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HEALTHCARE MODELLING THROUGH ENTERPRISE ARCHITECTURE: A HOSPITAL CASE

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Abstract

Enterprise Architecture (EA) is a strategic activity and planning tool for an enterprise, which facilitates decision-making by enabling a conceptual view of the enterprise. The main objective of an EA approach is to define the layout of organizational components and relationships among them, in order to understand the integration of objects for further improvement. In a healthcare context, EA has the potential to facilitate integrating healthcare units with business architecture. Adapting appropriate tools for management analysis and decisions by healthcare management could have a significant impact on healthcare organizations such as in hospital goal achievement. Process analysis within EA has the potential to improve understanding of healthcare functions leading to better healthcare-IT alignment. The healthcare domain is significant due to its sensitivity of operations and human involvement. Although improvement is welcomed in the healthcare arena, it is problematic and challenging to manage resources and service improvement is difficult due to the complexity of operations. This research is intended to explore a process view and modelling of healthcare using EA. Also, this research is based in a hospital in the United Kingdom. The research aims to design and provide the insight of an EA approach to process architecture for healthcare-IT alignment. In our case study, we analyzed healthcare organizational processes. This paper conceptualizes this analysis and provides an overview of healthcare processes in the context of EA to improve healthcare management.

1. Introduction

Enterprise Architecture is a management practice approach, which offers performance improvement to an enterprise in many ways. Firstly, it enables management to view strategic goals in a more precise way. Secondly, it provides knowledge of information needs, exchange, availability and flows. Finally, it enables a view of technology integration and business practices [1].

EA can provide: standardized policies, decision support, resource alignment and resource supervision. A construction metaphor is often used to illustrate the importance of an EA approach [2]. The construction of part of a building without design or architectural layout of the whole building would not be considered to be a suitable approach for developing a complete building. This analogy is extended to highlight the inappropriateness of developing business processes or business systems execution without a holistic view of the enterprise architecture [3]. Without an enterprise architecture based development of business resources or systems, the result could be resource duplication, lack of integration, inefficient information exchange or ineffective technology support [4].

Although enterprise architecture concepts are not very mature, many multinational companies are recognizing the strategic importance of it and adopting it. The main contribution of EA can be classified as: integration, reusability, reduced risk, systematic regulation, decision support, strategic alignment [3, 4]. Thus, it is worth attempting to understand complex healthcare operations and strategic philosophy through enterprise architecture, in order to provide healthcare managers with improved and suitable tools for devising healthcare systems.

2. Enterprise Modelling from available Frameworks

It is clear that framework and architecture approaches are available to apply in any business scenario. However, the application of tools and methods are mainly dependent on the particular goals and feasibility of the organization, which are fluctuating in nature [5]. While considering the enterprise architecture or framework for building an appropriate model for an organization, some

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properties or characteristics must be considered for the long-term feasibility of the model before selecting it for implementation [6]. The characteristics should be maintainability (precisely characterize the enterprise at all times), dynamic (provide important information on both the rate of change and the reason for change plus information changing itself when the system changes), expandable (model must also support the addition of new subsystems), decompositional (the enterprise must support not only the understanding, but also the decision making and control of the system at various levels of detail), consistent with key enterprise metrics (enterprise model is to ensure that the model has intrinsic value, consistency with current enterprise metrics, and may drive the metrics, also the model should be an integral part of the enterprise) and driven directly from actual enterprise data (inputs and outputs of the enterprise model must be actual data from the enterprise, the model must drive the enterprise and the enterprise must drive the model) [7].

The modelling of an enterprise is a very complex task, as it varies according to the viewer's perception and the goal of the enterprise [8]. Four major objects influence modelling: universe, viewer, conception and representation [9]. Universe is the world around the viewer, viewer is the actor perceiving and conceiving the universe by using their sense, conception is the result in the mind of a viewer (interpretation what they perceive), representation is the denotation of viewer result by using a form of language for expression.

