An approach to measuring business-IT alignment maturity via DoDAF2.0

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Abstract: Measuring the business-IT alignment (BITA) of an organization determines its alignment level, provides directions for further improvements, and consequently promotes the organizational performances. Due to the capabilities of enterprise architecture (EA) in interrelating different business/IT viewpoints and elements, the development of EA is superior to support BITA measurement. Extant BITA measurement literature is sparse when it concerns EA. The literature tends to explain how EA viewpoints or models correlate with BITA, without discussing where to collect and integrate EA data. To address this gap, this paper attempts to propose a specific BITA measurement process through associating a BITA maturity model with a famous EA framework: DoD Architectural Framework 2.0 (DoDAF2.0). The BITA metrics in the maturity model are connected to the meta-models and models of DoDAF2.0. An illustrative ArchiSurance case is conducted to explain the measurement process. Systematically, this paper explores the process of BITA measurement from the viewpoint of EA, which helps to collect the measurement data in an organized way and analyzes the BITA level in the phase of architecture development.

Keywords: business-IT alignment (BITA), measurement, enterprise architecture (EA), DoD Architectural Framework 2.0 (DoDAF2.0), meta-model.

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1. Introduction

The importance of business and IT alignment (BITA) has been well known since the 1990s [1 – 5]. BITA persists among the top-ranked concerns of business and IT executives in the last several decades [6]. Scholars tend to align the business and IT elements bidirectionally and evolve in the same direction. It demands a holistic view and sustainable interrelations between business processes, organizational structures, and IT systems, and helps to maximize IT investments and organizational performances. The

measurement of BITA determines the alignment level of an organization, and benefits further BITA governance and improvements [7 – 12]. However, the extant literature is inadequate in collecting the measurement data [7,8]. The corresponding organization contents, which can be used to measure BITA metrics, are not transparent in the literature. Scholars are likely to adopt questionnaire surveys or experience-based methods to analyze BITA metrics, rather than starting from organization contents.

The methodology of enterprise architecture (EA) forms a structured and aligned collection of plans for the integrated representation of the business and IT landscape of the organization [13]. EA is a superior approach to address BITA issues [14 – 16]. For example, Hinkelmann mapped a strategic alignment model [17] to the Zachman framework [18], and explained EA's capability to measure BITA [19]. Ori applied multiple misalignment symptoms to the open group architecture framework (TOGAF) meta-model, and argued that TOGAF can support the analysis of misalignment measurement [20]. Due to the identification of meta-model and models in EA frameworks, EA develops the business and IT contents of an organization with a self-consistent way. These contents help to provide data for BITA measurement.

Through our previous study [21], we have identified that the EA research on BITA measurement attracts the least attention, compared with the other BITA research streams combining with EA. We list fourteen representative measurement studies in Table 1. Within them, we identify that some just described the BITA measurement with EA viewpoints and models [22 – 25]. They tend to focus on simple mapping methods such as matrix or tables [24 – 27]. The majority of the papers collect data from questionnaires or experiences rather than from organization contents [27,28], which makes the measurement results subjective. Without systematic guidance of data collection, the extant research is difficult to exhibit a holistic, in-depth BITA measurement analysis.

Table 1   Literature analysis on BITA measurement with EA

Source	Description	Measurement approach
Pereira and Branco (2004) [22]	Presented a set of questions that are relevant to the alignment issues with regard to varied enterprise roles.	Questionnaire survey
Sousa, et al. (2004) [23]	Explained how alignment can be categorized on the basis of basic components.	Experience analysis
Plazaola, et al. (2006, 2007, 2008) [29 – 31]	Displayed a process that associates the artifact of a BITA framework to the meta-model of the Zachman framework.	Meta-model
Tapia, et al. (2007) [28]	Developed a value-based BITA maturity model based on inter-enterprise collaborations. EA is a key metric in this model.	Model description Questionnaire survey
Carvalho and Sousa (2008a, 2008b) [24,25]	Proposed a misalignment model to understand, classify, and manage misalignment through a medical sciences approach.	Experience analysis
Kang, et al. (2010) [26]	Developed a strategy alignment model based on the business EA from strategy, enterprise process, and enterprise resource.	Meta-model
Elhari and Bounabat (2011) [32]	Introduced a platform for modeling EA and assessing strategic alignment on the basis of internal EA metrics.	Questionnaire survey
Wagter, et al. (2011) [27]	Proposed an instrument to assess enterprise coherence from four levels.	Model description Questionnaire survey
Clark and Barn (2013) [33]	Introduced an EA simulation language to validate the conformance between logical EA and physical EA.	Meta-model
Ori (2014) [21]	Combined misalignment analysis to EA models, with the aim to set up an EA-based misalignment assessment method.	Meta-model
Vasconcelos, et al. (2015) [34]	Proposed 16 metrics for assessing information system architecture suitability. Alignment assessment is a key metric.	Model description

To address this research gap, we attempt to provide an association process combining the BITA maturity model [35 – 38] with a specific EA framework, i.e., DoD Architectural Framework 2.0 (DoDAF2.0). We will mainly discuss the mappings of each BITA metric with DoDAF2.0 meta-model and models, and then collect the required measure data from organization contents. Through this process, the BITA measurement is likely to achieve reasonable and convincible results. The remainder of this paper is structured as follows: Section 2 illustrates the background; Section 3 explains the association thought of the BITA model with DoDAF2.0; Section 4 describes the detailed association process; Section 5 introduces an illustrative case to verify the above process; and Section 6 functions as the conclusion of this paper.

2. Theoretical background

2.1   BITA measurement

BITA measurement has been studied since Henderson and Venkatraman proposed a strategic alignment model in 1993 [17]. Various BITA measurement models have sprung up in different forms since then. For example, Muñoz and Avila reviewed the extant BITA measurement models and methods [39]. McAdam explained the performance measurement of BITA through a dynamic capability perspective [40]. Trienekens provided a detailed measurement framework including five main factors [7]. Gerow in-

tegrated six types of alignment and measured them through surveys [8]. Hu and Huang introduced a balanced scorecard model to measure BITA [9].

Additionally, Luftman has conducted multiple research on BITA maturity assessment [35 – 38]. His maturity model has been widely adopted in other BITA research [41 – 43]. Six criteria are proposed in the maturity model. Among them, the "communication" criterion refers to the exchange of ideas and a clear understanding of strategies by different roles. The "competence/value measurements" focuses on the value of IT in terms of its contributions to the business. The "governance" criterion ensures the business and IT participants formally discuss and review the priorities and allocation of IT resources. The "partnership" explains the relationships between the business and IT organizations. The aspect of "scope and architecture" represents the maturity aspects of IT, and the "skills" criterion means the human resource considerations in an organization. The above six criteria and their respective metrics are displayed in Fig. 1.

