate and oversee the strategic objectives for their organisations.

The formation of strategic plans and the setting of strategic objectives in higher education is not a new phenomenon. For higher education senior managers and leaders, however, strategic plans and objectives act as a means of prioritising resources and provides the opportunity to focus on key strategic areas - especially during periods of economic turmoil when funding sources and alternatives are challenged. In 1981, Kotler and Murphy stated that an emphasis on strategic planning is essential during times of uncertainty for higher education senior

managers. Strategic planning has evolved significantly since the 1970s and 1980s; strategic plans were criticised for taking the form of mission and vision statements rather than a formalised plan with a set of key goals for implementation (Hinton, 2012). While strategic planning is not new to Irish higher education, the process of strategic planning has been given renewed impetus following the publication of the National Strategy for Higher Education to 2030. This report outlines that all higher education institutions in Ireland are required by legislation to prepare a strategic planning document for their institutions. Furthermore, the strategic objectives of Irish HEIs must closely match the national policy objectives.

For the purpose of this paper, the researcher is going to focus on the increasing importance of strategic planning and strategic objectives in Irish higher education. There has been little research conducted on the strategic planning process in Ireland's higher education institutions and, subsequently, the impact of these strategic plans. There is a gap in the literature as to how Irish higher education institutions are setting, implementing and achieving their strategic objectives in this current environment. It is important to understand how Irish higher education managers are coping in this environment and ultimately what impact the current environment is having on Ireland's higher education system. The findings of this research illustrate what areas or activities senior managers are prioritising and whether or not they are equipped and resourced sufficiently to pursue and complete these objectives. The findings of this research add to the existing discourse on strategic planning in Irish higher education and, in particular, showcase any differences exhibited between public and private higher education institutions in their implementation and pursuit of strategic objectives.

This paper focuses on the increasing importance of strategic planning, and the setting and implementation of strategic objectives across Ireland's public and private higher education institutions. It draws on findings that emerged from 47 in-depth interviews with higher education senior managers. The senior managers interviewed from Ireland's higher education institutions were at a level where they were part of the development and implementation of their institution's strategic plan and objectives, and where they were in a position to see how these strategic objectives impacted their specific unit. Depending on the type and size of higher education institution, senior managers interviewed held titles such as Head of Faculty, Head of School, Dean of College, or Head of Academic Affairs. To acquire a comprehensive overview of each higher education institution in Ireland, two respondents per HEIs were typically interviewed. These two respondents were, in the majority of cases, senior managers in their institution's two largest faculties, schools, or colleges. Respondents, for example, in an Institute of Technology tended to be Head of Faculty of Business, and Head of Faculty of Science and Engineering.

The application and use of strategic planning and objectives in Irish higher education institutions

Many authors (Hampsen, 2012; Sevier, 2003; Birnbaum; 2000) highlighted the benign impact of strategic planning and the failure to actively implement strategic objectives in higher education. Strategic plans, in the higher education sector, were often criticised for being developed simply as a management exercise and for being quite ineffective in achieving their objectives. Dooris *et al.* (2004), however, disagree and posit that strategic planning has now moved from a process of outlining intentions to actively implementing decisions deemed to be of strategic importance. Essentially, they are of the view that there is now less talk and more action amongst higher education institutions in relation to strategic planning. Findings from this research support the findings of Dooris *et al*. (2004). Strategic planning and the achievement of strategic objectives have now become an integral part of an Irish senior manager's duties and strategic planning is viewed as an important means of driving change and managing resources effectively in this challenging environment. Several senior managers referred to previous strategic plans as being less effective and ill-equipped to achieve their stated strategic objectives, supporting the view of Hampson (2012). The same senior managers, however, were much more positive and confident in the existing, more recent plan and its ability to achieve their strategic objectives:

> *We wanted what we thought were the shortcomings of the last plan to be addressed…we didn't really want another document like the last one where nobody takes ownership and it's difficult to measure* (Senior Manager, Institute of Technology).

The findings show that several senior managers believed that previous plans were ineffective or less impactful as they were too ambitious or not correctly aligned with the strengths and capacity of the HEI in question. Indeed, Richard *et al*. (2004) suggest that higher education strategic planning can only be effective if consideration is given to the threats and opportunities of the external environment and the institutional resources and capacities are organised around these factors.

Another viewpoint put forward by five senior managers was that the strategic planning was previously conducted by senior management without any or sufficient consultation with staff at all levels of the organisations. With more recent strategic plans and objectives, the majority of senior managers were of the view that they were more effective because of a purposeful effort to make the strategic planning process far more inclusive and consultative in nature. In other words, senior managers believed that they have learned from their previous mistakes and recognise the value and importance of having staff on-board.

> *My own view of the strategy in the past was that it was very top down…I think the faculty engagement with it was quite limited so people weren't as familiar with it* (Senior Manager, University).

More than forty senior managers were highly cognisant of their institution's strategic plan and were actively engaged in contributing to and formulating the strategic plan. In addition to being involved in formalising the strategic plan, senior managers believed that their everyday and operational activity was largely concerned with achieving the objectives and metrics set out in the strategic plan. The findings suggest that current strategic plans and objectives are much more actionable and achievable then previous plans and the interviewees perceived that there were opportunities provided for all staff to contribute to both their organisation's and academic unit's plans:

> *I've seen strategies over the years which gather dust on shelves. In this context, it's not a grandiose document that gets dusted down when somebody steps into the office…the strategy has to be a real living part of the college's activities* (Senior Manager, Private HEI).

The strategic objectives and objectives of most colleges tended to be similar across particular trajectories, such as 'Excellence in Teaching and Learning', 'The Student Experience', 'Continued Professional Development of Staff', 'Engagement with Community and Industry Partners', and 'Internationalisation'. There were also strategic objectives pursued by senior managers that were not visible in the organisation's strategic plan. Most senior managers, for example, discussed the necessity to explore alternative or multiple sources of funding, to reduce costs, and to ensure their staff are as productive as possible. These factors are strategic objectives in themselves as they assist in achieving the over-arching strategic goals as outlined in the organisation's strategic plan.

In larger higher education institutions, it was common for senior managers to design and implement a specific strategic plan for their academic unit. These strategic plans tended to adopt the top level headings from the institution's strategic plan, and create systems and processes that would ensure these headings were understood and addressed by academic and administrative staff within the senior manager's academic unit.

All of the senior managers interviewed for this study employed some form of measurement and tracking to monitor their progress in achieving the strategic objectives. Larger institutions tended to adopt formal management techniques such as key performance indicators (KPIs), balanced scorecard or a traffic light system. The smaller institutions were less formal in their approach, but no less vigorous. Smaller institutions tended to have regular meetings with staff to monitor, discuss and plan the achievement of the strategic objectives. Regardless of how each institution tracked and measured the progress of their strategic objectives, it was evident that senior managers were acutely aware of the status of their strategic objectives and the actions necessary to achieve them. Furthermore, the majority of senior managers demonstrated unreserved commitment and faith in their organisation's strategic plan:

> *The strategic objectives are there in front of us so we keep on going back to them and looking at them and everything that we do is on the basis of these things and in some cases we would have specific committees which would have these on their agenda…All of these things [strategic objectives] would be things people are thinking of all the time* (Senior Manager, University).

Although the findings suggest that senior managers are highly cognisant of their strategic objectives, not all institutions were able to plan and implement their strategic objectives within a planned time period. Several senior managers, particularly from the Institutes of Technology (IOT) sector, reported a lapse or delay in developing a new strategic plan or adjusting existing strategic objectives because of their institution's uncertain status within the Irish higher education system. This uncertain status is largely a by-product of the proposed mergers and alliances being proposed for many Institutes of Technology in Ireland. Although the IOTs were operating as normal, a few senior managers posited that their strategic planning had been put on hold until such a time as they knew what direction their institute was taking:

> *It's a difficult phase at the moment when we don't even know where we're going to be in the next few years. It's difficult to plan. We're in limbo at the moment and until we know where we are, we are constrained* (Senior Manager, Institute of Technology).

There were some key distinctions in the strategic objectives identified and pursued by senior managers from private institutions. Although private colleges also prioritised engagement and internationalisation in their strategic plan, and most of what private senior managers discussed, tended to centre on strategic objectives designed to improve and enhance the students' experience in their colleges. A strategic objective to invest in new programmes or disciplines, for example, is pursued with the sole intention of attracting and retaining students. While this may be implied in public colleges, it was explicitly stated consistently by private higher education senior managers. Private colleges, for the most part, do not receive State funding for students, therefore, senior managers believed that creating and delivering programmes with high quality lecturers and content was imperative for their survival:

> *The primary objective of the college is to deliver value for the learners. You're taking their money, they're going to stay here for three years and you're investing that money on their behalf. Ultimately if you do that well they'll tell their friends and more people will come and if you do it wrong, the college closes* (Senior Manager, Private HEI).

A further difference between the strategic objectives of public and private colleges lies in the domain of marketing. Public senior managers discussed the aspiration to be the college of choice for students in their region and beyond, where possible. This

aspiration, however, did not feature as highly as a strategic objective as it did for private senior managers. This was evidenced in the priority given to marketing activities designed to attract students from different regions and demographics of society.

It is evident that there are some differences exhibited in the strategic objectives of public and private HEIs. Despite this, the importance attributed to strategic objectives by senior managers is evident in both public and private HEIs. A potential reason for the increased recognition of strategic plans and objectives may be as a result of the challenging economic environment in which Irish HEIs are operating.

Conclusion

It is evidenced that strategic planning is now occupying a significant amount of time and attention for higher education senior managers in Ireland than before. Furthermore, the strategic objectives pursued by senior managers are ambitious and senior managers are clear in how they plan to achieve them despite the current economic climate. Although commonalities exist across HEIs, each HEI tends to employ their own method of tracking and monitoring the progress of their strategic objectives. The method used is determined by their own requirements or preferences with some more likely to adopt more formal business-like measures, such as KPIs. The findings suggest that strategic planning has become an integral part of the operations of a higher education institution and that senior managers consider the setting and implementation of strategic objectives crucial to their institution's future direction and success. Contrary to what was previously posited of strategic planning in higher education, the findings illustrate that strategic plans and objectives, within Ireland's higher education institutions, are viewed as the vehicle that drives and guides the direction of the institution.

It is important to note that the in-depth interviews were conducted over a period over 3-4 months. There are limitations in the research, therefore, around the achievement of the strategic objectives as set out in the strategic plan. The findings outline the areas and activities that senior managers are prioritising but limitations exist in the respect that the findings cannot verify whether senior managers successfully achieved or implemented specific strategic objectives as originally intended. A follow up study, therefore, may be beneficial to definitively establish whether senior managers and their team were successful in achieving the strategic objectives as originally identified.

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Facilitating the 'distributed museum' through digitally augmented artefacts

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Abstract

Through creative practice this research explores how digitally augmented museum artefacts can support a relationship between people and a museum over an extended period of time. Typically museum visits involve people taking short periods out of their everyday activities to immerse themselves in the history and heritage of the museum. Allowing people to engage with the museum over a longer duration of time involves us exploring the digital footprint of the museum and how this relates to physical artefacts. We adopt the notion of the 'distributed museum' to support the research which is conducted with the support of Cork Butter Museum (CBM). The heritage represented by Cork Butter Museum is linked to the surrounding environment in the form of roads, places, and artefacts which people may not necessarily see in a historical context. We therefore regard CBM as a particularly useful environment for exploring the notion of the distributed museum where an on-going engagement with heritage can be examined.

Keywords

Interaction, new media technologies, distributed heritage, physical computing.

1. Introduction

The design of contemporary museum exhibits often involves the integration of new media technologies in response to rising expectations visitors have for the possibility of interacting with artefacts or the spaces in which they are presented. The experience curators and designers have had in this regard is reflected in the discourse in recent conferences such as Re-Thinking Technology in Museums (Ciolfi et al., 2011) and Nodem ("Nodem 2010: From Place to Presence," 2010), peer reviewed research conferences where the vast majority of contributions have been informed by practical investigations. Museums and heritage centres may often be constrained to protect artefacts behind glass. To provide information about the artefacts there may be panels of text or summary guides that the visitors carry with them, and in some cases audio visual content can make the information more accessible. Traditional approaches to museum presentation therefore can be seen to cognitively load the visitor. Where museums are invested with an obligation to protect heritage it is understandable that the introduction of new media technology has been used to assist

in communicating information rather than encouraging visitors to explore the artefact or context in which it is presented. However, while this engagement between the museum and the visitor can be rich and rewarding for both parties, it is short-lived and often characterised by a sender-receiver type communication model. Giaccardi proposed a more long-term engagement with heritage, where people participate in their culture and heritage over a long 'duration' of time and not just within the course of brief museum visits (Giaccardi, 2011); this research is sympathetic to such an approach.

Much of the work in this area of research recognises the importance of the distinctions between place and space and how situated interaction is influenced by the features of place and the social interactions that it affords, such as projects located in the fixed museum (Ciolfi and Bannon, 2002) and in larger open-air museums (Ciolfi and McLoughlin, 2011). The work by Giaccardi and others (Pruulmann-Vengerfeldt and Runnel, 2011) (Giaccardi and Palen, 2008) has contributed to a redefinition of the museum, where it has renewed itself into an 'open institute', receptive to the contributions and participation of active and inquisitive visitors. The term 'open institute' centres around the belief that museums should engage in a more democratic dialogue with visitors, who are not be seen simply as a passive audience, but as participants and creators in the heritage that museum is exhibiting. This is especially pertinent in the case of folk museums, such as CBM, where content and material has often been donated by the public who may not necessarily be experts in museum curation, but do have a passion and interest in history and heritage. In (Bautista, and Balsamo, 2011), Bautista and Balsamo discuss the transformations that contemporary museums are going through, describing it as a move from a "centralised fixed location, bound by the physical walls and structure of the museum, out into a more open environment surrounding the museum". This move raises a number of opportunities that can be explored through design. Where the fixed museum is home to a certain set of behaviours and activities that visitors typically conform to, open environments such as cities host a different variety of social and cultural norms that 'the museum' must participate in if it wishes to successfully affirm its place in the local cultural landscape. Similar to (Bautista, and Balsamo, 2011), where-ever museums are attempting to engage with visitors outside the museum, a re-conceptualisation of the traditional museum-visitor communication and interaction paradigm is taking place (Ciolfi and Bannon, 2007), where museums embrace contemporary communication practices driven by technological innovation.

This paper discusses a number of practical investigative steps that have been taken thus far that aim to explore ways in which Cork Butter Museum (CBM) can engage with people by disrupting and/or participating in the ongoing 'lived' communication practices outside the museum. Rather than attempting to engage with them by enticing them into the physical space of the museum it bridges the museum experience with the everyday social and cultural activities of the city. The research is similar to action research in that it is related to experiential learning, reflective practice, and iterative cycles of planning, taking action, and evaluating that action (Coughlan and Brannick, 2010). However, it differs from action research in that it is looking at the curation and arrangement of museums from an interaction design perspective, aiming to put into practice a number of speculative design principles.

2. Towards speculative design principles

CBM itself is a small folk museum devoted to the history of butter trade in Ireland located close to Cork city centre. The history starts with the importance of dairying in Ireland in the 8th Century and accounts for how Irish butter was traded around the world from the 1700s to the 1900s. The curation style in the museum demonstrates a somewhat traditional approach to the display of the artefacts. Displays are continuously rearranged in response to people who donate artefacts to the museum.

At the outset of the inquiry into CBM it was essential we understood how it characterised its relationship with visitors, as this pre-assessment would provide directions to move in during the active process of designing prototypes. What in practice is the function of the CBM? Does it aim to preserve artefacts related to the traditions of the past, or is it mainly focussed on providing people with an experience of the past? Does the museum explicitly and intentionally offer an educational experience where people come to acquire historical knowledge of the butter trade? What kind of a relationship with visitors does the museum foster? We are interested in how such questions impact on the arrangement of the physical museum space, it's mode of presentation, and the kind of dialogue it wished to establish with its visitors.

Investigations began with researchers carrying out an initial study visit at the museum. Notes on the layout and organisation of the museum building and the content contained within it were made, along with any noteworthy actions or behaviours of the visitors that were present at the time. Following this some dialogue with museum staff was essential and an informal interview with the curator was arranged. It was envisaged a semi-structured interview would assist in allowing us to discover what the curator was trying to achieve and how this became expressed in the museum assemblies and through the general approach taken to the display of artefacts. Broad open-ended questions such as '*what would you like visitors to experience when they're here?'* and *'what was your intention with the layout of the artefacts?'* led the interview dialogue allowing the curator room to include an evaluative, as well as a descriptive, commentary. In this way we had the possibility of seeing the attitude of the museum relative to its content and stakeholders.

From initial observations and the interview material a number of issues began to emerge that also resonated with other work ongoing at Cork City Gaol. The table below outlines these issues which would potentially inform a set of design principles for developing content for the CBM. These principles, which we wish to address here are labelled as *footing*, *narrative*, and *collaboration*.

Footing: is a term used to reflect the attitudinal stance or discursive positioning taken in social interaction involving different parties. The term as it is used here is derived from Erving Goffman's definition in Forms of Talk (Goffman, 1981). In this case footing is used to characterise the kind of interaction between the visitor and the museum. Traditionally this might be imposed by the curator and seen to be *didactic* in that the discourse presented by the museum is that of a specialist communicating to a non-specialist audience; the non-specialist acquiring knowledge from the expert. In the case of the CBM however the curator suggests that the museum does not

aspire towards a purely cognitive goal of translating information about the history of butter. Instead the curator seemed to be more motivated by the affective experience of the visitor. The museum therefore might be considered as being 'goalless' in the sense that conversation can be. It does not set out with a strict agenda to inform the visitor; instead it leaves room for the visitor to explore, discover and (co-)construct meaning – that is, activities that support a participative and a potentially more engaging experience. The footing here might be considered as social, responsive, non-didactic, conversational, community oriented, and durative (in Giaccardi sense).

Narrative: The kind of museum experience supported by an easily accessible story-line - such as in the form of biography or historical events causally connected, is common-place in museums - is here not considered by the curator to be desirable. In an interview the curator indicates the museums attitude in this regard by revealing: *"it's not about stories, it's about experiences [...] museums are affective experiences and not cognitive experiences [...] you're not offering a narrative, you're offering fragments, and they've to put the pieces together as they wish, or as they can [...]"*. CBM's curatorial intention to exclude conventional narrative devices could be interpreted as an 'anti-narrative' stance. Such a footing underlines the desire to support a museum experience where the visitor is free to be inquisitive and interpret the function and meaning of the presented artefacts in a more open-ended and active way; to allow the visitors to make the connections themselves. The curator's view shows a certain artistic sensibility, which recognises that stories following traditional and well-worn narrative structures, while accessible, can in fact produce a disinterested museum experience. In our view however this does not constitute an anti-narrative position but makes use of narrative in the museum in a way that is distinct from the experience of narrative in other media such as the novel or film. For instance Henry Jenkins' concept of the 'narrative architect', which goes some way in describing what designers do when they develop environments for games seems a more appropriate fit in this context than the idea of the curator writing a 'sequence script' for the space. Jenkins refers to spatial stories as "stories that respond to alternative aesthetic principles, privileging spatial exploration over plot development." The view also resonates with post-structural reader centric theories of narrative which underline the constructive role of the reader in the process of constituting the story experience. In the canon of literature such aesthetic principles have been indicated by those such as W. Iser and F. Kermode and more recently translated into contemporary transmedial narrative theory by M.L Ryan and D. Herman. Other support for such constructivist approaches to narrative lie in social theory with the work of researchers such as L. Capps and E. Ochs (Ochs and Capps, 2001) whereby personal quotidian stories in everyday experience are co-constructed as a method of helping to arrive at the likely meaning of events. Stories emerge as temporary folk explanations of artefacts and may be constantly remodelled in accordance to plausibility. If the museum intends to set out assemblies of artefacts in a way that demand the visitor participate in the construction of meaning then it is possible to see narrative being involved, but in a way that is not necessarily informed by literary or cinematic models. In this way narrative might be characterised by keywords such as: multi-linear, co-constructed; sense-making; collaborative; explanatory.

Collaboration: In cases where museums are transforming into 'open institutes', they take to engaging with the general public in acts of collaboration and participation to create a shared sense of history and identity (Simon, 2010). It was clear from the interview that CBM is already doing this. The museum was described as 'reactive', in the sense that it facilitates donations of artefacts from people to the museum, artefacts that could otherwise be lost. This, on one hand, indicates a traditional responsibility for protecting heritage yet also demonstrates a kind of dynamic that is less common. Despite the museum having limited physical space the curator regularly accepts additional artefacts and alters the collections in response to these 'donations' from the community. There was a sense that this kind collaborative exchange was something which could be augmented or amplified by the use of new media technologies.

Authenticity: In short, the curator intends for the space to keep the appearance of an authentic and traditional museum environment. It is not the intention to fill it with mediating technologies such as screens and information panels for visitors to consume. Instead, the intention is to create an environment where primacy is given to real authentic artefacts placed in an appropriate setting.

Summary of Curatorial Intent	
Footing	The museum is goalless; it should be an affective rather than a cognitive experience. The content is not set out with a strict didactic agenda but offered up for consideration -for the visitor to explore, discover and construct meaning.
Narrative	The footing does not imply Constructivist model rather than prescribed events chronologically ordered/plotted in time; fragments of a narrative are distributed across the space, the narrative is heavily dependent on visitors understanding and interaction. Narrative in this case is not necessarily informed by literary or cinematic references as much as it is by games and quotidian stories.
Collaboration	The museum is 'reactive'; the museum responds to visitor contributions and the needs of subject matter; they collaborate in making history, to an extent. The museum is not author centric and subscribes to a distributed conversational model of communication rather than one which is didactic (expert curator -> non-specialist visitor)
Authenticity	The arrangement and appearance of the museum environment is in keeping with a traditional stance, giving primacy to artefacts.

Table 1: key principles relating to footing, narrative, and collaboration

These principles were extracted from the analysis of the data generated from initial observations and the interview. They helped provide a lens through which the museum could be interpreted and were used as a basis to begin practical design investigations into how CBM could further embrace the notion of the distributed museum. After identifying these principles we aimed to put the unfolding research into action by applying them to initial prototypes.

Designing interactions in the museum space using technology for goalless interaction and affective engagement has been discussed previously in (Pallud, 2009) and (Flint and Turner, 2011). In both cases, the intention was not to deliver information through technology enhanced mediating devices but instead to focus on the affective

experience of the 'user' or visitors to the museum. An immediate goal was to explore how the museum audiences could contribute to the heritage it acted custodian to. So, while there already existed an opportunity for stakeholders to contribute artefacts that the curator could integrate into the museum's assemblies, this particular form of integration was restricted to those who had artefacts in their possession and brought them to the building. What about those who had information and stories in their possession - handed down, or revisited in community folklore - was it possible that these could donated in a similar way to the physical 'things'? Enabling people contribute their opinions on heritage has been explored in a number of different contexts in recent times, ranging from allowing people to submit their thoughts 'in the moment' on site in both fixed museums (Ciolfi and Bannon, 2002) and open-air museums (Ciolfi et al., 2008), to allowing people to submit their reflections after a 'duration' (Giaccardi, 2011). Further to these examples, in (Giaccardi and Palen, 2008) we see the importance of using media technologies that create 'socio-technical infrastructures', which allow for novel interactions between communities and cultural or historical institutes and environments. Social remembering is seen as key in this process, as the heritage is re-mixed and re-imagined in a collaborative or co-constructed manner amongst contributors. Here, cultural and historical institutes are not just seen as keepers of the past, but collaborative environments that enable communities to share in remembering a living history.

3. Prototyping visitor–object–visitor communication

After some guiding principles emerged, three of which are summarised in Table 1 above, work started on prototyping artefacts that could support the kind of collaborative footing that appeared to mark the intentions of the CBM. The aim was to further the discussion on the value that augmented artefacts would add in attempting to support an ongoing relationship between the people and the museum over an extended period of time.

The concept for the first prototype was to connect an artefact to the web so that a communication channel could be established between those inside the museum and those outside. To begin, we set about creating a website that would allow the museum to reach out to people who may not necessarily visit the museum building. The website contained a map with a layer of short stories positioned on top of it relating to historical events or pathways such as the 'butter roads' that stretched from the south west of the country to Cork City. The story material was delivered through the map in audio format and related to relevant historical subjects. This was similar to approaches taken in other online or locative story projects such as 'Story Map' (Flaherty,, 2011) or 'Murmur' (*Murmur*, 2003). The website was developed for smart phone/mobile, and users are able to directly access stories on it via QR Codes printed onto posters that are distributed throughout the city. QR codes have by now become common and used notably in projects involving memory and story, such as 'Remember Me'(Speed, 2010). In this case QR provided a method of quickly prototyping access for users to the map in ways that are largely familiar to them and reduced the requirement for developing additional software for the mobile. The events on the map, identified by place markers, did not follow a particular sequence so users were free to explore it in whichever order they prefer – it was not arranged

linearly, but organised spatially according to the history and memories embedded in the landscape. The map was developed with Google Maps API using an 18th century historical map as an overlay on the base layer and users were restricted to a historically relevant region. The idea of using a story map with integrated historical maps is by no means new and 'Walking Through Time'(WTT) (Speed, 2009) is a particularly useful example in the context of heritage. WTT allowed smart phone users to locate themselves in the past and take historical walks on paths that no-longer exist in the present by using GPS to pin-point users on historical maps overlaid on contemporary maps. Here we see a transition where the history of a place has escaped the confines of any one fixed location; it is brought back into the present and negotiated by users who act in this 'new' world from the past, in the present. The information structure of the story layer on top of the contemporary map uses the principles manifest in the arrangement of the physical museum in the creation of a novel digital artefact.

In addition to the story map we connected a physical artefact in the form of a milk churn to the website. This artefact acted as a bridge between the tangible/physical environment of the CBM and the map's virtual footprint accessible from other locations around the city. The milk churn has the ability to sense limited interactions that people have with it. It has embedded sensors and actuators that see motion within a given radius and can recognise when it is approached or when the lid is removed. Under certain conditions it can send out information in the form of pre-recorded audio clips or by noise activated by actuators tapping inside the churn.

The artefact (a milk-churn) in the museum contained an Arduino board with a sensor that communicates values to a database through server-side script and a Processing sketch. When the sensor registered values above a certain threshold - which may be triggered by someone taking the top off the churn - the artefact sends this information to the database with a timestamp. If the artefact has not been active within the last two hours, the stories are temporarily 'forgotten' and inaccessible to users. When this happens, the user of the website is given the opportunity to 'poke' the physical artefact in the museum to replenish the stories. If a user does this information is sent to the Arduino which either plays a pre-recorded sound or activates an actuator in order to attract the notice of people in the museum. Figure 1 provides a visual representation of the interaction.

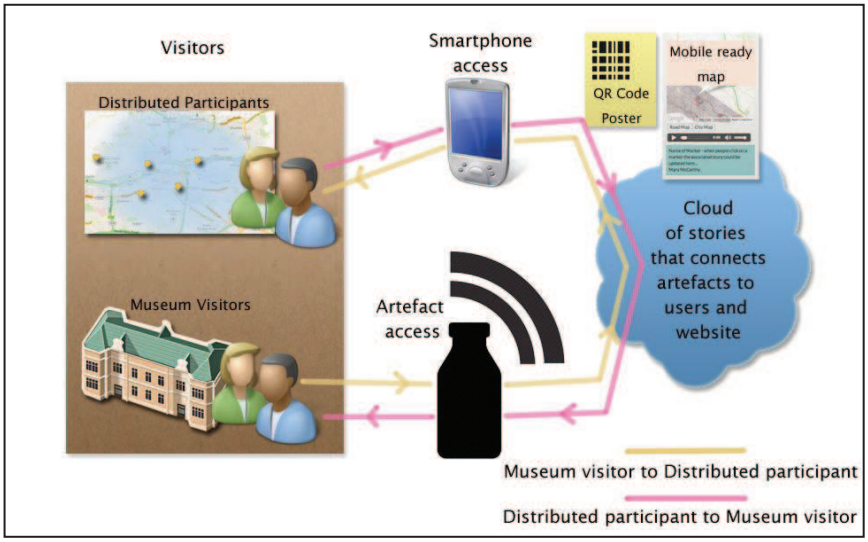

Figure 1 –visitor – object – visitor communication

The general concept we considered is that the stories on the website are part of the artefact's memory. Physical artefacts can be understood to store memory in a variety of ways and one example is in the scratches, dints, and discolouration or 'patina' that an object acquires through the history of its use. The memory inscribed into the surface of the object is closely related to the 'aura' recognised by Walter Benjamin in his seminal essay about the work of art in the age of mechanical reproduction (1935). The hand of the artist is there present in the creation the object. But of closer relevance here is the way memory can be regarded as an aesthetic property of an object. This is exemplified in the 'Remember Me' project cited above, where ones interest in an artefact is generated by the kind of memories associated with it. In our case we imagined the object personified; that is, it has memories. These memories are kept alive by the artefact as its stories are revisited over time. This resonates with Giacarrdi's notion of 'duration': "communities participating 'across time' (duration) in the cultural production of memory and identity". If people neglect to interact with the object then it 'forgets', and the stories become inaccessible to the community of users accessing the content on the website from outside the museum. In the event that someone visits the website and the stories have become inaccessible, they are prompted to digitally 'poke' the artefact. This action is connected to the audio outputs and actuators in the churn which are intended to attract attention of people nearby in the museum. When people in the museum interact with the churn they can hear stories by lifting the lid and placing their ear to the opening. The result of this action is the stories on the website become accessible again. In this way, visitors who have engaged with the material artefact or its digital footprint have collaborated to help keep the memories alive.

The augmentations support and reward the embodied inquisitive act of taking the top off the milk-churn to see what's inside by providing additional serendipitous content, in a novel and unique manner. The act of leaning over and putting one's ear to the churn is 'performed' in the space in a much more visible and socially available way

to other visitors than say listening to the same content through a set of personal headphones. By augmenting the artefact, listening becomes a 'gesture' of interest and inquisitiveness. Having the stories play through the churn also helps to create a goalless environment where inquisitiveness is fostered, which can help to create a sense of mystery and playfulness that will engage visitors further. The unique story map contextualises the heritage by adding a social-historical layer to the contemporary map. This helps to situate the content back into the communities that it originated from, whilst also making it easily accessible in ways that are familiar and intuitive to users.

Following this we developed the prototype further to allow visitors record their own interpretations and stories. We focused on trying to use the material artefact and the interactional affordances it presents to engage visitors in contributing during their visit. A microphone and microcontroller were embedded in a milk-churn, and to record a story visitors can speak into the churn. It begins to record once the cover is taken off the top, so the 'interface' was the milk-churn itself. Again, the prototype uses an Arduino connected to a PC running a Pure-Data (PD) patch that was designed to collect and write the visitors input to disk. The PD patch records in 20 second blocks but if the milk churn senses there is continued interaction from a visitor it dynamically extends the audio clip until the interaction is complete. Each recording is time-stamped and provides additional quantitative data in the sense that a full record of the interaction is automatically available without the need to conduct observations manually.

Though in the prototype's current form there remains significant design challenges. For instance getting visitors to record their own stories by using the churn does require instructional support and this somewhat undermines the possibility for the visitor to 'discover' interacting with the churn. Also within the quiet and relatively small space of the CBM people may be conscious of being watched while they interact with the object, a condition identified with interaction in public spaces previously referred to as 'performing perception'(Dalsgaard and Hansen, 2008). However, it is envisaged if these issues can mitigated then more thoughtful narrative contributions can be contributed by the community.

