An Impact Analysis Method of Business Processes Evolution in Enterprise Architecture

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一个好的EA使企业能够在IT效率和IT资源之间保持适当的平衡，
允许单个业务单元在追求竞争优势时安全地进行创新

***Abstract*—Nowadays, enterprises are facing lots of challenges, such as changing market and evolving technologies. Enterprises must continuously adapt themselves to the changing business mode. Enterprise Architecture (EA) is an efficient tool to manage enterprise strategies and IT architecture evolution. As a drive for EA evolution, changing business processes promote IT solutions evolution, and make IT architecture to align with business architecture. To maintain the alignment between IT and business during EA evolution, an impact analysis method of business processes evolution is proposed in the paper, which can automatically analyze impacted IT elements based on the dependent chains built by the core concepts in ArchiMate 2.0. Our approach can provide quantitative guidelines for IT architecture evolution and design support for IT architecture transition.**

Keywords—enterprise architecture; business process; evolve; ArchiMate

I. INTRODUCTION

Nowadays, enterprises are facing challenges such as changing markets, security threats, evolving technologies and new regulations, which drive the requirement to adapt themselves to the changing business mode. Enterprises continuously change and improve to respond to demands of their highly dynamic and competitive business and IT environment. Enterprise Architecture (EA) is an efficient tool which can be used to manage enterprise strategies and IT architecture evolution. ISO/IEC 42010: 2007 defines architecture as: "fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution" [1]. EA tries to describe and control organization's structures, processes, systems, and technology in an integrated way, and manage enterprise evolution as well.

EA定义

系统的基本概念或属性，其元素，关系，以及其设计和演化的原理

Enterprise strategies and IT solutions are important parts in enterprise architecture. Business architecture needs to reflect the enterprise strategies, and IT solutions must be evolved to adapt to business processes/functions, so IT solutions must align with business processes. When business architecture is changed, then information architecture and technology architecture need to evolve. Changes can create unexpected disruptions when dealing with EA, changes usually propagate in unexpected ways, which may result in increasing costs for adaptation and reducing flexibility. A good EA enables enterprises to keep the right balance between IT efficiency and business innovation, which allows individual business units to innovate safely in their pursuit of competitive advantage [2]. So it is crucial to identify the elements in architecture which are impacted by business changes.

中断

传播

To maintain the alignment between IT and business during EA evolution, an impact analysis method of business processes evolution based on The Open Group Architecture Framework (TOGAF) and ArchiMate 2.0 is proposed in the paper, which can be used to automatically analyze the affected elements in information systems architecture and in technology architecture, and provide support for enterprise architecture development, implement and governance.

The rest of the paper is organized as follows: related works are introduced in section II. Subsequently, section III discusses the relationship between TOGAF and ArchiMate, and section IV provides the impact analysis method. Finally, a case study is presented to illustrate the method.

II. RELATED WORKS

In the past, many researches have been carried out in order to manage enterprise architecture evolution. Most research consider the organization-wide impact of a change [3], expressing its complete business-to-IT-stack. For example, for a newly IT application or service, enterprise architecture models can be used to consider implications on business processes, human resources, organizational goals, and more. Enterprise architecture practice had focused primarily on the technological aspects of changes, the practice is evolving to use a rigorous business architecture approach to address the organizational and motivational aspects of change as well [4].

Benavides [5,6] and Sunkle [7] explore about the automated analysis over enterprise-level models. Lankhorst [3] and Iacob [8] propose the approaches which perform quantitative analysis of ArchiMate models and use attributes in the entities and relations as input of their analysis function. In order to take better design decisions during development phase, Johnson [9] proposes a framework, named Predictive, Probabilistic Architecture Modeling Framework (P2AMF), which is used to predict the properties of the system-to-be. Naranjo [10] proposes an enterprise architecture analysis approach and implements the approach in visual analysis tool, named PRIMROSE. PRIMROSE suggests an enterprise models analysis made with non-destructive functions that select and decorate an analytical abstraction. Andres Ramos [11] proposes a characterization of analysis functions, which

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makes explicit the information that each one requires to be executable.

G. Plataniotis [12, 13] provides EA Anamnesis approach for architectural rationalization. The approach captures decision characteristics, and shows the relation between business-level and IT-level decisions. EA Anamnesis relies on a formal linkage between enterprise architecture modeling languages and the corresponding decision aspects.

The impact analysis method of business changes is presented in the paper, which can automatically find impacted entities in the application layer and in the technology layer through dependency chain.

体系结构和建模实体的关系

III. RELATIONSHIPS BETWEEN ARCHITECTURE AND MODELING ENTITIES

The Open Group Architecture Framework（TOGAF）is used in enterprise widely, which is a framework — a detailed method and a set of supporting tools — for developing an enterprise architecture [2]. According to the architecture development method provided by TOGAF, enterprise architecture includes business architecture, information system architecture and technology architecture. Business goals, business processes, organization structure and actors or roles are described in business architecture.

