ACTA SCIENTIFIC MEDICAL SCIENCES

Volume 2 Issue 7 October 2018

Research Article

Using ArchiMate to Design e-Health Business Models

Shuichiro Yamamoto*, Nada Ibrahem Olayan and Shuji Morisaki

Graduate School of Informatics, Nagoya University, Japan

***Corresponding Author:** Shuichiro Yamamoto, Graduate School of Informatics, Nagoya University, Japan.

Received: August 06, 2018; **Published:** September 10, 2018

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 design business model to the success of e-Health services. Enterprise Architecture (EA) is also necessary to realize the business transformation using ICT. We are trying to propose the e-Health business model development method using ArchiMate to create e-Health services. ArchiMate is the EA modelling language to represent business, application and technology architecture.

Method: Five key elements of e-health business models were extracted from existing e-health business models. The e-health business model key elements are Actor, Service, Object, Means, and Goal. We call the five key elements as ASOMG. These elements are shown to be mapped to Enterprise Architecture model elements. By using the mapping, e-health business model is able to develop in ArchiMate which is a language to describe Enterprise Architecture.

Results: The approach is applied to describe two existing e-health business models. Both business models have been described by the proposed approach using ArchiMate, an EA modeling language. The result showed applicability of the method to create e-Health business model.

Conclusion: The proposed approach is effective to create e-Health business models by clarifying ASOMG elements.

Keywords: Enterprise Architecture Model; ArchiMate; e-Health; Business Model; Case Study

Abbreviations

ICT: Information Communication Technology; EA: Enterprise Architecture; ASOMG: Actor Service Object Means Goal; SW: Software; URN: User Requirements Notation; 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; KSF: Key Success Factor; THGS: Tele-Health Guidance Service

Introduction

e-Health is expected to realize the wellness of personal healthcare using Information communication technology (ICT) for healthcare services [1]. It is necessary to design business model to the success of e-Health services. Schiltz and others proposed use cases for the business models of e-Health service [2]. For example, there was a use case of cloud based image archive service named PACS (Picture Archiving and Communication System) utilizing Radiology Information System (RIS).

Business Model Canvas (BMC) had been used to describe e-Health business models [3]. The business process modeling approaches are also proposed [4,5]. Basyman *et al.* [6] proposed an Activity-based Process Integration approach that incrementally integrates activities of a new process to current processes. They use i* [7] and URN (User Requirements Notation) [8] to describe goal models and business process integration for the emergency process in the hospital. Goal oriented approaches [9] are applied to analyze healthcare processes [10,11].

Enterprise Architecture (EA) [12,17] is also necessary to realize the business transformation using ICT. EA has been used to model healthcare services. For example, Sharaf., *et al.* [13] discussed EA for the mobile healthcare cloud service. Ahsan., *et al.* [14] proposed a visual approach using ArchiMate to describe healthcare activities. ArchiMate [15-18] is a language to model EA. As ArchiMate has rich features to represent EA, there are many researches to design business models and business values. Meertens., *et al.* [19] proposed a mapping between ArchiMate and BMC by using business ontology. Iacob., *et al.* [20] proposed a mutual transformation method between EA and business model. Caetano., et al. [21] proposed an enterprise modeling method to integrate ArchiMate and BMC by using a semantic model. Yamamoto [22] proposed a design method to derive business values in ArchiMate based on actor relationships.

Yamamoto [23] surveyed approaches to visualize EA models. Yamamoto and others [24] proposed a method to visualize Jobs Theory [25] based on ArchiMate. The paper 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.

Muller., *et al.* [26] proposed to use BPMN for describing Healthcare processes. Although BPMN can be used to describe business processes, it is impossible to describe an application and technology components in BPMN. It is also impossible to describe interrelationships among business processes, application components and technology devices. Therefore, BPMN is not appropriate for representing business models including application and technology elements.

Although Silva., *et al*. [27] proposed automatic evolution operations for EA models and meta-models, these operations did not focus on business model evolution of the healthcare domain.

Bork., *et al.* [28] identified meta-model specification techniques and compared the expressive power of the techniques. As the paper focused on meta-model specification techniques they did not mention business model development processes. Santana., *et al.* [29] proposed a method to derive EA view point models from existing models at organizations. Smith., *et al.* [30] extracted functional requirements themes from Dutch government agencies to construct BRM (Business Rule Management). BRM focuses to transform legal requirements into business decisions.

