ACTA SCIENTIFIC MEDICAL SCIENCES (ISSN: 2582-0931)

Volume 4 Issue 9 September 2020

Research Article

An Approach to Visualize Digital Transformation in Healthcare

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Received: July 24, 2020

Published: August 18, 2020

Abstract

Background: The healthcare industry is faced to the digital transformation (DX) to realize the digital healthcare enterprises using digital technology for healthcare services. Japanese Ministry of Economy, Trade and Industry published the DX promotion index (DXPI) to assess the DX maturity of Japanese companies. Although the DXPI provides the requirements of DX, it lacks design approaches on business values, models and processes to digitalize healthcare services. We are trying to propose ArchiMate based diagrams on the business value, model and process to create healthcare services to meet the DXPI. ArchiMate is the EA modelling language to represent business, application and technology architecture.

Method: Three key business diagrams are extracted from DXPI. The business diagrams are business value, business model, and business process diagrams. We define the three corresponding tables for business diagrams. These table elements are shown to be mapped to ArchiMate model elements. By using the mapping, three business diagrams are able to develop in ArchiMate.

Results: The approach is applied to visualize a digital transformation in healthcare service in a large hospital. The visual diagrams have been described by the proposed approach using ArchiMate, an EA modeling language. The result showed the applicability of the method to visualize healthcare digital transformation.

Conclusion: The proposed approach is effective to visualize the digital transformation in the healthcare industry by clarifying business values, models and processes.

Keywords: Digital Transformation; Enterprise Architecture Model; ArchiMate; Healthcare; Case Study

Abbreviations

DX: Digital Transformation; EA: Enterprise Architecture; PI: Promotion Index; METI: Ministry of Economy, Trade, Industry; EAAS: Enterprise Architecture As Strategy; TOGAF: The Open Group Architecture Framework; DBSC: Digital Balanced Score Card; MBJT: Model Based Jobs Theory

Introduction

In order to promote the digital transformation of Japanese companies, the Ministry of Economy, Trade and Industry (METI) has published a DX promotion index (DXPI) that "visualizes" the digital transformation (DX). The author participated as a member of the "Study Group for Digital Transformation (DX)" by the METI.

The DXPI allows Japanese companies to self-diagnose DX maturity. The DXPI defines 35 questions to evaluate the maturity levels of DX for companies. For example, the DXPI "presentation of management strategy/vision" asks the following questions:

- What kind of value should be created by utilizing digital technology with innovation in mind?
- What kind of business model and business process should be constructed for that purpose?

For DX, a vision needs to be presented and, it is also necessary to define the business model and business process.

However, as the above DXPI shows it only defines the requirements that the DX should satisfy, and there is the problem that the DX design method is not clear.

DX is a means to realize digital enterprises. Therefore, diagrams for DX shall have the ability to express business goals and values and the ability to express business models and processes of digital enterprises.

Urbach and Röglinger [2] have summarized examples of DX efforts in Germany. They pointed out that the concept of enterprise architecture can be used to classify digital business and digital transformation (DX). According to them, digital transformation is to realize new digital business with digital technology. However, the visualization method of DX is not mentioned in [2]. For example, the book includes a case of digital transformation of hospitals [3], but it did not mention the visualization method of the hospital DX case.

Rogers [4] has proposed the Platform Business model map and Competitive Value train diagram as diagrams for DX. However, it does not mention the business process diagram for DX.

Ross., *et al*. [5] proposed a digital business design method for DX based on the concept of the Enterprise Architecture As Strategy (EAAS) [6], but did not show a visualization method for DX.

Skilton [7] proposed an Application Platform diagram using ArchiMate [9] based on the Integrated Information Infrastructure Reference Model of TOGAF [8]. However, it does not mention the business models nor value analysis diagrams. TOGAF 9.2 explains that EA can support the digital transformation, although the details is not clearly described.

Yamamoto [10] proposed a balanced scorecard DBSC (Digital Balanced Score Card) for DX. In DBSC, the four viewpoints of the Balanced Scorecard can be visualized as corporate profit, customer experience, digital business ecosystem, digital transformation demand, and DX evaluation index can be derived. Yamamoto., *et al*. have been conducting the following research on the Healthcare service domain using ArchiMate.

Yamamoto., *et al*. [11] proposed an e-Health business model review method using ARM (Actor Relationship Matrix) by analyzing the mutual relationships between stakeholders. Yamamoto., *et al*. [12] also proposed a business modeling method for e-Healthcare based on ASOMG analysis. ASOMG is an abbreviation for Actor, Service, Object, Means, and Goal. This approach can define actor services, objects, means, and goals, but does not consider the interdependencies between actors.

