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An Organisational Semiotics Inspired Information Architecture: *Pervasive Healthcare as a Case Study*

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Abstract: Information architecture (IA) is defined as high level information requirements of an organisation. It is applied in areas such as information systems development, enterprise architecture, business processes management and organisational change management. Still, the lack of methods and theories prevents information architecture becoming a distinct discipline. Healthcare organisation is always seen as information intensive organisation, moreover in a pervasive healthcare environment. Pervasive healthcare aims to provide healthcare services to anyone, anywhere and anytime by incorporating mobile devices and wireless network. Information architecture hence plays an important role in information provisioning within the context of pervasive healthcare in order to support decision making and communication between clinician and patients. Organisational semiotics is one of the social technical approaches that contemplate information through the norms or activities performed within an organisation prior to pervasive healthcare implementation. This paper proposes a conceptual design of information architecture for pervasive healthcare. It is illustrated with a scenario of mental health patient monitoring.

1 INTRODUCTION

Information has played an important role in an organisation. However, information is still not managed well in many organisations including the healthcare organisations, which is arguably the world's largest and most inefficient information enterprise (Martin et al., 2010, Hillestad et al., 2005).

The rise of pervasive healthcare in the early twenty first centuries aims to provide healthcare services to anyone, anytime and anywhere by integrating seamlessly the primary, secondary and home care service provisions (Varshney, 2007). The motivation is good and certain economic and patient care benefits have been achieved through pervasive healthcare. Still, the inefficient information management and poor information sharing issues remain unsolved. This will cost the healthcare organisation in terms of medical errors and hence putting patient safety in jeopardy. These issues rest the shoulder on the pervasive healthcare information management. Its role is to handle information requirements of a healthcare organisation and technically implemented on the electronic patient records (EPR) (Berg, 2003). EPR is the biggest

instrumentation in Health IT where social and technical factors have to be considered prior to its implementation (IOM, 2011). On this basis, information architecture thus plays an important role in capturing the information required and providing the right information at a right time, to a right person with a right motivation. In addition, information architecture would be able to help healthcare organisation to deal with the increasing volumes of information to be disseminated, digested and managed effectively.

However, there is a lack of social acumen in existing information architecture and pervasive healthcare literature. Information architecture is defined in various empirical contexts such as information systems architecture, web development, business process management, enterprise architecture and organisational change management. Still, there is no social construct on information architecture development which is vital to facilitate information provision for pervasive healthcare delivery.

Organisational semiotics is one of the social technical approaches that studies information within an organisation through its composition of norms and activities (Liu, 2000). The aim of this paper is to

propose a conceptual design of information architecture for pervasive healthcare with organisational semiotics as its theoretical foundation. Section 2 illustrates the related literatures that contribute to the conceptual design of information architecture for pervasive healthcare. This includes information architecture definitions on various contexts, pervasive healthcare information management and how organisational morphology contributes to information requirements elicitation. Section 3 discusses the conceptual design of information architecture for pervasive healthcare. The architecting process starts with analysing activities in the defined norm categories. This follows with a mapping between organisational activities with the pervasive healthcare requirements. Information requirements are hence derived from the pervasive healthcare related activities. This paper is concluded with future work.

2 RELATED WORK

2.1 The Notion of Information Architecture

The terminology of information architecture is coined by Richard Saul Wurman back in the mid-seventies to describe the need to transform data into meaningful information for people to use (Dillon and Turnbull, 2005). He sees the gathering, organising, and presenting information to serve a purpose, or set of purpose as an architectural task. Information architecture is later defined by Brancheau and Wetherbe (1986) as a high level map of information requirements of an organisation or a process of architecting information in order to achieve organisational benefits (Brancheau and Wetherbe, 1986, Evernden and Evernden, 2003). The information requirements elicitation starts from a high level conceptual view and refined until the lowest level where a physical database can be implemented. Information architecture carries numerous definitions depending on its application. This section probes into the technical and organisational aspects of information architecture.

