A conceptual model for organisational decision-making and its possible realisations

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Abstract. Industry practice follows a refinement-based iterative method for organisational decision-making. Current industry practice relies heavily on human expertise in realisation of the method. We propose a conceptual model for this method and discuss possible realisations of the model. Our explorations to support the latter using existing enterprise modeling technology are shared along with early lessons learnt.

Keywords: Organisational decision-making, Multi-modeling, Model-based decision-making.

1 Introduction

Modern enterprises operate in an increasingly dynamic environment wherein they have to respond to a variety of change-drivers while achieving their goals. The cost of an erroneous response is prohibitively high and may possibly reduce options for later alterations. Therefore, exploring all possible courses of action and selecting the best option are critical for the enterprise to stay viable [10]. This calls for in-depth understanding of various organisational aspects such as goals, policies, organisational structure, operational processes, automation support in the form of IT systems etc., [1]. This is a difficult endeavour for several reasons. Being large, modern enterprises typically operate as specialized functional units in order to improve efficiency and facilitate the ease of management. The unfortunate side effect is fragmentation of information pertaining to the various organisational aspects. Typically, this information exists in the form of text documents and pictures. Integrating these information fragments in to an enterprise-wide consistent view is an effort-, cost-, time- and intellectually-intensive endeavour. Moreover, as the enterprise operates in an increasingly dynamic environment, the enterprise-wide view needs to be frequently kept up-to-date with reality. With the information available in natural language text, human expertise is the only recourse for its analysis thus making the analysis quality largely person-dependent. Furthermore, large size of the information makes manual analysis quite untenable.

In this paper, we discuss the explorations made so far under our ongoing research program aimed at improving the current state of practice of organisational decision-making[1]. We begin with a description of a method typically deployed by industry practice for organisational decision-making (Section 2). We discuss how the existing EM tools fall short in effective and efficient realisation of this method (Section 3). We then propose a fit-for-purpose conceptual model for organisational decision-making (Section 4). We present three possible realisations of the conceptual model discussing their relative merits and demerits (Section 5). The paper concludes summarizing the progress made, the lesson learnt and future work required to meet expectations of industry practice.

2 Industry practice of organisational decision-making

Typically, industry practice follows a refinement based method for organisational decision-making. The method is guided by separation of concerns principle wherein at the onset it is concerned with questions such as: *What are the overall goals? Are there any dependencies between these goals? What are the various means of achieving them? How do these objectives differ qualitatively?* And so on. In a decision-making process, these questions are formulated and the high-level solution alternatives identified. Typically, human experts validate as well as rank the alternatives where their past experience plays a crucial role. However, lack of details, especially backed by data, means the decisions are guestimates at best. Decision-makers require more certainty about possible effects of choosing one alternative over the other, preferably in quantitative terms.

This requirement leads to a crystallization of specific metrics to be used for quantitative evaluation of competing alternatives. Metrics identify more specific questions in a more specific context. This leads to identification of a set of parameters that influence the desired metrics. These parameters too may interfere with each other. Thus, a need to answer more detailed questions in the light of a more specific context leads to the need for a model that can support quantitative analysis for the chosen context. However, several such context-specific models may need to be created in order to provide quantitative justification for each alternative derived from the qualitative analysis of earlier phase. Thus, iterative exploration of alternatives for achieving organisation goals leads to a set of candidate strategies along with qualitative as well as quantitative evaluation of their intrinsic worth. There could be multiple ways of operationalizing a strategy. Moreover, there would be a natural demand to leverage existing operational processes and organisational structures to the extent possible. Thus, this phase of decision-making is characterized by negotiation and trade-offs.

3 Current state of the art

Modeling offers a possible line of attack wherein solution to the problem can be attempted at a higher level of abstraction [3]. Elimination of unnecessary details

[1] www.tcs.com/about/research/research_areas/software/Pages/Model-Driven-Organization.aspx

makes the problem more approachable, and richness of the model (rather, the modeling language) can enable rigorous analyses that can even be automated. Enterprise Modeling (EM) attempts to address the organisational decision-making problem from this very perspective. However, EM languages capable of specifying all relevant aspects are found wanting in terms of analysis capabilities [2, 4, 11], and EM languages capable of sophisticated analysis can cater to specification of only a subset of relevant aspects [12, 7, 9]. Therefore, multiple candidate lines of attack emerge. For instance, having identified the organisational aspects that are necessary and sufficient for the specific decision-making problem under consideration: a solution based on integrated use of the relevant EM tools seems possible, a solution based on integration of the languages supported by the relevant EM tools seems possible, a solution based on an integrated language that in essence amounts to co-simulation of the languages supported by the relevant EM tools seems possible, and so on.

