

Challenges in Supporting a Goal-Oriented Enterprise Architecture Analysis

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Abstract. Enterprise Modelling is a discipline which tries to capture and reason about the distinct dimensions (e.g. structure, strategies and processes) involved in organizations by means of visual models. In this work, we are interested in using Enterprise Architectures to gain an understanding of the enterprise to promote a *goal-oriented enterprise analysis*. This paper describes the current state of art in literature of enterprise architecture and correlated areas and outline research questions that represent the open challenges that must be faced to promote this goal. In particular, the description of literature and the research questions are made in terms of the *languages* that model the enterprise architecture as well as the *techniques* that support architectural analysis.

Keywords: enterprise architecture, enterprise analysis, goal-oriented enterprise analysis, goal-orientation

1 Introduction

Mainly aiming at staying in business or seeking for higher profits, organizations today need support for fostering innovation and boosting production. To achieve both goals, it is crucial that they develop a deep understanding regarding their different dimensions, such as *structure*, *strategies* and *processes*. Such understanding can emerge through the discipline of *Enterprise Architecture* (EA) [1] which tries to capture and reason about the distinct dimensions or viewpoints [1] of the enterprise by means of *visual models*.

Among these viewpoints, the domain of “motivation” has been recognized as an important element of enterprise architectures [2]. Goal modeling allows architects to systematically express the choices behind multiple alternatives and explore new possible configurations for an organizational setting. This is essential for business improvement once changes in a company’s strategy and business goals have significant consequences within all domains of the enterprise.

Since changes in all organizational domains must be synchronized with the goal domain, in this work, we are interested in gaining an understanding of how these changes occur in the enterprise by promoting a *goal-oriented enterprise analysis*. The objective of this paper is to describe the current state of art in literature of EA and correlated areas in order to address this research problem. Furthermore, we outline the open challenges to promote this research goal by proposing research questions.

We have noticed during our literature review that such effort in enterprise analysis must initially capture the enterprise architecture in the format of models and subsequently, apply architectural techniques in these models. This observation led us to describe the literature concerning these two aspects, and for this reason: (i) we consider the *languages* to model the EA models and (ii) we also address the *methodologies* and/or *techniques* in EA and related fields that support enterprise model analysis.

The remainder of this paper is structured as follows: Section 2 describes the current state of art regarding the *languages* for modelling the EA (section 2.1) and *techniques* for architectural analysis (section 2.2). Section 3 concludes the paper with an outline of research questions that represent the open challenges that must be faced to promote our research goal.

2 Current State-of-Art in Enterprise Architecture and Related Fields

2.1 Languages for Enterprise Modelling

Architecture at the level of an entire organization is denominated as *Enterprise Architecture* (EA) and can be defined as “a coherent whole of principles, methods and models that are used in the design and realization of an enterprise’s organizational structure, business processes, information systems, and infrastructure” [1]. The first step to use some architectural approach is the documentation of enterprise descriptions through the use of modeling languages.

To cope with the complexity of enterprise architectures, however, the models produced in these modeling languages should capture only the adequate architectural concepts [1]. The right set of concepts that is captured within one model depends on the purpose for which this model is created [1]. In our work, we create our models with a specific concern in mind, that is, we intend to propose a *model-driven technique for goal-oriented enterprise analysis*. With this intent in mind, we set up some requirements that guide our survey among several approaches in literature. We can enumerate these requirements as follows:

1. **Requirement 1 (RQ1).** Since we intend to propose a *model-driven* approach, the proposals must include modeling languages to model the enterprise architecture;
2. **Requirement 2 (RQ2).** Our approach is also *goal-driven*, what makes the inclusion of goal-related concepts an important parameter in our analysis;
3. **Requirement 3 (RQ3).** We have the purpose of providing an *enterprise-wide analysis*, leading us to focus on how the goal domain is integrated with the other viewpoints of the enterprise architecture.

Starting our considerations, the concept of goal is widely used in a number of areas such as Requirements Engineering (RE) [3] [4], Enterprise Modeling [1] [5] and

Business Process Management (BPM) [6] [7] [8] [9]. In particular, we have surveyed only those approaches that provide *modeling languages* (RQ1) that explicitly capture *goal-related concepts* (RQ2). Furthermore, in each approach, we have focused on how these efforts propose to align goals with the other elements of the approaches such as roles, business processes, and so forth (RQ3).

