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Making Pre-Trip Services Context-Aware

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ABSTRACT
The process of selection, configuration and consumption of tourist information services is a complex task for the user. This is not least since existing tools most often focus on supporting either the pre- or post-trip phase or the on-trip phase itself by providing context-aware services. The goal of this thesis is to establish a framework that makes pre-trip services context-aware, thus reducing the gap between the pre-trip and on-trip phase by providing a single point of access. This is done by facilitating service selection and configuration in the pre-trip phase and context-aware service consumption in the on-trip phase. Its applicability and feasibility will be proved by a working prototype and evaluated through field studies.

Categories and Subject Descriptors
H4.m [**Information Systems Applications**]: Miscellaneous

General Terms
Algorithms, Design, Human Factors.

Keywords
tourist life cycle, customization, mobile tourist services, context-awareness

1. Introduction
Tourism is an information intensive business. Since tourism products are virtual products prior to consumption, travelers depend heavily on tourism information. In the ideal case, tourism services should support tourists with travel-related information during all phases (pre-trip, on-trip, post-trip phase) of the tourist life cycle [9] (cf. Figure 1).

Figure 1. Travel experience - tourist life cycle

In the *pre-trip phase*, tourists need information for planning purposes and decision making. *After their trip*, focus is on reminiscing about the journey and sharing the gained impressions and experiences with friends. In the *on-trip phase*, however, tourists are mobile and act in unknown environments where they would especially need personalized on-trip assistance in the form of information about accommodation, points of interest (POIs) (e.g., environmental and landscape attractions or gastronomy), weather forecasts, news or safety issues. Mobile services, i.e., services that can be used independently of temporal and spatial constraints and that are accessed through a mobile handset, may address these issues. They have the task to satisfy information requirements of tourists while being on the move by providing them with a broad range of up-to-date, situation-specific information. This information may be in addition adapted to the current situation of the user by exploiting user preferences, user location as well as mobile handset capabilities.

In the last years, research has been very active in each of the phases of the tourist life cycle. Research in the pre- and post-trip phase is closely linked to *online travel communities* [2], whereas the on-trip phase is targeted by research on *location-based, mobile tourist guides* [8].

The goal of *online tourism communities* is the provision of up-to-date, freely available tourism-related content, thereby enabling members to collect, view and exchange data items such as blog entries or pictures or to add own content and reviews. They provide good support for the pre- and post-trip phases but fail to support tourists sufficiently during the on-trip phase. A few communities such as the Tripadvisor[1] or the Yahoo Trip Planner[2] enable their users to download or print the personal trip plan, but do not provide support to access this information in a way suitable for mobile phones. Support for dynamic, on-the-move information is rare. Customization, i.e., adapting the information content towards the current context, is missing at all. As they only provide services which are useful before and after the trip and which are not interlinked to the on-trip phase, tourists have to use other sources to satisfy their information requirements while they are on vacation. Online tourism communities often provide personal trip planner tools (cf. e.g., [3]) that facilitate the time consuming planning process for tourists. They support tourists to select destinations of interest, to decide on activities and compose an itinerary.

Research with respect to the on-trip phase has resulted in a wide range of *mobile tourist guides*. Since one of the first famous prototypes [1], the sophistication of mobile guides has increased, and research in this field now specializes on features such as personalization, recommendation, context-awareness together with new forms of user interaction, collaborative usage and social integration. They may provide lots of useful information within

[1] http://www.tripadvisor.com/

[2] http://travel.yahoo.com/trip/

their field of application. The drawback is that they do not consider information generated by tourists in the pre-trip phase. In this way, they a) do not incorporate existing user profiles (e.g., profile of community member), b) do not exploit knowledge extracted from the personal trip plan and c) do not know the services the user is interested in and how these services should be delivered to fit the user's requirements and current situation.

In the current state, there is a perceptible gap between the respective phases of the tourist life cycle, resulting in the need for tourists to use different sources to satisfy the information requirements in each phase, ranging from travel communities, mobile applications, Internet websites, destination portals, meta-search & booking engines to traditional guide books. A single point of access that provides all the relevant services is still a preferable future state.

2. Goal & Use Case

The goal of this thesis is to make pre-trip services context-aware, thus reducing the gap between the pre-trip and on-trip phase by providing a single point of access for these two phases (cf. Figure 2).

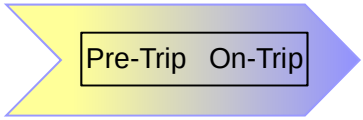

Figure 2. Integration of Pre- & On-Trip Phase

In the pre-trip phase, tourists should have the possibility to select and configure those tourist services that appear useful to them later in the on-trip phase. In the on-trip phase, the pre-configured services can then provide personal information that is tailored to the current situation and requirements of the tourist and presented on the mobile device of the user.

In the following, this visionary goal is presented by describing possible scenarios from a tourist's point of view. The vision might include many assumptions. We want to point out that it is not goal of this PhD to work on *all* these visionary service descriptions, but *some* of them will be realized within a working prototype. The envisioned system is called virtual tourist agent (VTA) since it should provide tourists the same comfort as if they would call their personal travel agent at home to satisfy their information requirements.

The show case gives some impression how the support of tourists in the pre-trip phase and during the vacation can be realized.

Pre-Trip Phase

In the pre-trip phase, tourists often do not plan all the activities they intend to undertake in advance, they rather follow an optimistic approach. For this, the VTA provides a trip-planner tool to establish a rough schedule that contains the cities/places they want to visit within a certain timeframe and the route between those places. Next, the tourists can *identify* and *select* all the tourist information services that they need later in the on-trip phase. Possible services include a flight information service, a tourist attraction service or a weather service. In [4], we showed a classification of these services and came up with a list of 12 generic tourist information services. Next, the tourist can *configure* those services with respect to delivery aspects that best fit personal requirements, thus resulting in value proposition and user satisfaction. For this, we proposed a framework in [4], comprising the three dimensions *service delivery*, *service customization* and *service initiation*. The *service delivery* dimension identifies different *consumer processes* how a user can satisfy her/his requirements. In the most simple form the user receives *information* about objects of interests. The *transaction* process allows the user to initiate transactional processes. The *community* process enhances the service with features enabling social integration. The *distribution* process enables the user to receive a digital product, such as maps or guides that can be downloaded to the device.

The *customisation* dimension expresses to which extent the information sent to the user is customized to fit the requirements of the respective user by taking into account various context factors.

Concerning the *initiation of delivery*, services can be classified into *pull* and *push services*. *Pull services* are characterized by a user-triggered search whereas *push services* deliver information to the user automatically.

For example, the user can select the weather service and configure it to push (service initiation) the up-to-date weather forecast (service delivery) every morning to the mobile device of the user, filtered to the destination of the user (customization).

Since a mobile device suffers from several limitations, e.g., small screen and network connection with low bandwidth, it is important to limit the amount of information that is presented to the tourist so that he or she can obtain the essential information in a non-intrusive way. After all, the mobile device should function as an assistive tool for the current task (e.g., sightseeing) and should not require full attention of the user. To fulfill this purpose, an automation of service delivery and decision making is required. This is done based on the definition and evaluation of rules that may partly be defined by the tourist. These rules are checked by the VTA in order to deliver only relevant information, leading to a more fulfilling user experience. For example, the tourist can define the rule that the VTA should contact him/her in security-related issues, e.g., he or she booked a flight to a country where an earthquake happened (security issue), so that he or she can decide to re-book the flight to another destination. In case of re-booking, the VTA may automatically cancel the accommodation booking on behalf of the user (if he defined another rule concerning this issue).

On-Trip Phase

During the on-trip phase, tourists receive support from the VTA based on the service selection and configuration done in the pre-trip phase. This means that they obtain information from all the services that have been configured to act in a push-based manner. Further, the situation of the tourist (comprising context factors such as location, time, user profile and travel schedule) is constantly checked by the VTA to detect reactive situations [6], thus requiring an action of the VTA. This can either be a change in context, such as an arrival at a new destination, or a new event fired by a service, such as the announcement of a delay received from the flight information service. Possible actions include pushing this information to the user or acting on behalf of the user based on rules defined in the pre-trip phase. For example the VTA might detect that tourists arrive at the booked hotel not in time and automatically informs the hotel about their late arrival.

Another example might be the case that tourists plan a bicycle tour on a specific day during their vacation. The VTA informs them that the weather forecast might be bad this day and instead suggest them indoor activities. Another case might be a planned mountain tour, e.g., on the vulcano Etna, situated on Sicily. The VTA can check whether it is allowed to go up on the Etna (it is still an active vulcano and dangerous eruptions may occur). In case that it is not, the VTA can suggest a tour on the vulcanos "Vulcano" or "Stromboli", being part of the Aeolian Islands in the north of Sicily by exploiting knowledge from a respective knowledge base. If a certain activity cannot be carried out at the destination, based on reasons such as bad weather, closing hours or long waiting lines, the VTA can look up the time frame planned for this activity in the trip schedule and suggest an equal activity instead. This shows that the travel schedule is an important source of knowledge next to traditional context factors such as location, time or user profile. The tourists may also pull for information, such as querying the VTA for a nice beach to go for swimming. The VTA can present a personalized list of nice beaches.

3. State of the Art

In the following, we report on state of the art in e-tourism by discussing research on online travel communities that focus mainly on the pre- and post trip phase and research in the field of mobile tourist guides, covering the on-trip phase.

Concerning online travel communities, we evaluated in [2] eight travel communities with respect to Web 2.0. This evaluation assesses services of travel communities within the context of the tourist life cycle. In the pre-trip phase, tourists have to cope with a large amount of unstructured information. Different search functionalities, e.g., destination browsing, are needed to support tourists during the information search. Some communities, e.g., Yahoo Trip Planner or the Virtualtourist platform[3] enable the aggregation of relevant trip information for later on-trip assistance by letting users create a personal trip plan. The relevant trip information, i.e., entries for travel location, may either stem from third party providers or from other community members. In most cases, the personal travel plan can only be printed or downloaded as PDF document to be used in the on-trip phase. Only a few communities provide access to mobile services. Travelpod[4], for example, supports travelers through a mobile blogging application. Lonely Planet[5] offers the functionality of downloading customized, targeted travel guides. In 2003, it launched CityPicks OTA downloadable travel guides together with Nokia. Recently, it launched, with Orange as partner, a WAP portal that provides chargeable travel information services.

In [4], we provided a classification of mobile tourist services that can be grouped into 13 service categories. Further, a conceptual framework is given that shows different design dimensions how those mobile services can be designed and delivered to tourists in order to generate value proposition and user satisfaction. This framework is then applied to mobile tourist guides that have been developed in the last few years, with focus on those systems that are used in real situations or that have been tested in the field. The evaluation results show that most of the services are provided by mobile tourist guides, while pointing out clearly that there is a large gap in the design of those services of the various tourist guides with respect to service delivery, service customization and service initiation.

Several surveys on mobile tourist guides have already been published that evaluate mobile tourist guides not in terms of provided services but focusing more on the technical side such as architecture, user interaction or context-awareness. In [8], we presented a comprehensive overview and comparison of mobile tourist guides. The comparison is based on an evaluation framework that focuses on context and adaptation criteria. In this way, this survey explores the capability of mobile tourist guides to provide customized services, i.e., services that can react to the context by adapting the information. The main statements are that most systems use their own content databases and do not exploit the potential of incorporating external content, e.g., through standardized interfaces such as web services. Most approaches only consider location and user profile as context factors, while neglecting other ones, such as time or network. Moreover, the potential of combining context properties to derive more valuable logical information is not exploited.

4. Methodology

As already mentioned, the goal of this work is to find a satisfactory solution for making pre-trip services context-aware. To reach this goal, an approach based on the design-science paradigm (cf. e.g., Hevner et al (2004)) is used. The design-science paradigm seeks to create knowledge and understanding of a problem domain and its solution through the building and application of innovative design artifacts. Thereby, artifacts are defined not only as the resulting instantiations (working prototype), but also comprise constructs (vocabulary), models (abstractions & representations) and methods (algorithms & practices) applied in the development as well. To demonstrate the applicability and feasibility of this work, the VTA system will be implemented as a working prototype. For its development, several other design artifacts are needed that will be outlined in detail in section 5. These artifacts further contribute to the knowledge in the field of e-tourism. The goal of design-science research is to address unsolved problems in innovative ways and to address solved problems in more effective and efficient ways. This goal is targeted by this thesis through an innovative approach that facilitates service selection, configuration and consumption through a single point of access. The effectiveness and utility of the VTA prototype will be assessed by a field study with tourists and compared to other systems that target the pre- or on-trip phase in isolation.

5. Research Contribution

The main contribution is the design of a conceptual framework and the prototypical implementation of the VTA system. Thereby, it is not the goal to implement each component from scratch, but to implement the whole system by heavily reusing and combining existing tools. Figure 3 illustrates the architecture of the VTA system. In the following, the architecture is explained by describing its components and listing research tasks that have to be addressed to develop the whole system.

[3] http://www.virtualtourist.com/

[4] http://www.travelpod.com/

[5] http://www.lonelyplanet.com/

In the pre-trip phase the user can select and configure all relevant *service types* and choose the adequate *service providers* from which the data is obtained during the on-trip phase. The *service instances* abstract from the different application programming interfaces (APIs) of the *service providers* and are linked over a standardized interface to the respective *service type*. For example, the *service type* "weather" can access *weather service providers* using different technologies, ranging from SOAP and restful web services to RSS feeds and finally to wrappers that extract the data from the provider's website if an API is not available. The different symbols of the service providers act as representatives for the different technologies that can be used to access the data. In the runtime phase, the *VTA system* exploits the situation of the tourist and manages the states of the *service providers* in order to detect changes that require an action on behalf of or sending some information to the user.

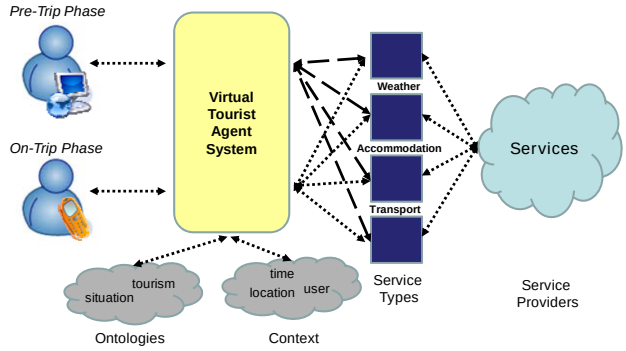

Figure 3. Outline of the VTA architecture

The main components of the VTA framework are described in the following. For this, Figure 4 shows a high-level view on the components of this framework. Context-aware information systems have to derive meaningful information based on the situation of the user. Ontologies are a promising technology to model the situation of the user since they can represent the knowledge in a semantically rich kind and are therefore a central part of the system.

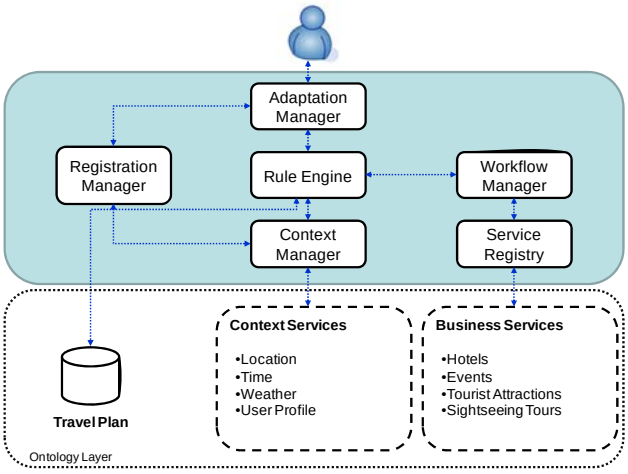

Figure 4. Components of the VTA system

Personal trip planner tool

In the pre-trip phase, the VTA needs to include a trip planner tool that assists in trip planning. A survey has to be done to select a promising trip planner tool that can be integrated within the VTA. The trip planner of the destination portal of New Zealand[6] seems to be a good starting point.

Business Services & Service Registry

In our previous work [4], we showed a classification of tourist services that are of high value to tourists being on the move. Of course not all of these service types can be addressed within our working prototype. We did an expert survey in [7], where we asked 40 international experts in the academic and industrial field, both with tourism and an 'e-tourism' background to rate the information services in terms of their relevance using a 6-point Likert-scale. Based on these results, we will implement promising service types and provide the necessary interfaces to service providers in order to access their data. All services are semantically described and registered within a service registry.

Context Services and Context Manager

The framework provides access to different context factors such as location time or profile of the user that are provided by the system or by the user or even external context factors such as weather information. As soon as a context change happens, either triggered by the user (e.g., location change), by the system (e.g., time) or by external providers (e.g., weather), the context manager forwards this event to the rule engine.

Rule Engine

The rule engine consists of an inference engine and a dependency checker. The inference engine takes the request from the user and the events from the context manager and matches them with the knowledge base that contains the situation of the user and his/her travel plan. In this way, the inference engine uses axiomatic knowledge in the knowledge base to derive new conclusions. For example, when the context manager sends a bad weather event for the next day, the rule engine checks all outdoor activities taking place next day and apply some actions on them based on predefined rules (such as canceling those actions). The activities in the travel plan show complex dependencies amongst each other. For example, if the user plans to stay at a certain destination for another day in order to attend a concert (new activity), this new activity might be dependent on the possibility to stay another night in the booked hotel. If the user already booked a hotel at another destination for this day, this has to be canceled as well. It is the task of the dependency checker to monitor coherent activities.

Workflow Manager

The workflow manager encapsulates all different services as workflow components. The workflow manager receives from the rule engine the information about those services that have to be called in order to perform the actions defined in the rule engine and composes the respective services to a workflow (e.g., cancel hotel, send confirmation in form of SMS to the user).

[6] http://www.newzealand.com/

6. Future Work

Future work concentrates on detailing the architecture and the necessary components. Based on the design decisions, e.g., heavy-weight vs. light-weight client, existing tools, middleware and frameworks have to be selected that facilitate the design of the conceptual architecture and the implementation of the resulting prototype. Surveys are needed to select the suitable tools and adapt them in a later step for our work. The system will be implemented based on a rapid prototypical approach, which allows testing the prototype in small, iterative steps in order to get fast feedback for further improving the prototype.

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Optimized advertising content delivery in affiliate networks

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ABSTRACT

This study tackles the problem of advertising content distribution in affiliate networks. We model the affiliate network as a new business-to-business relationship in which a master site tries to improve its profits by properly targeting the advertising information. In our specific case, we will optimize discount coupons delivery for one of the biggest coupons site in the world. In our study we will employ adapted recommendation strategies based on collaborative filtering methods. The purpose of the present paper is to correlate the display of advertising information on affiliate sites with the actual improvements in sales, as a direct method to obtain the user rating which does not exist.

Categories and Subject Descriptors

K.4.4 [**Computer and Society**]: Electronic Commerce—*Distributed Commercial Transactions*; H.3.4 [**Information Storage and Retrieval**]: Systems and Software—*User profiles*

Keywords

recommender systems, collaborative filtering, affiliates, content delivery

1. INTRODUCTION

This paper describes the research proposal we are working at and which is part of my PhD thesis. It specifically targets electronic business by tackling a new and emerging business-to-business relationship. In electronic B2B, a provider has various means of attracting new customers, one of them being to supply and promote discount coupons. A proper platform for spreading out advertising information regarding discounts is required, and the information providers should possess intelligent tools to observe and evaluate the efficiency of the discounts information distribution. Affiliate programs represent possible solution to be adopted. In e-commerce, an affiliate is a website which links back to an e-commerce site like Amazon.com. While in classical e-commerce, the provider can easily compute the efficiency and the effectiveness of a particular affiliate, because it can register all products sold through that affiliate, in discount information advertising this operation is no longer possible. In discount advertising, the customer usually buys the product directly from the provider e-commerce platform and the provider has no mean to directly identify how the customer acquired the information about the discount. Thus, classical tools for personalized content delivery can not be directly applied for optimizing the advertising delivery information, due to the fact that the direct feedback loop is missing.

In this paper we will give a brief description of the research problem stressed in the paragraph above, stating out the challenges we are facing. The paper is organized as follows. Section 2 presents the research problem of my PhD thesis. In section 3 we present the state of the art, mainly concerning the intelligent techniques for content delivery and studies concerning the affiliates problem. Section 4 describes the main challenges we face in our study, while section 5 presents the wow-coupons.com use case. We conclude the paper by presenting our future plans.