4. Conclusion

So far, this research has established some speculative design principles for practical investigations into how CBM can adapt the notion of the distributed museum to its specific heritage context. It has embraced a creative approach to expanding the footprint of the museum where focus is placed on the experiential nature of museum visiting. By allowing engagement with heritage to be extended to those outside the physical museum it engenders a wider and more inclusive method of remembering to be facilitated by the museum. This resonates with CBM's existing curatorial footing interpreted earlier from interview material. From here the research will begin to test the prototypes in real world setting, evaluating them on both technical and aesthetical grounds of inquiry, generating empirical data that will be direct following iterations. We are currently at the stage of the design cycle where we are beginning to test prototypes for technical robustness and early aesthetical evaluation, and so have not

yet reached a stage where we can carry out post-examinations of the state of the museum curation practices to measure the success of our speculative design principles.

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Preventing Digital Subcultures from becoming Victims of the Technological Change

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Abstract

Management and access of domain-specific knowledge is of relevance to ensure the perception and survival of cultural heritage. In addition analysis of digital subcultures is of interest for the Digital Humanities. The demoscene uses the internet as communication, organization and presentation medium. While databases are growing constantly productions have been archived and made accessible online by the scene community itself. This leads to problems in quality assurance, accessibility and reliability. Besides that the complexity of the scene is not easily comprehensible. The presented research contributes to the preservation and analysis of web-based cultural heritage using ontologies for knowledge acquisition and management. Within a first case study online available information has been collected and the characteristics of the demoscene have been analysed. Production and presentation practices, socio-cultural structures and influencing factors have been identified. Based on the results an ontological framework suitable for preservation, documentation and knowledge extraction will be examined.

Keywords

Demoscene, Online Communities, Digital Humanities, Case Study

1. Introduction

The Internet is an indispensable part of our daily life and includes a constantly growing amount of information. This information is highly topical and in general almost universally available. In addition the Internet offers everyone the opportunity to provide information to anyone. This leads to problems in quality assurance, accessibility and reliability. Characteristics of the Internet make the integration of domain-specific information rather difficult. On one hand it is hardly possible to gather all relevant information on a discipline or topic, on the other hand web-based information and community archives are becoming increasingly important for the research of cultural information in the humanities and social sciences as well as for knowledge management and transfer in general (Even, 2012). To obtain and use knowledge from web-based archives it is necessary to organize and to contextualize this domain-specific information and to support communication.

This paper presents an analysis of the demoscene, a European subcultural artistic art scene, with its artworks and social structures. In a structured and theoretical survey including multiple case studies online information resources of the demoscene have

been empirically explored and analysed. In summary the various analyses show the general characteristics of the demo art scene. The main concepts of the scene could be identified and described regarding production and presentation practices as well as socio-cultural structures. Based on the results of these case studies an interoperable semantic content model contributing archiving, mediation and long-term accessibility will be developed and evaluated within the next research steps.

2. Motivation

The Digital Humanities are concerned with all aspects of humanities research to gain and communicate new knowledge using and developing information science technology tools (Schreibman, 2004). First Digital Humanities scholarship tended to focus on digitalization projects and the establishment of technological infrastructure while currently it is deeply generative, creating environments and tools for producing, curating, and interacting with knowledge that is born-digital and lives in various digital contexts (Berry, 2011). Especially information generated from online communities or cyber cultures offers new opportunities and is challenging digital humanities research and the development of appropriate tools.

Particularly the demoscene, a digital artistic subculture using the Internet since the beginnings as communication, organization and presentation medium, is an example of networked collaborative artistic creation processes taking advantage of technological opportunities, constantly producing new genres and promoting the development of trends. For quite some time demo art productions have been archived and made accessible online by the demoscene community itself on websites such as *pouet.net* (pouet, 2000), *bitfellas.org* (bitfellas, 2006), *CSDb.dk* (CSDb, 2001), *scene.org* (scene, 1997), *ftp.amigascne.org* (Amiga, 2004) and more (dmoz, 2009). On one hand there have been several data losses, on the other hand databases are growing constantly and especially for non-demosceners the complexity of the scene regarding practices, structures and influencing factors is not comprehensible.

The presented research contributes to the preservation of cultural heritage of our digital age and the improvement of knowledge acquisition and management of the sub-cultural demo art scene. Goal is to use information science methods to support the preservation of the demoscene as well as the humanities and social science research. For this purpose within a first empirical research online available and relevant information has been collected and interpreted. Production and presentation practices, socio-cultural structures, patterns and influencing factors were examined and relevant domain-specific concepts identified.

3. Research Methodology and Study Design

Based on a case study research the characteristics, phenomena and main concepts of the demoscene are explainable and describable. This case study research includes multiple case studies based on a mix of qualitative and quantitative evidence relying on several resources. Focus of the exploratory and descriptive case studies were the empirical collection, interpretation and pattern recognition of online available web-

based information of the demoscene. This circular approach integrated inductive context-related data collection and analysis.

Data collection was based on structured sampling and theoretical sampling, each according to various criteria. The sampling frames were websites, online archives, documents and demo artworks. If possible relevant data was collected by partially automated extraction methods based on web mining approaches.

To accurately display the collected data about the demoscene and reconstruct the socio-cultural reality aiming to interpret statements correctly, semantic technologies are suitable (Gruber, 1993; Dengel, 2011). As the foundation and basis for a common understanding, but also to uncover new contexts particular ontologies are used (Allemang, 2011). Therefor necessary knowledge about concepts and relationships has been determined within this first research phase and is presented in a semantic taxonomy.

Target of the data evaluation was pattern recognition for classification and clustering of the characteristics, phenomena and main concepts of the demoscene. The collected domain knowledge has been displayed in a context based on semantic relations. Therefor production and presentation practices of the scene, socio-cultural structures and patterns have been explored. Scene inherent processes and influences of the scene were identified.

From the results of this first phase of research the central research questions will be developed. These raise scientific questions that have previously not at all or only partially been addressed or dissolved.

- How can characteristics as well as context information of the demoscene community be described and structured?
- How can actors be identified and located?
- How can demoscene productions be documented and made accessible?

Based on the results of this case study on demoscene specific practices and structures a content model will be developed within the next research phase (Hastik, 2013c). It will be investigated if the CIDOC CRM (CIDOC, 2006) which provides a common, extensible and object-oriented framework for any cultural heritage information is suitable for modelling the upper-ontology. The domain ontology will be described and formalized based on ontology engineering methods (Uschold, 1996; Fernández, 1997). Ideally results may be graphically illustrated using standardized visualization methods. In this context appropriate visualization methods such as maps, graphs, timelines and movements are useful to illustrate the results (Weischer, 2007).

4. Data Gathering, analysis and challenges

First the largest web repository for news, groups and productions of the demoscene *pouet.net* was systematically crawled (status November 2011) for each production by increasing index numbers for the main download link (Hastik, 2012a). If the

download failed all *scene.org* mirrors were parsed for the exact file name. If the production was still unavailable *CSDb.dk* was searched for C64 productions and *ftp.amigascne.org* was searched for Amiga productions. This raised the hit-ratio from 45% to over 95%. With the objective to collect all demoscene productions this sampling shows

- in total over forty thousand productions consist of an archive including a program file and a nfo-file
- the use of over 70 different platforms
- file names are neither standardized nor consistent
- links change syntactically
- file servers become unavailable
- web archives and portals are fragmentary
- documentation is not standardized.

Merging all these heterogeneous resources is a huge challenge. Linked open data would enable data from different sources to be connected and queried (Bizer, 2009). Therefor the demoscene community needs to publish open datasets. The correspondence between these datasets and the integration of heterogeneous databases can be achieved based on ontologies (Euzenat, 2007). Thus sources have to be evaluated and examined in detail.

Next demoscene productions have been examined regarding

- production practices (materials, tools, artwork)
- presentation practices (manifestations, aesthetics and festivals)
- socio-cultural structures (groups, artists, community, feedback).

Several partial samplings of platforms, the operability of artworks, used terminology, aesthetic aspects, group members and community feedback like top rated (top prods) and awarded (scene awards) productions were carried out manually.

4.1. Production Practices

At first platforms used for demoscene productions were examined. An external statistical survey of *pouet.net* by Bent Stamnes from January 2012 shows the demoscene productions in total, the categories and the use of platforms from 1978 to 2011. A detailed view of the years between 2001 and 2011 illustrates which platforms have been widely used for demoscene productions in recent years. An extrapolation of the details shows (Stamnes, 2011):

- Commodore 64 has doubled its popularity in the last two years
- web demos doubled their popularity in just one year
- Atari has been and remains popular.

To ensure the operability of the original program file of the demo art production the platform for which it was designed must be known and reconstructable. For this purpose info-files (nfo-files) of the 250 most popular demo works from *pouet.net*

were analysed and inspected in terms of technological aspects such as information on system requirements:

- Only 140 of the 250 top prods ran easily and accurately in a test environment
- many Windows-based productions caused problems like display or runtime errors
- C64 and Atari productions ran on emulators
- for slightly more than 100 productions the system and performance requirements were specified
- Only a fifth of the 250 analysed top prods included details about the tools used for creation.

For the next research phase an analysis of the 250 top rated demo art productions (top prods) on *pouet.net* indicates that demo artworks are always identifiable by title, group, platform type and artwork category. To validate the terminology used to describe these reference data a comparison search on other community portals such as *bitfellas.org* (Atari only), *back2theroots.org* (all types), and *csdb.dk* (C64 only) was executed. It was discovered that the used terminology is neither consistent nor standardized (Table 1).

pouet.net	back2roots.org	csdb.dk	bitfellas.org
Title	Title	Title	title
Group	Maker	Released by	Group
Type	Type	Type	Type
Platform	Config	C64	Atari
released date	n/a	Released Date	Released
release party	n/a	Released At	Released
Ranked	n/a	Achievement	Rank
Ratings	Rating	User Rating	User Rating
Records	n/a	Production Note	Info
used effects	n/a	Hidden Parts	n/a

Table 1: Comparative matrix

Describing production practices is a huge challenge because relevant and specific information often is incomplete. The use of non-uniform terminology is another major challenge for developing a content model. Semantic web specifications provide solutions to express whether different terminology is used to describe same objects (W3C, 2004).

4.2. Presentation Practices

Since demo effects together with music shape the aesthetics of demo artworks (Hastik, 2012b) the previous sample is analysed with regard to aesthetic aspects, such as effect, theme and genre. For the content analysis of demo effects a list of descriptors was created for indexing. This corpus was determined based on existing

literature (Reunannen, 2010; Trixter, 1994). Until now a thematic classification of demo artwork has not been developed. However it was determined in a study of Amiga demos (Borzyskoski, 2000) that demo productions are often inspired by science fiction and fantasy. Therefor the sample was thematically assigned. For determining the music genres a list of the most popular music genres exists (Wikipedia, 2012; Allmusic, 2013). An overall analysis of aesthetic aspects can be found in this table (Table 2).

Title	Music Title	Effect	Topic	Music Genre
Agenda Circling Forth	Demo	CNCD & Fairlight	Visuals by Desktop and Smash, Music by Varia	Best demo, Best effects, Best technical achievement
Fr-063: Magellan	Magellan (party version)	Mandelbulb, Fractals, Vector Balls, Metal-Shaded Vectors, Rotate, Shaded Vectors, Slime Vectors, Plasma, Vector Worlds	Science-Fiction, Landscape	Electronic, Trance
Ceasefire (All Falls Down..)	All Falls Down	Artifact Simulation, Particles, Srollers, Fire, Vector Balls, Shaded Vectors, Glitches, Delay Dots, Vector Worlds	Space, Architecture, Cityscape	Electronic, Indietronica, Pop
Finally Inside	Brainstorm	Scrollers, Glitches, Shaded Vectors, Particles, Metal-Shaded Vectors, Vector Worlds	CCTV, Technology, Architecture, Espionage, Surveillance, Science-Fiction, Dystopia	Electronic, Drum & Bass
Binary of Babel	Binary of Babel (Soundtrack)	Scrollers, Rasterbars, Palette Cycling, Rotozoomer, Metacloth, Dot Tunnel, Wireframe Torus, Texture Mapped Vectors, Copper Wobble, Mandelbulb, Zoomer, Fractals, Realtime Intersection, Sine Flag, Lens Deformed Shadebobs, Liquid Fill, Inference, Vector Balls, Fire, Voxels, Vector Worlds	Effects, Programming, Old School	Electronic
Ars Nova	Ars Nova	Metal-Shaded Vectors, Scrollers, Shaded Vectors, Glitches, Vector Balls, Vector Worlds, Lens Deform, Slime Vectors	Science-Fiction, Machines, Virtual Worlds, Racing	Electronic
Snapshot	Snapshot	Rotate, Scroller,	Old School, Pixel	Electronic,

		Rasterbars, Pixelgraphics, Palette Cycling, Vectors	Art	Chiptune
X Marks The Spot	Locomotion	Texture-Mapped Vectors, Vector Worlds, Shaded Vectors, Scroller, Glitches	Cityscape, Architecture, Dancing, Information	Electronic
Cdak	Cdak	Tunnel, Shaded Vectors, Vector Worlds	Geometry, Architecture	Electronic
Insert No Coins	Insert No Coins	Rotate, Glenz, Scroller, Sine Flag, Tunnel, Vector Balls	Old School, Technology, Information	Electronic, Chiptune

Table 2: Aesthetic analysis of nfo-files

The content analysis of demo artworks seems to be a challenge for non-experts. For this reason there is a need to repeat the content analysis with experts and to design a suitable methodology for further documentation.

4.3. Socio-cultural Structures

Within a further sample of awarded productions from 2010 (Scene Awards of 2010) the content of the nfo-files were structurally analysed. From 2002 to 2011 demo art productions were nominated and evaluated by the community in various categories such as best demo, best 64k and 4k intro, best effects, best graphics, best soundtrack, best direction, most original concept, breakthrough performance, best demo on an oldschool platform and best technical achievement. By this sample the following result have been made:

- The roles of demo group members can be determined
- the file formats of the nfo-files, the text descriptions and textual presentation of the content are heterogeneous and not standardized
- in addition the demo group members are using pseudonyms
- group formations are loose.

The extraction of actors and their roles from nfo-files is a huge challenge due to the diversity of layouts. It provides the question whether there are more valid and consistent sources for information extraction.

The analysis of *pouet.net* top prods shows that each demo artwork has received ratings from the community. These ratings are represented by icons (“thumb up”, “thumb down” and “piggy”) and text comments. Among the 250 analysed prods the most popular one has received more than 700 ratings and the remaining 249 no less than 130.

5. Results

When we speak about the demoscene we speak about a subculture of hobbyists who culturally produce and reproduce themselves. The demoscene has grown up with the Internet. Globalization and international networking soften cultural, social and

territorial boundaries and it is getting harder to locate cultural aggregation. Cultures are more and more anonymous and are ultimately analysable by decoding Internet networks (Hepp, 2005). A special aspect of the demoscene certainly is the collaboration of artists and the goal-oriented cooperation through virtual channels. Already in its early stages the demoscene used electronic mailboxes for communication and the exchange of content. So it is no surprise that the Internet has become the largest archive of the scene. In addition to these cyber cultural habits festivals are the focal point of the scene. Here productions are released, presented and admired and new trends are set. The vast diversity and the many facets of digital content make it difficult to describe and to structure it. The lack of historical distance makes it even more difficult to describe digital creative artwork, to identify artistic trends and to establish new forms.

5.1. Summary

In summary the various analyses show the general characteristics of the demo art scene. It becomes clear that:

- The Internet is the archive, communication and collaboration platform
- festivals set trends
- the platform causes development, aesthetics and categorization of the artwork
- productions and platforms are multifaceted
- documentation and description are not standardized, non-uniform and in some cases incomplete
- the artist influences the performance of the group
- productions are representative for scene specific aesthetics and technical culture.

Relevant elements of the scene and the importance of the objects can be described by associative relationships.

5.2. Taxonomy

With this first systematic survey the main entities of the demoscene could be identified and described:

- Production practices:
  Demo artworks are platform dependent and related to specific technical requirements. The artwork itself is identified by a title and can be categorized.
- Presentation practices:
  Demo productions are available in different formats; they have a publication date and place. In addition demo art can be aesthetically described.
- Social-cultural structures:
  Demo artwork is generally developed by demo groups, artists take certain roles. The community rates and comments the productions.

6. Conclusion and Outlook

Management and access to scene-specific knowledge is of relevance for the demoscene to ensure the perception and survival of this digital subculture. Analysis of digital subcultures is of particular relevance for the Digital Humanities. Based on the results it will be examined if the CIDOC framework is suitable for documentation and knowledge extraction of the demoscene. In this context the definition of target groups is necessary.

The developed model needs to be evaluated and tested. Classical methods are competency questions to verify the accuracy of reasoning abilities and personas to ensure the usability for the demoscene. In this context appropriate visualization is useful to illustrate the results.

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An Approach to Quantifying Latency Adaptability in Non-collaborative Musical Performances

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Abstract

Collaborative performances of musicians playing together, but in different physical places, e.g. over network such as the Internet, have become a new artist procedure, even though latency, which can be understood as the time it takes a sound to be transmitted and reproduced in a remote destination is still an issue. The effects of latency in performances over network and its technical issues have been researched for the last decade, however, just a few researches deal with the question of how musicians can cope with their own latency with regard to non-collaborative performances (performing music solo). This paper introduces the new concept of Latency Tolerance Range (LTR) and describes a methodological approach in order to develop an experiment the results of which may demonstrate the influence of the musicians' performed instruments (chordophones, aerophones and membranophones) on latency perception.

Keywords

Latency, Beats per Minute (BPM), Latency Tolerance Range (LTR), Latency Adaptability, non-collaborative musical performances.

1. Introduction

Both perception of music and musical interaction rely on time. Musicians are able to cope with delays, i.e. latency, of more than 100ms without having noticeable effects on music performing; nevertheless some researchers have shown that this threshold might vary depending on the performed instrument (Barbosa, 2006).

Recent work shows that there are two delivered concepts of latency (internal and external). In this paper, we only refer to the external latency, which is defined as the "delay due to physical constraints such as distance and Human Perception" (Bartelette *et al.* 2010).

It is well known that musicians in a small space like a chamber may experience latencies in the range of 5-10ms, which is a normal physical issue due to sound propagation in the air; on the other hand musicians in a large orchestra may encounter latencies within the range of 80 to 100ms. In such a situation the

conductor plays an important role, allowing the musicians to overcome latency by being the metronome of the orchestra (Olmos *et al.* 2009).

Latency has not been an issue for many years. However, since new technologies enable musical performances over large distances e.g. Internet, new artistic approaches are becoming state of the art and new challenges arise. Research has evaluated the impact of latency (mainly for collaborative musical performances) and has led to innovative solutions and even artistic approaches to moderate the effect of latency, allowing a successful musical performance; some of these are discussed in section 2.

In section 3 a different methodological conception with regard to latency research in non-collaborative musical performances will be exposed, defining specifications to be considered for the experiment and on test subjects as well. The development of the experiment, the definition of the new concept of Latency Tolerance Range (LTR) and possible results are presented in section 4.

2. Related Work

Existing research has established that a little amount of latency of about 20ms is necessary for ensemble performances. Musical collaboration might be possible within the range 20 to 40ms. Beyond 70ms it is almost impossible to talk about musical interaction (Schuett, 2002).

The key latency threshold for an acceptable and musically effective ensemble performance is described differently in the literature. Some authors i.e. (Bartlette *et al.* 2010) set this to 106ms, by (Schuett, 2002) this figure ranges between 20ms to 30ms and is called Ensemble Performance Threshold (EPT)". In the work of (Chafe *et al.* 2008) a "sweet spot" having a value of 11.5ms is introduced. Above this number the majority of performances will slow down, and below this threshold most ensemble performances will speed up (Bartlette *et al.* 2010). Some authors draw attention to possible bias within the methodology and conclusions of those works, due to the test subjects used and to the fact that the observations were made during clapping experiments with no music at all (Smith, 2011).

A systematic approach considering the performed instrument and its role in how a musician copes with latency can be found for live sound monitoring. According to (Lester and Boley, 2007) latency tolerance depends strongly on the specific musical instruments used. However, thereby the definition of an absolute threshold proved to be difficult due to the measuring methods utilised and the role of human interaction. Nevertheless, the approach was rather subjective as it relied on the test subject's judgement and answers (within a scale) with regard to their adaptability to latency for floor wedges (live sound monitor or loudspeaker system) and in-ear-monitors. The group of instruments analysed was a mix of electrophones (electric guitar, electric bass and keyboard), membranophones (drums) and aerophones (vocals and saxophone). Further research with respect to the number of test subjects and the researched instruments was encouraged.

Some experiments (Barbosa, 2008) showed the results determining a maximum individual latency tolerance from the musician's own instrument (bass, percussion, guitar, piano, etc.). Musicians listened to their feedback from their own instruments through headphones. Delays were variable. The performances were synchronised with a metronome. Different tempos measured in BPM were tested. From these experiments two interesting results were derived. Firstly, the maximum delay tolerance is different for each instrument (musician). Secondly, musicians tolerate more feedback delay for slower tempos, in other words the relationship between musical tempo and latency tolerance is inverse. This result is also confirmed by (Farner *et al*. 2006).

For describing the relationship between tempo and latency, the concept of Latency Adaptive Tempo (LAT) was introduced. The application principle of LAT is a simple software function. This function dynamically adapts the musical tempo to a maximum value to be tolerated by the least "latency-tolerant" musician who plays in an ensemble over network.

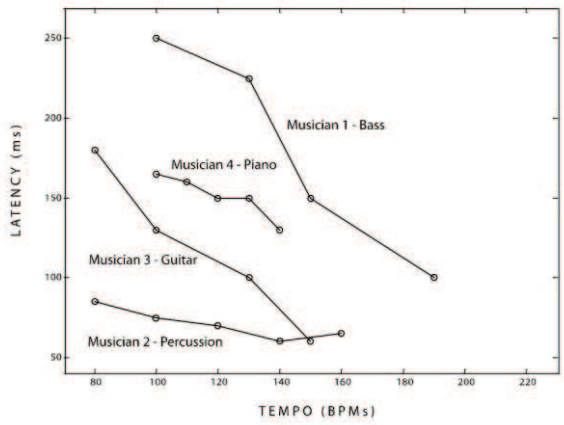

Figure 1: Self-Test for Latency Tolerance in Individual Performance- LAT (Barbosa, 2006)

Other strategies developed for coping with latency (Carôt and Werner, 2007) involve a whole range of artistic possibilities. For collaborative music performances with all musicians being in the same room, the Realistic Interaction Approach (RIA) is described. Here, musicians play conventionally with latencies under 25ms. A more artistic approach is the Fake Time Approach (FTA), whereby the main goal is experimentation and expression, as musicians play asynchronously to the music played by the other musicians one measure before (several seconds before).

It has been observed that a musician is able to compensate delay and improve his playing even on individual acoustic feedback conditions. The Individual Delayed Feedback (IDF) is defined as the better latency tolerance obtained by allowing a musician to listen to his acoustic feedback delayed together and in sync with the

others, instead of just receiving direct acoustic feedback from their own instrument mixed with delayed feedback from the other performers (Bartlette *et al.* 2010). It is normal to expect a detrimental effect on the musician's performance due to latency, except for percussion instruments in the case of overlapping structures (e.g. latency feedback is heard at the same time while the test subject strikes the instrument) (Bartlette *et al*. 2010), attack times, defined as the physical onset when a musician plays or strikes an instrument might play a very important role in this result.

Current research focuses on latency variations, while other parameters (dynamic, articulation, music structure and form, listening conditions, etc.) remain fixed; some tests have demonstrated the influence of conditions like musical attack (accents) in the ability to tolerate latency (Barbosa and Cordeiro, 2011). Expressive qualities such as these mentioned above are hard to identify and with today standards and methods it is very difficult to estimate and measure these parameters. Some musical styles, which rely mainly on rhythm, melody and harmony could be addressed and measured by means of intrinsic related parameters like tempo and score structure. However, even though the ability to cope with latency seems to be in dependence on the type of musical instrument, as shown in the experiments by Barbosa and Lester and Boley, so far no suggestion has been made how to quantify this.

3. Research Approach

The main aim of the present research is to show the existence or non-existence of a relationship between the characteristics of a musical instrument or a group of these instruments and the musicians' ability to cope with latency by means of an experimental approach while music is performed in a non-collaborative way. For this, a quantitative research approach has been chosen.

In order to assure comparable conditions for each test subject participating in this experiment, it is important to confine and delimit some of the conditions, which are relevant for the research:

- All test subjects have to be musicians or music students. Data reliability could be assured researching a specific group of test subjects with similar characteristics,

- Research will be made on non-collaborative musical performances (performing music solo),

- Musical instrument classification follows to the Sachs-Hornbostel system (mainly chordophones, aerophones and membranophones.

Latency levels used in other publications are not standardised. Normally, there the range varies between 6ms and 200ms (Bartlette *et al.* 2010). Chafe (Chafe *et al.* 2008) utilised delays between 0 and 77ms. In (Schuett, 2002) the delay ranges from 0 to 100ms. In reference to (Chew and Sawchuk, 2004) here the delay was set from 0

to 300ms. It is important to notice, that delay's increase is not linear but in discrete steps.

Standardising the experiment conditions and allowing a more regulated set of parameters should enable a better hindsight with regard to the way musicians cope with latency during a performance.

4. Experimental Setup

The experimental setup includes a Digital Audio Workstation (DAW), an audio interface, a microphone and a visual or aural metronome. The microphone records the audio signal from the instrument and sends it back to the musician through headphones with an added latency. Special care has been taken in defining the requirements of the headphones in order to achieve acoustical isolation. The directionality of the microphone (polar pattern) facilitates the recording of the acoustical signal of each instrument. In this, it can be assured that the surrounding conditions are the same for all the test subjects.

So far, the amount of internal latency of the DAW and audio interface has not been measured in previous research, but it would be accurate to consider such quantity. In our setup we utilised a state of the art audio interface (Fireface 400), the sample rate for the development of the experiment was set to 48 kHz. The internal latency measured was approximately two samples (<42μs). The estimated internal latency value of the DAW remains the same during the whole experiment and is to be expected to be the same value for future tests under the same conditions.

Volume level for each test subject (mainly for every instrument group) can be adjusted according to prior testing and adapted depending on the instrument sound pressure level. The different amounts of BPM (between slow or Adagio 60 BPM and very fast or Presto 160 BMP) should be adjusted, so that it is not too easy for the musician to cope with delay due to different strategies e.g. phrasing, anticipating, etc. During performance the amount of delay (latency) introduced in their headphone mix (closed headphones) will be increased discretely. An increasing delay progression lasts until the performance is interrupted. Thereby, a performance interruption is defined as the time when continuous playing becomes impossible. Every musician is able to determine when the performance (continuous playing) is not possible anymore. This definition is important and establishes what should be considered a performance breakdown.

An outlined procedure of the experiment's milestones foresees:

- Non reverberant conditions provided trough closed headphones,
- Delay introduced with software,
- DAW template with standard parameters for all test subjects,

- Visual or aural metronome (bars and beats),
- A sound test for audiometry and time reaction could be embedded in the template,
- BPM values (80 to 200) and delay values (0 to 1000ms) based on previous tries,
- A survey to collect data before the experiment is defined,
- Score which fits well for all instruments (transposition, easiness of playing) is encouraged,
- Sessions are indexed by a code system to preserve subject anonymity.

Figure 2 shows the first score developed for the experiment. This score was tested with the violin and is also meant to be performed with all the other instruments. The musical intervals were chosen, in order to produce a pattern with different level of difficulty.

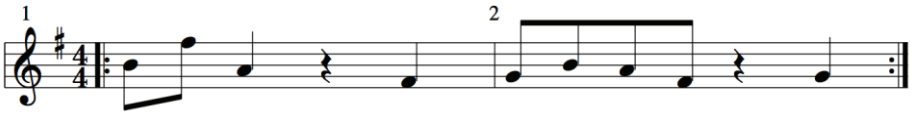

Figure 2. Score for violin

Important elements of the score are rests, 1/8 notes and their placement, demanding a more than novice level of musical skill from the performer. Although the notes may not be easy to transpose for each instrument, the time structure is playable with any instrument.

In this first attempt to develop the experiment setup, it has been shown that the majority of the issues and recommendations listed above could be embedded in a standard setup.

Figure 3 shows the experiment setup. The only invasive elements are the headphones and the microphone. It is expected from every test subject to perform the instrument in a seated position.

Figure 3: Experiment Setup

Readjustments with regard to BPM values (60 to 160) and the visual metronome regarded as (annoying and distracting) will be further developed. A metronome routed directly (aurally) to the headphones was preferred by the test subject. The metronome signal was not influenced by latency. Latency was introduced in 50ms increments.

5. First Results

Before running the experiment several times, some preliminary adjustments with regard to the volume level of the headphones and the microphone were made. The Sound Pressure Level (SPL) of the violin was measured as 98.5dB(C), the distance between microphone diaphragm and instrument body was 0.342m. The audiometry test was easy to implement and was helpful verifying the suitability of the test subject for the experiment.

Table 1 displays the first measured results.

Tempo BPM	Latency Tolerance Limit (ms)
60	≈225±25
80	≈200
100	≈175±25
120	≈150
160	≈125±25

Table 1: Experimental values Tempo (BPM) and Latency Tolerance Limit (ms) for the violin.

Figure 4 visually displays the values (or the averages) presented in the Table 1.

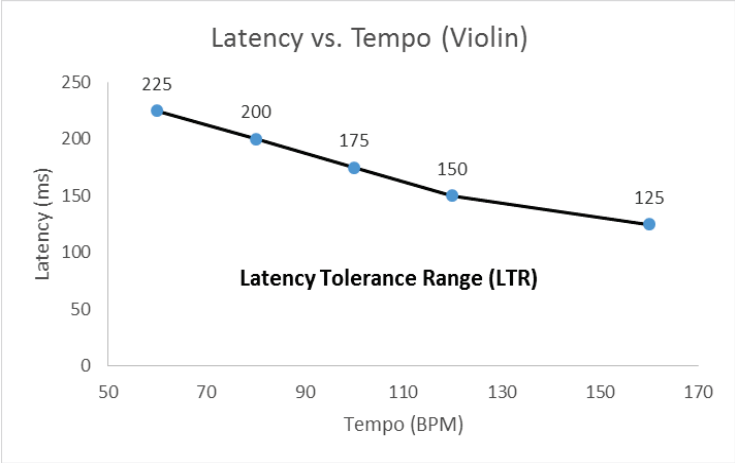

Figure 4: Latency vs. Tempo (violin)

The linear relationship of latency in comparison to tempo, similar to the research by (Barbosa, 2006), was confirmed by using a violin. The results are not statistically relevant (just one test subject), however is to be expected to find similar values (Latency Tolerance Limit) for different violin players. The values under the line (curve) are the range of tolerance. For describing this phenomenon, the new concept of Latency Tolerance Range (LTR) has been developed within the works of the research presented here. It is defined as the range within the instrument (in this case the violin) can be played without a performance breakdown due to latency.

For future experiments (including different test subjects and different instruments), results may show a normal distribution (bell curves as illustrated in Figure 5) for each group of instruments (aerophones, membranophones or cordophones). Similarity in the majority of latency values for any instrument within a group are expected as well as some outliers. Some non-measurable factors (e.g. mood, concentration, talent), were also observed during the performance. Any disturbing factor (e.g. visual metronome) was eliminated for further setups, though it is expected that such non-measurable factors would influence the outcome of the experiments.

