STRATEGIC REASONING IN SOFTWARE DEVELOPMENT

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Abstract: Information systems tend to be huger and of strategic importance in nowadays buisnesses. That is why software engineering is no more only a domain for middle managers and software engieering professionals but top managers require rich models leading to visions on which they can perform strategic analysis for determining their adequacy with long term objectives. The i* approach with its social modeling capabilities as well as service oriented modeling are part of this effort. The strategic services model combines those two approaches and defines a couple of environmental factors (namely threats and opportunities) enabling strategic reasoning on the bases of the enterprise "high-level" added values. Such a framework offers the adequate agregation level for enabling top managers to take the adequate long term decisions for information systems development. The aim of this paper is to illustrate the strategic services model application as well as a strategic reasoning in the context of the development of a collaborative software application for supply chain management. This case study is from particular interest since it must be adopted by several actors played by cooperating or competing companies that have to figure out the consequences of the adoption of such software.

1 INTRODUCTION

Nowadays software developments are mostly driven by engineering concepts; however, for the last ten years a clear trend is to spend more time and effort on the analysis disciplines. From poor (UML) use case analysis models to semantically rich (i*) strategic dependency and rationale organizational models the willingness to adequately represent the software problem and its operating environment has continuously increased. Even if the i* approach brings tremendous refinements in representing the problem into its organizational setting, such a representation is still too detailed for top management so that it is not adequate for the understanding they require. Moreover, service-oriented computing (SOC) is becoming increasingly popular. Flexibility offered by service-oriented architectures has rapidly been understood that is why it is widely used today. Services as conceptual entities can also be used as the fundamental scope elements in software development which gave birth to service-oriented modeling (SOM). They are based on the enterprise values and thus constitute an adequate abstraction level for reasoning in a strategic context.

This paper is part of the effort to offer a high level vision of software systems matching with the enterprise values in the form of services. It provides a real-life case study in the field of supply chain management (SCM) [1] which proves the applicability of the approaches suggested in (Pastor et al., 2010; Wautelet et al., 2008) in such a context.

The paper is structured as follows. First the need for a high level vision is enlighten, the suitability of service oriented modeling in such a context is motivated and related work is overviewed. The paper then turns to the case study with the presentation of the application domain, a collaborative platform for outbound logistics. The strategic view encompassing a strategic reasoning about the development of the platform is exposed. Finally conclusions are taken.

2 PROBLEM STATEMENT

This section motivates the importance of the framework and its application.

[1] In this paper we refeer to outbound logistics which is a part of SCM, this will be clarified later.

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2.1 The Need for a High Level Vision

Management sciences define several layers for decision making. Indeed, decisions do not have the same impact - from a marginal short term consequence to a major long term impact - so that their time horizon is variable. Traditionally, management sciences identify three levels for decision making to discriminate time horizons and resources that should be allocated:

- The Strategic Level. Strategic decisions are top level. Decisions taken here concern general direction, long term goals, philosophies and values;
- The Tactical Level. At the tactical level, more concrete decisions are taken which aim at implementing the strategy defined at the corporate level. The business units adapt this strategy in terms of policies under which the operations will happen;
- The Operational Level. These are every day decisions, used to support tactical ones. Their impact is immediate, short term, short range, and usually low cost. Operational decisions can be pre-programmed, pre-made, or set out clearly in policy manuals.

Most software development methodologies focus on tactical and operational aspects. The traditional analysis disciplines as for example *business modeling* and *requirements* defined in the *Rational Unified Process* (IBM, 2003) are focused on tactical aspects since they only describe business processes or requirements with a poor semantic i.e. use case models with no framework for strategic reasoning.

2.2 Towards Service-oriented Modeling

The framework presented here will be based on service oriented modeling (SOM). Following (Bell, 2008), *SOM is a software development practice that employs modeling disciplines and language to provide strategic and tactical solutions to enterprise problems. This anthropomorphic modeling paradigm advocates a holistic view of the analysis, design, and architecture of all organizational software entities, conceiving them as service-oriented assets, namely services.* Services represent the values offered by the enterprise (being here a high level actor) to their customers, that is why they are by nature more expressive than computer science driven concepts. They are also highly aggregated so that they are perfectly suitable for a high level view.

