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Measurement of the Business/IT Alignment of Information Systems

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Abstract. Nowadays, the performance of organizations is directly related to the efficiency of Information system (IS). It is crucial to quantify this efficiency and evaluate the alignment of the IS with the business. In this context, this work aims to propose a set of metrics to measure the alignment of IS to business requirements based on the constructs of an exhaustive framework. This multi-level and multi-aspect framework considers Information Technology (IT) and Business domains, as well as strategic and operational levels of the enterprise. A total of twenty-five metrics is proposed, within sixteen new ones, to evaluate functional integration at both levels, as well as strategic fit in each domain.

Keywords: Information systems, Alignment, Alignment levels, Metrics.

1. Introduction

In the context of agile and flexible factories of the future, Information System (IS) should be able to answer the new requests of business. In literature, it is generally accepted that business performances are highly related to IS performances [1, 2, 3, 4]. This stake is generally tackled in the alignment domain. In this context, there is a need for real-time alignment processes between IT and business domains [2]. This requires an evaluation of the initial and the final situations of alignment either using indirect or direct measures (metrics) that are based on separate assessment of business and IT constructs [5]. For that, the evaluation of alignment represents a top concern issue [1]. In literature, most of the authors who consider alignment evaluation, usually use qualitative methods owing to the sensitivity of alignment to the quantitative measurements [6]. And those who propose metrics, consider only the assessment of the operational level, and ignore the strategic level which is the most important according to Charoensuk et al. [7]. Therefore, our work aims to propose an exhaustive evaluation of alignment.

The sensitivity aspect of alignment to quantitative measurements comes mainly from the fact that alignment was always very hard to define. To overcome this problem, we propose to exploit the Strategic Alignment Model (SAM) of Henderson and Venkatraman [8]. According to Gerow et al. [6], Tarafdar and Qrunfleh [7], Benbeya and McKelvey [9], Goepp and Avila [10], Avila and Goepp [11], it is the most appropriate and widespread framework that aims to describe the alignment according to the external and internal levels of IT and Business domains. According to the SAM, there are four types of alignment: (1) Alignment in the strategic level (or functional integration in external level), (2) Alignment in the internal level (or functional integration in internal level), (3) Strategic fit in the IT domain, (4) Strategic fit in the business domain.

Our research aims to define a set of metrics enabling to evaluate the degree of alignment for each alignment types as defined in the SAM. To solve this problem, we present in Section 2, a literature review of the existing alignment evaluation methods. In Section 3, we exploit Archimate 3.0 as a mean to work out a meta-model detailing the modelling constructs involved in the assessment of the four types of alignment defined in the SAM. Section 4 presents a classification of the existing metrics in the light of the meta-model set up in section 3 and proposes a set of new metrics enabling to evaluate the remaining types of alignment. In the last section, we present our conclusion and possible perspectives.

2. Literature review

2.1. Alignment definition

The notion of alignment has no formal definition and there are lots of definitions in literature. Among them, we choose the one of Benbeya and Mckelvey [9]: "The degree of congruence of an organization's IT strategy and IT infrastructure with the organization's strategic business objectives and infrastructure" because it highlights the main features of alignment. In this view, the alignment is a process and not an end-state and has two levels also named strategic and operational in [2]. Alignment in the operational level is the one required for ensuring that information system is successfully implemented, maintained and used, and in turn delivers the targeted business benefits, according to Tarafdar and Qrunfleh [2]. Alignment in the strategic level is the degree to which the IT mission, objectives, and plans support and are supported by the business mission, objectives and plans, according to Benbeya and Mckelvey [9].
Another way to consider these levels is to analyse them in the light of the SAM (Strategic Alignment Model) detailed in [8]. It consists of four areas of strategic choices defined by (see Fig. 1):

- *Domains*: Business and Information Technologies (IT);
- *Levels*: (that split domains): external (strategy) and internal (operation),
- *Components* (that characterize and compose each level): scope, competencies and governance in the external level; infrastructure, skills and processes in the internal level.

These areas are linked together through four types of alignment: functional integration in the strategic and operational levels; strategic fit in the business and IT domains (see Fig. 1).