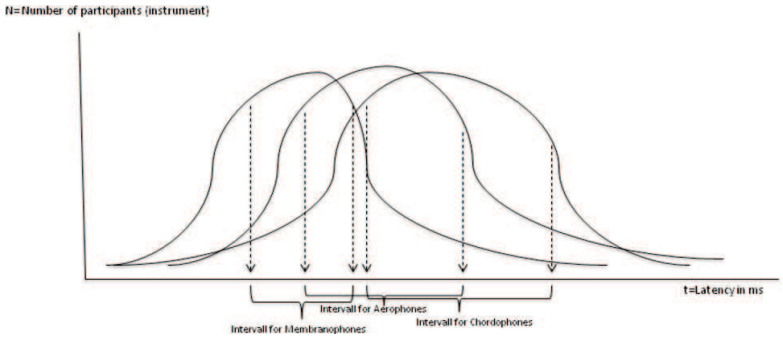

Figure 5: Expected Results

6. Concluding Remarks and Thoughts

In this paper an approach to quantifying latency tolerance ranges is presented. As a result, the inverse relationship of latency and tempo as observed by (Barbosa, 2006) was confirmed for a violin. In addition, the new concept of Latency Tolerance Range was introduced. Furthermore, the audiometry test, which is part of every experimental session, has proven to be a helpful tool for testing the reliability of each test subject's hearing capabilities.

The further development of the experiment is encouraged to avoid disturbing conditions, which may influence the results.

Overall, for each group of musical instruments, characteristic LTR curves are expected. Potentially, these results may serve as the basis for further research regarding solutions for coping with latency in non-collaborative musical performances.

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Designing for Play

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Abstract

This paper discusses the on-going research into using a play centred design approach for informal learning environments; the research is situated at Cork City Gaol, a visitor centre in Cork City. The paper introduces the concepts behind play-centred design taking into account three crucial areas; informal learning, play and games. We discuss the design process that is being undertaken at the gaol, focusing on current observation and dynamics of the museum. Finally, we reflect on the research so far and make recommendations for the future. This research locates itself within a context whereby the museum is perceived as an educational playground which takes advantage of new media technologies to extend a deeper interactive relationship between visitors and museum.

Keywords

Museum, Play, HCI

1. Introduction

In recent years there has been continuous growth in the research of interactive learning environments; science museums and heritage centres. Several factors have contributed to this situation. These include a change in the expectations of the museum visitor to encounter some form of interactivity within the museum space, and the change in the role from a passive to active participant. This is led partly by advances in multimedia technology, computers, and ubiquitous technologies, but is also influenced by a perceivable shift towards constructivist learning in interaction design, as well as changing strategies in exhibition design in contemporary museums.

Semper describes the museum as "an educational fair", an environment that teaches its visitors to play, because play is ultimately the basis of exploration, observation, discovery and experimentation (Semper, 1990). This connection between play and the informal learning environment, in this case the museum is what this research is exploring. Taking Semper's position into consideration and looking at the trend to have a more interactive museum experience, it could be surmised that exploratory play supports a more meaningful learning experience for some within museums when compared to other activities such as tours or presentation material that are prescribed by the museum curator. Play as it is discussed here should not be equated

with games where there may be a right and wrong outcome and a visitor learns the correct way to play; the value is in the act of play and playfulness, knowledge and learning are an outcome, but not the goal.

In the next section we will introduce and briefly expand on some key factors to be considered when designing for play. We also introduce the Cork City Gaol (CCG) where the research is being conducted, giving an overview of the current state of the gaol. Then we present our observations and findings and conclude with a discussion of future research.

2. Related work on Play

Here we provide some of the dominant perspectives within different disciplines on play and propose a deliberately broad and inclusive view. To do this and give context to the research we first attend to informal learning giving an overview of play theories, and differentiating between play and games including 'free play' and 'instructional play'. We will then move to describing some observations conducted in the Gaol.

2.1. Informal Learning

Informal learning can be defined as "…any activity involving the pursuit of understanding, knowledge or skill which occurs without the presence of externally imposed curricular criteria" (Livingstone, 2001). Typically, any learning that happens outside the classroom, workshop, training centre or similar environment. Informal learning relies on and is greatly influenced by our interaction with, exploration of, thinking about and reflection on the learning experience. (Dewy, 1938) It tends to be self-directed, relying heavily on personal experiences and often is impossible to distinguish a learning activity. Take the example of socialisation, the interaction of a young child and older adult. This is informal social and cultural training that is embedded within our everyday activities (Livingstone, 2001).

The museum is a prime example of an informal learning environment (Falk, 2004; Falk & Rielking, 2002; Hein, 1998). They grant unique opportunities for the visitor to explore and partake in self-directed learning; through interaction with artefacts, the physical space and the visitors around them. Dewey established that knowledge must be meaningful and relevant to the individual learner to be considered useful (Dewey, 1938). The learner constructs knowledge for themself, individually and in collaboration with others. In doing so, the learner constructs meaning from their experiences. To facilitate meaningful learning within the museum, it needs to encourage exploration and discovery, and construct meaningful learning by incorporating choice, challenge, control and collaboration (Paris, 1997).

2.2. Play

"Certainly everyone knows what play is not even if everyone can't agree on just what play is" – Gilmore, Barnard J.

To fully understand and utilise play in the design process one must try and narrow the concept of play. Many definitions of play have been put forward by psychologists, anthropologists, philosophers, historians and educators. There are also many misconceptions invoked by the word play. Rieber lists some of these as: only children play; play is easy; play is not an adult activity; adults participate in leisure activities not play; play is irrelevant. (Rieber, 1996) The following section endeavours to lay out some of the recent theories of play.

2.2.1. Caillois

Callois, in his seminal work, classifies play according to his four fundamental categories": agôn: competitive play, alea: chance-based play, mimicry: simulation or make-believe play, ilinx: vertigo or physically-based play (1962). Calliois combines these four categories into two more conceptual categories; paida: wild freestyle and improvisational play, and ludus: rule bound formalised play. His work is widely regarded as a reaction to Huizinga's original work, (Homo Ludens: A Study of the Play-Element in Culture) which tried to incorporate all play activities into one competitive form, agôn. He doesn't claim his categories to be exhaustive but that all types of play and games can be categorised between the extremes of paida and ludus.

2.2.2. Hirssch-Pasek and Golinkioff

Hirsh-Pasek & Golinkoff summarise play under four categories, not too dissimilar to some of Caillois' fundamental categories: Object play: exploring objects and their properties and often assigning them new functions as a result of the exploration. Pretend play: make-believe or fantasy play or symbolic play, where one takes on different roles through the act of make-believe. Physical play: this can be something as simple as peek-a-boo to wrestling with siblings. Guided play: play that is subtly guided by adults or someone leading the playful activity (Hirsch-Pasek, and Golinkoff, 2008). They also attribute the following characteristics to play: (1) it is usually voluntary; (2) it is intrinsically motivated; (3) it entails active engagement often physical; (4) it has a make believe quality; (5) it is generally pleasurable;(6) it has no extrinsic goals; (7) it is engrossing; and (8) it is often spontaneous.

2.2.3. Salen and Zimmerman

Salen and Zimmerman developed their criteria for play from the broad definition that "Play is a free movement within a more rigid structure" (Salen and Zimmerman, 2004). Play exists only because of the rigid structures in place and exists in opposition to them; it balances this opposition by using the existing structure and playfully inventing new ones. Take for example bouncing a ball against a wall; the player here is playing with structures such as gravity, the space and architecture, the physicality of the ball and their own skill. To play then is to test these structures and their limits and boundaries and ways of playing around and within them. From this broad definition they further group play into three categories: Game Play: a narrow category of predefined games, where there are set rules in place. Ludic activities: This includes games and all non-game behaviours often described as "playing".

Being playful: broadest category, not just playful activities but also includes the idea of being in a playful state of mind. An example they use to illustrate this playful state of mind is being playful with words through nicknames for friends.

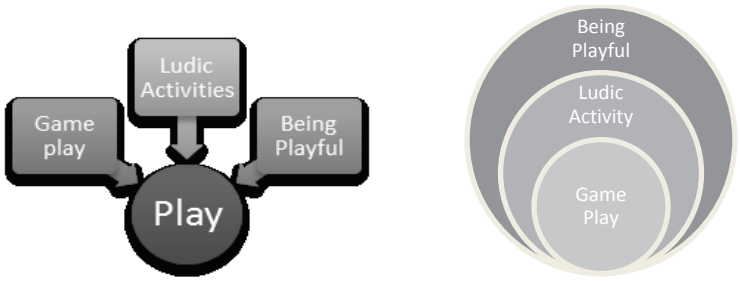

Figure 1: Salen and Zimmermans' criteria for play.

They also stated that after game play each of the categories is more open and inclusive; ludic activities includes game play; while being playful, incorporates both ludic activities and gameplay. Games in themselves are a subset of play and all play is not necessarily games.

2.3. Play vs Instructional Learning

It is necessary also to differentiate between instructional design and open-ended play. Stronmen argues that any interaction, playful or otherwise, that rewards "correct" or "right" responses are based instructional learning theories and not play. Instructional design does not promote the experimental and collaborative learning that comes from play and is in fact, at odds with the core elements of playful engagement (Stromen, 2004). Bradburne is critical of interactive exhibits in science museums; stating that they often resemble the traditional textbook with answers that both guide and limit the potential for deep exploration (2004). Our research does not aim to put in place games that produce correct answers and rewards but a space where the reward is intrinsic in the act of play and knowledge and learning is an outcome of play but not the goal itself.

2.4. Play and museums

Museums and play often can be seen as in opposition to one another and in no way compatible. Play and playfulness are often seen as fun, activity and entertainment while the museum is historically a more passive quiet and silent place (Hein 2002). The museum has many spoken and unspoken structures and rules in place. Some rules are implied; don't stand too close another visitor; don't run; don't speak to loudly. Some are explicitly stated, such as no flash photography. Two main points of view exist regarding the museum as an informal learning environment. First the museum is the teacher, actively directing and presenting the knowledge to you. Second is the museum as a place to learn where the choice and the power to determine their own learning experience are given to the visitor (Bradbourne, 2004). Historically museums assumed the role of teacher, but with the inclusion of a more active audience this is increasingly insufficient as a strategy in its own right.

Taking Salen and Zimmerman's definition above the museum then is an ideal environment for play to flourish. The question the current research is exploring is; how can we integrate playfulness into the museum structures already in place and how can this be achieved while still respecting the wider responsibilities of the museum to preserve cultural heritage.

2.5. Our criteria for play

Taking into consideration the various approaches to play outlined in section 2.2, the following criteria emerged as important:

- Play whether physical or virtual encourages exploration, observation, discovery and experimentation.
- It is nearly always pleasurable; it is active and not passive and requires the player's full engagement. You cannot simply observe play and say that you have played.
- It is a creative and often collaborative thing.
- The value of play is the act of playing. The player constricts their own meaning and value through the play experience.

These are the criteria that we regard as dominant in our approach to critiquing future development and prototypes.

3. Cork City Gaol

The work currently under development and presented here is situated in Cork City Gaol, Cork City. CCG comprises of two museums, the gaol and a radio museum, housed on the grounds of a 19th century gaol. The gaol opened in 1824 closing in 1923. It housed a diverse number of prisoners: well-known Irish Nationalists (Countess Markievicz and Frank O'Connor), the infamous Galtee brothers and many unknown locals arrested for a variety of petty crimes. After closing, the gaol was used as a radio broadcasting station, then as storage for the Department of Post & Telegraphs and became derelict until its restoration and reopening in 1993.

3.1. The Exhibition

The Gaol presents their information to visitors in one of several ways:

- An audio tour
- A booklet which is the text of the audio tour
- A map, which has short descriptions of the key points in the audio tour.
- A tour guide

The gaol is also populated by wax figures which link to stories within the audio tour they are spread out across the gaol. It is not a hands-on exhibit; most cells have barriers keeping the visitor apart from the contents of the cell. There is an on-going tension between the curatorial responsibilities to preserve the building and its

contents (the gaol is a listed building, an example of Sir Thomas Deane's work and an important part of Irish architectural heritage) while also engaging the visitor.

The Gaol's information, in its current form, promotes largely a reading and listening audience. There is little opportunity for the visitor to touch, explore, discover or experiment. There is a single "interactive" cell where the visitor is encouraged to go in, sit on the bed, shut the door and "experience life as a prisoner". This cell is the only cell without a barrier therefore allowing visitors to explore with more freedom.

4. Methodology

To this point the research adopted a *grounded* approach to help expose dominant behaviours within the space. As with other museums the CCG is host to many different kinds of visitor. For example, at any point a bus might arrive at the museum with mostly family groups or couples, and at other times a school trip would inject a different kind visitor into the space. The range of visitor types meant that some initial observations were used to help filter the visitor activity in the space. The goal of the observations is to identify some initial patterns of visitor behaviour and identify areas where these patterns can be further explored. Following the observations the next stage was to introduce interventions within the space enable further examination of the initial patterns observed. The next sections will outline the initial observation process and preliminary findings.

4.1. Observation

The observation looked at several aspects of visitor's behaviour. Specifically, it focused on where the visitors where going and how long they were spending in a particular area. Visitor time was compared against the time it took to complete the audio tour in each observed section. The observations were situated within the Western Wing Cell block, see figure 4 below. This was decided after initial uncontrolled observations which seemed to indicate that the majority of a visitor's time was spent in this particular section.

Observations extended over several weeks, usually 2-3 hours per visit. It covered peak and off peak times at the gaol and a multiple of visitor types. The observations took a naturalistic approach using field notes and observation sheets, and taken at a distance so not to intrude as much as possible. They were documented with photographs and some video documentation.

We will now describe visitor types and what patterns we saw emerging within the observations.

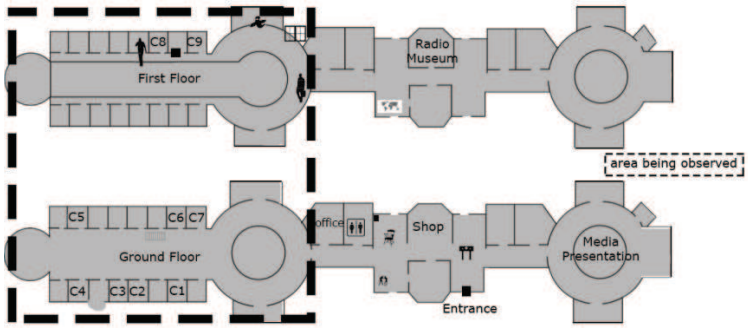

Figure 2: A map of the gaol with open areas marked, the area observed is highlighted.

4.2. Visitor Types

For our observation it was necessary to be able to differentiate between different user types. After preliminary, unstructured observations three distinct types of users became obvious; those that used the audio guide, those that didn't and those who were part of a tour group. The role of the average visitor in the gaol seems to be that of a passive observer, there are few obvious opportunities for the visitor to go from passive to active.

4.2.1 Patterns

The audio tour for the Western Wing lasts 18.5 minutes; on average, a visitor stayed 14.5 minutes; one minute less if they came by themselves or as part of a pair. Visitors tended to strictly follow the path as set out by the audio tour, tour guide or map. Visitors that did enter the cells spent on average less than one minute in each cell. Others did not venture into the cell at all, but just glanced inside. It seemed the visitor initially was engaged with the gaol (the architecture and the individual cells) but quickly interest waned; this showed an increase in the drop-off rate of visitors going into cells. In figure 5, a spike in the number of visitors entering the 6th open cell floor is seen; this could be linked to the content of cells C6 and C7 and how the content is presented. Both cells contain graffiti from inmates and are some of the only cells that a visitor cannot see the contents from the doorway; the graffiti is covered by a glass wall to protect it and often there is a glare, forcing visitors into the cell for a closer view. However C7 that also held graffiti was often neglected, 33% of visitors bypassed it completely. We could speculate about why the visitors lost interest in the cells; possible the narrative content of the tour; or a lack of engagement with the stories being told; future observations and interviews with visitors after a visit would give more definite data on this.

We observed visitors using the map often started with any cell, but quickly made their way back to the order that the cells are presented in. (The map follows a numbered route that is marked above each cell door.) Other visitors had a tendency to wander off the set tour path and explore the space freely, however most seemed to re-joining their original group/pair before moving on to the next area/cell. This

behaviour appeared to be affected by a visitors' waning engagement coupled with overcrowding of cells at busy times and having to wait for other groups to exit a cell. Exceptions to this pattern were family groups or young children, who wandered in no specific pattern.

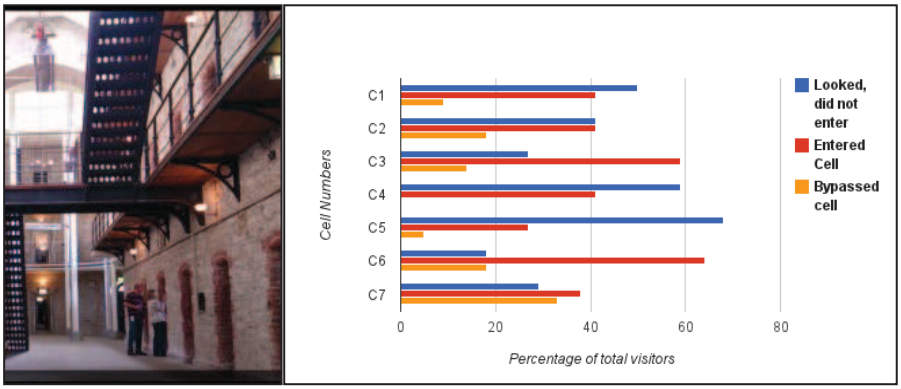

Figure 3: The left shows visitors engaging with the space, notice the couple on the right who do not enter the cell. The right shows the percentage of visitors stopping, entering and bypassing cells.

This wandering could be seen as an opening for playful open-ended interaction with the space, it is also one of the more interesting patterns to further explore. The visitors seem to be unfocused and unguided and potentially in a better position to explore the space more imaginatively. At certain points the audio guide allows for the visitor to stop the tape and to explore, yet our preliminary observations have showed that many visitors using the audio tour were not using the tape in this way. The observations also noted some technical difficulties visitors had with the handheld cassettes which might have reduced their engagement with the content as they attempted to stay synchronised with the exhibit.

It appears from the initial observations that the space does not foster exploration discovery or experimentation. Only 4% of all visitors ventured to look into an unopened cell, or try the door of a closed cell. It is also not apparent that visitors are engaging with the cells. The visitor path seems to be linear and methodical, with little or no exploration afforded by the current audio tour and map. The visitor then tends to be a passive observer, not an active one. The audio tour seems to be actively discouraging interaction between visitors, limiting playful activities; exploration, discovery and experimentation. Participating in a tour group tends to encourage questioning and opens up the ideas of exploration and discovery in some limited way. While the data from initial observations is limited in its scope it has begun to highlight areas of interest for further research.

4.2.2 Current Work

The work done in the gaol this far has also incorporated experimental design methods which have taken the form of new media interventions in the space. These are focussed on effecting visitor engagement. In one example a video screen was

placed behind the spyhole of a cell in such a way that it could only be found if a visitor happened upon it. Observations in the space made note of places along the

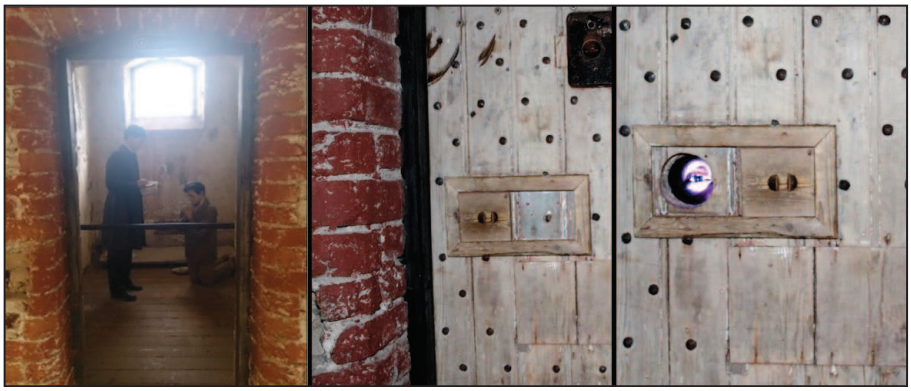

Figure 4: from left to right, an example of an open cell in the gaol with barrier and wax figures, the sensor activated spyhole in a closed state which with no indication of media content behind it, the spyhole in an open state, a Pure Data (PD) patch recorded the interactions with the hatch to a hard drive inside the cell.

audio tour that were invisible to visitors who chose to concentrate on the content of the audio tour. It was also noted that other visitors became disengaged with the content on the audio tour and began to 'wander' and these visitors then appeared open to exploration and discovery. As such we began to see points along the tour which were suitable for developing alternative narratives that could be made 'discoverable' for visitors who had become disengaged with other content provided to support their visit. We refer to these points as 'narrative holes' because they are places where a disengaged visitor's interest can be retriggered with alternative narrative content. It was noted that visitors who did discover the video behind the spyhole became animated and reported it to others in the space. They also appeared to become alive to the possibility that other media content might be available for them to discover and began checking other spyholes that had not previously been looked at. Currently the visitor sample size is insufficient to determine the impact of such interventions but some initial observations might indicate interesting possibilities for future work.

5. Conclusion

Our observations so far have highlighted the tendency of visitors to adopt a passive role in response to the gaol and the media provided to support their visit. Since we are motivated by encouraging 'playful exploration' and 'discovery' within the space the research will concentrate more intensely on developing design prototypes that will allow us to examine how best this might be achieved. While the spyhole prototype provided some clues as to how we might proceed we also need to establish tighter controls for collecting data from visitors when encountering our interventions in the space. While the spyhole was programmed to digitally record interactions people had with it, a broader suite of data collection methods and tools will need to support the next stage of the research enquiry. We also recognize that to do this

effectively a clear set of design principles, incorporating appropriate concepts of play, will need to be established to help guide the process.

6. Acknowledgements

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Computational Aesthetic Measures for Evolutionary Computation based Web Design

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Abstract

This paper introduces a novel tool for creating website colour palettes automatically using evolutionary computation. The aesthetic measures, colour contrast ratio (CCR), colour brightness (CB) and colour difference (CD) are used as a fitness function to check text/background colour combinations. Three different types of experiments were conducted to test colour combinations generated by our system. In the experiment 1 and 2 a readability test is performed to evaluate the colours created by 52 different users against system generated colours. The results showed that system colour palettes are ranked more highly than human selected colour palettes. In experiment 3, four well-known websites were taken to test their colour combinations with our system colours. This test is to compare the colours created by experienced web designers with our system generated colours. In less than one minute, our system generated colour palettes similar to designer colour palettes. Based on our experiment and results, our evolutionary system demonstrated that it possible to generate text/background colours automatically for readability and high aesthetic appeal.

Keywords

Website, Colour Palette, Evolution, Contrast Ratio, Aesthetic Measure.

1. Introduction

Nowadays, creating a website is easier than it has ever been. There are any numbers of dynamic website building tools available for this purpose. Individuals that do not possess proficiency in computing or in website creation can, in a few simple steps taking no more than a few minutes, build a professional looking website with basic functionality. The development of business or e-commerce websites however remains a more complex process involving decisions about the websites function e.g. whether to be an initial point of contact and a source of information for customers or to be a fully-fledged online store. Regardless of such business decisions and their design consequences, if the chosen website design template is incorrect or inappropriate then it will impact the site's aesthetic appeal. For high-end website design and implementation there are powerful website development platforms available (1&1, 2013) (Wordpress, 2003) that assist trained developers to build effective websites. A key feature of these tools is functionality that allows developers to choose from premade website templates that are often categorised e.g. business, e-commerce, education or personal sites.

A template is a hardcoded website "container" created by a web designer that is used as the basis for creating an actual website. A template's characteristics generally include a pre-defined style that incorporates a colour palette, theme, contains default

images, font style, pre-defined navigation sub-system and so on. If a user wishes to customise the colour palette themselves, he or she may run into difficulties in identifying the right colour combinations based on the main colour selected for the website. For example, the inter-relationships between background image colours with foreground colours, *text*, *links*, *buttons* etc. dictates the overall readability and look of a website.

Colour combination is an important topic that requires the combined efforts of both theoretical and experimental analysis by the research community and input from talented and experienced website designers. For example, a good contrast level between colours makes it easier for users to distinguish text from background and is a critically important parameter for users who suffer from colour blindness. Many tools exist to check contrast levels (Colourspire, 2013), (The Paciello Group, 2013). Most involve a manual process where the user or designer has to check and adjust colours one by one to find a good combination of matching colours. This is a significant undertaking when a full colour palette for a complete website is required. Figure 1, gives an example of the components that go to make up a typical colour palette used in a website template.

Figure 1: Template describing website colours

In this work we explore the use of automated approaches to finding effective colour palettes and we describe the implementation of a tool that recommends the relevant colours for the whole website automatically. This will assist web-designers and end users in creating their own colour palettes for websites more easily without requiring them to check the contrast level or the suitability of colour combinations. With just one main theme colour or an image as an input, our tool creates the remaining colours for the website template.

2. Related Work

The citations that follow suggest that much research to date has been focussed on investigating how to find the best colours palettes for websites that influence the users experience in terms of readability, time spent, fatigue, aesthetic and a desire to revisit the website.

Recently, Hussain and Hussain (2012) determined that colour contrast factor has great impact on readability. A survey conducted with forty members of various age groups found that poor contrast between the text and its background colour affected readability. Interesting and surprising results were found in Hall and Hanna (2003), which is a survey that found users tend to prefer various different colour combinations rather than achromatic colours (black and white). Based on these

survey results, the authors suggest using chromatic colours, which have hue, for e-commerce websites and traditional colour combinations, black and white, for websites that mainly promote education. Similarly, Pelet and Papadopoulou (2009) suggests that colour components such as hue, brightness and saturation on the e-commerce website pages impacts consumer memorization and buying intentions. Results showed that using chromatic colours with certain brightness and saturation rates helps consumer's recall and increases their buying intentions when compared to standard white and black backgrounds. Also, Camgöz et al. (2002) suggests that hue and brightness in colour combinations can encourage users to re-visit a website and encourage them to make purchases. Buchner and Baumgartner (2007) experimented with the user experience of searching, reading and understanding website content when 5 different background colours, white, blue, red, green and yellow were used. Their survey results showed that users spent more time on white, blue and green backgrounds for reading the content than red and yellow background colours. It was also observed that searching and memorizing the content of a website with a white background colour is more efficient, involves less fatigue and is less irritating for users than other background colours.

The objective of most of the cited researchers is to try and find colour combinations that make it easy to distinguish text from the background. Colour contrast is therefore an important factor to consider while developing colour palettes. There are some interesting semi-automatic tools available for web designers to check the contrast ratio between two colours.

In (Colour Scheme Tools, 2008), users can select the colours manually from the colour wheel to see their combinations and contrast ratio values instantly. A sample of a text block is shown to the user to give an impression on how the selected colours would look on actual web pages. There is also an option to select similar schemes that are generated interactively by the tool based on the chosen colours. Similar tools that are available to create professional colour palettes for websites include (Accart, 2013), (Snook, 2005), (Annika, 2013), and a browser plugin (Rumoroso, 2009). With all these tools, users can only check a pair of colour combinations by manually tuning to get a better contrast ratio. This takes up designer time that could better be spent doing other tasks. There is no such tool available that can dynamically generate a complete CSS colour palette that also performs colour contrast ratio checks to ensure easy readability.

3. Methodology

We implement a tool that uses an evolutionary computation (EC) process to generate colour combinations automatically without the need for user intervention. According to Black et al. (1997) EC solves problems via an evolutionary search on a population of randomly generated individuals, colour palettes in this case, over a number of generations, whereby successive generations of individuals are selected via a fitness evaluation. The fitness evaluation is a key aspect of the search heuristic and is commonly based on an objective measure within the domain of interest, which in this case is the colour contrast ratio between any two colours. During the process,

colour contrast is checked against the users preferred colour or a user specified image and generates the remaining best matching colours.

3.1. Aesthetic Measure

We used colour guidelines techniques and formulae are provided by (WCAG , 2013) which is recommended by (W3C, 2013) as our aesthetic measure to check the colour contrast ratio levels, colour difference and colour brightness between the participating colours. This is our main fitness function, and the ranking of the best colour combinations are done according by the following tests:

3.1.1. Colour Contrast Ratio (CCR) Test

CCR is a ratio between the relative luminance between lighter and darker colours. Here, the luminance ratio is calculated between the background colour and the foreground colour using the CCR formula (WCAG G17, 2013) for larger text and (WCAG G18, 2013) for smaller text, as shown in Equation 2.

$$L = (0.2126 * R) + (0.7152 * G) + (0.0722 * B) \tag{1}$$

if(R_{8bit}/255 <= 0.03928) *{* *R = R_{8bit}/255/12.92 ;* *} else* *{* *R = ((R_{8bit}/255+0.055)/1.055) $^{2.4}$* *}*	*if(G_{8bit}/255<= 0.03928)* *{* *G = G_{8bit}/255/12.92 ;* *} else* *{* *G = ((G_{8bit}/255+0.055)/1.055) $^{2.4}$* *}*	*if(B_{8bit}/255<= 0.03928)* *{* *B = B_{8bit}/255/12.92 ;* *} else* *{* *B = ((B_{8bit}/255+0.055)/1.055) $^{2.4}$* *}*

Table 1: Evaluating RGB values for Luminance ratio

Using the Equation 1, Luminance ratio is calculated as shown in Equation 2. Where, *L1* is the relative luminance of the lighter foreground colour, and *L2* is the relative luminance of the darker background colour.

$$Luminance\ Ratio = \frac{L1 + 0.05}{L2 + 0.05} \tag{2}$$

3.1.2. Brightness Difference Test

Brightness difference (BD) is tested to determine the variance of brightness between the two colours using formula provided by (WCAG Guidelines 2, 2013) as shown in Equation 5.

$$C1 = \frac{\big((R1 * 299)\big) + (G1 * 587) + (B1 * 114)}{1000} \tag{3}$$

$$C2 = \frac{\big((R2 * 299)\big) + (G2 * 587) + (B2 * 114)}{1000} \tag{4}$$

$$\Rightarrow BD = \mathrm{Max}(\mathrm{C1}, \mathrm{C2}) - Min(C1, C2) \tag{5}$$

3.1.3. Colour Difference Test

Colour difference is determined by summation of the difference between RGB levels of two colours. With colour1 (*R1, G1, B1*) and colour2 (*R2, G2, B2*), the colour difference is calculated using formula provided by (WCAG Guidelines 2, 2013) as shown in Equation 9. Ranking a pair of colours in our evolutionary system is based upon the results against to CCR, BD and CD as shown in Table 2.

$$RedD = Max(R1, R2) - Min(R1, R2) \tag{6}$$

$$GreenD = Max(G1, G2) - Min(G1, G2) \tag{7}$$

$$BlueD = Max(B1, B2) - Min(B1, B2) \tag{8}$$

$$Color\ Difference(CD) = RedD + GreenD + BlueD \tag{9}$$

Colours	CCR		BD	CD	Rank
	Smaller text	Larger text			
Smaller Text **Larger**	Fail	Pass	Pass	Fail	3
Smaller Text **Larger**	Fail	Fail	Fail	Fail	4
Smaller Text **Larger**	Pass	Pass	Pass	Pass	1
Smaller Text **Larger**	Pass	Pass	Pass	Fail	2

Table 2: Results of colour combinations after applying aesthetic algorithms

3.2. Process

The concept of this application is to let user decides the main background colour or an image for the website and then the rest of the colours are generated automatically using our evolutionary computation system guided using the aesthetic measures defined above. The user interface (UI) contains a predefined set of 12 website templates with randomly generated colour palette as shown in Figure 2.

Figure 2: UI showing initial generation

The user initiates the process by simply selecting a single base theme colour or an image using the user interface. If an image is selected, then the average pixel colour of that image is calculated and taken as its base colour. The machine-learning algorithm then runs in a loop a number of times until the right colour combinations are found. More details of the evolutionary algorithm used can be found at Walsh

and Gade (2010). When the system terminates a selection of 12 aesthetically pleasing colour combinations are ranked and are presented to the user, as shown in Figure 3.