2.1.1 Information Architecture from Technical Aspect

The technical aspect of information architecture can be examined from information systems development such as IT system development and web development. John Zachman introduced the concept

of information system architecture back 1987 with the aim to improve professional communications within the information system community for IT system development. It provides taxonomy for relating the concepts that describe information and its implementation. The initial Zachman's information system architecture contains six rows and three columns, where the columns cover the what (data), how (process) and where (network) integrates with scope, owner's view, designer's view, builder's view, out-of-context view and functioning system. It is further extended to include another three columns that covers who (stakeholders), when (time) and why (motivation) (Sowa and Zachman, 1992). Each cell contains information in various types such as a list, description, diagram or model. The information system architecture can be seen as an information architecture that contains the information required for various purposes in information system development. In addition, information architecture is employed in improving usability of the IT system (Henry, 1998). Henry (1998) identifies four key information elements such as labels, messages, online support elements and printed support elements that users will expect when designing information for information system development.

Similarly with Henry's (1998) definition for information architecture that is related to technical content design in order to increase usability, Rosenfeld and Morville (2002) associates the definition of information architecture with internet, intranet or any online sharing sites development. Information architecture in this context should contain aspects such as (Rosenfeld and Morville, 2002): 1) the combination of organisation, labelling, and navigation schemes within an information system 2) the structural design of an information space to facilitate task completion and intuitive access to content 3) the art and science of structuring and classifying websites and intranets to help people find and manage information 4) An emerging discipline and community of practice focused on bringing principles of design and architecture to the digital landscape. Therefore, the information architecture needs to be in place in order to effectively study the information within an organisation. This concept is widely applied in web design, e-commerce sites development, information design and needs that relates to improving website usability, and communication or interaction between the website and users.

2.1.2 Information Architecture from Organisational Aspect

The organisational facets of information architecture can be construed from business process management, enterprise architecture and organisational change management perspective. Business process management is defined as supporting business processes by using methods, techniques and software to design, enact, control and analyse operational processes involving humans, organisations, applications, documents and other sources of information (Van der Aalst et al., 2003). Information architecture can support or improve existing business processes by managing the deployment of resources and sequencing of deliverables (Dillon and Turnbull, 2005, Kettinger et al., 1996). Business process always involves information, and information always involves a business process, these two are inseparable (Dyer, 2012). Information architecture serves as a backbone in supplying the relevant information for each activity in the business process. A reusable template can be created when the patterns of information are identified for each activity in a business process.

Information architecture is one of the elements in the enterprise architecture framework apart from business architecture, application architecture and technical architecture. Enterprise Architecture is a process of translating business vision and strategy into effective enterprise change by creating, communication, and improving the key principles and models that describe the enterprise's future state and enable its evolution (Gartner, 2012). It is usually applied within an organisation in order to ensure that the IT investment is best fit with business purposes. The leading enterprise architecture frameworks include Tapscott and Caston's Framework (Tapscott and Caston, 1993), Archimate (Lankhorst, 2009, Op't Land et al., 2009), The Open Group Architecture Framework (TOGAF) (TheOpenGroup, 2011), The Zachman Framework (Zachman, 1997, Zachman, 2008) and The Integrated Architecture Framework (IAF) (Wout et al., 2010). Information architecture in this context describes how information within an organisation is stored, organised and accessed.

In the context of organisational change management, information architecture is a process of designing, implementing and evaluating information spaces that are humanly and socially acceptable to their intended stakeholders (Dillon, 2002). Organisational change management is a process of continually renewing an organisation's direction,

structure, and capabilities to serve the ever changing needs of external and internal customer (Moran and Brightman, 2001). This is motivated by globalisation, the rapid pace of technological innovation, a growing knowledge workforce, and shifting social and demographic trends (Graetz, 2000). The organisational changes hence could be business strategy changes, technological changes, cultural changes, and attitude or behaviour changes. Similarly to the purpose of enterprise architecture, information architecture addresses the structure of the information systems at the organisational level for planning and management of information assets and resources (Wang, 1997). In other words, architecting information is to manage both internal and external changes within an organisation. Information is thus helps in decision making.

2.2 Information Management for Pervasive Healthcare

Healthcare organisations such as hospital or general practitioner (GP) are information intensive industries. GP provides health services for the local community and usually is the first point of contact of most patients (NationalHealthService, 2012). There are at least three types of information in a healthcare organisation: (Berg, 2003): (1) patients' information that gathered in the electronic patient record (EPR), (2) management information that consists of aggregate information about the processes and outcomes of the organisation and (3) information about diagnostic and therapeutic decisions and procedures or usually is referred as the professional and organisational knowledge required to handle patients optimally. Health information management is hence important especially in providing right information at the right time with right motivation to healthcare professionals in delivering the best health services to patients. This will lead to increasing patient safety and eventually striving for better care quality.

