DESIGN OF ORGANISATIONAL UBIQUITOUS INFORMATION SYSTEMS: A FRAMEWORK FOR DIGITAL NATIVE AND DIGITAL IMMIGRANT USERS

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Abstract

This paper focuses on the design and implementation of Organisational Ubiquitous Information Systems for Digital Native and Digital Immigrant users. Organisational Ubiquitous Information Systems refer to information systems available through many devices such as smart phones that are used by employees of an organisation anytime and anywhere to achieve specific work related goal(s). A multi-methodological approach was used to explore the design requirements for Organisational Ubiquitous Information Systems design as compared with Traditional Information Systems design. The findings suggest that Organisational Ubiquitous Information Systems are part of a large organisational digital ecosystem, and hence a design and implementation framework for these systems needs to reflect this. This paper proposes a conceptual framework for the Organisational Ubiquitous Information Systems design process.

Keywords: Organisational ubiquitous information systems, traditional information systems, digital natives, digital immigrants, design dimensions.
1 INTRODUCTION

The past few years have seen the proliferation of Ubiquitous Information Systems (UIS) and devices in both personal and organisational contexts. These systems offer rich tools for improved computing and communication within organisations (Kleinrock, 2001), and are therefore being adopted by several organisations (Sambamurthy & Zmud, 2000). Organisations today are not only using UIS to reach out to more customers, but also for their employees, to provide more flexibility and convenience (Drumm, 2012).

In addition to the changes in information systems, organisations are also experiencing a change in their typical employee profile, as more digital natives (DNs) enter the workforce. Digital natives refer to those who have grown up with digital technologies, almost from birth (Prensky, 2001). Monica Basso, a Gartner research vice president states that by 2018, DNs impact on the workplace will drive significant change in an organisation’s approach to technology, business processes and organisational structure (Basso, 2008). Given Moore’s (2012) prediction that by 2025, 75% of the workforce will be DNs, the way forward for organisations is to ‘stay in step’ with the DNs (Ann, 2005; Manafy & Gautschi, 2011); as well as the systems that are transforming organisations (Sørensen, Group, & Yoo, 2005; Yoo, 2010). The remaining 25% of the workforce will be digital immigrants (DIs) i.e. those who learnt to use technologies at some stage in their adult life. This paper focuses on the design of UIS used by DN and DI employees of an organisation to achieve specific work related goal(s) – herein referred to as organisational ubiquitous information systems (oUIS).

The key research problem being addressed in this paper is the lack of a framework to design and implement oUIS for digital natives and digital immigrants (Vodanovich, Sundaram, & Myers, 2010; Yoo, 2010) in order to support the emerging and evolving organisational digital ecosystem. This research takes a multi-methodological approach to explore the design requirements, design patterns, and implementation needs of oUIS for both DN and DI users.

The paper begins with an overview of this research space, followed by a summary of literature on oUIS, and the design and implementation of oUIS for DN and DI users. Then, the research methodology is discussed in detail. The key contribution of the paper is outlined in the findings section – a framework for the design and implementation of oUIS for DN and DI users. The paper ends with a summary of key contributions, limitations and future research opportunities.

2 RESEARCH BACKGROUND

Much of the previous research on designing information systems is dominated by theories related to technology acceptance (Davis, 1989), perceived usefulness (DeLone & McLean, 2004), and IS usability. Historically, these theories have been relevant for digital immigrant (DI) users and traditional information systems. However, the rise of the digital native workforce questions the applicability and relevance of some of these theories (Vodanovich et al., 2010). The underlying assumption of these theories is that users have some kind of problem with technology – they resist new technology or have some difficulty in accepting it (Venkatesh, Morris, Davis, & Davis, 2003). But such assumptions no longer apply to DNs because they are quick to adopt and learn new technologies easily (Prensky, 2001). These changes potentially represents a “paradigm” shift in IS research (Vodanovich et al., 2010). The purpose of this research, therefore, is to explore the use of oUIS by digital natives and digital immigrants and to contribute theoretical artefact(s) that would help in the design and implementation of oUIS.