In general, collecting the varied kinds of measurement data is difficult when applying the measurement models to practices [29]. Experience-based methods are often used in the literature, which conduct the inadequate and subjective analysis. We believe the development of EA is superior to build a reasonable in-depth BITA measurement process, due to its advantages of organizing information.
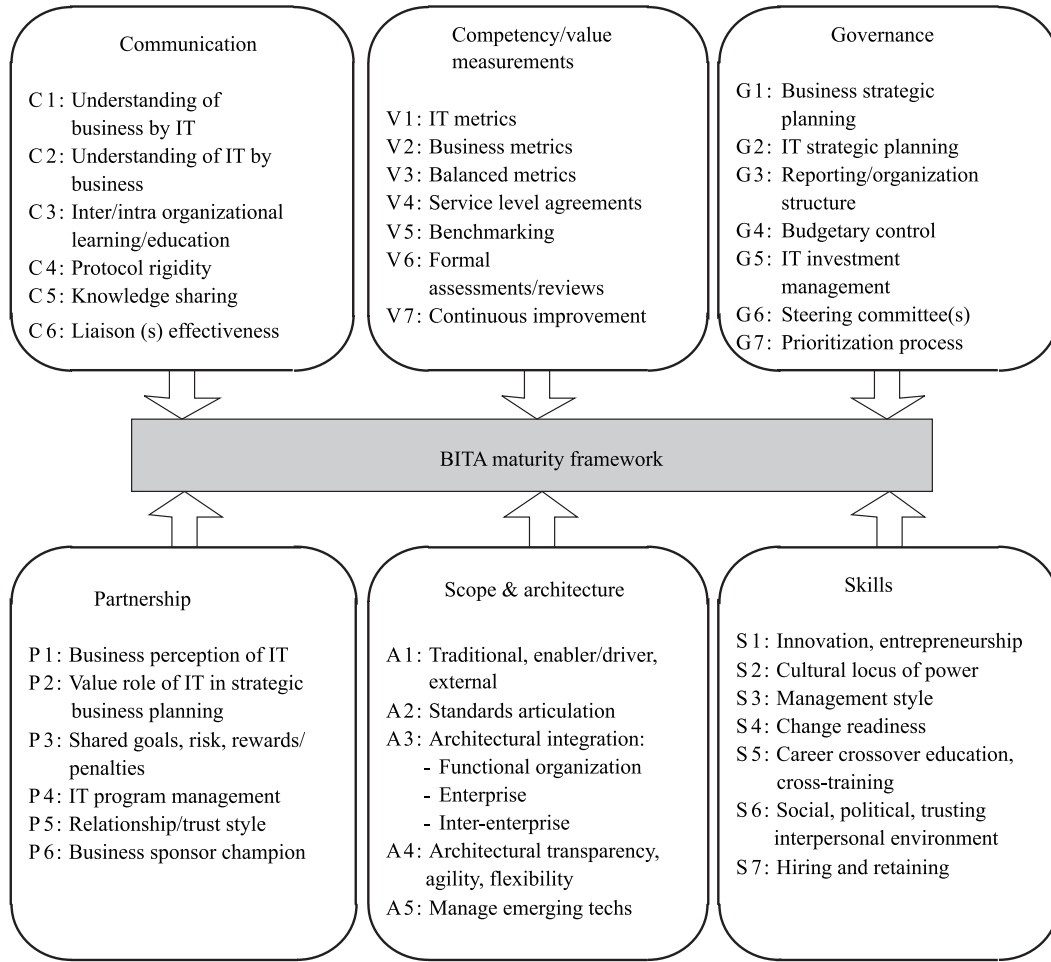
Fig. 1   BITA maturity framework proposed by Luftman [35 – 38]

2.2   EA framework

EA refers to a "fundamental description of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution" [44,45]. The EA framework acts as a guide to design EA, due to the complexity of an organization. In general, EA frameworks formalize multiple viewpoints and models, which helps to architect abstract from the level of detail to bring enterprise design tasks into focus and produce documentation of architectural descriptions. Varied EA frameworks have been issued in the world, such as Zachman framework [18], TOGAF [45], DoDAF [46], and MoDAF [47].

Without loss of generality, the 2.0 version of DoDAF, which exhibits eight viewpoints and quantity different models in each viewpoint, is adopted in this paper. Among the viewpoints, the capability viewpoint (CV) explains the capability requirements of an organization. The operational viewpoint (OV) describes business activities and processes. The services viewpoint (SvcV) articulates the information system (IS) services and their relationships. The systems viewpoint (SV) represents the systems and their relationships. The standard viewpoint (StdV) refers to the policy, standards, guidance, and constraints in the organization. The data and information viewpoint (DIV) displays the data relationships and structures of architecture contents. The project viewpoint (PV) articulates the various projects and their support for capabilities. The all viewpoint (AV) describes the overarching aspects of architecture contexts that relate to all views. Additionally, each of the above viewpoints includes descriptive models, e.g., the organizational structure model (OV4) in OV.

In order to maintain the consistency of the architectural contents in different models, the DoDAF2.0 develops an overall data meta-model (DM2). DM2 displays the abstraction of the above viewpoints and models as shown in Fig. 2. Fig. 2 includes different data entities (e.g., "Activity", "Project") and their relationships (e.g., hollow composition relationship, triangle correlation relationship). These entities and relationships help to ensure the formalization of

DoDAF models. For example, the organizational structure model (OV4) is composed of the data entities including "Performer", "PersonType", "Role", and so on. Complete DM2 can refer to DoDAF 2.0 [46].
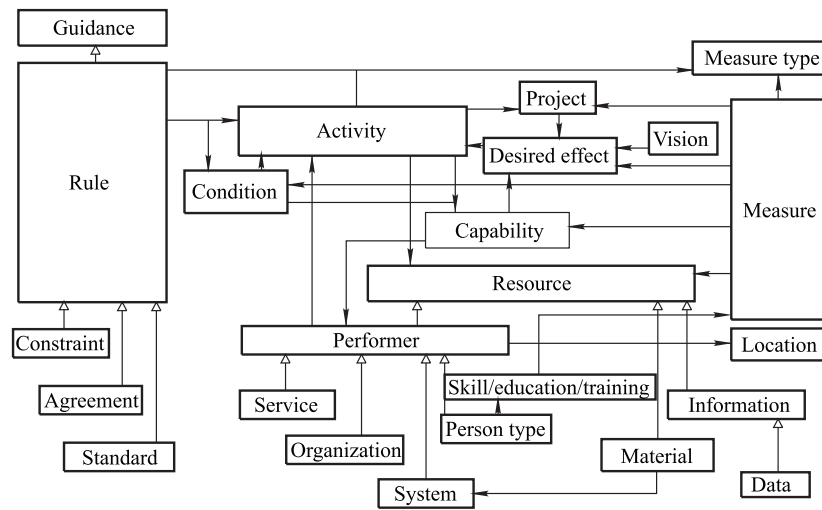

