Centre for Digital Built Britain

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Information Resilience in a Digital Built Environment.

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Abstract

Information is the underpinning driver in the Digitised Built Environment and crucial to the Centre for Digital Built Britain's agenda. Threats to information affect the intrinsic, relational and security dimensions of information quality. Therefore, the DBE requires capabilities of people, and requirements of the process, software and hardware for threat prevention and reduction. Existing research and protocols seldomly outline the capabilities and requirements needed to reduce threats to information. The aim of this report is to develop an information resilience framework which outlines the capabilities and requirements needed to ensure the resilience of information throughout its lifecycle; creation, use, storage, reuse, preserve and destroy. The findings highlight the need for people's (stakeholder) competencies and behaviours which are driven by cognitive abilities such as attention, learning, reasoning and perception. Furthermore, process' requirements such as embedding validation check process, standard requirements for Level of Detail, digital upskilling, among others, were identified. Additionally, identified software requirements include its ability to be customised to meet the project needs, detect conflicts and provide context of information. Finally, hardware requirements encompass facilitating backup, having a high capacity system and being inaccessible to peripherals. This research will be further extended to the development of a decision-making assessment tool to measure capabilities and requirements in the entire lifecycle of built assets.

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1.0 Research Background

Information is useful only if it fulfils its intended function and it requires socio-technical enablers to assure information quality. However, information is vulnerable throughout its lifecycle due to its exposure and sensitivity to internal and external sources of threats. Therefore, information needs capabilities and requirements to ensure its resilience.

For this research, Information Resilience (IR) is defined as the process of reducing the vulnerabilities affecting the intrinsic, relational and security dimensions of information quality through the identification of capabilities of people and requirements of process, technology and hardware. Information vulnerabilities are caused by stakeholders (people), process, software and hardware, and these challenge information quality throughout its lifecycle. Project stakeholders, though key contributors to information vulnerability, can also be key drivers for vulnerability reduction if frameworks are developed to enable them to change their behaviours, reduce bias and maximise their capabilities towards information vulnerability reduction given that, precise detail of the vulnerabilities is often unforeseen. In addition, software and hardware capacity requirements needed to ensure effective compliance requirements and other controls are required. Though studies to reduce security threats, example; Safa *et al*. (2016) and Moody *et al*. (2018) exist, they primarily focus on the information storage and reuse stage and incorporate little focus on the other information lifecycle stages. As such, they mainly focus on processes required to assist in implementing measures to reduce information loss or disclosure which could impact the safety and security of occupants, built asset and asset information. However, there is currently a lack of a holistic vulnerability reduction lens and the identification of capabilities and requirements needed to reduce information vulnerability through its lifecycle in the Digital Built Environment (DBE). This research presents a holistic sphere towards IR which guards against emergent vulnerabilities to information quality caused by project processes, stakeholders, software and hardware in addition to safeguarding the capabilities and requirements needed to reduce vulnerabilities throughout the information lifecycle.

The developed IR framework is intended to maintain and enhance information quality in the midst of threats and help assets to be managed more effectively over their extended lifecycles, as well as the reuse of information in future assets even after the original asset has been disposed. IR is central to the collaborative digitised asset development process in the Built Environment and therefore it is necessary to identify the capabilities and requirements needed to enable adequate decision making and planning. Thus, contributing to the capability and requirements for smart construction and digital design agenda in the Construction 2025 (Gov.uk, 2013 & 2017) and the following CDBB areas of focus: Data and Information - 'Data provenance and quality towards maintaining social values embodied in the data against threats' (numbers 13 and 14, under CDBB Focus areas), Complex Integrated System – Insight, understanding and management of information resilience (number 8, under CDBB Focus areas) and Stakeholders, purpose-setting and decision making- understanding and working with 'uncertainty' in a variety of forms, all within the context of insights and capabilities (number 2, under CDBB Focus areas) with the potential to inform future digital policies.

1.1 Research Aim and Objectives

The aim of this research is to develop an Information Resilience (IR) framework to leverage information to deliver a Digital Built Britain (DBB). To achieve this aim, the research sought to: 1) Categorise information types in the Built Environment; 2) Identify and classify information vulnerabilities; 3) Identify capabilities and requirements to ensure information resilience and 4) Develop an IR framework for Digital Built Environment.

2.0 Research Design Overview

LITERATURE REVIEW

Information in DBB is susceptible to diverse threats and therefore requires the capabilities of people, and requirements in the process, software and hardware to manage threats to information, adapt to the digital change and Leverage the data.