The IS discipline is faced with a number of research and practical problems related to the rise of DNs and the proliferation of oUIS (Lyytinen et al., 2004; Sørensen et al., 2005; Vodanovich et al., 2010). Firstly, there is a paucity of research on models, frameworks, and/or architectures for the design and implementation of oUIS (Boyd & Ellison, 2007), especially oUIS for the use of both DN and DI employees (Tilvawala, Sundaram, & Myers, 2013; Vodanovich et al., 2010). The practical problem associated with this research problem is that organisations currently lack tools or guidelines for
dealing with this specific combination of changes – oUIS and DNs (Vodanovich et al., 2010). Some IS researchers also argue that designing and implementing oUIS is radically different from traditional information systems (TIS) (Glissmann, Smolnik, Schierholz, Kolbe, & Brenner, 2005; Krogsrud et al., 2003; Lyytinen et al., 2004). oUIS design and implementation is expected to involve factors both within and beyond the boundaries of the organisation (Lyytinen et al., 2004; Scheepers & Scheepers, 2003). Furthermore, the design of UIS embroils a constant balancing act between various design dimensions and business requirements (Ochs, 2012; Weevers, 2011) unlike some traditional systems development methodologies.

The differences between DN and DI employees add to the system related challenges faced by organisations. Key differences between the two include their communication styles, connectivity requirements, and self-managing approaches (Tilvawala, Myers, & Sundaram, 2011). For example, DNs tend to be weaker in face to face communication and prefer text based systems when compared to DIs (Mullen, 2011; Small & Vorgan, 2008). Also, DNs like immediacy and real-time feedback facilitated by highly interactive systems (Nortel, 2008; Weil, 2010), whereas DIs are better with non-interactive systems like large-scale data manipulation or transaction processing, or systems which require great reliability or scalability (Harwell, 2009).

3 ORGANISATIONAL UBQUITOUS INFORMATION SYSTEMS

Organisational Ubiquitous Information Systems (oUIS) refer to information systems available through many devices such as smart phones that are used by employees of an organisation anytime and anywhere to achieve specific work related goal(s). This new wave of ubiquitous systems offers new opportunities and prospects for organisations to improve their capabilities (SørenSEN et al., 2005). Many business processes are now facilitated by computing devices that are embedded in the physical spaces or move with workers. Unlike TIS that perform dedicated tasks, oUIS perform diverse services using heterogeneous resources (Lyytinen et al., 2004). oUIS have the potential to improve intra-organisational and inter-organisational processes alike (Fleisch & Tellkamp, 2006). Examples of business activities supported by oUIS include sales related activities such as quota attainment and delivering proposals; workflows such as expense claims and tracking hours worked; as well as tracking progress of projects (Tilvawala et al., 2013).

With new opportunities, come challenges. Practitioners and researchers have found that UIS comes with a set of challenges and limitations, and its adoption inhibited by factors both internal and external to the organisation (Berkers, Goossenaerts, Hammer, & Wortmann, 2002; Lyytinen et al., 2004; Scheepers & Scheepers, 2003). IT departments are therefore facing problems and issues never envisaged before. These include limitations of ubiquitous devices, heterogeneity, support, and different security and privacy risks (Fleisch & Tellkamp, 2006; Sørensen et al., 2005). Furthermore, UIS exaggerate the already existing problems of integration and networking in organisations.

As such, the adoption of oUIS impacts organisations across five main areas, making it crucial to invest more time and resources in designing and implementing oUIS effectively. These five areas are: Workplace interaction and communication; work practices; work governance and management capability; organisational capabilities; and IT infrastructures and resources (Tilvawala et al., 2013).

