# Models to Aid Decision Making in Enterprises

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Abstract: Enterprises are complex heterogeneous entities consisting of multiple stakeholders with each performing a particular role to meet the desired overall objective. With increased dynamics that enterprises are witnessing, it is becoming progressively difficult to maintain synchrony within the enterprise for it to function effectively. Current practice is to rely on human expertise which is time-, cost-, and effort-wise expensive and also lacks in certainty. Use of machine-manipulable models that can aid in pro-active decision-making could be an alternative. In this paper, we describe such a prescriptive decision making facility that makes use of different modeling techniques and illustrate the same with an industrial case study.



## 1 INTRODUCTION

Globalization forces and increased connectedness have led to rise in business dynamics and shortened time-to-market window for business opportunities. Modern enterprises are subject to several change drivers such as opportunities in a new market, technology advance and/or obsolescence, regulatory compliance etc. Current practice is to rely solely on human expertise, which is largely a synthesis of past experience, in order to arrive at a suitable response to a change in the operating environment. This is an effort-, time- and cost-intensive endeavour and is also error-prone. Arriving at a response involves addressing issues like: many a time it is not clear which of the available options is the best option for a given evaluation criterion, what would be the ripple effect of taking that option and what is the best way of implementing that option. As the cost of taking a potentially incorrect decision is prohibitively high, it is highly desirable to have aids that can support pro-active (semi-) automated decision making, where it would be possible to play out various what-if (and if-what) scenarios to arrive at the right response, feasibility of the response, and ROI of the response (Kulkarni et al., 2013).

Typically, enterprises can be viewed as large-scale distributed systems characterized by high complexity, heterogeneity and intense dynamism leading to complex interactions among humans, business processes, IT systems and IT infrastructure. Therefore the key idea is to model an enterprise across various planes (see Fig. 1) namely, Infrastructure plane concerning hardware infrastructure and firmware managing it, Systems plane concerning IT systems and their inter-relationships and Business plane concerning organization's vision-mission-goals, structure and operational processes (Kulkarni et al., 2013). Furthermore, each plane of the enterprise is amenable for specification in terms of various kinds of models. For instance, intentional model for specifying enterprise objectives and goals; business process and/or event based models for specifying workflows; various UML models for specifying business applications; system dynamical model for specifying the stocks of interest, their flows and variables influencing the flows etc. These models need to be relatable to each other so as to ensure consistency and completeness within a plane and alignment across adjoining planes. Therefore, we believe a holistic model-centric approach will enable organizations improve agility leading to better adaptive responsiveness.

The rest of the paper is organized as follows. Section 2 of the paper presents a motivating example. Section 3 explains our modeling approach in the light of the motivating example. Finally, we discuss some of the key issues and present the related work in Section 4 before concluding in section 5.

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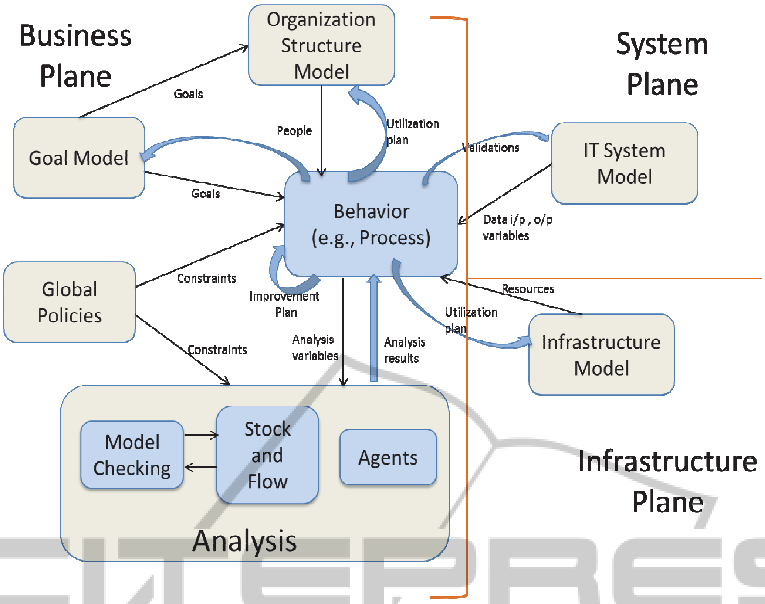


Figure 1: Modeling Approach.