Conclusion of literature review. In order to address RQ2, a careful examination of several areas that we may include RE, EA and BPM revealed that the predominant concept found in literature is the concept of *goal* (or objective) (a definition for the term is provided in section 3). Further, we also may find some *other related concepts*, such as softgoals [4] and strategies [7]. In its turn, these concepts may be related by a number of *relationships* such as AND/OR refinement [3] [4] or conflicts [3]. Concerning the integration of the goal domain with the other elements (RQ3), considering that such goal orientation is adopted by many proposals in a large number of areas; we concluded that the relations of the goal domain with the other concepts in the proposals are dictated by the *applicability* of the proposal in each specific area.

2.2 Techniques and Methodologies for Enterprise Architectural Analysis

Once we have understood which information we should capture in our model (goals, softgoals, strategies, etc.), their relations (e.g. AND/OR refinement) as well as the associations with the other elements of the EA, we need a technique/methodology to use this language in order to promote our *goal-driven enterprise analysis*. This leads us to stipulate the forth requirement:

1. **Requirement 4 (RQ4).** We intend to examine the approaches that provide *model-driven* architectural analysis, in particular, *goal-oriented model-driven* enterprise analysis.

Conclusion of literature review. There is a large body of knowledge that addresses *model-driven* techniques. Some of them can be found in the scope of EA such as [10] [11] [1]. However, we have found that none of them incorporate such goal-orientation (although some of them present goal languages as depicted in previous section). Most of the *model-driven* techniques for process analysis are actually included in the scope of BPM (the majority of them also do not have such goal orientation, but exceptions can be found in [12]). For instance, there is a plethora of *model-driven* methods under the BPM umbrella that are generally denominated as **Business Analytics** methods. Among these Business Analytics methods, we may cite the following areas (that address these methods): **Process (Re)design** (or (re)engineering) [13] [14], **Process Maturity** [15], **Process Controlling** [16], **Process Mining** [17], **Business Activity Monitoring** [18] [8] and **Process intelligence** [19].

3 Ongoing and Future Work

In order to promote a *goal-oriented enterprise analysis*, the current literature has been surveyed as means to understand how the related approaches could support this research goal. After this survey, we have noticed that the proposals are fragmented with respect to the issues that must be addressed in order to solve the problem, and none of them addresses these issues in its totality. This section is aimed at discussing some of these issues, proposing research questions that outline these open issues and depicting how the current approaches meet or fail these requirements. The research questions are drawn also in terms of the *language* and *techniques* mentioned in the previous sections.

3.1 Languages for Enterprise Modelling

Support for modelling goal-related concepts. Which concepts are necessary for such approach (such as goals, softgoal, and strategy)? Which are the relations among these concepts (such as AND/OR refinement and conflicts)?

Goal-related concepts. Goals can be defined as statements that declare desired states for the enterprise setting as well as the reasons and motivations (i.e., rationale) for the existence of the components in the other viewpoints [20], describing a desired state or development of the enterprise [21] [22]. The concept must be characterized with respect to the following attributes:

1. **Description.** Represents the description of the goal. In all the surveyed approaches, goals are informally specified in natural language, although a formal specification is required to enable automated analysis;
2. **Level of abstraction.** Since goal definitions may be stated in a broad scope within the organization, ranging from high-level concerns to the declarations of the values that must be operationalized by business processes, this dimension aims at classifying goals in relation to the level of abstraction. In that respect, some proposals [6] [23] [24] [7] present classifications about goal-related concepts such as mission, vision, strategy and its refinements, although a precise criteria for allocation of goal statements into the categories suggested by the proposals are still required;
3. **Ownership.** Given that an EA models are a joint effort involving several stakeholders, we have to be able to specify the goals' owners. These goals' owner can be individuals (agents) [4] [25] or organizations (including the whole enterprise, organization units or roles) [26] [23] [27] [22];
4. **Hardness.** This dimension distinguishes between soft and hard goals. Hardgoals are defined as goals whose satisfaction can be objectively

defined [4], while softgoals have their satisfaction subjectively evaluated. Some approaches do not recognize this distinction, such as [27] [25] [28];