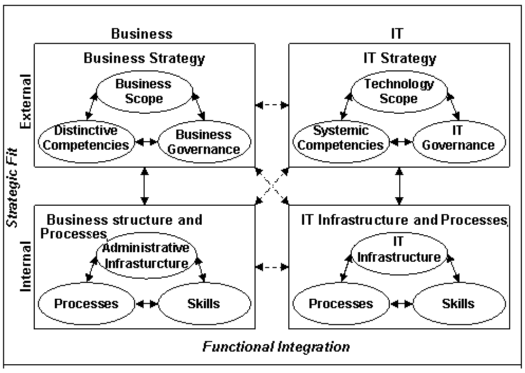

Fig. 1. Alignment types of SAM according to Henderson [8]

In addition to the alignment in the strategic level (functional integration in external level) and the operational level (functional integration in the internal level), Henderson and Venkatraman [8] introduces the strategic fit in the business and IT domains. According to Gerow et al. [6], strategic fit in the IT domain refers to the alignment in the IT domain and is the degree to which the higher level, externally focused IT strategies are aligned with the lower level, internally focused IT infrastructure and processes. Strategic fit in the business domain refers to the alignment in the business domain and is the degree to which the higher level, externally focused business strategies are aligned with the lower level, internally focused business infrastructure and processes.
According to the SAM, both functional integration and strategic fit are required to ensure a proper alignment. In other words, evaluation of alignment, in which we are interested, must enable the evaluation of the four types of alignment described in the SAM. Next section describes the main works related to alignment evaluation.

2.2. Alignment evaluation approaches

Alignment evaluation approaches can be divided into alignment maturity evaluation and alignment degree evaluation.
In order to evaluate the alignment maturity, Luftman and Kempaiah [12] propose a classification of the alignment systems in five maturity levels, based on six criteria (communication, value, governance, partnership, scope and architecture, and skills) by scoring each criterion from one to five. Also, Botta-Genoulaz and Millet [13] propose a qualitative method to classify companies regarding ERP use, based on two criteria (software maturity and strategy deployment). In order to assess the risk of non-alignment, the authors propose a set of alerts to characterize each situation. In addition, they propose a set of corrective actions in order to optimize the use of ERP, i.e. the alignment.

The alignment degree evaluation is either qualitative or quantitative. When the evaluation is qualitative, like in the ATIS approach of Avila and Goepp [14], the business analyst should assess on his own the alignment degree between different instantiated model elements.
The quantitative approaches are generally model-based as the evaluation of the alignment degree is made thanks to metrics based on a meta-model. For example, Pepin [15] divides the elements of his meta-model (processing and data) into: (1) off-line elements and (2) elements to align. Then he divides the elements to align into two subsets (alignable elements, and non-alignable elements). Finally, he divides the alignable elements into: (1) aligned elements, and (2) non-aligned elements. Etien [16] proposes metrics to evaluate the alignment, at the internal level of SAM, based on the correspondence of concepts between two meta-models the Business one (BPRAM) and the System one (SRAM). Otherwise, in Mamoghli [17], the evaluation of alignment is based on the confrontation between the modelling constructs of the Might-Be and As-Wished models, that correspond to each other in case of alignment. This approach is dedicated to the alignment of ERP systems, which is a specific case of alignment. Finally, in Aversano et al.'s approaches [1, 18] the assessment of the alignment is performed through the definition of a measurement framework based on the Goal Question Metrics paradigm. He defines seven metrics related to technological coverage and technological adequacy of the business processes.
Each quantitative approach is based on a specific meta-model that is not related to the type of alignment to be evaluated. To conclude, as the purpose of our work is to propose quantitative metrics to assess alignment, we need to define a common meta-model that enables to analyse the metrics proposed in Aversano et al. [1, 18] and Etien [16] in the light of the type of alignment they intend to evaluate. According to Goepp and Avila [10], Avila and Goepp [11, 19] and Gerow et al. [6], the SAM is the most widespread model proposed in literature that describes alignment. However, its components have a too high-granularity level to be suitable to represent the elements to be considered in alignment evaluation. Therefore, we propose to detail them through lower-granularity level modelling constructs stemming from Archimate 3.0.

3. Meta-model of Alignment Evaluation

The objective of this part is to enrich the components of the SAM with lower-granularity level constructs. For that, we decided to exploit the constructs of Archimate 3.0, the enterprise architecture modelling language from OMG, described in [20]. We choose it because it is a research and practitioner consensus and seems complete enough to consider all alignment types whereas others work [21] such as the meta-models of Etien [16], Pepin [15] or Aversano et al. [1, 18] consider only the functional integration at the operational level. The remaining of this section presents the Archimate language structure and the layer we consider for the mapping with the SAM components.

