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Evolvement of Business-IT Alignment: A Conceptual Model and Intervening Changes From Resource Allocation

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ABSTRACT Recently, dynamic business-IT alignment (BITA) has attracted increasing attentions. However, the description and the governance of dynamic BITA are insufficient in the literature. To address this gap, a conceptual BITA evolvement model is proposed combining enterprise architecture with the BITA maturity framework, and a sustainable BITA factor on dynamic resource allocation is introduced in this evolvement model. To discuss the sustainable factor in a comprehensive way, we explored a series of possible changes and corresponding resource influences within the alignment of business functions and applications. A dynamic resource allocation algorithm is proposed, and an illustrative case study is presented to verify the algorithm's efficiency.

INDEX TERMS Business-IT alignment (BITA), enterprise architecture (EA), resource allocation, business functions, applications.

I. INTRODUCTION

The advantages of business-IT alignment (BITA) have been well recognized and documented since the late 1970s [1]–[5]. In the past several decades, it persisted among the top-ranked concerns of business executives and IT executives [6]. Recently, dynamic BITA has been increasingly emphasized due to changes from various enterprise layers and domains. Baker *et al.* argued that there are two primary perspectives on alignment: alignment as an end-state outcome and as an ongoing process [7]. Chan *et al.* pointed out works that link the two perspectives are likely to be the most difficult but most beneficial [8]. Chen *et al.* deemed alignment as "a moving target" [9]. Benbya *et al.* explained that alignment is not a "state", but a journey that is not unfolded in predictable ways [10]. In brief, how to describe and sustain the BITA evolvement process is a challenging but pivotal issue.

Nevertheless, despite having recognized the importance of dynamic BITA, relevant literature is scarce. Prior studies on dynamic BITA are shown alike limitations which can be summarized into three main aspects. First, the deep structures for describing BITA are relatively inexhaustive, especially in terms of business strategy, IT strategy, business structure and IT structure [11], [12]. Second, with few exceptions, the BITA measurement methods in the dynamic evolvement process are usually insufficient with BITA deep structures. Third, the influence factors (e.g. shared knowledge or mutual understandings [13]) to sustain BITA are inadequately discussed in the literature. To address these limitations, this paper extends previous research from three aspects: (a) due to its abilities to abstract elements and relationships of enterprises, enterprise architecture (EA) is adopted as a comprehensive deep structure to express dynamic BITA; (b) the BITA maturity framework proposed by Luftman [12] is correlated with EA to be a BITA measurement method; (c) to go beyond traditional sustainable factors, a factor based on dynamic resource allocation is introduced, for which possible events that would change resources are explored and a dynamic allocation algorithm is proposed.

The rest of this paper is organized as follows. We first refine the research question on the basis of theoretical background, and then propose a conceptual model of dynamic BITA process. Next, we present a mechanism of dynamic resource allocation and introduce an algorithm to produce a dynamic resource allocation factor. This is followed by an illustrative case to explain the algorithm. Finally, we discuss

TABLE 1. **A few typical studies on addressing dynamic BITA.**

Source	Questions	Description	Characteristics
Sabherwal, et al (2001)	In what ways does alignment evolve over time?	Changes over time were examined using a punctuated equilibrium model, involving long periods of evolutionary change and short periods of revolutionary change.	● Measured alignment through various patterns at a given time. ● Validated dynamics of alignment through punctuated equilibrium model.
Benbya and Mckelvey (2006)	The coevolutionary and emergent nature of alignment.	Alignment is a continuous coevolutionary process that reconciles top-down rational design and bottom-up emergent process.	● Proposed coevolutionary alignment framework from strategy level, operational level and individual level. ● Provided principles to improve coevolution of alignment.
Luftman (2007)	Why attaining BITA has been so elusive and how to measure it?	Five levels of alignment maturity were proposed which help organizations determine their alignment stage and where should improve next.	● Six components and five levels of alignment maturity were proposed to measure BITA at a given time.
Lyytinen and Newman (2008)	How to explain complex IS changes with accuracy, generalizability and simple enough?	Viewed IS change as punctuated social-technical change and provided PSIC model to explain the change process.	● Explained IS changes with a punctuated social-technical model. ● Represented evolvement of a social-technical system by first order change and second order change.
Chen, et al (2008)	How does an organization develop IT to achieve sustain strategy alignment?	Dynamic capabilities perspective was adopted to achieve alignment through positions, processes and paths.	● Dimensions and categories of dynamic capabilities were introduced. ● The lifecycle stages of a case study were explained with dynamic capabilities.
Baker and Jones (2008)	How do organizations sustain alignment over time?	Proposed factors promoting sustained strategic alignment and argued organizations that have been at a high level of strategic alignment for one or more time periods are more likely to be at a high level in future time periods.	● Proposed conceptual model of sustained strategic alignment. ● Proposed factors promoting sustained strategic alignment.
Baker, et al (2011)	How can sustainable strategy alignment be conceptualized and quantified?	Conceptualizing strategy alignment as a dynamic capability from static alignment, historical alignment and the maturity of alignment processes.	● Conceptualizing and quantifying sustained alignment through three aspects.
Tallon and Pinsonneault (2011)	Faced with rapid and often unanticipated changed, what are the relationships between alignment and agility?	Discussed the relationships between alignment and agility under IT flexibility and environmental volatility.	● Alignment has no direct effect on firm performance. ● If considered the mediation effect of agility, the indirect effect of alignment on firm performance is significant.
Wagner (2014)	How are governance mechanisms, business outcomes, and business-IT alignment interrelated over time?	Discussed alignment levels under different governance mechanisms in different segments.	● Demonstrated specific mechanisms influencing alignment patterns. ● Depicted the co-evolvement of shared knowledge and mutual understanding over time.
Haes (2015)	How to apply enterprise governance of IT in achieving sustainable BITA?	A mixture of various structures process and relational mechanisms of enterprise governance of IT were deployed to achieve BITA.	● Proposed practices for enterprise governance of IT. ● Explained various enterprise governance of IT principles.
Ohlsson, et al (2016)	How to achieve sustainable BITA?	Designing a circular organizational Structure of business roles and IT roles in a case study.	● Proposed three components for achieving sustainable BITA within a circular organization.

our findings, as well as the limitations and implications of the paper.

II. RESEARCH QUESTION

BITA contributes to "maximize the return value of IT investments", "provide direction and flexibility to react to changes", and "improve company performance" [6]. Recently, scholars have recognized the dynamic characteristics of BITA and have developed studies with deep insights. After collecting the literature on dynamic alignment with a set of keywords including "dynamic", "change", "sustainable", "strategy alignment", "business alignment", "IT alignment", and "business-IT alignment" we found the volume of the literature on dynamic BITA is relatively small. While most of the literature acknowledge the importance of dynamic BITA, few has explored the mechanism of it in a sophisticated way. Wagner and Heinz-Theo pointed out that the literature on the interrelationships among capabilities of continuously adapting and changing, achieved levels of the alignment, and business outcome is rare and the goal of achieving alignment in this respect is elusive [13]. A few typical studies on dynamic BITA are listed and summarized based on their research questions and approaches, which are displayed in Table 1.

