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AI Service System Development Using Enterprise Architecture Modeling

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Abstract

In this work, we propose a model of a project to develop an artificial intelligence (AI) service system used in an office environment. Our model is based on enterprise architecture (EA) approach and consists of business layer elements, application layer elements, and motivation extensions, so that project participants from both business and IT divisions can have the same understanding of the project. By applying the proposed model to the project analysis results, we show that we can derive actionable insights for project risk management.

Keywords: AI Service System; Development Project, Enterprise Architecture

1. Introduction

Many machine-learning-based artificial intelligence (AI) programming modules, such as text classification and image recognition, have been developed and made available as application programming interfaces (APIs). As a result, it is now possible to apply AI technologies for practical business uses. When developing a system using these APIs, developers need not concern themselves with the details of the machine-learning algorithms, but they can use the module functions by simply preparing the training data required for the machine-learning programming module. In this paper, we consider system development projects using AI technology APIs.

Offices have started to apply AI technologies to support the operators of inquiry services; to answer queries about business operations, products, or services; or for screening operations using documents containing many types of individual data. When AI technologies are applied to these business activities, training data on the target business domain

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should be collected. In such situations, we need knowledge of or experience in the domain. Therefore, members from the business division are required to participate in the project.

There are some new features in AI system development projects and many challenges in the requirement, design, implementation, and test phases. In this research, we focus on the project design phase before starting an AI system development project and consider a consensus of the AI system development project between the business and IT divisions. Common understanding between the business and IT divisions on an IT system is important to maximize return of IT investment and it is one of challenge of the business–IT alignment. In this research, we consider the construction of a model representing AI service system development projects so that all stakeholders from both the business and IT divisions can understand the project from their own perspectives. To easily create such a model in various application domains, we propose an Enterprise Architecture (EA) based modeling approach. In this modeling approach, we introduce a view on business goals and try to represent how each development process can contribute to the project goals. By applying the proposed model to project analysis results, we confirmed whether we can derive actionable insights effective for project risk management.

The rest of this paper is structured as follows. In Section 2 we describe related work. In Section 3, we introduce the AI service system and describe the research hypothesis of this study. In Section 4, we describe our proposed model for AI service system development projects. In Section 5, we describe the application of our model to real project analysis results and try to derive actionable insights by using our model. In Section 6, we summarize the key points and future work after the discussion.

2. Related Work

In this research, we considered the assessment of a project developing a system using AI-related technologies, such as machine learning. For this purpose, an architecture for the whole project is needed.

It was noted that an architecture to represent an entire system is needed in a practical project applying Big Data analytics or machine-learning technologies[4], and some architectures for development teams have been proposed[3][6]. Although an architecture containing related business elements was proposed[5], it does not contain the project goals and main actors involved in each element in the project. Therefore, it is difficult to use these architectures for a discussion on AI service system development projects between business and IT organizations.

Furthermore, there are few studies on the assessment of an AI service system development project itself. In [8], it was proposed that some system evaluation issues should be solved when realizing prediction algorithms, such as machine-learning technologies, as a practical social system. In particular, it is important to assess a project by combining the business goal, business process, and developed application. However, for AI service system development projects, such multi-viewpoint evaluation methods have not yet been introduced.

One of the multi-viewpoint evaluation methods for an IT system is business–IT alignment. In enterprise system management, business–IT alignment is introduced. In business–IT alignment, relations between the business goal, business process, and IT system are defined. Business–IT alignment is used to discuss an IT system between business and IT organizations to decrease organization uncertainty, improve enterprise agility, and so on [19]. Some methods for constructing a business–IT alignment model by an enterprise architecture (EA) modeling approach and analyzing it continuously in a company were introduced in[7][12].

To promote the business–IT alignment approach in practice, it is important to prepare generic models for each application domain or each industry. For example, generic models for business–IT alignment by EA were proposed in the IT system operation management domain[17] and IT system risk management[11]. In the health insurance industry, a business–IT alignment model for an insurance system was proposed and used to discuss the digital transformation of the insurance system[2]. However, in these models, information about the business goal or stakeholders is not represented. It is therefore difficult to discuss an IT system from the higher business-management viewpoint. In the healthcare industry, a model representing relations between goals for each stakeholder, services, and business objects was proposed in[18]. In this research, the model was developed by ArchiMate, which is a common EA modeling language. It is expected that this model can be used for business–IT alignment effectively. In [15], alignment model between business and AI service system is proposed. Through this business AI alignment model, it is shown that project members from both business and IT divisions can have a common understanding regarding the system developed in the project.