With domain knowledge, the viewer represents the model of the enterprise through their conception and represents the information system within the organization by integrating and optimizing the system to fit the economy of information, in order to satisfy the value of information for its user or owner [3, 8]. This is achieved by using several approaches and methodologies such as automation for reducing the cost of operation with increasing accuracy, effectiveness of each individual enterprise operation and considering each task within the complete set of interlinked processes [10]. Another common aspect is to optimize the cost with respect to the system value by considering the dynamic nature of the enterprise domain.

3. Investigation

Observation of processes within healthcare settings, interviews from strategic management to operation management has been conducted and an investigation of an enterprise architecture framework for mapping onto a healthcare scenario methodology [11] has been adopted for this research. Patients' interaction has been monitored at various levels within a UK hospital.

4. Healthcare Modelling

Typically, simple and understandable architecture is more useful in an enterprise environment that can entertain various stakeholders together. In this respect, the ArchiMate framework is suitable because of its simplicity and expressive power [9]. Although a simplified version of Zachman describes the level of abstraction and level of granularity by proposing the matrix in which the questions what, how, where, who, when and why are answered on three levels of abstraction; enterprise model (owner), system model (designer) and technology model (builder) [12]. However, the enterprise modelling language in ArchiMate defines the domains, which enable the complexity of architectural domain analysis, especially their relations with instruments and visualization techniques. The presentation and view techniques depend on the stakeholders needs [13]. These provide the insight to the stakeholder in a particular domain analysis.

Figure 1, shows that in the ArchiMate framework the conceptual domain is divided into layers and aspects [8, 13]. Despite the fact, it is very difficult to define the exact boundaries between layers and aspects, it is important to understand the role of each concept with respect to its layer and aspect. The concepts that link aspects and layers play an important role for architectural description. The concepts with multiple aspects and layers can be complex, but mostly concepts within a particular domain link have more than one aspect for each layer and layers can be inter-related. This plays a significant role for overall architectural integration. For example, patients' care concept in healthcare domain covers all three aspects with business (healthcare) and application layers.

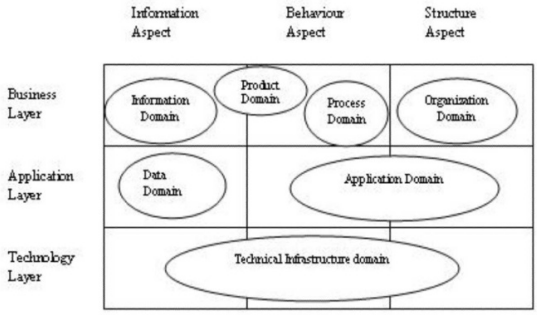

Figure 1. ArchiMate Framework [14]

The ArchiMate context is through viewpoints, which define the abstractions on the set of models that represent the EA [2, 9]. A viewpoint addresses the particular set of concerns and stakeholder's interest. Thus, it can be used solely and can be related with two more aspects of management interest [15]. The context views of ArchiMate are illustrated in figure 2.