According to the summary of the literature in Table 1, several limitations and implications can be inferred:

(1) The description of dynamic BITA process frequently involves several constructs. The first construct is deep structure, which helps to describe the alignment structure of organizations or firms. Sabherwal *et al.* described the deep structure with a strategic information systems management profile embracing business strategy, business structure, IS strategy, and IS structure [11], which is similar to the research of Henderson and Venkatraman [5]; Lyytinen *et al.* explained the deep structure of information system from the perspectives of structure, actors, task and technology [14]. However, the majority of the literature discussing deep structures is inadequate and conceptualized which may lead to a difficulty in measuring the alignment between business and IT in practice. The second construct is BITA measurement method, which is the methodology to measure the BITA with the deep structure at each given period of time. Sabherwal *et al.* applied distances of different alignment patterns between any two dimensions to express low, medium or high alignments [11]. Gaps between any two dimensions were used to represent the unbalance [14]. Haes *et al.* summarized several measurement methods [17]. As a result, with the limitation of deep structures, the BITA measurement methods were always unsophisticated or incomplete. The third construct is the critical incident, representing the events that may cause different kinds of misalignment, such as the volatility of the business or IT environment. The fourth construct is intervention, which is the attempt to mitigate the misalignment, such as skills training and enhanced communication. Finally, another concept is the punctuation, which explains the intervals between adjacent BITA evolvement stages. The BITA evolvement process may contain a series of punctuation. The five constructs from the literature provide a thread to understand the BITA evolvement process in a comprehensive way.

(2) Several papers have explored the antecedents for promoting sustainable BITA. Wagner *et al.* argued that shared knowledge and mutual understandings between business departments and IT departments are the main factors to sustain BITA [11]. Baker *et al.* discussed that shared domain knowledge, strategic business plans, aligned reporting relationships and aligned incentive structures are the most sustainable components of BITA [7]. Ohlsson *et al.* pointed out strong top leadership, business responsibility and CIO's role as a facilitator and coordinator is the key to achieve sustainable BITA [18]. In addition, dynamic resource allocation is considered an important factor of sustainable BITA in this paper. This antecedent hasn't attracted much attention in previous literature. The term "resources" we used here refers to an assemblage of systems, services, persons, and data. Luftman *et al.* pointed out the allocation of resources is among the most important enablers/inhibitors of alignment of any kind in firms [19], but most firms face severe challenges in succeeding effective allocation of resources [12]. From a perspective of his maturity framework, dynamic resource allocation helps improve the maturity level of budgetary control and IT investment management in governance criteria.

(3) Several papers argued that better firm performances can be achieved in the presence of sustainable BITA. Talion *et al.* discussed the relationships between BITA and firm performance, and reached a conclusion that sustainable BITA helps achieve better performances [16]; Jorfi *et al.* also explored the relationships between BITA, IT flexibility, and IT capabilities, and argued a positive effect of BITA on IT flexibility [20]. Therefore, integrating the above five elements and applying complete sustainable factors allow companies to successfully achieve high performance. Accordingly, there is a need to extend previous research from three aspects. First, a more detailed deep structure for describing dynamic BITA needs to be introduced given the extant discussion on deep structures. EA is a structured and aligned collection of plans for the integrated representation of the business and information technology (IT) landscape of an enterprise, in past, current and future states [21]. It is a comprehensive approach and tool to describe and achieve BITA [22]. EA helps shape the alignment structure in a more detailed way. In this paper, EA is adopted as the deep structure to suit our needs. Second, given the simplicity of BITA measurement methods, a more accurate and comprehensive measurement method is desirable. In his summary of BITA maturity assessment, Luftman *et al.* proposed a complete maturity framework involving six criteria and five levels [12], [19], [23]. The current research will incorporate the maturity framework and use those criteria and levels to combine with EA. Third, we go beyond those traditional sustainable BITA factors by integrating a dynamic resource allocation factor to address the incidents where resources are poorly allocated and ineffectively utilized. Various kinds of critical incidents that may lead to reallocation of the resources will be explored and corresponding dynamic resource allocation approach will be proposed.

In brief, compared to prior literature, this paper aims to develop a dynamic BITA evolvement model through an integration of EA into the BITA maturity framework, while considering a dynamic resource allocation factor to achieve sustainable BITA.

III. BITA EVOLVEMENT ANALYSIS

In this section, we first provide a conceptual model to frame BITA evolvement process. Then, we take into account the alignment pattern between business functions and applications from the EA perspective, and explore all of the possible critical incidents between them. Finally, we analyze the intervention of dynamic resource allocation,

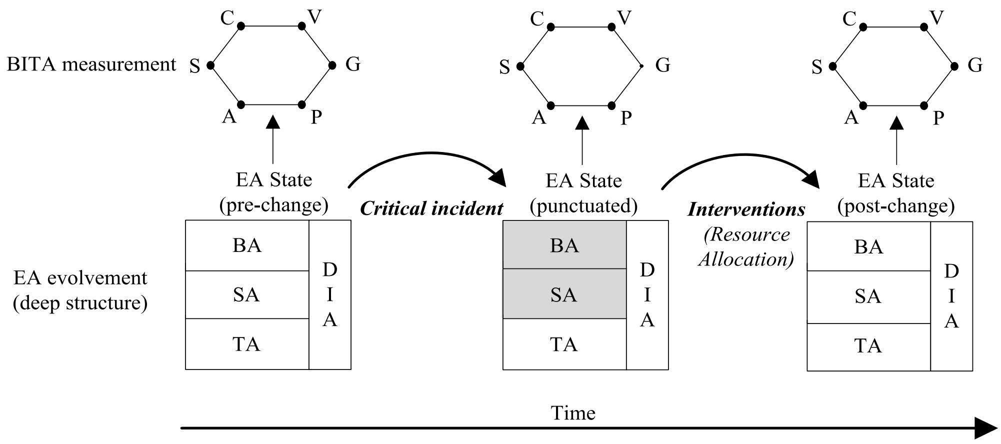

FIGURE 1. A conceptual model for BITA evolvement process.

and propose a corresponding algorithm for sustained realignment.

A. A CONCEPTUAL MODEL FOR BITA EVOLVEMENT PROCESS

The conceptual model proposed here is a structural abstraction combining alignment in an end state and alignment in the process. Based on the analysis in section 2, we integrate the deep structure, BITA measurement method, critical incidents, interventions punctuation in a punctuational model. The punctuational model is shown in Figure 1.

EA is a structured and aligned collection of plans for the integrated representation of the business and information technology (IT) landscape of an enterprise. Given the complexity and abstractness of EA, we adopt the EA framework which provides various viewpoints to shed light on enterprise design tasks and to produce valuable architecture description documentation. In our model, we select four viewpoints which are commonly used and central in various EA frameworks, such as DoDAF, TOGAF, and MoDAF [24]. First, Business Architecture (BA), used to define business strategies, processes, and functional requirements [25], typically contains business processes, organizational structures, business functions, etc. Second, System Architecture (SA), which describes the applications to fulfill business requirements [25], typically includes applications, application services, etc. Third, Technology Architecture (TA), which refers to the infrastructure and system components that are necessary to support the application, includes software, hardware, networks, etc. Fourth, Data and Information Architecture (DIA), which describes what an organization needs to know to successfully operate [25], includes data structures and information entities existing in each layer. With this simplified EA framework, the alignment of business and IT can be understood as the alignment of different contents within one EA layer or between two EA layers. An example of BITA in this framework would be the alignment between business functions in BA and applications in SA.