3.1. Archimate 3.0 modelling language structure

Archimate 3.0 is a visual enterprise architecture modelling language structured around aspects (behavioural, active and passive) and layers.
According our scope, the layers we are interested in are the business and the application layers. The business layer describes products and services realized in the organization by business processes to external partners. The application layer supports the business layer with application services that are realized by software and/or applications.
For the mapping between the SAM components and Archimate 3.0 constructs, we will also keep the Archimate 3.0 constructs belonging to the strategy and the motivation layers required to represent the SAM external level. The motivation layer contains the constructs used to model the motivations, or the reasons that guide the architecture of an enterprise. The strategy layer is composed of three constructs that describe the strategic level of an enterprise.

3.2. Mapping between Archimate 3.0 constructs and SAM components

Petit and Goepp [21] proposed a mapping between the SAM and the business and application layers of Archimate 3.0, we complete this work by mapping the SAM components with the strategic and motivation layers from Archimate:

- *Business scope and IT scope components* correspond to course of action as a strategic element and stakeholder, driver, assessment, goal, outcome, principle, and requirement from the motivation layer.
- *Business distinctive competencies and IT systemic competencies components* correspond to resource and capability from the strategy layer, principle, and constraint from the motivation layer.

- *Business and IT governance component*s correspond to resource and capability from strategy layer, and stakeholder from the motivational layer.
- *IT governance component*s also correspond to constructs from application layer.
- *Administrative infrastructure and Business processes components* correspond to the business resource from the strategy layer.
- *IT architecture and IT processes components* correspond to IT resource from the business layer.
- *Business and IT Skills* correspond to business role from the business layer.

On this base, we can reinterpret the metrics from literature in the light of the alignment types defined by the SAM. In addition, we can propose new metrics based on these constructs and affect them to their appropriate type.

4. Metrics to evaluate the alignment

In this section, first, we reinterpret existing metrics using Archimate 3.0 constructs and we classify them in the appropriate alignment type according to the SAM. Secondly, we propose new metrics in order to cover all the alignment types of the SAM.

4.1. Equivalence of the existing metrics and classification

4.1.1. Alignment evaluation meta-model mapping with Archimate 3.0

The main works that propose metrics to evaluate alignment are Aversano et al. [1, 18] and Etien [16] and any other work that propose metrics are included in [1, 16, 18]. In order to establish the equivalence between these propositions, we map the meta-models proposed with Archimate 3.0. Tables 1 and 2 detail the mapping between Archimate 3.0 and each construct from Etien and Aversano meta-models.

Table 1. Mapping between Etien [16] and Archimate 3.0 constructs

Etien	*Archimate 3.0*
System event	Application event
Business activity	Business process
Business goal	Business goal
System state	-
System object	Data object
Business resource	Business resources
Business actor	Business role
Business object	Business object
Business state	-
Business Path	Business process
Business transformation	-
System transformation	-

Table 2. Mapping between Aversano et al. [1, 18] and Archimate 3.0 constructs

Aversano et al.	*Archimate 3.0*
Business Activity	Business process
Business actor	Business role
Business artefact	Business object
System class (system artefact)	Data object
Transition	Business event

4.1.2. Equivalence of existing metrics with Archimate 3.0

Based on the mapping presented in Table 1 and Table 2, we propose, in Table 3, the equivalent metrics to the propositions of Aversano et al. and Etien using the Archimate 3.0 constructs. Thanks to the mapping between the SAM components and Archimate 3.0, we can conclude that these metrics only treat the functional integration in the operational level.

So, the remaining of the section proposes additional metrics that we work out by exploiting the relevant parts of the Archimate 3.0 meta-model in [20]. This meta-model formalizes the alignment links between constructs and layers and, in this way, enables a systematic definition of metrics or each alignment type.