(Pastor et al., 2010) proposes to evaluate the i* (i-star) framework (Yu, 1995) on the basis of a series of 9 features: refinement, modularity, repeatability, complexity management, expressiveness, traceability, reusability, scalability and domain applicability. The paper defines those features and they are exhaustively evaluated on the basis of a not supported/not well supported/well supported scale. Notably they enlighten as a main conclusion on the practical evaluation what is clearly needed to extend the i* framework with mechanisms to manage granularity and refinement. Indeed they point out that *the negative results in the evaluation of i* are related to the lack of mechanisms for defining* ***granules*** *of information at different abstraction levels, allowing modelers to structure the information represented in the model*. One of the lacks of the i* modeling framework is indeed that all of the organization modeling elements are represented in the same diagram with consequently a unique abstraction level and poor concepts hierarchy. Moreover, they also point out that *apart from the definition of abstract primitives as building blocks, analysts must be provided with guidelines to allow them to structure a complete Enterprise through a set of organizational processes. These building units could then be refined into a set of more specific components that encapsulate a certain organizational behavior*. So they conclude their must be some high-level enterprise view and propose a Business Service Architecture for the i* framework.

To that extend, they propose to focus the organizational modeling activity on the *values* offered by the Enterprise to their Customers. Those values are called (business) services. (Pastor et al., 2010) also points out that business services can be used as basic granules of information that allow us to encapsulate a set of i* business process models. The services the enterprise offers are used as high level scope elements. Business processes fulfilling those services are then decomposed and refined on that basis. This approach allows to combine the intentional and social characteristics of i* with the "traditional" business process modeling.

(Wautelet et al., 2008) proposes the FaMOS framework. This framework notably refines the proposition of (Pastor et al., 2010) and proposes the Strategic Services Diagram which supplement the services view with the definition of *threats* and *opportunities*. In this figure, those two elements are generalized as an *Environmental Factor*. Indeed, services face threats which is defined as every environmental factor that can avoid the adequate fulfilment of the service (both in terms of achievement and quality of service degradation) as well as opporutinities defined as an environmental factor that can potentially higher QoS.

This paper constitutes an elaborated case study of the strategic services diagram which is one component of the FaMOS framework proposed in (Wautelet et al., 2008)

3 APPLICATION DOMAIN

This section introduces the application domain, outbound logistics, as well as the third party components used in the context of the collaborative platform development. Note that for space reasons the domain description has been brought to its simplest form the strategic reasoning in section 4 goes into much more details. A complete description of the application domain and its associated workflows is depicted in (Wautelet, 2009).

3.1 Outbound Logistics

Outbound logistics is the process related to the movement and storage of products from the end of the production line to the end user. In the context of this paper we mostly focus on transportation. The actors of the supply chain play different roles in the outbound logistic flow. The producer will be a logistic client in its relationship with the raw material supplier, which will be considered as the shipper. The carrier will receive transportation orders from the shipper and will deliver goods to the client, while relying on the infrastructure holder and manager. In its relation with the intermediary wholesaler, the producer will then play the role of the shipper and the wholesaler will be the client.

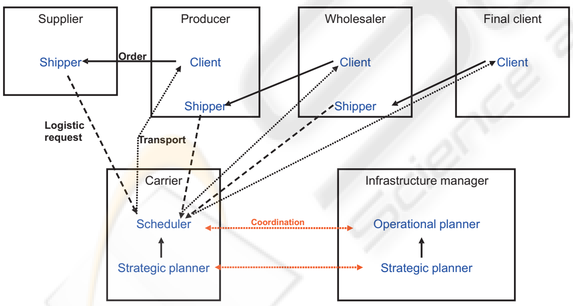

Figure 1: Material flows in the outbound logistics chain.

Figure 1 summarizes the material flows between the actors of the outbound logistics chain. The idea underlying the software development is to favour these actors' collaboration. Indeed, collaborative decision will tend to avoid local equilibriums (at actor level) and wastes in the global supply chain optimisation, giving opportunities to achieve the greatest value that the chain can deliver at lowest cost (see (Pache and Spalanzani, 2007)). More information on the applicative package development can be found in (Wautelet, 2009).