2. RESEARCH PROBLEM

Our main research problem is to build an e-business system in the area of affiliates marketing and content delivery. Specifically, we try to develop a delivery system for a major coupons site. Coupons represent a well-established way of providing benefits to customers for a specific activity to improve their business.

Online coupons or online coupon codes are discounts and bargain deals for all major on line stores and shopping sites on the Internet. Online stores creates discount codes to select groups of customers. By using coupon codes some groups of people will enjoy discounts when shopping online, like free shipping. Discount coupons is a way to save with on line shopping and some codes will be automatically applied at checkout. Other codes must be copy pasted intro a special coupon text box before to confirm the order.

An independent research agency made a recent survey on behalf of Pay By Touch on over 100 shoppers that were questioned in May 2007. The survey proves [12] that shop-

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pers develop a positive response to discount schemes if these are both highly targeted and convenient to use. In fact, the survey reveals that 88% of shoppers would use discount coupons, if these were more focused on their product preferences and were available in store while they were shopping. Of those surveyed, 95% of shoppers who used a retail loyalty card have received in-store discount coupons. However, 75% of these shoppers said they frequently *forget* to redeem them even if some of the discounts offered were on items they normally buy. Other factors that contributed to low redemption rates were the inconvenience of having to carry pieces of paper around and the fact that discounts were mostly for items the shopper did not have a history of buying. Therefore, it seems clear that retailers who offer targeted discounts and make it easy for those offers to be redeemed, could have a compelling way to develop customer loyalty and increase profit.

In our study case we want to specifically develop and implement a content delivery system for one of the top coupons site in USA (http://wow-coupons.com/). From now on, we will name this site as the master site. Our system will search, select and deliver coupons on behalf of 3'rd party sites that sell or recommend products, or for community sites that offer valuable user targeted content. Delivery will be targeted to a network of affiliates, established in order to enhance information dissemination. Delivered content will assist the site visitors, the community members in their online shopping activities and will help them to save money when they buy products. Our main target is to optimize the system such us to deliver highly targeted discount coupons. For our target, we intend to adapt recommendation systems and collaborative filtering technologies. Another feature of our interest is to technically enable the coupons site to deliver the content in real-time, i.e. without the usage of off-line information exchange with the affiliates. When a new coupon is added on the master site, the content delivered on the affiliate sites should be seamless updated.

Collaborative filtering is of our interest because it is a way to establish what items to display to web users who have browsed some ads or made purchases in the past. Collaborative filtering software compiles purchasing information on customers to pool them into clusters and uses some cluster members' purchasing patterns to predict the buying habits of others in the same cluster. It does this in real time and, for instance, puts an ad on the customer's screen while he or she is making a purchase [10]. In our case we want to display targeted discount coupons to users that are going to make a purchase. For example, we target an online shopping website that makes discount recommendations for the products the customer has in her shopping chart. This will help her to save money and also to develop a strong loyalty for that online shop because it proves that the shop cares about the customers and their needs.

To directly apply collaborative filtering, we need to collect and represent different partner sites and people preferences. Preferences are typically based on item ratings (i.e. posteriori feedback) explicitly delivered by users. The system recommends products which were evaluated positively by another similar user or by a set of such users.

Our main challenge is that we cannot collect the user ratings or preferences because we deliver the advertising content (coupon codes). The coupon code for a particular product and promotion campaign is the same, regardless the site that publishes it. When a user applies a coupon by buying a product, we do not have a direct method to identify the affiliate site that published the coupon to the user. Therefore, in our business setup, we do not have the feedback loop mechanism to allow us to use a classical collaborative filtering method.

Instead, we want to implement a module part of the master site system that will allow it build a profile for each affiliate. This module will track down and monitor how many times an affiliate user viewed and clicked on every coupon displayed. On the other side, the master knows the number of products sold per every coupon delivered to all affiliates. All these will aggregate in a statistical information that will replace the classical feedback from the partners and will provide the affiliate profile. The master can optimize and improve the coupons delivery algorithm for the entire affiliates network.

In this section we described our research problem in the terms of our B2B relationships. But, the problem is more general, spanning over all business relationships where direct feedback or user rating is not available. By tackling the affiliates problem, we intend to prove that intelligent techniques for content information delivery are more suited and can enhance the profit of the advertisers, even if there are only statistical glues about the real profile of the information users.

3. STATE OF THE ART IN THE FIELD

In this section we will investigate the state of the art in the fields covered by our research. We should emphasize that there is a lot of bibliography tackling recommender systems and collaborative filtering. Regarding the affiliates, there are a lot of business studies concerning the affiliates in e-commerce setups. In e-commerce setups, the feedback loop is closed because the master can identify through which channel a specific purchase was performed. Therefore, besides a proper advertising, one of their biggest challenge is how to compensate or reward each affiliate, accordingly to the profits they generated. In our study we are not interested in designing a proper reward scheme for affiliates, we suppose that we have good mechanisms to maintain the network and make it growing.

3.1 Recommender systems and collaborative filtering

Recommender systems are an important part of recent e-commerce. They enable the increase of sales by suggesting to users selected products on offer. The problem of how to choose the most suitable items, possibly with respect to the user's inclinations, is a challenging research problem that has been investigated for many years [3]. The purpose of a recommender system is to eliminate the need for browsing the entire item space by presenting the user with items of interest early on. Recommender systems strive to recommend items that users will appreciate and rate highly, often presenting items in order of highest predicted ratings first

[5]. The most well-known example of collaborative filtering is Amazon. The purchase recommendations are based on the following rule: "users who are interested in item X are also likely to be interested in item Y".

Four fundamental approaches to recommendation can be mentioned: demographic filtering, collaborative and content-based recommendation, and simplified statistical approaches [2]. We will describe them according to [3].

In *demographic recommendation*, users are classified based on their personal data, which was collected during the registration process, survey responses or other feedback methods. Each product is assigned to one or more classes with certain weights and the user is attracted to items from the class closest to their profile. This is attribute based recommendation.

Collaborative recommendation is typically based on item ratings explicitly delivered by users. The system recommends products, which have been evaluated positively by another similar user or by a set of such users, whose ratings have the strongest correlation with the current user. This is user-to-user correlation.

Content-based recommendation focuses on the similarity between products, usually taking into account their features like textual descriptions, hyperlinks, related ratings, or co-occurrence in the same purchased transactions or web user sessions. Items that are the closest to the most recently processed (viewed), are recommended regardless of user preferences. This is item-to-item correlation. Association rules and sequential patterns are the most interesting techniques used in recommendation based on item-to-item correlation. They are usually applied to data sets related to items such as purchases, ratings of TV programs, navigation paths rather than directly to item attributes.

In the *statistical approach*, the user is shown products based on some statistical factors; usually popularity measures like averages or summary ratings (the best rated), and numbers of sold units (the best buy) [9].

The *information overload* problem affects our everyday experience while searching for knowledge on a topic. To overcome this problem, we often rely on suggestions from others who have more experience on the topic. However, in web case where there are numerous suggestions, it is not easy to detect the trustworthy ones. Shifting from individual to collective suggestions, the process of recommendation becomes controllable. This is attained with the introduction of *Collaborative Filtering* (CF), which provides recommendations based on the suggestions of users who have similar preferences. Since CF is able to capture the particular preferences of a user, it has become one of the most popular methods in recommender systems [11].

A web site or other online service that receives extensive traffic has the potential to analyze the resulting usage data for the benefit of its user population. One of the most common applications of such analysis is collaborative filtering. A web site offering items for sale or download can analyze the aggregate decisions of the whole population, and then make recommendations to individual users of further items that they are likely to be interested in. The recommendations made to a specific user are thus based not just on his or her own previous actions, but also on collaborative information, the information collected from other users in the system [4].

Collaborative filtering algorithms can be categorized as [7]:

- User-Based algorithms: operate on the assumption that consumers who have bought similar products in the past will prefer to buy similar products in the future
- Item-Based algorithms: operate on the assumption that items that have been co-purchased in the past will continue to be co-purchased in the future

Regarding the technical mean of delivering the recommendations, CF are split in [8]:

- memory-based algorithms, which recommend according to the preferences of nearest neighbors. They utilize the entire user-item database to generate a prediction. These systems employ statistical techniques to find a set of users, known as neighbors, that have a history of agreeing with the target user (i.e., they either rate different items similarly or they tend to buy similar set of items). Once a neighborhood of users is formed, these systems use different algorithms to combine the preferences of neighbors to produce a prediction or top-N recommendation for the active user. The techniques, also known as nearest-neighbor or user-based collaborative filtering are more popular and widely used in practice.
- model-based algorithms, which recommend by first developing a model of user ratings. Algorithms in this category take a probabilistic approach and envision the collaborative filtering process as computing the expected value of a user prediction, given his/her ratings on other items. The model building process is performed by different machine learning algorithms such as Bayesian network, clustering, and rule-based approaches. The Bayesian network model formulates a probabilistic model for collaborative filtering problem. Clustering model treats collaborative filtering as a classification problem and works by clustering similar users in same class and estimating the probability that a particular user is in a particular class C, and from there computes the conditional probability of ratings. The rule-based approach applies association rule discovery algorithms to find association between co-purchased items and then generates item recommendation based on the strength of the association between items.

Both practical experience and related research have reported that memory-based algorithms present excellent performance, in terms of accuracy, for multivalue rating data. On the other hand, model-based algorithms are efficiently handle scalability to large data sets [11].

3.2 Affiliates marketing

Affiliate marketing is a web-based marketing practice in which a business rewards one or more affiliates for each visitor or customer brought about by the affiliate's marketing efforts. A merchant, also known as an advertiser or retailer, is a web site or company that sells a product or service online, accepts payments and fulfills orders. Affiliates (also called publishers) place merchants' ads, text links, or product links on their web sites, shopping engines, blogs, etc. or include them in e-mail campaigns and search listings in exchange for commissions on leads or sales.

4. MAIN CONTRIBUTIONS EXPECTED

We expect to contribute in several main areas.

From the systemic point of view, we intend to define the overall picture comprising all business to business relationships. Figure 1 presents an overall sketch of our system.

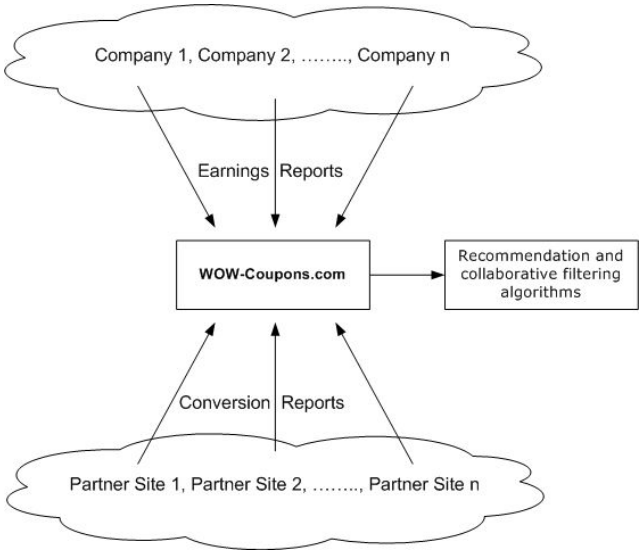

Figure 1: The overall picture of the B2B affiliates problem

Our contribution will mainly reside in the WOW-Coupons.com master site where we will technically embed a recommender system.

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From a technical point of view, a challenge is how to pack the content delivered to affiliate sites so as the partners will seamlessly accept the content and publish it into their websites. The content should be delivered in such a way that we will be able to register the number of views per coupon and number of clicks per coupon. We envisage the usage of server-controlled web development techniques that exchange small amount of information behind the scene. AJAX technologies [1] are a good candidate for our reason. We intend to fully describe our solution from the technical point of view.

From a algorithmic point of view, our research raises several open issues:

- to develop a statistical analysis tool in order to relate in a significant manner the collected information about content display (number of views and clicks) and the received payments from the earning reports. Statistical analysis will provide a way to collect the required feedback in the collaborative filtering methods
- to select a proper user profile management scheme. This is highly related with adapting a recommendation system or collaborative filtering method to our setup. Up to now, we only investigated several alternatives, but we did not established which algorithm would be more suited for us. We expect the ICEC doctoral symposium to allow us to progress on this issue, by having discussions with highly esteemed experts
- to compare the intelligent content distribution to the actual functioning of the affiliates system. Actually, there is not too much intelligence in the system, in the sense that the master delivers to each site the coupons related with the latest marketing campaign added in the master's database. In order to allow for a non-biased comparison, we need to design a controlled experiment on wow-coupons.com, covering a defined period of time and a stable part of the affiliates network. Designing and running the experiments are a big challenge, because, in meantime, we need not to downward the business performance over the period of the experiment.

5. WOW-COUPONS.COM

We started this research because we intend to improve the way that WOW-Coupons.com delivers the coupons for the affiliate sites. The actual system delivers the last coupons added on the master site, organized by store and by category. Up to now, this delivery scheme proved to be winning, but in nowadays this module needs some improvements because we intend to enhance the user usage of time and also the profits wow-coupons.com makes from the affiliates network. We will try to do a brief description of the site that will use the recommender system that we want to provide below.

The overwhelming majority of consumers in the US collect coupons to help them make the most of their money. Consumers spend plenty during the holiday season, and with tightening budgets, they are spending money where they see the best deals. During the holidays, an impressive 71% of survey respondents [12] say they're likely to use the Internet to research and compare holiday products and gifts.

WOW-Coupons.com is the fastest-growing coupons site on the web. It is a winner of 2005 LinkShare Gold Link "Innovative Affiliate" award. Averaging around 600,000 unique visitors a month and with a steadily growing community of e-mail newsletter subscribers, currently more than 80,000, it commands positions at the top of the search engines. A few time ago the company launched the UK version of

the site WOW-Coupons.co.uk. Categories include printable vouchers with Printable Retail, Printable Grocery, Printable Restaurant and Printable Travel Coupons subcategories, as well as Online Coupons.

Printable retail coupons section will provide real coupons buyers can take to favorite major retailers and national franchise stores. Shoppers choose the discount, print it out, and go shopping without needing to sign up. The process eliminates clogged inboxes with endless promotional e-mails from dozens of mailing lists. Grocery printable vouchers section will provide the grocery coupons users need, when they need them. Print coupons to save on favorite brands at supermarkets and drugstores everywhere. Restaurant printable vouchers section will provide coupons that can be printed out and used to save money at restaurants across the nation. When eating out may seem like an extravagance, think again and enjoy dinner. Travel and entertainment printable vouchers section will provide discounts and vouchers for diverse traveling destinations whether in US, U.K. or internationally. Travelers can still afford to take vacations or visit the family. The site has printable travel coupons and offers for car rentals, accommodations, amusement parks, museums and lots more.

Just like printable vouchers, the best and biggest retailers and service providers offer online coupons and special discounts. The difference is, these can be used only for purchases made online. On the site visitors can browse great offers, go straight to a favorite store (arranged alphabetically or by date posted) to see the latest deals, or to use the navigation menu on the right side of the site. When an item is found, the user can follow directions in the description of each coupon to be sure that savings have been applied before paying for an order.

For implementing the architectural design for coupons delivery, we employed the XML standard to provide an RSS [6] service. Wow-coupons.com has many sites that download the RSS and display the content that we deliver. For some affiliate sites we created a special customized RSS feed. Every coupon is part of a category and has a simple XML format. Now the system generates around 1500 different XML files that can be used on the Internet. The system generates an XML file and update it hourly for every company that have coupons in the database.

6. FUTURE PLANS

Our future plans intend to cover the above mentioned issues. We are only in the incipient stage of our research, because I have spent all the first year in taking exams and now, we worked on defining a proper problem and researching various technologies for this problem. Up to now, Wow-coupons got implemented without the optimization feature and to perform the optimization mentioned in this paper is a good plan for future research. We also think that this study will represent a good opportunity to advertise to the affiliate marketing community the potential of intelligent techniques.

7. ACKNOWLEDGMENTS

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A holistic Methodology for model-driven B2B Integration: From Business Values over Business Collaborations to Deployment Artifacts

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ABSTRACT

Business-to-business (B2B) electronic commerce based on the principles of Electronic Data Interchange (EDI) systems has been conducted for a long time. In recent years, we observe a switch to a rather business process-based thinking for implementing interorganizational systems. UN/CEFACT's Modeling Methodology (UMM) - which I co-authored - is considered as one of the mature graphical modeling approaches for modeling interorganizational business processes. However, UMM has still several shortcoming that prevent a throughout model-driven software engineering approach. In this PhD proposal, further contributions to the UMM are identified that are required to lift it to an holistic B2B methodology for the development of interorganizational systems. These contributions will extend the UMM to become an integrated approach starting with business models, leading over to business collaboration models, and finally resulting in deployable artifacts for business service interfaces. The proposed top-down approach is in line with the ideas of model-driven engineering resulting in shorter development cycles and reduced complexity.

1. MOTIVATION

Conducting electronic business between enterprises was not an invention of the internet age, but has existed for decades. However, requirements of business-to-business (B2B) electronic commerce have changed since that time. In former days, when B2B electronic commerce was referred to as Electronic Data Interchange (EDI), its focus was document-centric. This means, in order to avoid bilateral agreements on business documents, business partners agreed on business document standards. But, as history has shown, the results of these standardization efforts were overloaded and ambiguous document standards. This led to costly EDI systems and participation in electronic business was reserved to large companies that were able to afford such implementations. As a consequence, only circles of acquainted enterprises exchanged business messages electronically in order to reach their business goals and gain financial benefits.

With the advent of the internet, the area of electronic business started to boom. In the field of B2B electronic commerce, small and medium sized companies now saw their chance to enter electronic markets. Now, it seemed possible to find new business partners electronically and to dynamically conduct e-business. In addition, with the advent of XML, the problems of EDI appeared to be solved all of a sudden. However, this was a broad misconception - the pure mapping of EDI concepts to brackets did not yield a solution to the shortcomings of traditional EDI.

At this time, business process management was already in use to specify intraorganizational workflows. Enterprises started to adopt business process modeling in order to monitor their procedures and to design process-based solutions. In the context of EDI, the concept of a business process has already existed - but buried in the minds of those people that were responsible for the interorganizational systems. These people were aware, for example, what to do next when an invoice was received and how to trigger manual compensation if - in case of a failure - a dunning letter was received before an invoice. They were able to resolve the problem by phoning the business partner, because their counterpart was known to them. In this respect, the notion of a business process - as a protocol for specifying the course of business - was already there.

However, according to the idea of modern electronic markets where companies of almost any size conduct business in a dynamic way, business partners are not acquainted as described above. Dynamic B2B e-business involves spontaneous agreements, which might exist just for one economic transaction. There are no offline negotiations and no face-to-face relationships. Instead, agreements are made online, which requires business partners to unambiguously define how to conduct business with them. In other words, business partners must describe what business processes they offer in order to show potential business partners how to interact with them. It follows, that interorganizational business process models are the basic building block for flexible and spontaneous B2B e-commerce.

Figure 1 shows a slightly extended version of the Open-edi reference model [14]. It separates the development of interorganizational systems into business and technology concerns. Specifications for capturing collaborative business logic are covered by the business operational view (BOV). The functional service view (FSV) com-

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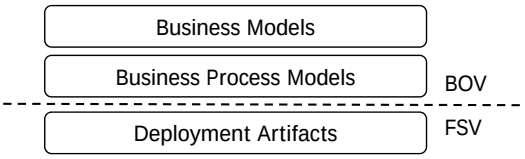

Figure 1: Refined Open-edi reference model

prises technology specifications for implementing business logic. In this thesis a holistic approach for B2B integration is developed starting with business models, leading to business process models, and finally resulting in deployable artifacts.

Modeling interorganizational business processes is considered as the foundation of this approach. Hence, the currently most promising approach for modeling interorganizational systems - UN/CEFACT's Modeling Methodology (UMM) - will be the starting point of this thesis. I co-authored UMM 1.0 during my undergraduate studies [15] and was one of the authors of the first book on UMM [23]. Considering figure 1, UMM sits on the business process layer. The first part of this PhD thesis will concentrate on amply improvements of the current UMM version [22]. The second part of this thesis lays focus on integrating value-based requirements engineering in UMM. By integrating business modeling, UMM enables to show the economic rationale behind business collaborations. Business models are considered as a layer on top of business process models. Finally, this thesis will propose approaches for deriving deployment artifacts for interorganizational systems from UMM business collaborations. The resulting approach that spans the three layers depicted in figure 1 corresponds to the overall goal of this thesis - a holistic methodology for B2B integration. We already published this three-layered approach in [11].