Fig. 2   Main entities and relationships of DM2

3. Association thought

This section aims to explain the association thought between BITA measurement and EA framework. We argue the data in EA models (Fig. 2) can be gathered to assess metrics of the BITA measurement model (Fig. 1). Fig. 3 schematically depicts this link.
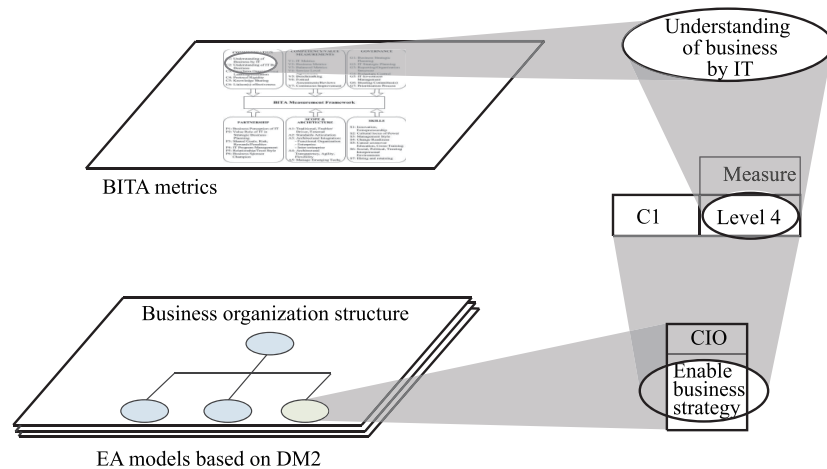

Fig. 3   The link between EA models and its associated BITA

In Fig. 3, the entire EA contents are composed of a multitude of description models (formed by DM2). We can explain the association by considering the organizational structure model (OV4). If a chief information officer (CIO) exists in the business structure and features an attribute (assumed as "enable business strategy"), we can suppose that business and IT roles have developed a good communication relationship. The BITA maturity model is displayed in Fig. 3, with 38 leaf metrics which need to be filled by maturity values. It is obvious that the value of the metric "Understanding of business by IT" (C1) can be explained by the above organizational structure model. Conforming to the five maturity levels proposed by Luftman [35], we can assume that the maturity of C1 is situated in level 4, with an "enable business strategy" attribute in the CIO entity. According to this example, the data in one EA model can be directly reflected as the maturity value of one BITA metric. Sometimes, one BITA metric may be simultaneously supported by several EA models. Anyway, the link between EA models and BITA models is concretely specified by the following requirement: the leaf metrics' maturity values in the BITA model are obtained by collecting

and integrating the data in one EA model or several EA models.

In general, the meanings of BITA metrics help to identify the supporting data entities, which can be tailored from architectural DM2. The exploration of the DM2 can further conclude the EA models and data in the support of BITA measurement. To measure the BITA maturity in the support of EA contents, we will first explore the relationships between DM2 and each BITA metric, and then determine the corresponding EA models. Then the maturity level of each BITA metric can be acquired with the data of these EA models. The association process can be divided into the following four steps.

Step 1   Identify relevant entities and relationships of DM2 for each BITA metric, in order to gather corresponding EA models;

Step 2   With regard to each BITA metric, determine corresponding EA models based on the above entities and relationships;

Step 3   Based on EA contents from the above models, introduce suitable measurement methods to assess BITA metrics;

Step 4   Measure the holistic BITA maturity with the maturity values of all the leaf metrics.

Through these four steps, we can build mapping relationships between BITA and EA models, which make the overall measurement reasonably and systematically. Concretely, each of the four steps will be discussed in the next section.

4. Association process

4.1   Identifying correlations between DM2 and BITA

This step aims to identify the entities and relationships of DM2 in the support of each BITA metric. We will first explain the meanings of BITA metrics and explore their corresponding organization contents (expressed by italics), and then identify the entities and relationships in DM2. For simplicity, the metrics under the same BITA criterion are discussed together.

(i) Communication

In the "Communication" criterion, C1 and C2 refer to the mutual understanding of business and IT roles. The understanding can be measured by determining whether *business/IT roles* are involved in each other's *organizational structures*, or in the *operational processes*. These contents can be checked through EA models organized by DM2. C3 refers to the educational background of an organization. This metric can be illustrated by the *education level* of the *personnel*. C4, meaning the rigidity of protocols, can be answered by the *conditions* of *business/IT processes*. C5 demands the knowledge sharing of business and IT roles. This metric should be checked by determining the existence of the *knowledge sharing processes* in an organization. Additionally, C6 shows the effectiveness of liaison between business and IT, which requires us to examine the presence of liaison roles in the *organizational structure*.

All of the above contents, including *roles, organizational structures, processes*, can find corresponding elements from the DM2. The entities and relationships of DM2 are tailored and displayed in Fig. 4. Fig. 4 includes different kinds of entities (e.g., "Performer", "System") and their relationships (e.g., "Overlap" relation, "Wholepart" relation). The hollow arrow represents the composition relationships, and the triangle arrow represents the relevance relationship. Fig. 4 is tailored from DoDAF DM2. Specifically, the *organization structure* includes "Organization Type", "Person Type", and "Individual Performer". "Person Type" features an *education* attribute. The "Activity" entity is performed based on multiple "Conditions" and "Rules". Then the *business process* is composed by "Performers" and business "Activities", and the *IT process* is composed by "Performers" and IT "Activities". All of the above entities can be combined to support the "Communication" metrics.
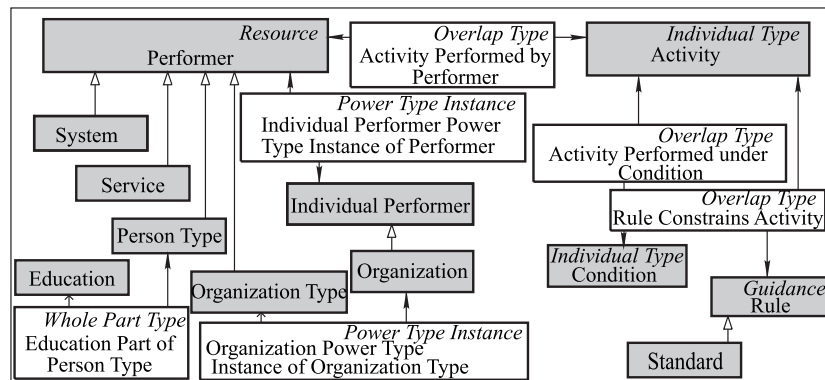

Fig. 4   DM2 fragment for "Communication" criterion

(ii) Competence/value measurement

The "Competence/value measurement" criterion includes seven metrics. To identify their corresponding organizational contents, we argue that V1, V2, and V3 represent the measures of the business and IT domain. They can be explained by varied *measure types* of an organization. V4 refers to the service level agreement, which should be supported by the *service structures* and *service measures*. V5 indicates the *standards* in the measurement process. The IT assessment process of V6 can be implemented by executing *IT activities* for *business capabilities*. Additionally, V7 represents the continuous IT measurement and improvement. This metric can be exhibited through consuming and allocating *resources*, and introducing *activities* for

new *capabilities*.