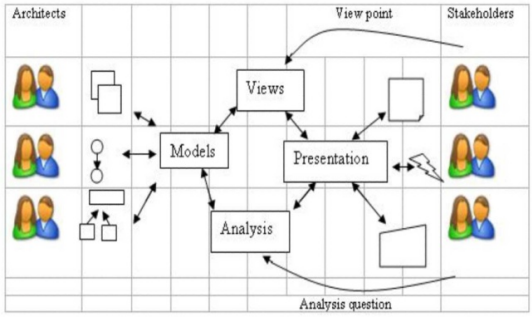

Figure 2. Context Views in the ArchiMate Framework [13], modified

In practice, enterprise architectural descriptions within organizations have several layers [13]. Typically, the layers comprise of three parts: business, application and technology [16]. Practically the lower layer functionalities support the higher layers [17]. Modelling support in these layers is straightforward and the appropriate selection of modelling for each layer is very necessary for business (healthcare)-IT alignment [18]. Appropriate selection of modelling/conceptual views is also essential for representing processes, applications, activities, components, objects and process relations in a systematic way [13]. Enterprise architecture is an appropriate approach for representation of healthcare processes onto different layers for designing and implementation of suitable healthcare applications [13, 17]. In figure 1, the ArchiMate framework, which is relatively simple and easy to understand [16], is illustrated. In fact, the framework is suitable for representing healthcare enterprises. Complex, sensitive functionality and service of healthcare can be decomposed onto three layers as described in the ArchiMate framework (see figure 1). Healthcare processes' representation and linking in conjunction with healthcare functionality and IT alignment is necessary for proposing an appropriate framework [16]. The ArchiMate enterprise architecture framework is useful for representing and linking of healthcare processes [17].

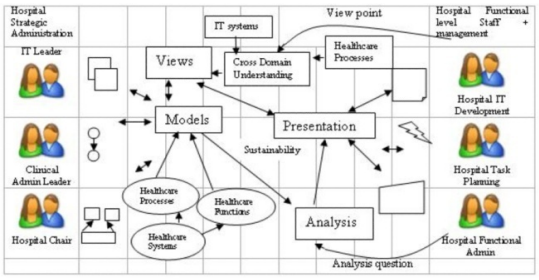

Figure 3. Mapping the Context Views of the ArchiMate Framework to Healthcare

Furthermore, figure 3 illustrates that presentation and views techniques depends on the stakeholders needs who in our case are the healthcare professionals such as hospital IT staff, hospital task planning staff and hospital functional administration staff. An enterprise modelling language that is clearly defined according to the domain supports presentation and view techniques. This particular domain set in modelling language enables the analysis of complexity of the architectural domain. In ArchiMate context views are specific to particular viewpoints. The viewpoint represents the current understanding of the domain and defines the abstractions with representation of EA through a set of models. Each viewpoint describe a particular set of concerns and defines that particular set in isolation that can be related to two or more aspects of management interests. Models evolve from enterprise architecture analysis that represents the healthcare processes, functions and overall system. These models facilitate strategic management to have a holistic view of the enterprise. These models present the views derived from viewpoints (sets of particular concerns of business) as a result of analysis of business modelling with the help of analysis questions with the consideration of each stakeholder.

For this purpose a meta-model is considered from generic to specific on different levels, as shown in figure 4.

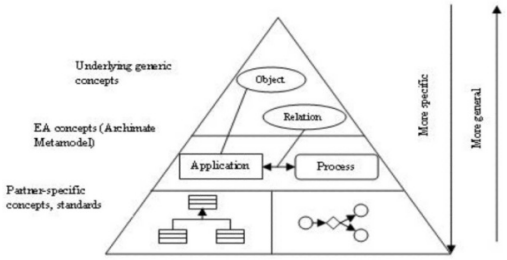

Figure 4. Meta-models from generic to specific on different levels [17]

A meta-model (generic to specific) for a more precise view has been developed and is illustrated in figure 5. At the generic level healthcare components could be defined as objects and their relationships. In our case the hospital patients, patients' reports and doctors activities could be defined as objects plus their relationship with each other could drive the execution of work in which the objects are involved. This shows the behaviour of the objects. At the operational level the meta-model works for hospital analysis in terms of applications and processes. Patients' processes could be considered and defined in this level and related with each other. In our case the patients' movement scenario could be considered with a set of processes, which defines patients' movement. At the same level the patients' IT applications could be considered for automation and definition of the functionality with respect to process automation and IT application automation. It is

actually a middle level (between generic and specific Meta model definition). That's why it is connected with the generic level in which objects and relations are defined with its applications and processes in the middle level. The middle level processes and applications connect with further more specific level models. These middle level process models should describe the functionality and in our case patients' flow processes should be modelled at this level. In the specific level, the system and database integration should also be defined with IT functional relation.