4 Conceptual model

Figure 1 shows a model that represents current industry practice of organisational decision-making. An organisation is visualized as a conceptual entity named *Organisation Unit*. An organisation unit can be *decomposed* into multiple *Views* along three dimensions: smaller *Organisation Units* supporting functional decomposition, multiple *Levels* supporting hierarchical structure, and multiple *Aspects* based on the concern of interest such as strategic, tactical, and operational aspects. An organisation unit may have many *Stakeholders* where each stakeholder plays a *Role*. A role is, typically, associated with a *Perspective* which is related to one or many organisation unit(s), organisational level(s) and aspect(s). A perspective is related to another perspective using *Perspective Relation*. The perspective relationship is a complex relation of multiple *View Relations*. Two organisation units are mainly related for data and behavioral coordinations. Two levels exhibit the *Refinement* and *Abstraction* kinds of relationships whereas the relationship like *Conceptual Mapping*, *Concept Unification* and *Ontological Relationship* are useful for relating aspects.

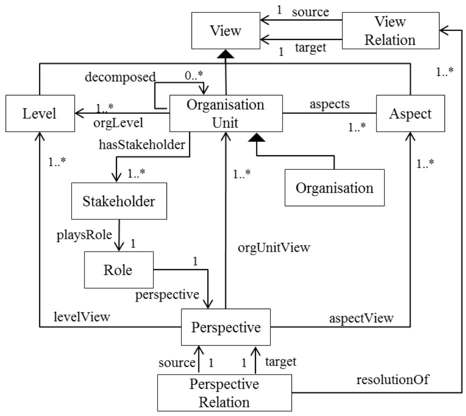

Fig. 1: Conceptual Meta Model for Organisational Decision Making

In this setting, the organisational decision-making is a process of understanding and analyzing the organisation from multiple perspectives wherein each perspective comprises multiple views. Analyzing multiple views within a perspective is a complex task as one needs to understand relationships between views. An-

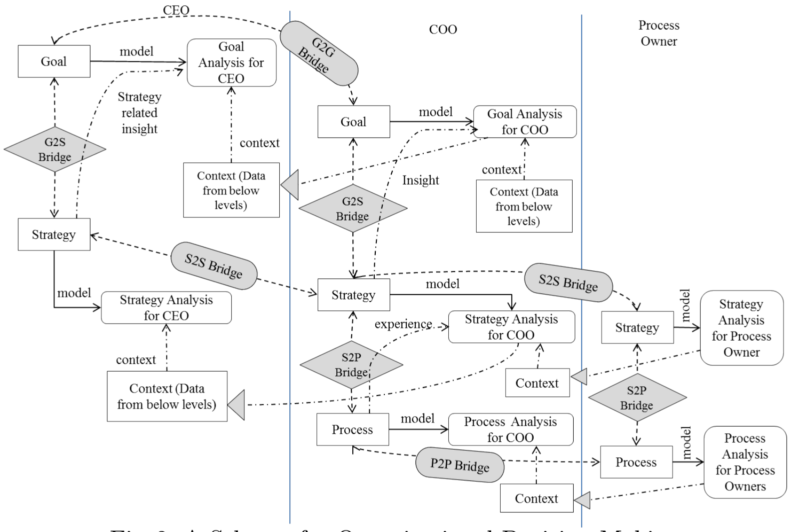

Fig. 2: A Schema for Organisational Decision Making

alyzing multiple perspectives for an organisational goal is a much harder problem as it involves negotiation and trade-offs while resolving conflicts between perspective-specific views. This is an iterative process where the analysis focus changes from one perspective to another, targeting a specific goal or conflict resolution in every iteration: from higher to lower level or vice versa, from one aspect to a set of relevant aspects, from one organisation unit to another, and so on. Analysis of higher-level aspects such as strategy moves down to lower-level perspectives while undergoing refinement on the way. Operational reality manifests in terms of various data elements which flow upwards through an aggregation and/or generalisation process. Typically, operational processes form the middle tier connecting strategy and operational reality layers.