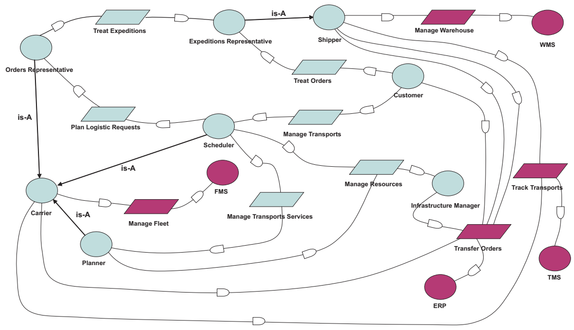

Figure 2: Strategic Services Diagram for the Collaborative Application Package.

4 STRATEGIC REASONING IN SOFTWARE DEVELOPMENT

This section introduces a strategic level vision of the collaborative platform to be developed; firstly the model based on services is overviewed, secondly a strategic reasoning overviews the consequences its adoption represents both in terms of threats and opportunities.

4.1 The Collaborative Application Package Services

The *Strategic Services Diagram* (*SSD*) of Figure 2 overviews the application package through multiple *Services*. We use the SSD which presents on highest aggregation level the services provided by the overall application with the actors involved in the software package as well as the potential threats and opportunities they are facing. By essence, the SDD helps to understand the purpose of the software project in terms of highly aggregated elements called *Services*. The theoretical model also allows to model the potential problems (i.e. *Threats*) they can face; the potential improvements (i.e. *Opportunities*) and the social structure (i.e. the *Dependencies*) which govern *Actor* interactions. This highest level view allows all project stakeholders to share a common aggregate view of what the applicative package should offer as well as their dependency relationships. The darkest services are the ones that can be fulfilled by already identified third party components. We will, in the context of this case study focus on *Track Transport*. This service is provided by the *Transportation Management System* (*TMS*) to the Shipper and the Carrier.

A definition of the concepts relative to outbound logistics - notably the actors in bold and the data structures in italic - depicted in the services description hereafter was made in section 3.1. Each service represents a complex workflow that is summarized here in a few sentences, the complete workflows are available in (Wautelet, 2009). The applicative package services are:

- The **Treat Orders** service represents the process to plan the coming material flows by building up *Logistic Requests* on the basis of the customers orders. The *Carriers' Expedition Representative* is the responsible actor;
- The **Treat Expeditions** service represents the process to build *Transportation Calls* on the available *Logistic Requests*. The *Carriers' Expedition Representative* is the responsible actor;
- The **Plan Logistic Requests** service represents the process to evaluate the possibilities (eventually by relaxing constraints) of accepting the transmitted *Transportation Calls*. The *Shipper's Orders Representative* is the responsible actor;
- The **Manage Transports Services** service represents the process to update the Carriers' *Transportation Services* offer in function of the general environment (demand and capacity on particular origins and destinations, new transportation possibilites, etc). The *Carriers' Planner* is the responsible actor;
- The **Manage Transports** service represents the process to plan the Carriers' physical *Transports* linked to its *Transportation Services* to answer to the accepted *Transportation Calls* demand. The *Carriers' Scheduler* is the responsible actor;
- The **Manage Resources** service represents the process to ensure an adequate planning of required resources (working teams, docks, cranes, etc.) for the planned *Transports*. The *Infrastructure Manager* is the responsible actor;
- The **Track Transports** service represents the process to track in real time the transported goods and perform a series of activities such as dynamic replenishments, alternative route calculation, etc. The *Actor's TMS* is the responsible actor;
- The **Manage Fleet** service represents the process to accomplish a series of specific tasks in the management of a carrier vehicle fleet as for example telematics (tracking and diagnostics), driver management, fuel management, vehicle maintenance and so on. The *Actor's FMS* is the responsible actor;
- The **Manage Warehouse** service represents the process to manage the movement and storage of materials within the warehouse and processing the associated transactions, such as shipping, receiving, putaway and picking. The *Actor's WMS* is the responsible actor;
- The **Transfer Orders** service represents the process to manage all the input data flows that must be transferred from the ERP system or to the actor ERP system. The *Actor's ERP* is responsible actor.