The above contents (in italics) can also be identified in DM2. Similarly, Fig. 5 is tailored from DM2. It includes the data entities and their relationships. For example, the "Performer" is composed by "System", "Service", and "Port", and can perform "Activity". In Fig. 5, "Measures" and "Measure Types" are introduced to support varied *measure types* in V1, V2 and V3. "Service" and "Service port" are elements of "Performer", which can represent V4 with "Service Level Measure" and "Service Level Agreement". "Standards" can support V5. Furthermore, the combination of "Activities" and "Performers" helps to implement "Capabilities" with "Resources", and consequently explains V6 and V7.
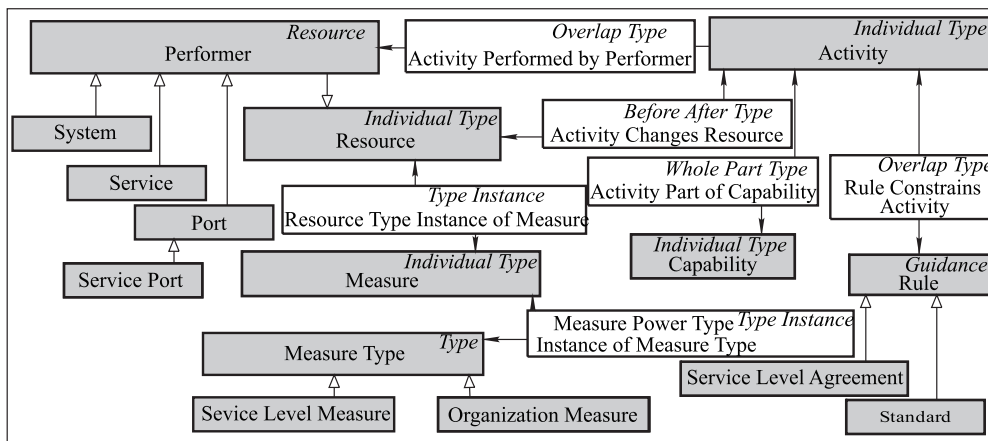

Fig. 5   DM2 fragment for "Competence/value measurement" criterion

(iii) Governance

In the "Governance" criterion, G1 refers to the business strategy planning. This metric can be fulfilled by performing *business processes* in the search of *business capabilities*. G2 displays the IT strategy planning, which can be supported by implementing *IT processes* by *projects*. G3 demands feasible *organizational structures*. G4 demands reasonable *resource* allocation for *projects*. G5 requires the IT investment scheme in *projects* management. G6 requires a steering committee in the *organizational structure*. Furthermore, G7 represents the prioritization process of IT governance. This metric should be supported by time sequences of *projects*.

The above organization contents can be located in the DM2. Fig. 6 determines the possible data entities and the relationships. For example, the business "Performer" can perform multiple "Activity" to satisfy "capability", which helps to support the business strategy in G1. Specifically, the process performing "Activities" for "Capabilities" can meet G1, and the process performing "Activities" to execute "Projects" can represent as G2. Here, the *organiza-*

tional structure is composed by "Organization Type" and personnel, which can support G3 and G6. "Data" and "Information" imply budgets and costs of G4. G5 and G7 are realized by "Projects", "Desire Effect" and "Measures". Thus, the "Governance" metrics can be measured by the combination of these entities and their relationships.

(iv) Partnership

With regard to the "Partnership" criterion, P1 focuses on the business perspective of the IT value. This metric should be measured by determining whether *IT roles* participate in the business *organizational structures*. Similarly, P2 can be supported by *IT roles* involving in the business planning *processes*. P3 refers to whether business and IT share *goals* when executing *projects*. P4 represents the levels of *projects'* management. P5 refers to the trust level between business and IT, which can be checked whether there are corresponding *standards* in an organization. P6 demands the business sponsor *roles* in the business domain.

The above contents including organizational structures and projects can be situated in the DM2. Fig. 7 explains the corresponding entities and relationships. It mainly includes

"Performer", "Activity", "Project", and their relationship such as "BeforeAfterType" and "OverlapType". In Fig. 7, the *organizational structure* composed by "Organization Type" and "Performer" is used to support P1 and P6. The *processes* of "Performer", "Activity", and "Capability" can be used to realize P2. The "Project", "Desire Effect" and "Measure" can be used to support P3 and P4. The "Rule" helps to measure P5.
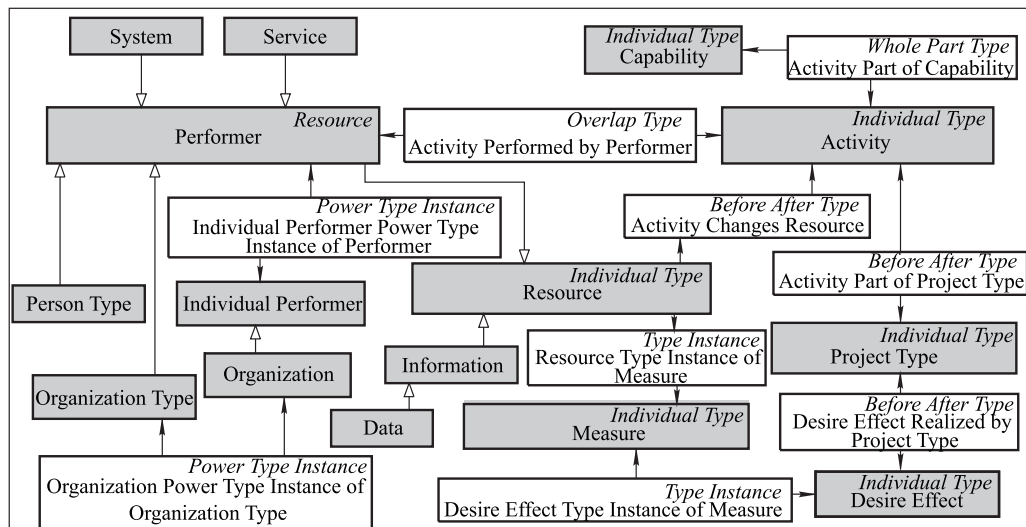