Although the developed system is represented in these business–IT alignment models from the business and application viewpoints, the processes representing how the system is developed and who mainly develop the system are not described. Consequently, we consider it important to develop a project model that includes development activities for AI service systems.

3. AI Service System and Research Hypothesis

3.1. AI Service System

In this study, we considered a practical AI project in which we developed a system containing AI technologies for an office environment. In an office, employees conduct various intelligent activities. It is said that there are three types of human intelligence: analytical intelligence, creative intelligence, and practical intelligence[13]. In our research, we considered developing a system with analytical intelligence for offices that supports human activities or that can act as a substitute for them.

Analytical intelligence selects the optimal option among predefined ones as the output for given input data[13]. In an office, this intelligence is used in daily activities, such as inquiry services for service queries or business assessments based on documents. We can use machine-learning technologies when we realize this intelligence as a software system. To use machine-learning technology for system development, we need to define options in the target business domain and collect example inputs assumed for each option. A machine-learning model is generated (Training) from training data containing such pairs of options and examples. This model is deployed into a runtime machine learning engine; the engine obtains input data and provides output data using the model (Prediction). This AI service system is illustrated in Figure 1.

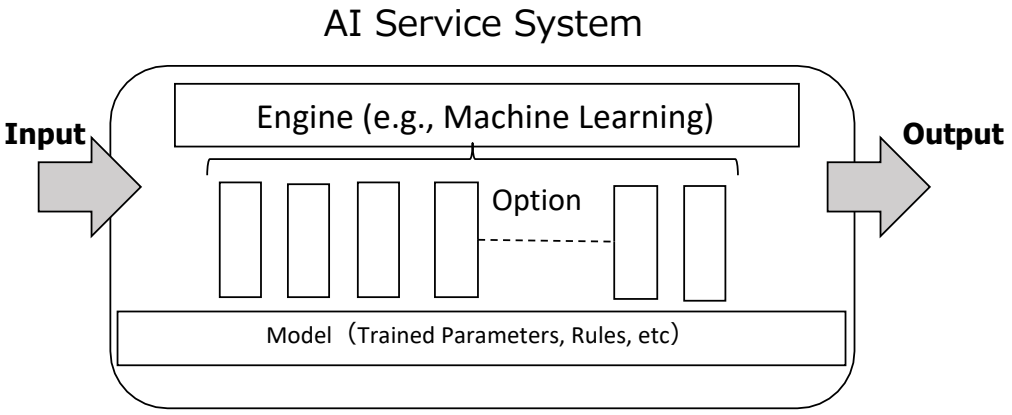


Fig. 1. AI Service System

3.2. Research Hypothesis

In projects developing business systems using advanced technologies, such as Big Data analytics or machine learning, developers often cannot elicit sufficient requirements for developed systems from users. In such a case, the minimum viable product (MVP) is considered a first step to prototype a system by implementing the bare minimum of functions[1]. After that, users use the MVP in their business and validate whether their business can be improved by the system using new technologies. Through this development-validation step, the developer elicits new requirements from the users and improves the system iteratively. Finally, it will be deployed as a production system when it satisfies all the requirements. In this research, we considered a project developing the MVP for a new AI service system used in an office and call it the AI service system development project.

In AI service system development projects, members from a business division need to be involved. When applying machine-learning technologies in the AI service system, we need training data on the target business for the machine-learning engine. Such training data is usually converted from business data (documents) and requires some human work by domain experts from the business division. When using machine-learning technologies, we sometimes obtain a different output, even if the input is slightly changed, and we obtain unexpected outputs for some inputs because the output of these technologies is probabilistic. To improve performance or consider implementing a workaround plan for cases in which we cannot obtain the expected outputs, members from the business division need to participate in the discussion of these activities.

In AI service system development projects, therefore, it is important that project members from a business division can understand not only the developed system itself, but also the significance of each development process from their own viewpoint. In addition, project members from the IT division do not have a method to obtain consensus effectively on the project. In this paper, we propose a generic EA-based development model for AI service system projects. In the proposed model, we represent elements for the developed application, development process, and project goals with relations between these elements. By using the proposed model, we confirmed the following:

- Project members can understand their role and main activities, as well as their significance.
- Actionable insights for project risk management can be derived from the project analysis results.