The ArchiMate, as an Open Group Standard, is an open, independent and common modeling language for architecture.

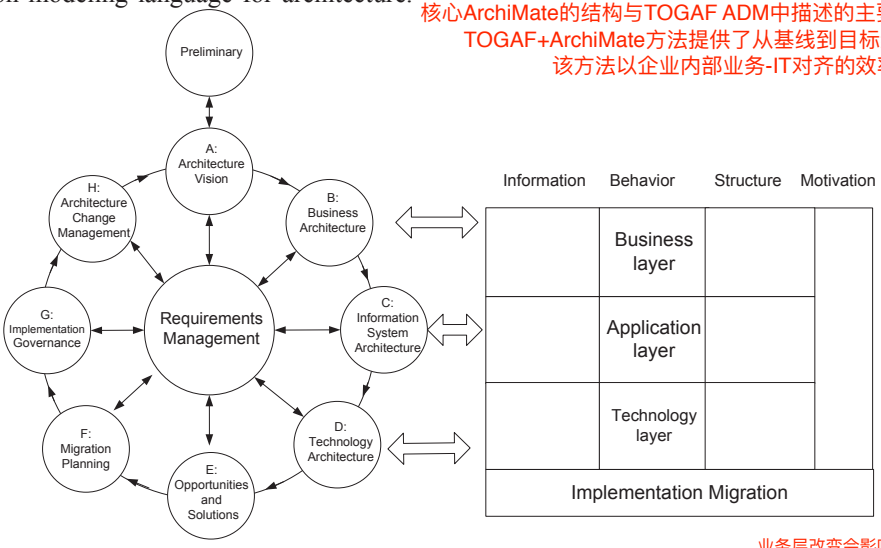
建模语言

ArchiMate offers a common language for describing the construction and operation of business processes, organizational structures, information flows, IT systems, and technical infrastructure. ArchiMate defines three main layers, Business Layer, Application Layer and Technology Layer, which describes the enterprise environment through layered view where the higher layers use services that are provided by the lower layers. The Business Layer offers products and services to external customers, which are realized in the organization by business processes performed by business actors. The Application Layer supports the Business Layer with application services which are realized by (software) applications. The Technology Layer offers infrastructure services needed to run applications, realized by computer and communication hardware and system software [14].

分为3层，业务层、应用层、技术层

Nowadays, ArchiMate 2.0 supports modeling throughout the TOGAF Architecture Development Method (ADM). The correspondence is a fairly easy mapping between TOGAF views and ArchiMate viewpoints. The structure of the core ArchiMate closely corresponds with the main phase as addressed in the TOGAF ADM, illustrated in Fig. 1[14]. The TOGAF+ArchiMate approach provides a solid way of designing an enterprise architecture from baseline to target line, this approach features the efficiency and effectiveness of business-IT alignment within an enterprise.

现在，ArchiMate 2.0支持整个TOGAF体系结构开发方法（ADM）的建模。
这种对应关系在TOGAF视图和ArchiMate视图之间是相当简单的映射。
核心ArchiMate的结构与TOGAF ADM中描述的主要阶段紧密对应，如图1[14]所示。
TOGAF+ArchiMate方法提供了从基线到目标线设计企业架构的坚实方法，
该方法以企业内部业务-IT对齐的效率和有效性为特征。



感觉这段讲的是，为什么要做这个事情，怎么做这个事情

Fig. 1. Correspondence between ArchiMate and TOGAF[15]

业务层改变会影响应用层，同理，影响技术层
直接依赖关系和间接依赖关系

Due to increasing competition and markets requirement, enterprise strategies or business need to evolve, it means that business processes and business functions need to change. In order to ensure that enterprise business is consistent with IT solutions, the IT architecture will change with business processes and functions. Therefore, when business processes change, IT architecture implement and governance must discover the objects or elements which are influenced by the changing business processes.

发现影响的因素

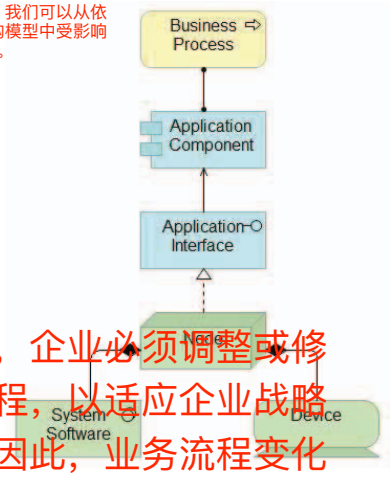
As can be seen from the three layer structure relationship of ArchiMate, changing objects in the business layer should affect the objects in the application layer, and then the impacted objects in the application layer should affect the objects in technology layer. The changing impact makes a chain in enterprise architecture. For example, if entity A depends directly upon entity B, entity C depends directly upon entity A, then any change made to B may affect A, any change made to A may also affect C . B and C is indirect dependency, which reflect the potential for changes to propagate in a system via a "chain" of dependencies. So changing impact chain analysis is a key factor for impact analysis.