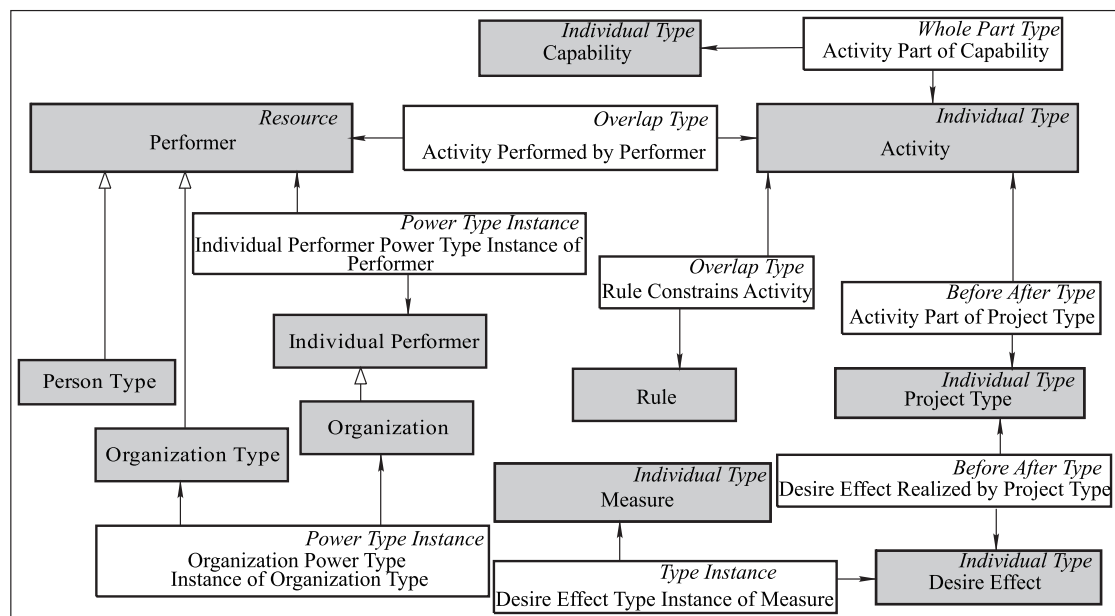**Fig. 6   DM2 fragment for "Governance" criterion**

Fig. 7   DM2 fragment for "Partnership" criterion

(v) Scope & architecture

Under this criterion, A1 refers to the various *roles* related to *IT architecture*. A2 represents the *standards* in *IT architecture*. A3 refers to the architecture integration among different organizations. This metric can be supported by *IT architecture* and its *organizational structure*. Similarly, the features of A4 can also be measured by the performances of *IT architectures*. A5 refers to suitable ways of managing emerging IT by specific *standards*. With regards to the above contents, the corresponding DM2 entities and relationships can be drawn as Fig. 8. Here, *organizational structures, IT architecture, and standards* can be formed by "Organization Type", "Performer", "Activity", "System", "Standard.", and so on.
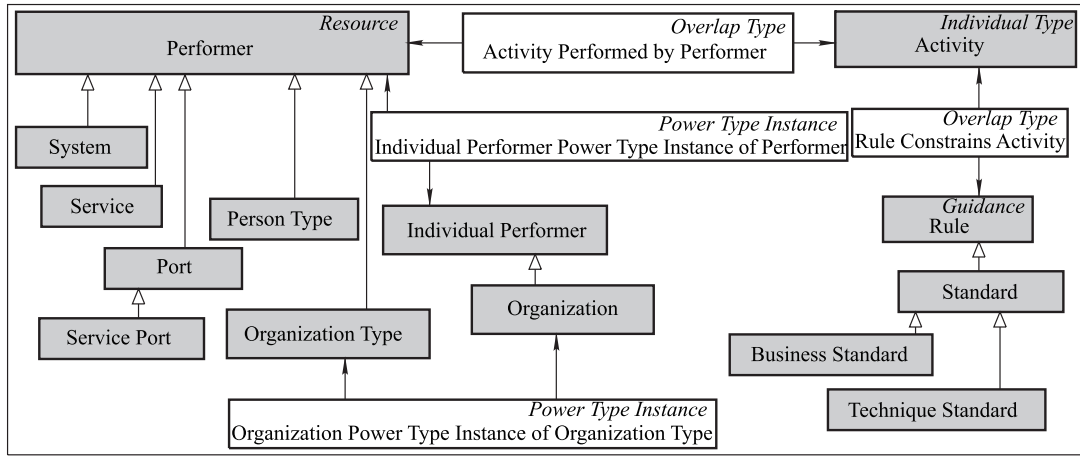
Fig. 8   DM2 fragment for "Scope & architecture" criterion

(vi) Skills

The "Skill" criterion mainly includes the standards and culture of an organization. Among them, S1 explains *standards* on innovation and entrepreneurship. S2 represents the cultural locus of power, which can be illustrated by the types of *organizational structure*. S3 represents the *skills* in the process of project management. S4 expresses *standards* in enterprise change management. S5 expresses *standards* of personnel training. S6 represents the market *environment*. S7 refers to the *rules* on person hiring and retiring.

The corresponding DM2 are displayed as Fig. 9, which also specify the contents such as "Skill", "Rule", and so on. Here, "Standards", "Organizational Structures", "Projects", and "Skills" can be used to support the above metrics. The entities and relationships are displayed in Fig. 9.
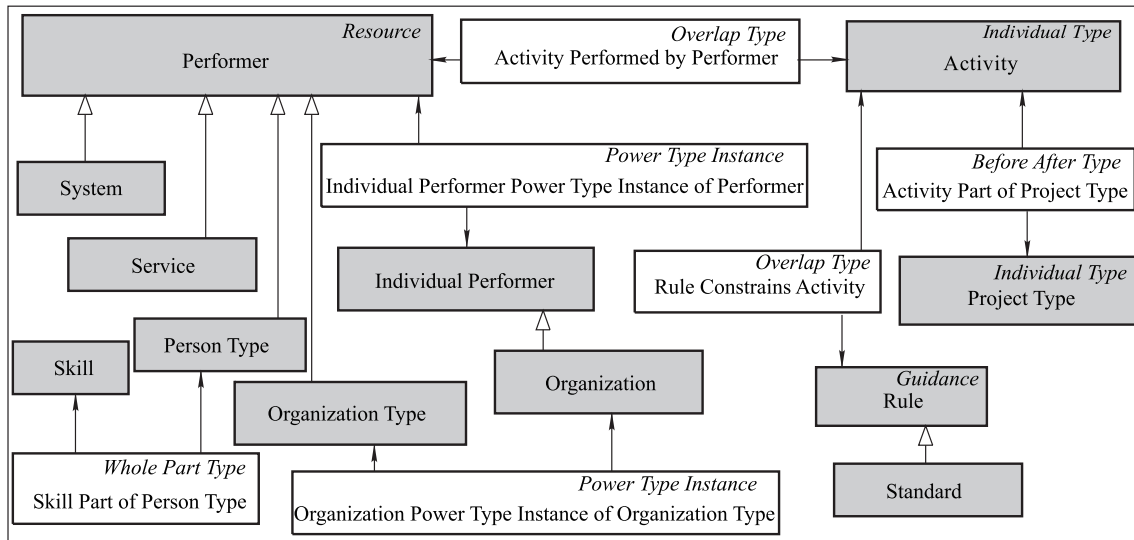

Fig. 9   DM2 fragment for "Skills" criterion

Overall, this step mainly identifies the relevant entities and relationships of DM2 in the support of the BITA metrics. The organization contents reflected by the BITA metrics are located in the DM2. The mappings help to develop relevant EA models and collect EA data in the next few steps.