Moreover, Yamamoto proposed a method to visualize the job theory (Jobs Theory) proposed by Christensen., *et al*. [13] using ArchiMate [14]. This MBJT (Model Based Jobs Theory) method uses ArchiMate. In addition, a case study of applying MBJT to e-healthcare use cases is also described [15].

However, above these studies did not consider the relationship with DX.

Focusing on the ability to classify questions about business models, the author proposed a unified method for comparing various business models by organizing 15 elements common to business model notation into five question sentences [16]. The paper reveals that ArchiMate has the highest expressive power of business models. Therefore, in this paper, we propose a DX visualization method using ArchiMate.

Methodology

Method to visualize DX diagrams

The method to visualize DX diagrams consists of the DX diagram drawing procedure and the mapping between diagram items and ArchiMate elements. The first subsection explains the DX diagram drawing procedure. The second subsection explains the mapping.

Procedure to draw DX diagrams

As mentioned above, in order to promote DX, it is necessary to illustrate what should be built by utilizing digital technology in according to the following three points: a) What kind of value is created, b) What kind of business model is defined, c) What kind of business process is operated.

Therefore, we propose the Value analysis diagram, Business model diagram, Business process diagram that represents (1) value analysis, (2) business model, and (3) business process, respectively. Figure 1 shows the procedure for creating DX diagrams consist

Figure 1: DX diagram development procedure.

of a value analysis diagram, business model diagram, and business process diagram. In order to create a diagram, it is important to extract the elements described in the diagram by using the corresponding tables. The reason for this is that if we decide what to draw in the diagram in advance, we can develop the diagram more efficient.

First, the value analysis table is developed, then the business model table and the business process tables are developed. The elements of the value analysis table are "Provider", "Business value", "Customer", "Problematic situation", "Acquisition", "Cause", "Business process", and "Service". The elements of the business model table are "Service provider", "Key partner", "Resource", "Cost structure", "Chanel", "Profit structure", "Value proposition", "Target segment", "Customer relationship", and "Business process". The elements of the business process table are "Process executor", "Business process", "Resource", and "Process goal".

When these tables are clarified, the corresponding diagrams are developed. In the course of drawing diagrams, if the change is necessary, then the value analysis table might be revised. In this way, the DX diagrams are also revised iteratively.

Mapping of key items to ArchiMate

Table 1-3 shows the value analysis, business model, and business process tables, respectively. Each table represents a mapping from table elements to ArchiMate elements.

Value items	ArchiMate elements
Service Provider	Business actor
Business value	Value
Customer	Business actor
Problematic situation	Driver
Acquisition	Business process
Cause	Assessment
Business process	Business process
Service	Business service

Table 1: Value analysis table.

Business model items	ArchiMate elements
Service Provider	Business actor
Key partner	Business actor
Resource	Resource, equipment, material
Cost structure	Outcome
Channel	Location
Profit structure	Outcome
Value proposition	Goal
Target segment	Business actor
Customer relationship	Business service

Table 2: Business model table.

Business process items	ArchiMate elements
Process executor	Business actor, application component
Business process	Business process
Resource	Resource, Material, Equipment
Process goal	Goal

Table 3: Business process table.

Results

In this study, the use case for the Aarhus Danish Hospital [3] is evaluated to derive the corresponding DX diagrams by applying the proposed method.

Overview

The Aarhus Danish Hospital (abbreviated as ADH below) is promoting a digital transformation plan for business processes by introducing a resource tracking service. The AHD is a huge super

hospital with an area of 10,000 square meters and 10,000 employees. For this reason, the efficiency of logistics operations in hospitals is required. The purpose of the resource tracking service is to optimize the logistics operation of the hospital by making it possible to immediately use the resources such as beds, meals, and testing equipment that hospital staff need, and where they are needed.

Table analysis

The value analysis table of the hospital is shown in Table 4. The provider is the ADH hospital. The business value is "Promptly provide resources to staff in need". Customer is the hospital staffs who have the benefit of the service. The problematic situation is the continuous change of the hospital environment. The acquisition is to introduce the resource tracking system. The causes of the situation are "Inability to use required resources in real time", "Patient hospitalization prolongs", and "Inability to improve utilization of hospital equipment". The business process is the operation process of the resource tracking system. The service is the resource tracking system service.

Value items	ADH value elements
Service Provider	ADH hospital
Business value	Promptly provide resources to staff in need
Customer	Hospital staff
Problematic situation	Hospital environment continues to change
Acquisition	Introduction of resource tracking system
Cause	Inability to use required resources in real time Patient hospitalization prolongs Inability to improve utilization of hospital equipment
Business process	Operation process of resource tracking system
Service	resource tracking system service

Table 4: Value analysis table for ADH.