The aim of this study is therefore to Explore ways of leveraging information through the development of an Information Resilience Framework

A review of the information Lifecycle stages and types was carried out. This is because the lifecycle stage influences the information's sensitivity and exposure and its handling, and the control put in place (Alshboul, Nepali & Wang, 2015; Reiner et al., 2004). From this, the information lifecycle stages from BS EN ISO/IEC 27001:2017 and ISO 14641: Creation, Use, Storage, Re-use, Preserve and Destroy were deduced, validated by Industry personnel and adopted for this study. These Lifecycle stages were then mapped on to the information requirements outlined by standards and reports (e.g. PAS1192, BS EN ISO 19650, Burgess, Tappenden, and Moore, 2018) using the theory of conceptual clustering (Stepp & Michalski, 1986). Following this, a number of repetitive information requirements were outlined so Information ontologies in DBB were reviewed. From this, Uniclass 2015 was identified to be the most suitable and complete information ontology and therefore employed for the study (Demian, Yeomans and Murguia, 2019).

A review on the theory of Information Quality (IQ) was carried out to identify the dimensions of information quality in DBE. From this, three dimensions: Intrinsic, Relational and Security, were identified. Given that very little literature on factors (capabilities & requirements) influencing IQ exist in DBE, a review in other digitally driven disciplines; Aviation, Healthcare and Manufacturing was carried out to identify these.
From this, the key drivers and barriers to information quality are from the People, Process, Technology and Hardware. These factors were also key sources of threats to IQ. Given that, the DBE sector is known to work under time pressure and delivers output within the shortest possible time, it is expedient to study Information Resilience, which goes beyond Information Quality and thus provides the ability of the industry to leverage data and information in the midst of threats.

From the review, a conceptual model capturing threats to, and capabilities/requirements for assuring Intrinsic, Relational and Security dimensions of IQ across the information lifecycle is developed.

DATA COLLECTION & ANALYSIS

Data was collected by conducting 30 interviews anchored to 3 case to identify and classify information vulnerabilities and the necessary capabilities/requirements needed to ensure information resilience in the Built Environment. Participants selected had diverse experience both within construction and their current roles on digital-enabled projects. Interviews were targeted specifically at key professionals from a wide range of disciplines/roles involved in the Information Lifecycle in DBE.

Within the interviews, the Critical Incident Technique (CIT) was employed to seek expert knowledge and experiences on threats, vulnerabilities, capabilities and requirements for information resilience (Flanagan, 1954; Eskerod, Huemann and Ringhofer, 2015).

Data from the 30 interviews across the three case studies has been thematically analysed using Nvivo 11. The data analysis process comprised two primary stages; (1) checking the credibility of data, (2) formulating categories (Eisenhardt et al., 2016; Butterfield et al., 2005). After analysing all three case studies the cross-case analysis was carried out by thematically extracting the common threats (Appendix 1), capabilities and requirements.

The cross-case analysis reinforced similar themes to those from literature and highlighted new themes. The key themes for capabilities from people include; Cognitive-Reasoning, Attention, Perception and Learning, whilst requirements for processes, include; Standards, Time, Checking, Collaboration and Support. Hardware and software requirements include, Capacity, Customisation of software and Plugins for enhancing information quality.

CROSS-SECTOR STUDY & FRAMEWORK DEVELOPMENT

Results from the interviews have been discussed with literature and findings, compiled in the Framework. This initial framework was sent to Chief Information Officers in DBE for validation. Respondents confirmed that, the framework identified capabilities/requirements from People, Process, Software and Hardware to assure Information Quality during disruptions. Comments on the outline of the framework required; reducing the words, using bright colours and making the figure more graphical. The framework was then revised and is shown in Figure 1.

Given that the DBE is relatively new to the digitalisation, there was the need to receive comments from other disciplines on the results from this study and recommendation on the best way to present the results. As such, a focus group workshop with four participants with experience in the Manufacturing, Library Service, Healthcare and Software Development industries was organised.

Recommendations for DBE from the focus group are:

1. Carry out Penetration tests for all software adopted,
2. Consider using software's that have a potential to last for a long time,
3. Professionals in DBE should not assume everyone speaks English and therefore should communicate clearly and use controlled vocabulary,
4. Professionals should bear in mind that people use different devices in accessing information, and
5. The need to continually think through the inputs and outputs in DBE.