Figure 3: UI showing Final generation

4. Experiment and Results

4.1. Experiment 1: Interactive test between user and automatic system

In the *user* selection mode, a base colour or an image is selected by the user and then the rest of the colours are matched by them *manually* using an user friendly interface as shown in Figure 4. The user sees the impact of the colour combinations instantly, and when needed they can go back and change selected colours any number of times if required. In the second part of the experiment the user simply chooses a single base colour and then the system will take over the control and will automatically fill up the template with colours by itself based on computational aesthetic measures, colour contrast ratio, colour brightness and colour difference.

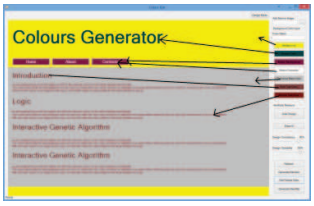


Figure 4: Interface showing how to select colours

A survey is then performed to let user decide which results are more pleasing to them using the conditions of colour combinations made the text, easy to read, easy to study, pleasing to look, stimulating to the eye and to be professional looking. We carried out this experiment with 52 users. Among them, 57% agreed that the EC generated colours are more pleasing in terms of colour combinations against to their *own* selected colour palettes. The average time taken by the user to manually select a partial set of colours for a real website was 2 minutes 45 seconds whereas the system found colour palettes in less than 30 seconds. For just seven colours, users were confused and reselected the colours a number of times before they were satisfied with the look and feel of the website. When the actual number of required colours was increased in the colour palette, there is a high probability that the user will spend more time re-adjusting colours for the whole website. Moreover the colours the user selected were not optimal and deviated significantly from the W3C

recommendations, where as our system produce substantially better palettes, see section 4.2.

4.2. Experiment 2: Preference of colours made by System and Users

With all the palettes produced by the users in experiment 1, a comparison test was performed with users to allow them to select the preferred template i.e. one filled with system colours and the other with user colours. There is no indication to the user which is the system and the user generated colour. Their position on the display given to the user is shuffled each time the user selects the template from the interface as shown in Figure 5. Depending on the user's patience, a minimum 10 to a maximum of 30 samples are given to the user where they are asked to rank the best template.

Figure 5: Comparison Interface test between System and User websites

Out of 52 users, 69% ranked the website with colours generated by the EC system as the one they liked more and the remaining 31% is ranked the website filled with colours created manually by users. Chart 1 gives the survey results in percentage of selection made by the users.

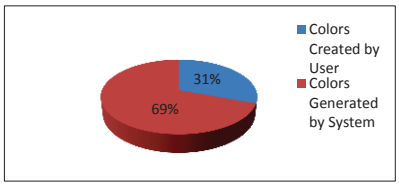


Chart 1: Most selected websites between system and user

In each individual trail, EC maintained the fitness value closer to the limit suggested by WCAG than to the value generated by the users. Chart 2 gives an average colour difference value achieved between the system and users. The required value suggested by WCAG (WCAG Guidelines 2, 2000) for colour difference should be greater than or equal to 500. Chart 3 and Chart 5 shows comparison of an average contrast ratio fitness value for smaller and larger text. Recommended ratio by WCAG for smaller and larger text is 4.5:1 (WCAG G18, 2013) and 7:1 (WCAG G17, 2013) respectively. Brightness difference average fitness value between user and system is shown in Chart 4 and the limitation for that fitness score given by WCAG (WCAG Guidelines 2, 2000) is 125. This shows the effectiveness of the EC system as it is significantly better in all four of these test.

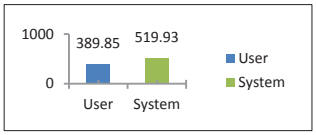


Chart 2: CD fitness test

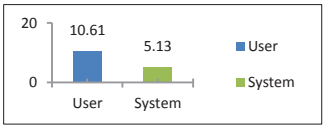


Chart 3: CCR test for smaller text

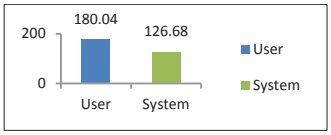


Chart 4: BD fitness test

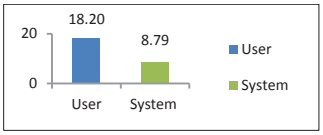


Chart 5: CCR test for larger text

4.3. Live Website Comparisons

Real world websites colours, (Stanford University, 2013), (CERC, 2013), (AIB, 2013), (Ryanair, 2013) were taken as a comparison set to test and compare the colours generated by our system. This experiment is performed to check our system capabilities against experienced artistic web designer skills, in terms of their colour selection for a website. The EC system automatically generated website template colours matching the colours of existing real world websites as shown in Table 4. While the evolutionary system found optimised colours for every run, we ran the experiment a number of times to get the output that best matches the choice of the designer. Experiment trails are recorded live and uploaded over YouTube website, see (Trails YouTube, 2013), showing real-time trails with their best solutions. As can be seen in the trails, aesthetically pleasing colours can be found automatically in a few minutes in total for all runs. It can take a human user many hours of trial and error to find optimal schemes.

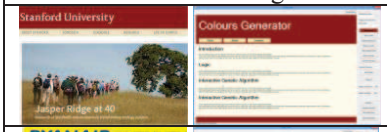
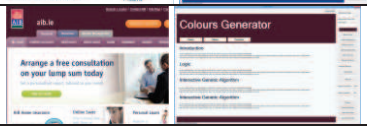
Live website Vs Auto generated	Runs	Live website Vs Auto generated	Runs
	2		5
	4		6

Table 4: Comparison of colour palettes with live websites

5. Conclusion

Even for the two colour combinations, there are no tools available to automatically find good colour contrast levels. Current tools offer templates and controls for manually selecting palettes. In this paper, we introduce the first tool that will generate a colour palette for websites, with proper CD, BD and CCR levels automatically. Based upon the results from experiment 1 and experiment 2, it is shown that our tool is capable of generating the right colour combinations for users to read and understand easily. From experiment 3, we demonstrate that our tool can

generate similar colours to what graphic designers had generated for well-known and highly popular web sites. "*Colour is a big part of any website's overall message, image, and feel*" Kaminski (2006). So for example, using our tool, end users could simply select one main base colour depending on their intended web site mood and the rest of the colours would be generated automatically. So far, we have implemented seven CSS components for the website design and in our future work.

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A Review of Relationship Classification of Object to Object Communication in the Internet of Things

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Abstract

In this paper methods of classifying relationships of object to object communication are proposed for Internet of Things research. The World Wide Web is a network linking digital information. The Internet of Things is a network that links and relates digital information to real world physical items. This network will evolve a hierarchy of control between things where a thing may be controlled but will also be a controller depending on the situation. There is therefore a need that this relationship be classified dynamically based on interactions taking place and data flowing between objects. The techniques investigated here are reality mining, graph analytics and artificial neural networks.

Keywords

Internet of Things, Reality Mining, Graph Mining, Neural Networks, Smart Objects

1. Introduction

The Internet of Things (IoT) envisions a world where things are tagged and communicating through a self-configuring wireless network of sensors. This is a virtually linked world in which every object is numbered, identified and providing information and the relationships that are uncovered form a digital real-time mirror of the physical world. To operate the IoT will need sensors which will measure physical changes in the environment and also the fast and cheap means of automatically identifying objects at a distance and without a line of sight provided by radio frequency identification (Gonzales, 2008). For the purposes of this research radio frequency identification (RFID) is a near field communication technology that registers if a thing is present or not by generating time-stamped logs pertaining to an objects position in relation to antennae. Automatic identification technologies such as RFID are fundamental players in the realization of the Internet of Things because they enable physical objects to be linked with their virtual identity on the Internet (López et al, 2013). In August 2013 the Internet of Things was added to the Oxford Dictionary as "a proposed development of the Internet in which everyday objects have network connectivity, allowing them to send and receive data" (Oxfordictionaries.com, 2013) and there are dozens of international events and conferences which include this topic among their coverage (Vazquez et al, 2010).

It is predicted that the world will have sixteen billion connected devices by 2020. An initial outcome of this many connected devices is the volume of data that will be generated. It has been forecast that the Internet of Things could result in consumer related IoT message volumes reaching between 1,000 and 10,000 per person per day (CIDS, 2013). The massive scale of data residing in the Internet of Things is orders larger than the current internet (Gonzales et al, 2006). As a retail distribution centre may generate many million readings per day ,information which will be useful is hidden in terabytes of data of low-level RFID readings, making it difficult for data analysts to gain insight into the set of interesting patterns influencing the operation and efficiency of [systems] (Gonzales, 2008). The worth of RFID is therefore intrinsically linked with the ability to mine data (Hanebeck, 2004).

Software to aggregate and analyse data must improve to the point where these huge volumes of data can be absorbed by human decision makers or as is the focus of this project, synthesised to guide automated systems more appropriately. There needs to be a way of classifying these relationships in the IoT. For the IoT to be realised novel fusion algorithms need to be developed to make sense of the data collected. State-of-the-art nonlinear, temporal machine learning methods based on evolutionary algorithms, genetic algorithms, neural networks, and other artificial intelligence techniques are necessary to achieve automated decision making (Gubbi et al, 2013). The European Research Cluster on the Internet of Things (IERC) outlines in their strategic research roadmap that intelligent approaches to knowledge discovery and device control will also be important research challenges (Vermesan et al, 2013).

2. Reality Mining

Relationships between smart objects in an IoT network may exhibit similar properties to humans interacting in a social environment (Doody and Shields, 2012).

Finding data on which to model Internet of Things systems is difficult due to the importance of such data to rival businesses. Object movement and related data is valuable business information and companies may be very reluctant to put their data in a shared central warehouse (Wu et al, 2011). This means a preliminary study of Internet of Things systems will be influenced by the data sets available. This project will study data from Nathan Eagle's Reality Mining dataset (Eagle and Pentland, 2006). The Reality Mining project (one of the largest mobile phone projects attempted in academia was conducted from 2004- 2005 at the MIT Media Laboratory. This experiment diverged from established data mining and transformed the social sciences by introducing the possibility of analysing massive amounts of machine sensed digital environmental data pertaining to human social behaviour. The reality mining research agenda exploited the increasingly widespread use of mobile phones to provide insight into the dynamics of both individual and group behaviour.

Opening social network analysis to new methods of stochastic modelling was a new area of research and proved to be a powerful analytical paradigm. Before this thesis, research had been done on static networks like predator-prey relationships and collaboration networks in which edges are forever fixed rather than dynamic

connections (Eagle, 2005). By leveraging recent advances in machine learning [it was possible to build] generative models that can be used to predict what a single user will do next, as well as model the behaviour of large organizations (Eagle and Pentland, 2006). To date little work has been done in applying these techniques to smart objects.

The idea of entropy or randomness is inherent in human social networks and this is likely to hold true for IoT networks, the entropy of a smart object may be used as a metric that can be quantified for a smart objects existence (Doody and Shields, 2012). To model entropy, the predictability of behaviour in an individual, the reality mining experiment used principal component analysis to show that a subject's behaviour can be approximated with 90% accuracy using only six primary eigenvectors. These eigenbehaviours are the eigenvectors of the covariance matrix of behaviour data, heavily weighted vectors that generally represent a type of repeated behaviour, such as sleeping in late and going out on the town. This method, spectral analysis on graphs using top k eigenvalues and eigenvectors is a crucial technique with many applications including SVD (Singular Value Decomposition), dimensionality reduction, triangle counting and community detection also used in the truly Big Graphs i.e. the 6.6 billion link YahooWeb (Kang and Faloutsos, 2013).

To exploit location data the reality mining methodology incorporated dyadic inference. This technique combined proximity information with temporal and contextual information and it became possible to infer relationships between members of a given dyad (Eagle and Pentland, 2009), "Moving from individuals and dyads to teams and organisations, we compare the proximity patterns between different research groups and quantify how the aggregate behaviour of the organization reacts to external stimuli such as a deadline" (Eagle, 2005). Knowledge of the shared context of smart objects may provide insight into the nature of their association; smart objects' true power arises only when multiple objects cooperate to link their respective capabilities (Kortuem, 2010). Applying techniques developed to understand human relationships to the Internet of Things will allow for the identification of patterns and interactions between smart objects, yielding with them new ways of seeing the world.

3. Graph Mining

Graph mining refers to a class of techniques that either use graph models to solve a problem or to analyse and exploit the inherent graph structures of a problem. This research is concerned with structural algorithms that analyse and exploit different topological properties of a graph as well as using visualization not only as a presentation tool, but as an analysis tool. Formally, a graph $G= (V, E)$ is described using a set of vertices V and the edges E that connect them. The number of edges can increase quadratically with at most V^2 edges. Each edge is a pair of vertices with a source and a target. $E = (V_{source}, V_{target})$. The Reality Mining network consists of 96 vertices and 1,086,404 edges (Kunegis, 2013).

Graphs provide perhaps the most fundamental understanding of communication. For a big set of actors, any time the actor interacts with another can be modelled as an edge. This paradigm in its simplicity can capture the behaviour of lots of different systems. Objects therefore, and the relationship between those objects is the most fundamental understanding of a system. The relational data model has tables in its records and attributes but even this has a modicum of complexity with records having schema. Graphs are in effect the lowest common denominator data model of objects and relationships (Howe, 2013) that can be applied to IoT systems.

3.1. The Basic Metrics of Graph Analysis

Most studies examine the nodes' degree, that is, the number of edges incident to each node, and the distances between a pair of nodes as measured by the shortest path length (Han and Kamber, 2006). The Reality Mining dataset forms an undirected network in which multiple edges may share the same end vertices. A random graph where vertices are connected to vertices at random would have an exponential distribution; however in practice human generated data has a power law distribution or Zipf distribution. Nathan Eagle did not discover a power law when he presented his thesis on this data "The broadness of the measured distribution of the persistence of edges is notable; however it is not so clear as to be a power law, as is often found in human systems" (Eagle, 2005).

Exponential Distribution	Zipf Distribution
$n(d) \cong c(\frac{1}{2})^d$ generally cx^d for some $x < 1$	$n(d) \cong \frac{1}{d^x}$ For some value $x > 0$

Table 1: Distribution Metrics

Zipf distribution looks similar to the shape of exponential distribution but with a fatter tail with x in the exponent (Newman, 2006). The Reality Mining dataset would be expected to have a Zipfian power law distribution with subjects favouring already well connected edges or in the case of the dataset or internet more popular people or websites.

3.2. Network Classification

Within Graph analytics are graph structural algorithms, commonly known as network analysis algorithms. These analyse symmetric and asymmetric relationships between networked entities by exploring the structure of the underlying graph. These networks can be structurally classified into the following categories.

Small-World Networks In these networks most vertices can be reached from each other in a small number of steps. The small-world network is a type of digraph in which the distance between any two randomly chosen vertices grows proportional to the logarithm of the total number of vertices in the network. In other words, in the

small-word network, most vertices may not be directly connected to each, but they can be reached from each other in a small number of steps (Watts and Strogatz, 1998). These graphs exhibit vertices (hubs) with large degrees (connectivity) and sub-networks with high clustering coefficients. (Bordwekar et al, 2011).

Scale-Free Networks In the scale-free network, the degree distribution follows the power law (Barabási and Albert, 1999). Vertices with low degrees are a part of a dense sub-graph which is connected via a high degree of nodes (hubs). Many small-world networks exhibit scale-free properties, but there are scale-free networks that do not have small world properties.

4. Artificial Neural Networks

Within machine learning artificial neural networks are one toolset that have proved particularly valuable in pattern recognition problems and are likely to prove valuable here too. Neural networks provide a methodology to learn from scenarios with quite possibly biological fidelity, that the human brain and humans have generally found too time consuming or difficult to explicate. These and have recently been supervised and trained to translate languages in real time (Markoff, 2012) as well as learn unsupervised to identify human and cat faces (Le et al, 2012). It should be noted here that the first successful attempt at facial recognition was done by training eigenvectors (Turk and Pentland, 1991) and conducted by Alex Pentland who is co–author of much of Nathan Eagle's work. Neural networks can be understood as combinations of additions and multiplication repeated many times and their processing of data is like biological neural networks, unintelligible and evidently workable. This project will investigate their possible usefulness here. It may even transpire that as in optical character recognition, ANNs are the best practical solution to the problem. Artificial Neural networks at the very least may prove their worth in obtaining an efficient and relatively accurate algorithm within a short time-frame, without a need for vast specialist knowledge and investment.

An artificial neural network is a computational model for information processing based on complex parallel interconnections of simple neurons. They are based loosely on the operation of the brain by modelling simplified versions of real neurons and synapses. The most common class of ANNs are feed-forward networks in which there are multiple layers of nodes connected in a directed acyclic graph. The first layer contains the input nodes while the last contains the output nodes. In between, there may be zero or more hidden layers. Input values are propagated through the network from the input layer to the output. Associated with each inter-node connection is a weight. Values passing along a connection are multiplied by this weight. Each node in a layer receives a value which is the sum of its inputs and performs a simple computation on it. A typical computation might be a sigmoid or tan-sigmoidal function This project will use neural network software to test different types of networks such as feed forward and recurrent neural networks, different sizes of hidden layers and different initial weighs.

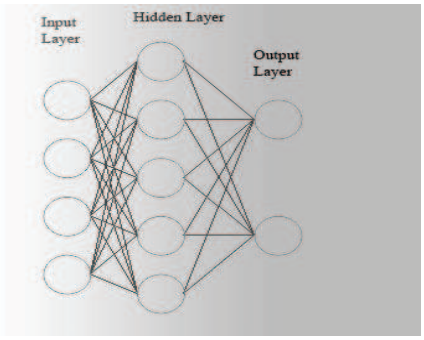

Figure 1: Structure Typical Feed forward Neural Network with Hidden Layer

The computation that a neural network evaluates is therefore defined by the combination of the network architecture and the set of weights. Selecting the optimal architecture and the weights is the key to solving a given problem. A large number of well-established techniques exist for both tasks. Genetic algorithms can be used in selecting network architectures and the back-propagation algorithm or delta rule can be used for training the weights. For a multi-layer perceptron, if a solution can exist, then with the appropriate choice of the number of layers and the number of perceptrons in each layer it should be possible to find that solution in a finite number of steps (Picton, 2000).

These techniques are well established and well regarded and are to be applied as a matter of course to IoT data. Neural classifiers are non-parametric and make weaker assumptions on the shape of the underlying distributions of input data than traditional statistical classifiers. Therefore, they can prove more robust when the underlying statistics are unknown or the data are generated by a nonlinear system (Lipmann, 1987). If the Internet of Things is to create a new layer of information, what Chinese researchers have poetically termed the wisdom of the earth (Ashton, 2011) possibly the optimum way to approach something like this is by using a neural network. The neural network approach is a likely procedure being used in Internet of Things research at the Google X lab (Tsukayama,2011).

5. Conclusion

People all over the world form complex social networks, among individuals these are maintained by agreement on common objectives or shared values. Due to the growing success of online social networks the services of the future will become multi-context and social-aware capable (Doody and Shields, 2012). However, to enable such a vision we need a ubiquitous technological platform that is prepared to address the associated challenges. The multi-context and socially aware capable Internet of the Future can be seen as a mixture of traditional networks and networked smart objects that will not only co-exist but also be intimately bound up with our human world. It will be an Internet with Things, where the content and services it facilitates will be all around us, always on, everywhere, all the time (Hourcade et al, 2009). The internet has always changed fast and is still evolving. However, instead

of just connecting computers and/or wearable devices, it is beginning to provide an embedding of physical reality into the Internet and information into physical reality (Cvijikj and Michahelles, 2011). In an Internet of Things envisioned future where everything is connected to everything else, the possibilities for the creation of innovative solutions linking the physical world to the digital world are endless (Coetzee et al, 2012).

This research functions as a review of the techniques in the previous sections; the reality mining methodology, graph mining and artificial neural networks. These are different techniques and have advantages and disadvantages unique to them. The different models are, computationally expensive in the case of the reality mining methodology and in the case of graph modelling, where possibly it is too difficult to realign the classification of vertices from controlled to controller and maintain fidelity to an original semblance of the network, untested. "Networks are dynamic not just because things happen in networked systems, but because networks themselves are evolving and changing in time, driven by activities or decisions of those very components. In the connected age therefore, what happens and how it happens depends on the network." (Watts, 2003). Artificial neural networks lastly (as would be applied to Bayesian learning models of the data among others), albeit generalizable and probably the optimum method, can suffer from a phenomenon overfitting where the algorithm is forced into an early minimum, a state from which the process would not learn. Typically a hybrid model yields the best solution.

The Reality Mining experiment was heralded in 2008 (Greene, 2008) as one of M.I.T.'s top ten breakthrough technologies and in 2013 big data from cheap phones, a similar concept was lauded in the same manner (Talbot, 2013). This means that the Reality Mining dataset has been the subject of any number of graduate theses and taught graduate programmes. Applying this data to an IoT scenario is, considering the breadth of the IoT endeavour certainly permissible. Different definitions for the IoT have been proposed (CASAGRAS, 2012), (Vermesan et al, 2012), (IOT-A, 2013) with some researchers designing solutions based on RFID technology or EPC mechanisms, (Ning and Wang, 2011) or an integration solution between mobile services and smart objects (Vazquez, 2010). Every day twitter account @TheIoT identifies on average eighteen new magazine or journal articles written about the Internet of Things (Chevalier, 2013) and over the past few years there have been a high number of semi-closed or proprietary solutions to the IoT. Along with the "My application is specific" syndrome, many non-interoperable "solutions", based on different architectures and protocols, have emerged to address particular problems. Consequently deployments of IoT applications have been limited in scale and scope, actually limiting the IoT to the dimension of a set of "Intranets of Things" (Santucci et al, 2012). The Internet of Things is a compelling vision with no consensus (Kortuem et al, 2010). Allowing computers to understand this world will require the creation of algorithms to guide automated systems appropriately for smart monitoring and actuation (Gubbi et al, 2013), algorithms capable of identifying and inferring relationships in IoT systems using smart objects and then using these inferences to predict behavioural patterns. Eventually by means of lower computation cost and testing, opportunities may arise to deploy these algorithms within the smart object devices themselves.

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An Analysis of Next Generation Sequence Clipping Tools

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Abstract

Many next generation sequencing technologies involve the use of short adapters that are ligated onto the ends of target fragments for both amplification and sequencing. It is important to accurately remove these adapter sequences as they are redundant once sequencing is complete and can hinder mapping, alignment and subsequent analysis. Through empirical research, this paper examines four commonly used command-line based adapter clipping tools: Fastx_clipper, Cutadapt, Adapter Trim and TagCleaner. The paper demonstrates that the performance of these tools varies widely across a benchmark problem set. This is significant as researchers could arbitrarily select clipping tools on the basis that they achieve the same end, whereas in fact our study shows that there is wide variation in performance. We also report that Cutadapt is the most effective adapter clipping tool among the four tools considered across a range of sequence data. This is an important finding as the choice of adapter tool can have an influential effect on subsequent analysis, leading to significantly different results.

Keywords

Bioinformatics, RNA-seq, adapter clipping, alignment

1. Introduction

Sequencing technology is used for establishing the exact order of bases in nucleic acid sequences, which are the macro molecules fundamental to all known forms of life on earth. High-throughput sequencing is considered to be a revolutionary improvement over first generation sequencing, known as Sanger sequencing, as it can read several million bases per run. This enables a more detailed picture of the genome, which is the hereditary information present in a cell. Applications of high-throughput sequencing data include genome wide association studies (GWA), single nucleotide polymorphisms (SNPs), gene expression analysis, epigenomics and De novo genome assembly. As the cost of sequencing is falling dramatically (see Figure 1), such technologies should enable a range of research and clinical applications.

There are several sequencing platforms. One such platform is Illumina sequencing which uses sequencing-by-synthesis technology. Based on the Sanger sequencing method, Illumina sequencing uses coloured fluorescence labels of four different proprietary types of dNTP (deoxyribonucleoside triphosphate), in each cycle, synthesizing a complementary DNA polymerase chain. The dNTP added in each cycle will release different fluorescence as it ligates with the target sequence. The

sequence information is obtained by recording the fluorescence signal and by the use of specific software processing. Each raw read base is assigned a Phred quality score (Cock *el al*. 2010) so that the software can apply a weighting factor in calling differences and generating confidence scores (Doe Joint Genome Institute, 2013).

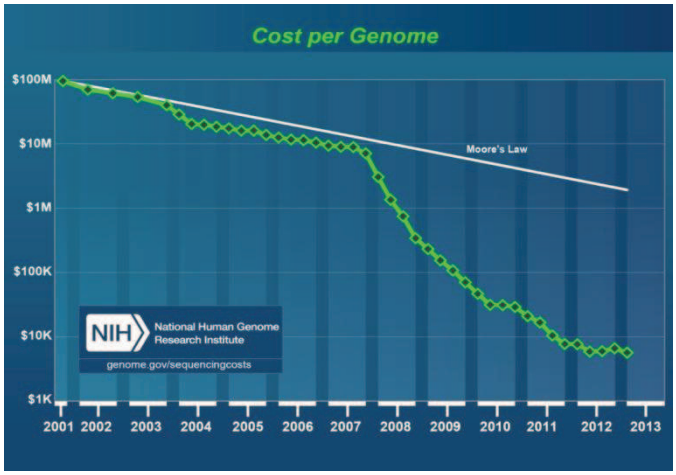


Figure 1: Cost per genome of sequencing compared to Moore's Law (used with permission).

Phred quality scores were initially designed by a computer programme named Phred base-calling for DNA sequence traces to assist in indentifying a nucleotide sequence produced by an automated DNA sequencer. It is widely accepted to characterize the quality of DNA sequences and compare the efficacy of different sequencing methods. The quality scores compress a variety of types of information about the quality of base calls into a readily usable probability-of-error value. Accurate quality scores generated by Phred are essential to provide a simple uniform foundation on which to build all applications that are concerned with read quality (Brockman *et al.,* 2008). Quality scores range from 4 to about 60, with higher values corresponding to higher quality. The quality scores are logarithmically linked to error probabilities, as shown in Table 1.

Phred Quality Score	Probability that the base is called wrong	Accuracy of the base call
10	1 in 10	90%
20	1 in 100	99%
30	1 in 1000	99.9%
40	1 in 10000	99.99%
50	1 in 100000	99.999%

Table 1: Quality Scores and Base Calling Accuracy (Illumina, Inc. 2011).

RNA-seq uses sequencing technology to generate millions of short reads that can be used to determine the transcriptome and measure gene expression (Mortazavi A, *et al*., 2008). Depending on the sequencing technology, RNA-seq reads can vary in length from ~50bp (Illumina, Solid) to 700bp (Roche 454) (Liu *et al*., 2012)

Ribosome profiling (ribo-seq) is a recent technique that takes advantage of high-throughput sequencing technology to provide a high resolution snapshot of the transcripts that are being translated in the cell at the time of the experiment (Ingolia *et al.,* 2009) (Ingolia *et al.,* 2012). There are different ribosome profiling strategies such as ribosome profiling of initiating ribosomes and ribosome profiling of elongating ribosomes. The applications of these are discussed in Michel *et al.,* 2013

In ribosome profiling, the mRNA fragment protected by the ribosome is around 30bp. Adapter sequences are ligated to the 3' end of each molecule during sequence library preparation. Many ribo-seq studies have used Illumina sequencing technology and the sequenced reads are typically 36bp in length (e.g. Guo *et al.,* 2010), although ribo-seq sequenced reads can be longer (e.g. 40nt sequenced reads in Ingolia *et al.,* 2011). Thus the sequenced reads contain the protected mRNA fragment and the ligated adapter. The adapter sequences must be removed or 'clipped' from the sequences in order for downstream analysis to be more accurate (see Figure 2).

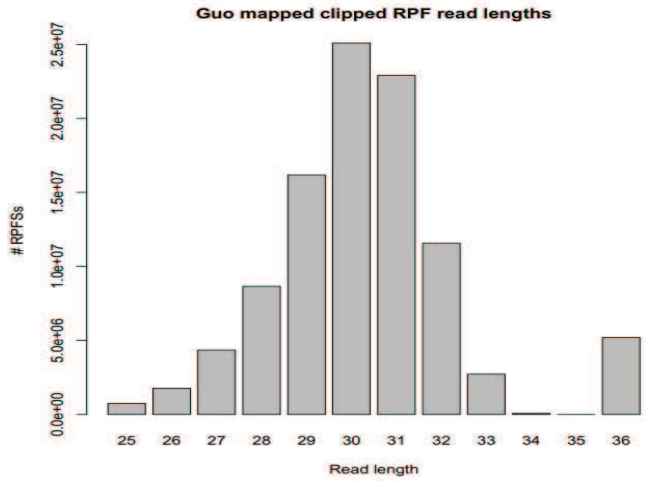


Figure 2: Plot of the distribution of read lengths (after they were trimmed) of a Human HeLa Riboseq dataset (Guo et al., **2010).**

There are some alignment tools that perform this trimming task such as SOAP (version 1) (Li *et al.,* 2008) and Novoalign (Novoalign Corporation Web Site, 2013), but there are many more alignment tools that do not provide this trimming feature, requiring the data to undergo pre-processing clean up to remove adapter sequences.

2. Overview of NGS Clipping tools

There are many tools available for clipping or trimming the adapters from a sequence file (see Table 2), most tools are command-line based and installed on a Unix/Linux system; some tools also have an interactive web interface, such as TagCleaner (http://edwards.sdsu.edu/TagCleaner) (Schmieder R *et al.,* 2010). Several tools also

remove low quality bases towards the 3' end (right side) of a read, such as simple repeat sequences like 'ATATATATAT' and reads with too many ambiguous bases 'N'. This paper is concerned only with removing the adapter from reads. To find the most effective trimming tool for removing adapters from 36bp reads, several tools were tested with generated benchmark data. The four trimming tools tested are: Cutadapt (Martin, 2011), TagCleaner (Schmieder R *et al.,* 2010), Fastx_clipper (Pearson *et al.,* 1997) and Adapter_Trim (Chapman, 2009).

	Illumina	Roche 454	ABI SOLID	Helicos	Single-end	Pair-end	Allow mismatch	Interface		Input Format		Output		License	Programming Language	platfrom
								command - line	Web based	FASTA	FASTQ	FASTA	FASTQ			
Adapterremoval	√				√	√	√	√			√		√	GPLv3	C, Perl	Linux
Adapter trim	√				√	√	√	√			√		√	Creative Commons Attribution 3.0	Perl	Linux
Biopiece (clio_adaptor)	√	√			√		√	√			√		√	GPLv2	Perl, Ruby, C, Python	MacOS X, Redhat, Ubuntu
Biostrings	√	√	√			√	√	√		√	√	√	√	Artistic-2.0	R	Linux, Mac OS X, and Windows
Btrim	√				√	√	√	√			√		√	No license	C	Mac OS X and Linux
Cutadapt	√	√	√				√	√		√	√	√	√	MIT License	Python, C	Linux, Mac OS X, and Windows
Ea-utils (fastq-mcf)	√	√	√			√	√	√		√	√	√	√	MIT License	C++	Windows, Linux
FASTQ/A Clipper	√				√		√	√	√	√	√	√	√	GPLv3	C++	Ubuntu and Debian, OpenSolaris, CentOS/RedHat, FreeBSD, MAC OS X
HTSeq	√		√			√	√	√		√	√	√	√	GPLv3	Python	Linux, Mac OS X, and Windows
Novoalign	√	√		√	√	√	√	√			√		√	Commercial	C++	Linux, Mac OS X, and Windows
PRINSEQ	√	√	√		√	√		√	√	√	√	√	√	GPLv3	Perl	All platform
Seqprep	√						√	√			√		√	MIT License	C	Posix
Tag cleaner	√	√					√	√	√	√	√	√	√	GPLv3	Perl	Linux, Mac OS X, and Windows
TagDust	√						√	√		√	√	√	√	GPLv3	C	Solaris, Unix, Linux
Trimmomatic	√				√	√	√	√			√		√	GPLv3	Java	Linux, Mac OS X, and Windows

Table 2: List of sequence adapter trimming tools with corresponding attributes.

