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Research Article

Analyzing e-Health Business Models Using Actor Relationship Matrix

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Abstract

Background: e-Health is expected to realize the wellness of personal healthcare using Information communication technology (ICT) for healthcare services. It is necessary to analyze interrelationships among stakeholders, such as patients, doctors, service providers, to achieve the success of e-Health services. Actor Relationship Matrix has been proposed to analyze goals of stakeholders. Therefore, we are trying to propose the e-Health service analysis approach by using the dependency of stakeholders with ARM (Actor Relationship Matrix). Then we apply the approach to review e-Health services.

Method: We use the ARM for analyzing e-Health business models among business actors. These elements are also shown to be mapped to business architecture elements of ArchiMate which an enterprise architecture modeling language is. By using the mapping, e-health business model is able to develop in ARM. The approach is then applied to review e-Health business models.

Results: The approach is applied to analyze two e-health business models. Both business models have been reviewed by the proposed approach using ARM. The result showed applicability of the method to review e-Health business models.

Conclusion: The proposed ARM based approach is effective to analyze e-Health business models.

Keywords: *Actor Relationship Matrix; Innovation; e-Health; Business Model Review; Case Study*

Abbreviations

ARM: Actor Relationship Matrix; ASOMG: Actor Service Object Means Goal; CVCA: Customer Value Chain Analysis; ICT: information communication technology; EA: Enterprise Architecture; JT: Jobs Theory; DEMO: Design and Engineering Methodology for Organizations; URN: User Requirements Notation; TOGAF: The Open Group Architecture Framework; BMC: Business Model Canvas; BPMN: Business Process Modeling Notation; PACS: Picture Archiving and Communication System; RIS: Radiology Information System; THS: Technology for Healthcare Service provider; THGS: Tele-Health Guidance Service

Introduction

Information communication technology (ICT) is used to develop e-Health services for the wellness of personal healthcare services [1]. It is necessary to design business model to the success of e-Health services. Business model describes key elements of businesses. The role of the business model is to capture the economic value of the new technology such as the e-Health solution. The typical elements of the business model are stakeholders, business process, business objects, business goals and technology solutions. For example, the X-ray image solution needs to clarify stakeholders such as patients, X-ray practitioners, and image diagnosis specialists. The business process for the X-ray image solution includes to capture, store, retrieve and diagnose X-ray images. The business object for the solution includes the X-ray image and diagnosis. The business goals for the X-ray image solution shall be identified for stakeholders, because stakeholders have different goals. Moreover, the interrelationship among business model elements shall also be clarified in the business model. Therefore, the analysis of the e-Health business models is also important. So far, the following methods are proposed to design e-Health services.

Business Model Canvas (BMC) [2] had been used to describe e-Health business models [3]. The business process modeling approaches are also proposed [4,5]. Chen and others [6] compared Telemedicine business models using nine key elements of BMC. Basyman., *et al*. [7] proposed an Activity-based Process Integration

approach that incrementally integrates activities of a new process to current processes. They use i* [8] and URN (User Requirements Notation) [9] to describe goal models and business process integration for the emergency process in the hospital. Goal oriented approaches [10] are applied to analyze healthcare processes [11,12].

Gailly and others [13] described Core Value Ontology. The focus of the e3-value fragment is on the exchange of the maternity care services (i.e., a value object) between the hospital (i.e., an actor) and the high-risk pregnant client (i.e., a market segment). As a compensation for these services, the client will pay money to the hospital. Furthermore, the responsibility of the hospital for executing the activity of monitoring the high-risk patients is also incorporated. This activity is the end of a scenario path, which starts with the need of the future mother to obtain maternity care (see dotted lines). Although the e3-value approach describes functional goals as the end of scenario paths, non-functional goals are not considered in the approach. Gordijn and Akkermans [14] proposed the e3-value ontology. Dantanarayana and others [15] described the value object category for the surgery case using the e3-value model. Kinderen and others [16] proposed a mapping between e3-value model and ArchiMate [17-19] using the DEMO process model. ArchiMate is the standardized language to model Enterprise Architecture based on TOGAF [20]. TOGAF is the most popular EA framework [21]. As ArchiMate has rich features to represent EA, there are many researches to design business models and business values. DEMO [22] stands for Design and Engineering Methodology for Organizations. Singh and others [23] also proposed a value creation modeling approach by integrating the e3-value model and ArchiMate.