The remainder of this proposal is structured as follows: Section 2 describes the state of the art in regard to current B2B modeling approaches. Section 3 elaborates the contribution of this work by outlining solutions to current shortcoming of the UMM. Each shortcoming as well as the corresponding solution is discussed in its own sub section. Finally, section 4 concludes this proposal.

2. STATE OF THE ART

People have learned that traditional EDI concepts do not realize the idea of dynamic e-commerce as envisioned at the beginning of this proposal. In this respect, the need for modeling interorganizational business processes has become evident.

Traditionally, business process modeling focused on intraorganizational business processes in order to capture workflows that are internal to an enterprise. Internal processes are always modeled from the perspective of the respective company. In a collaborative context, however, a partner-specific view on a process is not sufficient. If each participant in a collaborative process describes its own perspective on the same process in isolation, the resulting process descriptions will most likely not match. Thus, modeling interorganizational processes requires a global perspective.

Today, several modeling approaches exist for capturing collaborative business processes. Some appropriate approaches have been identified in [2]. Amongst these approaches, UN/CEFACT's Modeling Methodology (UMM) [22] is the most promising one. UMM builds upon the Unified Modeling Language (UML), which is considered as the "lingua franca" in software development and also widely accepted for business process modeling. UMM is standardized by UN/CEFACT (United Nations Center for Trade Facilitation and Electronic Business) known for its standardization efforts in EDIFACT and ebXML.

UMM defines a meta model and a development process ranging from requirements elicitation to business collaboration design. In previous versions of the UMM - before version 1.0 - there was a lack of formal correctness of the meta model, which made it impossible to derive software artifacts from the model according to a model-driven software development approach. In addition, the meta model's complexity was the reason that applying the UMM was a tremendous task - oftentimes it resulted in faulty business collaboration models. The current version 1.0 of the UMM [22] is a considerable improvement. Nevertheless, UMM is still rather accepted in academia than in the industry.

The current UMM 1.0 will be the starting point for this thesis. On top of UMM, an integrated B2B methodology following three layer approach will be defined as outlined in the section before. A detailed description of current problem fields and the contributions of this thesis are given in the next section.

3. PROBLEM FIELDS - CONTRIBUTION OF THIS THESIS

When I started to work on the UMM, it was a so-called "UML profile" but it was not formally specified as one. A UML profile customizes UML for a domain-specific purpose by defining a set of stereotypes, tagged values and constraints. The versions before UMM 1.0 [22] lacked the definitions of constraints. Hence, there were no unambiguous and formal definitions of UMM modeling artifacts as well as which relations between UMM stereotypes are allowed and which are not.

3.1 Migrating UN/CEFACT's Modeling Methodology to UML 2

The UMM Foundation Module 1.0 is the first UMM version that satisfies the formal requirements of a UML profile. When the UMM 1.0 project was started within UN/CEFACT, UML 2.0 was not considered as stable enough. Hence, UMM is currently built on UML 1.4, but today UML 2 is considered as the state of the art. Consequently, UMM stakeholders ask for a "UMM 2.0" that is defined on top of UML 2. In addition, UML 2 provides major improvements to key modeling elements of the UMM (e.g., activity diagrams). It follows that moving UMM to UML 2 is required. Beside the criticism that the current UMM is based on an outdated UML, the meta model of the UMM is still often bashed as too complex (e.g., UMM 1.0 models often result in excessive package structures). Furthermore, some workarounds that were necessary in the meta model due to the use of UML 1.4 contribute to often bloated UMM models.

For this reason, the initial contribution of this thesis will be a definition of UMM on top of UML 2, reflecting experiences and comments from stakeholders. The result is an easier to use UMM that builds on current standards. This ensures further adoption by potential users and fosters the support of tool vendors. The new UMM version serves as the core for the further extensions and improvements suggested throughout this thesis. The use of UML 2 also eliminates the above mentioned workarounds in the UMM meta

model. In [7] we give an outlook on the migration of UMM to UML 2 and [24] covers a detailed presentation of UMM 2.0.

Beside UML activity diagrams several other notations and modeling languages emerged in the past to capture process flows. In the past, the Business Process Modeling Notation (BPMN) [19] has gained very much attention from end users and tool vendors. People often consider UMM and BPMN as comparable approaches for modeling interorganizational processes. So when presenting UMM 2.0 in this thesis, the differences between UMM and the BPMN will be discussed and it will be shown why BPMN is not sufficient for designing interorganizational processes.

3.2 Introducing value-based requirements engineering into UMM

Modeling business processes shows how an enterprise acts in order to reach an economic goal. In the context of B2B, the business process model captures how different enterprises interact to exchange objects of economic value. However, a business process model does not concentrate on economic reciprocity - what objects of value are exchanged to gain other objects of value. It is the purpose of business models to capture this aspect of economic transactions. According to Timmer [21] a business model is an architecture for the product, service and information flows, including a description of the various actors and their roles, together with a description of the sources of revenues and potential benefits. In other words, a business model captures what economic values are exchanged between enterprises and collaborative business process models describe the interactions required in order to implement the value exchange.

The current UMM concentrates on specifying business process models as well as their requirements, but lacks value-based requirements engineering by means of business models. However, it is an interesting fact for an enterprise to combine these different views on economic transaction. It helps identifying business processes that have to be supported in order to realize a given value exchange. In addition, it allows monitoring if a deployed business process still fulfills a given business model.

In order to provide value-based requirements engineering in UMM, this thesis will propose the integration of an e-business modeling approach. As identified in [2], currently popular business modeling approaches are e3-Value [4] [3] [5], the Resource-Event-Agent Methodology (REA) [17] and the Business Model Ontology (BMO) [20]. The work in this thesis will concentrate on e3-Value. In e3-value, a business model is regarded as a value constellation, i.e., a network of enterprises that jointly create and distribute objects of economic value to satisfy a consumer need. Focus is on an economic value proposition, i.e., expressing the objects of values an actor is willing to exchange for other objects. The model ensures the concept of economic reciprocity, i.e., if an actor delivers an object of value, he or she gets another object of value in return. Hence, the model illustrates which actors can have economic transactions with each other on an abstract level, without the internal processes necessary to create these values.

The e3-Value approach currently defines its own notation. A first step towards the integration of e3-Value into the UMM is definition of a UML profile for e3-Value. This contribution has been published in [13]. Still an issue to address is aligning the e3-Value concepts with the UMM development process. In addition, specifying that a business model fits to a certain business process models (or vice versa) necessitates consistency checks between those artifacts. In [1] the authors propose consistency checks between e3-Value models and petri nets. [25] outlines an analog approach for e3-Value and activity diagrams. A similar approach has to be researched for UMM and e3-Value.

3.3 Deriving deployment artifacts from UMM models

According to the idea of model driven software development the derivation of deployable artifacts from collaborative business process models is desirable. In the field of Web Services, the Business Process Execution Language (BPEL) [18] gained a lot of attention for implementing business processes. BPEL describes a business process from a partner-specific view. In contrary, UMM focuses on global choreographies. Thus, in order to generate BPEL artifacts from UMM, global UMM business collaboration models have to be mapped to partner-specific BPEL processes. Starting with a graphical model showing a global perspective provides major benefits for three reasons: Firstly, the business collaboration model serves as a kind of contract partners agree on. Secondly, the business collaboration model allows the generation of complementary process specifications for each partner's interface. This ensures that the partner interfaces interact according to the global choreography of the business collaboration. Finally, the generation of such artifacts allows quick and cheap customizations of a B2B system to changing business requirements.

There already exists some work in the field of deriving deployment artifacts from business process models. In [6] the authors outline a proof-of-concept approach generating BPEL code from UMM. This approach was implemented in [16] and its shortcomings are described in [15]. It does neither map all UMM concepts nor is the generation of executable artifacts possible. Recently, we published an unambiguous mapping from UMM to executable BPEL artifacts [8]. The UMM to BPEL mapping will be another contribution of this thesis.

Besides the pure Web Services approach, this thesis will also focus on the implementation of UMM processes using workflow frameworks. The Windows Workflow Foundation (WF) is an upcoming technology allowing developers to create workflow-centric applications. The WF approach is not limited to workflows internal to a company, but allows the implementation of interorganizational business processes. Similary to the BPEL approach, this thesis will propose a derivation algorithm for generating Windows Workflow artifacts from UMM business collaboration models.

3.4 Managing UMM artifacts within business registries

The vision of dynamic B2B presupposes that business partners find each other electronically based on the descriptions of business processes and of the services they need and offer. This idea requires that business partners are provided with means to publish as well as to consume information related to their business conditions. It follows, that the concept of a business registry is required in order to provide enterprises with a central site for to find each other. Such a business registry must be capable of managing UMM artifacts. Artifacts might be whole models or just parts thereof. Parts of a UMM model might be re-used in another interorganizational business process.

In order to solve the issue explained above, this thesis will describe

the representation and management of UMM artifacts within business registries. More specifically, ebXML registries will be the target platform for managing UMM artifacts. The work in terms of registering artifacts is made up of two parts:

Firstly, approaches are proposed to store UMM models as a whole or just several parts thereof. Since dependencies might exist between different parts of a UMM model, the proposed approach will outline how to maintain these relationships in a business registry. We already published this contribution in [10] and [9].

Secondly, since business models and UMM business collaboration models are combined a representation of business models within a business registry is required. The thesis will include an approach describing semantic links between business models and business process models. This enables potential business partners to find each other based on business models or business process models. This contribution was published in [12].

4. CONCLUSION

The goal of this thesis is a holistic B2B modeling methodology potentiating enterprises to participate in dynamic e-business environments. The current UMM will be revised and amply extended in order to be a tool for enabling successful and real-world B2B integration. The resulting methodology follows a three step top-down approach starting with business models, leading to business collaboration models, and finally resulting in deployable artifacts for business service interfaces. Applying the methodology will foster the vision of dynamic B2B e-commerce.

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Multi-Agent Decision Support System for Supply Chain Management

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ABSTRACT
This paper presents an extended abstract of the author's doctoral research project on developing a multi-agent intelligent system for automatic managing supply chains. Supply chain management (SCM) is a very complex and dynamic environment. The doctoral work, which started in October 2005, is dedicated to finding better solutions for successful performance in the domain of real-time SCM.

Categories and Subject Descriptors
I.2.6 [**Artificial Intelligence**]: Learning

H.4.2 [**Information Systems Applications**]: Types of Systems – *decision support*

General Terms
Economics, Algorithms, Design, Experimentation

Keywords
Supply Chain Management, Trading Agents, Decision Support Systems, Multi-Agent Systems, Prediction, Learning, Neural Networks, Genetic Programming.

1. INTRODUCTION
While running their business, enterprises usually deal with a number of activities, such as: procurement, production, warehouse management, selling, marketing, and customer servicing among others. To help them to manage these activities, organisations try to automate their business processes. Usually, independent software and hardware solutions are used for each of the activities. However in practice, all the activities are highly connected and interdependent. To integrate some of them in a single process is the task of supply chain management (SCM). The SCM is concerned with negotiating with suppliers for raw materials, competing for customer orders, managing inventory, scheduling production, and delivering goods to customers. In addition to its complexity, the SCM is also a time-constrained and ever-changing process, especially nowadays, when enterprises move their business on-line. Taking into consideration market globalisation, companies often run distributed businesses, having suppliers and customers all over the world. To deal with their contractors, organisations use the Internet to participate in electronic commerce, where business occurs very fast. To be able to react to all changes quickly, companies are looking for applications that can support dynamic strategies and adapt to new conditions in the environment. The development of such an intelligent decision support system for SCM is the main objective of the author's PhD project.

Although the aim is to develop an integrated application for SCM, due to its complexity, it is difficult to address all the issues which can arise in the domain of SCM. To narrow the research scope, the project is mainly focused on the demand part of the supply chain. In particular, different methods for predicting customer offer prices that could result in customer orders (winning bidding prices) are explored and compared in the system. The motivation is that expected findings not only can improve a company's performance while running its supply chains, but could also be applied to financial markets and online auctions where the task of predicting winnings bidding prices is crucial. The TAC SCM game, where software agents developed by different research groups can compete against each other in the context of the SCM, is used as a test bed to evaluate the proposed algorithms. This simulated environment was implemented by Carnegie Mellon University and the Swedish Institute of Computer Science (SICS) in 2003 as part of the International Trading Agent Competition (http://www.sics.se/tac/). The game is now probably the best vehicle for testing SCM systems as it encapsulates many of the tradeoffs that could be found in real SCM environments: time-constraints, network latency, unpredictable opponents, etc.

The rest of this paper is organized as follows. The description of the TAC SCM scenario and overview of related work are provided first. Then, the research approach followed is presented. The results achieved so far along with the plans for future work are given next. The paper closes with the conclusions.

2. THE TAC SCM SCENARIO
According to the TAC SCM scenario [4], there are six agents competing in the game that act as product manufacturers (Figure 1). Their main tasks are to buy components from suppliers, produce computers and sell them to customers. The behaviour of both suppliers and customers are simulated by the TAC server.

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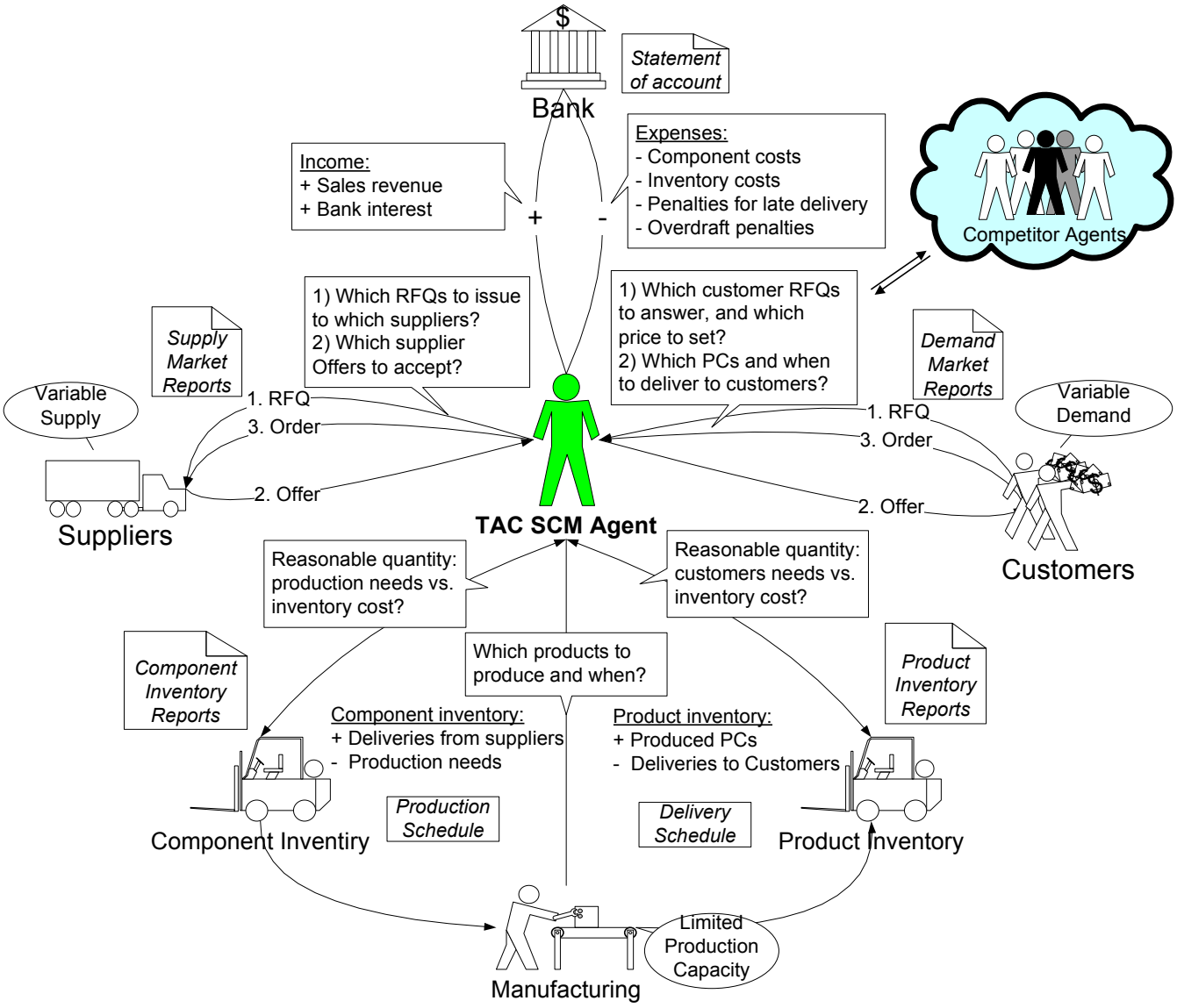

Figure 1. TAC SCM environment

The game lasts for 220 simulated days, 15 seconds of real time each. Each day an agent has to perform the following activities: (i) component procurement, (ii) product sales, (iii) production scheduling, and (iv) delivery scheduling. The aim of each participating manufacturer is to maximize their profit: the agent with the highest bank balance at the end of the game wins. The agent spends money on buying components, paying a storage cost for keeping an inventory of components and PCs, paying penalties for late deliveries of customer orders, and for bank overdrafts. The income of the agent consists of the revenue from PCs sales and interest on positive bank balance.

3. RELATED WORK

The TAC SCM community involves many research groups throughout the world. Each team investigates different issues within the SCM domain and develops various methods to tackle them. A number of works have been dedicated to the problem of finding optimal prices to offer customers in response to their requests. As this problem correlates with the objectives of the author's PhD thesis, the overview of these works is presented here.

The methods applied by different agents to solve the issue can be divided into two major categories. The first group of agents estimates the winning price for each RFQ and assumes that this price would result in an order [5, 7, 9]. The second group predicts for each possible bidding price the probability that it is going to be accepted [1, 10, 11, 12, 14].

An overview of the strategies applied to the problem of finding optimal offer prices up to 2004 is provided in [15]. The paper also presents the comparison of different learning algorithms for

accomplishing the task in the context of the TAC SCM environment. Specifically, the following methods were analyzed: neural network with a single hidden layer and using back propagation, M5 regression trees, M5 regression trees boosted with additive regression, decision stumps (single-level decision trees) boosted with additive regression, J48 decision trees, J48 decision trees boosted with AdaBoost and BoosTexter [20, 21], support vector machines, naïve Bayes, and k-nearest neighbours. Their experimental results showed that M5 trees and BoosTexter give the minimum root mean squared error.

In their up-to-date versions in addition to the above mentioned methods, the TAC SCM agents also use other techniques. In particular, SouthamptonSCM [7] applies a fuzzy reasoning inference mechanism to determine offer prices according to the agent's inventory level, the market demand and the time in the game. TacTex uses additive regression with decision stumps [13]. In the earlier version of the agent, the developers used linear regression on six data points to generate a linear function which is modified then by the day factor [14]. The day factor measures the effect of the due date on offer acceptance. A similar approach is implemented in Botticelli [3] and CMieux [2]. The latter computes a linear least squares fit for the selling prices of each product over the past several game days. Additionally, the agent enforces lower and upper bounds on the predictions to ensure that the prediction remains relatively conservative. The agent maintains the probability distribution for each PC type mapping bidding prices to the likelihood of winning orders with these prices. The distributions are learned off-line using data from previously played games to build a regression tree. The developers of the agent showed that under certain assumptions this pricing problem can be reduced to the continuous knapsack problem [1]. Mertacor [12] selected the M5 data mining algorithm applied to historical data from past games in order to choose which attributes influence offer prices. It also uses two on-line modelling mechanisms in order to handle unexpected circumstances that may arise with regard to selling prices. The agent applies the k-Nearest Neighbours algorithm then to find the probability of offer acceptance for each bid placed. The probability of winning customer offers is also used in the bidding strategies implemented by MinneTAC [10] and DeepMaize [11]. RedAgent [9] uses an internal marketplace structure with competing bidders to set offer prices. The agent computes offer prices as a sum of 3 terms: a base price of the PC, an estimated discounted profit for the product (the difference between base price and order price, discounted according to the number of days left until the order expires), and a discounted penalty. PackaTAC [5] sets prices according to the market state taking into consideration the lowest and highest previous day prices and the current demand level.

According to [8] all the aforementioned methods do not take into consideration market conditions that are not directly observable. The authors propose a clustering based approach to identify the market regime and predict market changes. They use a Gaussian Mixture Model to represent the probabilities of market prices that allows the determination of the probability of receiving an order in different regimes for different prices. The authors assume the following factors which correlate with market regimes: the finished goods inventory of other agents; the ratio of offer to demand; and normalized price over time.