3. Performance Evaluation

3.1. Empirical Testing Environment

Simulated benchmark data was generated with a Python script where the location of the adapter was known *a priori*. Several benchmark FASTQ files were generated and each file had the adapter starting at a different location in the read and/or some mismatches added to the adapter part of the read. Each file generated had 100 reads with the same adapter information; Table 3 shows an example of the reads generated for each file. Three tests have an adapter with mismatches added and are denoted with '#' in the adapter. The adapter 'TCGTATGCCGTCTTCTGCTTG' is 21 bp (base pair) in length and is taken from Illumina DpnII gene expression oligonucleotide sequences. The four trimming tools were downloaded and the tests were run on a dual core machine with Ubuntu 9.10 installed. All tools except Fastx_clipper have a mismatch parameter which is the maximum allowed error rate when aligning the adapter to the read. For example the mismatch in Table 3 has a mismatch of 2. If a tool allows reads with a mismatch of two or less to be trimmed, reads with three mismatches would be ignored. The tests undertaken are shown in Table 4, with variations of adapter sequence length and mismatches. It is not known how Fastx_clipper manages the mismatches as there is no parameter in the tool and no published information on mismatch allowance. All tools had an option to remove untrimmed reads and store in another file but this option was disabled to allow for

the comparison of trimmed and untrimmed reads in the same file. This option may be enabled in a next generation sequencing (NGS) pipeline to improve results downstream.

Read	CTTTGGGGGGGCGAGACTTTAGCTGATCG#ATGC#G
Adapter	TCGTATGCCGTCTTCTGCTTG

Table 3: A read showing 2 mismatches (#) when aligned to the adapter.

Test	Read (X) with adapter and random base (#), Total length is 32	Adapter length (starting position)
1	XXXXXXXXXXXXXXTCGTATGCCGTCTTCTGCTTG	full adapter (16)
2	XXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTTCT	16bp (21)
3	XXXXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTT	13bp (23)
4	XXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTATGC	8bp (29)
5	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTAT	6bp (31)
6	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGT	4bp (33)
7	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCG	3bp (34)
8	XXXXXXXXXXXXXXXXXXTATGCCGTCTTCTGCTTG	Last 18 adapter bases (19)
9	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXCTTG	Last 4 adapter bases (33)
10	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTTG	Last 3 Adapter bases (34)
11	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTG	Last 2 Adapter bases (35)
12	XXXXXXXXXXXXXXXXCGTATGCCGT#TTCTGCTTG	20bp (17) 1 random base
13	XXXXXXXXXXXXXXXXCGTATGCCGTC#TCT#CTTG	20bp (17) 2 random bases
14	XXXXXXXXXXXXXXXTCGTAT#CCGTC#TCTG#TTG	20bp (17) 4 random bases

Table 4: The tests performed on each trimming tool

3.2. Analysis of NGS Clipping Tools

Cutadapt (Martin, 2011) is a tool that trims adapters from Illumina, 454 and SOLiD reads. It has more parameters than other tools giving users more flexibility when cleaning or trimming read files. Cutadapt was the most effective tool and trimmed reads from all files even where there were only a few bases of the adapter present in the read. It was the only tool to trim with 100% success even with only 4 bases of the adapter present. This result may be significant for ribosome profiling data where short reads can contain a significant number of adapter bases relative to the ribosome protected fragment length and if not trimmed may affect down-stream analysis. Unlike most of other adapter clipping tools which only take a positive integer as the number of mismatches regardless of the length of adapter in clipping process, the error (mismatch) rate for Cutadapt is calculated as the max number of mismatches allowed divided by the length of the adapter (error rate = no. of errors / length of adapter), i.e. Maximum allowed 2 mismatches will be recognized with given adapter of 21 bases long if the error rate is set to 0.1. The default setting of 0.1 had to be changed to 0.2 for the last test where there were 4 mismatches in the test data.

Test	Reads tested with Cutadapt	Succesfully Trimmed	Mismatch(es)	Notes
1	Full adaptor	100	10%	All reads trimmed
2	XXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTTCT	100	10%	All reads trimmed
3	XXXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTT	100	10%	All reads trimmed
4	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTATG	100	10%	All reads trimmed
5	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTAT	100	10%	All reads trimmed
6	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGT	99	10%	1 bad trim at wrong place
7	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCG	99	10%	1 bad trim at wrong place
8	XXXXXXXXXXXXXXXXXTATGCCGTCTTCTGCTTG	100	10%	All reads trimmed
9	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXCTTG	100	10%	All reads trimmed
10	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTTG	0	5%, 10%, 15%	No reads trimmed
		2	20%	2 reads trimmed
		6	25%	6 reads trimmed
11	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTG	0	5%, 10%, 15%	No reads trimmed
		3	20%	3 reads trimmed
		36	25%	36 trimmed
12	XXXXXXXXXXXXXXXXCGTATGCCGT#TTCTGCTTG	100	10%	All reads trimmed
13	XXXXXXXXXXXXXXXXCGTATGCCGTC#TCT#CTTG	100	10%	All reads trimmed
14	XXXXXXXXXXXXXXXTCGTAT#CCGTC#TCTG#TTG	0	10%, 15%	No reads trimmed
		100	20%	All reads trimmed

Table 5: Results for Cutadapt

Fastx_clipper is part of the Fastx_toolkit (http://hannonlab.cshl.edu/fastx_toolkit/) developed by Assaf Gordon at Hannon lab as a collection of command line tools and is included as part of the Galaxy NGS suite of tools (https://main.g2.bx.psu.edu/). Fastx_clipper performed nearly as well as Cutadapt and was slightly better when trimming with 3 mismatches and would be perhaps a better tool when trimming longer reads of 50bp, 75 bp or 100 bp length. There is no mismatch parameter input into the tool so it is difficult to know how many bases can be random in the adapter sequence part of the read. The inability to restrict reads trimmed with too many mismatches may result in reads being incorrectly trimmed which can affect alignment downstream.

Test	Reads tested with Fastx_clipper	Succesfully Trimmed	Mismatch(es)	Notes
1	Full adaptor	100	n/a	All reads trimmed
2	XXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTTCT	100	n/a	All reads trimmed
3	XXXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTT	100	n/a	All reads trimmed
4	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTATG	98	n/a	2 reads trimmed incorrectly
5	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTAT	98	n/a	3 reads trimmed incorrectly
6	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGT	78	n/a	13 reads trimmed incorrectly
7	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCG	34	n/a	10 reads trimmed incorrectly
8	XXXXXXXXXXXXXXXXXTATGCCGTCTTCTGCTTG	100	n/a	All reads trimmed
9	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXCTTG	37	n/a	37 reads trimmed but not all correctly
10	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTTG	14	n/a	38 reads trimmed but not all correctly
11	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTG	9	n/a	39 reads trimmed but not all correctly
12	XXXXXXXXXXXXXXXXCGTATGCCGT#TTCTGCTTG	100	n/a	All reads trimmed
13	XXXXXXXXXXXXXXXXCGTATGCCGTC#TCT#CTTG	100	n/a	All reads trimmed
14	XXXXXXXXXXXXXXXTCGTAT#CCGTC#TCTG#TTG	100	n/a	All reads trimmed

Table 6: Results for Fastx_Clipper

TagCleaner (Schmieder R *et al.,* 2010) is a tool for trimming 454 data. 454 sequencing machines produce reads of up to 1000bp where Illumina reads are up to 100bp. The tool was included as it is popular and it would be interesting to investigate how the tool would perform with much shorter reads. TagCleaner has been made available online by Edwards Laboratory in San Diego State University at http://edwards.sdsu.edu/cgi-bin/TagCleaner/tc.cgi. The results from TagCleaner were poor especially where only a small fragment of the adapter was in the read but performed much better when most of the adapter was included. These results were

expected as 454 reads are much longer than Illumina. This result shows it should not be used for short reads but would be acceptable where long Illumina reads had a very large proportion of the adapter.

Test	Reads tested with Tagcleaner	Succesfully Trimmed	Mismatch(es)	Notes
1	Full adaptor	100	0	All reads trimmed
2	XXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTTCT	0	0,1,2,3	No trimming done
3	XXXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTT	0	0,1,2,3	No trimming done
4	XXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTATGC	0	0,1,2,3	No trimming done
5	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTAT	0	0,1,2,3	No trimming done
6	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGT	0	0,1,2,3	No trimming done
7	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCG	0	0,1,2,3	No trimming done
8	XXXXXXXXXXXXXXXXXXTATGCCGTCTTCTGCTTG	0	0,1,2,3	No trimming done
9	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXCTTG	0	0,1,2,3	No trimming done
10	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTTG	0	0,1,2,3	No trimming done
11	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTG	0	0,1,2,3	No trimming done
12	XXXXXXXXXXXXXXXXCGTATGCCGT#TTCTGCTTG	0	0,1,2	No trimming done
		100	3	All reads trimmed
13	XXXXXXXXXXXXXXXXCGTATGCCGTC#TCT#CTTG	0	0,1,2,3	No trimming done
		100	4	All reads trimmed
14	XXXXXXXXXXXXXXXTCGTAT#CCGTC#TCTG#TTG	0	0,1,2,3	No trimming done

Table 7: Results for TagCleaner

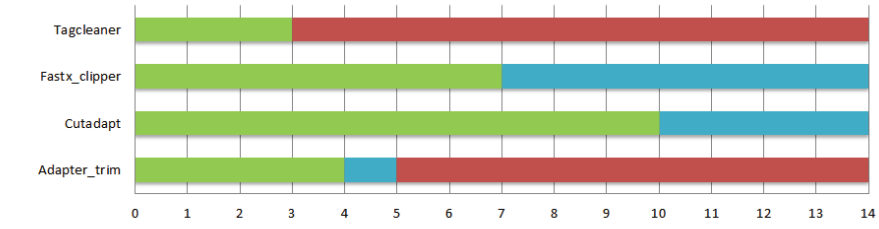
Adapter_trim makes use of Bio.pairwise2 from Biopython (Cock *et al.,* 2009) for pairwise alignments between the adapter and the reads and Adapter_trim is available at (https://bcbio.wordpress.com/2009/08/09/trimming-adapters-from-short-read-sequences). The Adapter_trim script was written in python (Lutz, 2001) by a bioinformatician called Brad Chapman working at the bioinformatics core in Harvard School of Public Health while researching an alternative method to trim adapters from short reads. Adaptor_trim performed poorly trimming reads with only a part of the adapter sequence. Again it is a tool suited to reads that have a significant number of adapter bases in the read and would perform better with longer reads.

Test	Reads tested with Adaptor_trim	Succesfully Trimmed	Mismatch(es)	Notes
1	Full adaptor	0	0	No trimming done
		100	1	All reads trimmed
2	XXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTTCT	0	0,1,2,3	No trimming done
3	XXXXXXXXXXXXXXXXXXXXXTCGTATGCCGTCTT	0	0,1,2,3	No trimming done
4	XXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTATGC	0	0,1,2,3	No trimming done
5	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGTATG	0	0,1,2,3	No trimming done
6	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCGT	0	0,1,2,3	No trimming done
7	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTCG	0	0,1,2,3	No trimming done
8	XXXXXXXXXXXXXXXXXXTATGCCGTCTTCTGCTTG	0	0,1,2,3	No trimming done
		100	4	All reads trimmed
9	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXCTTG	0	0,1,2,3	No trimming done
		1	4	Only 1 read trimmed
10	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTTG	0	0,1,2,3	No trimming done
11	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXTG	0	0,1,2,3	No trimming done
12	XXXXXXXXXXXXXXXXCGTATGCCGT#TTCTGCTTG	0	0,1,2	No trimming done
		100	3	All reads trimmed
13	XXXXXXXXXXXXXXXXCGTATGCCGTC#TCT#CTTG	0	0,1,2,3	No trimming done
		100	4	All reads trimmed
14	XXXXXXXXXXXXXXXTCGTAT#CCGTC#TCTG#TTG	0	0,1,2,3	No trimming done

Table 8: Results for Adaptor_trim

3.3. Discussion and Findings

Figure 3 shows how each tool performed in the 14 tests. The figure shows the number of read files for each test with 100% of reads trimmed, the files where only some reads were trimmed and files where no reads were trimmed.



	Adapter_trim	Cutadapt	Fastx_clipper	Tagcleaner
100% trimmed	4	10	7	3
Some trimmed	1	4	7	0
No reads trimmed	9	0	0	11

Figure 3: Summary results of tests showing 100% trimmed, partially trimmed or no trimming.

The results show that Cutadapt is the most effective performing tool for trimming adapters for short 36bp Illumina reads. The Cutadapt algorithm calculates regular semi-global (end-space free) alignment (Gusfield, 1997) or modified semi-global alignments. In end-space free alignment (See Figure 4), spaces at either left or right end of the alignment are ignored (score zero), which reduces the requirement of aligning sequence to start or stop at the same location, that is the sequence can be aligned overlapping or include one another. For two strings that have an overlap, a suffix of one string should align to a prefix of another string (including a small number of sequencing errors); end-space free alignment will detect the overlap with a high score.

Example:

Consider the sequence:

C A C T G T A C
G A C A C T T G

with end-space alignment , two spaces at left end and three spaces at right end are free:

- - C A C - T G T A C
G A C A C T T G - - -

Figure 4: An example of end-space free alignment

So when part of an adapter linker sequence is found to ligate on the right end of the read, the behaviour of Cutadapt is to remove the adapter and the sequences after it. Because a short, random match that overlaps at the beginning of a read may result in the removal of the entire read, a modification is made to end-space free alignment to solve this problem by taking into account spaces at the beginning of the read, thus all characters before the first non-adapters character are discarded. If multiple adapters were provided, then only the highest number of matching between read and adapter is selected. The error rate e/l (number of errors/length of matching segment between read and adapter) is then applied to ensure that the read is trimmed as the error rate is below the permitted maximum (Martin, 2011) (See Figure 5).

Figure 5: All possible alignments of Cutadapt on 5' end or 3' end with trimming options of -a and –b.

Fastx_Clipper also performed well in most tests specially where there were 4 mismatches. TagCleaner is optimised for 454 reads so was not expected to perform very well. None-the-less this shows that the task of clipping short reads is a distinct challenge to that of clipping longer reads. However, Adaptor_trim performed poorly on the test data, in comparison to Cutadapt, even though it is optimised for short reads. While Cutadapt performed most effectively for short reads, further testing would be required with the tools to determine which tool would be best for longer reads of 100bp. The results highlight that there is wide variation across the tools so it is important to carefully assess these tools and select the clipping tool that is best adapted to the length of the sequenced reads.

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Exploring Links Between National Culture, Inclusion and Organizational Citizenship Behaviour: Evidence From Nurses in The Irish Healthcare Sector

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Abstract

This paper presents preliminary findings from research being undertaken on Organizational Citizenship Behaviour (OCB). Primary research was undertaken in the form of in-depth interviews with 26 nurses from four particular cultures, specifically Ireland, India, the Philippines and the United Kingdom. The interviews were conducted in four hospitals in Cork, among nurses of various staff grades. One of the main aims of the research is to add to the dearth of literature in the field by exploring linkages between employee perceptions of inclusion, national culture, and the undertaking of OCBs. The results of the research should not only assist hospital managers in Ireland, but, managers in various organisations both nationally and internationally, in developing an understanding of why employees may or may not undertake OCBs. Although on-going, a number of findings have begun to emerge from the research conducted to date. These significant emergent findings are discussed in this paper.

Keywords

Organizational Citizenship Behaviour, Culture, Inclusion, Healthcare, Diversity

1. Introduction

Defining diversity is a complex and difficult process, as diversity concerns both visible and invisible characteristics (Morley *et al*., 2004). Diversity can also be considered a subjective concept, created by individuals who categorise other individuals as similar or dissimilar based on their own social identities (Bechtoldt *et al*., 2007). Regardless, however, diversity has always been present in societies (Arredondo, 1996). Arguably, therefore, organizational workforces have also always been diverse. Indeed, Jackson and Joshi (2011) propose that diversity exists in all work groups, albeit to varying levels.

Despite the ever presence of diversity, workforces today are rapidly becoming increasingly even more diverse (Bell and Kravitz, 2008). In the Irish context, IBEC (2003:5) has identified a comprehensive list of factors which have contributed to increasing diversity. The increased globalisation of business markets has resulted in an increase in the amount of business conducted on an international scale, while

information technology improvements has given rise to increased interaction between Irish employees and international counterparts. Additionally, the presence of multinational companies in Ireland has resulted in a consequential increased presence of more diverse cultures. Furthermore, there is increasing interaction of different nationalities and cultures in the workplace due to net immigration, while globalisation of the market economy has brought about a more diverse customer base.

From an Irish organizational perspective, recent years have seen a sharp rise in immigration, which has brought with it the diversity of many cultures (Connolly and McGing, 2006; SIPTU, 2006). As a result, one of the most prevalent forms of diversity in Irish workforces at present is cultural diversity. Furthermore, in the context of the Irish Healthcare sector, a shortage of nurses since the 1990s resulted in active, rapid, overseas recruitment (Humphries *et al*., 2008). The extent of overseas recruitment initiatives meant that while in 1990, three of every four new registrations with An Bord Altranais (/The Irish Nursing Board) were Irish, by 2006, three of every four new registrations were from another country (Buchan, 2009). Evidently, the Irish Healthcare Sector has become heavily reliant on migrant nurses (Humphries *et al*., 2009).

2. Cultural Diversity and Inclusion

There is, as yet, no single, agreed definition of the term culture (Kokt, 2003). Seminal research conducted by Hofstede (1991:5), however, defines the concept as:

> *The collective programming of the mind which distinguishes the members of one group or category from another.*

In essence, culture, involves shared meanings and taken-for-granted assumptions that exist in the subconscious, dictating how individuals think and act (Kinicki and Kreitner, 2006). Cultural diversity holds particular significance for organizations, as culture influences the behaviour of employees (Gardenswartz and Rowe, 2001). It also impacts the manner in which people solve problems and resolve dilemmas (Trompenaars and Hampden-Turner, 1997). Additionally, it has been suggested that culture has implications for other concepts and practices, for example, motivation and motivational theories, leadership, employee participation and organizational structure (Bing, 2004; House *et al*., 2001). In practical terms, the dimensions of culture as proposed by researchers should assist in making organizations aware that employees from different countries may think, feel and act differently than others in various situations (Hofstede, 1993).

When considering the differences among people, however, there is a tendency to become rigid or simplistic. Rather than cultural differences becoming the source of division between individuals, they should be a source of pride, used for the benefit of all (Ferdman and Brody, 1996). Consequently, diversity management needs to move beyond reacting to a shift in workforce dynamics (Pless and Maak, 2004). Indeed, while addressing how diversity should be dealt with in an organisation, Davidson

and Ferdman (2001) propose that the answer lies in an inclusive version of diversity. Such an inclusionary approach is one in which differences are recognized, valued and engaged (Pless and Maak, 2004:130).

This approach is concerned with not just identifying the differences of all individuals in the workplace, rather, integrating them into the culture of the organization. Such an approach has been supported by a report examining global diversity and inclusion published by Forbes in (2011), which proposes that both a diverse workforce and an inclusive culture are necessary for global success. The report further suggests that when diversity exists in an inclusive environment, it is a key driver of innovation and creativity and can also guide business strategies. Inclusion is considered by Gasorek (2000) to be a multi-dimensional concept concerning, for example, the degree to which employees believe they are valued and whether their ideas are taken into account, and used, employees feel they belong in the organization, and employees feel committed to each other, the organization and the organizations goals.

An underlying assertion of this current research is that as, according to cultural theory, culture affects how individuals, thus employees, behave and possibly therefore perform in the workplace, it may also impact whether they undertake Organizational Citizenship Behaviours (OCBs). The following section, therefore, briefly addresses the concept of OCBs.

3. Organizational Citizenship Behaviour

The concept of Organizational Citizenship Behaviour (OCB) is not new. Indeed, Barnard (1938) first alluded to the idea in relation to willingness to cooperate, following which in 1964, Katz suggested that social organisation faces a paradox, proposing that human variability must be reduced to ensure predictable performance, while simultaneously, spontaneous and innovative activity and behaviour that goes beyond role requirements must be encouraged. Bateman and Organ termed these behaviours "citizenship behaviours", resulting in the construct of Organizational Citizenship Behaviour being explicitly developed in the 1980s (Markóczy *et al*., 2009; Becton *et al*., 2008; Bateman and Organ, 1983). Essentially, OCBs are supra-role, contributory behaviours undertaken by individuals of their own volition, which are not required as part of their role or task fulfilment, thus, not practicably enforceable by superiors, but often help the organisation the individual works for in some manner (Markóczy *et al*., 2009; Borman, 2004; Konovsky and Organ, 1996; Organ 1988).

The importance of OCBs has been stressed by Jahinger *et al*. (2004), who contend that organizations could not survive without the undertaking of OCBs by employees. Becton *et al*. (2008) concur, further proposing that, based on existing research, organisations should have an interest in encouraging OCBs. OCBs have the potential to enhance the productivity of both colleagues and superiors, help coordinate organisational activities, increase performance stability, and assist in the attraction and retention of employees (Borman, 2004). OCBs are also thought to increase available organisational resources, and decrease the need for more formal and

expensive control methods (Organ, 1998; Podsakoff and MacKenzie, 1997). Not every instance of OCB by an individual employee contributes to organisational outcomes, however, rather, multiple displays of OCB across the range of behaviours in aggregate contributes to the effectiveness, thus performance, of the organisation (Organ, 1997). Indeed, a wide-ranging, multi-dimensional concept, OCBs can be categorised into seven dimensions, specifically, Helping Behaviour, Sportsmanship, Organisational Loyalty, Organisational Compliance, Individual Initiative, Civic Virtue and Self-Development (Podsakoff *et al*., 2000).

Previous research has focussed on the relationship between various contextual factors, and the undertaking of OCBs. Areas previously addressed include the relationship between OCBs and job satisfaction (Bateman and Organ, 1983), an individual's disposition (Borman, 2004), equity sensitivity (Konovsky and Organ, 1996), perceptions of organizational justice (Blakely *et al*., 2005), a supportive work environment (Boorman, 2004), and gender roles (Kidder and McLean Parks, 2001), viewing the aforementioned as antecedents or predictors. This research aims to add to the existing literature on OCBs and antecedents by exploring whether a link exists between national culture, the perception of inclusion, and the undertaking of OCBs. This research is on-going, but the methodological approach being engaged is outlined in the following section.

4. Methodology

A number of hospitals have been chosen for this research, with the Irish healthcare sector being chosen for a number of reasons. This sector has, for example, over the past decade, employed a large number of non-Irish employees, making it suitably culturally diverse to enable analysis. Further, for many users of the Irish public service, healthcare is one of the most important priorities (Byers, 2010). Additionally, nurses, in particular, were also chosen for a number of reasons. One such reason is that nurses constitute over a third of healthcare corkers (Department of Health and Children, 2011). Moreover, in many parts of the world nursing staff are the principal primary health care providers (Kendall, 2008).

The nurses participating in the study are from four countries, specifically, Ireland, the United Kingdom, India and The Philippines. These countries were chosen as they are currently the four most represented countries in the nursing workforce in Ireland, as per the Active Register. The sampling frame included nurses (both male and female) of different staff grades (from Registered General Nurse/RGN to Assistant Director of Midwifery), from Ireland, the United Kingdom, India, and the Philippines.

Exploratory and descriptive research has been deemed most appropriate to gather information to answer the research question. Generally, exploratory research is undertaken to enable the researcher to gain background information about the research problem (Burns and Bush, 2006). Descriptive research provides an insight into the thoughts, feelings, or behaviours of respondents, allowing for the development of a greater understanding of what is happening (Stangor, 1998). In

specific, in-depth interviews are being used, and are considered suitable for a number of reasons. In-depth interviews afford an opportunity to gain a depth of information on the interviewees' thoughts, interpretations, and feelings. Additionally, in-depth interviews enable participants to elaborate on their responses, and also afford the researcher an opportunity to ask additional questions leading on from respondents' answers to questions.

To date, 26 interviews have been conducted with nurses from different staff grades in four hospitals in Cork, with 10 Irish, 6 Indian, 9 Filipina/o and 1 UK nurses taking part (21 female, 5 male, and 6 CNMs, 18 RGNs, 1 Assistant Director and 1 Clinical Midwife Specialist). Another 10 interviews have been arranged and will be undertaken in Cork over the coming months. Ethical clearance processes have begun in order to gain access to a further five hospitals in Dublin. The first step in gaining entry to the hospitals was to contact each hospital to obtain the directors of nursing's email contact information. Once this contact information had been obtained, each director was contacted individually by email with a detailed explanation of the study. All directors responded positively, and the process of gaining access to nurses was initiated. The process varied for each hospital. In some hospitals the lead researcher was set up with a liaison, in others prior meetings were held with senior staff, in others contact details of suitable wards were given to the lead researcher and access was established without a middle party.

All interviews bar three were, with the permission of the nurses, recorded on a dictaphone, and transcribed as soon as possible after the interview. These transcripts are necessary for content analysis. Content analysis, which involves coding groups of words or phrases from the research transcripts into categories, is being used to analyse the data. Coding refers to putting data into theoretically defined categories to analyse it (Carson *et al*., 2001). Although it is expected that there will be a large volume of data, manual coding and analysis will be utilised.

5. Discussion of Findings

Although interviews are on-going, a number of findings have begun to emerge strongly from those conducted this far. One such finding concerns individuality. The nurses interviewed assert that cultures in other countries are different from that in their own country. The majority (18) of the 26 respondents thus far are of the opinion that individuals within the same country differ from each other, rather than being culturally constrained.

Such employee opinions regarding individuality are reflective of previous research conducted by O'Donovan and Linehan (2012; 2011) which also suggested that individuals may not be culturally constrained, in particular to the degree suggested by previous cultural studies. An implication of this finding is that individuals are not culturally constrained, but, rather are shaped by their individuality. Trying to better understand the behaviour of employees by viewing them through a lens which applies particular cultural dimensions to an individual based on their country of origin, therefore, may be futile. Weight is added to this finding when the makeup of

the respondents is considered, as employees from each of the four different countries stated that individuals are not culturally constrained. A further implication of this assertion is that, should employee behaviours result from individual makeup rather than collective cultural shaping, encouraging OCBs based on cultural expectations of behaviour and reactions to stimuli may not be entirely possible. It can be suggested, therefore, that managers consider culture as one possible contextual factor to understand behaviour, rather than the primary factor.

An additional finding stems from respondents suggesting that organisational and national culture are equally important, with some respondents so far suggesting that organisational culture is slightly more important while at work. Twelve of the 26 respondents interviewed to date were of a similar opinion to those expressed in the quotations above. In addition, a further five respondents suggested that both national and organizational culture are equally important, and coexist, while a further three indicated that they perceive no difference between the two, or that it does not matter. Interestingly, only two respondents indicated that their national culture was more important than the culture of the hospital. One respondent did so as they perceive organizational culture as occasionally carrying negative connotations. The second respondent who viewed their culture as more important did so as she associated the organizational culture with rules and procedures, which she follows but works around, or beyond, in an attempt to improve the service offered to patients.

Regarding using culture to increase the undertaking of OCB's, the above sentiments regarding the importance of culture are significant. As illustrated, the majority of respondents indicated the culture of the organization was more important, while other interviewees suggested that national and organizational cultures were equally important, or that there was no perceived difference between them. Consequently, organisations may be able to capitalise on this finding by striving to develop an organisational culture that encourages the undertaking of OCBs, rather than attempting to manipulate an employee's national culture to encourage said behaviours.

A further significant theme emerging from the early stages of this research concerns the role inclusion has on employee performance. Through the course of the interviews, nurses were asked whether they had a sense of inclusion in the ward or in the hospital, and whether feeling included impacted their performance. Of the 26 respondents interviewed to date, one interviewee was of the opinion that being, or not being, included on the ward had no bearing on performance. A further interviewee also stated that not feeling included would not affect their performance, but because when they do not feel included, they actively engage with others in the ward to make themselves included.

Significantly, however, 24 of the 26 nurses interviewed believe that feeling included does impact their performance, in a positive manner. It is evident, therefore, that for these respondents, inclusion is rated as important in terms of their daily performance. It can be recommended, therefore, that hospitals, and organizations as a whole, build on this finding and aim to foster a culture of inclusion, with a view to enhancing and

encouraging performance. Such a feat may be more readily achievable in hospitals where wards could be considered as teams or groups. It can also be suggested that creating a culture of inclusion, for example, an organizational-wide 'team' or 'family' could be encouraged for organizations which do not readily lend themselves to dividing employees into groups in order to give a sense of inclusion and belonging.

6. Conclusion

Although this research is on-going, a number of themes have begun to strongly emerge. In particular, the findings of the research indicate that the interviewed nurses are shaped by their individual contextual factors, rather than by cultural constraint. Indeed, the nurses indicated that while they acknowledge that their respective country has a culture, individuals within cultures can be, and are, different from each other. This carries significance for managers who are attempting to understand employee behaviour by applying cultural dimensions to them. It also indicates that employees may be capable of adapting to the culture of other countries far more readily than previously thought.

A further finding emerging from the research is that organizational culture is considered more important than national culture by almost half of the respondents. Additionally, organizational and national cultures were deemed to be of equal importance by a further five nurses. This suggests that organizations can use organizational culture to encourage and reinforce appropriate, desired behaviours, or perhaps "positively manipulate" the behaviour and perceptions of employees with a view to encouraging the undertaking of valuable OCBs.

Finally, inclusion is emerging as a factor of importance for increasing employee performance, with 24 of the 26 nurses interviewed so far deeming it to have a positive impact of their performance. As such, organizations are encouraged to actively foster inclusion, by creating a culture which moves beyond simply accepting the presence of differences among employees towards integrating them into the very seams of the organization, with a view to capitalising on the importance of organizational culture to employees.

To conclude, each of the three themes which have emerged from the research to date carry significance for both hospitals and for organizations in general. One finding indicates that individuality is stronger than cultural constraint, signifying that attempting to understand employees, and shape or predict, their performance by considering cultural dimensions may be ineffective. As outlined, organizational culture, however, was deemed more important than, or as important as, national culture by the majority of employees. Moreover, feeling included on the ward has a positive impact on work performance according to 24 of the 26 respondents interviewed to date. This constitutes one of the main findings, as it indicates that organizations attempting to encourage Organizational Citizenship Behaviours may do so by creating an organizational culture of inclusion, and by further using that culture to positively manipulate employee behaviour. It can be recommended,

therefore, that organizations should aim to move beyond diversity management, in the traditional sense, and steer their organizations towards creating a real sense of inclusion for all employees irrespective of their national origins.

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The Influence of Network Positions and Self-monitoring on Individual Job Performance in Teams

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Abstract

Performance of individuals especially in a work or university context is very important and determines e.g. further career plans. In spite of this focus on individual performance, teamwork has become a part in nearly every work context. A team is a group of individuals and can also be understood as a social network. Network researchers found that the position of an individual in a network may determine the job performance of that individual. The influence of the network position on job performance derives from the fact that some individuals have more advantageous positions, e.g. better access to more information. But the performance between individuals with advantageous networks positions differs widely. The reason for this differential could be related to personality differences. Self-monitoring is such a personality trait which has been shown to be particularly relevant in occupying advantageous network positions. The presented paper describes the planned procedure for a research project with the aim to determine how network position and self-monitoring affect individual job performance in a team-based work environment. In order to answer the research question it is planned to examine two scenarios by using social network analysis, regression analysis and structural equation models. The first scenario is set in a team-based work environment in a public relations agency. However, teamwork is not only important within professional but also in higher education contexts. Hence, a second scenario will be included, which examines teamwork in university courses.