To measure BITA at each given time with EA, a comprehensive BITA measurement method to reflect where BITA stands accurately is critical. Luftman's maturity framework is widely adopted for BITA measurement. His framework includes six criteria: communications (C), competence/value measurement (V), governance (G), partnership (P), scope & architecture (A) and skills (S) [12]. Several articles have integrated the EA framework with Luftman's measurement method [26]–[28]. For example, to evaluate BITA with the Zachman framework, Plazaola compared the metamodel of the Zachman framework and Luftman's maturity model, and proposed a process for collecting data for BITA measurement with Zachman artifacts [27]. Overall, as in Figure 1, we calculate the BITA maturity level at each given time with EA documentation.

General speaking, due to strong inter-dependencies among EA artifacts, an enterprise would have achieved BITA after EA development. Occasionally, a misalignment occurs when one artifact becomes incompatible with others due to business dynamics or IT changes. The situation would render certain risk and consequently harm the enterprise. For example, changes in business functions may lead to misalignment between business functions (BA) and applications (SA), as shown in grey in Figure 1. As a result, the misalignment is reflected in the BITA measurement model, as represented by the small dot G in Figure 1. The misalignment is a contingency in the EA that threatens the BITA and reduces company performance. Any event that generates a misalignment is a critical incident, such as the changes of business functions in the above example. Thus, we consider critical incidents as events that affect EA states in a way that threatens or significantly decreases the alignment level reflected in Luftman's maturity framework.

Attempts to remove misalignments are specific types of events called interventions [14]. They are measures oriented towards one or multiple EA viewpoints or artifacts that can be controlled or manipulated to mitigate or to remove an observed misalignment. For example, in order to realign the business functions and applications in Figure 1, allocating resources to applications for creating new applications or updating old applications is an effective intervention. To analyze this intervention thoroughly, we explore all possible critical incidents that may influence the resources and propose a dynamic resource allocation mechanism to address these critical incidents.

Obviously, critical incidents may cause misalignment and resources should be consumed to achieve realignment. For example, due to changes of environment, a firm introduces a new ''innovation management'' function into its existing business function set, causing a misalignment with existing applications. To realign the new business function set with the applications, it is necessary to add new applications and update or even obsolete old applications. To this end, resources such as budgets or technicians should be allocated to implement different realignment strategies. With regard to the EA framework in Figure 1, the misalignment may occur within a layer, such as misalignment between business processes and business functions in BA, or between different layers, such as misalignment between business functions in BA and applications in SA. For brevity, misalignment between business functions and applications is selected to be discussed in this article for demonstration (located in the grey part of Figure 1). A business function (e.g. an ''investment management'' function) is a description of work performed to accomplish responsibilities of business units. Business functions result from the process of BA development. An application (e.g. an ERP system) is a building block to provide services to fulfill business actions. Applications are expected to satisfy the requirements of business functions.

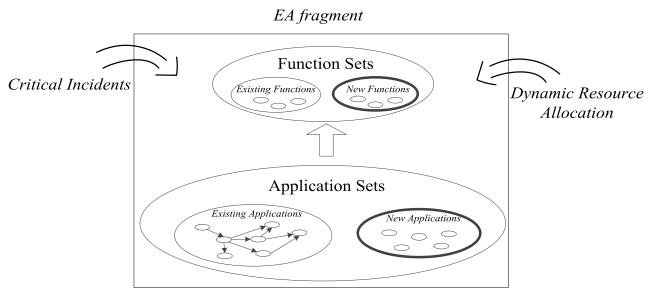

FIGURE 2. A sub-conceptual model of alignment between business functions and applications.

A sub-conceptual model for the alignment between business functions and applications is shown in Figure 2. ''Existing Functions'' and ''Existing Applications'' are contents in EA prior to changes. In the pre-change stage, the applications have formed a structure to support existing business functions. When critical incidents occur, ''New Functions'' or ''New Applications'' are added to the original sets (as the bold ellipse in Figure 2), and thus cause a misalignment. To realign the function and the application sets, the firm is required to interfere with proper strategies which would usually consumer additional resources. Therefore, the question in the following sections aims at realigning business functions and applications in EA through dynamic resource allocation mechanism. Solving this question helps improve the maturity level of governance criteria of the BITA maturity framework.

To answer the question, the target is to achieve an efficient value for functions with different application portfolios, based on pre-determined resource restrictions. Therefore, we propose a quantitative mathematical programming method to simplify the complexity and scale of the solution.

B. CRITICAL INCIDENTS CAUSING MISALIGNMENT BETWEEN BUSINESS AND APPLICATIONS

Exploring different kinds of critical incidents helps induce changes in EA evolution, and allows managers to take proactive actions. From the literature, critical incidents may root in dynamic volatility of business environment or rapid innovation of information technologies [16]. Without loss of generalizability, we list three categories of critical incidents that occur in the EA framework and directly lead to misalignment between business functions and applications: business function changes in BA, application changes in SA, and data changes in DIA.

Business function changes are reflections of business environment volatility. For example, an ''innovation management'' function is added to the existing business function set as a response to the increasing market pressures. The changes in business function include adding new business functions, updating existing business functions, or removing existing business functions.

Application changes are results of dynamic system requirements. For example, applications are updated to take advantage of new technologies. Simon *et al.* analyzed optimization of options of applications from creating applications, modifying applications and obsoleting applications [29]. Similarly, to satisfy the dynamic system requirements, we deem that the application changes include adding new applications in existing application structure, replacing existing applications with new applications, updating existing applications and disposing applications.

Data changes refer changing the data used for achieving the alignment of business functions and applications. For example, the weights of business functions may change due to dynamic market environments, leading to an unbalanced and insufficient existing applications set. Data changes include changing weights of business functions, changing costs of applications, and changing applications' supporting values for various business functions.

Overall, different kinds of changes directly lead to misalignment of business functions and applications. The mappings between critical incidents and leaf changes are called composition relationships, as shown in Figure 3.

To respond to the leaf changes, we consider various coping strategies to realign business functions with applications. Provided that a new business function needs to be added in existing business function set, the coping strategies may

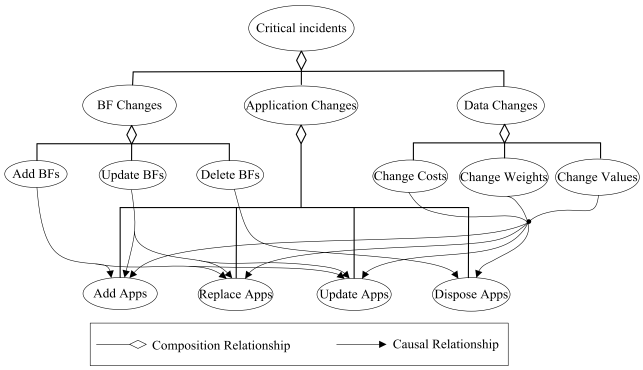

FIGURE 3. **Various types of changes on alignment between business functions and applications.**

include adding new applications to fulfill the new function, updating existing applications to enhance their functionality, or replacing existing applications with more capable applications. For example, assuming a firm intends to add a ''quality management'' function, the strategies would be either introducing an ''online store'' application, or updating the existing ''ERP system'' application, or replacing ''ERP system'' with a new ''SAP system'' application. The key issue is how to select the combinations of different strategies to form an effective application portfolio constrained by limited resources. Furthermore, the strategies to manage the changes of ''Update business functions'' and ''Delete business functions'' can also refer to the application changes.