ARM had been proposed to resolve problems to create i* goal models [24,25]. However, the business modeling approach using ARM has not been discussed. Moreover, interrelationship between ARM and Enterprise Architecture (EA) models was not clear.

EA has been used to model healthcare services. For example, Sharaf., *et al.* [26] discussed EA in the mobile healthcare cloud service domain. Ahsan., *et al.* [27] proposed a visual approach using ArchiMate to describe healthcare activities. Meertens., *et al.* [28] proposed a mapping between ArchiMate and BMC by using business ontology. Iacob., *et al.* [29] proposed a mutual transformation method between EA and business model. Caetano., *et al.* [30] proposed an enterprise modeling method to integrate ArchiMate and BMC by using a semantic model. Yamamoto [31] proposed a design method to derive business values in ArchiMate based on actor relationships.

Yamamoto., *et al.* [32] proposed a method to visualize Jobs Theory [33] based on ArchiMate. They proposed the MBJT by integrating the Jobs Theory and the goal oriented requirements model by using ArchiMate. Moreover, a case study for applying MBJT to an e-Healthcare use case was described. The meta-model of MBJT has also been proposed.

Yamamoto., *et al.* [34] proposed a business modeling method for e-Healthcare based on ASOMG analysis. ASOMG stands for Actor, Service, Object, Means and Goal. Although the approach identify services, objects, means and goals for actors, the interdependency among actors has not been considered.

The CVCA (Customer Value Chain Analysis) was proposed by Ishii to analyze customer value chain [35]. Although CVCA describes actors and value exchange flows among actors, it can't represent goals of actors.

We propose the e-Health business model review method using ARM by analyzing interrelationships among stakeholders. The contribution of this paper is as follows.: the ARM (Actor Relationship Analysis) is explained to review the e-Health business models; the meta-model of ARM is defined, the mapping from ARM to ArchiMate is defined to visualize ARM and also the ArchiMate pattern for ARM is also proposed.

The two case studies are showing to clarify the effectiveness of ARM for reviewing e-Health business models.

Overview of ARM

ARM was originally proposed as the method to identify the interactions of stakeholder's requirements in the form of the matrix. ARM can potentially be useful as an analytical precursor to the goal oriented requirements modelling, it also can help ensure completeness of requirements.

The ARM is the two dimensional matrix that defines the interrelationship between actors. The matrix elements are used for representing requirements and goals.

Next, we define the ARM as follows. For actors Ak, where k = 1 through N, the two dimensional matrix M is defined as follows.

M [Ai, Aj] shows elements that actor Ai expects for actor Aj.

M [Ai, Ai] shows elements that actor Ai expects and provides by themselves.

Where i and j are 1 through N.

Figure 1 shows the meta-model of ARM. The relationship corresponds to non-diagonal elements. Actors also correspond to the self-elements. The element can represent business goal, device, data, action and value. These are important elements to innovate e-Health business models and extracted from existing e-Health case studies [3]. These elements are also the constituents of our previous ASOMG meta-model [34].

