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Using Agent Oriented Technology on Developing an Effective Enterprise Architecture Implementation Methodology

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Abstract

Enterprise Architecture (EA) is a holistic view of an enterprise, including the business, Information Technology, and infrastructure. EA is managed, developed, and maintained through Enterprise Architecture Implementation Methodology (EAIM). There are complexities in current EAIM's method, practice, and modelling, which cause the ineffectiveness of EA implementation. The objective of this study is to present the current problems of existing EAIMs and highlight the application of Agent Oriented Technology (AOT) on developing an effective EAIM, which can address the ineffectiveness of EA implementation. Several Agent-Oriented Methodologies (AOM) have been proposed in literature for developing an application and they have potentials in their modelling methods, practices, and development phases, which can contribute on developing an effective EAIM. This contribution can effect on improvement of EA implementation by reducing the complexity of EA implementation, increasing the alignment between business and IT, providing appropriate requirement analysis for developing, and reducing impedance mismatches between different development phases. This research opens new topics in AOT and EA domain, which would follow by other researcher and extend the usage of AOT in IT and Information Systems.

Keywords: *Enterprise Architecture, EAIM, Agent Oriented Methodology, Agent-Oriented Technology, Implementation Methodology.*

1 Introduction

Enterprise Architecture (EA) is a holistic blueprint of an enterprise, including the business, Information Technology, and infrastructure [1].

In EA, the framework represents the structure to model enterprise's business and IT entities [2]. There are different models for various perspectives in EA Framework (EAF), each with different scope and activities. The outputs of EAF are EA's artefacts that consist of models, diagrams, documents and reports [2]. Since EA artefacts are not sufficient for enterprises by they own, enterprises are looking to find a method to address theirs challenges on competiveness by implementing those artefacts. In addition, enterprises implement the EA in order to find appropriate answers for their business's demands [3].

EA is developed, managed, and maintained by means of EA Implementation Methodology (EAIM) [4]. EAIM covers all aspects of the EA lifecycle - the planning for enterprise understanding projects, the analysis of business requirements, the design of systems, the evolution of systems, and the ongoing enhancements of all of the above [3]. The methodology is both complete and concise, serving as a coherent guide for practitioner professionals. It allows paths and pieces of content to be selected and extracted for application on specific projects [4].

Appropriate EA implementation provide both stability and flexibility for enterprise [5]. Several EAIMs have been proposed, each with different plan and practice but common in reaching to enterprise desire architecture [6, 7].

1.1 EA Implementation Methodology

There are several EAIMs. Although they are different in implementation practices and development phases, they are common in the concepts, principles of transition from current architecture (As-Is) to desire architecture (To-Be). This transition is known as "Migration Plan".

Migration plan includes a set of methods with a clear definition of business objectives. The method is needed for the transitional processes in order to implement new technologies in response to the changing business needs. This means the EA includes also the process to create, update and manage the evolution of the architecture domains in line with business strategy. EAIM focuses on migration plan and provide some techniques and tactics to reaching to the TO-Be architecture [8, 9].

In EA, the effectiveness is determined by the degree in which the outputs of EA implementation can help the enterprise attain its intended goals [10]. If the intended goals of the enterprise regarding EA coincide with the individual goals of stakeholders, then EA effectiveness determined. An effective EAIM should lead the enterprise to reach to intended goals of EA project by means of its practices and methods [11].

1.2 Agent-Oriented Technology

Agent-oriented techniques represent a new means of analyzing, designing and building complex software systems. They have the potential to significantly improve current practice in software engineering and to extend the range of applications that can feasibly be tackled [12].

Agent-Oriented Technology (AOT) can help eliminate some of IS developing problems by facilitating the incorporation of reasoning capabilities within the business application logic and by enabling the inclusion of learning and self-improvement capabilities at both infrastructure and application levels [13].

Modern businesses are too complex and dynamic to be managed optimally using traditional IS [14]. Agent-based systems claim to be next generation software capable of adapting dynamically to changing business environment and of solving a wide range of business problems in areas such as enterprise integration, supply-chain management (SCM), process control applications, and knowledge discovery [15].

In general, agent software offer one of two things [16, 17]:

- The ability to solve problems that have hitherto been beyond the scope of automation - either because no existing technology could be used to solve the problem, or because it was considered too expensive (difficult, time-consuming, risky) to develop solutions using existing technology.
- The ability to solve problems that can already be solved in a significantly better (cheaper, more natural, easier, more efficient, or faster) way.