Table 3. Equivalence of existing metrics using Archimate 3.0 constructs

Metrics formula	**Equivalent metric in literature**	**Metrics definition**
$\text{Business process support rate} = \dfrac{\#\text{Business process served by application services}}{\#\ \text{Business process}}$	"Rate of supported activities" of Etien and "Activities coverage" of Aversano et al.	It allows to define the supporting rate of activities by Information system.
$\text{Business role support rate} = \dfrac{\#\text{Business role served by an application interface or application service}}{\#\text{Business role}}$	"Rate of actors existed in the system" of Etien and "Actors coverage" of Aversano et al.	It allows to define the supporting rate of business actors by Information system.
$\text{Business object correspondence rate} = \dfrac{\#\text{Business object realized by data object}}{\#\text{Business object}}$	"Artefact coverage" of Aversano et al.	It allows to define the supporting rate of business objects by Information system.
$\text{Resources correspondence rate} = \dfrac{\#\text{Resources realized by data object}}{\#\text{Resources}}$	"Rate of resources existed in the system" of Etien.	It aims to measure the supporting rate of resources by Information system.
$\text{Business event support rate} = \dfrac{\#\text{Business event served by application service}}{\#\text{Business event}}$	"Transitions coverage" of Aversano et al.	It aims to measure the supporting rate of business events by system.
$\text{Completness of information} = \dfrac{\#\text{Business object accessed by business process and realized by data object}}{\#\text{business object accessed by business process or function}}$	"Completeness of information" and "completeness of activities" of Etien.	It aims to measure the completeness of business processes and activities support.
$\text{Business Object Adequacy} = \dfrac{\sum \text{Business Object Adequacy (i)}}{\#\text{business object}}$, with i belongs to business objects. And, $\text{business Object Adequacy (i)} = \dfrac{\#\text{Business process that accesses to i business and served by application services}}{\#\text{Business process that accesses to i business object}}$	"Artefact adequacy" of Aversano et al.	It aims to measure the support adequacy of business object by the system.
$\text{Business Process Adequacy} = \dfrac{\sum \text{Business Process Adequacy (i)}}{\#\text{Business process}}$, with i belongs to business process. And $\text{Business Process Adequacy(i)} = \dfrac{\sum \text{Business Object Adequacy (i)(j)}}{\#\text{Business object accessed by business process i}}$ with j belongs to the set of business objects accessed by business process i.	"Activity adequacy" of Aversano et al.	It aims to measure the support adequacy of business process by the system.
$\text{Role Adequacy} = \dfrac{\sum \text{Role Adequacy (i)}}{\#\text{Business role}}$, with i belongs to business role. And $\text{Role Adequacy (i)} = \dfrac{\sum \text{Business Process Adequacy (i)(j)}}{\#\text{Business process assigned from the business role i'}}$ with j belongs to the set of business process assigned to the business role i.	"Actor adequacy" of Aversano et al.	It aims to measure the support adequacy of business role by the system.

4.2. Evaluation of functional integration in internal level

Besides the existing metrics from literature and based on the alignment links between the Archimate 3.0 constructs defined in [20], we propose two additional metrics that aim to evaluate the support of business function and business interaction (collaboration between two or more business roles) by informatics system.

Table 4. Definition of metrics aiming to assess functional integration in internal level

Metrics formula	**Metrics definition**
Business function automation rate $= \frac{\#\text{Business function assigned to an application component}}{\#\text{Business function}}$	This metric presents the percentage of business functions supported by an application component of system software. It aims to measure the support of business functions by the system.
Business interaction support rate $= \frac{\#\text{Business interaction served by an application service}}{\#\text{Business interaction}}$	This metric presents the percentage of supporting rate of business interaction by the application services. It aims to measure the support of business interactions by the system.

4.3. Evaluation of functional integration in the strategic level

In order to evaluate functional integration in the strategic level, we present, in Table 5, a set of new metrics. They stem from the analysis of the Archimate 3.0 meta-model [20] alignment links related to the strategic and motivation layers.

Table 5. Definition of metrics aiming to assess functional integration in the strategic level

Metrics formula	**Metrics definition**
Business actor support $= \frac{\#\text{Business actor that serves an application service}}{\#\text{Business actor}}$	This metric expresses the rate of support of business actor (services department, customer, partners…) which constitutes an important element of the business governance of an organization by informatics systems.
Business service correspondence rate $= \frac{\#\text{ Business service realized by an application service}}{\#\text{business service}}$	This metric expresses the supporting rate of business services, which is a representative element of business scope and business distinctive competences by the system.
Capability automation rate $= \frac{\#\text{Business capabilities assigned to IT resources}}{\#\text{Business capabilities}}$	This metric expresses the rate of support of the business capabilities, which is a representative element of distinctive competences by informatics systems.
Requirements correspondence rate $= \frac{\#\text{Requirement realized by IT resources}}{\#\text{Requirements}}$	This metric expresses the supporting rate of requirements, which constitutes a representative parameter of business scope by informatics systems.
Outcomes correspondence rate $= \frac{\#\text{Outcome for which the correspondent Requirements are realized by IT resources}}{\#\text{Outcome}}$	This metric expresses the business outcomes (which is a representative parameter of business scope) supported by informatics systems, through measuring the support rate of outcomes requirements.
Rate of goals correspondence $= \frac{\#\text{Goals for wchich the correspondent outcomes for which the correspondent requirements are realized by IT resources}}{\#\text{Goals}}$	This metric expresses the business goals (main representative element of business scope) supported by informatics systems, through measuring the support rate of its outcomes requirements.