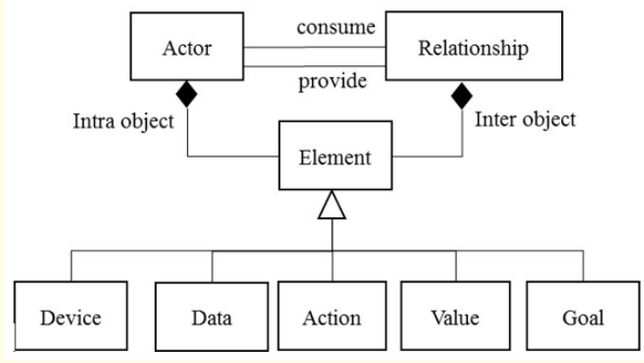

Figure 1: Meta-model of ARM.

Table 1 shows an example of typical ARM for the consumer and service provider. Consumer and service provider are actors.

	Consumer	Service Provider
Consumer	Consumer's Goal	Service, Information
Service Provider	Payment, Value	Provider's Goal

Table 1: Example of ARM.

ARM [Consumer, Consumer] = {Consumer's goal}.

ARM [Consumer, Service provider] = {Service, Information}.

ARM [Service provider, Consumer] = {Payment, Value}.

ARM [Service provider, Service provider] = {Provider's goal}.

The key elements of business models for the meta model are Actors, Data, Actions, Values and Goals. These ARM elements are mapped to the ArchiMate elements as shown in table 2.

ARM elements	ArchiMate elements
Actor	Business Actor
Data	Business Object
Action	Business Service/ Process
Value	Business value
Goal	Business Goal

Table 2: ARM elements and the corresponding ArchiMate elements.

Figure 2 shows the ArciMate pattern for the ARM described in Table 1. The picture was described by using Archi [36]. In Figure 2, goals are realized by two actors, respectively. The payment process is assigned to the customer. The value is attached to the payment process with a general relationship. The payment process is related to service providers using the serving relation. The service provider is assigned to the business service. The business service is related to the customer by using the serving relation. The business service is related to the business object by using the access relation. The customer also uses the business object with the access relation.

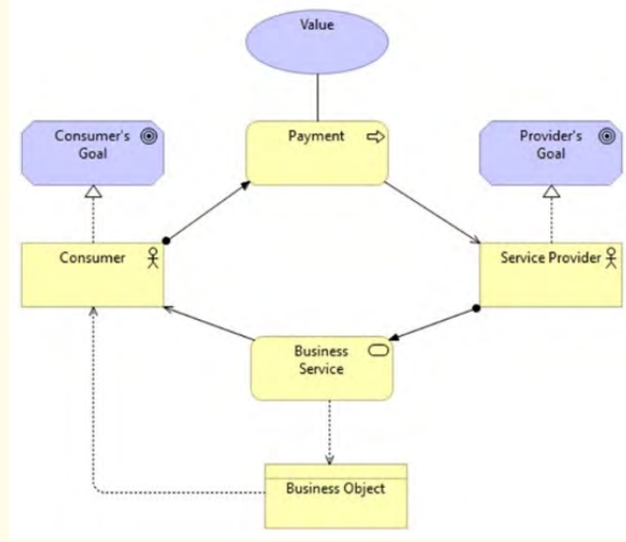

Figure 2: ArchiMate pattern of ARM.

Results

In this study, two use cases for PACS (Picture Archiving and Communication System) and THGS (Tele-Health Guidance Service) are evaluated to review the corresponding business models by applying the ARM. PACS is the shared medical Imaging solution to host medical images taken by hospitals in a centralized and secured data center. THGS is the tele-communication service that connects elderly at local area to specialists at urban area to provide advice using TV phone and health sensors and instruments. In the course of the study, we verify the applicability of ARM for reviewing these e-Health business models. We first develop the ARM for the e-Health business model, then analyze the completeness of the ARM.

Picture Archiving and Communication System

Overview

PACS provides Shared Medical Imaging service deployed to host Medical images such as X ray taken by hospitals in a centralized and secured data center. Actors of PACS are patient, X ray practitioner, telecom service provider, image diagnosis specialist, image retrieval experts and platform service provider. Services are X ray image capture, Consultation using X ray images, Image transmission, and X ray image retrieves. Objects are X ray images. Means are X ray camera, communication network, X ray image storage, X ray image retrieve server, and image display. Business goals are low overload, security, efficiency, interoperability, rapid response and reliability.