Healthcare information management is often a term that relates to paper patient record in that past and electronic patient record (EPR) in this century (Berg, 2003). EPR is a tool to managing healthcare information hence supporting care process with order communication and decision support techniques. Healthcare information management is defined as a job of handling information requirements of a healthcare organisation and this could be achieved by establishing the information architecture (Berg, 2003, Brancheau and Wetherbe, 1986). EPR implementation is always the biggest

part in health IT. Health IT is viewed as a part of larger socio-technical system that comprises technology such as software and hardware requirements, people such as clinicians and patients, processes such as workflow and clinical pathways, organisation such as capacity, decisions about how health IT systems are applied and incentives and the external environment such as regulations, public opinion and norms (IOM, 2011). By other means, these five factors should be considered prior to EPR or any health IT implementation.

Pervasive healthcare broadens the healthcare service provision by taking it outside the healthcare organisation. Pervasive healthcare is a concept that to deliver healthcare services under pervasive computing (Weiser, 1991) environment. This concept has emerged in the early twenty first century due to accelerating operational costs, growing numbers of medical errors, insufficient staffing and lack of health services coverage in rural areas (Varshney, 2003). Pervasive healthcare aims to provide healthcare to anyone, anytime and anywhere by removing locational, time and other restraints while increasing both the coverage and the quality of

healthcare (Varshney, 2007). Examples of some commonly used pervasive healthcare services are mobile telemedicine, both long term and short term patient monitoring, location based medical services, incident detection service, emergency response service and pervasive access to medical data. Showing in table 1 is the social and technical requirements for implementing pervasive healthcare (Brown and Adams, 2007, Kulkarni and Öztürk, 2007, Varshney, 2007).

Table 1 summarises that pervasive healthcare information management is part of healthcare information management as a whole. The application of mobile devices for pervasive healthcare information management has already been established (Hameed, 2003, Mendonça et al., 2004). Various studies have concluded that limited access to patient related information during decision making and the ineffective communication among healthcare team members are jeopardising patient's safety (Doukas et al., 2010). Therefore, the focus of pervasive healthcare information management should be on supervising the information transmission inside and outside of a healthcare

Table 1: Social and technical requirements for pervasive healthcare implementation (modified from Brown and Adams, 2007, Kulkarni and Öztürk, 2007, Varshney, 2007)

Social requirements (requirements that involves human)	Business requirements	Initial costs of pervasive healthcare Patient care delivery Training for clinicians and patients
	Ethical requirements	Patient's information must be protected Healthcare organisation should be responsible for any pervasive healthcare service delivery failure that caused by technology breakdown
Technical requirements	Network and wireless support	The implemented wireless infrastructure should be highly reliable and stable
	Mobile devices, sensors and sensor applications	The representation of medical information (i.e. multimedia, resolution, processing and storage) The application is able to support location management (i.e finding people with matching blood groups, locating organ donor, providing post-op care for people and helping old and mentally challenged people in hospitals and nursing home) The application is context aware and able to provide information for clinicians and patients to conduct certain activities (i.e. vital sign information that is needed by the clinician to monitor patient's health status) The applications are standardised to facilitate the interoperation of the healthcare services The application should be easy to use. The mobile devices and sensors should be in a portable size, lightweight and non-intrusive. There is a security or role based access control in accessing the sensor applications

organisation and providing the most accurate information to patients and clinicians. Patients can then use the information obtained for prevention purpose whilst for clinicians, they can use the information to monitor patient's health status. This can be achieved via establishing the information architecture where it captures the information needed by an organisation.