There are many approaches to represent healthcare business processes as follows.

Mertens., *et al.* [31] proposed a recommendation-based robust business process engine to realize flexible healthcare processes. Behnam., *et al.* [32] proposed a Care Process Metamodel (CPM) to describe healthcare processes and to implement business intelligence care process monitoring solutions. The CPM did not include healthcare devices and application services. Dogac., *et al.* [33] proposed a business process specification language to support collaborative eHealth processes. Vilasdechanon., *et al.* [34] used the function modelling method (IDEF0) to present saline management processes. Brown., *et al.* [4] introduced a Healthcare Business Process Reference Model to standardize business process roles and interactions between them. They also showed the Healthcare reference model concepts. Antonacci., *et al.* [35] have introduced a model-driven method to enact the simulation-based analysis of healthcare processes. Blijleven., *et al*. [36] proposed the process deliverable diagram consists of activity and class diagrams to represent healthcare processes. Braun., *et al.* [5] extended BPMN based on clinical pathways to model hospital resources, activities and data objects.

However, these business process oriented approaches did not model business goals and technological devices. Grand [37] surveyed business model representations of the healthcare domain. He emphasized the importance to differentiate the business model concept from business processes. The business model consists of business goals that are realized by business processes. However, he did not mention the technology elements could be constituents of business models.

Fattah., *et al*. [38] proposed a Conceptual Strategic Alignment Model for Organizational and Culture Adopter. However, the approach did not include business process models nor business goals. Although An *et al.* [10] showed the goal oriented approach is effective to elicit requirements for a healthcare system, they did not mention the business modeling using goal oriented approaches. Baslyman., *et al*. [39] proposed using goals to represent indicators for the activity based process integration. They used goal models to quantitatively evaluate the performance of the healthcare process integration. They did not consider to design business models using goals but evaluate business processes.

Carroll., *et al.* [40] introduced Design Thinking to align healthcare innovation and software requirements. Although they showed the connected health innovation framework based on Design Thinking process, the details of business models and processes were not clear.

Although business process modeling has been used in the e-Health domain so far, the key elements of business models are not clear. Moreover, a business model design method based on the key business elements has not been proposed. We are trying to propose the e-Health business model development method using EA modeling language ArchiMate to create e-Health services by extracting key e-Health business model elements.

Methodology

Method to Design E-Health Business Models

Elicitation of key business model elements

The key elements of e-health business models for this paper is collected from use cases in [3]. The key elements are Business Actor, Business Service, Business Object, Business Means and Key Success Factors (KSFs). Patient and service providers are examples of business actors. Sensors, servers, and network are examples of business means.

Figure 1 shows a meta-model of the e-Health business model. KSF is replaced by Business goal for understandability in figure 1. The constituents of business means are technology elements to represent devices, servers, and networks. These are important elements to innovate recent business models, although these are not included traditional business process model notations such as BPMN. BPMN did not include business goals, although BPMN can represent business actors, service processes and objects.

e-Health business elements	ArchiMate elements
Business Actor	Business Actor
Business Service	Business Service
Business Object	Business Object
Business Means	Technology elements (Device, Node, Network)
KSF	Business goal

Table 1: e-Health business elements and the corresponding ArchiMate elements.

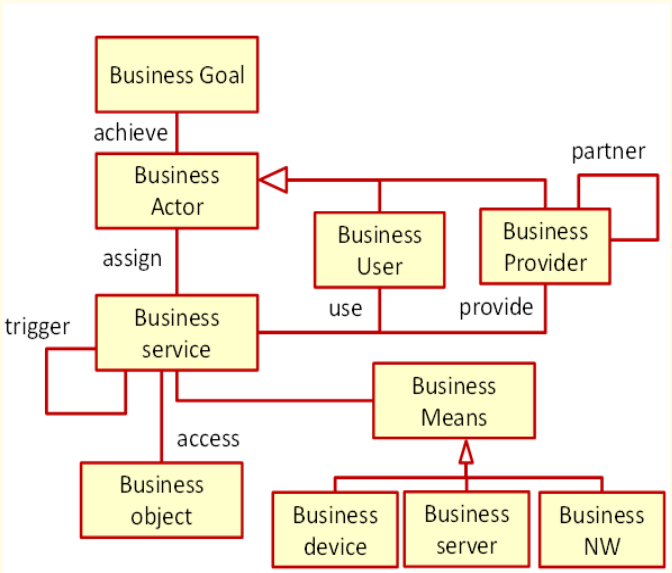

Figure 1: Meta-Model of the e-Health business model

Figure 2 shows a pattern of e-Health service in ArchiMate. The pattern can be instantiated by replacing generic names into specific names to create a business model of concrete e-health services. The goal is achieved by actors. The service provider is assigned to the business service. The business service is used by a patient. Business object is accessed by the business service. Business means realizes the business service. Device, communication network and server are examples of business means.