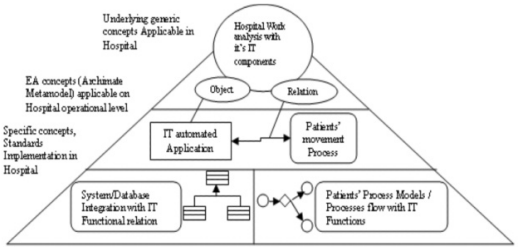

Figure 5. Meta-models from generic to specific on different levels for Healthcare.

A modified generic to specific meta-model (figure 5) is mapped to a healthcare reference model based on Archimate as is outlined in figure 6, which shows the classification of concepts. These classifications depend on the conceptual domain. The conceptual domain is divided into layers and aspects [13]. Although it is very difficult to define the exact boundaries between layers and aspects; it is important to understand the role of each concept with respect to its layer and aspect. The concepts that link aspects and layers play an important role for architectural description. The concepts with multiple aspects and layers could be complex, but most of the time concepts within a particular domain link have more than one aspect for each layer and each layer could be inter-related. But this plays a significant role for overall architectural integration. For example, patients' care concept in healthcare domain covers all three aspects with business (healthcare) and application layers.

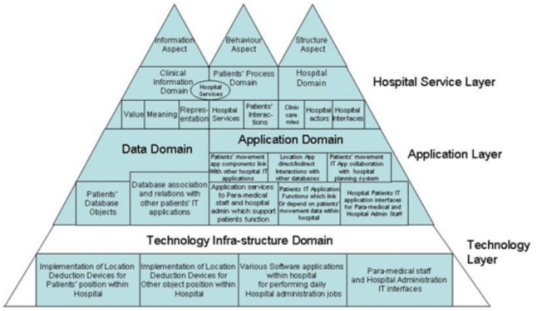

Figure 6. Healthcare Reference Model (HRM)

In figure 6, the layer concept is linked with aspects, which are informational, behaviour and structure. These aspects are related with each layer. The business layer of the reference framework corresponds to hospital services, which provides a clear picture of information domain, process domain and in broader vision hospital domain. These domains further describe the hospital values, clinical information meanings, information representation, patients' services, patients' interconnections, clinical rules, hospital actors and hospital interfaces. These hospital/patients' values, information and representation connect and map with the application layer of the hospital, which further provides the data domain and application domain understanding. These two domain understanding is described as the patients' database objects and database relations within database domain. In application domain the patients' process consider with its applications. In our case the patients' flow is considered. So, the patients' movement process is considered and mapped with its' various applications within application domain at the middle layer. In the lower level definition layer, the technology is defined for healthcare in relation with information, behaviour and structure aspects. These technologies are considered in hospital service layer relation, which further elaborate and define in application layer. The technology layer defines the selection and implementation of information systems, location deduction systems and paramedical staffs IT interfaces. These are the result of the set of processes and application that features within the healthcare domain in our research with hospitals.

In the ArchiMate framework [13] inter layer relationships can be defined in the following manner [5]:

Access: Modelling of accessing the behaviour concept of business and data is represented in this relation; **Aggregation**: In this relation group of object represent by an object; **Assignment**: This relationship links the activities elements (roles or components), actors (role performed by actors) and artefact (actual deployment); **Association**: Shows the relationship between the objects; **Composition**: Models the object, which consists on several other objects; **Realisation**: Links concrete and logical entities; **Specialisation**: Shows object specialization for other object; **Triggering**: Defines the event relationship with processes and functions through different aspect of interaction; **Use**: Shows the use of services by processes and interaction and collaboration by roles and components.

In the ArchiMate framework relationships between layers can be understood through figure 7 (adapted from [18]).