5. **Priority.** Stipulates an order for the achievement of goals [3] [22] [28];
6. **Deadline.** Represents the maximum point in time that the goal can be achieved [22] [28];
7. **Evaluation type.** Specifies how the satisfaction of the goal must be checked for a given interval of time. In [22], goals have *goal patterns* that are properties that can be checked for a given state/time point or interval in order to evaluate if the goal is satisfied or not (this pattern have types, namely: *achieve/cease*, *maintain/avoid*, *optimized (maximized/minimized/approximated)*). This proposal builds its definition on [3];
8. **Measurement.** The satisfaction of goals needs to be quantitatively evaluated. This is usually achieved by associating goals with *Key Performance Indicators* (KPIs) [27] [22] [28] [24].

Goal-related relations. Goals can be related through some types of relations. The survey revealed that there are the following types of goal relations: *AND/OR decomposition*, *conflict*, *influence* [27], *(positive/negative) contribution* and *means-ends* [4].

Alignment of goal-related concepts with the viewpoints of EA. Which are the relations between the goal domain and the other domains of the EA, such as business process, organizational structure domains, etc?

With our analysis of the literature, we have observed that the response of such question is related with the intended *applicability* of the model in the several areas. For instance, in RE and EA, goals are aimed at capturing stakeholders' *requirements* for a target computational system (RE) or an architecture yet-to-be constructed or redesigned (EA), what lead them to be associated with *agents/roles/stakeholders* [4] [3] [21] [25] or even with organizational units [23] or communities [26]. In these areas, goals statements can also be defined on the basis of *objects/resources* [3] [4] since these resources can be used by the stakeholders in the achievement of goals.

The only two approaches that consider goals as being linked to the normative aspect (*rules*) are the BMM model [23] and the Business Motivation Ontology [24]. Possibly, this can be accounted by the fact that in EA, norms may constrain the achievement of goals within the enterprise setting.

Finally, the majority of the approaches recognize *business processes* as the most important asset responsible for the achievement of goals in organizations such as [5] [4] [29] [30] [26] [23] [21]. Some works in the discipline of BPM have been inspired by this goal-orientation [9] [6] [12], by adding goal-related concepts in order to *overcome the semantic gap* between high-level enterprise's goals and the business processes which are responsible for implementing these goals. Other approaches are intended to provide additional support in *business process reengineering* activities [7] [31] [32]. Furthermore, some proposals appear in the context of BPM using ontologies [28] [24] [33] to promote *semantic interoperability of business processes* at the conceptual level with the other viewpoints of the enterprise.

Concerning this problem of identifying the set of concepts in each viewpoint that have associations with goals (and the nature of these relations), we have already started an effort [34]. We observed this connection is far from trivial and not addressed by any of the aforementioned approaches, requiring us to consider the semantics of goals, the semantics of many other enterprise elements as well as the nature of the relation between goals and these other enterprise elements. As a consequence, we tackled the problem using an *ontological approach* [35].

3.2 Techniques and Methodologies for Enterprise Architectural Analysis

Use of BPM approaches. How BPM methods can be adapted to perform architectural analysis?

Within the BPM approaches, processes can be evaluated with respect to their *structural properties* or the *execution characteristics*. Within the field of **Business Process Reengineering**, the approaches are concerned about guiding the (re)design of processes so that they contain only activities that generate value for the organization (*structural properties* of business processes). They commonly comprise recommended best practices [14] and other informal methods like "classic" reengineering view [13]. Concerning the *execution characteristics* of business processes, three types of analysis can be made [16]: *past analysis* to evaluate what happened in the past (**Process Controlling** [16]), *real-time analysis* to monitor the currently active business processes (**Business Activity Monitoring** [18] [8]) and *predictive analysis* to predict what may happen in the future (**Process intelligence** [19]).

We can argue that BPM methods concentrate in the analysis and optimization of business process models (process viewpoint of the EA). These methods can be considered of great value in our approach, since we may adapt the optimization techniques in the process viewpoint taking the goal viewpoint into consideration.