Further, application changes are immediately deployed in EA to better fulfill business functions. They are the coping strategies in their own right. However, the resource constraint is a pre-condition for the changes.

Data changes also demand a new alignment between business functions and applications. To achieve effective business functions, adding new applications, replacing existing applications, updating existing applications or disposing applications are all possible strategies. For example, when the weights of business functions are changed, it is likely that the existing application set no longer satisfies business functions efficiently. As a response, introducing new applications, or other feasible strategies, is required. Thus, the mappings between business functions and applications need to be rebuilt.

Accordingly, we use the four application strategies to address each kind of critical incidents. Casual relationships exist between the leaf changes and strategies, as shown in Figure 3. An analysis of the application strategies help form an effective dynamic resource allocation intervention. Exploring the resource influences on different kinds of application strategy, and analyzing the combination of the total resource consumption in different strategies, help realign the business functions and applications efficiently.

C. RESOURCE ALLOCATION ON REALIGNMENT BETWEEN BUSINESS FUNCTIONS AND APPLICATIONS

In this section, we firstly explore the resource influences for the aforementioned four kinds of application strategies. Then we present a resource allocation formula and the detailed algorithm.

1) RESOURCE INFLUENCES OF APPLICATION STRATEGIES

This section will discuss the resource consumption in each of the strategic scenarios. Because an application structure exists in the initial alignment (Figure 2), there is a need to consider the structure's change when modifying the applications. We introduce a method based on application degree to measure the changes of the application structure, which is the sum of in-degree and out-degree of an application. Applications with a higher degree are more difficult to update or replace than the others because they contain multiple, complex relationships with other applications, and thus the corresponding cost of updating or replacing will be higher. Below we separately discuss the four kinds of application strategies.

a: ADDING NEW APPLICATIONS TO EXISTING APPLICATION STRUCTURE

Supposing a new application from a new application set is introduced to an existing application structure, this new application typically developed based on other existing relational applications, as shown in Figure 4 where the black ellipse in Figure 4 represents the new application. The new application set would be acquired from BA design, on the basis of experiences or knowledge.

From the perspective of expense, there is a creating cost for adding a new application ($\cos t_{ad}^{j}$, j represents the jth new application). Meanwhile, there is a creating cost for building relationships with existing applications ($\cos t_{cr}^{j}$), which is the sum of the number of relationships. We adopt the application degree to calculate the cost for building relationships ($\cos t_{cr}^{j} = de_j \times \cos t_{cr}^{re}$, where de_j represents the sum of relationships with existing applications, which is 2 in Figure 4, and $\cos t_{cr}^{re}$ is a constant unit cost to establish each relationship). Therefore, the overall cost of adding a new application in existing application structure is the sum of the creating costs for the application and the creating cost for the relationships ($\cos t^{j} = \cos t_{ad}^{j} + \cos t_{cr}^{j}$).

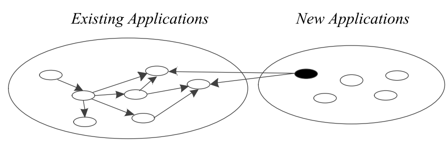

FIGURE 4. **Adding new applications.**

b: REPLACING EXISTING APPLICATIONS WITH NEW APPLICATIONS

Supposing an existing application in an application structure is going to be replaced by a new application from a new application set, the new application needs to be created and to replace the existing application, and to relate with other existing relational applications, as shown in Figure 5 where the black ellipse application replaces an existing application

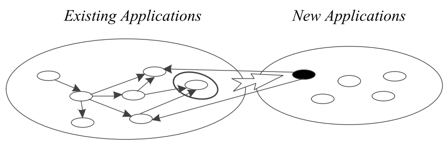

FIGURE 5. Replacing existing applications.

and establishes relationships with other two existing applications. For example, the "cloud computing" application replaces traditional "data process" application, followed by establishing new connections with other applications.

From the perspective of expense, there is a replacing cost to create and to deploy a new application ($\cos t_{re}^{j}$, j represents the jth new application). Meanwhile, because the new application has to build relationships with other existing applications, there is a creating cost for building relationships ($\cos t_{cr}^{j} = de_j \times \cos t_{cr}^{re}$, the same as the equation in the first scenario). Therefore, the total cost for replacing an existing application with a new application is the sum of the replacing cost and the creating costs for relationship building($\cos t^{j} = \cos t_{re}^{j} + \cos t_{cr}^{j}$).

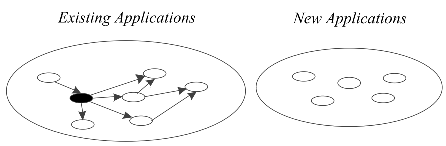

FIGURE 6. Updating existing applications.

c: UPDATING EXISTING APPLICATIONS

In order to meet new business or system requirements, it is possible for an existing application to update to enhance its functionality, while retaining the relationships with other applications. This is shown in Figure 6 where the black ellipse application is the one to be updated, and it has five relationships with other applications to maintain. For example, to improve the flexibility of an enterprise, component-based applications need to update to service-based applications. Their application interfaces would be changed accordingly.

From the perspective of expense, renewing the application entails an updating cost ($\cos t_{up}^{i}$, i represents the ith existing application). Meanwhile, a maintenance cost is also necessary to retain the relationships between the updated application and other applications, as calculated by the sum of all the relationships to be maintained ($\cos t_{ma}^{i} = de_i \times \cos t_{ma}^{re}$, where $\cos t_{ma}^{re}$ is a constant unit cost for maintaining each relationship). Therefore, the total cost for updating an existing application is the sum of the updating cost of an application and the maintaining costs of all its relationships ($\cos t^{i} = \cos t_{up}^{i} + \cos t_{ma}^{i}$).

d: DISPOSING EXISTING APPLICATIONS

Obsoleting existing applications is likely the preferred option when applications are no longer necessary. This is managed specifically for a business unit considered no more financially viable [29]. For example, traditional "database storing" application may become obsolete with the introduction of "XML storing" application. There is no cost associated with this strategy.

The holistic resource allocation intervention for managing each critical incident can be seen as a combination of the four types of application strategy. Nonetheless, the original application set supports unchanged requirements, if any. The intervention aims at obtaining a proper application portfolio from existing and new applications to satisfy both the unchanged and new requirements.

2) DYNAMIC RESOURCE ALLOCATION MODEL

Considering a situation in practice where a proper application portfolio is extracted to satisfy both the changed and unchanged part in BITA evolvement. For example, when new business functions are introduced to address dynamic business requirements, some of the existing business functions remain as they were to support the unchanged business requirements. The acquired application portfolio is expected to support both the changed part and unchanged part.