2.3 An Organisational Semiotics Approach for Information Architecture

Organisational semiotics is the study of organisation using concepts and methods of semiotics (Liu, 2000). The study is based on the fundamental observations that all organised behaviour is affected through communications and interpretation of signs by people hence helps in understanding the nature of information. Organisation is comprehended in terms of the signs and how, through norms to perform certain action, or by other means, organisation is characterised as a structure of social norms from organisation semiotics perspective (Stamper et al., 2000). A sign can either be an object or the effect produced by an object that conveys message or something verbal such as words, an index is a sign that signifies meaning and refers to by a causal process which may be distinguished by repeated observation, and a symbol is a sign that associated with norms or rules which depends upon social conventions to form and sustain them (Peirce, 1935, Stamper, 1985). Semiosis is a sign mediation process or a sense making process in relation to a context that consisting three universal

categories (Liu, 2000): 1) firstness, a representation or sign that could be any quality, thing or idea that applied to second, 2) secondness is an object or actuality that can be further interpreted to third, 3) thirdness is the resultant of the whole sense making process

Stamper et al. (2000) claimed that information requirements can be deduced once the norms within an organisation are identified. Every norm has the general shape: If CONDITION then CONSEQUENT. The condition part determines what information the norm-subject (an individual person or a group) requires to be able to obey it, while the consequent leads, sooner or later, to the generation of information for others either directly through sending messages or indirectly through the influence of the norm upon actions. The three layers in organisational union, technical, formal and informal layer defines the three taxonomies of norms in an organisation (Liu, 2000). The informal layer refers to organisational culture, customs and values that are reflected as beliefs, habits and patterns of members within the organisation. The formal layer denotes the rules and bureaucracy to perform the organisational activities. The technical layer contains technical systems that enable actions to be performed for formal and informal layers.

Norms embedded in each organisational layer can be further analysed in substantive, communication and control perspective that guides the performed activities within an organisation. It is also known as organisational morphology (Mat Ali and Liu, 2010).

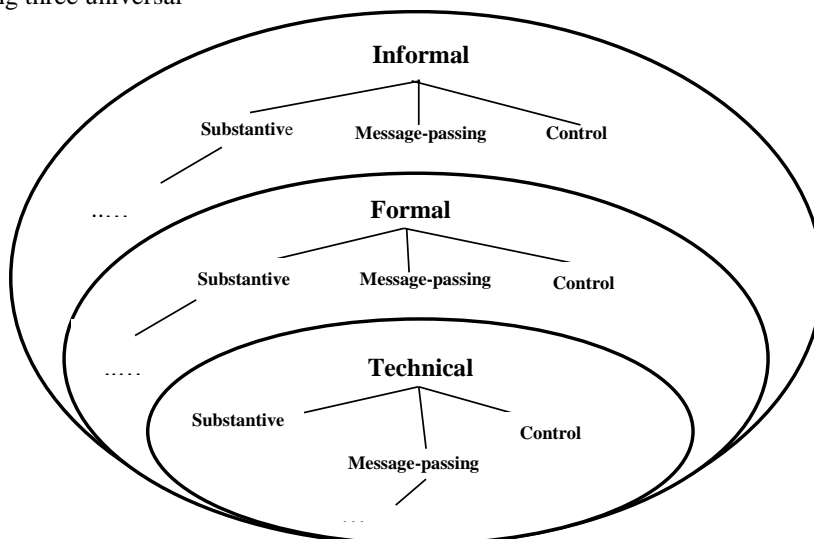


Figure 1: Three functional views of norms within Organisational Union

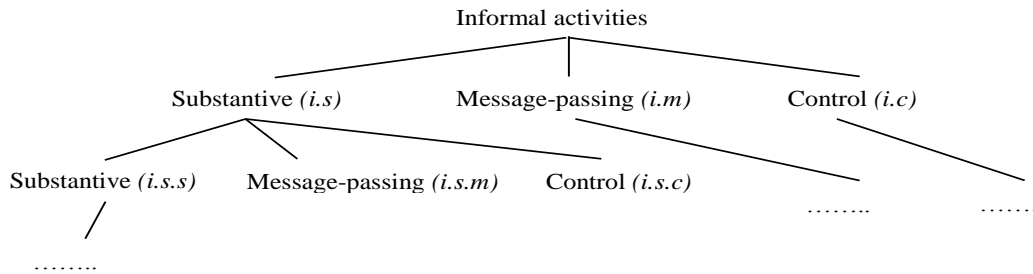


Figure 2: Further analysis of informal activities within an organisation

Substantive activities are productivity related action. Communication activities administer actions such as informing relevant people about the relevant facts, work procedures, what action to be taken, when and by whom. Control activities reinforce the substantive and communication norms through rules and regulation. In this definition, there are nine activity categories derived in the first level of analysis such as:

<i>organisation.informal.substantive</i>		<i>(o.i.s)</i> ,
<i>organisation.informal.message</i>	<i>passing</i>	<i>(o.i.m)</i> ,
<i>organisation.informal.control</i>		<i>(o.i.c)</i> ,
<i>organisation.formal.substantive</i>		<i>(o.f.s)</i> ,
<i>organisation.formal.message</i>	<i>passing</i>	<i>(o.f.m)</i> ,
<i>organisation.formal.control</i>		<i>(o.f.c)</i> ,
<i>organisation.technical.substantive</i>		<i>(o.t.s)</i> ,
<i>organisation.technical.message</i>	<i>passing</i>	<i>(o.t.m)</i> ,
<i>organisation.technical.control</i>		<i>(o.t.c)</i> .

Each norm can be taken to another level of analysis or expanded depending on the types of activities or tasks within an organisation. Showing in figure 2 for example, a substantive activity in the informal layer of the organisation can further derive sub activity such as *informal.substantive.substantive*, *informal.substantive.message-passing* and *informal.substantive.control*, so on and so forth. There are no restrictions on the levels of analysis. Norms govern the tasks and activities within an organisation. Information is used to facilitate norms in order to perform certain tasks. In contrary to the conventional information requirement elicitation process, information requirements hence are deduced from analysing the tasks or activities that are being performed within an organisation

3 CONCEPTUAL DESIGN OF IA FOR PERVASIVE HEALTH CARE WITH EXAMPLE

There are three areas discussed in section 2 that contributes to deriving the conceptual design of information architecture for pervasive healthcare. It is vital to first understand information architecture in various contexts, and then determine how it is best represented for pervasive healthcare. Ultimately, information architecture is about capturing information requirement of an organisation (Brancheau and Wetherbe, 1986) where in this context, the information architecture will be capturing the information requirement for implementing pervasive healthcare. It is concluded that the information architecture should cover the following key aspects:

- (1) *Interrogatives with representations*: covers the six interrogatives what (data), how (process), where (network), who (stakeholders), when (time) and why (motivations) with representations
- (2) *User friendly navigation*: this can be examined through the organisation of information, labelling and navigation scheme, how easy for user to find and access information and how quickly is the task completion
- (3) *Document templates for each activity*: the document template will be used to capture information for the activities within the business processes
- (4) *Information management*: facilitates how information is stored, organised and accessed
- (5) *Change management*: shows the change effects of business strategy changes, technological

changes, cultural changes, attitude or behavioural changes

The existing literature for information architecture and pervasive healthcare remains very

technical still and it is lack of the contributing social factors. Therefore, the organisational semiotics

Table 2a: The informal layer of information architecture for pervasive healthcare

Activity categories	Pervasive Healthcare Requirements	Example of Activities	Information requirements
organisation.informal.substantive (o.i.s)	Business requirements (cost of pervasive healthcare)	provide better remote monitoring service for mental health patient	What are the pervasive healthcare services to be implemented for monitoring mental health patient? (i.e. telemedicine, location management etc.) Why there is the need for the pervasive healthcare implementation for mental health patient? Where it is going to be implemented? (i.e. which hospital, which residential area)
organisation.informal.message-passing (o.i.m)	Business requirements (patient care delivery, training)	increase awareness of remote mental health patient monitoring	When this is going to be implemented? Who is involved / affected in this implementation?
organisation.informal.control (o.i.c)	Ethical requirements (protected patient's information, responsibility of error)	ensure the mental health patient's information is protected and all wearable sensors are safe	How this is going to be implemented?