## 2 MOTIVATING EXAMPLE

In this section we introduce a motivating example that sets the context for the rest of the paper. Let us consider a large financial company (FinCom) whose earnings model is based on the number of financial products (e.g., loans, mutual funds, insurance etc.) to be sold to potential customers. To sell its products, the company needs to acquire a large customer base. Customer acquisition is an expensive process that involves investment in advertisement, promotions, publicity etc. However, instead of incurring such financial expenditure, FinCom intends to maintain a minimal customer acquisition cost by partnering with large retail chains selling consumer durable products such a televisions, refrigerators etc.,to a sizeable customer base. FinCom targets this customer base by providing attractive loans at 0% interest for 1-2 years duration. In this manner, FinCom acquires new customers, then cross-sells other financial products to them. FinCom works on a very thin margin for individual clients; however, their overall profitability remains high due to high volume sell to a substantial customer base. FinCom business model works for the retailers too who can offer their clientele attractive third party credit facilities.

The business model of FinCom seemed to have worked very well. The company is able to hook increasingly large number of customers at a faster growth rate of 20% Quarter_on_Quarter. They are also able to convert a healthy chunk of prospects to customers with minimal selling cost. Cost of servicing customers is also quite low. Thus, overall their business is growing at a pretty fast pace.

However, the company has identified new challenges that are vital for their future growth and expansion into new markets. The company aims to scale up revenues by a factor of 10 without having to increase the associated cost. In other words, FinCom would like to have a non-linear revenue growth. As the company ventures into emerging markets, most of the IT intensive business processes need to scale and seamlessly integrate with newer systems. Currently the IT operations are managed by FinCom itself but the company is finding it increasingly difficult as managing IT is not their primary forte. Instead they would like to concentrate on developing new financial products, perform various market analyses and focus on diverse data-centric analytics on its existing customer base.

FinCom is looking for able IT service providers who can manage their end-to-end IT operations including guidance towards future IT expansion. For example, to remain competitive, FinCom would like their gadget savvy customers to avail new channels like smartphones, tablets and other ubiquitous devices for making payments towards their loans or mortgage products. Similarly the company would like to evaluate whether some of their IT services could be moved to a cloud-based infrastructure without compromising any security issues or

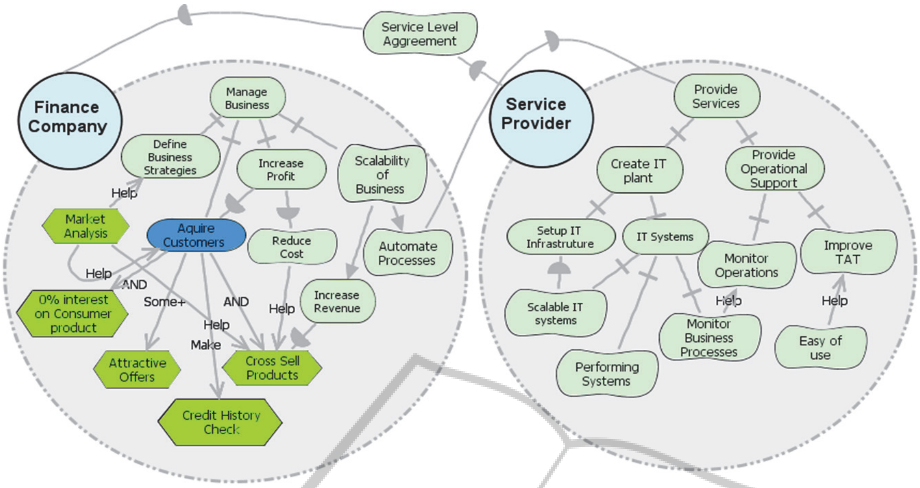


Figure 2: Intentional Model to capture Stakeholder goals.