Further, although there is little support (or inexistent) in BPM methods to address optimizations in other viewpoints of the EA, the Business Process Maturity Model from OMG [15] could be used as an instrument of enterprise analysis, since it enables description of "as-is" enterprise's state, from the perspective of process management maturity [36]. This enterprise description will enable us to gain understanding of the current situation of the enterprise, what ultimately represents our objective of *enterprise analysis*.

Enhancement of enterprise modeling techniques with goal-oriented analysis. How enterprise analysis techniques can be enhanced with goal-oriented analysis?

Current enterprise architectural techniques [1] are able to perform some types of analysis in EA models, such as *functional analysis* and *quantitative analysis*. Although these techniques are very useful for performing an enterprise-wide analysis, they still do not incorporate goal-oriented concepts to perform such analysis and may be used as a starting point in our work.

Adaptation of current goal-oriented analysis techniques. How current goal-oriented techniques from other areas can be used in enterprise analysis?

A first effort into the incorporation of goal-oriented techniques for enterprise analysis is proposed in [37]. The work proposes a quantitative-reasoning based approach to model and simulate feedback loops of goal influences relations in the ArchiMate Motivational Extension language [21] [27]. Although the proposal is very useful in the scope of evaluating goal satisfaction, it still lacks an evaluation of goal satisfaction considering values that come from enterprise architectural analysis. This is an open challenge that may be addressed in the context of our future work.

To summarize our discussion, after addressing the issues of *language* and *techniques* for enterprise analysis, we also envision that methodological guidelines for producing models using this language must be developed and the resulting techniques must be validated through real-world case studies with the purpose of validating them in practice.

References

- [1] M. Lankhorst, M. E. Iacob, H. Jonkers, L. van der Torre, H. A. Proper, F. Arbab, F. de Boer, M. Bonsangue and W. Janssen, *Enterprise Architecture at Work - Modelling, Communication, and Analysis*, Springer-Verlag, 3rd edition, 2012.
- [2] J. Zachman, "A Framework for Information Systems Architecture," *IBM Systems Journal*, pp. 276-292, 1987.
- [3] A. Dardenne, A. v. Lamsweerde and S. Fickas, *Goal-directed Requirements Acquisition*, vol. 20, Amsterdam, The Netherlands, Elsevier Science Publishers, 1993, pp. 3-50.
- [4] P. Bresciani, P. Giorgini, F. Giunchiglia, J. Mylopoulos and A. Perini, "Tropos: An Agent-Oriented Software Development Methodology," *Journal of Autonomous Agents and Multi-Agent Systems*, p. 203-236, 2004.
- [5] A.-W. Scheer, *ARIS – Business Process Modeling*, Springer, 2000.
- [6] D. Neiger and L. Churilov, *Goal-Oriented Business Process Modeling with EPCs and Value-Focused Thinking*, 2004b, pp. 98-115.
- [7] S. Nurcan, A. Etien, R. Kaab and I. Zouka, *A Strategy-Driven Business Process Modelling Approach*, 6 ed., vol. 11, 2005, pp. 628-649.
- [8] H. Kwan Hee, C. Sang Hyun, J. G. Kang and G. Lee, *Performance-centric business activity monitoring framework for continuous process improvement*, United Kingdom: World Scientific and Engineering Academy and Society (WSEAS), 2010, pp. 40-45.
- [9] P. Kueng and P. Kawalek, "Goal-based business process models: creation and evaluation," *In Business Process Management Journal* 3, pp. pp. 17-38, 1997.
- [10] P. Johnson, E. Johansson and T. Sommestad, *A Tool for Enterprise Architecture*

Analysis, Annapolis USA, 2007.