4. Proposal

4.1. EA and AI Service System

In this research, we used ArchiMate[16] as an EA modeling language. To represent an AI service system, we used three business concepts and three application concepts defined in ArchiMate, as follows:

- Business service: an explicitly defined exposed business behavior.
- Business process: a sequence of business behaviors achieving a specific outcome.
- Business object: a concept used within a particular business domain.
- Application service: an explicitly defined exposed application behavior.
- Application component: an encapsulation of application functionality aligned to the implementation structure.
- Data object: data structured for automated processing.

By using concepts, we defined model elements for the AI service system in Table 1. In ArchMate, various relationships between model elements are defined. In this research, we used the relationships in Table 2. With these elements and relations, the AI service system is represented in Figure 2

4.2. Model Elements

4.2.1. Actor

In the model, we considered two organizations: the business division and IT division. In the business division, there are a planning group and practitioners. In the IT division, there are 4 actors: A business analyst, data scientist, data engineer, and application developer. To apply AI technologies to a real business, data scientists must have deep domain knowledge[10], or business analysts with domain knowledge need to be involved to support the data scientists. In real projects, IT vendors sometimes have the same role as the IT division and develop an AI system. In such a project, data scientists familiar with the target business and business analysts with a deep domain knowledge will participated with the IT vendor. Therefore, in our proposed generic model, we assign business analysts and data scientist to IT division.

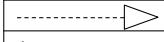
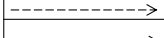
4.2.2. Process

In system development projects where we develop an MVP for a business, there are three processes “Value discovery,” “MVP development,” and “Technical and business evaluation” considered in [1]. In the value discovery step, use

Table 1. Elements in AI Service System

AI Service System Model Element	Element in ArchiMate	
New business service		Business service
Business process preparing AI engine		Business process
Develop AI resource for a target business.		
Generate a model from AI resource.		
Business process using AI application		
Source(e.g., business data and business document)		Business object
AI resource (e.g., training data)		
Runtime input		
Runtime output		
Application service for developing AI resource		Application service
Application service for training a model		
AI application service		
Tool for developing AI resource		Application component
AI training engine		
AI runtime engine		
AI Model		Data model

Table 2. Relations Defined in ArchiMate

Notation	Relationship	
	Association	General or unspecified relationship
	Triggering	Temporal or causal relationship
	Realization	A left-hand-side entity plays a role in the creation or achievement.
	Composition	A left-hand-side element consists of one or more other elements.
	Influence	A left-hand-side element affects the implementation of motivation elements.
	Access	A left-hand-side element observes or acts upon right hand side elements.
	Assignment	A left-hand-side element allocates responsibility or execution.

cases are developed and required functions are identified. In the MVP development step, an MVP with the bare minimum functions. After that, by using the MVP, we validate whether the business can be improved by the new system. On the contrary, in AI service system development projects, it is said that a business goal is divided into AI goals, and each AI goal is divided into AI engine goals[15]. We need two steps to make an AI system available: training the AI engine and implementing an application using the AI engine. In our research, therefore, we divided the value discovery step and the MVP development step into detailed steps, as shown in Table 3.

4.2.3. Goal

In this research, we consider AI service system development projects in which we develop an AI service system and assess whether the new AI service system provides functions that meet the needs of the users under specified business conditions. Therefore, the top goal for developing AI service systems based on MVP is that the system satisfies functionality.

Functionality is further divided into 5 sub-characteristics. These 5 sub-characteristics are defined for general software systems[9] and they have been customized for AI service systems[14]. Using these customized sub-characteristics, we decompose the top goal into sub-goals. For some sub-goals that represent functionality sub-characteristics, we further decomposed the sub-goals. Finally, we obtain the goal tree for an AI service system development project. Figure 3 shows the goal tree represented by ArchiMate.