4. RESEARCH APPROACH

To deal with the complexity of the SCM domain, a multi-agent approach is applied to design the system. This allows to break the whole system down into separate building blocks, each concentrating on a particular part of the supply chain. By replacing one building block with another and by combining them in different ways, different versions of the system can be created in order to check how separate algorithms affect its overall performance. The system includes the following agents: Manager, Demand Agent, Supply Agent, Inventory Agent, Production Agent, and Delivery Agent. The Manager agent is responsible for the communication with the external contractors (suppliers, customers, bank, etc.), as well as managing all other agents. The Demand Agent decides which customer RFQs to answer and with what price. The remit of the Supply Agent is the procurement of low cost components on time from suppliers; the agent tracks the supplier market in order to choose the suppliers with lower prices and lower level of suspended deliveries. The Inventory Agent manages the component and PCs stocks in order to satisfy the needs of the Production and Delivery Agents while at the same time minimising holding costs. The Production Agent is responsible for scheduling current production and projecting production for the future. Finally, the Delivery Agent deals with delivering PCs to customers according to their orders and on time to prevent penalties.

To model the agents' behaviour, different techniques are used in the system, such as: constraint satisfaction, planning, logical rules, and online adjustments. The majority of the algorithms are based on simple heuristics. However, testing the system in the TAC SCM game showed that these algorithms do not perform well against stronger agents developed by other research teams. To improve the performance of the system, a predictive approach is required. According to this, a number of predictive algorithms are implemented in the Demand part of the SCM that deals with selling products to customers. The most crucial problem here is of predicting customer winning bidding prices. More specifically, a customer sends requests for quotes (RFQs) indicating which products, in what quantity and for when he wants them. The customer also indicates the reserve price – the highest price he is willing to pay for the product. Competing agents answer these customer RFQs with their offers specifying the bidding prices they are willing to offer to the customer. For each RFQ, the customer chooses the lowest price proposed by all manufacturers and places an order. So the problem here is to set optimal customer offer prices, which should be high enough to allow for profit and at the same time low enough to be accepted by customers.

So far, 3 different strategies have been developed to tackle the problem. According to the first strategy, the system predicts bidding prices for each customer RFQ which will more probably result in customer orders. The predictions are based on the current market situation and also on RFQs' details. 3 algorithms based on the Neural Network (NN) learning technique are implemented to perform the forecasting. In particular, for each algorithm a set of ensembles of 3-layered NNs for every product available on the market are constructed; each NN in the product ensemble predicts the probability that the winning bidding price will be in the price interval assigned to the ensemble. The algorithms differ in the number of inputs they consider and their

methods for input normalization. The Back-propagation algorithm and sigmoid function as the activation function are used to train the NNs.

The second strategy for deciding on offer prices is to predict the lowest order prices for each product based on the time series of these prices. All TAC SCM competitors get daily market reports, where the lowest order prices proposed by all agents on the previous day for each product available on the market are specified. Using the previous values of these prices, their values for one and ten days in the future are predicted. The Neural Networks and Genetic Programming (GP) learning techniques are used to design 33 different models of predictors. Apart form the difference in the learning technique they use, the models also differ in their data transformation and normalization methods applied over inputs, and also the number of observables considered in the time series.

Finally, the third strategy implemented in the Demand Agent is to model the competitors' behaviour and to predict their bidding prices according to the models evolved. Having predicted prices of its competitors, the agent can bid just below them and thus win customer orders. Again, the NN and GP learning techniques are used and 4 different algorithms are developed to deal with the task. The algorithms differ in their approaches for selecting features to model competitors' behaviour.

To evaluate the proposed approaches and algorithms, a number of games were played in the TAC SCM simulated environment. Different combinations of participant agents were used. In some games, the competitors were different versions of own agent. For other games, highly competitive agents developed by other TAC SCM participants were run. Binary code of these agents is available from the TAC web-site repository. In order to decide on the most successful strategies to follow in each part of the supply chain, the game results were compared in terms of (a) overall scores of competing agents, (b) rates of customer offer prices proposed by them, and (c) order winning rates (the ratio between the number of offers send to the number of orders received). To evaluate different algorithms for predicting customer winning bidding prices implemented in the Demand Agent, the root mean square errors of their predictions were calculated to estimate the models' accuracies. In addition, the complexity of algorithm implementation and time of their execution were taken into consideration. The last parameter (execution time) is important as in the TAC SCM game all the decisions have to be made within 15 seconds.

5. RESULTS AND FUTURE WORK

The experiment results demonstrated that the agents that track the supplier market, plan their production in advance, and/or pick only profitable customer RFQs, perform better than those that do not support these strategies. The agents that use one of the proposed algorithms for predicting customer winning bidding prices outperform agents that do not make any predictions. The strategy of setting customer offer prices according to the algorithms which predict probabilities of the winning bidding prices to be in a particular price interval appeared to be less successful than using other predictive methods (predicting lowest order prices or competitors' prices). Although the algorithms for predicting lowest order prices and competitors' prices demonstrated different results across the games played, all of them showed high level of prediction accuracy. Both Neural Networks and Genetic Programming learning techniques appeared to be appropriate for predicting order price time series and competitors' bidding prices. At the same time, NN surpassed GP in terms of complexity of algorithm implementation and time of execution in the case of predicting competitors' prices (1 second for NN versus 90 seconds for GP). The disparity in the models' performance leads to another conclusion that different models might work better in different market conditions, which, in their turn, depend on the strategies applied by competitors. According to this, the task for future work is to develop a meta-model, which can consolidate the results obtained from individual models and find dynamically the best solution for the current market environment.

The experiments reveal that the prediction of the competitors' bidding prices themselves is not enough for making optimal decisions on offer prices: if the agent with the lowest predicted price does not bid for an RFQ, then the winning price will be the lowest among the ones set by the other agents who actually bid. Thus, in addition to the prediction of the agents' bidding prices for every RFQ, the classifiers, that will specify whether the agent will actually bid for the RFQ at such price level, have to be introduced. This will help to make decisions on which RFQs to bid for and what price to offer. Another task for future work is the problem of Feature Subset Selection. In particular, the experiments showed that the knowledge of the features that the competitors are using for making their decisions, could improve the predictive models of these competitors. The following claim has been proved empirically: if a player knows which features its competitor is using for making its bidding decisions, then, even without knowing the exact strategy of the competitor, it is possible to predict its bidding prices more accurately than in the case when these features are not known. Thus, there is a task of finding the method for predicting which parameters competitors are using.

With regard to the other agents implemented in the proposed SCM system, there is plenty of room for improvement of the performance of the Supply and Production Agents. Having the limited production capacity, the Production Agents tries to maximize its utility, i.e., the potential profit that might bring the scheduled production. At the moment, the agent schedules production for 12 days in the future using the following heuristics. For every day in the future, the agent leaves some capacity for future demand (the further production date, the more cycles are reserved), then schedules current and late orders, depending on their due date, profit and availability of components, and after this, it allocates current RFQs, again considering their due date, profit and availability of components. To schedule the production more accurately and to use the limited production capacity more efficiently, the agent needs to predict future customer demand, as well as reconsider its planning for the future dynamically, depending on the level of orders actually received from the customers. With respect to the Supply Agent, it places only short-term RFQs at the moment. On the one hand, this approach gives low holding costs. At the same time, the agent takes the risk not to get components on time or to get them at higher rates. Thus, there is the need to find the way to balance short-term and long-term requests for components.

6. CONCLUSIONS

The main objective of the author's PhD thesis is the development and implementation of an intelligent multi-agent decision support system for supply chain management (SCM). The SCM environment is very complex, highly dynamic, and with many constraints. It is unresolved issue at the moment on deciding which strategies to follow and which learning methods to use in order to perform more successfully in this domain. Within the scope of the presented work, the effort is made to contribute to finding better solutions by developing different algorithms and testing them in the TAC SCM simulated environment. In particular, a number of approaches for predicting customer offer prices that could result in customer orders are explored. To the best of author's knowledge, the proposed strategy of modelling competitors' selling behaviour is novel for the TAC community. With respect to the approaches of predicting winning price probabilities and the lowest order prices, which have been considered by other researchers, new methods to solve the problems are investigated. The results of the current research will be valuable for both academia and real industries. More specifically, the work is dedicated to applying machine learning techniques for forecasting and optimisation problems, which is an open issue within the research community. At the same time, the aim of the project is to build up an integrated solution to assist managing supply chains. Nowadays, enterprises are looking for implementing such systems to run their businesses. Moreover, various techniques for predicting bidding prices in the context of dynamic competitive environments are explored. Apart from the SCM, the solutions can be used in forecasting financial markets and participating in on-line auctions.

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A Holistic Approach Towards a UML Profile for Business Modeling

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ABSTRACT

Due to faster and faster changing business conditions, companies must be able to quickly adopt these changes to their IT infrastructure. Thus, business models must reflect these changes in order to design/align business processes supporting the value exchanges defined in the business model. Presently there are three major and well-accepted business modeling techniques - e3-value, Resource-Event-Agent (REA) and the Business Modeling Ontology (BMO). All of them use their own proprietary notation, which is incompatible with UML - the de-facto modeling standard in software engineering. In order to allow a straight-through modeling approach from business models over business process models to software artifacts, it is desirable to use a common modeling approach. Therefore we propose to specify a UML profile for business modeling integrating all benefits of these methodologies in one ontology. As a result this new ontology helps to cover our main research question - the transition between a business model and a business process model. Furthermore the introduction of a framework for measuring the quality of business models as well as the definition of business modeling patterns is discussed.

1. MOTIVATION

With the growing importance of web services, companies need to align their IT applications in order to compete within the growing service industry. However, the environment as well as customer decisions are changing over the time leading to a re-engineering of company's processes and business goals. In such fast changing environments it is of overall importance to align IT applications to the related changing company goals. Therefore a flexible design, implementation and delivery of B2B information systems is necessary, which links business modeling aspects with IT implementation.

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This approach is also reflected in the ISO 14662 standard on the Openedi reference model [15]. The reference model groups EDI related standards into two categories. i) The business operational view (BOV) addresses the semantics of electronic business, i.e. the semantics of business collaborations and related business information exchanges. Specifications going into the BOV capture business knowledge in a technology independent way. ii) The functional service view (FSV) addresses the technologies and the implementation aspects to support business collaborations specified in terms of BOV related specifications.

Figure 1 depicts an extension of the Openedi reference model. This three layer approach is proposed in one of our papers covering the different aspects of a B2B information system [13]. In other words, it is a model-driven top-down approach, in order to reach agreements between business partners (1) on the economic level, (2) the (inter-) organizational process choreography, and (3) on the services implementing the choreography. The upper layer describes the economic goals and values from a management perspective. It captures the rational as well as the economic resources being exchanged with business partners. The second layer in the middle specifies a flow of business activities and their dependencies specially designed to reach the business goals. The business models and the resulting business processes of the two BOV layers must be supported by IT systems on the FSV layer. Therefore the IT layer implements the business processes by means of tools, frameworks, API's, Web Services, etc. As one can recognize, the overall goal of this three layer approach is the mapping from business models to deployment artifacts.

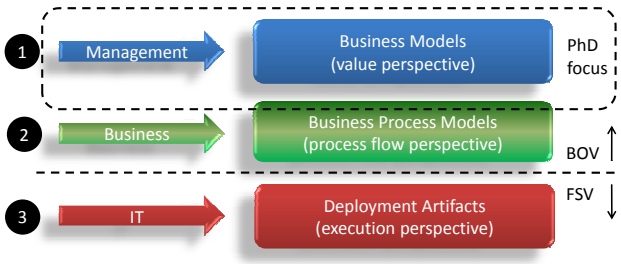

Figure 1: A 3-layer approach - from business models to software artifacts

We, the authors of this PhD proposal, are contributing to a

national funded IT project, called BSopt (Business Semantics on top of process technology)[1], where this three layer approach has its origin from. Within this project we are both responsible for the elaboration of the top layer and the transition to the second one. Therefore our PhD thesis focuses on the top layer - the business modeling layer. In order to get an overview about the different business modeling methodologies we firstly establish a survey about the existing approaches. Secondly we compare these approaches with each other to see where they differ and elaborate potential shortcomings. Moreover, we propose a methodology in order to measure the quality of business models. Furthermore, the reuse of business modeling patterns is an important issue of our PhD thesis. This will be established by the definition of a global business modeling ontology, incorporating aspects of other approved ontologies in this area. Finally, the transition from a business model (layer 1) to a business process model (layer 2) covers the main research question in our PhD thesis.

2. PROBLEM

As motivated in section 1, integrating business processes into a Service Oriented Architecture (SOA) is certainly a hot topic. However, most current approaches are limited to the technical process aspects, disregarding the economic drivers of the information society. In order to open-up enterprise applications to e-business and make them profitable for a communication with other enterprise applications, a business model is needed showing the business essentials of the e-commerce business case to be developed. In former days business modeling was done by using standard process modeling methodologies such as UML's activity diagrams [24], Petri Nets [25], IDEF0 [1] or STRIM [22]. Since these methodologies have been designed for modeling a sequence of activities, modelers tend to develop their business models in a workflow-oriented way. Therefore specific business modeling techniques have been introduced in order to capture the business perspective of an e-commerce information system.

There are three major business modeling methodologies our thesis is focusing on. Firstly, the e3-value methodology has been developed to model a value web consisting of actors who create, exchange, and consume things of economic value such as money, physical goods, services, or capabilities [8]. It is an ontology-based methodology for modeling and designing business models for business networks incorporating concepts from requirements engineering and conceptual modeling. Secondly, the REA (Resource-Event-Agent) Ontology is an approach for gathering the rationale behind business collaborations [7]. REA captures the declarative semantics of the collaborative space between enterprises from an economic viewpoint. It describes the involved actors (A), their value exchanges (R) and holds the triggers for economic exchanges by the means of economic events (E). Finally, the Business Model Ontology (BMO) [20] describes business models with respect to four elements and their relationships: product innovation, infrastructure management, customer relationship and financial aspects. In contrast to e3-value model, which describes the network constellation from a global point of view, the BMO ontology rather focuses on a specific actor and outlines his position in the business network and how he can make profit.

All these methodologies mentioned above have its own notations, concepts and rules. In order to allow a straight-through modeling approach between the different layers in the BOV as we proposed in figure 1, it is desirable to base the different steps in developing inter-organizational systems on a single modeling paradigm. Most of the business process modeling steps in the second layer are already based on the Unified Modeling Language (UML). This means that business process technologies customize the general purpose language UML by means of stereotypes, tagged values and constraints for their specific purpose. Therefore we will create a UML profile for business modeling integrating all benefits of these methodologies in one ontology.

Since business models are the starting point for the design of an information system and the driver for an alignment of the business processes of an enterprise, it is important to measure the quality of a business model. Although the term quality has been defined in many ways, ranging from extremes as *conformance to requirements* to *fitness for use* [16], we will specify a small set of quality properties for our metrics. Thus, we investigate business models for their effectiveness, efficiency, suitability, completeness and coherence, in order to define a framework for measuring the quality of business models.

A major research question to solve in our PhD thesis is the transition from business models to business process models. Thus, it is important to identify the dependencies between the approaches on the management layer and the business layer. This is a prerequisite to define a semiautomatic mapping between the artifacts on the different layers and to reflect changes on one layer to the other ones. As a demonstrating business process modeling methodology for our approch we take UN/CEFACT's Modeling Methodology (UMM) [11] and the Business Process Modeling Notation (BPMN) [18].

3. METHODOLOGY

In order to solve the identified problems we subdivide our approach into 4 parts as depicted in figure 2. Part 1 evaluates current business modeling approaches to show similarities, strengths and weaknesses. The result of this survey is a general description of relevant concepts for business modeling. Part 2 will cover all necessary aspects in order to link business models to business process models. To provide interoperability and best practices a UML profile based on the resulting description developed in part 1 is required. Additional to the UML profile quality measurement methods for business models as well as reuse, and classification principles will be considered in part 3 and 4. The final achievement of our thesis is a holistic UML profile which is able to cover business modeling aspects and combines relevant concepts from mature business modeling ontologies.

3.1 Evaluation of current business modeling approaches

The field of business modeling is a broad and complex domain. As introduced in section 2 there exist several solutions

[1] http://www.bsopt.at

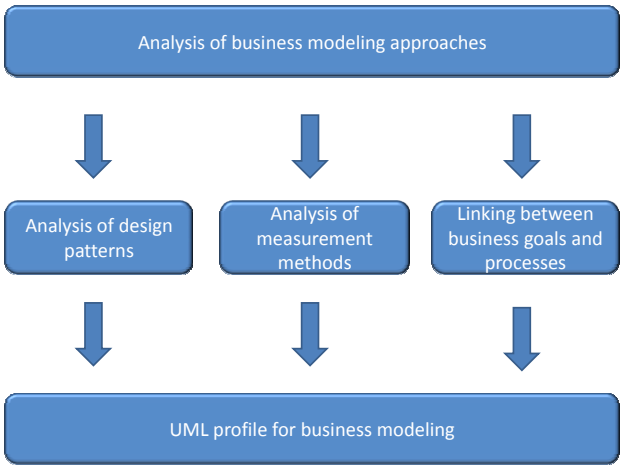

Figure 2: From the analysis of business models to a UML profile

which try to contribute their part to business modeling research. Theses ontological approaches are focusing on different aspects within the field of business modeling. Hence, a survey in order to investigate existing similarities between these ontologies, as well as their strengths and weaknesses will be necessary.

First steps towards a general description for business models have been done by [2] where a reference ontology for business models was introduced. The survey is focused on inter-organizational processes and includes concepts from operational and knowledge level. Therefore, their survey is an optimal starting point for our investigations on business models. In contrast to the reference ontology our exploration purpose is more widespread and can be summarized as follows:

- A comprehensive evaluation of the major business modeling ontologies.
- An overview about strengths and weaknesses of current modeling approaches.
- Review about similarities of concepts.
- Identification of shortcomings.
- First indications to link business models with business process models.
- New cognitions concerning a method to measure business model quality.

Additionally we will examine concepts from more broader approaches like the Business Motivation Model (BMM) developed by the Object Management Group (OMG). BMM is primely focused on the development of business plans and supports the modeling of so called ends, means, and influences an enterprise has to overcome in order to reach its business goals [**?**].

3.2 Linking between business models and business process models

Flexibility in concerns with services requires a persistent path from management (business models) to business (business process models) and finally IT (deployment artifacts like web services). In order to provide such a persistence a semi-automated mapping between each of these layers is necessary [5]. Therefore, the overall goal is to abstract business behavior from technical aspects. However, this thesis focus on the linking between business goals and business processes. Business modeling approaches like REA, e3-value, and BMO will be used to capture management aspects. These technologies are represented in their own proprietary notation technically specified by formats such as the Resource Description Framework (RDF)[17] or the Web Ontology Language (OWL)[4].

In order to overcome these limitations we propose to specify a UML profile for the general business ontology described in section 3.1. First approaches towards a definition of a UML profile have been outlined in [14]. In this paper work the authors focus on a mapping from the e3-value ontology to UML. According to their investigations not all aspects of e3-value could be integrated into the UML profile. Nevertheless the developed UML profile captures all necessary aspects to link UN/CEFACT's Modeling Methodology (UMM) with their e3-value profile. However, this approach highlights the mapping between business and business process models.

3.3 Quality measurements for business model ontologies

Current business modeling approaches focus primarily on economical indicators. E.g., BMO and e3-value have integrated concepts to analyze monetary flows within a business model. According to [21] BMO distincts between three evaluation elements: (1) The *revenue model* which measures the ability of a firm to generate incoming revenue or with other words translate offered value into money. (2) *Cost structure* shows all costs the firm incurs in order to create, market and deliver value to its customers. (3) And finally the *profit module* which is the output of revenue model and cost structure. A less widespread concept is supported by e3-value. The e3-value editor allows to generate net value flow spreadsheets to assess economic sustainability on a per enterprise basis [10]. Such spreadsheets express the economic value flow for each participant in the value network.

The introduced concepts are both pure economical and therefore do not state the architectural quality of the underlaying business model. Hence, our measurement approach is more focused on the business model graph. In order to realize such a solution the first step will be to evaluate measurement metrics which indicate significant information about the business model. E.g., the number of partners or the complexity of the graph itself which can be measured trough value flows or relations within the network. In the following we introduce a metric for evaluating the quality of business models regarding different quality properties - such as e.g. effectiveness, efficiency, suitability, completeness and coherence.