3.0 Research Outcome

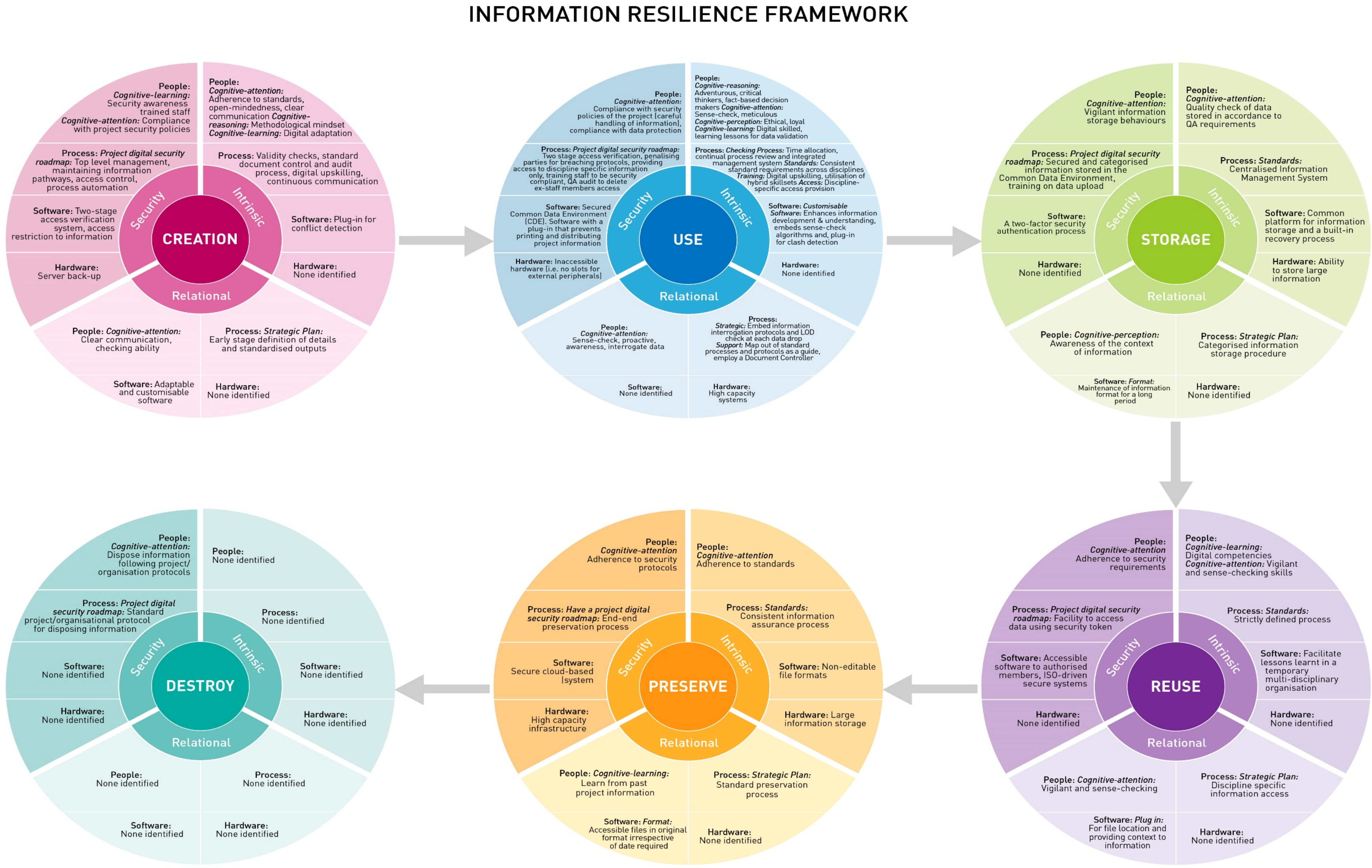

Figure 1. Information Resilience Framework

3.1 Framework Explanation

In the framework, there are 6 main circles which each represent the information lifecycle stage. Within each circle are the three areas of information quality: intrinsic, relational and security. Under each of these areas are listed the capabilities from people and requirements from processes, software and hardware needed to ensure information resilience and assure information quality during a digitally enabled asset delivery process.