- [11] M.-E. Iacob and H. Jonkers, *Quantitative Analysis of Enterprise Architectures*, Geneva, Switzerland, 2005, pp. 239-252.
- [12] P. Soffer and Y. Wand, *On the Notion of Softgoals in Business Process Modeling*, vol. 11, Emerald Group Publishing Limited, 2005, p. 663– 679.
- [13] M. Hammer and J. Champy, *Reengineering the Corporation: A Manifesto for Business Revolution*, London, England: Nicholas Brealey Publishing, 1993.
- [14] S. Mansar and H. Reijers, *Best Practices in Business Process Redesign: Use and Impact*, vol. 13, 2007, pp. 193-213.
- [15] The Object Management Group (OMG), “Business Process Maturity Model (BPMM),” 2008. [Online]. Available: URL <http://www.omg.org>. <http://www.omg.org>.
- [16] J. vom Brocke and M. (. Rosemann, *Handbook on Business Process Management 2 - Strategic Alignment, Governance, People and Culture*, Springer, 2010.
- [17] W. M. P. van der Aalst, *Process Mining - Discovery, Conformance and Enhancement of Business Processes*, vol. 1, Springer, 2011.
- [18] J. Kolár, *Business Activity Monitoring*, Masaryk University, 2009.
- [19] D. Grigori, F. Casati and M. Castellanos, “Business Process Intelligence,” *Computers in Industry*, vol. 53, no. 3, pp. 321-343, 2004.
- [20] J. Bubenko, A. Persson and J. Stirna, “D3 Appendix B: EKD User Guide,” Royal Institute of Technology (KTH) and Stockholm University, Stockholm, Sweden, 2001.
- [21] D. Quartel, W. Engelsman, H. Jonkers and M. v. Sinderen, *A Goal-Oriented Requirements Modelling Language for Enterprise*, Auckland, New Zealand: IEEE Computer Society, 2009.
- [22] V. Popova and A. Sharpanskykh, *Formal goal-based modeling of organizations*, INSTICC Press, 2008.
- [23] Object Management Group (OMG), *Business Motivation Model (BMM)*, 2008.
- [24] C. Pedrinaci, I. Markovic, F. Hasibether and J. Domingue, *Strategy-Driven Business Process Analysis*, 2009, pp. 169-180.
- [25] A. Dardenne, A. van Lamsweerde and S. Fiskas, *Goal Directed Requirements Acquisition*, vol. 20, 1993, pp. 3-50.
- [26] ISO - International Organization for Standard, *Information technology – Open Distributed Processing – Use of UML for ODP system specifications*, 2008.
- [27] W. Engelsman and R. Wieringa, *Goal-oriented requirements engineering and enterprise architecture: Two case studies and some lessons learned*, vol. 7195 of Lecture Notes in Computer Science, London, UK: Springer Verlag, 2012, p. 306–320.
- [28] I. Markovic and M. Kowalkiewicz, *Linking Business Goals to Process Models in Semantic Business Process Modeling*, Munich, Germany, 2008, pp. 332-338.
- [29] British Ministry of Defence, “MOD Architecture Framework (MODAF)”, 2005.

<http://www.mod.uk/DefenceInternet/AboutDefence/WhatWeDo/InformationManagement/MODAF>. [Accessed 16 02 2013].

- [30] USA Department of Defense, *DoD Architecture Framework version 1.5 Volume I: Definitions and Guidelines*, 2007.
- [31] P. Halleux, L. Mathieu and B. Andersson, *A Method to Support the Alignment of Business Models and Goal Models*, Montpellier, France: CEUR Workshop Proceedings, 2008, pp. 120-134.
- [32] G. Koliadis, A. Vranesevic, M. Bhuiyan, A. Krishna and A. Ghose, *A Combined Approach for Supporting the Business Process Model Lifecycle*, Kuala Lumpur, Malaysia, 2006a.
- [33] Y. Lin, *Semantic Annotation for Process Models: Facilitating Process Knowledge Management via Semantic Interoperability*, Trondheim, Norway, 2008.
- [34] E. Cardoso, J. P. A. Almeida and R. Guizzardi, "Analyzing the Relations between Strategic and Operational Aspects of an Enterprise: Towards an Ontology-based Approach," *International Journal of Organizational Design and Engineering (IJODE)*, 2012, vol. 2, no. 3, pp. 271 - 294, 2012.
- [35] G. Guizzardi, *Ontological Foundations for Structural Conceptual Models*, University of Twente, The Netherlands, 2005.
- [36] M. Pestic, *Business process management maturity model and Six Sigma: An integrated approach for easier networking*, Sarajevo: Springer, 2009.
- [37] A. Teka, *Analysis of indirect influence relations in goal-oriented requirements engineering*, Electrical Engineering, Mathematics and Computer Science (EEMCS), University of Twente , 2012.