1.3 Paper goals and contribution

This study is partial of the research of developing an effective EAIM based on AOT. A first step towards developing an effective EAIM is to identify effective practices and the factors that affect the effectiveness of EAIM, which has been identified by means of Systematic Literature Review (SLR) [18]. The second step is to identify and capture the appropriate practices and methods from AOT, which have potential to be used on developing an effective EAIM. Therefore, this paper

aims to represent the application of AOT on developing an effective EAIM. This information could extend the Enterprise Architecture Body of Knowledge (EABOD) by adding the new information on EA implementation practices. Moreover, it extends the usage of AOT in other aspect of ISs and business.

The remainder of this study is structured as follows: section 2 is indicated current problems of existing EAIMs; the potentials usage of AOT in developing an EAIM is represented in section3. Discussion and conclusion are expressed in section 4 and 5 respectively.

2 Current problems of EAIM

The importance of EA is to provide new solution or upgrade existing ISs in order to provide integrated IT environment in accordance with enterprise's business demands. In EA project, the Enterprise Architect must consider all aspect of activities and processes of enterprise, including: business, marketing, human resource, IT, finance, and others, so implementing the EA is complex. Therefore EA project needs a comprehensive implementation methodology in order to support all needed process from beginning of project (planning) up to accomplished (implementation) [16, 17].

Several studies have been done in order to describe and address EA implementation methodology problems [19]. This section focuses on current issues on EAIMs.

There are some problems in existing EAIMs, which have rooted in complexity of implementation methods. IT and business are even more complex in theirs processes, therefore bringing these two sides together in EA is a critical problem. Existing EA methodologies do not address complexity in any meaningful manner by providing models for complexity against which architectures can be validated [20]. Since the involvement of heterogeneous stakeholder groups such as application owners or business developers may create conflicting requirements in a complex environment, an appropriate documentation and communication of the enterprise models are vital [21, 22].

There are some problems, which have rooted in incompleteness and ineffectiveness of EA methods activities mentioned in some researches. Some methodologies provide a number of analyses that may be employed in an EA transformation method or a list of EA application scenarios for which methods may be developed. However, this list is not complete. A method may be defined as a systematic aid that guides the transformation of a system from an initial state to a target state. It is unlikely that there is an EA method, which fits to every problem situation in the field. Instead it is advisable to adapt an existing method or to use dedicated parts, like method components or method fragments.

There are several EA methods which they are created by architecture based on theirs experiences from preceding projects and there is not any theoretical foundation behind them. The main reason is practitioner and Consultant Company are trying to use concise and efficient method to cope with complexity and project time [23, 24]. Another significant reason is existing EA implementing method are either too abstract so it difficult to implement, or too extensive to be use in all project [25].

As a result, mentioned problems reflect that there is lack of effective EAIM in current EA project. Thus developing an effective EAIM could positive effects on elimination the ineffectiveness and reduction the complexity of EA implementation [1].

3 Relation of AOT and EAIM

There is trend in current EA research area to use AOT. Several researches have been done about the usage of AOT in EA and Enterprise Integration such as: [25], [26], [27], and [28]. Although most mentioned researches were done in order to use AOT concepts and principle inside the EA, this research more focuses on capturing the practices and modelling method from Agent Oriented Methodologies (AOM) to use in developing an EAIM.

There are a number of AOMs which are different in development phases, methods, and modelling such as: TROPOS, MAS, PASSI, Gaia, ADELFE, INGENIAS, and MESSAGE. There are potentials within AOMs for contributing in developing EAIM with some key support's elements and components.

3.1 Agent-Oriented Methodology and EAIM

Business and IT are complex, and bringing these two approaches together in EA would make a project more complex [23]. AOM represents new software methodology, which addresses the complexity of analysis, development, and maintenance in a better and appropriate plan [26].

EA is an ongoing process and needs to adapt to future changes, this is because of business changes or competitiveness in business [22, 29]. In this regard, the EAIM should consider this situation and provide an appropriate plan in order to cope with the complexities and mismatches of required changes. Continuum development is a mechanism that is used by EAIM to keep updated with the processes and interactions of applications in order to figure out the challenges that come from changes. AOM can provide appropriate communication, interaction, and collaboration among the systems by defining the interdependency between them. By doing so, the AOM can provide an adoptable and dynamic environment for EAIM for future changes with minimum conflicts and impedances [26].

Moreover, AOM emphasizes communication and interaction among analyzing and designing the organizational ISs [30].

Providing appropriate requirement architecture is another concern in the current EAIM, which needs to be considered as a key requirement. Complex systems like EA are systems for which the behavior cannot be predicted by such analysis [4]. Complex systems are non-deterministic. Typically, a system including humans, such as a company, is a complex system. The key characteristic of complex systems is continuous evolution. AOM can figure out this concern based on its concepts and principles. AOM emerges as such a new paradigm in business modelling and IS [25, 31].