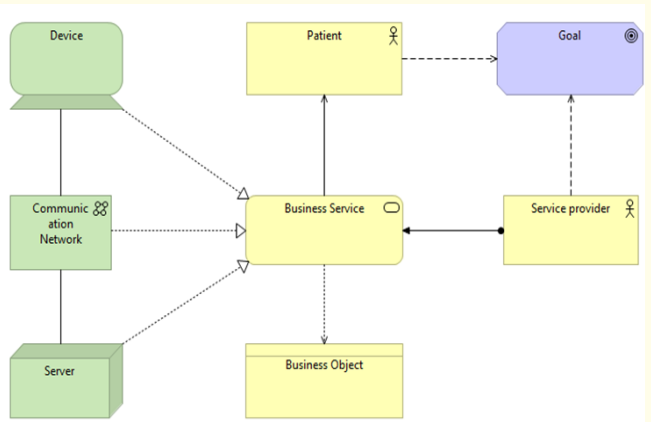

Figure 2: Pattern for e-Health Business Model.

e-health business modeling method

The e-Health business model is developed by the following two steps. At first, ASOMG key elements are analyzed and described in the ASOMG table. Then, ASOMG elements are transformed into ArchiMate elements using the mapping defined in table 1. The overview of the method is shown in figure 3.

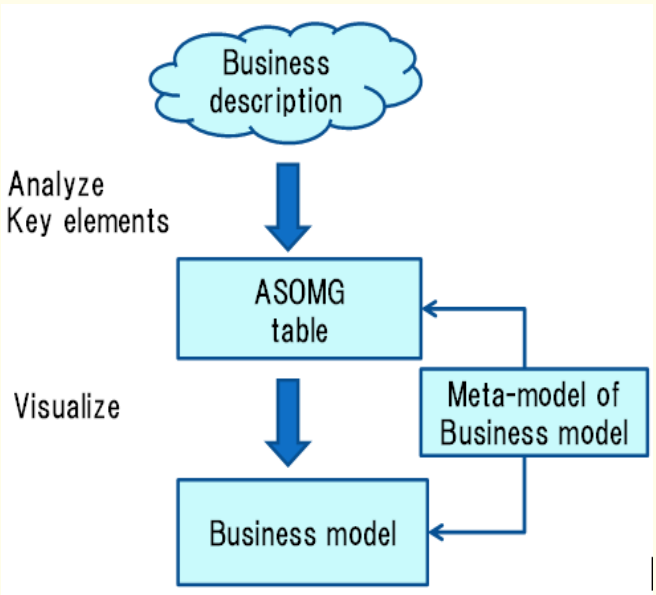

Figure 3: Overview of the e-Health Business Modeling Method.

Result

In this study, two use cases for PACS and THGS are evaluated to derive the corresponding business models by applying the proposed method.

PACS

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.

ASOMG analysis

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, inter-operability, rapid response and reliability.

Business model development

Based on the above ASOMG analysis, the PACS business model can be derived using ArchiMate as shown in figure 4.

Actor	Service	Object	Means	Goal
Patient	X ray image capture	X ray image	X ray camera	Low cost, security
X ray practitioner	X ray image capture	X ray image	X ray camera	efficiency
Platform provider	Platform service	X ray image	DB server Image retrieval server X ray image diagnosis	Quick response Availability
Image retrieval experts	X ray Image retrieval	X ray image	Image retrieval SW	Availability, security
Image diagnosis specialist	X ray Image diagnosis	X ray image	image diagnosis SW	Reliability

Table 2: ASOMG table for PACS.

Tele-Health Guidance Service

Overview

The service connects elderly at local area to specialists at urban area to provide personal healthcare advices using TV phone and health sensors and instruments.