Table 2b: The formal layer of information architecture for pervasive healthcare

Activity categories	Pervasive Healthcare Requirements	Example of Activities	Information requirements
organisation.formal.substantive (o.f.s)	Business requirements (cost of pervasive healthcare)	establishing clinical pathway for remotely monitoring mental health patients	What are the behavioural and physical symptoms for mental health patient? Why there is a need of observing patient's behavioural and physical symptoms? Where (which area) the monitoring is covered?
organisation.formal.message-passing (o.f.m)	Business requirements (patient care delivery, training)	publishing information of remotely monitoring health patients in hospital website and knowledge base	When the formal communication of the implemented pervasive healthcare services (i.e. email, internet, intranet, press release, white papers etc.) is going to take places? Who are the audiences in the communication chain?
organisation.formal.control (o.f.c)	Ethical requirements (protected patient's information)	Ensuring only authenticated information published is always up-to-date for both clinician and patient benefit	How the clinical pathway is going to formulated? How to ensure that the communication established is abiding the healthcare policies?

Table 2c: The technical layer of information architecture for pervasive healthcare

Activity categories	Pervasive Healthcare Requirements	Example of Activities	Information requirements
organisation.technical .substantive (o.t.s)	Mobile devices, sensors and sensor applications	Device and software installation for mental health patient monitoring	What type of mobile devices, sensors and sensor applications are going to be used? Why (the justifications) such particular mobile devices, sensors and sensor applications are selected? Where the mobile devices, sensors and sensor applications are going to be installed?
organisation.technical .message-passing (o.t.m)	Network and wireless support	Information flow between device carried by patient and clinical system	Who in particular the clinician and patient are involved in the information transmission process? When information such as vital signs and activity level are going to be triggered?
organisation.technical .control (o.t.c)	Mobile devices, sensors and sensor applications	ensuring information transmitted is secured and authenticated	How to ensure the reliability and security of the mobile devices, sensors, sensor applications and data transmission?

4. DISCUSSIONS

Information architecture is seen as a mechanism to capture information requirements of an organisation or defined context where the context in this paper is pervasive healthcare. Information architecture is applicable in five areas such as information systems development, enterprise architecture, business processes management and organisational change management. A collective view of information architecture has been derived based on these five perspectives where it should contain the five key aspects such as interrogatives with representations, user friendly navigation, document templates for each activity, information management and change management. By other means, information requirements are derived based on the specified purposes.

However, these key aspects are still only on the surface of organisational and technical. In organisational semiotics definition, they fit into the formal and technical layer. The key aspects for the informal layer are yet to be addressed in the existing literature. It is important as the informal norms are the fundamental element embedded within an organisation that portrays how people perform certain actions. In this context, it is about how to derive the information requirements based on the performed activities. It implies that the information architecture is built based on a standardised context across the industry and not organisational specific if the informal layer of information requirements is not being gathered. It is catastrophic when the information architecture developed contains

information requirements that are not fulfilling the needs in day to day activities. In short, the strength of the proposed conceptual design of this information architecture is to offer an approach in capturing information requirements from informal, formal and technical perspective.

5. CONCLUSIONS AND FUTURE WORK

In summary, this paper has proposed a conceptual design of information architecture for pervasive healthcare by adopting organisational semiotics as its theoretical foundation. The information architecting process starts from analysing the organisational norms by employing the organisational morphology, which is one of the organisational analysis approaches in organisational semiotics. The activities are then classified in various norm-based categories. Information requirements are hence derived based on the activities conducted for the pervasive healthcare environment.

The proposed information architecture employed the interrogatives in eliciting information requirements through activities performed within an organisation. It has portrayed the information management capability where clinicians can obtain information based on their projected activities in pervasive healthcare environment. The assumption made here is that document templates will be produced to capture information for the activities conducted.

As the whole information requirement eliciting process is guided by organisation norms, it is down to the information architect on how he or she perceives the meaning of the substantial, communication and control activities. Therefore, the information architects should communicate regularly with stakeholders involved to define the activities and decide the level of organisational analysis needed.

This research work is currently conducted in an acute Trust in England. The development of a technical tool based on this conceptual design of information architecture is aimed towards the end of this research work. For example, the process of eliciting information requirements can be developed to a tool. The information obtained together with the document templates can be kept in the information management tool such as SharePoint. The information navigation in regardless the SharePoint page or on the mobile devices such as the mobile EPR should be user friendly so that clinician can easily find and access information. In addition, the business intelligence or reporting element should be incorporated in the information management tool. This is to ensure clinicians obtain the relevant information in making medical decisions and for management staff to make organisational related decisions. The change indicators can be further developed so relevant information can be extracted to justify the changes made on the healthcare organisation such as business or technology strategy.

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