ARM for reviewing PACS business models

Actors of PACS are patient, medical service provider, and THS (Technology for Healthcare Service provider) service provides. The matrix of ARM for PACS is shown in table 3.

	Patient	Medical SP	THS
Patient		Diagnose using X-ray images	
Medical SP	Photograph X-rays image	Realize open use of medical image information Medical image diagnosis process -Diagnose X-ray image	Convenient use of medical image technology -Store X-ray image -Retrieve X-ray image
THS		Use MIRCS Service fee	Medical image remote collaboration service (MIRCS)

Table 3: ARM for PACS.

The diagonal elements of ARM for PACS show the intra elements for the corresponding actors. The non-diagonal elements of ARM show the inter elements between actors.

The intra element for ARM [THS, THS] is the Medical image remote collaboration service. The inter element for ARM [Medical SP, THS] is the Convenient use of medical imaging technology.

As shown in Table 2, there are three empty elements of the ARM. The empty elements are ARM [Patient, Patient], ARM [Patient, THS] and ARM [THS, Patient]. These empty elements showed the omission of the business model for PACS.

All the empty elements relate to the patient actor. This shows that the business model for PACS lacks the concerns of the patient who is the most important actor for e-Healthcare services.

Tele-health guidance service

Overview

The Tele-Health Guidance Service (THGS) connects elderly at regional area to specialists at urban area to provide personal healthcare advices using TV phone and health sensors and instruments. Actors of THGS are patient, healthcare organization, telecom operator, and sensor device provider. Services are sensing service, telecommunication, healthcare data hosting, web meeting, and healthcare guidance. The object is the personal healthcare information of patient Means are healthcare sensors, telecom network, TV phone, and Data Base server. Goals are low cost, privacy, reliability, interoperability, availability, and security.

ARM for reviewing THGS business models

Actors for THGS are Patient, Telecom operator, Sensor provider, and Healthcare organization. The matrix of ARM for THGS is shown in Table 4. The diagonal elements of ARM for THGS show the intra elements for the corresponding THGS actors. The non-diagonal elements of ARM show the inter elements between THGS actors.

- The intra element for ARM [Patient, Patient] is low cost, privacy and Healthcare information.
- The intra element for ARM [Telecom operator, Telecom operator] is availability, interoperability, TV communication and Information hosting.
- The intra element for ARM [Sensor provider, Sensor provider] is reliability and healthcare sensor.
- The intra element for ARM [Healthcare organization, Healthcare organization] is security, healthcare guidance and Personal healthcare information.
- The inter element for ARM [Patient, Telecom operator] is TV phone.
- The inter element for ARM [Patient, Sensor provider] is Healthcare information sensing.
- The inter element for ARM [Patient, Healthcare organization] is Healthcare guidance.
- The inter element for ARM [Telecom operator, Patient] is empty.
- The inter element for ARM [Telecom operator, Sensor provider] is Healthcare information hosting.
- The inter element for ARM [Telecom operator, Healthcare organization] is empty.
- The inter element for ARM [Sensor provider, Patient] is empty.
- The inter element for ARM [Sensor provider, Telecom operator] is DB server.
- The inter element for ARM [Sensor provider, Healthcare organization] is empty.

- The inter element for ARM [Healthcare organization, Patient] is personal healthcare information.
- The inter element for ARM [Healthcare organization, Telecom operator] is Video meeting.
- The inter element for ARM [Healthcare organization, Sensor provider] is sensing service.

As shown in table 4, there are four empty elements of the ARM. The empty elements are ARM [Telecom operator, Patient], ARM [Telecom operator, Healthcare organization], ARM [Sensor provider, Patient] and ARM [Sensor provider, Healthcare organization]. These empty elements showed the omission of the business model for THGS.