4 DESIGN AND IMPLEMENTATION OF OUIS FOR DNs AND DIs

Several IS researchers have looked at the design and implementation of ubiquitous computing (Akyildiz, Mohandy & Jiang, 2005; Heckmann & Krueger, 2003; Huber, Pustka, Keitler, Echtler, & Klinker, 2007; McCurdy & Griswold, 2005; Soldatos, Dimakis, Stamatis, & Polymenakos, 2007), however, literature on design and implementation of UIS is lacking (Boyd & Ellison, 2007). Specifically, literature on oUIS is almost non-existent but some of the growing research in the area of design and implementation of ubiquitous computing (Lyytinen et al., 2004; Waller & Johnston, 2009) lends itself to oUIS research.
Designing and implementing an oUIS is radically different from designing and implementing a TIS (Lyytinen et al., 2004). Glissmann, Smolnik et al. (2005) note that applying traditional software life cycle models and design principles have resulted in mobile business applications that are not very usable. Waller and Johnston (2009) further explain that the reason computing artefacts designed with traditional models fail is due to the transformation in society at large. Traditionally, IS were designed to assist us by providing a representation of the world which we can reflect on before acting. However, the use of UIS is meant to be more seamless, and natural. The differences in DN and DI approaches and beliefs about work further add to the complexities. A similarity between TIS and UIS design however, is that for both types of systems, researchers believe that identifying the needs of your users is the most important part (Brereton & Buur, 2008; Glissmann et al., 2005; Iqbal, Gatward, & James, 2005). The concept of design is a result of this very need. It is a constant challenge trying to understand what users of systems want, identifying what they think they want, and what they will eventually want from the system in the near future (Agarwal, Sinha, & Tanniru, 1996; Lamsweerde, 2000). Understanding user specific oUIS characteristics including users’ activities, the kind of task, frequency of use, where used, how long it is used for are important. Iqbal, Gatward et al. (2005) find that it is also important to understand the culture in which the oUIS will be used. This involves users, but more importantly the nature of their communication and collaboration within their context of use. This is similar to Brereton and Buur (2008)’s recommendation that rather than trying to identify and plan the all-encompassing systems development project, there is a need for more iterative and experimental design to truly understand the complexities and requirements of the environment in which the oUIS is to be deployed.

This research is interested in the actual design dimensions and requirements that need to be considered. UIS as such are very different to TIS in terms of their purpose. There are numerous UIS used for personal purposes, some of which are extremely successful. Therefore, when exploring oUIS design, some of the personal UIS “success” factors have been taken into consideration, and adapted to fit the organisational context. Given the limited amount of academic research in the area (Vodanovich et al., 2010; Yoo, 2010), we draw mostly from research done by organisations in the IT industry. To ensure the validity of some of the electronic articles, we have primarily used those that have been applied in practice such as Weevers (2011).

<table>
<thead>
<tr>
<th>Main dimension</th>
<th>Sub dimensions</th>
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<tbody>
<tr>
<td>User (interface/experience)</td>
<td>amazing, delights, valuable, lasting experience, usability, validation (to improve performance, responsiveness, interruptions), user controls, intuitive, elegant, accessible, engaging, unique, natural, fun, appealing, interactive, aesthetics, quality, relevant, animations, entertaining</td>
</tr>
<tr>
<td>Activity (user activities)</td>
<td>secure, reliable, responsiveness, interruption management, interoperability with other apps, configuration, forgiveness (error handing), flow, seamless transitions, collaboration, transactions, decision support, parallel-processing</td>
</tr>
<tr>
<td>Device and Operating System (OS)</td>
<td>performance, battery life, processing speed, memory, power usage of app, screen real-estate, input method</td>
</tr>
<tr>
<td>Organisation and Implementation</td>
<td>integration, synchronization, supportability, compatibility, adaptability (keeping current), flexibility, customisability, feedback, maintainability</td>
</tr>
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Table 1. Design dimensions of oUIS for DNs and DIs (Beck & Wade, 2004; Chong, So, Shum, Li, & Goyal, 2004; Editorial, 2011; Lentz., 2011; Manafy & Gautschi, 2011; Microsoft, 2012; Ochs, 2012; Prensky, 2001; Rainie, 2006; Tilvawala et al., 2011; Tilvawala et al., 2013; Weevers, 2011)