In a way, adopting existing applications to address the unchanged part can be considered as an alternative strategy in addition to the four strategies discussed above. When original applications are still fit in the system, it is uneconomical to create new applications to satisfy original functions. Therefore, the total cost to fulfill an unchanged part with an existing application is 0 ($\cos t^{i} = 0$).

$$
\begin{aligned}
&\max \sum_{k=1}^{p} \omega_k V_k(x) \\
&= \max \sum_{k=1}^{p} \omega_k \{V_k^{(1)}(x) \cup V_k^{(2)}(x) \cup V_k^{(3)}(x) \cup V_k^{(5)}(x)\} \\
&\quad \times eg. \sum_{j=1}^{l} (\cos t_{ad}^{j} + \cos t_{cr}^{j}) x_j^{(1)} + \sum_{j=1}^{h} (\cos t_{re}^{j} + \cos t_{cr}^{j}) x_j^{(2)} \\
&\quad + \sum_{i=1}^{m} (\cos t_{up}^{i} + \cos t_{ma}^{i}) x_i^{(3)} + \sum_{i=1}^{m} \cos t^{i} x_i^{(5)} \\
&\quad - \sum_{i=1}^{m+h+l} \sum_{j=1}^{m+h+l} syn(i,j) \le Cost, \quad x_i, x_j = 1,\ 0 \\
&\quad \times x_i^{(3)} + x_i^{(5)} \le 1, i = \{1 \ldots m\} \\
&\quad \times x_j^{(2)} + x_i^{(3)} \le 1, ifjreplacesi, i = \{1 \ldots m\}, j = \{1 \ldots h\} \\
&\quad \times V_k(x) > 0, \quad k = \{1 \ldots p\}
\end{aligned}
$$

We compose these 5 strategies to form a proper application portfolio to shift from original applications to new applications to address changes in business functions, data, and applications. This is simplified as a mathematical optimization problem: the aim is to achieve a high value on business functions; the constraints involve budgets, cost, and preference relationships A resource allocation model for application portfolio analysis is developed as formula 1.

The first row of the formula aims to maximize the total value of business functions. Here, p is the number of business functions, which include the existing business functions and new business functions. ω represents the weights of the functions, and are different from the initial weights in the EA design stage. The weights may be point values or interval values. Interval values are discussed in this paper due to the difficulty to acquire exact weights. V refers the supporting values of corresponding application portfolio, which varies in different application strategies. The calculation of the values requires addition rules.

The first constraint limits the total cost of each possible application portfolio to avoid over budget. Here, m is the number of existing applications, h is the number of new applications used to replace existing applications, and l is the number of applications used to add in the existing application structure. x represents whether the application will be selected, denoted as 1 or 0 (selected = 1). The cost of each application is the same as it was in the above section. $syn(i, j)$ represents the synergic relationship between two applications. It is a cost discount if both are selected.

The second and third constraints indicate that statuses of an application are mutually exclusive. That is, in the second constraint, an application cannot be updated and kept unchanged simultaneously. If the updating strategy is applied to one existing application, there is no reason to assume this application would remain unchanged. Similarly, in the third constraint, an application is not supposed to be updated while simultaneously be replaced by a new application. The fourth constraint describes the positive definition of the value of each business function.

The above mathematical optimization model simplifies the application portfolio selection problem under different kinds of critical incidents, such as business function changes, applications changes and data changes. The model helps optimize the mappings between business functions and applications with a relatively low cost and a relatively high supporting value. As a result, the maturity level of governance criteria in BITA maturity framework will be improved.

3) DYNAMIC RESOURCE ALLOCATION ALGORITHM

This section proposes an algorithm to solve the above model. Part of the algorithm adopts a bubble comparison algorithm on portfolio decision analysis provided by Kangaspunta [30]. As follows, the overall algorithm includes four steps.

Algorithm 1 Determine the Ultimate Application Portfolio After EA Changing

Step 1: Calculate all of applications' cost in each strategy
Step 2: Get all of the feasible portfolios P_F
Step 3: Get all of the cost-efficient portfolios P_{CE}
Step 4: Get the ultimate portfolio P_U

In Step 1, we calculate the costs of applications in each strategy. An application may include several kinds of cost because of its presence in multiple strategies. For example, two kinds of costs would be calculated if an existing application can be either updated to fulfill new business functions, or kept unchanged to satisfy the original business functions. All kinds of cost for each application are inputs for the following steps.

In Step 2, we obtain all of the feasible portfolios, denoted as P_F. Feasible portfolios refer to the application portfolios that meet all of the four constraints in formula 1. It is a key step to integrate the five strategies.

In Step 3 we aim to obtain all cost-efficient portfolios, denoted as P_{CE}. Cost-efficient portfolios achieve higher business function values with lower total costs. Cost-efficient portfolios are a subset of feasible portfolios. Because the weights are interval values, there are multiple cost-efficient portfolios. The cost-efficient portfolios are obtained by Kangaspunta's algorithm used to address a weapon portfolio problem [30].

Given the cost-efficient portfolios, we aim to select one ultimate portfolio, P_U, as an optimal solution in step 4. Several principles in the domain of operation research are applied here, including a minimum-regret rule, maximum rule, and so on [31]. Consequently, we acquire an ultimate application portfolio to align with business functions.

Specifically, we propose the pseudocode to address step 1 and step 2 in detail. This includes 5 sub-steps. In sub-step 1, applications are enumerated by order of strategy (5), (3), (2), (1). The applications would be repeated with different strategies. The total number of X is $2m + l + h$. Each possible value portfolio in X forms an application portfolio. Sub-step 2 calculates the costs of applications in X, including degree calculation and cost calculation. Sub-step 3 stores all of the synergic relationships by enumerating each pair of applications in X. Sub-step 4 enumerates all of the possible combinations of 1 or 0 for each application, and then all of the application portfolios are stored. Sub-step 5 is the core to calculate the feasible portfolios which can be divided into 5 steps. In sub-step 5(a), all of the possible application portfolios are enumerated by varying the value of X. In sub-step 5(b), the set of feasible portfolios is initially empty and the index k and p are set to zero. In sub-step 5(c), the index p is increased by one and in sub-step 5(d), the algorithm iterates through all portfolios in an increasing order until the index reaches k. In the next few steps, we ensure the constraints in formula 1 by checking the constraints one by one. Finally, in sub-step 5(e), the final set of all feasible portfolios is recorded.

Furthermore, we acquired all cost-efficient portfolios applying Kangaspunta's portfolio decision analysis algorithm [30]. Finally, the maximum rule or minimum-regret rule help determine the ultimate portfolio. As a result, an application portfolio is acquired to fulfill the business functions suffering various critical incidents.

The algorithm provides a reference for other types of alignment in EA, such as alignment between business processes and business functions, alignment between applications and

TABLE 2. Mappings between existing business functions and applications.

	F_1 : Operations Management	F_2 : Customer Management	F_3 : Innovation
A_1 : Kookaburra	X	X	
A_2 : SAP	X		
A_3 : Dashboard metrics data	X		
A_4 : Respect inside conformity website	X		
A_5 : B2B platform		X	
A_6 : Switcher Friends		X	
A_7 : Web presence		X	
A_8 : Respect-code.org		X	X
A_9 : Respect inside community website			X