影响链分析是影响分析的关键因素

As the models of entities and their relationships discussed in ArchiMate 2.0, Business Process - Application Component – Infrastructure Interface – Node forms a dependency chain to business change impact , depicted in Fig.2, where Application Component is assigned to Business Process, Infrastructure Interface is used by Application Component , Infrastructure Interfaces is used by Node, and Node is composed of System Software and Device. We can discover impacted entities in enterprise architecture models from the dependency chain when business processes evolve.

分配

当业务流程发展时，我们可以从依赖链中发现企业架构模型中受影响的实体。



的推动下，企业必须调整或修改业务流程，以适应企业战略的变化。因此，业务流程变化

Fig. 2. A dependency chain to business changes impact

IV. THE CHANGING IMPACT ANALYSIS METHOD

Promoted by market competition, enterprise development, business transformation or new IT technologies, enterprise must adjust or modify business processes to adapt to the changes of enterprise strategies. So the drive of business processes change comes from the enterprise strategies.

Business process evolution includes three types, add, delete and modify. For added business processes which do not exist in as-is enterprise architecture models, we cannot find dependent entities through dependency chain, so architect must design entities in application and infrastructure layer, which support or implement the added business processes

重要，业务流程演化包括三个方面：增加、删除、修改

For deleted or modified business processes, which exist in as-is enterprise architecture models, we can use automated mechanisms to support impact analysis based on the dependency chain.

The automated impact analysis method is presented as following.

Step 1: Create Business Process & Application Component matrix based on relationships between them in enterprise architecture models.

Let BA indicates Business Process & Application Component matrix , in which the rows represent the set of business processes and the columns represent the set of application components, the elements $\{ba_{ij}\}$ of BA represent the relationships between business processes and application components, The element ba_{ij} of BA is defined as following:

If the business process in i_{th} row assigns to the application component in j_{th} column, then $ba_{ij}=1$.

Else $ba_{ij}=0$.

Step 2: Create Application Component & Infrastructure Interface matrix based on relationships between them in enterprise architecture models.

Define matrix AI indicates Application Component & Infrastructure Interfaces matrix , in which the rows corresponds to the elements of application components, the columns to the elements of infrastructure interfaces, and the intersection between them represents the relationships between them. The element ai_{ij} of AI is defined as following:

If the application component in i_{th} row uses to the infrastructure interface in j_{th} column, then $ai_{ij}=1$,

Else $ai_{ij}=0$.

Step 3: Create Infrastructure Interface & Node matrix based on relationships of infrastructure interfaces and nodes in enterprise architecture models.

Define matrix IN indicates Infrastructure Interface & Node matrix, in which the rows corresponds to the elements of infrastructure interfaces, the columns to the elements of nodes(system software or devices), and the intersection between them represents the relationships between them. The element in_{ij} of IN is defined as following:

If the infrastructure interface in i_{th} row uses to the system software or device in j_{th} column, then $in_{ij}=1$,

Else $in_{ij}=0$.

Step 4: Impact analysis

Based on the matrix defined above, the objects which are impacted by business processes change can be determined through matrix operations.

Define operator $\times$ as follows

Suppose Matrix $A=\{a_{ij}\}_{L\times N}$ and $B=\{b_{ij}\}_{N\times M}$, define $C=A\times B$, $C=\{c_{ij}\}_{L\times M}$,

$$c_{ij}=\bigcup_{k=1}^{N} a_{ik}b_{kj}$$

Where $\bigcup$ denotes OR operator.

In order to analyze the impact to IT solutions or nodes, Business Process & Nodes matrix is defines as BN, and BN represents the relationships between business processes and nodes, in which the elements in rows of BN composed by business processes, and elements in columns by system software and devices, BN=$\{bn_{ij}\}$ is defined as follows

$$BN=BA\times AI\times IN \quad (1)$$

The value of bn_{ij} represents the relationship between the business process in i_{th} row and the software or device in j_{th} column.

If bn_{ij}=1, then the business process in i_{th} row is dependent on software or device in j_{th} column, it shows that if the business process in i_{th} row is changed then the software or device in j_{th} column may be impacted.

Similarly, if we want to determine how business processes change impact application components or infrastructure interfaces, the method can be used.