ASOMG analysis

Actors of THGS are patient, healthcare organization, telecom operator, and sensor device provider. Services are sensing service, telecommunication, healthcare data hosting, web meeting, and

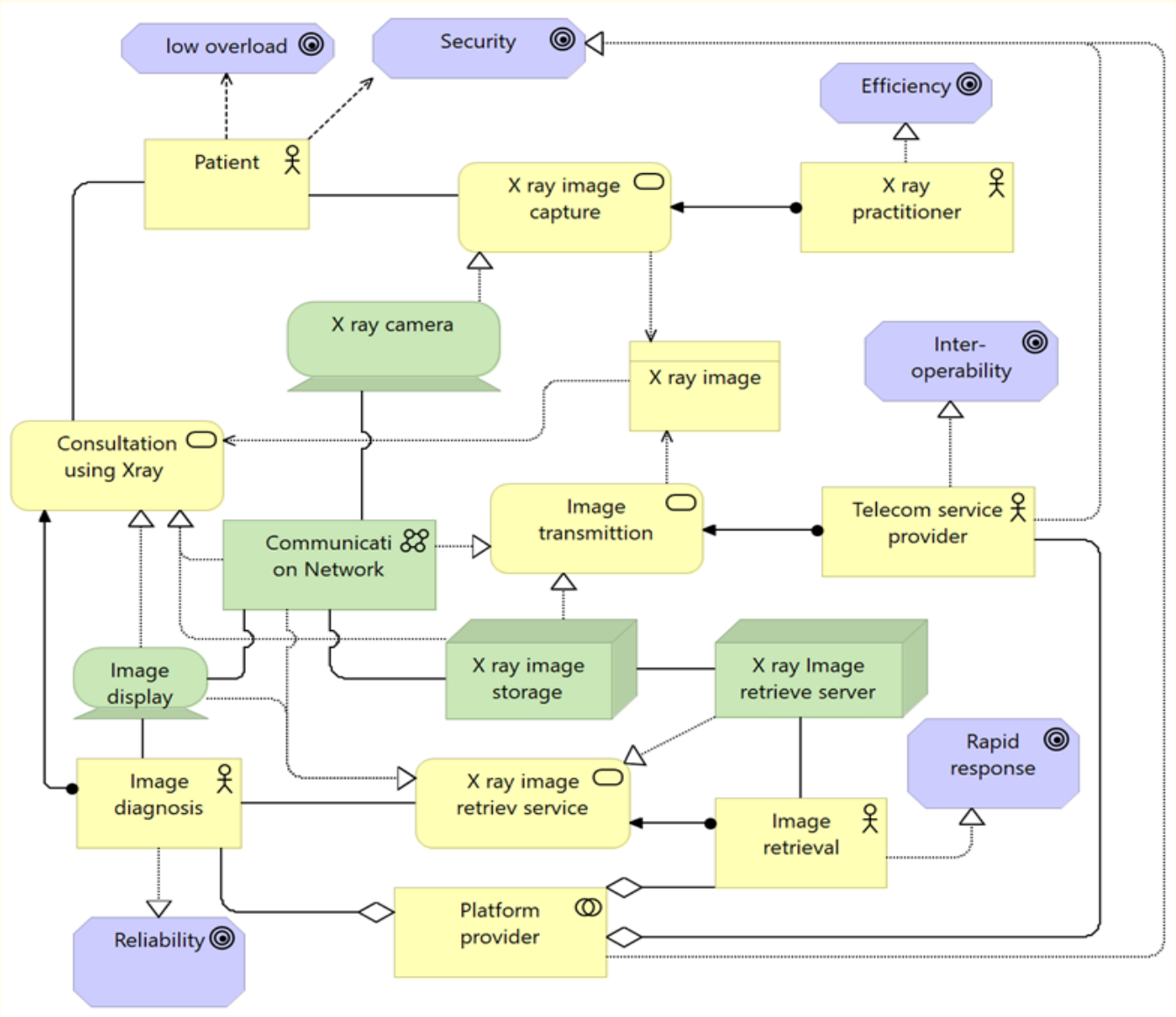

Figure 4: PACS Business Model Using ArchiMate

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, inter-operability, availability, and security.

Business Model Development

Based on the above ASOMG analysis, the THGS business model can be derived using ArchiMate as shown in figure 5.