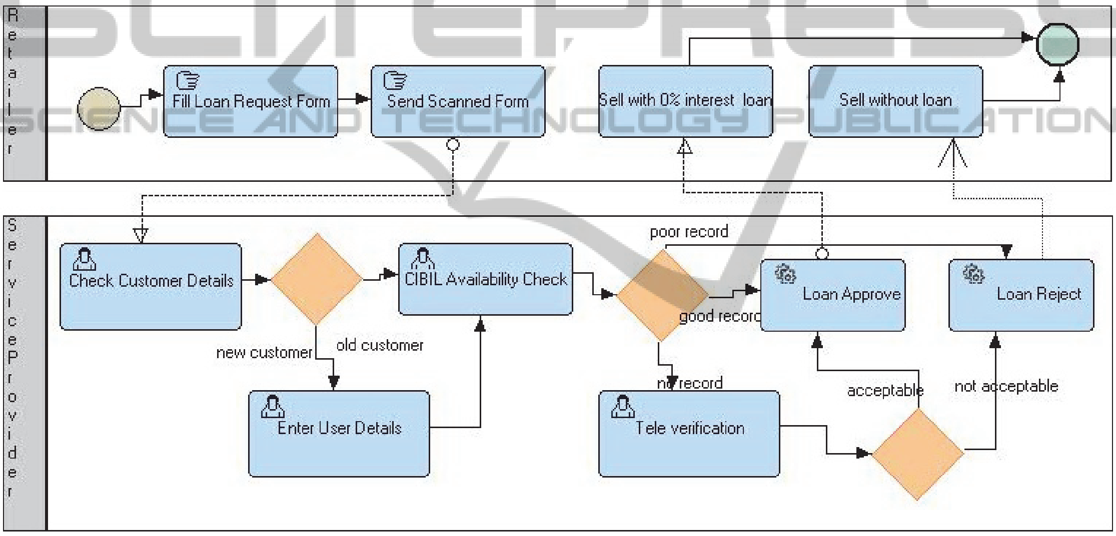


Figure 3: Customer Acquisition Business Process Flow.



degradation of quality of service (QoS). However, their internal IT is not well equipped to provide these additional pervasive channels or move to a cloud-based infrastructure at a rapid pace. Therefore FinCom would like to outsource their non-core business to external IT service providers.

## 3 MODELING APPROACH

In the context of the above business case, Fig. 1 presents our holistic modeling approach aimed at pro-active data-driven decision making. The goal is to capture various facets of an enterprise belonging to each of its plane (i.e., *Business*, *System* and the *Infrastructure* plane) with precise modeling techniques and finally analyzing the result by simulating them in concert. For example, in Fig. 1, the goal model captures the business objectives of the enterprise, while the organization structure model describes the people/role aspect of the enterprise along with vision, mission, local policies etc. Similarly, the IT System model describes the overall IT need of an enterprise from a system perspective i.e. which steps of operational processes are being automated using which application services and what data needs to be monitored. Apart from the structural aspects of the enterprise, the general behaviour of the enterprise is realized in the form of a behavioural model. Currently this is realized using Business Process Modeling Language (Scheer, 1996) but in future will be extended to a

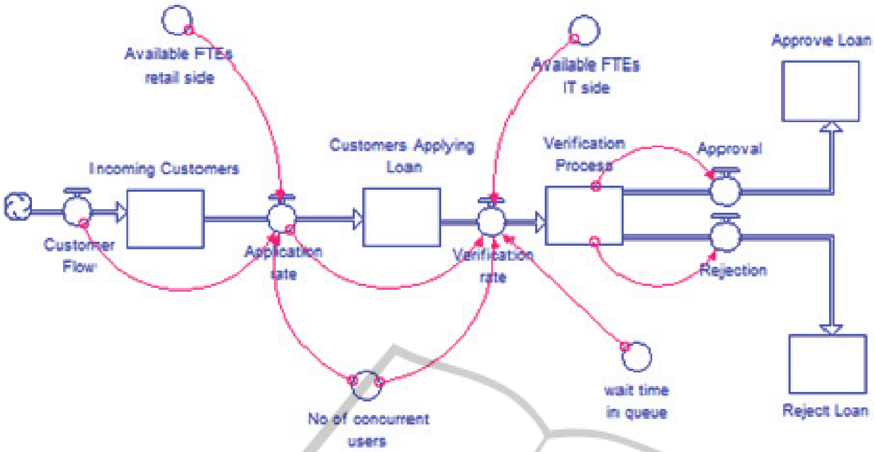


Figure 4: Stock-n-Flow model to analyze peak season load.

more general modeling language such as event based modeling (Clark et al., 2011).