4.2   Determining EA models for each BITA metric

According to the above DM2 fragments, DoDAF2.0 mo-

dels can be further determined to support the BITA metrics. The mappings are displayed in Table 2.

In general, one BITA metric can be measured by one or several EA models. Taking the "Communication" criterion for example, C1 is supported by organizational relationships chart (OV-4) and operational activity model (OV-5b). These models can be used to check whether IT roles have been involved in business organizational structures and business processes. Similarly, C2 is supported by or-

ganizational relationships chart (OV-4), services resource flow description (SvcV-2), and systems resource flow description (SV-2). In addition, C3 is supported by the integrated dictionary (AV-2) and standards profile (StdV-1). These models involve the contents of the personnel education level. C4 is supported by the operational rules model (OV-6a), services rules model (SvcV-10a), and systems rules model (SV-10a), which include all of the rules in EA. Furthermore, C5 is supported by operational activity decomposition tree (OV-5a), which can be used to check whether knowledge sharing activities exist in the organization. The organizational relationships chart (OV-4) can check the presence of liaison roles in C6. With the same way, the other metrics can be supported by EA models in Table 2.

Table 2   DoDAF models for measuring each BITA metric

Criterion	Metric	Supportive EA model	Explanation
Communications	C1	OV-4, OV-5b	Check whether business and IT roles share organization structures, and whether IT roles participate in business processes.
	C2	OV-4, SvcV-2, SV-2	Check whether business and IT roles share organization structures, and whether business roles participate in IT processes.
	C3	AV-2, Std-1	Check whether business and IT roles receive education training.
	C4	OV-6a, SvcV-10a, SV-10a	Check whether the agreements in business and IT processes are rigid or not.
	C5	OV-5a	Check whether there exists knowledge sharing process in a firm.
	C6	OV-4	Check whether there are liaison roles between business and IT.
Competence & value measurements	V1	SvcV-7, SV-7	Check whether there are measures on IT values.
	V2	CV-2, CV-5	Check whether there are measures on business values.
	V3	SvcV-7, SV-7	Check whether there are measures in IT aspects to achieve business.
	V4	SvcV-1, SvcV-10a	Check whether there are agreements in service structure and process.
	V5	Std-1	Check whether there are standards on measure benchmarking.
	V6	CV-6, OV5b, SvcV-2, SvcV-7, SV-2, SV-7	Determine whether business process and IT process have realized relative requirements.
	V7	CV-6, SvcV-5, SV-5a, SV-5b	Analyze the weak points of results and provide adjustment demands.
Governance	G1	OV-2, OV-5b, CV-1, CV-3, CV-6	Express the business strategy planning.
	G2	SvcV-2, SV-2, PV-1, PV-2, PV-3	Express the IT strategy planning.
	G3	OV-4	Express the relationships among different person types.
	G4	DIV-2, DIV-3	Check whether there is information on budgets and costs.
	G5	CV-2, DIV-3, PV-2, PV-3	Analyze the IT investment in project executing process.
	G6	OV-4	Check whether there exists steering committee in organizational structure.
	G7	CV-3, OV-6c, SvcV-10c, SV-10c, PV-2	Analyze the time sequence relationships in EA.
Partnership	P1	OV-4	Check whether IT participates in business organizational structure.
	P2	OV-4, OV-5b, CV-6, CV-1	Check whether IT participates in business strategy planning.
	P3	OV-4, PV-1, PV-2, CV3, SvcV-7, SV-7	Check whether business and IT roles share goals and risks in projects executing.
	P4	PV-1, PV-2, PV-3	Analyze the project management activities.
	P5	OV-6a, SvcV-10a, SV-10a, Std-1	Check whether there are rules or standards on trust.
	P6	OV-4, CV1	Check whether there are business sponsors or champions in organizational structure.
Scope & architecture	A1	SvcV-5, SV-5a, SV-5b	Determine the enabling or driving factors in IT.
	A2	Std-1	Check the IT standards.
	A3	SvcV-2, SV-2, OV4	Analyze the architecture integration on functions and structures.
	A4	SvcV-2, SV2, SvcV-3a, SvcV-3b, SV-3, OV-6b, OV-6c	Analyze the performances of IT architecture, such as transparency, agility, and flexibility.
	A5	Std-2	Check whether there are standards on managing new ITs.
Skills	S1	Std-1, OV-6a, SvcV-10a, SV-10a	Check whether there are standards and rules on enterprise innovation.
	S2	OV-4	Analyze the organization types for power structure.
	S3	OV-4, PV-1, PV-2	Analyze the management styles in projects executing.
	S4	Std-1, Std-2	Check whether there are standards on changes.
	S5	AV-2, Std-1	Check whether there are standards on personnel training and education.
	S6	AV-1, AV-2, CV-1, OV-1	Check whether there are illustrations on enterprise environments.
	S7	OV-4, Std-1	Check whether there are standards on personnel retiring and hiring.

The data in EA models can be used to measure BITA metrics. For example, the contents in OV4 provide evidence for C1, C2, and C6. In the next step, we will consider how to use these data to calculate the alignment level of each metric.

4.3 Measuring BITA metrics with the above models

With the above EA models, varied measurement techniques can be introduced to evaluate the alignment level of each metric. As the example of Fig. 3, the maturity level of C1 is acquired by the automatic data collection from OV-4. This is an automatic measurement method. Additionally, some BITA metrics cannot be directly measured by EA contents. Measurement techniques should be introduced to integrate the EA contents in different models. We explain three measurement techniques in this paper.

(i) Automatic measurement refers to the capability of reading EA data and calculating the maturity level automatically. According to DoDAF2.0, its architecture data is stored as XSD format based on the physical exchange specification [46]. The architecture data of some BITA metrics can be gathered automatically and converted to the maturity level directly, as the example in Fig. 3.