3.4 Design Patterns and Classification

Design patterns have been introduced to the object-oriented world in the 90s and since then got more and more popular. In OOP a design pattern is defined as *an abstract key aspect of a common design structure that make it useful for creating a reusable object-oriented design.* [6]. The use of design patterns allows to solve common problems in a clean and reusable way by abstracting the problem structure. However, a design pattern in the field of business modeling can be seen as an abstraction of business behavior. In [12] the most common business patterns were introduced and implemented using the REA ontology. The author depicts the fundamental patterns such as economical exchange, conversion, value chains, etc.

Another approach for capturing and managing business models is presented in [19]. The author presents the idea of business model portfolios. He argues that a stock of business models can help an enterprise to cope with change and innovation. A first step toward such an business portfolio is the classification of business models. Michael Rappa [23] identified 9 different basic e-business models. An automated identification process could lead to a template based business modeling approach which would increase the usability and reuse of innovative business models.

This thesis aims to combine the introduced concepts and develop a holistic framework which allows to combine business patterns with business ontologies. Therefore our PhD thesis covers the following issues:

- A method to analyze business model structures.
- Template based modeling approach.
- Classification of business models according to Rappa.

4. RELATED WORK

Especially with the rise of SOA business modeling has become more and more important to face nowadays business challenges. Several design approaches have been initiated. The most popular solutions are the Resource-Event-Agent Ontology (REA), the Business Modeling Ontology (BMO) and e3-value. A comparison between BMO and e3-value showed that the main difference between them is the point of view they address business modeling [9]. REA and BMO propose to capture a whole enterprise, whereas REA intends to focus on an economical point of view. BMO captures aspects such as infrastructure management, customer relationships, and capacities as well as financial aspects [19]. In contrast to BMO e3-value addresses collaborative networks and the exchange of value objects [8]. In [2] the authors examined each solution and tried to shape a general understanding for the different business modeling aspects. However, their approach does not consider measurement methods or analytical problems, design patterns or the linking between business models and business process models. Our dissertation aims to close these gaps. Regarding the transformation of business models towards business process models we examined the work of Andersson et al. In [3] the authors discuss the problem of how to go from a business model to a process model in a systematic way.

5. CONCLUSION

The introduced holistic approach shows current lacks in the field of business modeling. Using the approach from our dissertation current business modeling issues such as the linking between business models and business process models, business model measurements and design patterns for effective reuse of innovative business models will be examined. The final result of our PhD thesis will be a UML profile which enables UML supported modeling of business models.

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Business documents in a service oriented context

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ABSTRACT

In a SOA based inter-organizational business process different business documents are exchanged in an agreed order between business partners. Although several standards for the definition of a process choreography exist nowadays, the precise and unambiguous definition of the exchanged business documents is still an open research task. However, if the business partners do not commonly agree on a business document format, interoperability is unlikely to be achieved. A solution can be provided by defining a UML profile, integrating concepts from UN/CEFACT's Core Components standard and industry specific requirements and best practices. The UML profile allows to define business document models on a conceptual level. These conceptual level models can be used to exchange business document information between software developers and more important to automatically derive logical level models e.g. XML schema. These logical level artifacts can be automatically deployed in IT systems of a service oriented architecture.

1. MOTIVATION

With the introduction of Electronic Data Interchange (EDI) initiatives the need for a standardization of the exchanged information became apparent. One of the best known EDI standardization initiatives is the UN/EDIFACT [20] [1] standard. Typical EDI agreements involved a well defined set of business partners collaborating with a predefined set of business documents over a longer time-frame. Thus adaptations of the exchanged business documents were rather rare and if they occurred the changes were mostly minor ones. An early and interesting survey on the determinants of EDI diffusion has been published in [16]. Since the first EDI initiatives in the early sixties which were reserved for large companies and industries, the IT landscape has changed significantly. Today service oriented technologies enable small and medium sized enterprises to participate in electronic collaborations as well. The before rather hard-wired processes between enterprises have been replaced by loosely-coupled and service oriented ones. Service orientation allows for faster changes in B2B processes and thus also in the exchanged business documents. The hard wired EDI approach is too inflexible for these new ad-hoc business processes. Several initiatives, mostly industry specific ones, have been found in recent years - some with notable, others with almost no success. Since almost all of these initiatives were focused on a certain domain or industry, a broad cross-industry acceptance could not be reached. As part of the UN/CEFACT (United Nations Center for Trade Facilitation and Electronic Business) initiative for document standardization the core component [21] standard has been developed, consisting of reusable building blocks for the definition of business documents. However, core components are a theoretical concept and no integration into a modeling tool exists until today.

In order to allow for a better understanding of the industry-specific business document modeling requirements a precise survey of the various business document standardization efforts is necessary. Thereby the specific advantages and disadvantages in regard to a use in a service oriented context have to be examined. Using the results of the survey and the concepts of the core component standardization, a common solution allowing for the integration into a UML modeling tool has to be found. Eventually the business document modeler should be able to construct business documents on a conceptual level with a UML modeling tool of choice. Finally another important question remains - how to uniquely derive deployment artifacts from conceptual data models which may then be employed in a service oriented context e.g. XML schema. Furthermore it must be examined how conceptual business document models can be integrated into business process models.

2. PROBLEM

If two businesses engage in an automated business process two major agreements are necessary. First, the order of the exchange of business documents has to be agreed upon - the so called business choreography. Using the global business document exchange choreography each business partner can configure his own IT system. Second, the business documents and their precise semantics have to be settled. In figure 1 an example business process `order from quote` between a *buyer* and a *seller* is shown. First the *buyer* requests a `quote` from the *seller* and submits a `purchase order` to the *seller*. The *seller* either replies with an `order acceptance` or with an `order rejection`. In a service ori-

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ented context the interfaces (WSDL) [26] and the messaging (SOAP) [25] are well defined. However little or nothing is said about the actual workload being exchanged between the two companies.

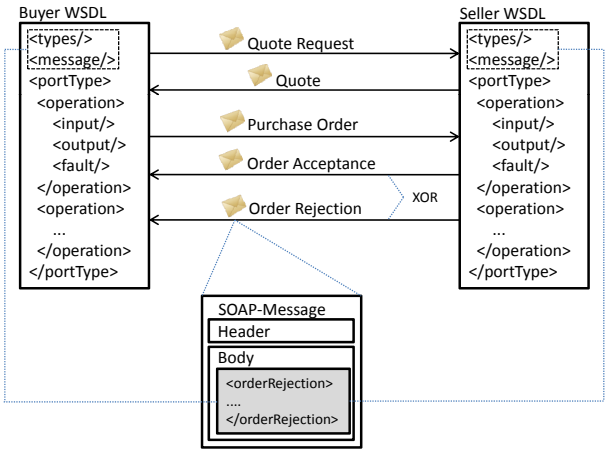

Figure 1: Business Documents in a SOA context

On the lower side of figure 1 an example SOAP message is shown. Whereas header and body of a SOAP message are well defined, the actual document format carried in the body remains undefined. However, in order to allow the two WSDL interfaces to be compliant the message types have to be defined as well. Standardization efforts in recent years have brought up a multitude of different standards and approaches for the definition of business data. Unfortunately the different standards have a set of shortcomings.

First, the multiple initiatives being based on XML are mostly incompatible to each other. Since the different standards are not based on a common semantic base difficult mappings between different standards are necessary. However, data mappers are expensive to implement and inflexible to changes of the structure of the exchanged business documents.

Second, a lot of the different standards aim at the inclusion of every possible element in a business document. This results in a strong overhead of a standard. Furthermore, such an overhead makes a standard difficult to implement - in particular for small and medium sized enterprises. Whereas for instance a regular invoice just requires a small set of elements and attributes an invoice standardized by UN/EDIFACT contains a multitude of possible elements not needed in a regular business transaction.

Third, most of the standards are transfer syntax specific. Standards such as UN/EDIFACT are tightly bound to the implementation syntax. Instead of defining a business document on a conceptual level most of the standards are based on a logical level e.g. XML schema. Changes in the transfer syntax therefore require a complicated reengineering of the entire standard. Thus future adaptations of the standard are difficult and time consuming to implement.

Finally the exchange of a logical level business document definition between two business partners is complicated and error prone during the development phase of the B2B process. Instead of exchanging e.g. XML schema definitions, a conceptual business document model is easier to understand for the developers on each business partner's side.

To sum up, a new methodology for the definition of business documents is needed in particular to meet the needs of a service oriented context. A SOA context requires regular changes in the exchanged document structure and the automatic derivation of deployment artifacts in order to quickly meet the changed business document requirements.

3. HYPOTHESIS

In order to allow two companies to agree upon a common document semantic a methodology for defining business documents is needed. UN/CEFACT's Core Components [21] is a methodology to uniquely define business documents. The current core component version is 2.01 with the development of 3.0 [24] currently going on. The development of core components is backed up by the United Nations and can therefore be seen as the most promising global approach for business document standardization. However, several other industry initiatives and standardization bodies have developed business document standards as well. Nevertheless, the different standards are largely incompatible to each other, thus hampering a broad proliferation of business document standardization.

Hypothesis 1. It is necessary to find a common base between different industry specific requirements and the global core components initiative. Since core components are a generic concept the different industry requirements can be reflected. However core components are a theoretical concept and therefore no real integration into a modeling tool is possible. Recent years have shown, that the Unified Modeling Language (UML) is becoming a very promising technology for the modeling of structural and dynamic behavior. If the core components technology together with the identified industry requirements could be integrated into a UML modeling tool, the proliferation of the technology would be accelerated, thus leading to a broader acceptance. A UML tool of choice could be used to model conceptual business document models. Therefore a solution for the integration of the core component concept into a UML modeling tool must be found [7].

Hypothesis 2. If core components are modeled using a UML tool of choice, the result would be conceptual business document models based on UML. These models can be used to exchange structural business document information between business analysts, software developers and other stakeholders. Although a conceptual model is appropriate for the exchange of structural information, it cannot be used in a real-world IT system. In order to allow for the integration of a business document in a SOA context it must first be represented on a logical level e.g. XML schema. Therefore a solution for the derivation of logical level business documents (e.g. XML schema) from their conceptual level core component representation must be found. However, not only the forward engineering (UML to XML) must be addressed, but also the reverse engineering (XML to UML).

Hypothesis 3. As already outlined in section 2 business process modeling and business document modeling are strongly

interlinked. First, a business process model indentifying the exact exchange order of business document is constructed. Second, a business document model defining the exact outline of the exchanged business documents is created. In recent years UN/CEFACT's Modeling Methodology (UMM) [22] has established itself as a very promising approach for the definition of inter-organizational business process model. In order to allow for a seamless integration into business process models, an integration approach for the core components technology into the UMM has to be found. A UMM model defining the process perspective together with a core components model defining the document perspective provides a holistic B2B methodology for the definition of SOA requirements.

4. METHODOLOGY

In order to provide a solution to the current problems defined above a specific methodology will be employed which consists of five distinctive steps. Figure 2 gives an overview about the used approach.

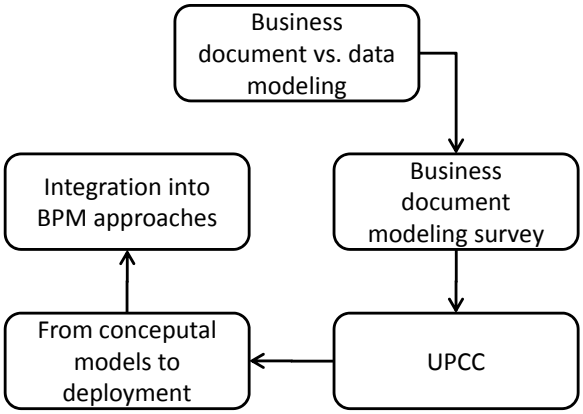

Figure 2: Dissertation approach

Business document modeling vs. regular data modeling. In the first step the specific differences between regular data modeling techniques such as the ER-model [3] from the relational database management systems (RDBMS) design and business document model requirements will be examined. In particular the specific requirements necessary for business document modeling are going to be revealed. Since the overall goal is to develop a holistic business document methodology a profound knowledge of the different modeling techniques is necessary. Furthermore it provides a good introduction into the domain of document modeling per se.

Business document modeling survey. The second step will comprise a survey of current business document modeling approaches, their advantages, disadvantages and application scenarios. Using the survey a precise overview about current industry approaches and best practices will be given. Furthermore a classification of the business document approaches in regard to their applicability in a service oriented context will be defined. The specific requirements of the different industry solutions will be reflected to the maximum extend possible in the overall core component methodology. Since core components provide a generic concept, the integration of domain and industry specific requirements is easily feasible.

UPCC - A UML Profile for Core Components. As outlined before, core components are reusable building blocks for the definition of business documents. However, core components are a theoretical concept and no integration into a UML modeling tool is possible. In order to merge the industry specific requirements identified in the step before and the core component technology a common solution based on UML must be found. However, UML is a very generic concept allowing the construction of a multitude of different structural and behavioral models. In order to restrict the UML meta model to the specific needs of business document modeling, a UML model will be defined. A UML profile tailors the UML meta model using stereotypes, tagged values and OCL constraints. The profile can be imported into any UML modeling tool of choice and provides the business modeler with the necessary artifacts to define business documents. If both modelers use the same profile, the conceptual business document models are compatible to each other, overcoming the interoperability limitations of the different standardization initiatives. We have already started to address this issue in [9] and also co-authored the first experimental UML profile for the core components standard 2.01 [23]. With the advent of the new core components standard 3.0 [24] the old profile is obsolete and a new profile has to be constructed. The definition of a new profile, reflecting industry specfic requirements will be an integral part of this dissertation.

From conceptual models to deployment artifacts. A UML profile for core components allows the definition of conceptual business document models. Since the core components standard is employed, the different business document models share the same semantic base, thus guaranteeing interoperability. However, a conceptual model cannot be deployed in a real world IT system. Thus a derivation mechanism will be developed, allowing the generation of deployment artifacts such as XML schema from conceptual business document models. The logical level XML artifacts can be deployed in a IT system of choice. However, the generation of deployment artifacts must not necessarily be restricted to XML schema - the generation of UBL [14], Relax NG [13] or any other appropriate artifacts is also possible since the conceptual core component model does not mandate any specific implementation technology. As a proof-of-concept a generation of deployment XML schema artifacts will be developed on top of the UML modeling tool Enterprise Architect [18].

Integration into BPM approaches. Since business documents in a SOA context are exchanged in a collaborative process, the exemplary integration of a conceptual business document model into inter-organizational business process technologies will be subject to the last step of the thesis. As a process methodology of choice UN/CEFACT's Modeling Methodology (UMM), which we have co-authored, will be chosen. UMM itself is also defined as a UML profile on top of UML 2.0. Since the core component profile will also be defined on top of UML 2.0, a seamless integration is feasible. Of particular interest will be the derivation of artifacts from both methodologies - UMM on the process side and core components on the business document side. Given this

holistic approach, the easy configuration of a SOA system will be possible.

5. GOAL

In figure 3 the overall goal of the dissertation is shown. First two business partners have to agree upon a common process choreography. The process choreography defines in which order the different business documents are exchanged between the two business partners. In the context of the thesis the global choreography will be defined using UN/CEFACT's Modeling Methodology. After having found a common agreement on the business document exchange order, the business documents per se have to be defined. Using the UML Profile for core components, which will be developed in this dissertation, the two business partners uniquely define the document semantic. In the next step the common business document model is used in order to derive XML schema deployment artifacts. The XML schema is then fed into the IT systems of the two business partners. Since both IT systems are configured on the same basis, a common agreement on the interface definitions of the respective WSDL is found.

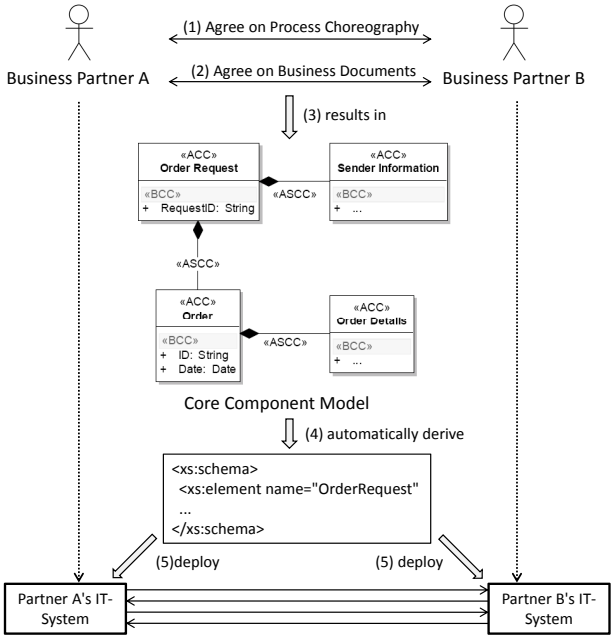

Figure 3: From a conceptual model to deployment

By setting the business document semantic on a conceptual level using the core components semantic, a quick agreement between the two business partners is possible. Since the derivation of the XML artifacts is done automatically, a fast deployment is possible after the requirements of the business documents have changed.

6. RELATED WORK

For the interested reader a general introduction into the field of business document engineering is given in [6]. In the field of business document standardization several initiatives have been found in recent years. Mostly the efforts are industry specific and bound to the XML standard. The most important standards include CIDX [4], SWIFT [19], HL7 [8], and PapiNet [15] just to name a few. A lot of research has been conducted in the field of XML artifact generation out of UML artifacts. Generally a distinction is made between forward engineering (XML artifact generation from UML models) and reverse engineering (UML model generation from XML artifacts). Whereas the first approach is often straight-forward the second one contains some obstacles. E.g. a derivation by restriction cannot be modeled with the Unified Modeling Language. A profound overview on the reverse engineering of XML schema to conceptual models is given in [27]. Thereby the authors examine several reverse engineering techniques and assess their applicability. In the field of forward engineering several research efforts can be named e.g. [17] and [5]. Several research efforts have also been conducted in the field of business process and business document modeling alignment e.g. [10] [11]. As outlined before core components define the semantics on a conceptual level and the semantics are transformed to the logical level XML schema by derivation. Several other research efforts have already addressed the definition of semantics in XML schema e.g. [12] and [2]. Most of these approaches however are missing a holistic approach for the specific needs in regard to a use within a SOA context.

7. CONCLUSION

Common modeling approaches for B2B scenarios often only reflect a particular part of a business collaboration e.g. only the process perspective or only the data perspective. In order to allow for a holistic view on a B2B collaboration a solution embracing all necessary views and technologies is necessary. We have already actively developed the UN/CEFACT's Modeling Methodology, reflecting the process perspective of a business collaboration. This thesis will close the gap to a holistic B2B methodology by incorporating the business document modeling perspective as well. Thereby different business document modeling standards will be evaluated and their advantages and disadvantages will be assessed.

Based on these results and using UN/CEFACT's core components technology, a UML profile will be developed. The UML profile will allow to easily assemble business documents on a common semantic basis. The conceptual business document models will then serve as the basis for the derivation of logical document models e.g. XML schema artifacts. The XML schema artifacts can be fed into IT systems of participating business partners and guarantee, that all partners have the same understanding of the exchanged information. Finally the integration into the process modeling methodology UMM will be examined. After the finalization of the thesis a business modeler will be given a holistic methodology for the modeling of B2B scenarios.

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Semantic based Project Management

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ABSTRACT

In the past and still today, projects miss their goals or are cancelled because of overruns in time and budget. Reasons for their failure are that information often gets lost or that it is hard to remember how and where to find the needed information.

To improve this situation it is intended to enhance a project management system with semantic technologies, such as ontologies and semantic search. For access via client this project management system will enhance a fat-client on the Semantic Desktop system. The usage of this semantically enhanced project management system will be demonstrated by a prototype.

Categories and Subject Descriptors

H.3.2 [**Information Storage and Retrieval**]: Information Storage

General Terms

Management

Keywords

Project Management, Semantic technologies, ontologies, Semantic Desktop

1. INTRODUCTION

In the past and still today, projects miss their goals or are cancelled because of overruns in time and budget. Reasons for their failure are that information often gets lost or that it is hard to remember how and where to find the needed information.

The idea to enhance project management systems with semantic technologies enables for example a better search and reuse of already existing data. Thus it reduces time and costs and in addition, it reduces the effort of project management and increases the probability of project success.

To enable a better comprehension of this topic chapter two specifies the research problem and the benefit and chapter three the economic relevance. Chapter four describes the state-of-the-art of current Project Management and Semantic Desktop systems and the innovation of this topic. The proposed technical solution will be explained in chapter five, while chapter six gives an overview of the future work. Last but not least chapter seven gives an overview of the scientific contributions and chapter eight gives a short conclusion of this PhD thesis.