4.2 Strategic Reasoning

At strategic level, we mainly study the long-term strategic impact of adopting the collaborative software package through its relevant services for the concerned actors. This study is mainly concerned with two aspects that are balanced and that must be evaluated and focused on when taking the strategic decisions, namely *opportunities* and *threats*. Indeed, e-collaboration in SCM can potentially deliver series of advantages as information sharing, real-time decision making, online auctions and notably global optimization. Nevertheless, this advantage and others can have drawbacks for some of the concerned actors and they may thus not want to adopt it or, in case of adoption, have disastrous consequences on their businesses. To that end, a first strategic analysis - independent of any cost evaluation - on the basis of the proposed services, the opportunity they represent and the threats they face and targeted to the involved actors is made here.

As defined in the FaMOs framework (Wautelet et al., 2008) one of the most important benefits of the SSD is to directly incorporate opportunities and threats as elements of the model. For clarity reasons we will however not represent them graphically into the model but list them and draw an opportunities/services matrix as well as a threats/services one. This analysis is generic in the sense that we adopt the point of view of the leading actor (that can be visualized in the SSM) for each of the opportunities and threats we evaluate at the light of a particular service.

The added value/risk exposure for each particular service to each particular opportunity/threat is then evaluated on the basis of a low/medium/high/none scale. The opportunity/threat hierarchy is established through an "Opportunity/Threat Table" assigning to each service an opportunity added value/threat exposure probability. We basically define four values for opportunities added value/threats exposure probability:

- **Low:** ”L” in a yellow filled cell, has a weight of 1;
- **Medium:** ”M” in a orange filled cell, has a weight of 2;
- **High:** ”H” in a red filled cell, has a weight of 4;
- **Non-existing:** an empty cell, this service is not concerned by this opportunity/threat, has a weight of 0.

Global optimization cannot be introduced as such as an opportunity to the involved actors. However, that target has a particular interest for the environment in the sense that optimized transports leads to less wastes which lowers negative externalities. Indeed, since a variety of stakeholders are involved into the package, each of them must be demonstrated its ”local” advantage to adhere. More precisely, we identify here the following opportunities and their associated weight:

- **Real-time Information Transmission.** Information has become a strategic resource of our modern times so that information availability through adequate transmission represents a strategic tool for each of the actors involved in the supply chain. The applicative package thus represents an opportunity since it enables to lower information transmission time. This opportunity has been given a weight of 5;
- **Business Process Optimization.** Reengineering business processes notably through standardized information transmission can lead to avoid wasting resources (among which human ones) so that time and money can be spared. This opportunity has been given a weight of 4;
- **Symmetric Information.** The use of the applicative package ensures that when an actor has a specific demand of services it is transmitted to whole of the concerned actors. For example the shippers' logistic requests are transmitted to whole of the carriers so that each of them can propose its transport services until an agreement has been found. Information symmetry tends to lower the eventuality that suppliers are unfairly favored. This opportunity has been given a weight of 3;
- **Unified Data Structures.** The use of unified data structures ease the everyday communications between supply chain actors and constitute a standardized formalization that can serve as a legal basis. This opportunity has been given a weight of 2;
- **Integrated Information Portal.** The use of a single portal for managing all the aspects of an actors' business eases the everyday transactions and lowers maintenance costs so that resources can be spared. This opportunity has been given a weight of 1.

	Opportunity weight	Treat Orders	Treat Expeditions	Plan Logistic Requests	Manage Transports Services	Manage Transports	Manage Ressources	Manage Warehouse	Track Transports	Manage Fleet	Transfer Orders
Real-Time Information Transmition	5	H	M	H		H	H	M	H	M	M
Business Process Optimization	4	H	H	H	L	H	H	H	L		
Symetric Information	3	M	M	M	M	H	H				
Unfiied Data Structures	2	L	H	H	M	H	H	M	M	M	H
Integrated Information Portal	1	H	H	H	H	H	H	M	M	M	M
Overall Service Opportunity Added Value		48	44	54	18	60	60	32	30	16	20

Figure 3: The Opportunities/Services Matrix.