(ii) Semi-automatic measurement refers to the calculation of some metrics' maturity levels through integrating and processing different EA data. Computational formulas may be necessary for the integration of the EA data. For example, with the structural data in DoDAF2.0, a network connectivity algorithm can be adopted to calculate the value of architecture flexibility (A4). Additionally, simulation methods may also be introduced to operate the EA data. For example, the architecture agility (A4) can be simulated by experimenting architecture reaction speed with different changes.

(iii) Manual measurement refers to the measurement of BITA metrics with manual methods, such as questionnaire surveys and experience-based analyses. The manual measurement exhibits the incapability of EA data in the supporting of the BITA metrics. For example, the enterprise innovation and entrepreneurship metric (S1) cannot be totally explained by EA standards and rules. A questionnaire survey may be needed here.

Therefore, each BITA metric can be measured by the above techniques. The mappings of BITA metrics and measurement techniques are displayed in Table 3, in which the automatic measurement holds the most and the manual measurement holds the least. Table 3 also verifies EA's capability in the supporting of BITA measurement, because quite a lot of metrics can be directly/indirectly measured by EA contents.

Table 3   Measurement techniques for BITA metrics

Technique	Metric
Automatic measurement	C1, C2, C3, C5, C6, V1, V2, V3, V4, V5, G3, G4, G6, P1, P2, P6, A1, A2, S5, S7
Semi-automatic measurement	C4, V6, V7, G1, G2, G5, G7, P3, P4, A3, A4, A5, S2, S3, S4
Manual measurement	P5, S1, S6

4.4 Measuring the holistic BITA maturity

The holistic BITA maturity of any organization can be calculated by the maturity values of leaf metrics and the weights among layers of Fig. 1. These weights can be obtained by qualitative analysis, e.g., questionnaire surveys [6] or quantitative analysis, e.g., structural equation modeling [38,48].

Through the explanation of the above four steps, the BITA maturity can be measured with the help of the DoDAF2.0 meta-model and models. The next section will validate the steps of this section with an illustrative case.

5. An illustrative case study

To demonstrate the proposed process, we introduce an ArchiSurance case [49] in this paper. This case is often used in the EA community. As Iacob argued [49], this case takes the advantage of being realistic and of manageable size without being overly simplistic. ArchiSurance is a fictitious company that provides the home, travel, and car insurances. It focuses on keeping relationships with customers, handling claims and financial issues. Iacob developed the ArchiSurance architecture with an Archimate language [49]. We will explain the BITA measurement process of the ArchiSurance case step by step.

5.1 Identifying correlations between DM2 and BITA metrics

For the sake of simplicity, we will mainly calculate the maturity values of architecture agility and flexibility (A4). According to Fig. 8, A4 is mainly supported by the DM2 entities such as "Organization Type", "Performer", "System", "Service", and so on. These entities and their relationships can form multiple EA models in Table 2.

5.2 Determining and developing DoDAF2.0 models

According to Fig. 8 and Table 2, the corresponding business models, e.g., state transition description (OV-6b), event-trace description (OV-6c) and application models, e.g., services resource flow description (SvcV-2), systems-services matrix (SvcV-3a), services-services matrix (SvcV-3b), systems resource flow description (SV-2), and systems-systems matrix (SV-3) need to be built to support

the architecture agility and flexibility. The above OV models explore the overall business landscape, and the SvcV and SV models compose the physical architecture which can support the business strategy.

We adopt the IBM Rhapsody tool to model the ArchiSurance case. The DoDAF2.0 package is embedded in the IBM Rhapsody. The entities and relationships in IBM Rhapsody are inherited from DM2. According to DoDAF2.0, OV-6c describes the sequence of actions in a scenario. One OV-6c is developed in Fig. 10, which de-scribes the time sequence of handling claims. Six operational nodes exist in this model. Among them, the "Customer" node produces claims. The "Mailroomdeck" node is responsible for receiving and reporting claims, and notifying results to customers. The "Frontofficedeck" node registers claims and produces claim forms. The "Backofficedeck" node produces the claim decisions. The "Evaluator" node assesses claims. And the "Financialdeptclerk" node pays claims.
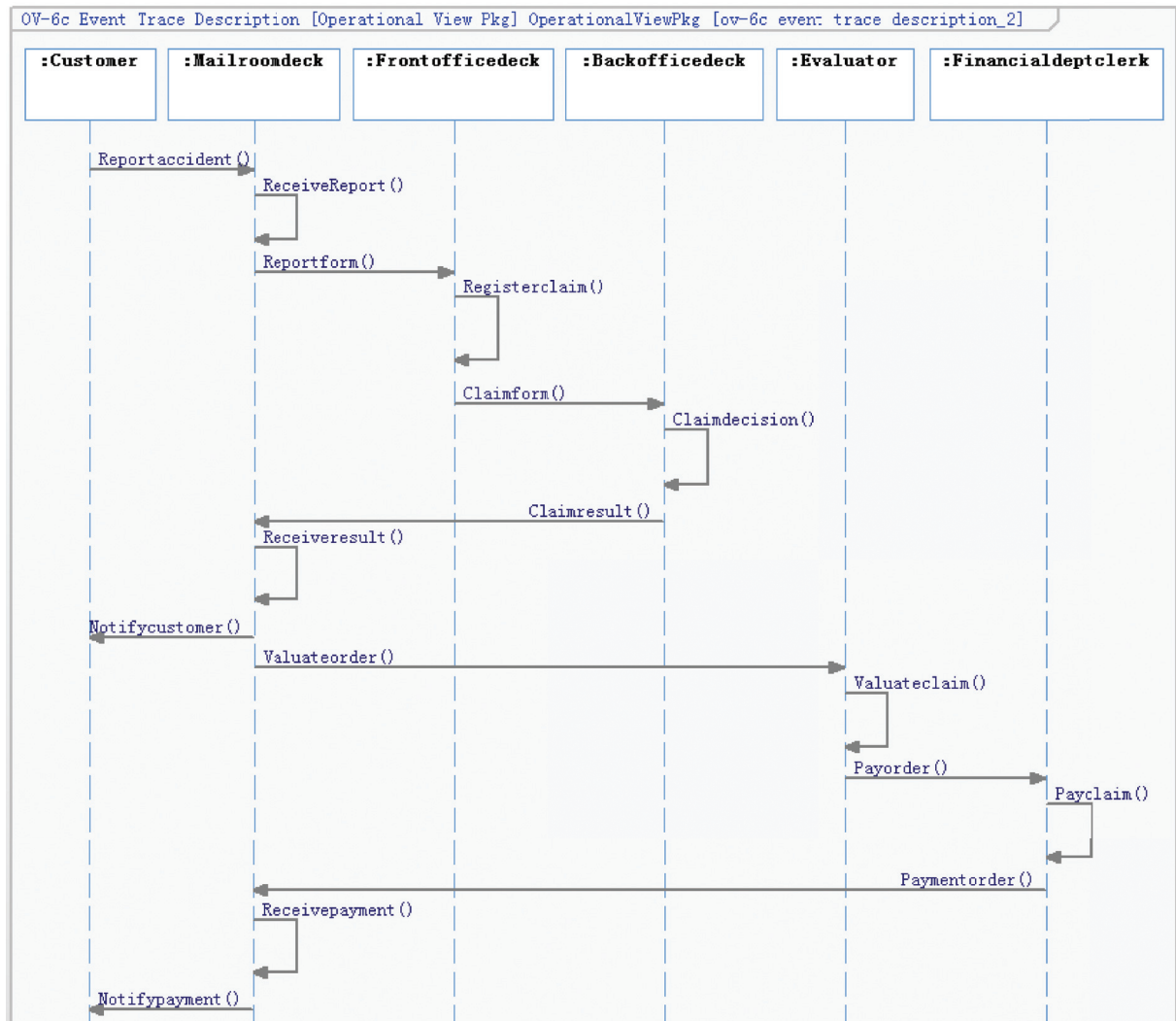