Algorithm 2 Dealing With Step1 and Step2 of Algorithm 1

1. *Define* $X = \{x_1, \ldots x_m, x_{m+1}, \ldots x_{2m}, x_{2m+1}, \ldots x_{2m+l}, x_{2m+l+1}, \ldots x_{2m+l+h}\}$
2. $for(i = 1, \ldots 2m + l + h)$
   $\deg(x_i)$; $Cost[i] = \cos t(\deg(x_i))$
3. *Define* $k = 0$
   $for(i = 1, \ldots 2m + l + h; j = 1, \ldots 2m + l + h; i \neq j)$
   $if\ \exists syn(i, j) < 0$
   $Syn(i, j, k) = syn(i, j); k = k + 1$
4. *Define* $k = 1$
   $for(v_1 = 0, 1; v_2 = 0, 1; \ldots; v_{2m+l+h} = 0, 1)$
   $List(k) = [v_1, v_2, \ldots, v_{2m+l+h}]; k = k + 1$
5. (a) *Define* $P = \{List(1) \ldots List(2^{2m+l+h})\}$
   (b) *Set* $P_F^0 = \Phi\ k = 0\ q = 0$
   (c) *Set* $q = q + 1$;
   (d) *While* $k < 2^{2m+l+h}$ *do*
   $for(i = 1, \ldots, m)$
   $if\,(P(k)_i + P(k)_{m+i} > 1)$ *then* $k = k + 1$ *and go to*(d)
   $for(i = 1, \ldots, m; j = 1, \ldots, l; x_{2m+j}$ *replaces* $x_i)$
   $if\,(P(k)_{m+i} + P(k)_{2m+j} \neq 1$ *or* $P(k)_i + P(k)_{2m+j} \neq 1)$ *then* $k = k + 1$ *and go to* (d)
   $if\,(P(k) \otimes Cost - Syn(P(k)) > Budget)$
   then $k = k + 1$ *and go to* (d)
   Set $P_F^q = P(k) \cup P_F^{q-1}$ *then* $k = k + 1$ *and go to* (c)
   (e) *Set* $P_F = P_F^{2^{2m+l+h}}$

technologies, alignment between capabilities and services, and so on. Due to the complexity and scale of the resource allocation problem, mathematical solution is necessary to align different contents in EA. The solution helps restore alignment in a timely manner after misalignment occurs.

In summary, the algorithm helps choose proper dynamic resource allocation interventions to address the different kinds of critical incidents in the BITA evolvement process (Figure 1). While meeting the budgets, a new application portfolio obtained would achieve a higher maturity level of governance criteria in BITA maturity framework.

IV. AN ILLUSTRATIVE CASE STUDY

In this section, we verify the above resource allocation algorithm through a modified case of Switcher SA [32]. Fritscher and Pigneur developed business models for Switcher SA in detail and built the alignment between business models and EA with Archimate language [32]. The business contents and applications are selected in this paper for demonstration. Switcher SA is a small private company engaged in the manufacture and distribution of garments with a particular focus on social responsibility throughout the whole value chain, from resource production to product distribution. In this section, we firstly describe the case background as well as the emergent changes of their business functions; then we collect the data for realigning business functions and applications; finally, we illustrate the achievement of alignment using a new application portfolio structure derived from the algorithm discussed above.

A. CASE DESCRIPTION

We explore the business contents and system contents of Switcher SA in terms of its EA and business model. According to the case, there are three main business functions in Switch SA, including operations management function (F1), customer management function (F2) and innovation function (F3). Nine applications are selected to support the three functions [30]. The applications and their supporting functions are displayed in Table 2. The firm has achieved the alignment of the business functions and the applications through the mapping relationships. The initial data including weights of the functions, supporting values and costs of the applications.

Recently, the garment market is highly competitive due to globalization [33]. The trend of globalization and intensive competition increases a collaborative culture in the enterprises. The supply chain has gradually changed to

TABLE 3. Costs of applications, relationships and budget.

	$cost_{ma}^{re}$	$cost_{cr}^{re}$	$cost_{ad}$	$cost_{re}$	$cost_{up}$	**Budget**
Cost	100	150	900	1000	800	6000

TABLE 4. Cost synergies of applications and their discounts.

	A5, A7	**A3', A4'**	**A10, A11**
Discount	-150	-150	-200

TABLE 5. Supporting values of all applications for new functions set.

Value	**A1**	**A2**	**A3/A3'**	**A4/A4'**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**
F1	0.7	0.7	0.7/0.8	0.8/0.9	0/0	0/0	0/0	0	0	0	0	0
F2	0.7	0	0/0	0/0	0.7/0.9	0.7/0.8	0.8/0.9	0.8	0	0	0	0
F3	0	0	0/0	0/0	0/0	0/0	0/0	0.8	0.8	0	0	0
F4	0	0	0/0.8	0/0.9	0/0.8	0/0.7	0/0.8	0	0	0.9	0.8	0.7
F5	0	0	0/0.7	0/0.8	0/0.8	0/0.6	0/0.7	0	0	0.9	0.8	0.7

collaborative networks. Enterprises composing the collaborative networks are integrated with each other and become more competitive and efficient. Therefore, the enterprises become more complex and hard to understand. In order to meet these trends, two business functions are introduced to the existing function set. One is personnel training function (F4), which is used to cultivate knowledge and skills for different roles in Switch SA and its partners; and the other is partner management function (F5), which is used to manage relationships and share information with partners such as garment manufacturers and logistics companies. In the new setting, five business functions exist and the business function changes, resulting in a new function set which we called post-change business function set.

In order to support the post-change business function set, the above five application strategies are considered. The application set is composed of the original application structure and several new applications. New applications are gathered through analyses on new business functions within EA. We won't discuss those analyses in detail in this paper.

Given the post-change business function set, several application strategies are introduced. First, existing 9 applications still function well to support the original 3 functions (the unchanged part). Second, 3 new business functions are introduced to support F4 and F5: the first is a collaboration network application (A10), which harmonizes different roles in Switch SA and its partners; the second is a knowledge generation application (A11), which induces and stores knowledge from daily experiences; the third is a knowledge training application (A12), which cultivates the skills and understandings on businesses and IT. Third, updates are available for A5, A6 or A7 to take the roles of partners into account. Fourth, two applications can be replaced by more capable applications: A3 can be replaced by a cloud oriented dashboard (A3'), which implements cloud technology to advance data computing; A4 can be replaced by a virtual conformity network (A4'), which strengthens inside conformity from

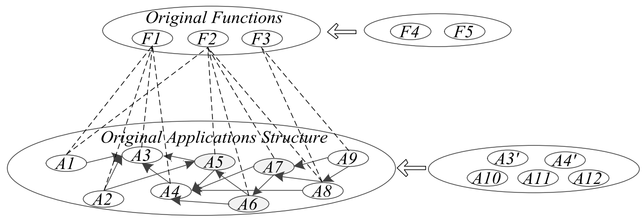

FIGURE 7. Business functions changes and application strategies.

network technology. We assume all of the possible strategies are able to support both F4 and F5. In order to achieve a higher overall function value for the post-change business function set with a lower cost, we need a new application portfolio combining some original applications and new applications. Diagrammatic sketch of the description above is showed in Figure 7.

B. DATA COLLECTION

This section aims to collect relevant data for the parameters in algorithm 1 and 2. The data are hypothetical in this article. For getting reasonable analysis results, assumptions for the data have to meet several rules: the maintenance costs of relationships should be lower than the creation costs of relationships; application update costs should be lower than the creation costs, and creation costs should be lower than the replacement costs; the supporting values of applications after changing should be higher than that before changing. The costs of applications and relationships, and the budget are presumed in Table 3. Cost discounts of synergy relationships are presumed in Table 4. All the data are given in dollars.

For maximizing the total value, all of the applications' supporting values for each function are pre-determined in Table 5. The numbers on the left to the slashes describe applications' supporting values before the changes, and the number on the right describe the values after the changes.