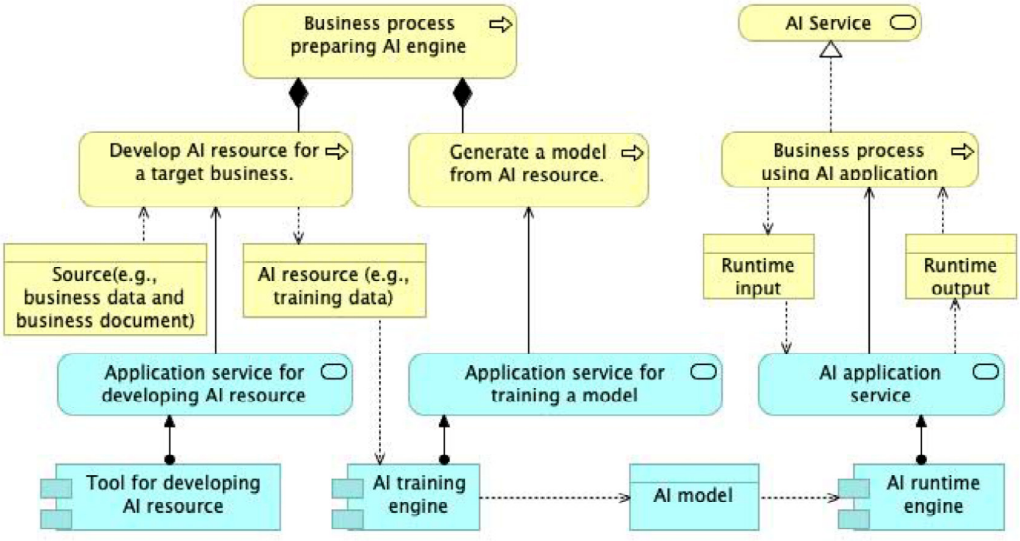


Fig. 2. AI Service System Represented by ArchiMate

Table 3. Development Processes for AI Service System

Process defined in [1]	Process in AI service system development project
Value discovery	Identify a business goal and a new business service.
Value discovery	Identify AI service for business service and its goal.
Value discovery	Identify AI engine required for the AI service and its goal.
Value discovery	Identify business data required for AI engine.
MVP development	Collect and manage business data (source).
MVP development	Develop AI resource from source data.
MVP development	Generate a model from AI resource.
MVP development	Develop an application using AI engine.
Technical and business evaluation	Use and evaluate AI application,

4.3. Model View

By using the model elements introduced above and relations defined in ArchiMate, we derived The model views. First, we show a view representing the relationships between goals, processes, and actors in Figure 4. From this "Why-What-Who View," project participants can understand the following:

- Why should we execute this process?
- Who should lead this process?

Next, we show a view representing the relationships between actors, processes, and applications in Figure 5. From this "Who-What-How View," project participants from a business division can easily understand how each process will be executed.