V. THE CASE STUDY

To demonstrate the usage of the method described in the previous section, we briefly present the ArchiSurance case, which often uses in the enterprise architecture community. In order to simplify the problem description and its scope, we limited the business scenario to part of main business. According to data in reference[14] and [15], ArchiSurance architecture includes Business Process subset {Close Contract, Create Contract, Register, Accept, Valuate, Pay}, Aapplication Component subset {Risk Assessment, Call Center Application, Document management system, CRM System , Financial Application, Policy Administration}, and Nodes subset {Message Queuing, DBMS, Financial Software, Unix Server, NAS File Server }. Some related models are represented in Fig. 3,4 and 5.

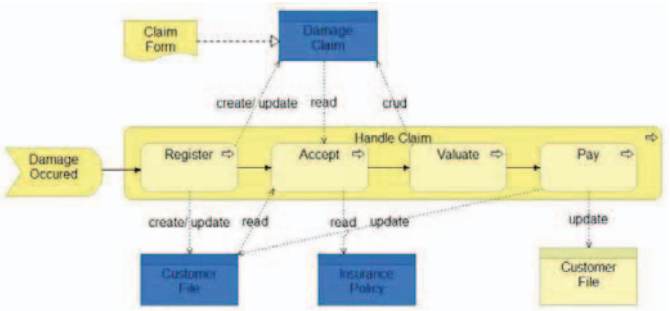


Fig. 3. Business process view

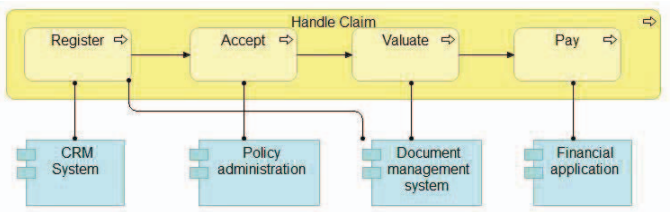


Fig. 4. Application Usage Viewpoint

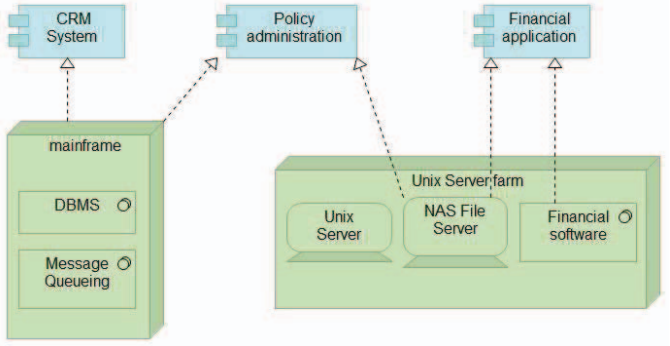


Fig. 5. Infrastructure Usage Viewpoint

In Ref.[14] and [15], the relations between application components and nodes instead of the relationships between application components and infrastructure interfaces. According to the former method, the matrix Application Component & Node can be built similarly.

Based on the data of ArchiSurance architecture model, Business Process & Application Component matrix (BA) is defined as following:

$$BA = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Each row of matrix BA represents Close Contract, Create Contract, Register, Accept, Valuate and Pay, each column of BA represents Risk Assessment, Call Center Application, Document management system, CRM System, Financial Application and Policy Administration respectively.

Application Component & Node matrix (AN) is defined as following:

$$AN = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 \end{pmatrix}$$

Each row of matrix AN represents Risk Assessment, Call Center Application, Document management system, CRM System, Financial Application and Policy Administration, each column of AN represents Message Queuing, DBMS, Financial Software, Unix Server, NAS File Server respectively.

So Business Process & Nodes matrix (BN) is:

$$BN = BA \times AN = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 \end{pmatrix}$$

The values of the elements in BN represent the relationships between Business Process and System Software or Device. If bn_{ij}=1, then the business process in i_{th} row is dependent on system software or device in j_{th} column.

Suppose Business Process "Pay" need to be modified, we can seen bn_{63}=1 and bn_{65}=1, the element in 3th column and in 5th column may be impacted by "Pay" change, so System

Software "Financial Software" and Device "NAS File Server" may be impacted. Similarly, if Business Process "Accept" need to evolve, and bn_{41}=1, bn_{42}=1, bn_{45}=1, then it may affects "Message Queuing"，"DBMS" and "NAS File Server".

Similarly, we can find the impacted application components or interface infrastructures through matrix operations.

VI. CONCLUSIONS

Enterprise architecture must adapt to enterprise strategies changes. As business processes in enterprises become more complex and overleaping, so do the corresponding information systems, which make it difficult to design proceedings for EA evolution. To solve this problem, the impact analysis method is proposed in this paper. Based on the architecture modeled by ArchiMate, the objects impacted in application and technology layer can be found automatically when business processes change. Our approach ensures that IT architecture can align with business architecture during EA evolution by quantitative guidelines.

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