	Patient	Telecom operator	Sensor provider	Healthcare organization
Patient	Low cost, privacy Healthcare information	TV phone	Healthcare information sensing	Healthcare guidance
Telecom operator		Availability Interoperability TV communication Information hosting	Healthcare information hosting	
Sensor provider		DB Server	Reliability Healthcare sensor	
Healthcare organization	Personal healthcare information	Video meeting	Sensing service	Security, Healthcare guidance, Personal healthcare information

Table 4: ARM for THGS.

These empty elements are related to Telecom operator and Sensor provider. This shows that the business model for THGS requires the concerns on the intermediary service actors for the e-Healthcare services.

In this section, we have applied the ARM to review the e-Health business models for PACS and THGS. The result showed that ARM can detect omissions of the PACS and THGS business models by developing the ARM and then executing exhaustive analysis on the ARM elements. For the PACS case, we found the three business model omissions by using ARM. In the same way, we found the four business model omissions for the THGS by using ARM.

Discussion

ARM can be applied to analyze and identify the omissions on e-Health Business Models. As elements of ARM can be used to represent those of BMC, BMC can also be mapped to ARM. Therefore ARM is able to use for reviewing BMC. Moreover, ARM can also be used to define the semantics of e-Health business models described by several diagrams such as i* framework, e3-value model, CVCA and ArchiMate. For example, it will be able to design ArchiMate diagram based on ARM. Future work includes the ArchiMate diagram design approach based on the ARM matrix definition.

In this way, different business modelling approaches can uniformly be reviewed by using ARM. Future work includes to describe the ARM mapping approaches to the e3-value model, CVCA and BMC.

As ASOMG table [34] contains the set of rows for < actor, service, object, means, goal>, the proposed analysis approach seamlessly can be integrated into an ASOMG table by classifying service types of the rows into “provider” and “consumer”. If the service type of the row is “consumer”, the actor in the row consumes the service provided by another actor. If the service type of the row is “provider”, the actor in the row provides the service. Therefore, the diagonal elements of ARM include the “provider” services. On the other hand, non-diagonal elements of ARM include “consumer” services.

Although the proposed ARM approach is applied to the e-Health business models, the elements of the meta-model and the pattern of ARM approach are not depended on the e-Health domain. We expect our proposed approach can be applied to other domains and create new business innovations.

This paper only showed the applicability of the proposed review approach qualitatively. Future work includes to quantitatively show the effectiveness of the approach.

Summary

The main contributions of this paper are as follows.

The five key business model elements ASOMG of e-Health services have been extracted by analyzing existing e-Health business models. The elements of the ARM meta-model are not depended on the e-Health domain. Actor, Service and Object are corresponded to the Subject, Verve, and Object. SVO is the basic elements of natural

language statements. Means and goals are also generic. This consideration derives the generality of the ARM structure.

The meta-model of e-Health service has been developed based on ARM.

The ArchiMate pattern of e-Health service has also been developed by mapping ARM elements to the corresponding ArchiMate elements.

The e-Health Business Modeling Review Method has been proposed based on ARM.

The applicability of the proposed e-Health Business Modeling Review Method has been evaluated by the case study on e-Health services developed by ASOMG approach.

Although the e-Health Business Modeling Review Method was created using ARM meta-model derived from e-Health domain, the resulted method is not depended on the e-Health domains. Therefore, the proposed review method is expected to apply various business domains including e-Business, e-learning, and e-Government.

Conclusion

We have shown the e-Health business model review approach can be developed based on the analysis of actor relationship. Then we applied the approach to the two e-Health business models designed by using ASOMG approach. The case study on e-Health business cases showed the applicability and effectiveness of the proposed business model review approach. Future study includes applications of the proposed method not only for e-Health, but also for e-Business, e-Learning, and e-Government.

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