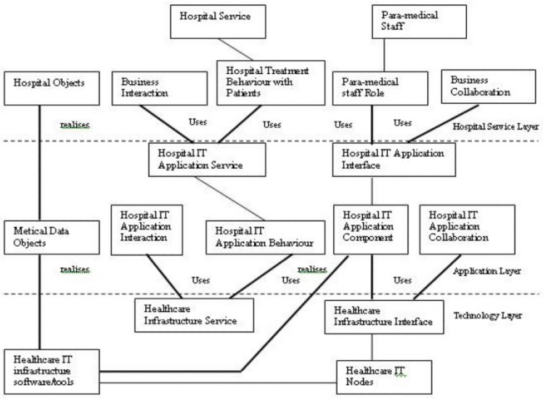

Figure 7. ArchiMate concepts relationship between layers, adapted [18]

In figure 7, the three layers (Business, Application and Technology) of the ArchiMate framework are linked through concepts. Business objects and data object are not directly operationally linked. Rather they are linked through certain behaviours that are known as services, in other words the data object can be available in further higher layers (Business layer) through defined services. These services usually operate in the application level and work as a component within the application level, providing an interface between business and application layers. In fact, one data object can correspond to one or more business object at the business layer and vice versa and this phenomenon is known as realization. These data objects or application components are represented at the lower layer (Technology layer) as artefacts.

In hospital objects, services and staff are important and inter-related as they provides the basis of hospital operations and result in the hospital treatment behaviour with patients. Objects drive the hospital applications through staff and provide services to patients, creating the hospital IT application components and collaboration of these components through integration is important to perform group of tasks or certain processes. These hospital application components are directly related with the technology infrastructure, which defines the software tool or IT nodes such as servers and networking for mobile devices.

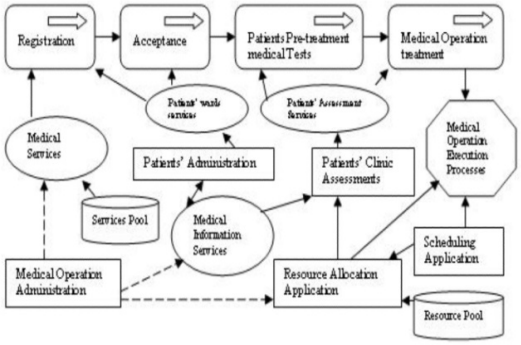

Figure 8. Hospital, Healthcare Service Assisted Alignment Model (SAAM) View

In connection with figure 8, it is easy to further explain the services provided by the hospital and the process of execution of the patients' treatment in relation of these services. Figure 8, shows different stages of patients' interaction with hospital departments and reveal services throughout the patients' journey within the hospital. This enterprise level service and IT alignment view illustrates the current situation with potential automation at different parts within the patients' journey.

This mapping of the ArchiMate framework in the healthcare scenario and representation of service alignment and concepts through different views/levels (strategic, operation and technology) will help in adapting system selection, design and implementation methodology at a strategic level.

5. Conclusion

Enterprise Architecture provides a more precise view of organizational goals and acts as a management tool, which enables management to consider organizational performance in order to improve the situation within organization. EA not only enables performance analysis but also provides the structure for improvement plans. EA illustrates information flow, distribution and exchange at various levels. EA facilitates decision making through its strategic aspects. EA acts as a planning tool for an enterprise and facilitates decision-making by enabling a conceptual view of the enterprise. The healthcare domain is significantly important due to patients' involvement and considerably higher human/staff attachment in each healthcare task at various levels. Although healthcare recognises the need for improvements; it is often problematic and complex to manage its resources and difficult for service improvement due to the complexity of its operation. This research developed the ArchiMate EA framework into a healthcare reference moedel. This model provides a representation of service alignment with the help of views/levels (strategic, operation and technology) concepts, research that is intended to enable IT service alignment in

healthcare. It provides the basis, for adapting system selection procedures, design and implementation methodology at a strategic level for healthcare.

6. Outlook

We would like to thank the SaTH NHS Trust management for allowing us access to their hospitals for our research. Our work continues to develop an enterprise architectural framework for managing contextual knowledge by exploiting object location deduction technologies in healthcare processes that involve the movement of patients. Such a framework is intended to facilitate healthcare managers in adopting location deduction technologies for patient care resulting in improvements in clinical process management and healthcare services.

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