We illustrate this decision-making process for an organisation with three different aspects namely, *Goal*, *Strategy*, and *Process*, and consider three stakeholders namely, CEO, COO, and Process Owner (PO). The CEO defines a set of organisational goals and high-level strategies, and breaks them down appropriately before delegating to COO for their management and control. Similarly, COO transforms the inherited goals and strategies into further granular units, and delegates them to multiple POs. Any change in goal, strategy or organisational structure, typically, moves from CEO to COO to PO whereas qualitative and quantitative data required for analysis moves up the other way round and may need transformations such as refinement, detailing, aggregation, abstraction, averaging etc. For example, CEO expects averaged-out Sales and Operational data figures i.e. an aggregation function over data from several organisational units. A schema for supporting the above organisational decision-making process is depicted in Fig. 2. In this diagram, the gray shapes represent desired view-to-view relationships, the diamonds indicate expected relationship between two aspects, the ovals indicate relationship between two levels, and the triangles indicate relationship between two organisation units.

5 Implementing the conceptual model

The discussion so far can be synthesized into a modeling language architecture as depicted in Fig. 3. A *View* is specified in terms of a set of core concepts having high internal cohesion enabling specific semantics to be imparted to the view leading to definition of a *Language*. We posit that all Languages of interest are definable in terms of a single *MetaLanguage*. Typically, a finite number of languages would be requiried for bounded *Aspects* and *Levels* of an organisation. View specifications of an organisation are so organised as to lead to relationships between *Aspects* at the same as well as different *Levels* of abstraction. The former is specified in terms of *LanguageMap* between corresponding view specification languages whereas the latter is specified in terms of a suitable *Language*. Proposed modeling language architecture can be realized in multiple ways that essentially differ in terms of the reliance on and sophistication of the modeling languages and the language engineering machinery used. We discuss three broad approaches using an instance of modeling language architecture depicted in Fig. 3. The instance model is illustrated in Fig. 4.

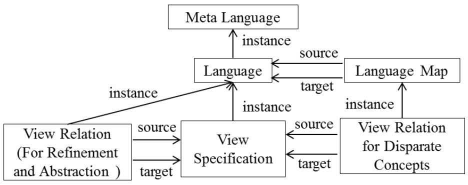

Fig. 3: Schema for Language Usages

5.1 Integration of tools approach

This approach advocates minimal use of language engineering principles and therefore relies heavily on human expertise. The central idea is to use existing tools in as is manner ensuring their concerted use by following a-priori defined guidelines and best practices. As each tool supports modeling only a partial view, the separately specified views need to be integrated to ensure consistent and well-formed enterprise model. Paradigmatically diverse nature of languages such as