The basis of this research is a list of UIS design dimensions proposed for DN and DI users; reorganized and improved under four main design dimension categories (Table 1): User, Activity, Device and Operating System (OS), and Organisation and Implementation (adapted from Tilvawala et al., 2011; Vodanovich et al., 2010). This research further explores these dimensions, specifically their application, and interrelated nature.
5 MULTI-METHODOLOGICAL RESEARCH METHOD

The main purpose of this research is to build a framework to support the design and implementation of oUIS for DNs and DIs. We followed Nunamaker et al.’s (1990) multi-methodological model for the design of this framework viz. exploration and observation (gathering and analysing current and related research on design and implementation of oUIS for DNs and DIs); theory building (creating theoretical artefacts for guiding the design and implementation of oUIS for DNs and DIs); and observation through design & implementation (validating and proposing revised theoretical artefacts for guiding the design and implementation of oUIS for DNs and DIs through observation and creation of a prototype). Figure 1 illustrates the adapted multi-methodological model used for this research, entailing the various phases.

Figure 1. Multi-methodological research (adapted from Nunamaker et al. 1990)

Phase 01: Literature review (LR) - This phase involved preliminary steps of searching all academic literature on UIS, DNs and DIs in organisations. The literature review also draws from published work involving surveys, as well as some expert comments and discussions on the topic.

Phase 02: Theory Building (TB) - The main purpose of phase 02 was to establish guidelines for the Observation phase. The secondary goal of this phase is to contribute to the IS knowledge base by providing relevant tools for further research in the area. As such TB was done almost concurrently with LR, as concepts are explored, definitions cleared, and themes become apparent. TB was also done iteratively after each observation phase.

Phase 03: Engagement with Usability experts (O1) - This phase involved detailed discussions on UIS design theories and requirements with usability experts and representatives from a variety of industries.
**Phase 04: Interviews with DNs and DIs (O2)** - This phase was aimed at understanding DN and DI oUIS design requirements and needs. Semi-structured interviews with DN and DI participants were conducted to get first-hand information on user experiences.

**Phase 05: Review of UIS (O3)** - This phase involved first hand observation of various UIS used in personal as well as organisational contexts. It involved reviewing the UIS against the design dimensions established in theory building phases.

**Phase 06: System Design (SD)** - This phase was aimed at assessing the design patterns established in the previous phases. This was done by applying design science theory to create a design prototype for an oUIS; assessing various design dimensions being addressed, and considering potential trade-offs in the process.

Figure 2 summarises the overall research methodology and process implemented. As illustrated, every observation phase was followed by theory building (TB1, TB2, TB3 and TB4). For example, After O1 (engagement with usability experts), the findings were analysed to extract any new design dimensions for the design and implementation framework. This phase was in essence TB2 before proceeding to conduct interviews with DNs and DIs.

The multi-methodological model draws from both interpretive and critical research paradigms, which are important for understanding the rich dynamics of this research area. In addition, design science theories were applied to create a prototype to evaluate the theoretical artefacts generated. The selected methodology was therefore in concurrence with several researchers’ call for IS research to look beyond a single methodology in order to explore a research domain adequately (Adams & Courtney, 2004; Mingers, 2003; Mingers & Brocklesby, 1997; Nunamaker et al., 1990).

6 FINDINGS

Overall, the findings suggest that the design and implementation of oUIS is indeed different to traditional system design (Glissmann et al., 2005; Krogstie et al., 2003; Lyytinen et al., 2004). This research project resulted in a conceptual design and implementation framework that is fundamentally different to TIS design and implementation (Figure 3). The framework includes a comprehensive list of oUIS design dimensions, which takes into consideration the design needs of both DN and DI users. This confirms the need to reassess the traditional design and implementation models given both a new set of users, and varying platform capabilities (Waller & Johnston, 2009). The findings demonstrate that oUIS design dimensions are highly inter-related (Microsoft, 2012); but also need to be
continually balanced (Weevers, 2011). This is because core design dimensions such as *functionality, desirability,* and *usability* can be inhibited by *performance* related dimensions (Figure 3). And all these dimensions can in turn be limited by the implementation platform and/or *organisational* limitations (Ochs, 2012) and *needs*. Overall, the design pattern for oUIS is rather chaotic, and involves jumping from one design dimension to another to eventually achieve a balanced design decision (Figure 4).