Once the structural and behavioural aspects of an enterprise across multiple planes are captured, different what-if scenarios are played out and the results so obtained are provided as feedback to fine tune the models in each of these planes. For example, analysis of workflow can lead to restructuring of business process and/or task assignment resulting in improved resource utilization. Similarly one can validate if none of the critical business goals are compromised or the IT system model is in conformance with the perceived IT needs of the enterprise. The analysis models are chosen such that they are best suited for what-if analysis, for instance, stock-n-flow, agent-based, petri-nets and event-based models (Forrester, 1958; Reisig, 1991; Bresciani, 2004). In the following section, we demonstrate use of various models and their relationships with an objective of automated analysis. We start with an intentional model that captures the overall goals of the enterprise (Yu et al., 2006).

### 3.1 Modeling Goals with Intentional Model

In Fig. 2, the ovals represent the strategic rationales (SR) for the two primary stakeholders (i.e., FinCom and SP). Each SR is further decomposed into goals, soft-goals and tasks that are means by which the goals can be reached. For example, the root-level goal '*Manage Business*' can be achieved by defining business strategies, acquiring customers, making profit, and scaling up business. The links between the stakeholders represent strategic dependencies. For example, FinCom is dependent on SP to automate some of their business processes, while SP is dependent on FinCom to define appropriate SLAs.

The highlighted part in Fig. 2 shows specifically the customer acquisition process that is one of our primary point of interest. Some of the sub-tasks of *Acquire Customers* are *Credit History Check*, *Cross-Sell products* etc., while *Market Analysis* helps to acquire new customers. Although Intentional model can capture goals, tasks and their dependencies, it does not capture the sequence of events that truly describes the process.

Therefore to capture such event-oriented process behaviour, we use standard BPM language as depicted in Fig. 3. The process model shows two primary stakeholders, namely the consumer durable *Retailer* who offers customer with various products along with attractive financial schemes and the *Service Provider* who facilitates the customer loan request process. Fig. 3 describes the process, i.e., the customer fills the loan request form, which is then scanned and send to SP for credit check. Loan is approved if the customer has a good credit score, otherwise it is denied. However there are SLAs that guarantees that the entire approval process from loan application to approval/rejection should not take more than 3 minutes. Moreover, during peak festive season, there is a sudden increase in number of customers to be serviced. Keeping this concern in mind, the business process must be able to adapt to changing business scenario without any significant increase in cost or deviation in SLAs. Since it is not possible to analyze such a scenario using standard BPM time, cost and resource analysis techniques (Scheer, 1996; IBM RSA, 2014), we use stock-n-flow model which provides quantitative analytical modeling abilities to play out various what if-scenarios, the results of which are used by the process models for further optimization. The next section demonstrates use of stock-n-flow model for this purpose.

### 3.2 Analyzing Peak Season Load Stock-n-Flow Model

Stock-n-flow models (Forrester, 1958) typically capture the temporal behaviour of an enterprise. For example, during peak season (e.g., festive holidays), there is a steady rush in sale of consumer durable products. As a result the number of consumers applying for loan increases. To ensure there is no bottleneck, FinCom would like to know whether they can still manage their loan approval business process with existing manpower without compromising on QoS. Fig. 4 shows the stock-n-flow model to analyze peak season load. The stocks are typically the *Incoming Customers*, Customers Applying Loan etc., while the flows are *Application rate*, *Verification rate*, *Customer flow* etc. Some of the key variables that are used to analyze the peak season load are *Available FTEs*, *wait time in queue*, *no. of concurrent users* etc. Using stock-n-flow model one can parameterize and then refine the values of the variables to play out various what-if scenarios for pro-active decision making. For example, the model can simulate the impact on verification rate or loan application rate during peak season (i.e., when customer flow increases). Consequently, one can reason about the number of FTEs required at the retailer side or IT side or both. Similarly, additional questions like how many concurrent requests can still be handled without significant degradation in QoS (e.g., *wait time in queue*). All such questions and scenarios can be played out in advance and thereby help both the service provider and the enterprise to arrive at more informed decisions.