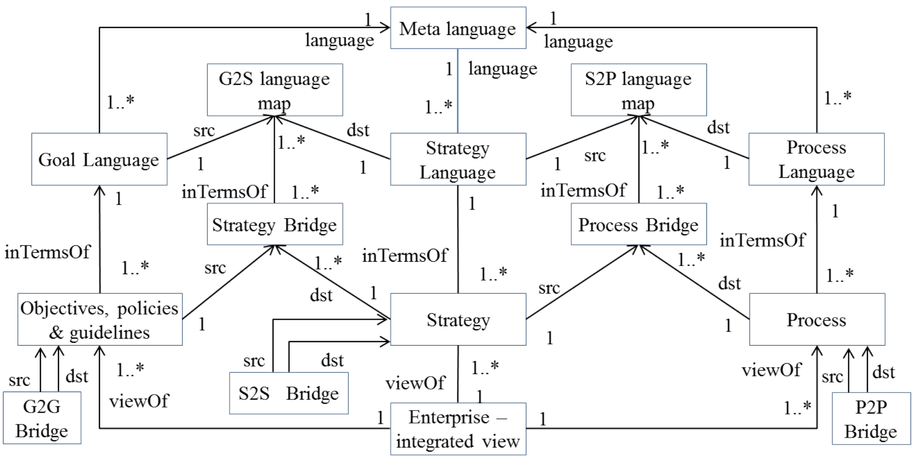

Fig. 4: Languages and specifications for our example

goal modeling [12], Stock-and-Flow (SnF) [7], and business process modeling [9] means it is hard to come up with a single meta-language in terms of which the modeling languages can be expressed. As a result, mappings between goal- and strategy-modeling languages (i.e. *G2S language map* of Fig. 4), and strategy- and process-modeling languages (i.e. *S2P language map* of Fig Fig. 4) are nothing more than links enabling navigation from one model to another e.g., like the links supported by AnyLogic[2] and Simudyne[3]. Naturally, concerted use of these tools has to rely heavily on human expertise for adherence to guidelines leading to correctness of execution. Moreover, these guidelines, being purposive, are rarely reusable. As a result, decision-makers find the modeling endeavour of little practical value while being effort- as well as cost-intensive.

5.2 Language integration approach

This approach advocates the use of a single meta-language that is capable of specifying goal modeling, strategy modeling, and process modeling languages. Being expressible in terms of the same meta-language, transformative relationships between goal and strategy modeling languages (i.e. *G2S language map* of Fig. 4), and strategy and process modeling languages (i.e. *S2P language map* of Fig. 4) can be given well-defined semantics and hence become amenable to automated analysis. As a consequence, bridging models between goal and strategy specifications (i.e. *Strategy Bridge* of Fig. 4), and strategy and process specifications (i.e. *Process Bridge* of Fig. 4) are amenable for automatic verification of their well-formedness, consistency as well as correctness. However, bridging models between two layers expressed in terms of the same language (i.e. *G2G Bridge*, *S2S Bridge* and *P2P Bridge* of Fig. 4) can be specified and checked for well-formedness only if a language supports generalization, specialization, aggregation, etc. Therefore, *Language* must be evaluated and extended accordingly to support comprehensive mappings. Use of a single meta-language can also help in machine-processable specification of model integration leading to automated derivation of integrated enterprise model. Thus, language integration approach seems substantially useful for organisational decision-making. However, conceiving a meta-language capable of specifying languages of interest i.e., one per organisational aspect, is an open-ended problem and hence impossible to have a solution for a variety of reasons. Besides the obvious technical difficulties, this option requires wide consensus among language and tool developers a thing that has rarely occurred if at all.

5.3 Integrated language approach

This approach advocates the use of a single language to specify enterprise at multiple levels of abstraction. It proposes a set of core concepts to be used to specify an enterprise at strategy, process as well as systems levels. These concepts are made available to the decision-maker in terms of [level specific] simulatable

[2] http://www.anylogic.com
[3] http:// www.simudyne.com/

language[s]. As a result, decision-maker is able to explore the solution space through what-if scenario playing thus leading to informed decisions as opposed to ad hoc reaction to an event. This can impart the much needed certainty to the decision-making while reducing intellectual burden on the decision-maker. Specifications of different views at the same level or at multiple levels can be easily related as they are expressed using a common set of concepts. By giving well-defined semantics to the common set of concepts, these specifications can be verified for well-formedness, consistency as well as correctness. Also, use of a single language enables automatic transformation of one view into the other. In essence, the set of common concepts enables co-simulation of view- and level-specific languages. Such a modeling language is briefly introduced in Fig. 5.

Organisation is a *Unit* that comprises a set of Units and strives to accomplish its stated *Goals*. It does so by responding to events taking place in its environment (*InEvents*), processing them, and by interacting with other external Units in terms of *Events* raised/responded (*OutEvents*). A Unit may choose not to expose all events to the external world (*InternalEvents*). A declarative specification of event processing logic constitutes the *Behaviour* of a Unit. Thus, looking outside-in, a Unit is a Goal-directed agent that receives events (*InEvents*), processes them as specified in *Behaviour*, and raises events (*OutEvents*) to be processed by other Units. Also, Unit is a parameterized entity whose structure and behaviour can be altered through *Levers*. A Unit interacts with other Units in a-priori well-defined Role-playing manner. In this formulation, the decision-making is a process of choose effective Levers that have the best potential to achieve stated Goals.