In addition, some AOMs are requirement-driven such as TROPOS. These types of AOM propose requirement driven development phases and processes in order to develop ISs with lowest complexities and mismatches [32]. The technical issues balance with organizational issues within the requirements analysis. In requirement analysis the operational environment of the system is modelled and analyzed [32].

AOM also provide an ideal level of abstraction for modelling complex applications where distributed and heterogeneous entities need to cooperate to achieve a common goal, or to concur for the control of shared resources [12]. It is suitable for modelling entities, which communicate (social ability), monitor the environment and react to events, which occur in it (reactivity), are able to take the initiative whenever the situation requires it to do so (pro-activity) without human beings or other agents intervening (autonomy) [27].

Since, within an EA implementation the alignment between business and IT is the most important factor, using the appropriate plan in order to align those leads to have an effective implementation. AOT aligns the requirements analysis with system design and implementation, which it makes the perfect approach for utilizing in EA implementation. The alignment reduces impedance mismatches between different development phases of EAIMs and it can streamline the development process [32].

EA should implement a process of the enterprise to meet business goals, tightly integrating all relevant functions of their operational environment. In order to reduce the mismatch between the system analysis and development, and enterprise's environment, using requirements-driven AOM in developing an EAIM would be useful.

Modelling is considered central in EA, especially at the higher levels of abstraction for sharing systems-related knowledge across the enterprise. Most of the modeling relies on existing modeling methods, with static and dynamic

ontologies. The use of i* as intentional social models for EA is suggested in [33], [34], and [35]. This research proposes the notation and model type of i* for developing an effective EAIM.

Based on the mentioned AOT principle and concepts the following items could have potential to be utilized in developing proposed EAIM:

- Utilizing requirement analysis entirely of implementation
- Agent-Oriented Methodology's modelling
- Agent-Oriented Methodology's development phases
- Agent-Oriented Methodology's development practices

4 Discussion

Todays, there are several studies have been done in order to apply new perspective of software development in EA implementation and improve the existing methods, such as service-oriented enterprise architecture [26-28], and agile enterprise architecture [29-31], but they did not completely succeed on reducing the complexities of EA implementation and appropriate alignment between IT and business [32].

AOT represents a set of methodologies and techniques, which concern on developing complex systems and reduce the mismatch between analysis and development. Thus it seems that AOT has ability to use in EA implementation, but this idea still need more enrichment.

Using the social modelling method in EA implementation such as i*, which use by AOM could extend the domain of modelling in EA project. Using the requirement analysis, which use by some AOM such as TROPOS, can improve the realizing of functional and non-functional requirement of EA project. Using the architectural design and detailed design of some AOM such as MAS, TROPOS, can improve the transition plan and application development practices. Table 1 shows the summary of AOT aspects that can be used on developing an EAIM [33].

As mentioned in the section 1.3, this study is partial of the research of developing an effective EAIM based on AOT. The main project has been divided into three steps. A first step towards developing an effective EAIM is to identify effective practices and the factors that affect the effectiveness of EAIM, which has been identified by means of Systematic Literature Review (SLR) [18]. The second step is to identify and capture the appropriate practices and methods from AOT, which have potential to be used on developing an effective EAIM. Finally the last step is to develop an effective EAIM based on identified foundation from SLR repost and AOT potential.

Table 1: AOT aspects for using on developing an effective EAIM

Section	Description
Modelling	Employing the AOM model style and notation within EA implementation
Requirement	Using the requirement analysis of AOM in EA implementation
Development Practices	Using the development practices from AOM in EA implementation
Alignment	Reduce the mismatch between business and IT by using the AOM activities
Effectiveness	Reduce the complexity of implementation by considering the requirement analysis, development practices, and reduce the mismatch between business and IT

Fig. 1 illustrates an effective EAIM conceptual model based on AOT. The proposed methodology [33] used several aspects of AOT including: In order to support the EA implementation the proposed methodology provides an appropriate requirement management based on Agent-Oriented Methodology (AOM). In this regards, early requirement and late requirement of TROPOS are employed in As-Is and To-Be architecture of proposed EAIM. These requirements support functional and non-functional aspect of EA; In order to manage the EA implementation the proposed methodology uses the development practices, which capture from AOM. In this regards, architectural design, detailed design, and adaptability are employed in implementation phase of proposed EAIM; In order to support EA modelling, the proposed methodology employed agent based modelling notations. The i^* modelling is employed by proposed EAIM for designing and developing EA artefacts. Besides, Fig. 2 shows the practices of each phase of AOT based EAIM [33].