4.4. Evaluation of the strategic fit in the business domain

In the same way as Table 5, Table 6 details a set of metrics aiming to evaluate the strategic fit in the business domain based on the analysis of the alignment links of the Archimate 3.0 meta-model [20] related to the business layer.

Table 6. Definition of metrics aiming to assess strategic fit in business domain

Metrics formula	Metrics definition
$\text{Business service correspondence rate internally} = \frac{\#\text{Business service realized by business process or function}}{\#\text{Business service}}$	This metric presents the rate of support business processes or function to business services.
$\text{Requirements correspondence rate internally} = \frac{\#\text{Requirement realized by business processes, business events or business functions}}{\#\text{Requirement}}$	This metric presents the rate of requirements treated by business behavioural elements.
$\text{Business resource correspondence rate internally} = \frac{\#\text{Business resource realized by business role, business actor or collaboration}}{\#\text{Business resource}}$	This metric presents the rate of business resources that correspond to the business structure active elements.
$\text{Business capabilities correspondence rate internally} = \frac{\#\text{Business capability realized by business processes, and business functions}}{\#\text{Business capability}}$	This metric presents the rate of correspondence of business capabilities to business behavioural elements.

4.5. Evaluation of alignment in IT domain

Finally, the metrics defined in Table 7 aims to evaluate the strategic fit in the IT domain based on the analysis of the alignment links of the Archimate 3.0 meta-model [20] related to the application layer.

Table 7. Definition of metrics aiming to assess strategic fit in IT domain

Metrics formula	Metrics definition
$\text{Application service automation rate internally} = \frac{\#\text{Application service assigned from application interfaces}}{\#\text{Application service}}$	This metric aims to calculate the automation rate of application services (representative element of IT scope) by applications interface.
$\text{Application service correspondence rate internally} = \frac{\#\text{Application service realized by Application functions}}{\#\text{Application service}}$	The purpose of this metric is to calculate the correspondence rate of application services (representative element of IT scope) to application functions.
$\text{IT resources correspondence rate internally} = \frac{\#\text{IT resource realized by application components}}{\#\text{IT resource}}$	This metric aims to present the rate of IT resources support by application components.
$\text{IT capabilities correspondence rate internally} = \frac{\#\text{IT capabilities realized by application services or application function}}{\#\text{IT capabilities}}$	This metric presents the rate of correspondence of IT capabilities to IT behavioural elements.

5. Conclusion and perspectives

IS Alignment being nowadays a crucial issue for all companies around the world. It became clear that IS have a great impact on the global performance of organizations. So, making it evolves at the same pace as business strategy is a very important stake for companies. Many researchers deal with the alignment problem. However, its evaluation remains less discussed. Existing evaluation approaches are either qualitative or quantitative. The quantitative one are based on different meta-model and do not address the functional integration at the strategic level, nor the strategic fits in the business and IT domains whereas these alignment types are, according to the SAM [8], the most important model to describe and define alignment types, also required to ensure a proper alignment. To tackle this research gap, we first propose a general meta-model based on the components of the SAM. To obtain a lower-granularity level meta-model that is necessary for alignment evaluation, we map the SAM components with Archimate 3.0 constructs [20]. On this base, we reinterpret existing metrics in the light of this meta-model and the related alignment type. We also complete these metrics with a set of new metrics that aim to evaluate all the alignment types.

The working out of these metrics is systematic and complete because we exploit the alignment links of the Archimate 3.0 meta-model.
All these twenty-five metrics are a first step to evaluate IS alignment in a complete way. However, these metrics are only partial because we did not include constructs linked to business or system states, and business or system transformations. Those constructs could help us to measure the alignment degree of the dynamic behaviour between IT and business. In parallel, an implementation and validation of these metrics should take place, by applying it to a real case study.

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