2. Research problems

The main goal of this PhD work is to enhance Project Management (PM) with semantic technologies and further, to enable an interchange of information between a Semantic Desktop and a Project Management System.

By combining semantic technologies and PM systems, a reduction of the administration effort and an improved control of the progress of a project seem possible. Introducing semantic technologies, such as ontologies, semantic annotation of content and semantic search open up new ways of delivering the needed insight and experience of past projects. Relevant information of former projects is consolidated in a knowledge base. With the use of ontologies project members can search for concepts and do not have to search for exact keywords. Furthermore, different information items are set in relationship which simplifies and optimises the search process. All information items for a project are on one platform or at least a relationship exists between the project data on a desktop and on the platform related to a project. With the availability of the knowledge of already finished, running and planned projects the probability to deliver a project in time, in budget and with the specified capabilities is improved.

For a better understanding what the expected added value of this PhD topic is, a small Use Case is given in the following:

There is a large company, which has lots of different (past, current and future) projects. Very often, new projects are similar to already finished ones or problems might appear in current projects, which were already solved in similar projects in the past. In those cases, it is necessary to look up again the information, such as documents, contact information or statements of costs of those finished projects.

A project member of a big company is involved in a project where some problems have appeared. This person remembers that similar problems arose in another project a few years ago. To save money and time he wants to get the information of this project and therefore searches for information about it. But he doesn't know the exact terms to get the description of how the problem was solved in the last project, the name of the person who solved it or wrote the documentation. Current project management tools only allow to search for keywords, different information items, and full text search or maybe in time categories. Hence, the search will be quiet difficult and of course will need time.

The goal of this PhD is to tackle this problem. The user can search for the name of the producer of the document, the creation date, the milestone in which the document is part of, an email where the document is attached or for a name of a project member. The result of this search is presented as an ontology tree that makes it possible to navigate through the possible results until the needed information is found. A normal listing of documents or information items is included in addition, but the main issue is to navigate through different information items based on the semantically annotated data until the user can find the needed information. In this way, the PhD work contributes to research in project management systems. Currently, the user has to know what he/she is looking for. Semantic annotations allow

connections between items and the establishment of an ontology so that users can navigate easily through all information items.

In addition, an interface between a Semantic Desktop system and the PM system shall be built, thus enabling an up-to-date access to the relevant information of a project. With this interface, relationships between data and information items of projects on multiple systems and information items on a desktop are established. Hence, also the desktop can be searched for project relevant information.

Another benefit of this thesis is its domain independencies. Project Management is part of every project, independent if it is part of a health care or of an e-commerce project.

To enhance an existing PM system with semantic technologies the following sub-goals are relevant:

- **Definition of a Project Management Domain Ontology and PM related Ontologies**

  For the PhD topic a project management domain ontology as well as other related ontologies have to be developed. These ontologies concern project related issues (e.g., milestones, tasks), project documents, temporal issues, or project members and their capabilities. All these ontologies are not on the same level, but they support and complement each other.

- **Interface Semantic Desktop – Semantic PM**

  An interface between the client, a Semantic Desktop system and the semantic PM system must be implemented. The Semantic Desktop system must be extended with a fat-client with the functionalities to search and to set links to PM information as well as to edit them. The ontology of the Semantic Desktop must be adapted with parts of the project management ontologies.

- **Flexible Architecture of the System**

  To guarantee a positive result of this PhD a detailed architecture of the system has to be designed. This architecture has to be built in a modular and flexible way to allow future extensions. Also all interfaces of this system must adhere to open standards.

- **Proof of Concept of the PM System**

  The proof of concept of the PM system includes a prototype of the system with the following parts: ontologies, databases, semantic technologies (metadata, tagging …), interface to the Semantic Desktop, adaptation of the Semantic Desktop and the functionalities of PM. It also includes the evaluation of the prototype. The PhD deals with project management in general. But to receive useful test results, the prototype directs its attention to project management for IT projects and in greater depth to the tourism (industry) domain.

The main problems of the PhD will be

- **The evaluation of existing Project Management Systems**

  One issue of the PhD work is to find an OpenSource Project Management System, based on a client-server application. Further consideration regards the types of documents that are to be integrated in the system as well as their storage. Another question is if the system will support automatic annotation of metadata or if the users have to annotate their inputs by themselves. To address these risks, an in-depth evaluation of existing OpenSource PM Systems as well as of possible semantic systems, such as document management or knowledge management systems, will be done.

- **To develop ontologies and combining them**

  A major problem is to develop the different types of ontologies, such as a domain ontology for project management and a time and date ontology for time data, and then to link them. The risk here is that the matching does not fit. To avoid these problems an evaluation of possible existing ontologies will be done. Based on these experiences, possible problems should be avoided. A further preliminary consideration regards whether the ontologies should be merged. The PhD work will start with the assumption that they will not be merged, but properly interlinked.

- **To ensure valid test results**

  A problem at the end of the work could be poor test results in case of poor test scenarios and questionnaires. To avoid this problem, requirements and use cases will be done at the beginning of the project. In addition, useful test scenarios are needed. Therefore the main tests will be at the Electronic Commerce Group of the Institute of Software Technology and Interactive Systems at the Vienna University of Technology. During and after using the prototype (for a few weeks) questionnaires and test scenarios concerning the usage will be carried through and analyzed.

3. Economic relevance

Today many projects miss their goals or are cancelled because of overruns in time and budget. The Chaos Report [10] identifies that 31% of IT projects were cancelled or never completed and nearly 53% of the projects cost almost twice the initial estimate. Reasons for their failure are that information often gets lost. It is hard to remember how and where to find the needed information.

The working prototype enables a better search and reuse of already existing data by using semantic technologies, reducing thus time and costs. In addition, it reduces the effort of project management and increases the probability of project success.

Information of already finished projects can be used as input for planning of new projects and to monitor progress and risks of projects underway. That is because of better storage of project relevant information. Due to explicitly describing the relationships between various project documents in machine accessible form, better administration of projects and easier identification of relevant information is possible. Based on improved relationships between different information tasks, connections between previous and current projects are possible and a better administration of projects is feasible as well. Another advantage is a faster reaction to project changes because experiences and problems of previous projects and their management are traceable and visible.

Since project management software is a high volume market, and since the solution envisaged tackles the major problems in project management, the economic potential is very high.

4. State-of-the-art

This chapter is divided into three parts, the state-of-the-art of Project Management, of ontologies and of Semantic Desktop systems. All of them include the innovation aspects of this PhD thesis.

4.1 Project Management

There are several Project Management software tools, which help companies to manage IT projects. Currently, there are no solutions in the field of project management which contain semantic technologies. The available systems differ considerably with regard to their functionality. The spectrum ranges from just time planning (milestones) or resource planning to tools that assist the entire project management process, as for example project-open[1] or dotproject[2].

Problems with projects and their management are often a mix of information storage (PM platforms, personal computer …), neglecting of milestones, costs, etc. and inconsistence of stored information (versioning of documents). These are only some reasons why projects might suffer overruns in time or budget or miss their goals or are cancelled. The Chaos Report of the Standish Group [10] identifies that in 1994 US companies invested approx. $250 billion in IT development. 31% of the projects were cancelled or never completed and nearly 53% of the projects cost almost twice the initial estimate.

The PhD work explicitly defines and employs the relationships between different data items and their semantic descriptions. It allows a better search and reuse of already existing data and reduces the effort of project management and thus increases the probability of project success. Information of already finished projects can be consulted and be used as input to plan new projects, as well as to monitor progress and risks of projects underway.

4.2 Ontologies

Ontologies are the backbone of Semantic Web technologies. They establish a common understanding of a domain by making the shared conceptualization explicit in a machine-accessible manner. An ontology represents the domain knowledge by describing its concepts or entities, and the relationships between these concepts in a precise, detailed way, so that all relevant knowledge of the domain is actually made explicitly. PROMONT [9], for example, is a basic project management ontology which formalizes the typical elements for project structuring. Another already existing ontology is Harmonise [6], which is a tourism domain specific ontology. Harmonise could be consulted for adapting the project management ontology (with an industry specific domain) to enhance test results. An example of a time ontology is a part in ONTO-SD [7], which will be part of the evaluation of existing time ontologies.

In this PhD the innovation is to develop a project management domain ontology, as well as the development of related ontologies, like date, time or events and the matching of the ontologies. However, the primary focus will be on IT projects.

4.3 Semantic Desktop

Semantic Desktop systems provide personal information management where a user can store personal information items (documents, emails …). These information items are interpreted as Semantic Web resources, identified by a Uniform Resource Identifier (URI) and all data tasks are accessible as RDF Graphs. Ontologies allow users to qualify their information with their own words and enable the relationships between different information tasks (documents, contact information, calendar …). There are already some Semantic Desktop systems available, like Gnowsis [2,4], which is part of the NEPOMUK project, or IRIS [1], which belongs to the CALO research project at SRI International. Current work in the field of Semantic Desktop is to enable collaboration between such systems [3] or [5].

In the PhD work one existing Semantic Desktop system, either IRIS[3] or Gnowsis[4], will be adapted for including project relevant information and therefore an interface between a Semantic Desktop and the PM system will be built. The idea is that project members can search on their personal desktop for project relevant information.

5. Technical solution

The PhD work is still at the beginning and thus, this technical solution is a first draft how it should look like.

The ontologies will be developed in OWL (Web Ontology Language) using Protegé. The programming language of the application depends on the selected project management system, which will be evaluated. It was decided that the PhD application will rely on an OpenSource solution. The database will be either PostgreSQL or MySQL and the application will run on a Linux server.

The implementation will follow a client-server architecture. The client uses Web Services, interacting with the Project Management application. The application includes the project relevant functionalities as well as the semantic ones. The application communicates with the database, ontologies and data storage via standard interfaces. The types of these interfaces depend on the finally selected PM system. Figure 1 gives an overview of a draft architecture of the PhD project (SemProM is short for Semantic based Project Management).

The fat-client offers functionalities, such as upload and download of documents, editing (e.g. tasks, milestones, calender), annotation of information, etc. With this client in the Semantic Desktop, relationships are enabled between project management information and information on the personal desktop.

[1] http://project-open.org

[2] http://www.dotproject.net

[3] http://www.openiris.org/

[4] http://www.gnowsis.org/

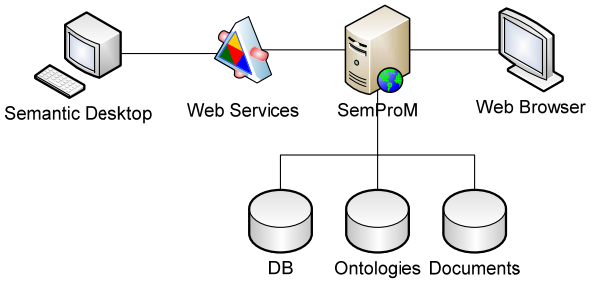

Figure 1: Draft architecture of the PhD project

Another possibility of implementing the client is a conventional Web Browser. Therefore an evaluation is needed for studying the feasibility of useful functionalities. However it is not guaranteed that all the functionalities of the fat-client are feasible for the Web Browser.

6. Future work

The work is at the very beginning and hence an in-depth study of the available literature is necessary to understand the general terms and methods which already exist. In addition, already existing ontologies as well as project management systems must be analyzed and proofed if they can be taken as basis for this PhD work.

During this study, a detailed architecture of the prototype should be designed to specify all relevant interfaces and potential difficulties as well as a time plan for the programming part, where the building of the ontologies and their combination, the extension of the project management system, the extension of the Semantic Desktop, the interfaces and the combination of all these tasks are part of it.

Furthermore use cases and requirements will be defined by means of evaluations.

Based on these results the domain ontology for project management and the other ontologies will be developed, implemented and combined.

After these steps the prototype as well as the interface between the Semantic Desktop and the PM system and the fat-client on the Semantic Desktop will be implemented and tested by the staff of the Institute of Software Technology and Interactive Systems.

7. Scientific Contribution

Current research in the area of semantic desktops focuses on integrating those systems in order to interchange information. The work in this thesis concentrates on integrating a Semantic Desktop and a project management system extended by semantic functionalities. Thus, this thesis is in line with current research in this area and an exchange of information between them and us is preferable.

The main goal of this thesis is to accomplish an integration of two systems having different business justifications – a project management tool and a semantic desktop. Best to our knowledge, this has not been done before. The integration challenge is twofold: firstly, both systems must be aligned on the semantic layer. Secondly, information items on the semantic desktop (client) must be linked on the technical layer with items on the project management system (server). The user benefits from such an integrated environment by having project management items enriched with semantic descriptions readily available on the desktop.

8. Conclusion

The main advantage of this PhD thesis is the higher probability of successful delivery of projects based on better information retrieval. The use of semantic technologies may lead to less expenditure of time and therefore fewer costs. Also a better storage of project relevant information is given due to for example, metadata and relationships between information items. By the improved relationships between different information tasks connections between previous and current projects are possible and therefore a better administration of projects is feasible. Also a faster reaction to project changes is possible because experiences and problems of previous projects and their management are traceable and visible.

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A Multi-Agent System for Content Trading in Electronic Telecom Markets Using Multi-Attribute Auctions

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ABSTRACT

The advent of the Internet and the development of the New Generation Network (NGN) has enabled, while investments in licenses and the desire to stay competitive in the future has triggered the development of value added services (VAS). Due to high market penetration, the telecommunication industry has been facing income stagnation. Consequently, it has been shifting focus to VAS in order to increase income. When forming VAS, special attention needs to be paid to the purchase of resources (e.g., transport capacity and information resources) needed for the service creation. The fact that information resources (i.e., content) are not commodities, opens the question of what is the best (i.e., efficient) mechanism that should be used for trading. As the number of participants on the B2B telecom market increases, the need for the automation of transactions carried between them is critical. The automation of transactions should lower operational costs and speed up the service provisioning process. In this paper, we try to identify stakeholders on the telecom e-market, establish their roles and relationships and find an appropriate model which captures their transactions. Finally we consider the use of multi-attribute auctions for content trading in telecom markets.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Intelligent agents, Multiagent systems. J.4. [**Social and Behavioral Sciences**]: Economics. I.6.5 [**Model Development**]: Modeling methodologies

General Terms

Management, Design, Economics.

Keywords

Multi-attribute auctions, Multimedia Content Trading, B2B e-markets, Intelligent Software agents, New Generation Network

1. INTRODUCTION

The advent of the Internet and the development of the New Generation Network (NGN) provide connections which enable a particular lifestyle that is aspiring to digital humanism where people's daily activities are becoming more digitalized, convenient and intelligent [27]. Actors on the telecom markets are pursuing innovations and launching new value-added services (VAS) [5] in order to increase revenue. This is due to the fact that provisioning basic telecommunication services (i.e., fixed and mobile communication, data transfer) is no longer enough to keep existing customers, let alone attract new ones, due to high market penetration. Investment regain of licenses and staying competitive in the future are key drivers for the expansion of new VAS on the market. This new market demand and technological development has led to the convergence of different domains (i.e., telecommunications, information technology (IT), the Internet, broadcasting and media) all involved in the telecom service provisioning process. The ability to transfer information embodied in different media into digital form to be deployed across multiple technologies is considered to be the most fundamental enabler of convergence [14]. An important feature of convergence is the composition of services and content derived by combining multiple simpler services or types of content in order to provide more powerful services.

The research problem addressed in this paper concerns the automation of business processes related to the creation of VAS that are traded on the telecommunication electronic markets (e-markets). There are two types of resources needed for the creation of telecom VAS. They are the information resources (i.e., content) the service is based on and the transport capacities needed for service provisioning. The telecom market is divided into two submarkets, the B2B (*Business-to-Business*) market and the B2C (*Business-to-Consumer*) market. Our research is focused on B2B telecom e-market trading with information resources using multi-attribute auctions.

The rest of the paper is structured as follows. Section 2 describes the participants on the telecom e-market. Section 3 describes the phases we need to go through in order to conduct a transaction on the B2B telecom e-market. Section 4 addresses general auction mechanisms and presents multi-attribute auctions. Section 5 states the main questions of this research effort and proposes some answers.

2. TELECOM E-MARKETS

The appearance of new stakeholders on the B2B telecom market had to be taken into account so new business models were formed. One of the long-term objectives of the NGN is to support business models that open the market to emerging service providers [14]. The volume and dynamic nature of VAS offered

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in the NGN place novel demands and challenges on telecom stakeholders. In this newly developed situation it is not enough just to adequately respond on the existing requests but also to intelligently anticipate the development of the future events and adapt to their environment. In order to understand the relationships between stakeholders and the way they interact it is important that their roles are well classified. We use the classification determined in [8] as shown in Figure 1.

Consumers are service users that have at their disposal various devices (e.g., mobile phone, laptop, PDA) and are connected through various access networks (e.g., 3G, WiMax). *Access Provider* ensures telecommunication access for service consumers. *Service Provider* facilitates a variety of basic and integrated services for consumers enabling easy content consumption. *Carriers* provide a transport service for the data traffic and they usually buy bandwidth from *Network Infrastructure Owners* who provide transmission lines. A large number of Carriers are at the same time also Network Infrastructure Owners. *Wholesaler of Capacity* provides lower-cost transmission and storage capacity. *Content Owner* possesses the information in its original format while *Content Enabler* converts this information to a format eligible for the transmission over heterogeneous networks. Content Provider is at the same time Content Owner and Content Enabler. *Wholesaler of Content* provides lower-cost content. *Server Infrastructure Owner* provides storage capacity and server functionality. *Information Enablers* enable information resources while *Transport Enablers* provide transport of information resources through the various networks swiftly and seamlessly.

We are focusing on the B2B e-market since it is widely believed that it will become the primer way of doing business [21]. The assumption is that the telecom B2B e-market will grow with other B2B e-markets. A special intention is paid to the negotiation phase since the outcome (i.e. financial efficiency) is still the premier performance measure for most businesses [16, 17].

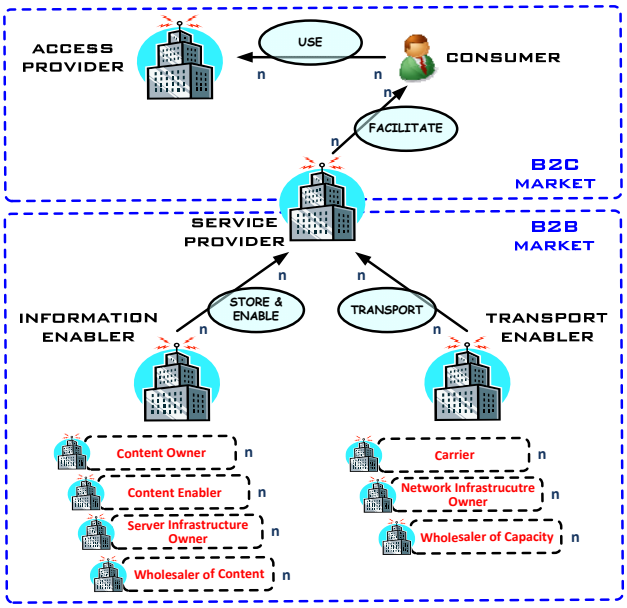

Figure 1. The roles and relationships of stakeholders in the telecom market

3. B2B TELECOM E-MARKET

The BBT (Business-to-Business Transaction) model [15] systematically analyses processes in B2B e-markets. The proliferation of auctions on the Internet, and the dynamic nature of auction interactions, argues for the development of intelligent trading agents which act on behalf of human traders (i.e., buyers and sellers). Intelligent trading agents can also be used to impersonate stakeholders in the environment of the NGN in order to enable automated interactions and business transactions on the telecom markets [20]. Namely, an agent can monitor and participate in the market continuously. Software agents [7, 19] are programs which autonomously act on behalf of their principal while carrying out complex information and communication tasks that have been delegated to them. A software agent is intelligent (its intelligence is grounded on its knowledge base, reasoning mechanisms and learning capabilities), autonomous, reactive, proactive, cooperative, and persistent. Additionally, a software agent can also be mobile.

From the BBT model perspective [15], we can formally identify six fundamental steps which must be executed in order to successfully complete one transaction in a B2B environment. These steps are as follows (Figure 2): 1) *partnership formation*, 2) *brokering*, 3) *negotiation*, 4) *contract formation*, 5) *contract fulfillment*, and 6) *service and evaluation*. B2B negotiation is complex since it typically involves larger volumes, repeated transactions and more complicated contracts. This is the reason why most researchers have concentrated on the negotiating phase of B2B market transactions.