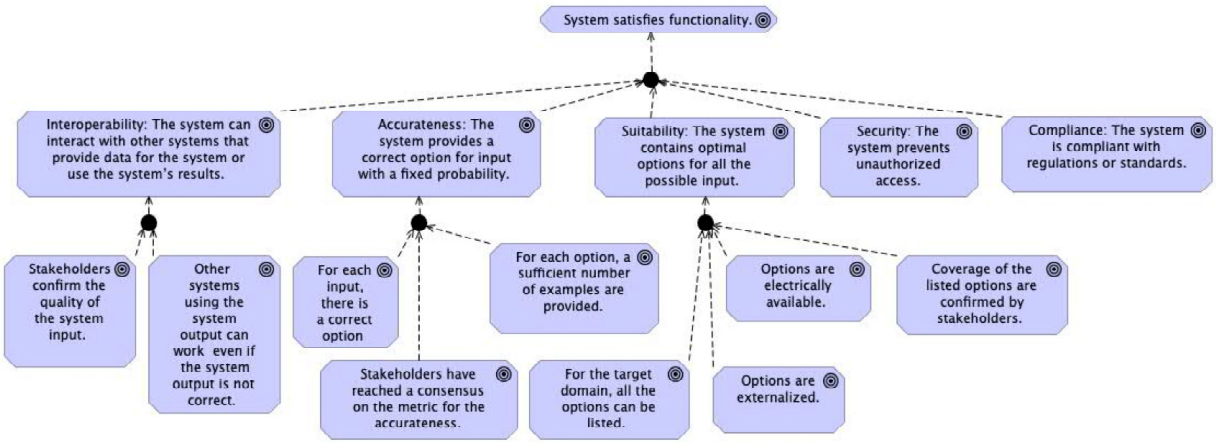


Fig. 3. Goal Tree for AI System Fuctionality

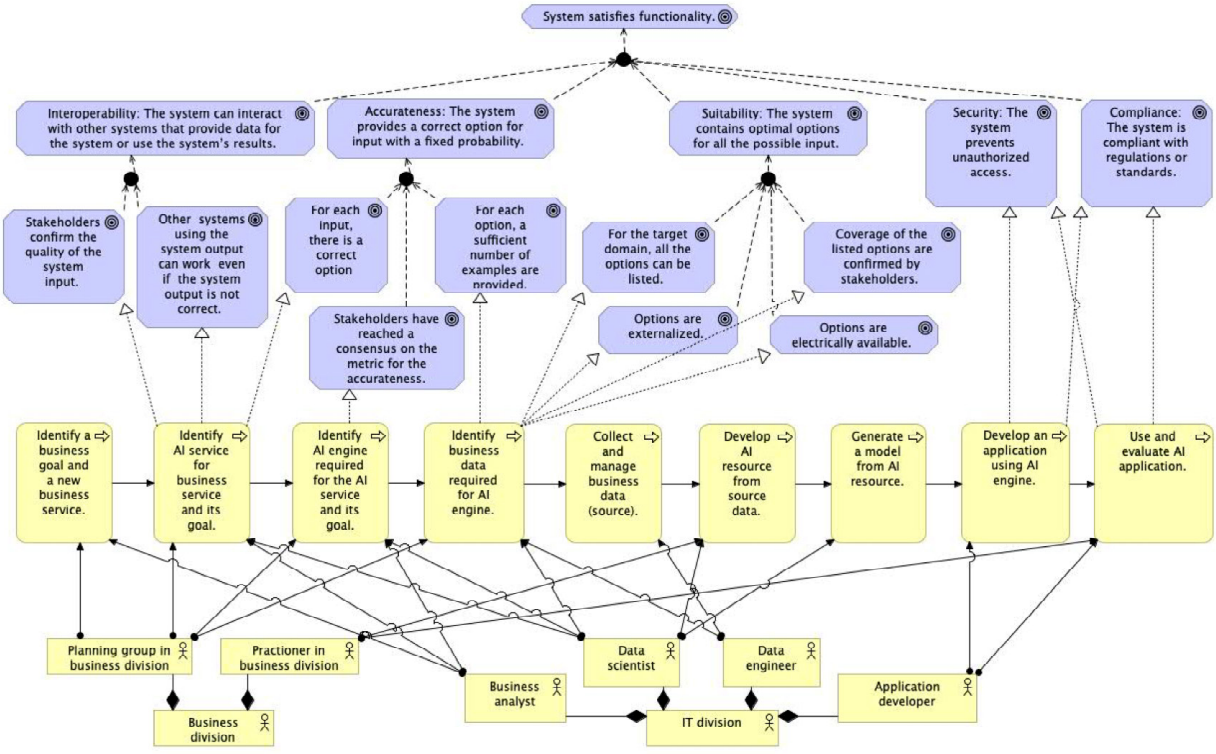


Fig. 4. AI Service System Development Model (Why-What-Who View)