Keywords

Social Networks, job performance, learning, social network analysis, self-monitoring, network position

1. Introduction & Research Context

Project-based work in teams has become an integral part in nearly every work context. This development also finds its way into universities, where lecturers integrate project-based learning into their course work because it gives students the opportunity to gain knowledge about real project and team situations as they may occur in their future jobs. Despite this development the job performance of individuals is still very important and “one of the enduring questions we face as

human beings concerns why some people perform better than others" (Mehra *et al.*, 2001, p. 121), especially in job situations (Mehra *et al.*, 2001, p. 121). When thinking about a team, we think about a group of people who work together to achieve a common goal. Such a group can also be understood as a social network. This network focuses on the relationship between individuals and emphasises details about the connections between them (Haythornthwaite, 2007). These connections are called *ties* and span the network space. The result is a network structure, in which every individual assumes a certain network position. For example, there are individuals in the centre of the network with a lot of connections to individuals who are further away from the centre with fewer connections. The influence of the network position on job performance derives from the fact that some individuals have more advantageous positions. In network research, *models of advantage* take a look at how information is distributed in a network of individuals (Burt *et al.*, 2013). Advantage can be described as having better access to more information. An individual, who is able to connect different clusters or subgroups of a network which would otherwise not be connected, occupies such an advantageous position. Individuals who fulfil this function are referred to as *brokers* (Burt, 2004). Within the context of a work group a broker is an individual with connections to other subgroups or individuals.

Network researchers, including Burt (2004), have conducted studies in corporate settings and have found that individuals who occupy broker positions are more likely to be promoted or earn higher salaries. However, Burt (2005) also found that the job performance of brokers differs widely. Brokers often perform below their potential network advantage and the differences of job performance between brokers were higher than between non-brokers. The reason of this could be personality differences. Theses personality differences affect network structures and therefore shape how networks evolve (Burt *et al.*, 2013).

This leads to the question which personality traits enable individuals to occupy advantageous network positions. Burt *et al.* (2013) and Mehra *et al.* (2001) have identified self-monitoring as such a personality trait which has been shown to be particularly relevant to occupying advantageous network positions. Self-monitoring measures the extent to which a person feels that she can adapt to social situations. Thus, high self-monitors are better at adapting to social situations than low self-monitors (Mehra *et al.*, 2001).

How does this relate to brokers? A group often develops a homogeneous way of thinking and behaviour. Brokers access information from different groups and therefore have to adapt to these different ways of thinking and behaviour (Burt, 2004). Researchers found that high self-monitors are more likely than low self-monitors to occupy broker positions (Mehra *et al.*, 2001) and (Oh and Kilduff, 2008). Moreover, these studies show that high self-monitors perform better in work than low self-monitors (Mehra *et al.*, 2001) and (Oh and Kilduff, 2008).

These findings leads to the questions: How is the relationship between broker position self-monitoring and job performance? Mehra *et al.* (2001) tried to discover the relation between these three aspects and therefore developed and tested three

different models before designed a fourth yet untested model, which is called the emergent model.

The objective of this research project is to find out how network position and self-monitoring affect job performance in project-based work groups. Testing the emergent model is the key to this. This research project investigate this question in two scenarios: The first scenario is a project work group in a corporate context (scenario 1). As described above a lot of university courses also integrate project-based work groups in the curriculum. To take this into account and as project-based work groups in universities are comparable to corporate work groups, the findings from the corporate will be transferred to the educational context (scenario 2).

The literature review is divided into four parts: The first section provides a short description of job performance. The second part gives an overview of studies that investigate the relationship between broker position and job performance, whereas the third part presents insights regarding the relationship between self-monitoring and job performance. The different sections of the literature review cover both scenarios (corporate and educational context). Finally, the fourth part of the literature review looks at the relationship of all three aspects by introducing the different models by Mehra. Section 3 describes the expected progress with respect to the current literature and the testable hypotheses. The section on research methodology (section 4) describes the approach to answering the research question and the procedure that will be used to test the hypotheses. This paper ends with a chapter about the expected outcome and the contribution to the research field of this research project.

2. Literature Review

2.1. Job Performance

There are several definitions of job performance from different disciplines, professions and researchers. Most of the studies conducted with regards to find a relationship between job performance and network position (Burt, 2005) or self-monitoring, measure job performance by salary or job advancement, which is the outcome of the work activities. The presented research project based on a different definition of job performance, which comes from social psychology. Motowidlo (2003) defines job performance "as the total expected value to the organization of the discrete behavioural episodes that an individual carries out over a standard period of time." (Motowidlo, 2003, p. 39). This definition refers to individual behaviour rather than to the outcomes or results of work activities (Blickle, 2011). This means the planned research project is concentrated on the behaviour or rather a set of behaviours that could lead to a positive outcome rather than on the outcome or result itself. Following Motowidlo *behaviour is what people do. Performance is the expected value of what people do. Results are states or conditions of people or things that are changed by what they do (...)* " (Motowidlo, 2003, p.39) "The performance construct by this definition is a variable that distinguished between sets of behaviours carried out by different individuals and sets between sets of behaviours carried out by the same individual at different times." (Motowidlo, 2003, p. 39)

There are several advantages mentioned in the literature in tying the performance construct to an individual's behaviour rather than to the results of that behaviour. Firstly, outcomes of work activities are often affected or changed by factors that are not under the control of the individual professional. This can be for example economic situations, reorganisation of companies or the availability of appropriate tools. Those factors and the influence on the individual performance is difficult to measure. Moreover, the outcome is often not known for month or weeks (Blickle, 2011).

2.2. Job Performance and Broker Position

Burt (2005) conducted several network studies in corporate settings and found evidence that network positions related to brokerage affect job performance. For example, brokers earn on average higher salaries and are promoted more often than non-brokers. In those studies job performance was measured by the outcomes or results of the work activities. The approach described in this paper differs, as mentioned above, as it is planned to measure performance by the behaviour of the individuals. Moreover, Burt (2005) found that it was more likely for individuals who build bridges in networks to discuss an idea or vision with colleagues. Ideas contributed from brokers are often considered more valuable than others. There is only one study in an educational context which integrates broker measurements and relates them to performance in university settings. Cho *et al.* (2007) demonstrate that individual communication styles as well as pre-existing friendships shape the way in which learners create social structures. Moreover, they found that the network position is crucial for learning performance. However, they did not fully determine which position was most helpful for learners with respect to improving their learning performance. Most of the above mentioned studies from corporate settings show that broker positions could have an impact on job performance. However, with the exception of two studies (Cho *et al.*, 2007), the relationship between broker position and performance in educational settings has not been examined yet. Therefore this research project aims at revealing details about this relationship by applying the findings from corporate settings (scenario 1) to project-based learning (scenario 2), as this learning method creates an environment that realistically simulates the challenges in job situations.

2.3. Job Performance and Self-Monitorning

In this section details are given regarding the connection of personality, especially self-monitoring, and job performance. Mehra *et al.* (2001) state that out of different personality traits self-monitoring could be linked to a range of job outcomes including "performance in the workplace, leadership emergence in work groups, conflict management, information management, impression management, and boundary spanning" (Mehra *et al.*, 2001, p. 12).

Most of the studies that explore the link between self-monitoring and performance were conducted in corporate contexts. Kilduff and Day (1994) showed the impact of self-monitoring on job outcomes of former graduate students. They found that high self-monitors were more likely to achieve cross-company promotions than low self-

monitors, to change employers, and to make geographical moves. The level of self-monitoring had no statistically significant effect on within-company promotions, though.

Day *et al.* (2002) conducted a meta-analysis to examine the relationship between self-monitoring and work-related variables. Their results indicate that "high self-monitors tend to receive better performance ratings, are promoted more frequently and are more likely to emerge as leaders than low self-monitors" (Day *et al.*, 2002, p. 397).

Only one study linked self-monitoring to learning performance. Lan *et al.* (1993) conducted an experiment in which they divided 72 graduate students into three groups. The first group recorded its learning activities (self-monitoring group), the second group evaluated the instructors' teaching ability (instructor-group), and the third group was without any evaluation (control group). Lan *et al.* (1993) found that the self-monitoring group performed better than the other two groups on the course test. They also had a better knowledge representation of the course content.

Most of the above mentioned studies from corporate settings show that self-monitoring could have an impact on job performance. However, with the exception of the study by Lan *et al.* (1993), the relationship between self-monitoring and performance in educational settings has not been examined yet. Therefore one aim of this research project is to investigate the relationship between self-monitoring and performance in project-based learning (scenario 2).

2.4. The Relationship Between Job Performance, Network Position, and Self-Monitoring

So far, I described the relationship between network position and performance as well as between self-monitoring and performance. This section focuses on models which describe the relationship between all three variables self-monitoring, network position, and job performance. Mehra *et al.* (2001) introduced three different models that are shown in Figure 1 to describe how self-monitoring and network position may affect performance.

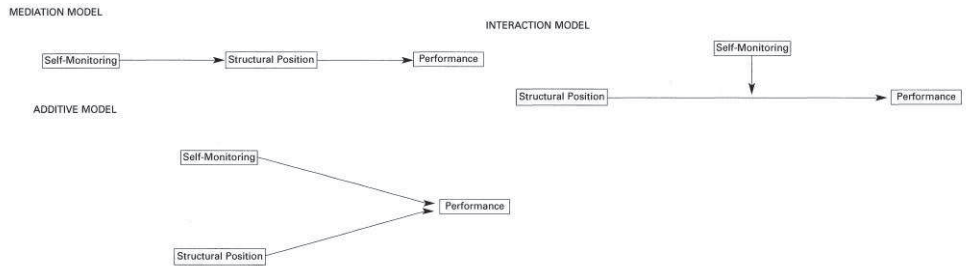

Figure 1: Three models (Mehra *et al.*, 2001)

The first model is the *mediation model*. According to this model, high self-monitors occupy advantageous positions in a network and thereby achieve a better performance than low self-monitors. According to the *interaction model*, in contrast, both a high self-monitoring personality characteristic and an advantageous network position in the social network are necessary to achieve high performance. This means that self-monitoring moderates the effect of broker positions on performance. Finally, the *additive model* hypothesises assumes that there are two independent ways of achieving a high performance: the first is occupying a structurally advantageous position and the second is being a high self-monitor. Mehra *et al.* (2001) tested all three models and found that the additive model explained the pattern in the data. However, they argued in favour of a more complex relationship between self-monitoring, network position and performance. They described this relationship using the model shown in Figure 2 and explained that high self-monitoring scores as well as an advantageous position were both predictors for high performance, but also affect each other in turn. According to this so-called *emergent model* the structural position has a direct impact on performance, while self-monitoring has both a direct effect and an indirect effect on performance. The indirect effect is driven by the impact of self-monitoring on the network position.

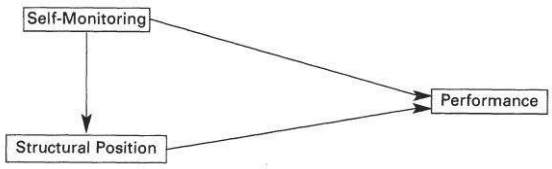

Figure 2: Emergent model (Mehra *et al.*, 2001)

According to the findings from corporate settings the emergent model could be crucial for explaining the relationship between broker position, self-monitoring and performance. Therefore, one aim of this research project is to test the emergent model.

3. Expected Progress and Testable Hypotheses

As described in the introduction, project-based work groups have become important in both corporate and educational contexts. However, the question what determines individual job performance in project-based work groups has not been adequately addressed yet. The previous chapters presented evidence from recent research and identified two factors which were related to job performance: Network position, in particular the broker position, and the personality trait of self-monitoring. None of the tested models explained the relationship fully. Hence, the aim of this research project is to examine how self-monitoring and network position influence job performance in project-based learning settings. With respect to the two scenarios, the corporate setting (scenario 1) and the educational settings (scenario 2) the objectives of this research project can be separated in the following four testable hypotheses:

Hypothesis 1: Individuals, who occupy broker positions, have higher job performance in project-based work as opposed to individuals, who do not occupy broker positions.

Hypothesis 2: High self-monitors achieve better job performance in project-based work than low self-monitors.

Hypothesis 3: High self-monitors are more likely to occupy broker positions than low self-monitors.

Hypothesis 4: The relationship between self-monitoring, network position and job performance can be described with the emergent model suggested by (Mehra *et al.*, 2001)

To answer the research question and test the hypotheses a correlational study is appropriated. The methods that will be used, are described in the next chapter, followed by a description of the analysis process for testing the hypotheses.

4. Research Methodology

In order to answer the research question this research includes the examination of two scenarios by using social network analysis (Scott, 2011), regression analysis and structural equation models. The first scenario is set in a team-based work environment in a public relations agency. As described, self-monitoring is a personality trait which is especially relevant in jobs which require strong self-presentation skills, and a public relations agency constitutes the ideal sample. However, teamwork is not only important within a professional but also in higher education context. Hmelo-Silver (2004), for example, states that team and project-based learning helps students to develop life-long learning skills which could be extremely helpful in future job situations. To take this into account, team-based work in university courses will be included as a second scenario. The following sections distinguishes between scenario 1 and 2 only if the research process differs.

4.1. Participants & Material

Participants in the first scenario will be employees of a large public relations agency. The decision which agency will fit best in the study context will be made in the course of the research process in a next step.

It is planned to conduct the study for the second scenario at the University of Applied Sciences in Darmstadt, in an undergraduate and graduate courses in the study programme Online Journalism and Public Relations (PR). The study focuses on the main project-based course that every student has to take at least one of these courses in each semester.

Throughout the study the participants of both scenarios have to work on different questionnaires.

4.2. Design

In both scenarios a *performance indicator* will be introduced as the *dependent variable* that operationalises performance for each individual. The performance indicator will be measured through evaluation sheets in a peer-review process. This offers the opportunity to receive several evaluations for each individual from her direct team members.

Self-monitoring scores for each participant as well as several *network measures* are to be introduced to the regression analyses as *independent variables*. Self-monitoring scores are to be measured with the 18-item self-monitoring scale and used as suggested by (Snyder and Gangestad, 1986); These scores will be added as a variable to the regression model. This variable operationalises the probability that an individual is a high or low self-monitor (Snyder and Gangestad, 1986).

There are several network measures that can be related to broker position. Thus, *betweenness centrality*, *aggregate constraint*, and *broker roles* will be introduced as *independent variables* to find the best data fit. These variables operationalise the network position of a broker.

Furthermore, *gender* and *age* are to be added as control variables to the model specification based on the findings by Day *et al.* (2002) that these two variables influence self-monitoring. Since the *grade of the last school assessment* is likely to be correlated with grades achieved at university, I control for entry grade in scenario 2.

4.3. Analyses

First, the data will be examined with methods from social network analysis. This allows for determining the network variables betweenness centrality, aggregate constraint, and broker roles as the key independent variables as well as closeness and degree centrality as control variables. The second analysis step is foreseens as a series of regression analyses.

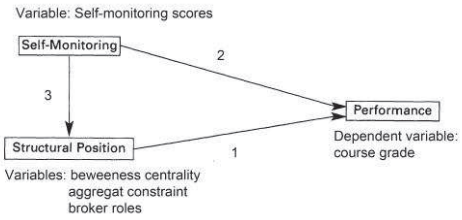

Figure 3: Variables

The first hypothesis is: Individuals, who occupy broker positions, have higher performance in project-based work as opposed to individuals, who do not occupy broker positions. To test this, the relationship between network position and

performance is examined which is marked in Figure 3 as "1". The second hypothesis states that high self-monitors achieve better performance in project-based work than low self-monitors. This is to be tested by examining the relationship between self-monitoring and performance which is marked in Figure 3 as "2". The third hypothesis claims that high self-monitors are more likely to occupy broker positions than low self-monitors. This is to be tested by examining the relationship between self-monitoring and network position as shown as "3" in Figure 3. To test each of these three hypotheses linear regression models is used. Hypothesis 4 relates to the overall model and states that the relationship between self-monitoring, network position and performance can be described with the emergent model introduced by (Mehra *et al.*, 2001). To test this model, more advanced statistical methods such as structural equation modelling is required.

5. Expected outcome and scientific contribution.

Nowadays project-based work is important in nearly every work environment. This includes corporate and educational settings. Therefore, it is interesting to understand which factors determine performance in project-based work. As project-based learning and job situations are similar, this research project contributes to answering this question by examining two scenarios, one being a corporate setting and the other an educational setting. Studies show that job performance is influenced by both network position and self-monitoring as a personality variable. However, the relationship between self-monitoring, network position and performance is not fully explained. Mehra *et al.* (2001) introduced several models which try to explain this relationship. I will contribute to this research field by examining project-based work and analysing the relationship between network positions, self-monitoring and performance which results in the first empirical test of the emergent model. The results of the planned research project presented here may lead to new insights about the underlying effects which determine performance in project-based work environments. These could be, for example, an understanding of problems in project work. Moreover this research project can lead to a framework for the analysis of project-based teamwork. This framework could help to identify positions in a network which are necessary for team processes. Moreover, knowledge about the influence of the personality trait self-monitoring can, e.g., lead to the suggestion to improve team processes by offering seminars about the personality component self-monitoring.

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The Role of Technological Innovation in Strategic Human Resource Management

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Abstract

Based on today's available information and communication technology (ICT) we examine the capabilities to develop the role of Human Resource Management (HRM) in direction of strategic HRM (sHRM). HRM in today's business has limitations to meet the challenges regarding personal capacity requirements, surpluses, capabilities, skills/knowledge and costs. On-going international competition, shareholders expectations, pressure from the legislative side, for instance by financial regulations, reinforce the pressure to succeed. Historically HRM was used primarily as a support-function for administrative tasks like salary accounting und employment contracting. Today for a company, or their departments or their individual's it is often extremely rare to find appropriate knowledge, capabilities or project experience, which is available, accessible, transferable or sellable, and this probably on demand. Therefore a model, called "Flexana", in form of a ICT-solution, is developed and proposed here, which enables HRM-functions to leverage human resources demands against surpluses, spanning company borders and to profile human resources in a precise and well-defined fashion. Under utilisation of Analytics and Metrics (A&M) the approach is, to allow HR-decisions be evidence- based. To validate this approach, will use a specific developed application-software. The goal is to converge the HRM with the ICT as well as with the A&M to bring the intersection of research, for the three of them ahead. As qualitative research generates rich, detailed and valid (process-) data that contribute to in-depth understanding of the context of the research, this will be the preferred methodology. The intended results are, on the one hand applicable and sustainable pattern of characteristic attributes for HRM-decisions-processes, on the other hand a blueprint for a convenient practice model. The conclusion of this research will lead to valuable insights in the interplay of the HRM, ICT and A&M.

Keywords

Human Resource Management, Information and Communication Technology, Analytics and Metrics, Resourced Based View, Evidence-Based Management, Transaction-Cost Economy, Innovation Processes, Capability Development, Knowledge Management, Labour Market, Coo-petition, HRM Decision-Making, strategic Human Resource Management, Outsourcing of HR practices

1. Introduction

This paper is based on the work for a Ph.D.-proposal and the aligned research so far. Business and progress - its all about humans, for and with humans. Business and progress are major driving forces and play a major rule in the quality of our environment and life. HRM in today's companies is often incapable to supply added value, for instance on demand for their strategic role, e.g. under appliance of analytic HRM. HRM decisions often lack rational facts. Hiring is seldom done on pure rational facts, promoting of individuals will not consider the real capability gaps of the company. As the objective of this research proposal is to converge the capabilities of ICT with the methods and tools of A&M, to bring sHRM ahead. Find here an overview of the key areas addressed in order to answer the research questions: **Human Resource management** (HRM) is an essential part of business management. The increasing importance of people to organizational success corresponds with the rise of **strategic human resource management** (sHRM) as a field of study worldwide (Boxall, 2003). No one can predict the organization of the future. No one can predict the course of the HR profession. No one can predict how HR practices will change in the future. Thinking about the future, however, helps us to prepare it. Thinking about the future may lead to innovative insights. Thinking about the future may help to change today´s HR practices in positive ways. (Ulrich, 1996) We will emphasize the importance of balancing the interests of multiple stakeholders such as company's, employees, unions, governments, and societies. The research subject "**Flexana**", as a convenient practice model for the proposed solution, will balance the interests of the multiple stakeholders. Flexana is designed as a database application with the ability, on the one hand, to leverage human resources demands against surpluses spanning company borders. On the other hand Flexana is designed to determine the actual skills, knowledge and behaviour capabilities of a company, as well as the demand for these attributes. As **ICT** is one of the major drivers in accelerating progress all over the business disciplines and has impact to every human being and might have influence to the whole environment, it is worth considering the possible influence, challenges and options of the technological innovations, here for sHRM. We will investigate in the following disciplines to learn about Flexana's potentials: What makes a company unique is their ability to turn their core competencies into success. When concentrate on, it is wise to take a look on the "**Resourced Based View**". (RBV) Despite the fact, that the RBV discipline is often criticized (tautological /self-verifying), it seems encouraging to figure out, in respect to RBV, if we can expect to sharpen a companies competitive advantage by Flexana. The resource-based view of the firm and strategy, in contrast to the product, or positional, view: This view of the firm started with the seminal work of Penrose (1959), was touched on by Selznik (1957) with his notion of distinctive competencies, defined by Wernerfelt (1984), and elaborated on by Barney in several works (1986a, 1986b, 1991, 2001). The RBV combines the internal analysis of phenomena within companies (a preoccupation of the 'distinctive' and 'core competency' group) with the external analysis of the industry and the competitive environment (a focus of the industrial organization group).

As the **Transaction-Cost Economy** (TCE) gave quantitative and qualitative information about the cost-transparency of HR, beside direct labour costs, it is meaningful to examine if there is a potential contribution by Flexana.

Transaction costs can be divided into three broad categories:(Dahlmann, 1979)

- Search and information costs are costs such as those incurred in determining that the required good is available on the market, which has the lowest price, etc.
- Bargaining costs are the costs required to come to an acceptable agreement with the other party to the transaction, drawing up an appropriate contract and so on. In game theory this is analysed for instance in the game of chicken. On asset markets and in market microstructure http://en.wikipedia.org/wiki/Market_microstructure, the transaction cost is some function of the distance between the bid and ask.
- Policing and enforcement costs are the costs of making sure the other party sticks to the terms of the contract, and taking appropriate action (often through the legal system) if this turns out not to be the case.

As the **Evidence-Based Management** (EBMgt) movement is a young discipline in making managerial decisions based on the best evidence available, it is valuable to research, whether Flexana is able to supply evidence-based information in decisions taken for HRM. EBMgt is making managerial decisions based on the best evidence available (Keans, 2012) All managers make decisions based on evidence. Many managers, however, give little or no consideration to the quality of the evidence they base their decisions on. Evidence-based management aims to change this situation. Evidence-based management is a decision-making process combining critical thinking with use of the best available scientific evidence and business information. Evidence-based management focuses on the decision-making process and thinks in terms of probability, instead of 'golden bullets'. Although many definitions of are available, the most frequently quoted and widely used is the definition by Briner, Denyer and Rousseau (2009):

"Evidence-based management means making decisions about the management of employees, teams or organizations through the conscientious, explicit and judicious use of four sources of information:

1. The best available scientific evidence
2. Organizational evidence and characteristics
3. Stakeholders' values and concerns
4. Practitioner expertise and judgment

Innovation Processes are the major drivers for progress. Looking at the innovation processes as a real key business process what drives business success, it's worth to investigate the influence of Flexana to master this key business process. "Great companies cannot be built on processes alone, but believe me, if company has antiquated, disconnected, slow-moving processes – particularly those that drive success in your industry – you will end up a loser." (Gerstner, 2002) As the

innovation process is not only a cluster of ideas or their implementation within the business, today it is has to be evaluated as a real key business process what drives business success. It is obviously that the fulfilment of a innovation process is a stringent discipline. (Morris, 2011) Enabling of **Capability Development** is one of the objectives in sHRM. Reality is, that HR often lacks this type of analytics and data based decision-making capabilities. So it challenges to investigate in the ability of Flexana in regard for this objective. If HR can make a strong case for being an important part of strategy development and implementation because of the importance of human capital, why does HR often fall short of being a strategic partner? At least one possibility is because HR lacks the type of analytic and data based decision-making capability needed to influence business strategy. One of the reasons for this may well be, because it lacks the right metrics and analytic models (Lawler, 2004). There are also other differences in the definition of capability, some have sought to define the key clusters of management competence (e.g. Cheetham and Chivers, 1996) and others have suggested a number of behavioural dimensions with good management determined by positioning behaviour along these dimensions (e.g. Winterton, 2001). If definition is a problem, measurement will inevitably be difficult too, and there are very few existing readily available measures of capability. We present some data that maps onto this element of the framework but feel that this is an area where the data is light (Tamkin, 2001).

Knowledge Management in HRM is a welcome area for this research proposal, because the "knowledge-creating" company, whose sole business is continuous innovation, is one of the most promising business-models. There is a need for related tools to detect and produce knowledge creating resources. Flexana is an example for this kind of demanded tools. And yet, despite all the talk about "brainpower" and "intellectual capital," few managers grasp the true nature of the knowledge-creating company—let alone know how to manage it. The reason: They misunderstand what knowledge is and what companies must do to exploit it. (Nonaka, I. 2007) …the knowledge and the skills of key employees are the most important assets (Cockburn and Henderson 2004) and the creation of knowledge is the key driver of competitiveness (Pavitt, 1984) (Ordaninia,Andrea and Silvestri,Giacomo, 2008). Because of these findings, it even leads to the key focal points for the demanded transformation-process in HRM, while heading to the future competitive organisation. As the supply shortage in **today's Labour Market** for the "right" human resources is on going and increasing the challenge in business-competition, there are solution approaches assumed by the usage of Flexana. Will investigate there. With a supply shortage in the labour market (during the economic upturn of the 1990s), the individualisation of society, and the increased educational level of citizens (and thus of employees), the power balance in the employment relationship has shifted in the direction of employees: they want to set their own career paths. (Bondarouk, Tanya, 2010). The actual status for acceptance of **Coo-petition** (in the Financial Services Industry (FSI)) will give us information about the fruitful mission of collaboration between companies (in FSI) and how Flexana will support this approach. Relationships between cooperating firms are usually visible even to outsiders. Especially small and medium sized firms commonly lack resources (Holmlund & Kock, 1998) and need consequently to cooperate with others, but at the same time they have to challenge their opponents, in order to survive.

As **HRM-Decision-Making** is a complex process under consideration of structured, semi-structured and unstructured decision challenges, it is valuable to know, what metrics and Decision-Support-Systems (DSS) and Business-Intelligence (BI) capabilities are requested to best support the wide range of the HRM-Decision making processes. Flexana will be a useful tool therefor.

Electronic Human Resource Management (eHRM) as a new discipline combined out of their parent disciplines ICT and HRM will cover today's methods, practices and tools to obtain success and progress in the human resources discipline. The study will take the actual status, demand and weaknesses into account, to investigate whether Flaxana contributes here. The combination between HRM, ICT with the statistical science and the managerial controlling discipline, stated by the term **A&M**, has the potential for a powerful tool and strategic impact on business management and the working environment. ...I defined HR analytics to be "the application of a methodology and integrated process for improving the quality of people-related decisions for the purpose of improving individual and/or organizational performance" (Bassi, et al., 2010). Perhaps most fundamentally, "what" HR analytics is about is taking an evidence-based approach to management. According to Pfeffer and Sutton, " Evidence-based management is based on the belief that facing the hard facts about what works and what doesn't, understanding the dangerous half-truths that constitute so much conventional wisdom about management, and rejecting the total nonsense that too often passes for sound advice will help organizations perform better" (Pfeffer and Sutton, 2006). But too often one-size fits-all measures of employee engagement have somehow become equated with organizational performance in the minds of many HR professionals, as well as their senior executives, despite the fact that it's now possible to link people factors directly to business outcomes themselves. The focus on employee engagement requires serious examination if HR professionals are to become able and respected practitioners of HR analytics (Bassi and McMurrer, 2010). Workforce analytics enable HR to analyse the impact that training has on business outcomes. Years ago, it was about time-to-hire. Today, it's about quality-of-hire. To begin the process of managing the data and transforming it to valuable business information, HR must be able to:

- Define and outline the desired future state for the enterprise, for the business in general and HR in particular;
- Identify, define, and quantify key performance indicators (KPIs) to achieve the desired future state;
- Assess and validate the current level of adoption of workforce intelligence practices, and identify the gaps;
- Develop a business case to "zap the gaps"; and
- Get management buy-in and support.

(Sudhakar Pemmaraju, 2007)

sHRM has to move towards fact-based decisions meeting the business demands. Companies (FSI's) generally number-driven, and HRM must be able to develop reliable figures and explain them, their coherence and their influence to decision-making process, therefor it is worth to examine the status of analytics in HRM to figure out gaps to close, probably under support of Flexana. For the FSI's the most critical and important resources are the human resources, despite the capital. Thus this tertiary economic sector has to focus on HRM and should use sHRM as a key-discipline. The constraint for the research has a geographical and industrial kind, because we will focus on FSI in Central Europe (with priority in Germany). Going to literature regarding the intersection of the HRM-, ICT- and A&M-Sciences and their contribution to business and progress in sHRM, will find underexplored areas, although real demand for comprehension and solutions are required. The aim is to demonstrate, how Flexana will contribute to HRM progress and which today's gaps in the intersection of HRM, ICT, Analytics and Metrics can be closed.

2. Problems identified

HRM in today's business has limitations to meet the challenges regarding personal capacity requirements, surpluses, capabilities, skills/knowledge and costs. On-going international competition, shareholders expectations, pressure from the legislative side, for instance by financial regulations, reinforce the pressure to succeed. Historically HRM was used primarily as a support-function for administrative tasks like salary accounting und employment contracting. Later on, as a second force, during recruitment-processes. HRM in today's companies is often incapable to supply added value, for instance on demand for their strategic role, e.g. under appliance of analytic HRM. HRM decisions often lack rational facts. Hiring is seldom done on pure rational facts, promoting of individuals will not consider the real capability gaps of the company. Today for a company, or their departments or their individual's it is often extremely rare to find appropriate knowledge, capabilities or project experience, which is available, accessible, transferable or sellable, and this probably on demand. A bundle of demanding challenges require solution approaches which, under support of ICT and A&M, should in future (and by support of these research) in place.

3. Research Questions

Following the problems identified, the research questions are: "Does technological innovation (ICT) contribute to our understanding of strategic sHRM?" As specified in the introduction section, are the described disciplines consistent to implement and apply in sHRM? Are there technological tools already in place to support? If not, what is the demand therefore and how is a realistic model look like, to satisfy the demand?

More specifically the questions are:

- Are technological tools enhancing the efficacy of sHRM processes?
- Which tools are available to address the problems identified? (Market Research)

- What and why does sHRM measure today, and when?
- How should sHRM performance be measured ideally?
- How should decisions to be taken in sHRM?
- Which technics lead to promising results?
- What are the critical components of a successful model?
- How should a sample implementation look like?

The answers to these questions will lead to an in depth understanding, of the actual status and gaps, in sHRM. The aim of the study is, to research the added value of ICT, in combination with A&M, within sHRM, in the context of business excellence. Having already defined the research objectives, derived from the themes, stated in the introduction section and the literature review the outcome was, that the single themes were defined and explored, more or less, well, but a combination, or a convergence and the resulting mode of action, of some or many of them, is not explored today! So, there are undetected potentials of benefits to expect, by convergence of ICT, A&M within HRM.