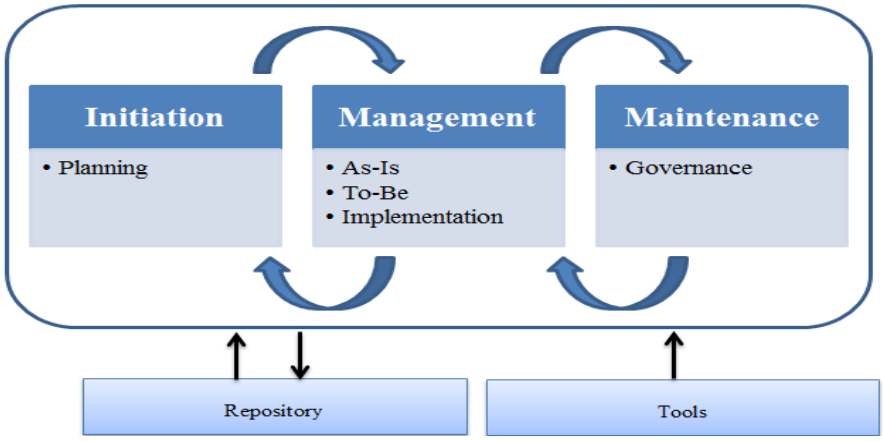

Fig1. Conceptual model of an effective EAIM based AOT [33]

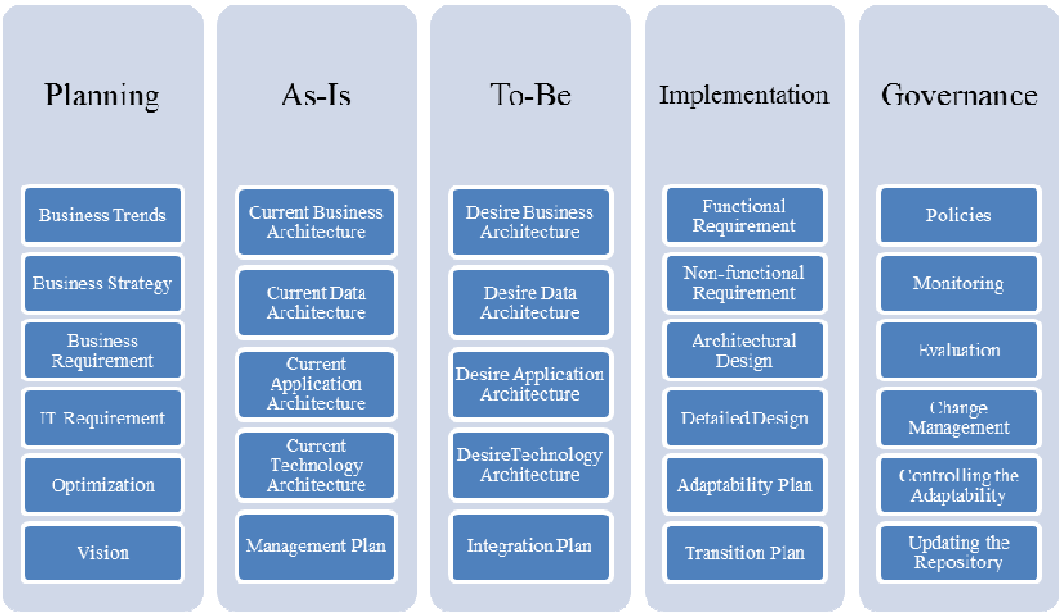

Fig 2. The Phase's practices [33]

5 Conclusion

This study described the application of some AOT concepts and principles, which can address the ineffectiveness of current EAIMs. In this regards, this paper firstly stated the problems of existing EAIMs and secondly, mentioned appropriate potentials of AOT in order to use in developing an effective EAIMs. The given potentials of AOT could contribute on:

- Reducing the complexity of EA implementation
- Increasing the alignment between business and IT
- Providing appropriate requirement analysis for developing
- Reducing impedance mismatches between different development phases

Meanwhile, this research effects on extending the application of AOT and provide new research topics in EA area. The future works related to this subject are: highlighting the exact parts of AOM's practices and development phases for developing an EAIM, developing an effective EAIM based on AOT, providing appropriate plan for requirement analysis within EAIM, and providing agent-oriented based modelling method for EA implementation. Based on the finding of this research, an application of AOT on developing an effective EAIM has been mentioned and illustrated.

Besides, the results of this research would be useful for academics and practitioners in ways of using in EA project and also extending the research on EA implementation area.

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