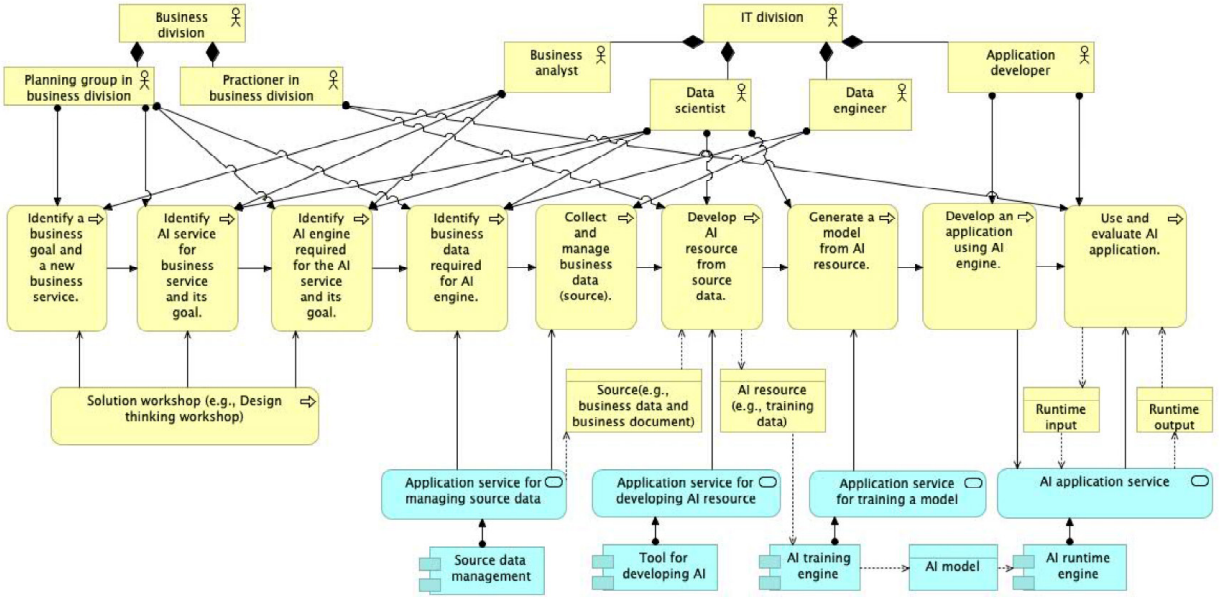


Fig. 5. AI Service System Development Model (Who-What-How View)

5. Example and Discussion

In this section, we show the effectiveness of our proposed model. We apply our model to existing project analysis results and derive actionable insights. First, we apply our model to tips about practical machine learning projects. It is said that there are nine reasons why machine-learning projects will fail, as follow: [1].

1. Asking the wrong question
2. Trying to use it to solve the wrong problem
3. Not having enough data
4. Not having the right data
5. Having too much data
6. Not having the right yardstick
7. Hiring the wrong people
8. Using the wrong tools
9. Not having the right model

Among these, issues 1–7 are related to project management. From the "Why-What-Who Model View," it is found that data scientists should be involved in the project ' s early stages and discuss with the planning group members in the business division whether the new service can be realized as an AI service. Therefore, from the "Who-What-How view," we can skirt issues 1 and 2 by by designing the project so that a solution workshop is held in an early stage. In this workshop, data scientists and business analysts can also discuss what metrics should be used for the AI engine and AI service with members from business division to assess the effectiveness of the new service. This activity can solve issue 6. For issues 3, 4, and 5, it is found that we should have a data inventory stage in which members from both the business and IT divisions participate and assess whether business data required for the AI engine are available. By

[1] https://www.kdnuggets.com/2018/07/why-machine-learning-project-fail.html

dividing the project into two phases and deciding at this stage whether the project should proceed, the project manager need not to assign application developers when the project starts. This means that we can partially avoid issue 7.

Second, we try to apply our model to an analysis result of AI service system development projects. In [14], it is found that for the project to succeed, sub-goals in the goal tree representing the functionality of the AI service system should be discussed between project stakeholders before starting the project. Based on the analysis result of six projects, the following sub-goals in the goal tree (Figure 3) are highly correlating to the project success[14]:

A Other systems using the system output can work even if the system output is not correct.

B A sufficient number of examples are provided for each option.

C Options are externalized and electrically available.

D Coverage of the listed options are confirmed by stakeholders.

To satisfy these project success factors, it is important that project members from both the business and IT divisions have the same understanding of the objective and significance of each project work item. From our model views, the project participants understand who should be involved in each process and what the objective of each process is. For example, on the third and fourth successful factors (C and D), planning group members in the business division should be involved in the business data inventory activity with data scientists and data engineers from the IT division. Through this activity, the suitability of the AI service system is confirmed. It is found that we can derive recommended actions from the project analysis results by using our development model.

From the above examples, we expect that our proposal can be used as a reference model when proposing an AI service system development project. Furthermore, we can refer to our proposed model when executing a development project. For example, when some issues occur in a development activity, we can use the proposed model to identify project participants involved in the related activities or estimate the impact of the issue on the project. Investigating the effectiveness of this use case is one of our future work.

6. Conclusion

In this research, we considered the common understanding of projects developing AI service systems between business and IT divisions. We proposed an EA-based development model for AI service systems and represented elements of the developed application, development processes, and project goals with relations in the model.

Our proposed model provided two views, the “Why-What-Who View” and “Who-What-How View.” From these views, project members can understand the development activities in which they are involved and the impact or significance of each activity on the project. We also applied the proposed model to the existing project analysis results on AI service system development projects and derived actionable insights into the project risk management, by which we can solve well-known project issues and satisfy the success factors before starting the project.

From these examples, it is found that we can use the proposed model as a reference model when proposing AI service system development projects. Furthermore, it is expected that we can use the proposed model during execution of the project. Investigation of such a use case a topic for our future work.

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