Actor	Service	Object	Means	Goal
Patient	Healthcare information sensing	Personal healthcare information	Healthcare sensor	Low cost, security
Patient	Healthcare guidance	Personal healthcare information	TV phone	Low cost, inter-operability
Telecom operator	Healthcare information communication	Personal healthcare information	Network	Low cost, inter-operability
Telecom operator	TV communication	Personal healthcare information	TV phone network	Reliability, security
Telecom operator	Healthcare information hosting	Personal healthcare information	Data base server	Availability, security
Sensor provider	Healthcare information sensing	Personal healthcare information	Healthcare sensor	Reliability
Healthcare organization	Healthcare guidance	Personal healthcare information	TV phone	Low cost, inter-operability

Table 3: ASOMG table for THGS.

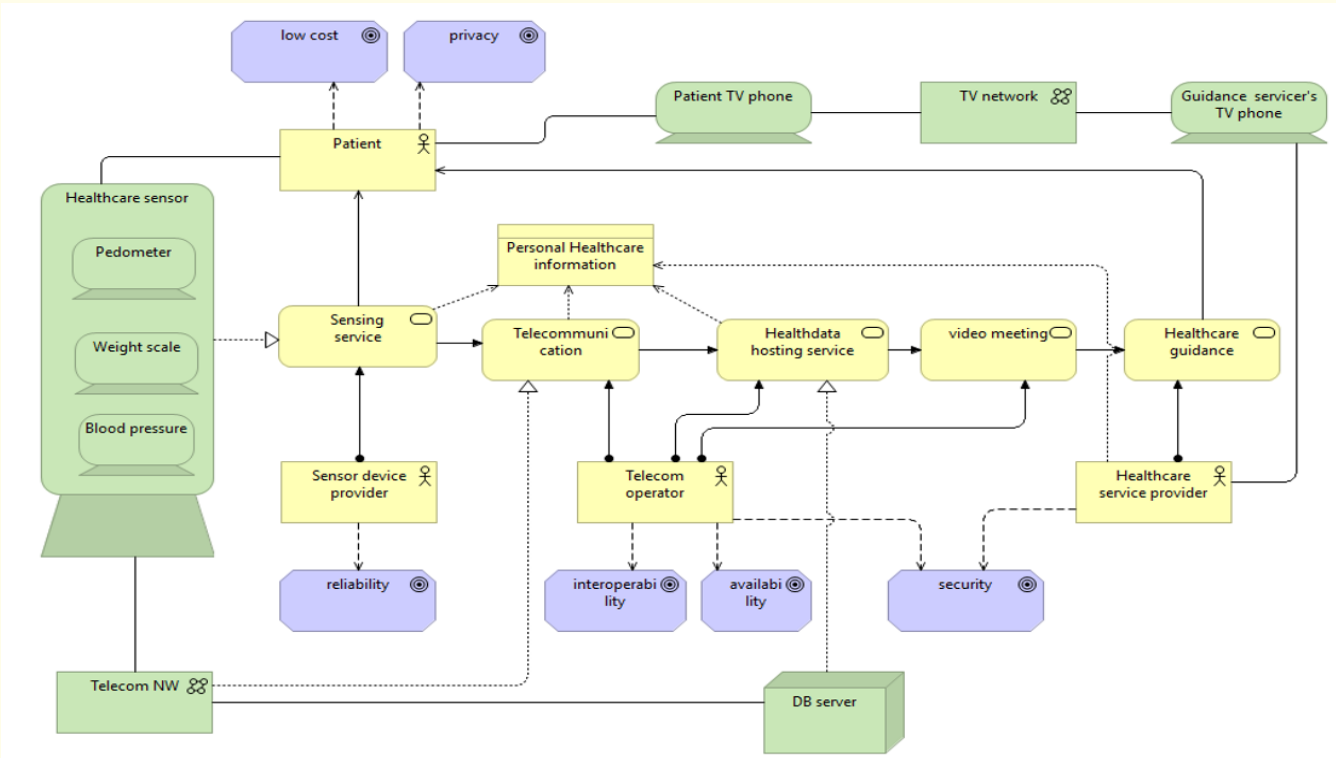

Figure 5: THGS Business Model using ArchiMate.