Fig. 10   One OV-6c

Within each operational node, there is one OV-6b that determines the states and transfers in executing business processes. The OV-6b of "Mailroomdeck" is exhibited in Fig. 11, which includes six states and transfers among the states. Operational actions and judging conditions are listed in states and transfers, such as the ReceiveResult action and the ClaimFlag judging condition. These actions determine the holistic function of the operational node. Therefore, the complete business landscape can be built with all of the OV-6bs and OV-6cs.

In addition, the SV and SvcV models can be built based on the above OV models. We integrate the main system contents in one SV-2 model. The SV-2 model identifies the system components, service components, and the actors.

The SV-2 includes the operational nodes and their corresponding systems and services. This model forms the overall physical structure.
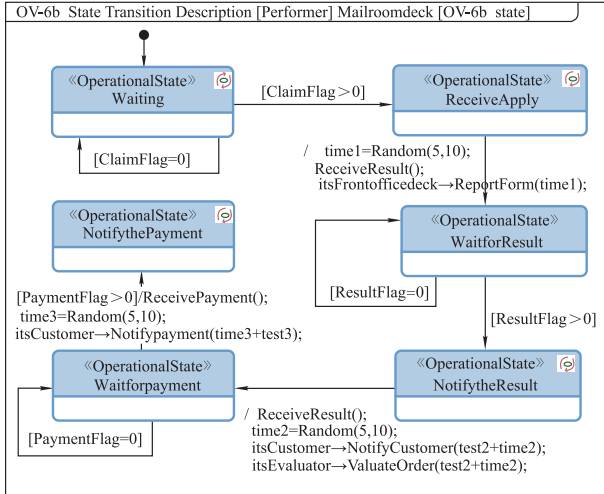

Fig. 11   OV-6b of the "Mailroomdeck" node

5.3 Measuring BITA metrics with the above EA models

As in Section 4.3, this section aims to calculate the maturity levels of architecture agility and flexibility, with the EA data in the above models.

We argue that the architecture agility refers to the firm's average reaction time after receiving claims from customers. We adopt a simulation method to execute the business processes and to acquire the overall processing time in each experiment. Input data should be determined at first. In this paper, we assume the probability of false claims by a customer is 10%, and that of a true claim is 90%. We also assume that the handling time of each information processing event in Fig. 10 accords with a uniform distribution U(5, 20). These events include receiving claims, registering claims, deciding claims and notifying customers. Additionally, the handling time of evaluating and paying claims are also assumed to accord with a uniform distribution U(30, 60). The unit is in minutes.

All of the OV-6b and OV-6c are simulated with the above random data in the models. The overall reaction time has been acquired in each simulation. The running time is plotted in Fig. 12 after executing 100 experiments. The X axis represents the 100 simulation tests and the Y axis shows the time consuming of each simulation. In Fig. 12, quite a lot of claims have received the payments, while several claims are false and rejected. The average reaction time of the 100 experiments is 136.07 min. This value can be used to measure the maturity level of the ArchiSurance firm's agility.

Furthermore, the architecture flexibility refers to the extent of modifying the application structure. In this paper, the graph density can reflect the connectedness of the network structure. As for the SV-2, the higher the graph density is, the higher the architecture flexibility will be. With the help of the graph density algorithm, the graph density of the SV-2 is 0.115, indicating a rather low level of network connectedness. This result can also be converted to the maturity level of the ArchiSurance firm's flexibility.
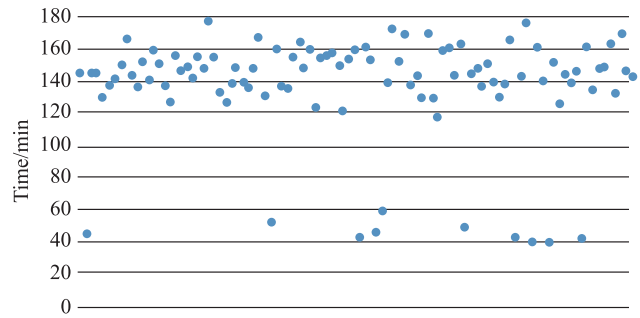

Fig. 12   Reaction time of 100 simulating results

5.4 Measuring the holistic BITA maturity

Through the above illustrations, the maturity levels of architecture agility and flexibility are separately calculated by the simulation and network connectedness algorithm, which provides better support for the measurement of BITA metric. Similarly, the values of other BITA metrics can also be acquired by different measurement techniques. As in Section 4.4, all of the values can be converged into the BITA maturity of the whole organization.

Overall, the whole measurement process represents our thought to associate the organizations' BITA level with EA development results. The same EA development plan may produce different BITA results, which depend on the specific measurement techniques adopted. The four steps are conducted structurally to make the holistic approach more reasonable.

6. Conclusions

To mitigate the insufficient research on BITA measurement with EA, this paper links the BITA maturity model with DoDAF2.0 meta-model and models. The specific association process is divided into four steps. This paper explains each step in detail, and demonstrates the process with an archisurance case.

This paper provides insightful contributions compared to the previous literature. Given the inadequate BITA measurement with EA, this paper proposes a thorough association attempt and illustrates the combination clearly. Further, this paper puts more emphasis on data collection and

integration from EA models. These contributions help to promote the research of combining BITA with EA. However, limitations still exist. For example, this paper does not explain the entities of DM2 and DoDAF models in detail, and this paper does not apply the association to a practical case. These limitations demand motivations for further research. To validate the capability of the proposed method, we will conduct practical research in the next step.

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