The findings of this research can be sub-divided into three broad categories. Findings on: (1) oUIS design requirements for DN and DI users; (2) oUIS design dimension inter-relationships; and (3) oUIS design and implementation pattern.

### 6.1 oUIS design requirements for DN and DI users

The findings from all the research phases highlight three key aspects that need to be considered when designing oUIS: (1) the main purpose of the oUIS (2) managing user expectations, and (3) organisational needs. The more successful oUIS tend to focus on the design dimensions that explicitly address these three aspects.

The oUIS review phase suggests that “Device and OS” related design dimensions are most important for any UIS (Table 1). “Device and OS” design considerations came up several times when looking at user reviews, and interacting with the UIS first hand. These appear primarily in the *reliability* layer of the oUIS design and implementation framework for DNs and DIs (Figure 3). Most of the unsuccessful UIS observed failed despite having a plethora of functionality, and addressing detailed user needs because none of it was usable. This lack of *performance* came down to other design dimensions being impacted, for example, processing speed, memory, and battery life, hence not living up to user expectations. The same reasoning applies to the UIS that were rather simple, with limited functionality, but still quite usable.

### 6.2 oUIS design dimension inter-relationships

The process of exploring and identifying new design and implementation dimensions also helped establish the complexities of oUIS design and implementation patterns (Figure 4). These were realised primarily through the process of creating a prototype (Hevner, March, Park, & Ram, 2004; Nunamaker et al., 1990). A prominent and recurring difficulty was the delicate balancing of the various design dimensions of an oUIS keeping in mind the organisational needs (Ochs, 2012; Weevers, 2011). The interview and system design phase suggest that it is important to establish the most appropriate design trade-offs depending on the purpose of the oUIS.

In terms of design patterns and trade-offs, the balancing was centred primarily around *reliability* again. The reviews indicate that with every *functionality* upgrade, there needs to be a consideration of how it will affect the other sub-dimensions such as *performance* and *connectivity*; as well as *usability*. The design process is therefore highly iterative going back and forth, looking at the functionality being added, and how it affects other dimensions. Overall, keeping it simple is the key - only presenting users with functionality relevant to them at the particular point of interaction with the UIS.
Figure 3. oUIS Design and Implementation Framework for DN and DI users
Another example of interrelated sub-dimensions is **validation**, which improves **usability**, and at the same time enables more **responsiveness** in an oUIS. This results in the user experiencing fewer interruptions, and an improved overall customer experience (Microsoft 2012). Figure 4 illustrates the inter-related design dimensions, and the expected design pattern when applying the oUIS design and implementation framework. It involves considering the core **organisational needs** first. The next step would be identifying the **performance** and **connectivity** design dimensions necessary to support the **organisational needs**. These affect the overall **reliability** of the oUIS. Then, there are core **functionality** and **usability** dimensions that determine the **capabilities** and **usefulness** of the oUIS. These will depend on, and affect all the design dimensions in the layers below that, as well as design dimensions in the same layer. Lastly, there are advanced **desirability** related dimensions that can be added on after ensuring that core **functionality** and **usability** elements are addressed. These are especially importantly in terms of catering to the DNs. However, as important as they are, considering them involves reflecting on all the other dimensions present in the layers below. Trade-offs can then be determined based on the organisational oUIS requirements.

Overall, the layered design approach for oUIS helps consider all the potential design dimensions for a given oUIS catered to both DNs and DIs. It also ensures that the oUIS is always supportive of the organisational core system needs, hence facilitating a better digital ecosystem in organisations.