Although stock-n-flow models helped us to simulate various what-if scenarios, however, one needs to refine the values of the stocks, flows and variables to arrive at an optimum solution. That is, to carry out the simulation, an initial set of valid input values from the sample space is required. This is a manual time consuming process because one needs to keep all the dependency constraints in mind while assigning values to variables. For example, *FTE productivity* can be increased with improved training and additional incentives like increase in salary. However, this increases *FTE cost*. FTE cost can also increase with increase in *total number of FTE*, which in turn increases administration cost and as well impacts on Service Provider profitability. Similarly, Retailer and FinCom profit increases with increase in total number of customers. Thus one can observe that there is a dependency relationship among various parameters and considerable manual effort is required to assign right values to all the parameters without breaking any of the pre-defined organizational policy constraints. Also, there are pre- and post-condition constraints from the business process model and business rule constraints that need to be considered. In order to remove such manual intervention, we have introduced model checking (Merz, 2001), by which we automatically obtain values that satisfy the given constraints in the stock-n-flow model.

Once a valid set of input values from the model checker is automatically obtained, the stock-n-flow model is then simulated and the results so obtained are used as feedback to other models in the three planes. For example, using stock-n-flow we obtained the optimal number of FTEs for managing peak season load and feed these results back to infrastructure and organization structure model as the new utilization plan (see Fig. 1).

### 3.3 Discussion and Future Work

So far we have seen how each of the models belonging to *Business*, *System* and *Infrastructure* planes of Fig. 1 captures a specific problem of the enterprise. However, it is important to relate the analysis results and percolate them across different planes to get a more holistic view of the enterprise. For example, using intentional models we captured business objectives or tasks. But these tasks were not ordered or sequenced. Therefore, by using BPM language we were able to describe the sequence or ordering of events as well as associate cost, time and resources to these events. However, since BPM models were not sufficient to play out certain analyses, other suitable modeling techniques were employed. For instance, stock-n-flow models were used for analyzing peak customer load. Moreover we related the key variables used in the stock-n-flow models with the "data" variables available from the BPM and System models. Thus, we were able to establish an initial relationship between these disparate models.

## 4 RELATED WORK

Enterprise Architecture modeling is prevalent for a number of years (Lankhorst, 2005). There are a quite a few EA frameworks like FEA (FEA, 2006), Zachman (Zachman, 1987) TOGAF (TOGAF, 1995), Archimate (Archimate, 2012), that provide holistic blueprints for the organizational and architectural models. However, a key aspect that is missing is machine processability analyzability, which is the core contribution of this paper. MEMO (Frank, 2002) provides a method to support the development of enterprise models. Abstractions for various interrelated aspects like corporate strategy, business processes, organizational structure and information models are provided, but, with limited support for automated analysis. Other key topics like Business-IT alignment, landscape mapping etc, are covered in detail over the past (Schekkerman, 2006), however the focus of this paper is more on automated machine-dependent (i.e., minimum human dependency) decision making using a variety of appropriate modeling techniques. From a tooling perspective, various tools exist for enterprise architecture and business process modeling (Scheer, 1996; IBM RSA, 2014; iGrafx, 2014; MEGA, 2014), however analysis support is limited to simulation of business processes so as to identify process bottlenecks and suggest optimization in terms of resources, time and cost. These tools do not provide support for taking forward analysis results of one model onto another. Moreover, analysis capability of these tools is limited to business process models only. Existing literature on enterprise modeling research (Schekkerman, 2006) also does not include evidence of use of multiple modeling techniques in conjunction, or of model checking to verify multiple modeling paradigms. To this respect, our previous work on mapping Intentional models with System Dynamic models in the context of EA (Sunkle et al., 2013) was an early start. In this paper, we have extended that work by introducing the concept of modeling across various layers of the enterprise with suitable techniques that are appropriate for that layer and finally we propose to orchestrate them in concert to get a holistic view of the enterprise.