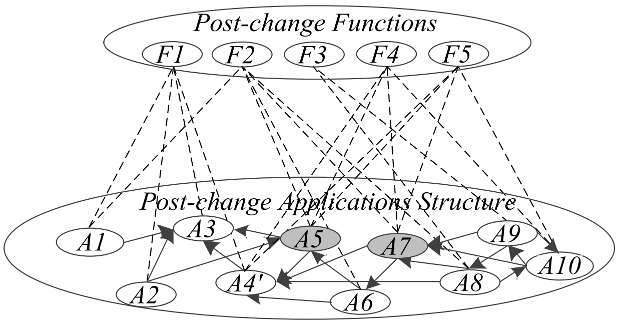

FIGURE 8. Realignment of business functions and applications.

Additionally, the weights of the 5 functions are presumed in a relative sense in the following formula.

$$\omega_5 \geq \omega_4 \geq \omega_2 \geq \omega_1 \geq \omega_3$$

C. RESULTS ANALYSIS

Using algorithm 2 and Kangaspunta's portfolio decision analysis algorithm, we acquire 11 cost-efficient application portfolios, among which an ultimate portfolio prevails over the others by the minimum-regret rule. The post-change application structure, which aligns with the post-change business functions, is shown in Figure 8. According to the modifications, the "respect inside conformity website" application is replaced by the "virtual conformity network" application; the "B2B platform" and the "Web presence" applications are updated; additionally, the "collaboration network application" application is introduced to the original application structure. This would be our resource allocation invention that allows efficient reconstruction of the alignment between business functions and applications.

In the above case, the portfolio selected by the algorithm has satisfied the budget and achieved the highest function value than any other application portfolio. The quantitative resource allocation method takes a short reaction time when misalignment occurs, and helps enterprise return to its trajectory rapidly.

D. METHOD EXPLANATION

The resource allocation algorithm is viable for dynamic BITA problems. Dynamic resource allocation intervention is regarded as a sustainable factor in BITA evolvement, and helps improve the maturity level of governance criteria. Besides, due to the complexity and scale of data and model, a mathematical solution is beneficial and helpful to deal with this issue in a timely manner.

This paper discusses the influences of limited resources on different kinds of application strategies, and how to comprehensively understand those influences to obtain the most feasible application portfolio. We adopt Kangaspunta's portfolio decision analysis algorithm [30] to confront the mathematical analysis of the various resource influences. In the research stream of portfolio decision analysis (PDA), Systems Analysis Laboratory at Aalto University School of Science has done considerable research. Salo and his coauthors issued a book to explain PDA's definition, source, quality framework and some relevant techniques [34]. Liesio *et al.* proposed robust portfolio modeling [31], scenario-based portfolio selection [35] to deal with incomplete information. In order to validate feasibility of methods, Salo and Liesiö applied the PDA in a Scandinavian Research Program [36]. They also studied the strategy to produce a portfolio in a telecommunication company [37]. Kangaspunta *et al.* studied the weapon system portfolio using cost-efficient analysis [30]. The maturity and feasibility of PDA increases along with the growing attention on this topic. There are some similarities between the objects discussed in this paper, functions and applications, and objects in prior research such as projects, products and weapons. Therefore, it is reasonable to adopt PDA in this paper, and to propose such a mathematical solution for sustaining BITA.

In order to apply the current study in practice, a number of issues are noteworthy. The first issue concerns the accessibility of relevant data. As we know, we need to collect several kinds of data to fuel the algorithm. According to Figure 1, the data may exist in the EA documentation. Thus, an automatic data collection method to collect data from EA documentation is feasible. As an alternative, Systems Analysis Laboratory also studied how to gather the analysis data through survey. The second issue is how to apply this algorithm to alignment with different patterns. While we mainly discussed the alignment between business functions and applications in this paper, we acknowledge that there are other types of alignment in EA that require resource allocation. As a result, new data need to be collected, and new constraints other than those in formula 1 may emerge. The third issue is that applying the sustainable factor of dynamic resource allocation in practice requires a comprehensive consideration that takes other sustainable factors, such as sharing knowledge and aligning reporting relationships, into account. One needs to determine the priority and interactions of the sustainable factors. For example, when sharing domain knowledge between business roles and IT roles, we may have a clear perception of the applications' supporting values for business functions, and this would help us implement the resource allocation algorithm in an accurate way. Therefore, we should give priority to the sustainable factor of sharing domain knowledge over the dynamic resource allocation factor.

Several constraints of the proposed mathematical solution require additional explanations. In our illustrative example, we find that the algorithm is able to deliver desirable outcomes if multiple applications are supporting one single function. However, if each function is only supported by one application, the values of such algorithm would be extensively decreased. In practice, there are one-to-many (many-to-one) or many-to-many mappings between the aligning elements, making the algorithm more feasible. Moreover, the algorithm would be generally more powerful in a data-normative company due to the importance of availability of the data.

V. DISCUSSIONS

This paper aims to address some limitations in the previous literature. Given the three drawbacks discussed in section 2, we propose a holistic conceptual BITA evolvement model that combines EA with BITA maturity framework. To this end, a resource allocation factor was discussed as a neglected sustainable BITA factor beyond the factors that are analyzed in previous literature. The possible critical incidents and dynamic algorithm were proposed to align the business functions and applications. Besides this alignment, the sustainable factor can be applied to other alignment patterns in EA.

The paper makes some potential contributions to the literature. By combining EA and Luftman's BITA maturity framework, we develop a useful framework to describe the organization structure and to evaluate the BITA. Meanwhile, focusing on the categories of changes and their resource allocation mechanism helps make the BITA sustainable and flexible. Furthermore, complementing this quantitative sustainable factor with other qualitative factors helps facilitate BITA sustainability in a holistic way.

However, some challenges in the current study limits the generalizability of the findings. First, the conceptual model is relatively simple. We only adopted a few common EA viewpoints rather than an entire EA framework, such as TOGAF or DoDAF. Besides, we didn't present the detailed BITA measurement method with EA at a given time. Second, we didn't propose a holistic view to combine the resource allocation factor with other traditional mechanisms. Third, our findings were demonstrated merely using a hypothetical case. To explain the conceptual model at different time segments, a practical case with a long evolvement period is required. At the same time, to deal with the dynamic business environment and IT innovations currently, we will consider how to coevolve the business and IT in the next step. The coevolution of business and IT is often studied from a complexity perspective. Within this situation, multiple critical incidents may appear and need to be addresses at the same time, which also provides a repuirement for future research.

VI. CONCLUSION

Given the insufficiency of current research on dynamic BITA, this paper proposed a conceptual model combining EA with BITA measurement method. Besides the traditional sustainable factors, a resource allocation factor was particularly discussed in this paper. Considering the alignment between business functions and applications, this paper took into account the possible changes and corresponding resource influences. We propose a dynamic resource allocation algorithm and verified using an illustrative case. The explorations in this article contribute to sustainable BITA research.