### 6.3 oUIS design and implementation pattern

Based on the experience of designing the prototype and implementing a small part of it, it was found that the actual design decisions always get centred around oUIS **capabilities and usefulness**, and in some cases digress to **desirability** related dimensions without much consideration of the bottom two layers. Typically, it starts with **functionality** and **usability**, and then calls for a need to reflect on the other design dimensions. Overall, designing oUIS is a chaotic process, constantly jumping from design dimension to the other, to eventually achieve a design decision.

For example, in the system design phase, each mock-up was revised multiple times as different elements for interaction and **functionality** were missing. It was easy to get carried away into thinking of new, more intriguing, and interesting icons and features to be included on the screen (**desirability**). This research phase demonstrated how potential trade-offs can be overlooked creating new design conflicts, and the need to introduce some structure or guidance to the process. Figure 4 illustrates a typical oUIS design process/pattern, indicating the potential benefits of referring back to the layered conceptual framework proposed (Figure 3).

The implementation of oUIS is complex given the variety of ubiquitous devices and support available (Glissmann et al., 2005). A number of factors within and beyond the organisational boundary determine the successful implementation or otherwise of oUIS (Scheepers & Scheepers, 2003). Failure to consider these interdependent factors and the dynamics of the entire digital ecosystem of the organisation may have several flow-on effects. Depending on the platform of implementation, it is easy to get carried away into focusing on the top layer (**desirability**) in the oUIS design and implementation framework, rather than focusing on the core bottom layers. For example, in the case of iOS, the platform itself calls for appealing and aesthetically pleasant UIS, driving attention to the **desirability** layer first. As such the design and implementation of oUIS is iterative as illustrated in Figure 4, and the conceptual framework (Figure 3) helps streamline this process.
Over the last few years two major IS related changes have been observed in organisations - the growth of ubiquitous information systems and rise of a new kind of user (digital natives). These changes imply that our previous theories and models relating to the design and implementation of traditional information systems by digital immigrants might not be so relevant in this new world. This makes the design and implementation of oUIS (for both digital natives and digital immigrants) a timely and important topic to research.

This paper has proposed a conceptual framework for the design and implementation of oUIS for DN and DI users based on the use of a multi-methodological research method. The findings suggest that the design and implementation of oUIS, and UIS in general is different to TIS design and implementation. The oUIS design process is found to be more ‘chaotic’, with the need to constantly balance various design dimensions and adapt to new design requirements. The proposed conceptual framework aims to lessen the ‘chaos’ involved in the design and implementation of oUIS. It does this through a layered framework comprising a comprehensive list of oUIS, DN and DI related design dimensions. The framework entails the dynamics within and beyond the organisation that have been the main cause of oUIS not being successful and/or usable.

The conceptual framework (Figure 3) helps administer the ‘chaotic’ and ‘highly iterative’ oUIS design and implementation pattern in three main ways: (1) To balance the design dimensions more thoroughly, and in a shorter amount of time; (2) to consider the feasibility of emerging design
requirements more promptly and accurately; and (3) to ensure careful, thorough, and timely adaptation of the oUIS in a resourceful manner (Figure 4).

This research lays the foundations for further research on designing and implementing oUIS and UIS. The oUIS design and implementation framework can be used as a basis for creating a more comprehensive, and/or creating other variations of the framework. Most of the artefacts proposed in this research also have practical implications. Our findings indicate that organisations need to be mindful of the numerous trade-offs between the various design dimensions.

One of the limitations of this research project is that the focus was on “business to employee” oUIS. However, oUIS can range from simple, to highly complex types. We caution therefore that the design dimensions we have identified might not apply so well to “business to consumer” and “business to business” oUIS. This aspect needs further work. Another limitation is the rather lean implementation in the system design phase. The oUIS design and implementation framework was evaluated based on design mock-ups and minimal implementation; hence the results may vary widely when implemented fully. It would be insightful to apply the design and implementation framework to other scenarios.

References