Terms

- ***Intrinsic:*** Internal attributes and characteristics in relation to some reference standard (Accuracy, Validity, Completeness)

- ***Relational:*** When performing a task, the user must be able to retrieve, interpret and make decisions (Accessibility, Coherence, Format, Compatibility Relevance, Timeliness)

- ***Security:*** Information is protected from unauthorised access

4.0 Research Implications

The main implications of the research include:

Capability and Requirement Identification for Information Resilience

This study has identified:

- Capabilities and the required cognitive drivers of people (Project Stakeholders, Asset Stakeholders) needed for Information Resilience and to assure information quality across the information lifecycle in a Digital Built Environment. The identification of these abilities addresses the needed team capabilities stated in BS EN ISO 19650-1 section 8.2. The findings highlight the need for people's competencies and behaviours which are driven by cognitive abilities such as attention, learning, reasoning and perception. Stakeholders (people) are required to use their senses, be thinkers and judgers when interacting with information. For example, during information creation through to the destroy stage, stakeholders are required to; judge by contextualising the data and based on facts, comply with standards, have an open-mind and a willingness to learn; be a thinker by sense-checking the information, be vigilant and digitally savvy.

- Process Requirements needed to ensure information resilience in the midst of threats across the information lifecycle and adds on the Information Requirements outlined in the UK Government BIM Working group report on Information Requirements (Burgess, Tappenden, and Moore, 2018). Examples of additions to process requirements are: a Common Data Environment with a built-in recovery process, a clear definition of Level of Details (LoD), allowing for time to check the accuracy of work done, new sections covering digital upskilling/training, utilisation of hybrid skill set, embedding processes to ensure adequate LoD at each stage (data drop) in a timely manner, mapping out of standard processes and protocols to enable parties to follow process automation, showing parties the implication of their behaviours and employing roles with document controller skills. Security-wise, addition to Built Asset Security Information Requirement and Built Asset Security Management Plan of PAS1192:5 include project digital security roadmap and process automation among others.

- Software and Hardware Requirements, such as its ability to be adapted and customised to meet project's needs, detect conflicts and provide context of information. These requirements can be included in the data and file store section of the Asset Information Requirement Document set up by the UK BIM Task Group. The results of this study iterate the need for software to be customised to meet user needs as stated by Underwood (2016) and highlights the usefulness of this ability to reduce threats through its conflict detection and provision of context to information abilities. Hardware requirements such as facilitating backup, having a high capacity system and being inaccessible to peripherals are required to ensure information resilience.

Decision Making checklist for Chief Information Officers in Digital Built Environment

The Framework will provide Chief Information Officers information about the cognitive abilities needed by the team and the requirements of the process, software and hardware to ensure information resilience and assure quality.

Standards and Policy

Specifically, this study identifies the capabilities needed for assuring the intrinsic and relational information quality dimensions in the midst of threats and adds to requirements in Burgess *et al*. (2018) and on Security in PAS 1192:5. This study also highlights security compliance capabilities which could be added to the Built Asset Security Information Requirement and Management Plan in PAS1192:5.

5.0 Conclusions and Limitations

This research has developed and presented an Information Resilience Framework to leverage digital information in a Digital Built Britain. The proposed framework aims to cause a substantial social and economic impact. The social impact will be realised by the identification of capabilities of design, construction and operation teams and therefore create the awareness for information stakeholders to prepare for and reduce vulnerabilities and ensure information resilience. The framework could be used to outline roles and responsibilities and foster decision-making throughout the information lifecycle. Economically, the framework will help to improve the quality of information and thus improve productivity during project and asset management. Decision-makers and policymakers would make informed decisions based on good information and thus ensure that the value of the asset is maintained whilst maximising economic and social impact. The identified requirements will reduce the risk of unexpected incidents which may lead to additional costs and therefore contribute to leveraging data and information to deliver a Digital Built Britain and provide ‘insight, understanding and management of information resilience’. This will contribute to the exploration of existing or emerging tools, technologies and techniques and their role in delivering a Digital Built Britain to ensure that the asset being developed will fulfil the function for which its being created and the value of the information will be sustained after the asset life.

This study is not without limitations. While the case studies were selected to represent UK Level 2 BIM-enabled projects, interviewees might not necessarily represent the experiences of all designers, contractors and facility managers in the UK construction industry. Whilst the pool of interviewees represents experienced Architecture, Engineering, Construction and Operations (AECO) professionals, interviewing more Operational professional may have deepen the findings in the reuse, preservation and destroy phases of the information lifecycle.

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Further Information

Detailed literature and findings from this research will be published in the Journal of Management Information Systems later this year. Enquiries about the research should be directed to:

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