The business model table of the hospital is shown in table 5. Key partners are System developer and Resource provider. Resources are Medical equipment and Meals. Cost structure consists of the resource tracking service development and operation cost. The channel is the hospital environment. Profit structure consists of the Resource tracking system usage fee and patient treatment fee. The value proposition is "optimization of resource use in the hospital". The target segment is the hospital staff. The customer relationship is the use of the resource tracking system.

Business model items	ADH business model elements
Service Provider	ADH hospital
Key partner	System developer, Resource provider
Resource	Medical equipment, Meal
Cost structure	Resource tracking service development and operation cost
Channel	ADH hospital environment
Profit structure	Resource tracking system Usage fee, treatment fee
Value proposition	Optimization of resource use in the hospital
Target segment	Hospital staff
Customer relationship	Usage of the resource tracking system

Table 5: Business model table for ADH.

The business process table of the hospital is shown in table 6. The process executors are hospital staffs and the resource tracking system. The business process consists of the resource tracking request, resource usage instruction, resource usage, and resource return. The resources are medical equipment and meals. The process goal is the optimization of hospital resource utilization operations.

The following sections describe the results of the DX diagram of the Aarhus Danish Hospital by the proposed method using ArchiMate. Archi [17] was used to create these ArchiMate diagrams.

Value analysis diagram development

Based on the above table 4, value analysis diagram of ADH can be drawn using ArchiMate as shown in figure 2.

Figure 2: ADH Value analysis diagram using ArchiMate.

Business model diagram development

Based on the above table 5, the ADH business model diagram can be drawn using ArchiMate as shown in figure 3. In the diagram, the business object named as "resource information" is added to manage the location of the resources by the resource tracking system.

Figure 3: ADH business model diagram using ArchiMate.

Business process diagram development

Based on the above table 6, the ADH business process diagram can be drawn using ArchiMate as shown in figure 4. In the diagram, the "resource location" data is added to manage the location of the resources by the resource tracking system.

Figure 4: ADH business process diagram using ArchiMate.

Discussion

The proposed DX visualization approach have been effectively applied to the targeted DX case and able to draw value analysis, business model, and business process diagrams.

By using ArchiMate, the elements extracted in the table in advance can be described using one kind of diagram, so it is simple and efficient. Since it is not necessary to use the three different types of diagrams, it is only necessary to learn ArchiMate, which reduces learning costs.

When we try to visualize DX by different diagrams for value analysis, business model, and business process, there is a problem that the traceability relationship between the diagrams becomes complicated. On the other hand, if it is possible to create DX diagrams only with ArchiMate, it is considered that it is easy to ensure consistency among DX diagrams.

In this paper, we apply the proposed method to the digitalization of the resource tracking system in hospitals. In the future, it will be necessary to apply it to other DX cases and to quantitatively

evaluate its effectiveness. Moreover, it is necessary to apply the proposed method and evaluate it from the initial stage of the DX project, instead of visualizing existing DX cases.

As the proposed DX diagram elements are extracted from the generic value analysis, business models, and business processes, these elements are not depended on the Healthcare domain. For example, the value analysis, business model and business process tables can be applied to e-Business, e-Learning and e-Government. We expect our proposed approach can be applied to these domains and create new digital transformations.

Summary

The main contributions of this paper are as follows.

The three key DX diagrams, i.e., value analysis, business model and business process diagrams, have been identified based on the DX promotion index. Moreover, table items for each diagram are extracted and mapped to ArchiMate elements, respectively. The elements of the three tables don't depend on the healthcare domain. This consideration indicates the generality of the proposed table structure.

The ArchiMate drawing method of DX diagrams has been explained by mapping value analysis, business model and business process table elements to the corresponding ArchiMate elements. The applicability of the proposed DX visualization method has been evaluated by the case study on a hospital digital transformation.

Although the healthcare DX visualization method was explained by the existing hospital DX case, the resulted method does not depend on the healthcare domains. Therefore, the proposed method is expected to visualize DX in other industry domains including e-Business, e-learning, and e-Government.

Conclusion

We have shown the three key diagrams, i.e. value analysis, business model, and business process, and their elements based on the analysis of the DX promotion index published by METI. Then we defined the ArchiMate mapping tables of these diagram elements. We also proposed the DX visualization procedure by using the tables to draw DX diagrams. The case study on a hospital digital transformation case showed the applicability and effectiveness of the proposed DX visualization method using ArchiMate. Future study includes applications of the proposed method not only for the healthcare industry, but also for smart Manufacturing, e-Retail, e-Business, e-Learning, and e-Government.

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