4. Proposed Solution

The proposed solution-model targeted on applicable solutions for the challenges of today's and future sHRM. The demographic change on the one hand, and the challenging demand of increasing competition in international und virtual markets on the other hand, often competing against alliances composed on different limbs of powerful value-chains, will foster companies and especially FSI's, to apply on ICT-based solutions in HRM. Flexana, as the proposed ICT-based solution model, will combine at least competencies out of the disciplines for HRM, ICT and A&M to equip sHRM with effective tools to encounter the described challenges. The mode of operation for Flexana tends in two main directions. The first one will act as a potential equalisation mechanism to leverage human resources demands against surpluses, spanning company borders. The second one is able to operate like a gap-analyser. This in order to determine the actual skills, knowledge, behaviour capabilities, range of responsibility for a company, a part of a company, like a division, department or an individual as well as the demand for these attributes. Thereby detected mismatches and gaps will give valuable information, for instance on decision-making. Centred in a technical database, with very in depth descriptions of HR-profiles, knowledge, capabilities, extensible in any desire, there are valuable insights available, which lead the sHRM, for instance, to evident based decisions. At least it supports HRM to gain a strategic role within a company's management.

5. Flexana as a prototype for the proposed solution in a HRM-Model

Motivated by FSI requests for the right quality and quantity of human resources, to the right time, at the right location, at fair pay, I have designed the Flexana-approach. Based on a survey at major German banks, about the trend for request on additional

human resource requirements for the upcoming 5 years, it was evident, that there is, on the long run, a common trend, but in comparison to the individual FSI's, a reverse trend frequently is in place. Common practice for recruitment is to hire job-candidates or mandate service-provider, personnel consultants, freelancer, depending on qualification and maturity. Concerning over-capacity of human resources, typical instruments are outplacement, partial retirement, specialised personal units, legal regulations or termination of employment for operational reasons. Flexana, as a prototype for the proposed ICT-solution-model in sHRM, is a database software application with the ability, on the one hand, to leverage human resources demands against surpluses company boarder spanning. Especially, while a company is in search for a human resource, temporary or permanently, in regard for a defined project or for a permanent appointment. As well, if a company is willing and prepared to release a human resource, temporary or permanently. Even, if a company (FSI) is willing and prepared to take over services or a project, or is searching for such accomplishments. At least, if a company (FSI) is searching for defined banking-specific knowledge, or is willing and prepared to share this. So Flexana is a solution-model in the form of a software-based platform, with the potential to leverage within the labour market. Obviously that conterminously a permanently demand for concrete, probably measurable qualities, of characteristic attributes exits. The model of Flexana is designed as a tool, to determine the actual skill, knowledge and behaviour capabilities of a human being, a department of any desire or a total company. Because out of this ability it is possible, to define a requested profile for an individual position or a complete demanded team. As a result the applicant obtains a well-defined gap analysis. Flexana is a useful model to analyse objectives and deviations of HRM in an analytical manner and therefore it is a valuable source for further analytics. As a compensative approach, Flexana enables companies (FSI's) to support their actual / temporary demand on HR-, service- and knowledge-requirements. As Flexana is a model for an ICT-platform,, which might run independent from legal locations and users, there is a potential to outsource tasks of the "Professional and Advisory" area. As a decision-supportive tool, Flexana is able to prepare, analyse and document decisions, which are evidence based, by pre-defined metrics. Flexana will help FSI's, their management, their employees, the related union's, their service-providers, their shareholder and the FSI-community to gain better and smoother benefits out of their related requirements on sHRM. Last, but not least, Flexana will identify and fill-up research gaps in the intersection of HRM, ICT and A&M.

6. Research Methodology to prove the model via prototype

Finding of the study will add to the understanding and knowledge of HR-Management challenges for today's the future needs, how technological innovation can contribute to our understanding of sHRM and to explore how technological tools are enhancing the role and efficacy in sHRM processes. To find the right research approach, I have to consider the research-object and the aim of the research-question. As the focus lies on how ICT are enhancing HRM efficiency under consideration of A&M, it might be wise to analyse the pros and cons of the qualitative versus the quantitative research and assess as well a combination of both methodologies. HRM consist of different fields of knowledge and disciplines and grows by on-going

adding of new disciplines, for instance like innovation processes and evidence-based management. That's to accomplish their essential functions like aligning HR and business strategy, re-engineering organization processes, listening and responding to employees, and managing transformation and change (Ulrich, Dave 1996). Thus the research objectives of the study lead to complex combinations, exponentiate by the reflections of ICT and A&M. The Question whether to apply qualitative or quantitative research can be answered by considering the respective characteristics. In respect thereof, will do in depth interviews with HR-Manager's in the FSI-Sector to find out the applicability of the Flexana model and evaluate the added value of the model. In addition will discover patterns, which indicates qualitative evidence as basis for rational HR-decisions taken. Where appropriate, align the approach by the upcoming learning's while the research. As well do in depth interviews with employees, unions, managers, providers… (Depending on the object of study). As well will capture interviews, and then anonymise them. As qualitative research generates rich, detailed and valid (process-) data that contribute to in-depth understanding of the context of the research, this will be the preferred methodology. As Quantitative research generates primary reliable population based and generalizable data and is well suited to establishing cause-and-effect relationships, it is the less preferred methodology, because the aim of the study will focus on the intersection of ICT, sHRM, A&M and requires a in-depth understanding in there principle of operation.

7. Conclusion and Outlook

The study will lead to an improved understanding of sHRM and how ICT considering A&M, can enhance these research area and the related processes. Defined instruments and tools, which supply valuable perceptions for HRM, the "Analytics approach" in HRM, is a reasonable way to proceed for evidence-based decision-making. The sHRM obtains the basis to transform to the next level in companies management, by usage of a powerful ICT and A&M tools, to solve major (upcoming) challenges in regard of recruitment, outplacement, forecast, detection of deviation in HR-objectives, -quantities, -qualities, -capabilities, -skills and knowledge. Recommendation is to invest in direction for convergence of technological innovation, by ICT, and HRM, considering A&M, to face the described challenges of today's and future demand in sHRM. The innovation approach lies in the convergence of the described fields. The intended results are, on the one hand applicable and sustainable pattern of characteristic attributes for HRM-decisions-processes, on the other hand a blueprint for a convenient practice model. The conclusion of this research will lead to valuable insights in the interplay of the HRM, ICT and A&M. Abstractly defined, the study will be an academic contribution to the literature as well as a managerial and practical contribution. The results will be applicable to other industries/sectors, beside FSI, and in further parts of the world, as well.

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An Investigation into the Marketing, Advertising and Labelling of Processed Food in Ireland and its Influences on Consumer Choice and Subsequent Health Issues

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Abstract

Ireland has experienced much economic and social change in recent years, along with these changes many new food choices are on offer. A simple diet of fresh, unprocessed foods that existed in Ireland in the past has for many consumers been replaced by processed, convenience foods. This change in diet has led to an increase in the incidence of overweight and obese adults and children, and an increase in Type 2 diabetes, the Irish Universities Nutrition Alliance, (IUNA) 2011. The purpose of this study is to examine the marketing, advertising and labelling of processed food in Ireland and the ensuing influence on consumers choice of food. It is also the purpose of this study to examine the links between consumption of processed food and the increase in health concerns including obesity and Type 2 diabetes. Consumers are confronted with the naming of complex ingredients, nutritional values and guidelines as well as health and nutrition claims when buying these products. The advertising claims and labelling of these foods is of interest in this research because consumers are challenged to understand and interpret exactly what additives are contained in processed food products. Nutrition labelling may be in one of two different formats and manufacturers guidelines regarding portion size can differ in products. The nutrition labels must list energy, protein, carbohydrate and fat. However the Food Safety Authority of Ireland (FSAI) states that nutrition labels are voluntary for the manufacturer and are only compulsory if a nutrition claim is being made, for example claims such as high in fibre or low in fat. The nutrition and health claims made by food manufacturers in marketing and advertising campaigns and how these influence consumers will be investigated. The difficulties which consumers encounter when trying to interpret the information on food labels will be researched.

Keywords

Food marketing, Food Advertising, Food Labels, Obesity, Type 2 diabetes

1. Introduction

In this study it is proposed to link the advertising of highly processed foods to children with poor eating habits. The factors which influence consumers food choices is of interest in this research and the influences, if any which advertising and marketing of these foods have on food choice will be explored. The understanding and frequency with which consumers read nutrition labels on food products will also

be examined. The role played by schools in promoting and encouraging healthy eating in children and any subsequent influences this has on food choice will be explored. This research is also concerned with the link between unhealthy diets and disease, especially obesity and Type 2 diabetes and how this type of diabetes may be prevented. Campaigns promoted in Ireland to encourage healthy eating and their effects, if any, on consumers' food choice will also be examined.

1.1. Aims

There is a lack of Irish studies on the effects that the marketing, advertising and labelling of food products have on consumers food choices. This research aims to establish a link between the advertising of processed foods high in fat, salt and sugar and the increase in obesity and Type 2 diabetes in Ireland. The following research is particularly concerned with the effects of advertising foods to children especially the advertising of those foods which are energy rich but nutrient poor. This study also aims to examine the subsequent effects, if any, on those children and whether or not this advertising affects their parents or guardians choice of food for both them and their children. The labelling and marketing of these calorific foods in Ireland is also of interest in this research. This research aims to explore the link, if any, between the ability of children and adults to make healthy food choices while being exposed to advertising of processed foods.

The ability of consumers to understand food labels and the claims made by food manufacturers is of particular interest as the styles of labelling of food products can vary greatly for different foods. The role of education in instilling an understanding of basic nutrition necessary to make informed food choices is also of interest and will be investigated. The availability of processed food creates many challenges for consumers; the ability to understand what is contained in the food may be difficult as many of the ingredients listed are not familiar natural products. The terminology used on food labels may also lead to confusion for consumers. A label and ingredients list on a processed food product is often the only means available to the consumer to identify what is present in the product. This study aims to assess the ease with which these labels and lists of ingredients contained can be interpreted by consumers leading to informed food choices. The attempts by various governments to consolidate food labels into a single format are of relevance as many different variations exist at present.

A further aim of this study is to explore the influence which advertising and marketing campaigns have on consumers' food choices. The advertising of processed foods high in fat, salt and sugar is disproportionate to the amounts of these foods recommended in a healthy balanced diet. Celebrity endorsement of products, the relationship between processed foods and celebrity advertising and promotions of high energy foods including free gifts is also of interest.

The presence of calorie counts and nutritional information on menus and whether or not consumers will use this information is also of relevance in this research as there is a perception that consumers are capable of understanding calorie information if they are to use them to make food choices based on the calorie content. This research

aims to evaluate the capability that consumers have to understand this calorie information and if it influences their subsequent food choices. A further aim of this research is to examine if consumers are influenced by health and nutrition claims on food labels.

1.2. Objectives

One of the main objectives of this research project is to investigate the role of diets, high in processed foods, as a causative factor in Type 2 diabetes and obesity and how the increase in the incidence of Type 2 diabetes and obesity may be prevented through diet. The role of advertising to children and the subsequent effects on those children and whether this affects their parents or guardians choice of food will be considered. The advertising of unhealthy foods in a positive manner and whether this encourages people to make unhealthy food choices will be studied. The labelling of food products and whether they are clear and informative for consumers to decipher and therefore lead the consumer to make informed choices when purchasing food will be explored. The health and nutrition claims on a sample of food labels will be studied and whether these claims are an influencing factor in food choices made by consumers will be surveyed.

The impact of healthy eating campaigns and the current recommended dietary guidelines in Ireland, including the Food Pyramid will be considered. The importance of dietary habits learned in childhood and the influence of these on adult eating habits will be examined. The inclusion of calorie information on menus will be examined and the possible effect this may have on consumers' food choices will be assessed. The introduction of measures adopted in other countries to encourage consumers to select healthy food options will also be evaluated.

2. Review of the Current Literature in the Field of Research

The World Health Organisation (WHO) states that Type 2 diabetes usually develops during the adult years and is related to obesity, lack of physical activity, and unhealthy diets. The World Health Organisation (WHO) defines diabetes as:

> *A metabolic disorder of multiple aetiology characterized by chronic hyper glycaemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both. The effects of diabetes mellitus include long–term damage, dysfunction and failure of various organs. Type 2 diabetes usually develops in adulthood and is related to obesity, lack of physical activity, and unhealthy diets.* (1999).

The WHO state that ninety per cent of diabetes worldwide is in the order of Type 2 diabetes. Modern dietary habits and current trends in eating will be examined and possible links to conditions such as obesity and Type 2 diabetes will be examined. The link between the so called Western lifestyle and the prevalence of Type 2 diabetes will be investigated. *Results from ecological and migration studies indicate*

that a western lifestyle is associated with a higher prevalence of type 2 diabetes (Van Dam 2003). The role of advertising processed foods to children and its relationship to the increase in obesity and Type 2 diabetes, if any, will be examined. In a performance report issued by the Health Service Executive (HSE) in 2009 it is stated that obesity *accounts for 80% of the dramatic rise in type 2 diabetes.*

Growing Up in Ireland is a National Longitudinal Study of children; the study was officially launched in January 2007. The study is taking place over seven years and is following the progress of two groups of children; 11,000 nine-month-olds and 8,500 nine-year-olds. In November 2009, the Growing Up in Ireland study found that nineteen per cent of nine year old children were classified as overweight and seven per cent as obese. *Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health*. World Health Organisation (2012). They also state that *the fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended* and that one of the vital changes needed to prevent overweight and obesity is to encourage people to choose healthy foods. In a Summary Report from the National Adult Nutrition Survey released by the Irish Universities Nutrition Alliance (IUNA) in March 2011, a total of twenty four per cent of those surveyed were obese (twenty six per cent men/twenty one per cent women) and thirty seven per cent were overweight (forty four per cent men/ thirty one per cent women). Other findings of the research identified that concerns about diabetes among those surveyed have doubled in the last year. The survey also found that the prevalence of obesity in eighteen to sixty four year old adults, the age group of those surveyed, has increased significantly since 1990 from eight per cent to twenty six per cent in men, and from thirteen per cent to twenty one per cent in women. Studies relating to these statistics will be researched to ascertain if there are links to the consumption of processed foods and the increase in obesity and Type 2 diabetes. In a report comparing the heights and weights of Irish children in 1948, 1970 and 2002, Perry *et al.* (2009) stated that there is *stark and compelling evidence on the evolution of the obesity epidemic in Irish children in tandem with the increase in economic prosperity.*
A fact-book published by the Organisation for Economic Co-operation and Development (OECD) in 2010 states that *half or more of the adult population is now defined as being either overweight or obese in thirteen OECD countries*, Ireland is one of those thirteen countries. It is also stated that obesity is a known risk factor for numerous health problems including diabetes. The Safefood Omnibus survey of 1948 adults in Ireland in April 2011 found that ninety six per cent of adults agree being overweight impacts a person's health while fifty two per cent were aware of Type 2 diabetes as a health condition associated with excess weight. Safefood describe their organisation as a North-South body, responsible for the promotion of food safety on the island of Ireland.

In a report on Noncommunicable diseases (NCD) issued by the WHO in 2010, it is stated that in 2008 diabetes caused 1.3 million deaths worldwide. The report also states that the World Health Organisation *projects that diabetes deaths will double between 2005 and 2030.* The WHO also states that Type 2 diabetes can be prevented. According to World Health Organisation statistics diabetes is predicted to become the seventh leading cause of death in the world by the year 2030. In a report

published by the Institute of Public Health in Ireland, Balanda *et al.* (2007) state that *in 2007, nearly 144,000 adults in the Republic of Ireland (4.5%) have diabetes. By 2020 this is expected to rise to over 233,000 (5.9%). This represents a 62% increase, an additional 89,000 adults, in less than 15 years.* In 2008 the Health Service Executive (HSE) released a report, Health Status of the Population of Ireland, which states that:

> *The actual prevalence (number of cases) of diabetes in Ireland is not known. It is known, however, that the number of people affected by Type II diabetes is increasing rapidly due to the increasing levels of obesity. It is thought that 1 in 20 people in Ireland may have diabetes, with half still undiagnosed.*

In January 2009, the Voluntary Health Insurance organisation (VHI Healthcare) undertook a screening project, the largest ever study of its kind, in Ireland. In this study nineteen thousand people were screened for Type 2 diabetes and cardiovascular risk factors; two thousand four hundred of those screened were found to have either diabetes or pre–diabetes. The screening project also found that sixty three per cent of participants were either overweight or obese. This research is topical as the Minister for Health in Ireland, Dr James Reilly has said that he will regulate food and drink companies to comply with labelling requirements. On September 29th 2011 a debate was held in Dáil Éireann about childhood obesity. During the debate Dr Reilly outlined how an action group to tackle childhood obesity was set up in 2011. He proposed that a combination of measures was needed to tackle the problem of obesity and outlined the proposals being considered.

> *The group is concentrating on a range of measures, including actions such as calorie posting in restaurants, the introduction of a sugar tax on sugar-sweetened drinks, nutritional labelling, restrictions on the marketing of food and drink to children, the improved detection and treatment of obesity, revised healthy eating guidelines and the promotion of physical activity.*

The progress of this action group will be followed and reviewed. On February 2nd 2012 The Food Safety Authority of Ireland (FSAI) announced a national consultation to seek opinions on the best way of putting calorie information on menus in Ireland. According to the FSAI, Dr James Reilly wrote to Fast Food outlets and cafes in 2011 requesting that they *consider including calories on their menus* .This consultation process was seen as a way in which both consumers and those in the food industry could make their views known on the inclusion of nutrition and calorie information on menus. Mandatory inclusion of calorie content on menus in the United States has incurred opposition by some chain restaurants and restaurant associations. Bollinger *et al.* (2010). In June 2011 the Irish Minister for Children and Youth Affairs, Frances Fitzgerald, spoke at a Public Health Policy Framework Consultation Day. According to the Minister 'the greatest public health threat may well be posed by childhood obesity'. She went on to outline how obesity is often a causative factor in a number of conditions including Type 2 diabetes. She also proposed that the Food Pyramid and Healthy Eating Guidelines would be revised and that the matter of including

calorie content on menus would be investigated. The importance of dietary habits formed in childhood is of particular significance when considering the advertising of food to children as *food behaviour and concrete food choices are established already in childhood or adolescence and may significantly track into adulthood.* Mikkilä *et al.* (2005).

In an Irish context children are becoming more overweight and obese, Perry *et al.* (2009) state that *the data provide stark and compelling evidence on the evolution of the obesity epidemic in Irish children in tandem with the increase in economic prosperity.* The increase in the incidence of overweight and obesity is a global problem and the links to other life-threatening conditions are of interest in this research. *Rising prevalence of obesity is a worldwide health concern because excess weight gain within populations forecasts an increased burden from several diseases, most notably cardiovascular diseases, diabetes, and cancers.* Wang *et al.* (2011).

2.1. Research Contributions

There is a lack of Irish studies on the effects that the marketing, advertising and labelling of food products have on consumers food choices. This research aims to prove a link between the advertising of processed foods high in fat, salt and sugar and the increase in Type 2 diabetes in Ireland. This research is particularly concerned with the effects of advertising foods to children especially the advertising of those foods which are energy rich but nutrient poor. The increase in the incidence of obesity leading to health problems, including type 2 diabetes, has been the subject of many studies in the United States. Dietary habits formed during childhood persist into adult years Mikkilä *et al.* (2005) and the ability of children to make healthy food choices while being exposed to advertising of processed foods is of interest in this research. The ability of consumers to understand food labels and the claims made by food manufacturers is of particular interest as the labelling of food products can vary greatly for different products. The role of education in instilling an understanding of basic nutrition necessary to make informed food choices is also of interest. The availability of processed food creates a challenge for consumers to understand as many of the ingredients listed are not familiar natural products. The ease with which these labels and lists can be interpreted by consumers leading to informed food choices is of particular interest. The attempts by various governments to consolidate food labels into a single format are of relevance as many different variations exist at present.

The association of processed foods with celebrity advertising and promotions including endorsements from animated film characters is also of concern as there is a lack of studies relating to Ireland. The inclusion of calorie information on menus and whether or not consumers will use this information is also of interest as there is an assumed knowledge that consumers understand calories if they are to use them to make food choices based on the calorie content. The possibility of confusing messages surrounding the marketing, advertising and labelling of foods is an area of interest in this research. The use of terminology such as low fat, high fibre, no added sugar, on the labels of packaged foods will be examined and the understanding that consumers have of these terms will be studied.

3. Research Methodology

In a very simple explanation Kumar (2011) describes that the main purpose of research is to *discover answers to questions through the application of scientific procedures.* It is the objective of this research to identify any links and influences that the marketing, advertising and labelling of food products have on consumers' food choices and to determine the influence of diet in the prevalence of Type 2 diabetes. A thorough literature review will be conducted by studying previous research on this topic available in textbooks, research papers, journals and websites. Kumar (2011) also states that *research is one of the ways to find answers to your questions.* The Organisation for Economic Cooperation and Development (OECD) define research as: *Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.* The main purpose of research is *to discover answers to questions through the application of scientific procedures*. Kumar (2011). *Research results do not always reflect a definitive answer with clearly revealed conclusions and, in fact, often seem to generate more questions than they answer*. Gerhardt (2004).

It is the purpose of this research to investigate the link between advertising of food and consumers food choices, and whether or not these food choices are influenced by the advertising, marketing and labelling of foods. The health issues related to diets high in the consumption of processed foods will be studied. Qualitative research methods focus on description, qualities and observation. Qualitative researchers seek insight rather than statistical analysis (Bell, 1999). Coolican (2004) states that quantitative research is high in reliability but low in validity, while qualitative research is high in validity but low in reliability. This research will be primarily qualitative. Validity refers to how well an instrument measures what the researcher wants to calculate. Validity encourages confidence and integrity in the research undertaken. Reliability is the ability of a chosen research method to produce similar results when performed under similar conditions. Reliability is the consistency of a measurement. *Reliability is a measure of accuracy, stability and predictability* (Kumar 2011). *Reliability is the extent to which different methods or people would arrive at the same data or result* (Keller, Casadevall-Keller 2010). Objectivity is defined by Hitchcock and Hughes (2003) as *a way of looking at a situation from the outside, that is, without making prescriptive value-laden judgements or moral assumptions about the phenomena.*

In this research it is the decision of the researcher to adopt a predominantly qualitative approach. A detailed review of current studies in the implications of advertising food and the consequences which these processed foods have on health will be undertaken. The ability of consumers to understand and interpret food labels will be assessed by conducting thirty in-depth interviews using a thoroughly prepared interview guide. The effects of advertising, marketing and labelling of foods will also be investigated during these interviews. The selection of interviewees will be a random selection of parents and guardians in charge of the purchase of household food. The interviewees will come from a cross section of socioeconomic backgrounds to best assess how general consumers interpret food labels. A

qualitative research method is valid in this study as the information and statistics needed to form realistic conclusions will be gathered over a number of years. Therefore a comprehensive review of studies relevant to this research will be undertaken. This research is on-going and will be completed by June 2014.

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The perception of German fur buyers – an empirical analysis of buying behavior

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Abstract

This paper presents a research proposal for the investigation of the buying behavior of German consumers in the luxury segment of furs. So far, the German fur and clothing industries have neglected to conduct an investigation on the target group "fur buyers" based on scientific methods. The numerous publications in the area of the luxury goods market are concerned, among other things, with brand recognition, purchasing motives and industry branch-specific investigations — with a focus on fashion. One area in which there are no empirical findings as yet is the buying behavior of German consumers in the luxury segment of furs. The dissertation will first investigate the complex consumer behavior in the purchase decision process with the help of a quantitative survey of the target group and identify factors of influence. The results obtained from the empirical investigation should also allow a suitable initial market segmentation according to classical segmentation criteria.

Keywords

Fur, fur clothing, clothing industry, luxury, luxury goods, marketing, purchase decision process, buying behavior, target groups, market segmentation.

1. Introduction

Fur has always been a form of clothing, as well as an essential component of human civilization. In the past, fur was reserved for the upper social classes (Reichel, 1998), but today it has become affordable for a wide category of buyers. While the demand for furs is sinking in large parts of Europe, and especially in Germany, countries like China and Russia are currently experiencing a real boom in demand (Deutsches Pelz Institut Web Site, 2013). The worldwide fur trade was valued at USD 15.1 billion for the 2010/2011 financial year; 4.5 billion in the EU and 10.6 billion in non-EU countries. While the turnover of the German fur trade in 2001 was 1.9 bil euros in 2001, it only achieved a turnover of 1 bil euros in 2011(Deutsches Pelz Institut Web Site, 2013).

It can be observed that turnover from furs in Germany has constantly remained at approx. 1 bil euros since 2002. This has only remained so stable because, according to a statement of the German Fur Association, the export share of the German fur industry currently lies at 80% (Sixt, 2013). With this high export ratio, the turnover of the German fur industry has remained more or less constant, but the low

percentage of turnover within Germany (approx. 20%) is an indication of the situation in Germany.

The German textile industry has been a key market for the fur industry for many years now. Here, one is confronted with the same set of problems that is also present in the fur industry. The turnover from furs from the area of women's clothing in Germany has dropped sharply in the past few years. Although the turnover was 500 million euros in 2005, it was only 80 million euros in 2013 (Rößler and Engmann, 2012). The situations described highlight how drastically domestic demand for furs from German consumers has dropped.

In retail stores and in manufacturers' flagship stores, furs are offered in the form of trimmings or complete articles. This means that, in addition to their own products, retail stores for women's outerwear also offer jackets, coats or accessories that are made entirely of fur, such as e.g. fur jackets, fur coats, vests, accessories, or which only have trimmings made of fur, such as the fur on the hood of a jacket or in the form of a jacket collar.

2. Initial position

According to a study by the German publishing house Spiegel in which 10,167 persons were surveyed on their attitudes towards the use of fur in clothing, 82 % of the German population have a negative opinion of fur and cannot imagine wearing fur as an article of clothing. Only 16 % had a favorable or neutral opinion regarding fur, while 1 % declined to comment (Spiegel Verlag, 2007).

Existing studies (Bruckert, 2001; Baumanns 1989; Werkmeister, 1989) by the German Fur Institute and reports from the media illustrate why the German customer continues to distance himself from luxury product fur. These are, for example:

- Fur is ethically (animal welfare, killing animals) incorrect (Mail Online Web Site, 2011)
- There is no need to wear a fur coat (Landestierschutzbeauftragte Hessen Web Site, 2013)
- Sustainability and fur is seen as a contradiction (Model Vita Web Site, 2013), etc.

It is to be assumed that disinterest (IFTF, 2007) regarding fur and the negative opinion (Karmasin, 2003) of fur among opponents of fur are too strong for them to be positively influenced by the fur industry. This is why this dissertation distances itself from the inclusion of this group of customers. Rather, there is a need to more closely examine the target group of fur buyers, who have a positive attitude towards fur. Their buying behavior is to be examined more closely, and the findings obtained should not only allow recommendations, but mainly it should also involve a segmentation of the target group.

Almost all investigations done by the fur industry have attempted to find out if German end consumers would buy fur in the future. It should be noted that existing studies generally did not differentiate between fur coats/jackets, accessories made of fur (handbags, scarves etc.) and fur trimmings (fur on a hood or as a collar) in the surveys made. Today, this differentiation is of central importance, as the willingness to buy accessories and articles of clothing with fur is demonstrably much higher than for a fur coat or fur jacket. In the case of the latter, sales continue to recede (Kolb-Wachtel, 2013).

Furthermore, the methodical execution of the studies was such that a negative evaluation of the fur industry and a categorical rejection of fur by the consumer were to be expected from the very beginning. The findings may represent the majority opinion of the German consumer, but the few remaining supporters of fur were given insufficient representation in the sample size. This means that the studies carried out were designed for all potential buyers. Hence, the target group "fur supporters/fur buyers" did not receive adequate representation.

However, it should be the goal of such studies to better understand potential buyers, to understand how they behave before and during the purchase decision, which external influences affect them and which purchasing motives they have. The proposed dissertation uses exactly this as a starting point and will survey this target group at random at the point of sale. The aim of using this methodology is to obtain valid results that allow inferences to be made about the population. In addition, it is also important to perform a segmentation, as is common in consumer goods markets, in order to address the target group in an appropriate manner.

3. Relevance of the topic

Fur is a luxury good, and the market for luxury goods shows above-average growth. According to a study by the consultancy Roland Berger (Berger 2012), the global growth of the luxury goods market was 9 % in 2011. The German market for designated luxury brands even expanded by 16 %, reaching 12.9 bil euros, which means that the global growth average (approx. 9%) was even exceeded. However, one should bear in mind that this only includes the classic luxury markets, i.e. clothing, jewelry, watches, cosmetics etc. Other areas such as property, cars etc. were not included (Eggert Web Site, 2013).

One possible cause for this positive development for the luxury goods market is the way numerous luxury brands have revised their strategies. In this respect, it is not only differentiation strategies (Wieske *et al.* 2013) that are in the foreground - there is also an emphasis on geographical and brand expansion strategies (Meffert *et al.* 2005). This means that providers of luxury brands no longer market their products only to small and exclusive groups, but also increasingly to a wider consumer segment (Catry, 2003). Goods and services are now no longer reserved exclusively for a particular social class (American Express Web Site, 2006). Despite this obviously positive development in the luxury goods market, the German end consumer remains reluctant to purchase fur products. It is justifiable to point out at this stage that the fur industry and clothing industry have neglected to investigate

these buyers and hence have no substantiated empirical information on the target group. The market for luxury goods continues to grow. This potential with regard to fur has definitely not yet been exhausted in Germany, and opens up new possibilities.

The increased economic importance of the luxury goods market is apparent from the large number of scientific publications. Among these are studies on brand recognition (Dion and Arnould, 2011; Wiedmann *et al.* 2009), purchasing motives (Han *et al.* 2010; Wiedmann *et al.* 2007; Wilcox *et al.*, 2008), the management and direction of luxury brands (Atwal and Williams, 2009; Büttner *et al.* 2008) and on investigations specific to certain industry sectors - with a focus on fashion (Okonkwo, 2009; Joy *et al.* 2012). One area in which there are no empirical findings as yet is the buying behavior of German consumers in the luxury segment of furs. It is the aim of the proposed dissertation to provide a scientific contribution to this neglected area of research.

4. Approach

The dissertation with the topic "The perception of German fur buyers – an empirical analysis of buying behavior" uses a well-founded methodology to answer the question of how German end consumers behave during the individual phases of the purchase decision process when buying fur (Figure 1).

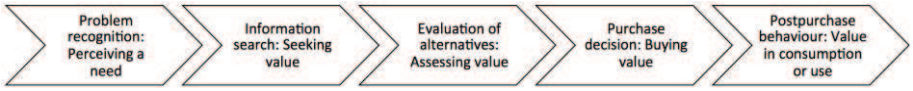

Figure 1: Consumer purchase decision process model (Kotler and Amstrong, 2013)

To do so, it is of key importance to show which determining interpersonal (culture, norms, social standing, groups, family) and intrapersonal (activity/involvement, emotion, motivation, attitude, values, personality) factors (Meffert, 2000) affect the consumer in the individual phases of the purchase decision process.

A quantitative survey will be carried out in order to analyze buying behavior during the purchase decision process. This will be done with the use of a standardized survey form directly at the POS (point of sale) immediately after the purchase of an article of clothing made partially or entirely of fur. The consumer will then be asked about his behavior in the individual phases of the purchase decision process and what affected his decisions:

Recognition of a problem: The buying process begins with the buyer identifying a problem or a need. The identification of a need takes place via internal (e.g. self-validation, social affiliation) or external (influence from commercials, encouragement from environment) stimuli (Kotler and Bliemel, 2001). For this aspect, the circumstances which triggered the need will be investigated.