Discussion

In order to get a smoother evolution of the distance of the beacon to the receptors, we implemented the Kalman filter [24], one of the most widely used methods for tracking and estimation due to its simplicity, optimality, tractability and robustness. This algorithm takes a series of measurement over time containing noises and other inaccuracies and produce a variable that tend to be more accurate than just the raw values. Figure 4 shows values received from beacon signals with and without the Kalman filter, allowing us to conclude we would increase the precision of the system by using it.

BMC only describes partners and customer segments for the value propositions. It is difficult to clarify the goals for each actor in BMC. In contrast, ASOMG table describes goals elements for each actor. Therefore, ASOMG table can clearly elicit relationships between actors and goals.

In general, EA includes business architecture, information system architecture, and technology architecture. The created business models in the proposed method only provide business and technology architecture. This is because the meta model extracted by the existing e-health business cases did not consist of elements of information system architecture. We can extend the e-Health meta model to include information system architecture in the future.

Although the proposed meta-model and business model pattern are extracted from the e-Health business models, the elements of the meta-model and the pattern are not depended on the e-Health domain. For example, the business model pattern can be applied for e-Business, e-Learning and e-Government by replacing the patient in the pattern for customer, student, and citizen. We expect our proposed approach can be applied to these domains and create new businesses innovations.

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 ASOMG are not depended on the e-Health domain. Actor, Service and Object are corresponded to 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 ASOMG structure.

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

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

The e-Health Business Modeling Method has been proposed based on ASOMG, and the ArchiMate pattern using the meta model of e-Health service.

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

Although the e-Health Business Modeling Method was created by existing e-Health business models, the resulted method is not depended on the e-Health domains. Therefore, the proposed method is expected to apply various business domains including e-Business, e-learning and e-Government.

Conclusion

We have shown the key e-Health business elements based on the analysis of the previous business cases of e-health. Then we defined these key elements as ASOMG and proposed the e-Health business model design method using ArchiMate that clearly defines ASOMG elements. The case study on e-Health business cases showed the applicability and effectiveness of the proposed business model design method using ArchiMate. Future study includes applications of the proposed method not only for e-Health, but also for e-Business, e-Learning, and e-Government.

Bibliography

1. "E-Health - making healthcare better for European citizens An action plan for a European e-Health Area". *Commission of the European Communities* 539 (2004).
2. Schiltz A., *et al*. "Business Model Analysis of E Health Use Cases in Europe and in Japan". *Journal of the International Society for Telemedicine and eHealth* 1.1 (2013): 30-43.
3. Alexander Osterwalder and Yves Pigneur. "Business Model Generation". *Wiley* (2010).
4. Brown P., *et al*. "Toward a Healthcare Business-Process Reference Model". *IT Pro* 13.3 (2011): 38-47.
5. Braun R., *et al*. "Clinical Process from Various Angles - Amplifying BPMN for Integrated Hospital management". *International Conference on Bioinformatics and Biomedicine* (2015): 837-845.
6. Baslyman M., *et al*. "Using Goals and Indicators for Activity-based Process Integration in Healthcare". 7th International Conference on Current and Future Trends of Information and Communication Technologies in Healthcare, *Procedia Computer Science* 113 (2017): 318-325.
7. Yu E. "Towards Modelling and Reasoning Support for Early Phase Requirements Engineering". 3rd IEEE International Symposium on Requirements Engineering (1997): 226-235.

8. ITU-T. Recommendation Z.151 (10/12) User Requirements Notation (URN) - (2012).

9. Yamamoto S., *et al*. "Goal Oriented Requirements Engineering: trends and issues". *IEICE* E-89D.11 (2006): 2701-2711.

10. An Y., *et al*. "Collaborative social modeling for designing a patient wellness tracking system in a nurse-managed health care center". Proceeding of the 4th International Conference on Design Science Research in Information Systems and Technology (2009).

11. Hagglund M., *et al*. "A New Approach for Goal-oriented Analysis of Healthcare Processes". *Studies in Health Technology and Informatics* 160 (2010): 1251-1255.

12. Yamamoto S., *et al*. "Another Look at Enterprise Architecture Framework". *Journal of Business Theory and Practice* 6.2 (2018): 172-183.

13. Sharaf A., *et al*. "Enterprise Architecture of Mobile Healthcare for large Crowd Events". International Conference on Information and Communication Technology and Accessibility (2017): 1-6.