The opportunities/services matrix presented in Figure 3 allows determining a hierarchy among the services to determine the one which could benefit of the most added value by adopting the collaborative software package solution. The *Manage Transports* and *Manage Resources* services have an added value of 60 which underlies the solution could potentially bring the most added value for carriers and infrastructure managers. The matrix also shows that the identified opportunities are adding substantial value to all of the collaborative application package's services so that each of the collaborating actors can potentially have an interest by the adoption of the solution which however has only sense if all of them use it or at least feed it with data flows.

Global optimization and the adoption of a global applicative package can however have a series of drawbacks. These are studied hereafter in the form of threats. More precisely, we identify here the following threats and their associated weight:

- **Loss of Local Optimality.** Actors are continuously seeking for optimal solutions within their business processes especially when competition is high and concerns rather standardized services as for example for carriers. A global optimization process could lead actors of the supply chain to a worse situation that when they only managed their own business strategy so that they would reject such a tool. This threat has been given a weight of 4;
- **Loss of Local Autonomy.** The autonomy of an actor refers to its capability to make and influence decisions. The provided information of an actor to the other can lead its autonomy to be adjusted in one sense or the other so that it can be an opportunity or a threat (we nevertheless only consider the ”threat side” here). In other words, increased transparency can lead to a loss of autonomy. This

threat has been given a weight of 3;

- **Transmission of Strategic Information.** By advertising all of the transportation offer and demand, one could determine information that the company's would prefer to remain confidential. This threat has been given a weight of 3;
- **System Intrusion.** An intrusion takes place when a user of an information system takes an action that he is not legally allowed to take. The intruder may come from outside, or it may be an insider exceeding his limited authority when taking action. The intruder's actions may be detrimental to the health of the system or to the services it offers. This threat has been given a weight of 2;
- **Data Loss.** Facing huge data transfers between actors some required data can be lost or never furnished. This threat has been given a weight of 2;
- **System Failure.** The information system may be down and cannot be used for some time. This threat has been given a weight of 2.

	Threat weight	Treat Orders	Treat Expeditions	Plan Logistic Requests	Manage Transports Services	Manage Transports	Manage Ressources	Manage Warehouse	Track Transports	Manage Fleet	Transfer Orders
Loss of Local Optimality	4		L		H	H	H	H	H	M	L
Loss of Local Autonomy	3		L		H	H	H	M	H	H	L
Transmission of Strategic Information	3	M	H	H	H	M	L	M	M	L	L
System Intrusion	2	M	M	M	M	H	M	M	M	L	M
Data Loss	2		L			L	L			L	L
System Failure	2	L	L	L		L	M	M	M	M	
Overall Service Risk Exposure		14	27	18	44	46	41	36	42	31	16

Figure 4: The Threats/Services Matrix.

The threats/services matrix presented in Figure 4 allows determining a hierarchy among the services to determine the one which is the most exposed to risks. The *Manage Transports* service has an overall risk of 46 which underlies risks are potentially highest for carriers. The matrix also shows that the identified threats have an impact on all of the collaborative application package's services so that each of the collaborating actors has to overview the drawbacks and compare them to the potential benefits to run its cost/benefits study.

5 CONCLUSIONS

Software engineering tends to devote more and more time and effort on analysis disciplines. In such a context, it is no more only the concern of software analysts, architects, developers and other project managers but top management has to understand the long term implications of software systems that can be developed. SOC promises to change the way business and technology vendors buy, sell, deploy, and manage application portfolios. For the first time, business users will be able to summon applications to support a business process rather than launch a business process constrained by the application. That is why the application of such technology into large hybrid software projects combining self-developed services with third party vendors components is particularly interesting.

In this context, we applied a SOM framework onto the development of a SCM platform for providing an high-level view to top management for strategic reasoning. The main contribution of the paper is the case study itself showing the approach proposed in (Pastor et al., 2010) and in (Wautelet et al., 2008) is applicable in a large industrial context.

The Strategic Services Model and its use are however just a preliminary step of a broader methodology using more detailed i* diagrams at analysis level as well as design diagrams and project management.

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