The *partnership formation* phase usually includes forming of a new virtual enterprise or finding partners to form a supply chain. A virtual enterprise represents a form of cooperation of independent stakeholders which combine their competencies in order to provide a service [6]. On the B2B telecom e-market, *Content Owners*, *Content Enablers*, *Server Infrastructure Owners* and *Wholesalers of Content* can form a *virtual enterprise* in order to successfully place and sell information resources to various service providers. Moreover, *Carriers*, *Network Infrastructure Owners* and *Wholesalers of Capacity* may also form a *Virtual Enterprise* to enhance trading with transport capacity. With the expansion of the e-market, the number of buyers and sellers grows accordingly making it more difficult to find all potential business partners trading a requested service/resource. The main role of the *Brokering* phase is to match service providers with information/transport enablers that sell information resources/transport capacities needed for the creation of a new service or improvements of an old one.

Negotiation is a process which tries to reach an agreement regarding one or more resource attributes (e.g., price, quality, etc.). Each stakeholder in the negotiation process is represented by an intelligent trading agent that negotiates in his behalf (e.g., *Information Agent* trades in behalf of *Information Enabler*). The trading agent uses a negotiation strategy suitable for the type of auction applied (i.e., negotiation protocol) on the market. The negotiation protocol defines the rules of encounter between trading agents. It should ensure that the negotiation's likely outcome satisfies certain social objectives, such as maximizing allocation efficiency (i.e., ensuring that resources are awarded to the participants who value them the most) and achieving market

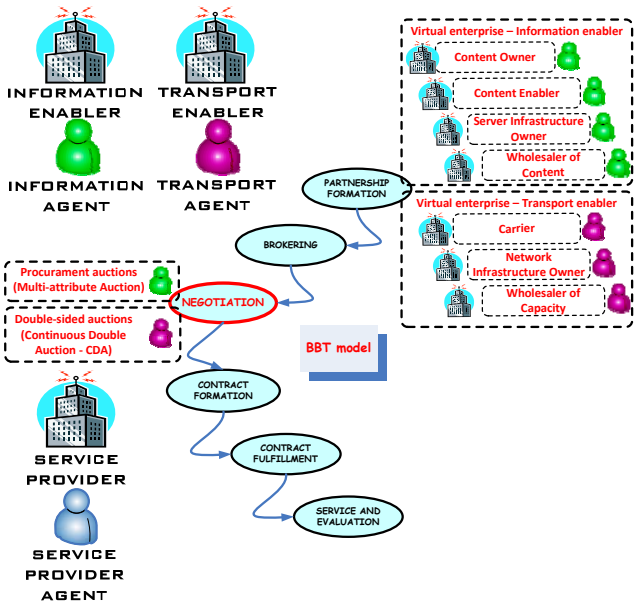

Figure 2. The BBT model for the B2B telecom domain

equilibrium [9]. The negotiation strategy represents a set of rules that determines the behavior of a trading agent.

The negotiation process can be either distributive or integrative [22]. In distributive negotiations, one issue is subject to negotiation while the parties involved have opposing interests. One party tries to minimize loss and the other party tries to maximize gain. Distributive negotiations are also characterized as "win-lose" negotiations. The continuous double auction (CDA), which is suitable for transport capacity trading in a B2B e-market, represents a distributive type of negotiation in a multi-unit auction with multiple buyers and sellers [25].

In integrative negotiations, multiple issues are negotiated while the parties involved have different preferences towards these issues. For example, two information enablers may want to sell multimedia information resources to a portal provider, but one is primarily interested in the sale of news, whereas the other is interested in the sale of movie clips. These variant valuations can be exploited to find an agreement resulting in mutual gain. If their preferences are the same across multiple issues, the negotiation remains integrative until opposing interests are identified. In such a case, both parties can realize gains: consequently, another name for this class of negotiations is "win-win" negotiations. A multi-attribute auction represents an integrative negotiation process which can be used for trading with information resources.

Last three phases include termination of negotiation where negotiated terms are put in a legally binding contract (contract formation), carrying out the transaction agreed in the contract (contract fulfilment) and traders evaluating the received service (service evaluation). Due to legal issues and subjective judgments it is not likely that these phases are going to be automated with the use of intelligent agents.

4. AUCTIONS

Auctions, due to their well defined protocols, are suitable enablers of negotiations in e-markets. The variety and value of goods that are sold in auctions has grown to tremendous proportions. Auctions are defined as a market institution that acts in pursuit of a set of predefined rules in order to compute the desired economic outcome (i.e., high allocation efficiency) of social interactions [26]. Based on bids and asks placed by market participants, resource allocation and prices are determined. There are two main directions to take when designing auctions, namely we distinguish efficient and optimal auctions. The objective in efficient auctions is to maximize allocative efficiency and deal with dividing the surplus in an auction among the auctioneer and bidders, while optimal auctions concentrate on maximizing revenue or the expected utility of the bid taker [3].

4.1 Multi-attribute auctions

Item characteristics (i.e., attributes) represent an important factor in deciding which auction should be used in the negotiation phase. Negotiation on commodities, such as transport capacities, focuses mainly on the price of the item. These items are mostly sold in conventional single-attribute auctions. On the other hand, complex items such as information resources often require negotiation of several attributes, and not just the price [6]. They are sold in multi-attribute auctions [3] which are a special case of procurement auctions. Procurement auctions are also called reverse auctions since there are multiple sellers (e.g., information enablers) and only one buyer (e.g., service provider) that purchases items (e.g., information resources). Multi-attribute auctions have been attracting more and more attention in B2B markets since the price is not the only important attribute considered in the decision making process[1].

The first step in a multi-attribute auction is for the buyer to specify his preferences regarding the item he wishes to purchase. Preferences are usually defined in the form of a scoring function based on the buyer's utility function [2]. In order to familiarize sellers with buyer's valuations of relevant attributes, the buyer usually publicly announces his scoring function. Sellers are not obligated to disclose their private values of an item. The winner of the multi-attribute auction is the seller that provided the highest overall utility for the buyer. The buyer sends a request to all interested sellers which than reply by sending bids. The buyer selects the bid with the highest overall utility. If the auction is one-shot, this bid is declared the winning one, otherwise it is declared as the currently leading bid and the new round of the auction begins. The buyer can also define the bid increment or minimum requirements the bid has to fulfill in order to compete in the next round. Figure 3 shows a multi-attribute auction between a service provider and several information enablers. Information enablers offer multimedia content composed of video and audio streams with different performances. Based on its utility function, the service provider reaches an agreement with the information enabler whose information resource has the highest overall utility.

4.2 Content trading

The term content encompasses movies, songs, news, images and text, in other words data and information within various fields [14, 23]. The NGN brings its own new added value into the market and one of these added values is multimedia content composed of several types of content (e.g., audio, video, data…)

[1] http://www.cindywaxer.com/viewArticle.aspx?artID=149 (Business 2.0 magazine)

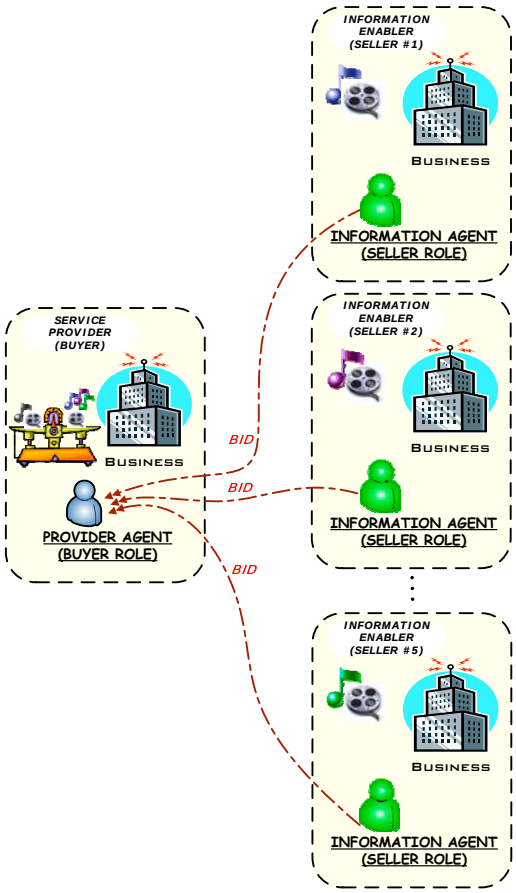

Figure 3. An agent mediated e-market for content trading

[11]. When trading with multimedia content there are several attributes that are negotiated on; the quality of the audio and video content (i.e., audio bit rate, resolution of the video), type of the information provided (i.e., music, video clips, games, news, sports, weather…), time of origin of the content (e.g., two days old weather forecast is of no use, one minute old stock market news could be worth a lot), reusability of the content (i.e., using the content in forming various services), potential number of users interested in this content, and the price. An example of trading with multimedia content by using multi-attribute auctions is shown in Figure 3 where several agents posing as sellers offer different multimedia (i.e., audio and video) content while the agent posing as a buyer must decide which content holds the highest utility for him and then buy the content in order to resell it further on the B2C e-market [18].

5. PROPOSAL OF THE RESEARCH PLAN

The research plan consists of four stages[2]. The aim of the first phase is to explore the telecom market, identify participants on the market, establish their roles and relationships, and, finally establish with what goods and services are being traded on the market. This phase is completed and is described in Section 2. We can se that a service provider actually manages a supply chain by buying information and transport capacities on the B2B telecom e-market, forming value added services from purchased goods and then selling those services to consumers on the B2C telecom e-market.

Due to the lack of research related to B2B telecom e-markets [13] (i.e., most research is related to the B2C telecom e-market [5, 10, 12, 18]) and the expected growth of B2B e-markets in general, the second phase is oriented to finding an appropriate model which captures all stages related to transactions carried out on the B2B telecom e-market. As shown in Section 3, the BBT model was used to describe B2B telecom transactions, while intelligent agents were used to impersonate stakeholders on the market. Since the B2B e-market includes repeated transactions with existing and/or new business partners, a new phase should be introduced into the BBT model. This phase will be in charge of collecting knowledge regarding the state of the e-market, processing information collected in the service evaluation phase, and deciding on the changes that need to be applied in the next round of negotiations.

The third phase is dedicated to the negotiation phase of the BBT telecom model. Well defined and widely researched CDA is used for trading with transport capacities. Consequently, we decided to focus on multi-attribute auctions for trading with information resources (i.e., content). In order to trade with content, the first step is to define relevant attributes and form an ontology which adequately represents multimedia content. The next step is to study existing models of multi-attribute auctions using different approaches (i.e., defining utility functions [2, 3], fuzzy multi-attribute decision making algorithms [24], introducing pricing functions and preference relations for determining acceptable offers [1], defining reserved and aspiration levels of attributes and distinguishing negotiable and non-negotiable attributes [4]). After studying the existing models, we plan to choose the best features from each approach and try to incorporate them into a new unified model most suitable for content trading. The new approach will be incorporated into to the multi-attribute auction mechanism based on the English auction. Due to the specifics of the B2B telecom e-market (e.g., larger values of single transactions, repeated transactions, and a smaller number of participants than on B2C e-markets) the goal is to create a balance between maximizing the allocative efficiency of the B2B market and maximizing revenue or the expected utility of bid takers characteristic for multi-attribute auctions.

The fourth phase will be devoted to implementing the multi-attribute auction with agents as representatives of telecom stakeholders using the JADE (Java Agent DEvelopment Framework) agent platform and evaluating the designed mechanism with the existing mechanisms mentioned in the previous paragraph.

6. ACKNOWLEDGMENTS

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[2] I am a 3rd year PhD student.

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Development of an extended selection algorithm for projects in a project portfolio

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ABSTRACT

This paper touches the current state of the art for selection algorithms of projects in a project portfolio and extends the existing approaches by prioritizing projects according to their strategic contribution based on a Balanced Scorecard (BSC).

Keywords

Balanced Scorecards(BSCs), project portfolios, selection algorithm

1. INTRODUCTION

Project Portfolio Management (PPM) is a field of research that becomes more and more important – mostly driven by economic thinking, competition and regulations. Especially regulations like the Sarbanes-Oxley Act (SOX) require companies to document decisions and the according decision making process. PPM represents a framework for doing this in the environment of projects and project portfolios. The paper gives a short overview on the fundamentals of PPM and focuses on the selection process for projects to become part of a portfolio. The other parts of the PPM-process are not touched in this paper – reference for continuative literature is made at the respective sections in the paper.

The algorithm developed in chapter 3 can be applied to any kind of project in any industry, as the criteria are based on Project Management Standards and on company-specific criteria coming from the implementation of a Balanced Scorecard (BSC). If the company has already a BSC in place, the algorithm can be directly implemented.

After the development of the algorithm, the paper shows the application with some test-data taken from a bank. This part focuses on optimizing a sample portfolio with test data and given constraints.

The methodology itself cannot guarantee the success of the projects in a portfolio, as this depends on various other factors as well, but it ensures the traceability of the selection of the projects in this portfolio.

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2. STATE OF THE ART IN PROJECT PORTFOLIO MANAGEMENT (PPM)

The role of Chief Economic Officers (CEOs) in the past was mainly driven by optimizing economies of scale for the companies they were leading. Research and development was a minor success factor as the life-cycles of products lasted over years and the competition was driven by the price rather than by unique selling points for specific products. Over the time markets evolved and products moved closer and closer to the special requirements of various customer groups – the diversification increased.

The companies needed to adapt their organizatorical structures and processes in a way to be more efficient and to react quicker to the needs of the market. In parallel legal restrictions like the Sarbanes-Oxley Act (SOX) and the right of the stakeholders to understand and follow up on the decisions made by the board forced them to increase their level of Corporate Governance. Criteria like Profitability, Return on Investment (ROI) and Windows of Opportunity were extended by topics to optimize the implementation of the company's strategy:

- What mix of potential projects will provide the best utilization of human and cash resources to maximize long-range growth and return on investment for the company?
- How do projects support strategic initiatives?
- How will the projects affect the value of corporate shares (stock)?

To answer these questions, the projects within the company needed to be managed following the mission and implementing the strategy of the company. This is what led to the current best-practice in the implementation of PPM.

2.1 Historical development of PPM

In 1952 Harry Markowitz described the Modern Portfolio Theory (MPT) for the first time in his seminar paper "Portfolio Selection" in the Journal of Finance [MAR52].

In 1981 F. Warren McFarlan applied MPT to the management of projects. In the Harvard Business Review entitled "Portfolio Approach to Information Systems" [MCF81] he recommended employing a risk-based approach to select and manage projects.

In 1994 the US Government Accountability Office's (GAO) report "Improving Mission Performance Through Strategic Information Management" [GAO94] described the private

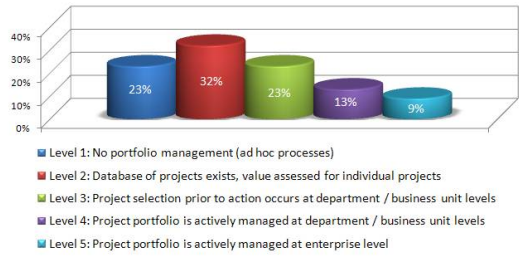


Figure 1: Distribution of organizations regarding the implementation of PPM

Figure 2: PPM seen as a bridge

sector organizations using a portfolio investment process to select, control and evaluate projects.

In 1998 the GOA published the "Executive Guide: Measuring Performance and Demonstrating Results of IT investments" [GAO98]. Portfolio management and analysis were pointed out as one of four strategic enterprise objectives.

Since the introduction of SOX in 2002, companies noted at the stock exchange have a special demand to be transparent in the use of their capital and the actions they pursue. Project Portfolio Management proved to be one possibility to comply with the regulatory standards by effectively managing the companies' resources. Figure 1 describes the level of implementation as of 2005 [PS05].

2.2 Definition of PPM

As projects became more and more important over the years, traditional organizations organized around operations where extended with a second field for project execution. They were controlled separately from each other and many of the stakeholders recognizing the shortcomings of this approach considered PPM to be the bridge between the two worlds like shown in figure 2. The reasoning behind this is based on the fact that operations and projects utilize the same resources but have different views on them. The functional departments focus on business performance, project manager focus on their projects' performance; the satisfaction of the stockholders is of interest for the business whereas projects are more interested in the satisfaction of the stakeholders – just to give two examples. In fact PPM is much more than that; following the definition of [CEK99] and [CEK01] PPM needs

- to maximize return and achieve financial goals
- to maintain the competitive position of the business – to increase sales and market share
- to properly and efficiently allocate scare resources
- to forge the link between projects selection and business strategy

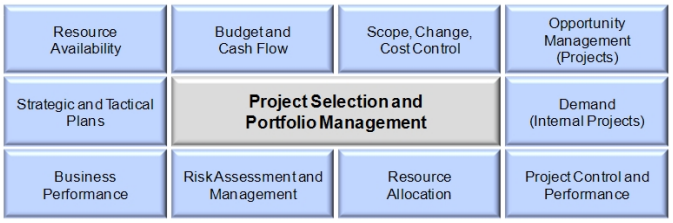


Figure 3: PPM seen as a hub

- the portfolio is the expression of strategy – it must support the strategy
- to achieve focus – not doing too many projects for the limited resources available and providing resources for the great projects
- to achieve balance – the right balance between long- and short-term projects and high-risk and low-risk ones, consistent with the business's goals
- to better communicate priorities within the organization vertically and horizontally
- to provide better objectivity in project selection and weed out bad projects

This alters the original picture towards a new understanding of PPM: PPM acting as a hub servicing various interests and functions (figure 3).

- Strategic and tactical plans
  the proper prioritization of projects according to their relevance to the strategy and the progress of execution to achieve the targets set need to be monitored.
- Resource Availability
  resources for upcoming projects need to be scheduled and planned carefully as there is normally some lead time for all of them: e.g. human resources need either to be trained or hired, financial resources like loans need to be applied for.
- Budget and Cash Flow
  budgets for projects need to be cross-checked and the cash flows determined to plan the needed financial resources.
- Scope, Change and Cost Control
  the scope of any of the projects in the portfolio needs to be monitored tightly as all the dependencies to other projects in the portfolio depend on it. Changes might affect not only a project but the whole portfolio.
- Opportunity Management
  if there are opportunities for optimizing the portfolio, they need to be recognized and managed. This function has a wide field of activity starting from the recognition of newly raised dependencies between projects in the portfolio over changes in the market to better allocate resources to moves of competitors that might change the implementation plans for the company's strategy.

- Demand (Internal Projects)
  besides the strategic projects of a company there is also the need for projects that might not have direct impact on it but are required to improve certain processes.

- Project Control and Performance
  the ongoing projects need to be monitored in terms of classical project management procedures to understand the progress and realize the impact of the evolvement on other projects in the portfolio.

- Resource Allocation
  the resources need to be distributed over the projects to optimize the possible output. As the resources are limited this needs to be handled in with a portfolio optimization approach like the Modern Portfolio Theory (MPT) from H. Markowitz.

- Risk Assessment and Management
  the risks for the projects and the whole portfolio need to be accessed during the selection of the projects and during the whole life-time as risks evolve over time. The responsibility of PPM is to protect the company from unexpected risk.

- Business Performance
  the execution of the projects and the portfolio is very important but the crucial point for the company's success is, if the projects delivered return the business value expected. Therefore the implemented projects need to be reviewed after their closure for the return of the investment and the conclusions for ongoing and future projects need to be drawn.

2.3 The Process Model of PPM

In contradiction to the execution of projects PPM does not have a defined beginning nor has a defined end as it is an ongoing process. However the process can be divided into five phases which are often separated with methods like the Stage Gate® Process, meaning that they are only allowed to enter the next phase if the phase before is finished and certain criteria are fulfilled. The phases for PPM are defined as follows:

- Identification of needs, goals and objectives
  in the first step the requirements for the portfolio are defined. The needs describe the reasons why the company implements PPM. The goals and objectives define the targets to achieve and the measures to quantify them. Taking these as a baseline the selection criteria are built or updated to choose the proper projects for the portfolio. As expectations towards PPM evolve over time and the acceptance and success of PPM depends on clear expectation management, this step is not defined as a one-time preparation step but is an integral part of the PPM-life cycle. Important to mention is that the objectives should stay as stable as possible over the time – a change in the objectives for the PPM means that the traceability of the portfolio is disturbed.

- Selection of the best combinations of projects (the portfolios)
  the quality of the portfolio depends to a large extend on the quality of the selection-criteria defined in the first step. In addition the current business strategy and actual targets are taken into consideration to pursue the right set of projects. Details will be discussed in the chapter dealing with criteria for selecting projects.