14. Ahsan K., *et al*. "Healthcare Modelling Through Enterprise Architecture A Hospital Case". Seventh International Conference on Information Technology (2010): 460-465.

15. Van Haren. "ArchiMate 3.0 Specification" *The Open Group* (2016).

16. Wierda G. "Mastering ArchiMate - A Serious Introduction to the ArchiMate Enterprise Architecture Modeling Language". Edition II the Netherlands Published by R and a (2014)

17. Lankhorst M. *et al*. "Enterprise Architecture at Work -- Modeling Communication and Analysis". Third Edition, *Springer* (2013).

18. Archi.

19. Meertens L., *et al*. "Mapping the Business Model Canvas to ArchiMate". *SAC* 12 (2012): 1694-1701.

20. Iacob M., *et al*. "From enterprise architecture to business models and back". *Software and Systems Modeling* 13.3 (2014): 1059-1083.

21. Caetano A., *et al*. "Analysis of Federated Business Models-- An Application to the Business Model Canvas, ArchiMate, and e3value". IEEE 17th Conference on Business Informatics (2015): 1-8.

22. Yamamoto S. "Actor Collaboration Matrix for Modeling Business Values in ArchiMate". Asia Pacific Conference on Information Management 2016 Vietnam National University Press (2016): 369-378.

23. Yamamoto S. "A Survey on Visualizing EA models toward Consolidation". IIAI-AAI 2018, EAIS (2018): 775-780.

24. Yamamoto S., *et al.* "e-Healthcare Service Design using Model Based Jobs Theory". *Procedia Computer Science* (2018): 198-207.

25. Christensen C., *et al*. "Competing Against Luck". *HarperCollins Publishers* (2016).

26. Muller R and Rogge-Solti A. "BPMN for Healthcare Processes". *ZEUS* (2011).

27. Silva N., *et al*. "CO-EVOC An Enterprise Architecture Model Co-Evolution Operations Catalog". AMCIS (2018).

28. Bork D., *et al*. "How are Metamodels Specified in Practice? Empirical Insights and Recommendations". AMCIS (2018).

29. Santana A., *et al*. "Deriving Viewpoints for Enterprise Architecture Analysis". AMCIS (2018).

30. Smit K., *et al*. "Functional Requirements for Business Rules Management Systems". AMCIS (2017).

31. Mertens M., *et al*. "Supporting and assisting the execution of flexible healthcare processes". 9th International Conference on Pervasive Computing Technologies for Healthcare (2015): 329-332.

32. Behnam S and Badreddin O. "Toward a care process metamodel for business intelligence healthcare monitoring solutions". 5th International Workshop on Software Engineering in Health Care (2013): 79-85.

33. Dogac A., *et al*. "Collaborative Business Process Support in eHealth Integrating IHE Profiles Through ebXML Business Process Specification Language". IEEE Transactions on Information Technology in Biomedicine 12.6 (2008): 754-762.

34. Vilasdechanon S and Sopadang A. "Business process reengineering for the saline management in hospitals". 5th International Conference on Industrial Engineering and Applications (2018): 84-88.

35. Antonacci G., *et al*. "A BPMN-Based Automated Approach for the Analysis of Healthcare Processes". IEEE 25th International Conference on Enabling Technologies Infrastructure for Collaborative Enterprises (2016): 124-129.

36. Blijleven V., *et al*. "A meta-modeling technique for analyzing, designing and adapting healthcare processes A process-deliverable perspective". IEEE-EMBS International Conference on Biomedical and Health Informatics (2016): 316-319.

37. Grand K. "Investigating on Requirements for Business Model Representations the Case of Information Technology in Healthcare". IEEE 19th Conference on Business Informatics (2017): 471-480.

38. Fattah F and Arman A. "Business-IT Alignment Strategic Alignment Model for healthcare (case study in hospital bandung area)". International Conference on ICT For Smart Society (2014): 256-259.

39. Baslyman M and Amyot D. "A Distance-Based GRL Approach to Goal Model Refinement and Alternative Selection". IEEE 25th International Requirements Engineering Conference Workshops (2017): 16-20.

40. Carroll N and Richardson I. "Aligning Healthcare Innovation and Software Requirements through Design Thinking" IEEE/ACM International Workshop on Software Engineering in Healthcare Systems (2016): 1-7.

Volume 2 Issue 7 October 2018