Search for information: An increased amount of attention is paid to the acquisition of products which are not everyday necessities. Usually, in this case an active search for information is started before the purchase decision. What is interesting in this case is where this search takes place (catalog, online, magazine) and who (friends, sales staff) the consumer consults for information (Kotler *et al.* 2011). The duration and intensity of an active search for information depend for example on the consumer's personality, social affiliation, income and his experience. However, the satisfaction with previous purchases, the importance of the purchase and the (financial) risk related to the purchase also play a role (Assael, 2003).

Evaluation of alternatives: Once the collection of information is complete, the selection and evaluation of the various alternatives begins. The goal of this phase is to choose the best option out of all the alternatives from the perspective of the consumer. Beneficial aspects, such as the quality of the article of fur clothing, comfort and brand image are important here (Kotler *et al.* 2011). The task in this phase is to investigate which criteria the buyers use to compare the individual alternatives and if the attributes listed play a part at all.

Postpurchase behaviour: For this phase, it is of central importance to find out what ultimately made the customer purchase the product at the POS (e.g. sales staff, price, brand, location, quality). An intention to purchase does not always lead to the decision to make a purchase. Two factors may still disrupt or even cause the complete abortion of this process:

a) Intensity of negative attitudes of others such as influence from reference groups

b) Unforeseen situations and circumstances (e.g. the right size not being available, problems with payment).

The consumer's resolve to make the final decision, to delay it or to abandon it altogether is strongly influenced by the subjective perceived risk. Purchases with a high value are risky (Kotler and Bliemel, 2001). Existing uncertainty factors are the workmanship and quality of the product and if the price-benefit relationship still corresponds to the customer's wishes in such cases.

Postpurchase behavior: After the purchase, the customer is either satisfied or dissatisfied. In addition, there is also the risk of a cognitive dissonance. Customer satisfaction is important, because the group of buyers consists primarily of returning buyers and a small percentage of new customers (Kotler *et al.* 2011). Today, it is of particular importance in the area of high-quality and durable consumer goods to compile information on customer satisfaction via the use of targeted after-sales marketing and to work on any postpurchase dissonance customers have with products after their purchases. Product information, for example about the fur species or the promise of additional services and warranties are suitable measures for this (Fritz and Oelsnitz 2006).

The survey will be conducted exclusively for the women's outerwear segment, as it is the largest key market for fur. Selected retail stores for women's outerwear and from

the fur industry will be taking part in the survey. The desired rate of return is approx. 700 completely answered survey forms. An accurate determination of the sample size will be made.

An exploratory preliminary study is planned for the successful implementation of the survey. This study aims to discover reference indicators for the formulation of hypotheses for research and practical purposes. As part of this preliminary study, managers and sales staff from WO (women's outerwear) textile clothing companies and experts from the fur industry such as fabricators, commissioning agents and retailers will be surveyed on the possible factors in the form of an interview or a survey form. Another possible approach for a preliminary study would be the formation of a focus group of six to eight fur buyers who would then be surveyed on their buying behavior for an article of clothing made entirely or partly of fur in order to obtain objective answers and attitudes from the relevant target group.

The findings obtained in the empirical investigation will make it possible to identify factors in the individual phases of the purchase decision process that are relevant to the purchase and which influence the consumer, as well as the extent of such influence. Furthermore, an evaluation of whether the purchase decision process can generally applies to luxury goods will also be carried out. The statistical evaluation will be carried out with the use of a suitable multivariate analysis method.

The purchase decision process is meant to contribute to the visualization of the complex consumer behavior of fur buyers, to explain it and to illustrate factors of influence. However, during the collection of the data, consumer-oriented criteria should also be included in the survey for the purposes of market segmentation. In order to do so, the classic market segmentation criteria will be used, which can be categorized into behavior-related (Crobat, 2012) and consumer-oriented criteria (Meffert, 2000):

Behavior-related criteria:

- Price behavior
- Media use
- Preferred retailer
- Product selection

Consumer-oriented criteria:

- Psychographic criteria (general personality traits and product-specific criteria)
- Sociodemographic criteria (demographic characteristics and socioeconomic characteristics)

- Geographic characteristics (macro-geographic and micro-geographic characteristics)

The combination of behavior- and consumer-oriented criteria allows a first subsequent market segmentation of the interest groups on the fur market. This will initially allow fur buyers with their various motivations, wishes, resources and attitudes towards purchases to be categorized and presented.

5. Conclusion

This dissertation contributes to a closer examination of buyers of fur in Germany with selected empirical and economic methods for the first time. In addition to the empirical investigation of fur buyers during the purchase decision process, another main component is the subsequent market segmentation that aims to enable target groups to be addressed appropriately. The findings of this thesis also provide added value for the fur and clothing industries. They will receive the opportunity to find out which strategic marketing measures should be implemented in order to better appeal to their target groups in future. For both branches, it is important to know what drives and influences customers in the period from the point in time they recognize a need to the ultimate decision to purchase an article of fur clothing. It is the customer who decides to buy or not to buy a product, and only he knows what the customer's needs and desires are and attempts to satisfy them to the greatest possible extent has a chance at long-term success.

Fur as a natural product has also proven itself in battles against animal activists and a variety of animal rights organizations. If one looks at studies from the German fur industry from the 80s, it becomes apparent that the opinions and attitudes German consumers have regarding fur products have not changed significantly to this day. The only exception in this case was the upper social strata. There is room for more scientific investigation regarding the extent to which PETA and other organizations actually influence the individual consumer in his purchase decision.

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India, an Asian Giant: A Compass for the Future

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Abstract

In the 65 years since India formalised its independence from the British Empire, the country has experienced an immense metamorphosis in all aspects of its economy. This current study is an analysis of what the possible future economic prospects are for India. As part of the research process, the researcher initially delved into the history of the economy since its independence from British colonial power right up to its current economic situation.

The current global economic crisis has in part been the backdrop for undertaking this current study, as it has been the catalyst in shifting the pillars of universal economic power between the weakening West and the emerging East. Society is living through one of the most remarkable and intriguing economic times for many decades. Seismic shifts in economic dominance have occurred between these regions, the West and the East, the magnitude of which has not been seen for hundreds of years; not since the balance of power was held in the spice, silk and jewel-rich east. Consequently, this study empirically examines the key drivers that have influenced the Indian economy over the past number of decades and that have shaped its development to date and into the future. The qualitative data gathered from 10 experts in the field such as India economists, business professionals in India & academics, also examines those factors that are central to its continued evolution and those that are the driving force in moving the economy forward into the future.

The research reveals many interesting and important results, most notably that, despite numerous economic problems in India, it will be economic growth that will sustain it in the future. It is clear that India has yet to fulfil its maximum potential, but the drivers to enable it to do so are strong. This research has found that the demographics in India are very favourable for continued growth. This, coupled with the legacy of British colonial rule, means that India is one of the few low-cost labour countries with a large English-speaking population (in fact the largest in the world), making it a natural choice for many international companies to do business there. These elements, linked to strong predictions of economic growth for the country and empowered by favourable government handling, could lead India to be the second or third largest economy in the world, enjoying commensurate economic success once again. The study will be of interest to economists, academics and those considering doing business in India.

Keywords

Indian Economy, Economic Reforms, Economic Growth, Global Economic Shift.

1. Introduction

At a time when even the major economic players of the world are in turmoil, it may appear to be a less than sensible time to conduct research into the evolving economy of a country which for decades has been plagued by poverty, corruption and lack of political will. Yet, it is the intention of this study to review the Indian economy from the time of its independence from the British Empire in 1947 to present day with the ultimate aim of mapping the potential future economic prospects for India.

2. Methodology

An in-depth review of the existing literature, reading a focused selection of journals, books and reports on the subject of the Indian economy until the researchers extracted the relevant information was undertaken. It was the fruit of this research that was the basis for the researcher's literature review—a snapshot of which is outlined below.

A qualitative methodology was applied using a qualitative semi-structured interview technique guide. Ten purposely selected candidates were chosen and interviewed at length on the topic. Given the area of study that was to be undertaken, it was felt that the use of qualitative research in the form of semi-structured interviews would be the most appropriate method. These would enable the researchers to learn as much as possible from each respondent and to extract rich data.

The researcher drafted an interview guide from which relevant questions, based on the participant's particular area of expertise or knowledge, were posed to the interviewee. In line with the structure of a semi-structured interview, the order in which questions were asked varied according to the flow of the interview and the discussions that ensued. Whilst the questions listed comprised the bulk of the interview, the researcher, where appropriate and when the situation presented itself, asked additional questions so as to maximise the results of this aspect of the research process.

In determining what segment of the population would be interviewed, the researcher applied the non-probability sampling technique of judgment sampling for this qualitative study and so purposely selected each of the interview candidates. Given the nature of the study there was only a limited sample of the population the researcher could approach that would able to contribute to the research. To that end, the identification process involved approaching a vast array of industry-related experts across the globe who had or have detailed expert knowledge and experience of dealing with the Indian economy. Prospective candidates included authors, journalists, politicians, professors, economists and business people.

3. Literature Review

The literature review has been compiled through research gained from a focused selection of journals, books, and reports, each of which delves into particular areas of the Indian economy relevant to setting the foundation for the research question

3.1. Poverty

Diversity is a common theme in all areas of life in India—"some Indians have great wealth, but many others can spend only a few cents a day for the bare necessities of life. Some cannot afford shelter and must sleep in streets. Some Indians are college graduates, but many others have never gone to school at all", (Karan & Weiner, 1989:108). With this level of intense poverty the economy becomes indirectly affected in many facets of life, one major aspect being education, often reserved for those who have the money to afford it.

3.2. Education

For many in India, "education is perhaps the country's great unequalizer", (Ahuja *et al.*, 2006:18). Whilst much of the population of India attend school for only a few years, if at all, "about 16 per cent of India's children in the age group 6–14 do not go to school at all, amounting to tens of millions of children. Most also drop out of school well before completing high school", (Sabhlok, 2009:252). Compare this with the other portion of the population who experience the success of university and the associated accolades. "Today, India has 335 universities and almost 18,000 colleges", (Panagariya, 2008:432).

Education, and its treatment by the government, is very much mirrored in the state of the current health care system in India. Both have been severely neglected by reforms undertaken by the government, and both are often denied to much of the population. This matter is discussed in detail in the following section.

3.3. Health

India's health system "is still lagging behind otherwise comparable developing countries" (Panagariya, 2008:419). The public health system would possibly totally collapse without the support of the private health system which appears now to have become the de facto health service for the majority of the population. This is, in the most part, because of the lack of input, intervention and, most important, funding from the government: "expenditure on health are woefully low, at less than 1% of the country's GDP" (Ahuja *et al.*, 2006:19).

3.4 Corruption

In India, "official corruption is a major problem," (Chaze, 208:224) and, unfortunately, an integral aspect of life throughout the country. It is an issue which needs to be tackled by the government with the upmost urgency. Yet, these much-needed reforms are akin to dreams for the people of India as "there is often a lack of political will to introduce measures which are resented by the influential voters" (Rothermund, 2008:142) According to Irani, "the politicians say 'yes' to every populist demand they think will get them votes, and the civil servants tend to say 'no' because that's less risky than saying yes" (Tully, 2011:215). Consequently, this often results in the government making popular yet unconstructive decisions which

actually hinder the development of the country, yet allow politicians to retain their seats in parliament.

3.5 Infrastructure

According to Rothermund, "infrastructure everywhere is to a large extent a legacy of the past: it reflects the investment decisions of bygone days" (2008:152). In modern India, "infrastructure remains perhaps the greatest drag on India's current growth prospects" (Ahuja *et al*., 2006:15). India is only too aware of the issues that its poor infrastructure is causing to its development. "India's problems are painfully visible. The roads are atrocious. Public transport is a disgrace. Many of the country's dynamic entrepreneurs waste hours each day stuck in traffic", (*The Economist*, 2010:11).

3.6. An Economic Historical Context

"In the eighteenth century, Britain was still a very small nation of only a few million people who nevertheless managed to conquer India, the home of about 150 million people" (Rothermund, 2008:2). The British arrived in India under the guise of the East India Company, which came to India to trade spices and silks. However, "England slowly encroached upon India through the East India Company, and eventually exerted full control over the subcontinent" (Ahuja *et al*., 2006:4).

3.7. India's Economic Development

In the centre of India's flag sits a spinning wheel, a symbol used by Mahatma Gandhi to represent India's self-sufficiency through their enormous textile industry. "For much of its independence, India's economy was governed by the principle of the spinning wheel – with disastrous economic and social effects", (Ahuja *et al.*, 2006:3). According to Panagariya, "India wanted to be independent of the world markets" (2008:283), but it would pay a costly price for this desired independence.

3.8. An Economic Turning Point

The IMF bailout issued in 1991 "led to a very powerful series of reforms that catalyzed growth" (Chaze, 2006: 8): this was the turnaround for India. According to Ganguly and Garg, "the reforms aimed to undo the layers of controls on business activity imposed in the post-independence period" (2009:45). The country was about to close the door on decades of "slow growth under socialist rule and offered an opportunity to improve living conditions in the immense, poor country" (Ahuja *et al.*, 2006:3).The Indian government began to set the wheels in motion for much change "to expand industry and raise living standards" (Karan & Weiner, 1989:133).

3.9. India: Post-Economic Reforms

According to Panagariya, "most observers of the Indian economy now accept the view that reforms have been central to the turnaround of the Indian economy," (2008:xvii). Had the reforms not been undertaken, "India would not be filled with the

kind of wealth-creating opportunity, that is available today for investors, both within and outside its borders" (Chaze, 2006:8). On the other hand, "the image of an 'India Shining' post 1991 is hardly a representative or fully accurate portrayal of a country where over 100,000 villages have never heard a telephone ring" (Ahuja *et al.*, 2006:17). Whilst the 1991 reforms resulted in major progress for India, "the direct beneficiaries were more affluent urban dwellers" (Ahuja *et al.*, 2006:17).

3.10. India and the Global Financial Crisis

"There was an eruption of financial crisis in 2007–8, which originated in the US and spread to other advanced economies. The financial crisis has seriously affected the growth prospects of emerging market and developing economies" (Reddy, 2010:3). Whilst many suggest that India escaped collateral damage brought on by this global economic crisis due to its heavy reliance on the domestic market, such comments may very well be unfounded."It should be noted that India's integration with the global economy contributed noticeably to India's accelerated growth, while the global economy was prospering. Hence, it is logical that India would feel the impact of adverse developments in the global economy" (Chaze, 2008:353). Yet, India has maintained its stability in "a sea of global turbulence" (Reddy, 2010: 2).

3.11. India's Current Economic Status

'Unity in Diversity' was the slogan chosen when India celebrated fifty years of Independence in 1997," (Abram *et al.*, 2005:6). Since independence, India has experienced much turmoil, but much change for the betterment of the country. The journey the country has taken has been marked by many issues along the way; the most recent being the global economic crisis. "In 2011, India's economic growth had slowed to below 7 percent and the stock markets mirrored the weakening economic conditions" (Bartsch & Jos, 2012). Yet "India's exports were growing very strongly through 2011 despite the worsening economic conditions in Europe, which continued to be India's most important export market" (Bartsch & Jos, 2012). Nonetheless there continues to be great insecurity; "global economic conditions are fragile, and there remains great uncertainty as to how markets will evolve over the medium term" (Bartsch & Jos, 2012). According to Bartsch & Jos, "a worst-case international scenario would lead to a collapse of demand for India's exports and strong contraction in private sector spending" (2012).

4. Main Findings & Recommendations

During the qualitative research a number of key issues, outlined below, emerged from the data as problem areas that India will have to address and rectify urgently in order to facilitate its full potential growth, and rapidly correct many of the mistakes made in previous years.

4.1. Education

India has a very young population, which can further feed the country's economic growth. The government, however, will have to address the complicated issues affecting the education system, in order to move forward. These issues include corruption, teacher absenteeism, and poor quality of education due to inadequately trained staff, unsuitable facilities, poor enrolment figures and high dropout rates.

4.2. Health

India faces similar challenges with the health system. For the country to prosper the population must be a healthy one and have access to a health care system of an adequate standard. The issues concerning these two sectors are closely related. The government needs to urgently invest heavily in improving the public health care system so as to bring it up to a functional standard comparative to international standards. Medical graduates, many of whom emigrate to foreign countries in search of better employment and lifestyle opportunities, need to be enticed to remain in India through competitive employment packages and improved lifestyle possibilities. These graduates will play an integral role in making this aspect of the economy more acceptable and functional for the more vulnerable segments of society.

4.3. Political Will

The issue of political will, the research revealed, is a crippling factor in the growth of the Indian economy. The major barriers to progress and the negative factors holding India back have at their core a link to political will and the lack thereof. The nub of this issue is born out of the fact that politicians choose to make short-term, voter-friendly decisions to ensure that voters remain happy, continue to vote for them, thus keeping them in power. The long-term repercussion for the economy is that much of the work, such as increased long-term investment into areas such as health and education, is overlooked, with catastrophic long-term results for the economy.

4.4. Infrastructure

Good infrastructure, particularly both roadways and power, are essential ingredients if India is to continue to lure foreign companies to do business there and, indeed, continue to maintain those that have already made the transition to doing business in India. The concerns around having a constant power supply are very real, coupled with the increasing need for good roadways and a more efficient transport system to meet the demand. The research discovered that many of the larger companies operating in India provide their own transport systems to ensure the workforce arrives at the company buildings on time Likewise, they provide their own power generators to maintain a constant supply of energy and to ensure that plants do not experience any downtime with collateral loss of revenue for the enterprises. Whilst the research showed that the government is positively disposed to improving the full spectrum of infrastructure across the country, plans and associated investments need to be more proactive and be executed with greater time efficiencies and less central corruption.

4.5. Social Inequality

Poverty remains a constant blot on the landscape in India. Despite the increased prosperity being experienced by much of the population in India, there remains a larger segment of the population which is being left behind. This is causing an even greater divide between the various classes and, as such, the research found that civil unrest may be on the horizon if action is not taken to improve living conditions for the unprivileged and bring this segment of the population to a satisfactory standard within the fold. Improving the status of the vast poverty-stricken population of India would significantly enhance the economy in that the government would have a maximum participation and contribution to the economy from its people. Before this can become a reality, radical and effective work is urgently necessary to change the face of poverty which is evident to the world, creating new systems that will force immediately incremental improvements for this segment of the population so that their contribution to the economy can be unleashed.

4.6. Corruption

Corruption is such an integral element of the culture in India that it will take gigantic initiatives by the Indian government to alleviate it, or even dream of eradicating it. Yet, it is not impossible, and the government has to tackle the matter from the top down in order to make permanent changes to this overwhelming aspect of its culture. This research has found that the most dangerous factor is that corruption in all its forms is socially acceptable and an alternative way of life is unimaginable, presenting the government with an increasingly thorny issue to be tackled. Combating corruption is, however, essential in order for the country to maintain its prosperity and continue to promote itself to the outside world as an attractive place to do business. Ensuring that those found engaging in corrupt activity, either at government level or village level, are dealt with swiftly through the legal system will be the beginning of a slow arduous process that will free India of this intensely corrupt culture.

4.7. Indians Brain Drain

The ‘brain drain’ phenomenon, as universally found in countries with challenging economic conditions, is also used in India to describe those who have been educated there and who, after graduation, leave India in pursuit of greater opportunities and a better lifestyle abroad. Over the last fifty years, this issue has haunted India. Whether privately or publicly educated, these educated people are vital assets to the development of the Indian economy, and the fact that India has been unable to entice many of the generations past and present to remain in the country is a painful loss. Harnessing such skillful expertise is central to building its economy and their retention is yet another challenge for the Indian government. Offering these potential emigrants the possibility of a better lifestyle and promoting competitive employment possibilities will all play a major role in reducing the current ‘brain drain’ epidemic.

5. Conclusion

Whilst we are in the midst of a global recession, India is emerging relatively unscathed. India has been cushioned for the most part from the major repercussions experienced by many other countries, producing consistently high growth rates over the past number of years. Economic markers indicate that, due to its culture of good savings among the middle classes, and its large domestic economy, India will continue to prosper, perhaps at a slightly slower rate that was predicted prior to the global financial crisis; but on an upward trajectory, nevertheless.

Over the past number of decades, India has overcome many hurdles to arrive at its current standpoint, a country on the brink of global economic dominance. Whilst it may trail China in the short term, these are truly exciting economic times in which India is showing its truly expansive potential to regain its deserved place in the new world order.

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Quantifying Elite Athlete Performance based on Munster Rugby GPS Data

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Abstract

In professional sport, the use of Global Positioning Systems (GPS) are rapidly emerging to analyse game demands, build player profiles, monitor progress and identify trends. GPS systems have been employed extensively in Australian football with their benefits beginning to attract significant attention in Rugby Union. The technology offers an alternative strategy to the traditional, "one for all", model of training, facilitating player specific training. Such an approach is highly advantageous as players respond differently due to style and biological factors.

This research examines the performance of an elite rugby team by analysing 4 key performance parameters over 28 games using 22 catapult MinimaxS4 GPS units. The parameters analysed include Odometer, High Intensity Acceleration, High Speed Running and Tackle Count were evaluated at a macro positional level down to micro positional demands and player profiles.

It was found that there are significantly different demands placed on players depending on the position in which they play. The data was found to be of high value to coaches, offering insights into where players excel and are lacking compared to specific positional requirements and their peers in similar positions. It was found that GPS technology can be used effectively in analysing games to measure exertion and player performance, and would also be very effective when used to monitor training sessions and player improvement.

Development of a Multiple Sequence Alignment Algorithm using Cloud Computing and Big Data Technologies

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Abstract

Multiple sequence alignment (MSA) of DNA, RNA, and protein sequences is an essential process in the fields of molecular biology and bioinformatics. MSA algorithms can identify common homology, structure and function to aid in disease recognition and medical discoveries. In parallel, next-generation sequencing technologies are changing the biology landscape, generating vast raw sequence data sets and are becoming a significant bottleneck, both in terms of processing and analysis. In order to realise the promise of MSA for large-scale sequence data sets, which is fundamental to facilitate future medical discoveries, it is necessary for existing algorithms to execute in a parallel with the sequence data distributed over a computing cluster or server farm. Parallelised MSA algorithms deployed on elastic cloud computing technologies will improve the speed, quality, and capability for MSA to handle large numbers of sequences. This poster presents an over view of the Clustal Omega, a leading multiple sequence alignment algorithm scaled for elastic computing and parallelised processing using the Hadoop/MapReduce 'big data' paradigm. The protein sequence analysed is that of BetL, a membrane bound transport protein which facilitates compatible solute accumulation under stressful conditions; allowing the foodborne pathogen Listeria monocytogenes to survive and grow under refrigeration conditions.

Affective and Perceptive Computing for Computer Mediated Communication in Game Based Learning Applications

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Abstract

This research presents current limitations of computer mediated communications (CMC) in a typical online game based learning (GBL) platform and outlines how these limitations can be addressed by emerging affective and perceptive computing technologies. The paper presents a case study of the S-Cube CMC platform, which is currently undergoing trialling and development by research partners from across Europe as a game based learning tool. S-Cube is an open online virtual world for scenario based soft skills training, which by its very nature incorporates many aspects of emotions and gestures of role play participants.

While much effort has been made to incorporate emotions and gestures into the S-Cube platform there is a requirement, outlined in this study, for more seamless computer mediated communication of emotions and gestures between participants. This paper presents both quantitative and qualitative research data that has been compiled relating to trials of the S-Cube framework.

Extracts from the research data relating to emotions and gestures from the ninety five players that participated in the software trials has been analysed and is reported on. The research evidence presented outlines a case for developing more embedded affective and perceptive computing capabilities for S-Cube. Following the software research findings the paper concludes with a discussion on key software development proposals relating to the engineering of more intuitive affective and perceptive capabilities for the S-Cube GBL platform.

Molecular-based detection of the gastrointestinal pathogen *Campylobacter ureolyticus* in unpasteurized milk samples from two cattle farms in Ireland.

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Abstract

Campylobacter jejuni and *coli* are collectively regarded as the most prevalent cause of bacterial foodborne illness worldwide. An emerging species, *Campylobacter ureolyticus* has recently beed detected in patients with gastroenteritis, however it source, until now, remained unclear. Herein, we describe the molecular-based detection of this pathogen in bovine faeces (1/20) and unpasteurized milk (6/47) but not in poultry (chicken wings and caeca). This is, to the best of our knowledge, the first report of the presence of this potential gastrointestinal pathogen in an animal source, possibly suggesting a route for its transmission to humans.

Keywords

Campylobacter, Emerging pathogen, Food chain, Reservoir, Dairy.

Enhance process tracking for forensic readiness in operating system

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Abstract

Current system loggers do not record enough information for incident analysis and replay, and forensic analysis suffers from insufficient logging of events. Process activity tracking systems are capable of providing evidence for analysts to determine the root cause of incidents, similar to flight data recorders tracking specific performance parameters for assisting investigation into aircraft accidents. Through providing precise, timely, complete, and dependable information about process activities, comprehensive process activity tracking is able to ensure computer systems complies with information security policy. Comprehensive process activity tracking also has the strength to recover traceability links, even deemed as admissible evidence, between the incident and the person or action accountable for the incident. To make process activity tracking effective and efficient, process activity tracking systems have to meet the two objectives of forensic readiness: maximizing the usefulness of process activity information and minimizing the cost of process activity tracking. This research aims to enhance process tracking for forensic readiness in operating system by recording all state-changing activities of important processes.

Keywords

Logging, Forensic analysis, Forensic readiness

Decentralised optimisation solution for provision of value added services and optimisation possibilities in Smart Grids

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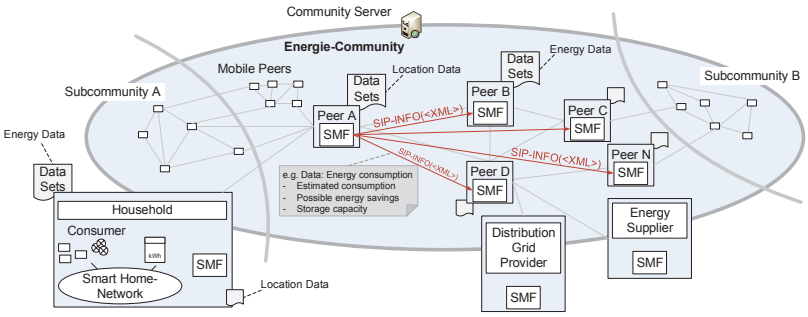
Abstract

This publication introduces a new overall solution for individual home and energy management and its application for optimisation of Smart Homes and Smart Grids. The user gets the possibility to develop personalised services for home and energy management on its own, according to its personal needs, using a Service Management Framework (SMF) which is developed based on OSGi. This SMF also includes the functionality for P2P interconnection of households which is used for simultaneous energy optimisation of peers inside a P2P network of households. Based on exchange of information between peers in terms of energy consumption, production, storage capacity, and potential energy savings, all involved peers autonomously optimise the energy consumption in their households.



The concept provides a mechanism for convenient networking of households, energy suppliers, distribution network operators and others with the objectives cost savings, avoidance of grid expansion, energy savings, CO2 reduction etc. This network offers statistical aggregation and optimisation through cooperation within a cluster of consumers. An Energy-Community forms a new comfortable way to join the network, whereby the connection of households is done by joining the users to a social network for energy-peers. Depending on the optimisation goal it is possible to achieve a financial benefit for each participant, as well as a relief of the energy grid through e.g. the reduction of the residual load. Furthermore the integration of mobile peers (via smartphone) allows e.g. to provide a value added service for the optimisation of the parking situation for electric vehicles. Through communication and exchange of information (capacity of battery and destination) between mobile peers an efficient discovery of available parking lots (i.e. short distances and low power consumption) can be realised.

Project Spraoi: A strategy to improve nutrition and physical activity in primary school children

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Abstract

The WHO recognises overweight and obesity as the most common childhood disorder in Europe (Department of Health and Children, 2011). Project Spraoi aims to address this issue in Ireland by increasing physical activity, decreasing sedentary time and improving nutrition amongst primary schoolchildren. It is based on international evidence of Project Energize, New Zealand (Rush et al., 2012) and is designed for schools but also extends to children's homes. Major programme components will include: i) promotion of key messages through social marketing techniques; (ii) incorporation of key policies into schools; (iii) provision of staff into schools to structure activity programmes that are aligned with the curriculum; and (iv) seeking opportunities to enhance nutritional intake.

This study aims to determine whether Project Spraoi has had any positive impact on weight gain, physical activity and hypertension. Children in senior infants and fourth class groups from the main study and the same number of children, who have not participated in the intervention, will be evaluated. This will involve measures (blood pressure, heart rate, height, weight, upper arm and abdominal circumference, body fat, accelerometry) at baseline and two years after study commencement. Parents/guardians are also asked to complete a written questionnaire.
While other interventions amongst Irish schoolchildren have been effective to some degree, they have concentrated on either nutrition OR physical activity; no intervention has focused on nutrition, physical activity and sedentary time, together.

Keywords

Physical Activity, Sedentary Time, Nutrition, School Children, Intervention

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A model of soil nitrogen and water fluxes in dairy cow grazed pasture

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Abstract

In temperate regions grass growth is highly variable within and between years. One of the main factors influencing grass growth is the soil reserve of nutrients such as nitrogen (N). Nitrogen availability for plant uptake is in itself highly variable, therefore soil models describing soil N reserves as influenced by environmental factors and sward management in grazed swards can be used as management tools. The present work is a mechanistic model describing daily water reserve, soil mineral N reserve and soil organic N reserve under a grazed sward as influenced by weather conditions, soil type and farm management. The model takes into account N fertilisation, N losses through volatilization and leaching, as well as the effect of paddock herbage production, through mineral N uptake and return of organic N through abscission. The model also calculates the exchanges between mineral N and organic N reserves by calculating mineralization and immobilisation on a daily basis. Some of the N flows and transformations simulated in the model are not routinely measured at farm or research level, but the magnitude of each flow simulated in this model corresponds with relevant published research.

Isolation and characterisation of Verotoxigenic *E.coli* in acute gastroenteritis patients in the Cork Region.

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Abstract

Verotoxigenic *E.coli* (VTEC) is a serious gastroenteric pathogen which is commonly linked with high morbidity and mortality. Currently VTEC is detected and diagnosed using traditional culture methods and limited stocks of antisera. Molecular diagnostics surpass traditional methods for sensitivity and speed of diagnosis. Microbiology, Cork University Hospital, is the first hospital in Ireland to avail of molecular diagnostics for the detection of VTEC; however, isolation is necessary for infection control. The main objectives of this study were to validate a method of isolation for diverse VTEC serotypes to determine the prevalence of the main serotypes in the Cork region and to characterise and type the isolates obtained by molecular methods. This study shows that optimum isolation of VTEC involves the overnight enrichment of the patient faeces in Enteric bio® broth followed by immunomagnetic separation prior to culture at 37°C. The isolation of VTEC from Enteric bio RT® positive samples had a success rate of 72%. The addition of Immunomagnetic separation increased isolation by 30%. In this 12 month period the prevalence of serotypes from isolated strains (n=36) were 28, 16.5, 16.5, 11 and 3 % for O157, O26, O111, O145 and O103 respectively with 25% non-groupable. National data obtained from the Health Protection Surveillance Centre (HSPC), from July 2012 to March 2013 identifies the prevalence of O157 and O26 as 48.3 and 27.2% respectively with non-O157 and non-O26 serotypes making up 24.5% of the 404 cases reported. In the Cork region, non-O157 and non-O26 serotypes make up 55.5% of the serotypes identified, indicating a different distribution of serotypes seen on the Cork region in comparison to national data. This may be attributed to increased detection sensitivity.

Keywords

Verotoxigenic *E.coli,* Enrichment, Immunomagnetic separation, Molecular Diagnostics, Epidemiology, Cork region.

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