## 5 CONCLUSIONS

In this paper, we discussed a model-centric approach to enable enterprises improve their agility and prepare them for better adaptive responsiveness. We proposed a layered architecture for modeling enterprises wherein the adjoining layers have a well-defined relationship and each layer addresses a set of coherent concerns as seen from the perspectives of a set of stakeholders. The key idea is to specify each layer in terms of a model which can be viewed as a set of relatable models each constituting an intuitive and closer-to-problem-domain specification of a concern – as advocated by separation of concerns principle. We argued the case for these models to be relatable, analyzable and simulatable. We illustrated the rationale behind the proposed model-centric approach through a motivating example. We described several modeling techniques (e.g., intentional, stock-n-flow, agent-based) that best match an underlying problem scenario. We described how each one of the models caters to specific goals and how they relate to and complement each other. We further described how our proposed solution percolates analysis results from one model to another model either in the same or in a different enterprise layer. Until now, we have found very little evidence of such an approach in the existing literature and believe that the enterprise engineering community can largely benefit from the investigations and position taken in this paper.



## REFERENCES


ArchiMate 2. 0 Specification 2012. Van Haren Publishing Series. Bernan Assoc.

Bresciani, P., Giorgini, P., Giunchiglia, F., Mylopoulos, J., Perini, A., 2004. Tropos: An Agent-Oriented Software Development Methodology,In *Autonomous Agents and Multi-Agent Systems, Vol. 8, No. 3*, pp. 203–236, Springer.

Clark, T., Barn, B., 2011. Event driven architecture modelling and simulation, In *SOSE'11*, pp. 43-54, IEEE Computer Society.

FEA 2006. Federal Enterprise Architecture Program EA Assessment Framework 2.1.

Frank, U., 2002. Multi-perspective enterprise modeling (MEMO) conceptual framework and modeling languages," In HICSS., pp.1258-1267. IEEE Computer Society.

Forrester, J., 1958. Industrial Dynamics--A Major Breakthrough for Decision Makers, In *Harvard Business Review, Vol. 36, No. 4*, pp. 37–66.

IBM RSA 2014. http://www-03.ibm.com/software/products/us/en/ratisystarchfami.

iGrafx 2014. http://www.igrafx.com.

Kulkarni, V., Roychoudhury, S., Sunkle, S., Clark, T., Barn, B., 2013. Modeling and Enterprises - The Past, the Present, and the Future, In *MODELSWARD'13*, SCITEPRESS.

Lankhorst, M., 2005. *Enterprise Architecture at Work: Modeling, Communication and Analysis*, Springer.

MEGA EA Tools, 2014. http://www.mega.com/en/solution/enterprise-architecture.

Merz, S., 2001. Model Checking: A Tutorial Overview", In *Proc of the 4th Summer School on Modeling and Verification of Parallel Processes*, pp. 3-38.
Scheer, A., 1996. ARIS-Toolset:Von Forschungs-Prototypen zum Produkt" *Informatik-Spektrum 19: 71–78,* Springer-Verlag.
Schekkerman, J., 2006. *How to Survive in the Jungle of Enterprise Architecture Frameworks: Creating or Choosing an Enterprise Architecture Framework*, ISBN-13: 978-1412016070.
Sunkle, S., Roychoudhury, S., Kulkarni, V., 2013. Using Intentional and System Dynamics Modeling to Address WHYs in Enterprise Architecture, In *ICSOFT-EA*, SCITEPRESS.
TOGAF Version 9.1, 1995. http://pubs.opengroup.org/architecture/togaf9-doc/arch/
Reisig, W., 1991. Petri Nets and Algebraic Specifications. *Theoretical Computer Science Vol. 80, No. 1,* pp. 1-34, Elsevier.
Yu, E., Strohmaier, M., Deng, X., 2006. Exploring Intentional Modeling and Analysis for Enterprise Architecture, In *EDOC Workshop on Trends in Enterprise Architecture Research*.
Zachman, J. A., 1987. A Framework for Information Systems Architecture. In *IBM Systems Journal, Vol. 26, No. 3*.