REFERENCES

[1] M. Parker and R. J. Benson, *Information Economics*. Englewood Cliffs, NJ, USA: Prentice-Hall, 1988.
[2] J. C. Brancheau and J. C. Wetherbe, "Key issues in information systems management," *MIS Quart.*, vol. 11, no. 1, pp. 23–45, 1987.
[3] P. J. Dixon and D. A. John, "Technology issues facing corporate management in the 1990s," *MIS Quart.*, vol. 13, no. 3, pp. 247–255, 1989.
[4] F. Niederman, J. C. Brancheau, and J. C. Wetherbe, "Information systems management issues for the 1990s," *MIS Quart.*, vol. 15, no. 4, pp. 475–500, 1991.
[5] J. C. Henderson and H. Venkatraman, "Strategic alignment: Leveraging information technology for transforming organizations," *IBM Syst. J.*, vol. 32, no. 1, pp. 472–484, 1993.
[6] D. Avison, J. Jones, P. Powell, and D. Wilson, "Using and validating the strategic alignment model," *J. Strategic Inf. Syst.*, vol. 13, no. 3, pp. 223–246, 2004.
[7] J. Baker and D. Jones, "A theoretical framework for sustained strategic alignment and an agenda for research," in *Proc. JAIS Theory Develop. Workshop. Sprouts, Working Papers Inf. Syst.*, vol. 8. 2008, pp. 1–30.
[8] Y. E. Chan and B. H. Reich, "IT alignment: What have we learned?" *J. Inf. Technol.*, vol. 22, no. 4, pp. 297–315, 2007.
[9] R.-S. Chen, C.-M. Sun, M. M. Helms, and W.-J. Jih, "Aligning information technology and business strategy with a dynamic capabilities perspective: A longitudinal study of a Taiwanese Semiconductor Company," *Int. J. Inf. Manage.*, vol. 28, no. 5, pp. 366–378, 2008.
[10] H. Benbya and B. McKelvey, "Using coevolutionary and complexity theories to improve IS alignment: A multi-level approach," *J. Inf. Technol.*, vol. 21, no. 4, pp. 284–298, 2006.
[11] R. Sabherwal, R. Hirschheim, and T. Goles, "The dynamics of alignment: Insights from a punctuated equilibrium model," *Org. Sci.*, vol. 12, no. 2, pp. 179–197, 2001.
[12] J. N. Luftman and R. M. Kempaiah, "An update on business-IT alignment: 'A line' has been drawn," *MIS Quart. Executive*, vol. 6, no. 3, pp. 165–177, 2007.
[13] H.-T. Wagner, "Evolvement of business-IT alignment over time: A situated change perspective," in *Proc. 47th Hawaii Int. Conf. Syst. Sci. (HICSS)*, 2014, pp. 4366–4375.
[14] K. Lyytinen and M. Newman, "Explaining information systems change: A punctuated socio-technical change model," *Eur. J. Inf. Syst.*, vol. 17, no. 6, pp. 589–613, 2008.
[15] J. Baker, D. Jones, Q. Cao, and J. Song, "Conceptualizing the dynamic strategic alignment competency," *J. Assoc. Inf. Syst.*, vol. 12, no. 4, p. 299, 2011.
[16] P. P. Tallon and A. Pinsonneault, "Competing perspectives on the link between strategic information technology alignment and organizational agility: Insights from a mediation model," *MIS Quart.*, vol. 35, no. 2, pp. 463–486, 2011.
[17] S. De Haes and W. Van Grembergen, *Enterprise Governance of Information Technology: Achieving Strategic Alignment and Value*. Cham, Switzerland: Springer, 2015.
[18] J. Ohlsson, S. Han, M. Hultin, and B. Rosengren, "How to achieve sustainable business IT alignment—Designing a circular organizational structure at SAAB," in *Proc. 49th Hawaii Int. Conf. Syst. Sci. (HICSS)*, 2016, pp. 5116–5125.
[19] J. Luftman, "Assessing business-IT alignment maturity," *Commun. AIS*, vol. 4, Dec. 2000, Art. no. 14.
[20] S. Jorfi, K. M. Nor, and L. Najjar, "The relationships between IT flexibility, IT-business strategic alignment, and IT capability," *Int. J. Manage. Inf. Technol.*, vol. 3, no. 1, pp. 16–31, 2011.
[21] K. D. Niemann, *From Enterprise Architecture to IT Governance: Elements of Effective IT Management*, vol. 1. Wiesbaden, Germany: Springer, 2006.
[22] J. Saat, U. Franke, R. Lagerstrom, and M. Ekstedt, "Enterprise architecture meta models for IT/business alignment situations," in *Proc. 14th IEEE Int. Enterprise Distrib. Object Comput. Conf. (EDOC)*, Oct. 2010, pp. 14–23.
[23] J. Luftman, "Strategic alignment maturity," in *Handbook on Business Process Management 2*. Berlin, Germany: Springer, 2015, pp. 5–43.
[24] V. Haren, *TOGAF Version 9.1*. Dordrecht, The Netherlands: Van Haren Publishing, 2011.
[25] P. Sousa, C. M. Pereira, and J. A. Marques, "Enterprise architecture alignment heuristics," *Microsoft Architects J.*, vol. 4, pp. 34–39, Oct. 2004.
[26] L. Plazaola, E. Silva, N. Vargas, J. Flores, and M. Ekstedt, "A metamodel for strategic business and IT alignment assessment," in *Proc. 4th Annu. Conf. Syst. Eng. Res. (CSER)*, 2006, pp. 187–196.
[27] L. Plazaola, J. Flores, E. Silva, N. Vargas, and M. Ekstedt, "An approach to associate strategic business-IT alignment assessment to enterprise architecture," in *Proc. 5th Conf. Syst. Eng.*, 2007, pp. 1–10.
[28] L. Plazaola, J. Flores, N. Vargas, and M. Ekstedt, "Strategic business and IT alignment assessment: A case study applying an enterprise architecture-based metamodel," in *Proc. 41st Annu. Hawaii Int. Conf. Syst. Sci.*, Jan. 2008, p. 398.

[29] D. Simon, K. Fischbach, and D. Schoder, "Application portfolio management—An integrated framework and a software tool evaluation approach," *Commun. Assoc. Inf. Syst.*, vol. 26, no. 1, p. 3, 2010.
[30] J. Kangaspunta, J. Liesiö, and A. Salo, "Cost-efficiency analysis of weapon system portfolios," *Eur. J. Oper. Res.*, vol. 223, no. 1, pp. 264–275, 2012.
[31] J. Liesiö, P. Mild, and A. Salo, "Preference programming for robust portfolio modeling and project selection," *Eur. J. Oper. Res.*, vol. 181, no. 3, pp. 1488–1505, 2007.
[32] B. Fritscher and Y. Pigneur, "Business IT alignment from business model to enterprise architecture," in *Proc. Int. Conf. Adv. Inf. Syst. Eng.*, 2011, pp. 4–15.
[33] A. Vargas, L. Cuenca, A. Boza, I. Sacala, and M. Moisescu, "Towards the development of the framework for inter sensing enterprise architecture," *J. Intell. Manuf.*, vol. 27, no. 1, pp. 55–72, 2016.
[34] A. Salo, J. Keisler, and A. Morton, Eds., *Portfolio Decision Analysis: Improved Methods for Resource Allocation*. New York, NY, USA: Springer, 2011.
[35] J. Liesiö and A. Salo, "Scenario-based portfolio selection of investment projects with incomplete probability and utility information," *Eur. J. Oper. Res.*, vol. 217, no. 1, pp. 162–172, 2012.
[36] A. Salo and J. Liesiö, "A case study in participatory priority setting for a Scandinavian research program," *Int. J. Inf. Technol. Decision Making*, vol. 5, no. 1, pp. 65–88, 2006.
[37] M. Lindstedt, J. Liesiö, and A. Salo, "Participatory development of a strategic product portfolio in a telecommunication company," *Int. J. Technol. Manage.*, vol. 42, no. 3, pp. 250–266, 2008.

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