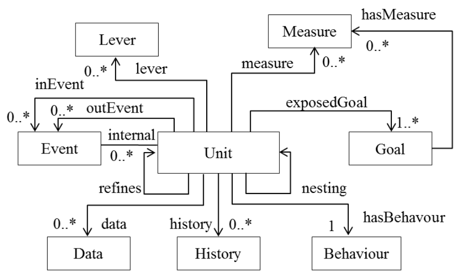

Fig. 5: Integrated Language Approach

6 Summary and future work

Modern enterprise is a complex system of systems that needs to respond to various change-drivers at increasingly rapid rate. Selecting the best from all possible courses of action is critical for the enterprise to stay viable. We showed how limitations of existing enterprise modeling technology makes this process excessively dependent on human experts an untenable option considering the large size of modern enterprise. In an attempt to bring technology to bear upon this problem: we proposed a conceptual model that captures current practice of organisational decision-making, three possible realisations of this model using available technology, and their relative evaluation.

Our exploration of integrated tool approach [5] indicates that existing model driven engineering technology suffices to implement the proposed solution and going forward we intend to focus on improvements as regards robustness, scalability and usability of the tooling infrastructure. We anticipate that the ensuing a toolset will provide practitioners with benefits such as: goal modeling, stock-n-flow modeling and process modeling tools being used in a better integrated manner; reduction in the current excessive reliance on human experts for doing the right things in the right order and the right way; how a machine-assited method can impart enhanced certainty to decision-making process, and so on.

Our exploration of integrated language approach [6] gives strong evidence that formal modeling of relevant aspects of enterprise in a manner that supports what-if and if-what simulation holds the key to effective and efficient decision-making. A simulatable language enables automated what-if scenario playing thus enabling informed navigation of solution space under human guidance leading to enhanced precision of organisational decision making as well as reduction in the present excessive analysis burden on experts. Going forward, we intend to extend the enterprise specification language with stochastic features in order to capture uncertainty that leads to variability in the simulation. In longer term, we are working towards a general purpose framework for organisational decision making where the simulation engine will be used in coordination with business facing DSLs to enable business experts to pose their questions using business facing language and get their answers back in business terms. We think ideas from game theory need to be incorporated to support negotiation and trade-offs [8].

References

1. Daft, R.: Organization theory and design. Nelson Education (2012)
2. Iacob, M., Jonkers, D.H., Lankhorst, M., Proper, E., Quartel, D.D.: Archimate 2.0 specification: The open group. Van Haren Publishing (2012)
3. Kramer, J.: Is abstraction the key to computing? Communications of the ACM 50(4), 36–42 (2007)
4. Krogstie, J.: Using eeml for combined goal and process oriented modeling: A case study. In: Proceedings of EMMSAD. p. 113. Citeseer (2008)
5. Kulkarni, V., Barat, S., Clark, T., Barn, B.: Toward overcoming accidental complexity in organisational decision-making. In: 17th Intl. Conf. on Model Driven Engineering Languages and Systems (MoDELS 15). IEEE (2015)
6. Kulkarni, V., Barat, S., Clark, T., Barn, B.: A wide-spectrum approach to modelling and analysis of organisation for machine-assisted decision-making. In: Enterprise and Organizational Modeling and Simulation, pp. 87–101. Springer (2015)
7. Meadows, D.H., Wright, D.: Thinking in systems: A primer. Chelsea Green Publishing (2008)
8. Nash, J.F., et al.: Equilibrium points in n-person games. Proc. Nat. Acad. Sci. USA 36(1), 48–49 (1950)
9. OMG: Business process model and notation (bpmn) version 2.0. Tech. rep. (jan 2011), `www.omg.org/spec/BPMN/2.0/`
10. Shapira, Z.: Organizational decision making. Cambridge University Press (2002)
11. Vernadat, F.: Ueml: towards a unified enterprise modelling language. International Journal of Production Research 40(17), 4309–4321 (2002)
12. Yu, E., Strohmaier, M., Deng, X.: Exploring intentional modeling and analysis for enterprise architecture. In: Enterprise Distributed Object Computing Conference Workshops, 2006. EDOCW'06. 10th IEEE International. pp. 32–32. IEEE (2006)