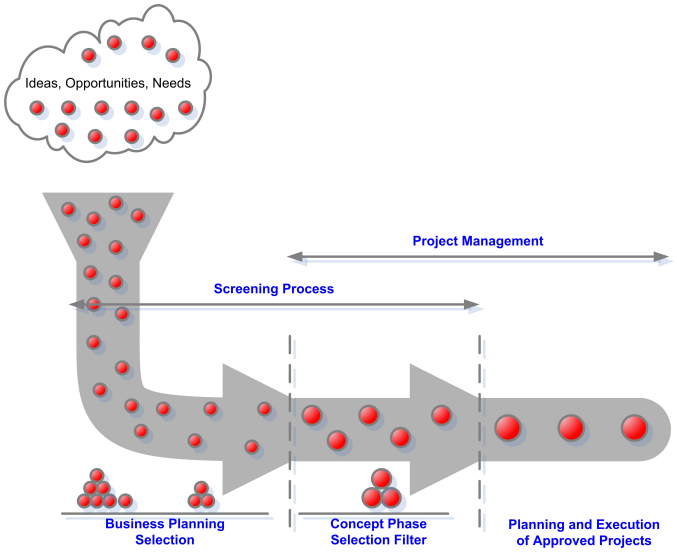


Figure 4: The first three steps of the Project Portfolio Life Span

- Planning and execution of the projects
  this step deals with the scheduling and the conduction of projects in the portfolio. It must not be mixed up with the planning and execution of projects in terms of project management as the focus on this phase is on the state of the portfolio and the contribution of each single project to the portfolio and not on the details of the projects in the portfolio.

- Monitoring portfolio performance
  the monitoring focuses on the delivery of the expected project deliverables and their contribution to the development of the portfolio. Variations of the plans are detected and corrective actions or change requests are set. The main deliverable of this phase for the board of the company is a dashboard providing them with the information what the actual status on the implementation of the strategy is.

- Realization of benefits
  the last phase in the cycle is used to compare the implementation of the project deliverables and their business impact to the expected results. This step does not only provide information on the achievements of goals but needs to be used to question the reasons in case of failure as well. They might give new or additional input to the first cycle again and help defining the needs, goals and objectives.

There is no general recommendation on the duration per iteration of the life cycle as a reasonable time frame depends on the projects in the portfolio. However, for most of the portfolios a benchmark should be a month.

The portfolio life-cycle described up to now leaves open, how the Project Management methodology is embedded.

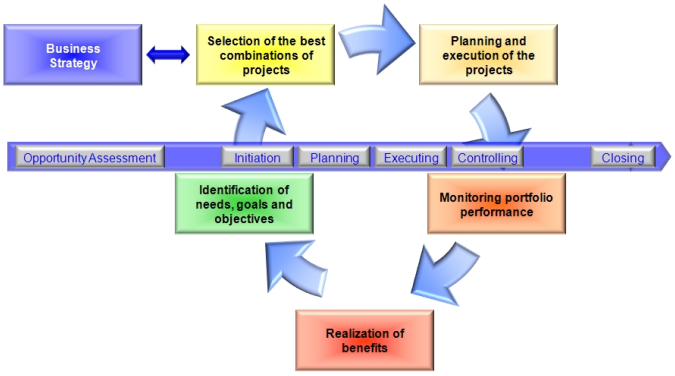


Figure 5: Life cycle of PPM in combination with Project Management

The best-practice solution which is proven by various implementations is shown in figure 5.

As projects have different start-dates, milestones and end-dates, they cannot be synchronized in a way that they fit in a phased approach were all of them sharing the same rhythm. Therefore PPM needs to adapt and be so flexible to handle projects in various stages of their life-cycle and still fulfil its function. The approach in figure 5 shows that ideas and opportunities are collected in the very beginning but are treated outside the PPM-Cycle itself (but in the PPM-responsibility as displayed in figure 3). After an opportunity or idea has been selected, the initiation phase for the project starts from where it continues through the whole project management life cycle (Initiation – Planning – Executing – Controlling) besides Closing. During all the time PPM oversees the project and monitors it. As soon as it comes to Closing, the project quits the life cycle, as this part is administrative only and does not impact the value delivered to the portfolio any more.

As this paper focuses on extending the existing selection algorithms, it will only deal with optimizing the value of the portfolio by using the proper set of criteria to prioritize projects. For the other process steps reference is made to the explanations in [LEV05], [PS05], [COO05], [PMI06] and [RMW07].

3. A NEW APPROACH FOR SELECTING PROJECTS IN A PROJECT PORTFOLIO

The existing approach introduced in chapter 2.3 contains weaknesses in terms that some major aspects of an efficient PPM are not fulfilled:

1. The existing project portfolio optimization models are based on the methodology of Markowitz [MAR52] but do not consider one important fact: Markowitz based his theory on financial portfolios. The difference between financial and project portfolios in this relation is, that financial ones are continuously distributed whereas project ones are discretely distributed. This is because in financial portfolios shares or derivatives can be sold or bought in arbitrary pieces whereas projects can be executed or not – the execution of 50% of a project by gaining 50% of the benefit is unrealistic. In projects the earned value cummulates over all deliverables of the project and the benefit cannot be split or partially fulfilled by a certain number of deliverables. Explanations on the difference between continuous and discrete distribution can be found in [KRE98].

2. Further the projects are evaluated by themselves but not by their value contribution they have with their dependencies to other projects. This means that projects with a low value by themselves but acting as an enabler for high-valued projects might not be implemented. A special case in this coherence are projects in a portfolio that do not provide a business need itself but are obligatory (e.g. needed to fulfil regulations set by the government).

3. The quantifying measures to prioritize the projects are related to financial figures only. They do not take the influences on other key performance indices (KPIs) relevant for the company into consideration. Therefore this approaching is lacking to optimally support the strategy of the company.

4. The assumption for most existing optimization algorithms is, that the limitation of human resources can be resolved by investing additional money to buy additional "Know-How". In reality, this is normally not true as sensitive and important projects require special people with high sophisticated skills.

The approach that should be developed in this chapter tries to address all these issues and will provide suggestions to resolve them in a way that project portfolios can be optimized fully considering them.

3.1 The distribution of a project portfolio

The first weakness identified goes along with the distribution of a project portfolio. [GRU05] explains that

> "The Efficient Frontier curve shows all of the best possible combinations of project portfolios and the value that can be created with available capital resources in an unconstrained mode."

and further

> "The Efficient Frontier shows the opportunity cost of investing an additional dollar versus the additional value received."

The second statement implies that an arbitrarily chosen amount of money adds additional value to the project defined by a certain function. This would also mean that projects can be split in smaller pieces by delivering a smaller value that can be determined.

In reality this does not work out. Imagine a car manufacturer that needs to develop two new cars: the first one takes development cost of 500 million dollar and the second one of 600 million dollar, the budget of the company is 800 million dollar. Following the Efficient Frontier approach would mean that the company could e.g. run the project for the first car and invest the remaining money into the project for the second car. Obviously there is a value for project one if we assume that it is finished successfully and it goes into production and into sales – the money invested into the second project does not provide any value so far: a car where the product development is not finished can neither be produced nor sold.

The issue can only be solved by changing the approach from arbitrarily changes in size to changes in terms of full projects – this implies further that the type of distribution that needs to be used is not a continuous one like [MAR52] used for financial portfolios but a discrete one: a distribution that shows all possible portfolio combinations. For simplification purposes at the beginning the following topics are not considered – they will be added later on:

- dependencies to other projects
- observations beyond the point in time t_0
- obligatory flags for projects
- limiting constraints

This determines the number of portfolios alternatives to be a combination of n different projects taken k at a time, without repetitions or

$$\binom{n}{k} = \frac{n!}{k!\,(n-k)!} \tag{1}$$

This needs to be repeated for possibilities of k (the number of projects that can be executed in parallel). In theory k can be any number between 1 and n because without dependencies and limitations all projects could be executed; limiting k only makes sense if the stakeholders do not want to support more than a maximum of k projects at the same time:

$$\sum_{k=1}^{n} \frac{n!}{k!\,(n-k)!} \tag{2}$$

The first complexity to be added are the dependencies. Formally it means that for a portfolio at t_0 only projects that to not rely on any other project can be executed. All other projects need to wait for the finishing of their predecessors; this reduces the complexity of the project portfolio by

$$\sum_{k=1}^{n} \frac{n!}{k!\,(n-k)!} - \sum_{k=1}^{m} \frac{m!}{k!\,(m-k)!}$$

or

$$\sum_{k=1}^{n-m} \frac{(n-m)!}{k!\,(n-m-k)!} \tag{3}$$

where m are the number of dependent projects in the portfolio. This finding needs to be handled with high caution as it might lead to a failure: prioritizing now the portfolio based on the value of the projects in t_0 would lack the vision that is necessary in PPM: a future oriented approach should keep in mind all combinations of projects including the value of each path – a sample path diagram based on dependencies in a project portfolio is shown in figure 6.

Thus the algorithm needs to be extended to not only look at t_0 but considering the whole timeline until the finalization of the last project to optimize the portfolio on the maximum expected benefit out of all options in the future. Therefore every project needs to be listed with all its dependencies:

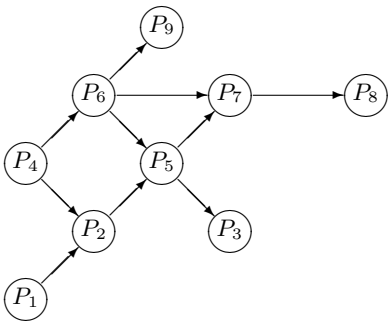


Figure 6: Sample dependency tree for a project portfolio

Project	Dependencies
P_1	-
P_2	P_1, P_4
P_3	P_1, P_2, P_4, P_5, P_6
P_4	-
P_5	P_1, P_2, P_4, P_6
P_6	P_4
P_7	P_1, P_2, P_4, P_5, P_6
P_8	P_1, P_2, P_4, P_5, P_6, P_7
P_9	P_4, P_6

3.2 The value of project options in a project portfolio

As the various paths in the project portfolio are known based on their dependencies, the next step is to benchmark every option for its value. Naturally the prioritization would take place by sorting them by a certain selection criteria. The issue using this approach is, that the duration of the project(s) is not considered and therefore the return on the various options is not evaluated on the same baseline. For this reason the indicator needs to be discounted over the duration of the project respectively the duration of projects within the option:

$$\text{Option Value} = \sum_{p} \frac{\text{Indicator}}{(1+r)^{d_p}} \tag{4}$$

where p represents all projects in the option, r is the discount rate per period and d_p is the period from the beginning of the portfolio's perspective to the end of the considered project (not the portfolio!). Caution needs to be taken in case the indicator chosen is already discounted like the NPV or a derived one. An effective indicator for the Option Value will be introduced in section 3.4.

There might be situations where projects in a portfolio are obligatory e.g. for regulatory reasons. These projects might not return any direct value to the company. Therefore they need to be incorporated separately as they would otherwise never make it into the project portfolio. The solution is to mark them and all the projects they depend on directly and indirectly as mandatory, considering them before the priority list given by the indicator.

By now the approach addresses the issues one and two identified at the beginning of the chapter – the next step must be to find a solution to problem number three: the solution described so far relies on financial KPIs only, but does not consider further influences of the project on the

company.

3.3 Quantifying measures beyond financial KPIs

This section deals with the fact, that indicators cannot only be taken from the financial information that goes along with the execution or finalization of the project but also with the influence on and from other components of the success of a company. This paper distinguishes between two types of such indicators: the ones derived from a Balanced Scorecard and others taken from standard project management methodology defined by the Project Management Institute (PMI) respectively well known indicators out of standard project management.

3.3.1 Measures from a Balanced Scorecard

The first possibility to extend the traditional view is to follow a Balanced Scorecard (BSC) [KN96] approach by taking the measures and KPIs identified in a BSC to determine the influence of a project on this BSC. This implies that the projects can be evaluated on their contribution to the strategy that is defined in the BSC.

The BSC identifies objectives and the influences between these and tries to bring them down to factors that do not represent aggregates figures but are pure values that cannot be further decomposed (so called α-figures). Their transformation to the operational KPIs is defined in the mathematical model of the BSC which provides the first of the transformations needed to get the target values for prioritization in this model. The figure below describes the projects in a portfolio ($P_1 \ldots P_m$), the BSC input variables ($\mathrm{B}\alpha_1 \ldots \mathrm{B}\alpha_n$) and the BSC output variables ($\mathrm{B}\beta_1 \ldots \mathrm{B}\beta_n$). The B stands for BSC – there will be additional input- and output-variables described afterwards, so this identifier is needed.

Project	BSC Input Variables $\mathrm{B}\alpha_1$	$\ldots$	$\mathrm{B}\alpha_n$
P_1	$P_1\mathrm{B}\alpha_1$	$\ldots$	$P_1\mathrm{B}\alpha_n$
$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	$P_m\mathrm{B}\alpha_1$	$\ldots$	$P_m\mathrm{B}\alpha_n$

$\Longrightarrow$

Project	BSC Output Variables $\mathrm{B}\beta_1$	$\ldots$	$\mathrm{B}\beta_o$
P_1	$P_1\mathrm{B}\beta_1$	$\ldots$	$P_1\mathrm{B}\beta_o$
$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	$P_m\mathrm{B}\beta_1$	$\ldots$	$P_m\mathrm{B}\beta_o$

For the evaluation of projects it is important to understand how the finished project will change the α-figures of the BSC. Out of the transformation (a n:m transformation between input- and output-variables) the expected change in the strategic figures can be calculated (the β figures).

3.3.2 Measures taken from Project Management

So far this section dealt only with KPIs determining the alignment of a project with the strategy of the company. In addition there are other KPIs that deal with project inherent data and are necessary for the selection process as well. The ones the paper is referring to are the ones of the Project Management Institute (PMI) defined in the Project Management Body of Knowledge (PMBOK®) [PMI04].

The input parameters (or α-figures) can be defined as follows:

- Planned Project Duration
- Skills
  gives a description for every skill the projects requires to be executed.
- Demand of the skill
  quantifies the amount of hours/days/weeks/months a skill is needed within a defined period. It is important to understand that the demand summarizes the whole demand of a specific skill in a requested period. This means if a project requires e.g. five persons full-time for a month then the demand is five man-months within a month.
- Rate of the skill
  describes the rate to be paid for the specific skill. The scale chosen needs to be the same as the scale the demand is given in and needs to be available or estimated for all periods the project is planned to be executed in.
- Investments
  depict the investments planned within the project.
- Investment cost
  determine the cost that go together with the investments described.
- Risks
  the risks that go along with the project need to be identified.
- Lowest possible impact for every risk identified
- Probable impact for every risk identified
- Highest possible impact for every risk identified
- Direct dependencies to other projects
  the dependencies included may only be mandatory dependencies for the execution of the project. Sometimes they become mixed up with so called discretionary dependencies sourcing from e.g. resource shortages – they need to be filtered and removed as the selection algorithm would not work efficiently in this case. Section 3.5 shows that this kind of dependencies comes from constraints within a portfolio.

Out of these factors the following output-parameters (or β-figures) can be derived. Formally they underlie the same kind of transformation that can be seen with the factors from the BSC – projects in a portfolio ($P_1 \ldots P_m$), the project input variables ($\mathrm{P}\alpha_1 \ldots \mathrm{P}\alpha_n$) and the project output variables ($\mathrm{P}\beta_1 \ldots \mathrm{P}\beta_n$).

Project	Project Input Variables $\mathrm{P}\alpha_1$	$\ldots$	$\mathrm{P}\alpha_p$
P_1	$P_1\mathrm{P}\alpha_1$	$\ldots$	$P_1\mathrm{P}\alpha_p$
$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	$P_m\mathrm{P}\alpha_1$	$\ldots$	$P_m\mathrm{P}\alpha_p$

$\Longrightarrow$

Project	Project Output Variables $\mathrm{P}\beta_1$	$\ldots$	$\mathrm{P}\beta_q$
P_1	$P_1\mathrm{P}\beta_1$	$\ldots$	$P_1\mathrm{P}\beta_q$
$\vdots$	$\vdots$	$\ddots$	$\vdots$
P_m	$P_m\mathrm{P}\beta_1$	$\ldots$	$P_m\mathrm{P}\beta_q$

Total Labour Cost (TLB).

The cost of labour depends on the demand for specific skills and their rate. This formula is only to calculate the cost of labour – at this point in time it is not yet considered that the availability might be an issue; it will be discussed later on during the further development of the algorithm.

$$\mathrm{TLB} = \sum_{p} \sum_{s} rate_{ps} \times demand_{ps} \tag{5}$$

where p represent the periods of the project and s the skills needed.

Total Investment Cost(TIB).

The investments planned within the project – also important to calculate depreciation for the spendings on inventory goods out of a project, which can also be used as an indicator in the prioritization of the portfolio (e.g. percentage of the project budget that can be activated for depreciation):

$$\mathrm{TIB} = \sum_{p} \sum_{i} investment_{pi} \tag{6}$$

where p represent the periods of the project and i the investment needed.

Total Risk Cost (TRB).

Every risk in the project needs to be quantified in a way that the monetary value that goes along with it becomes determined. Therefore the lowest possible impact, the probable impact and the highest possible impact are estimated and weighted for every risk:

$$\mathrm{TRB} = \sum_{r} \frac{x \times li_r + y \times pi_r + z \times hi_r}{x + y + z} \tag{7}$$

where r represents the risks in the project, li the lowest possible impact, pi the probable impact, hi the highest possible impact and x, y and z the weights. Further explanations on the estimation and calculation of risk can be found in [BRA07].

Total Project Budget (TPB).

The three figures discussed summarize to the Total Project Budget.

$$\mathrm{TPB} = \mathrm{TLB} + \mathrm{TIB} + \mathrm{TRB} \tag{8}$$

or

$$\begin{aligned} \mathrm{TPB} &= \sum_{p} \sum_{s} rate_{ps} \times demand_{ps} \\ &+ \sum_{p} \sum_{i} investment_{pi} \\ &+ \sum_{r} \frac{x \times li_r + y \times pi_r + z \times li_r}{x + y + z} \end{aligned}$$

Planned Value (PV).

This indicator is the baseline for Earned Value Methodology (see also [PMI04] p. 172–176 and [PMI05]) and the application of all budget related control mechanisms in a project. It is similar to the TPB but does not contain the risk budget. The reason behind is, that the PV is the basis all efforts within the project are tracked against – if risk cost would be included in this figure, non-occurred risks would be counted as success to manage the project below budget. Further the point in time for a possible incident cannot be determined a priori and therefore a valid cost plan could not be provided.

$$\mathrm{PV} = \mathrm{TLB} + \mathrm{TIB} \tag{9}$$

or

$$\begin{aligned} \mathrm{PV} &= \sum_{p} \sum_{s} rate_{ps} \times demand_{ps} \\ &+ \sum_{p} \sum_{i} investment_{pi} \end{aligned}$$

Total Effort (TE).

The total effort represents the timely effort invested in a project and is normally measured in man-years.

$$\mathrm{TE} = \sum_{p} \sum_{s} demand_{ps} \tag{10}$$

where p represent the periods of the project and s the skills needed.

3.4 Building the quantification criteria

Obviously all of the factors determined ($P_m\mathrm{B}\beta_1, \ldots, P_m\mathrm{B}\beta_o$; $P_m\mathrm{P}\beta_1, \ldots, P_m\mathrm{P}\beta_q$) need to be used to prioritize a portfolio effectively. This introduces two new problems:

- a standardization of the β-figures is needed, as most of them have different measures and scales. This is close to impossible because how should e.g. "Customer Satisfaction" and "Education days of an employee" be measured on the same – still meaningful – scale?
- a weight for every β-figure needs to be calculated to be in the position to aggregate the factors to a significant indicator. The word "significance" implies already that the weights need to be derived from the attitude of the decision-makers. As there is more than one decision-maker in a team, a compromise would need to be made which is again a sub-optimal solution.

The problem can be solved by looking at the different β-figures neither considering their measurement nor their weights but still offering a transparent and comparable figure. The solution is in the calculation of the area that is spanned by the different relative β-figures in a a radar-chart (also called spider-chart) in figure 7.

The table for the base values looks as follows:

	Criteria				
	1	2	3	4	5
Project 1 abs.	50	200	80	150	100
Project 2 abs.	120	40	160	130	140
Project 1 rel.	42%	100%	50%	100%	71%
Project 2 rel.	100%	20%	100%	87%	100%

Using this type of representation has several advantages:

- Every figure can be presented using its measure – the only topic of importance is, that the scale is used in a way that the better the result is, the larger the distance to the zero-point of the graph needs to be.

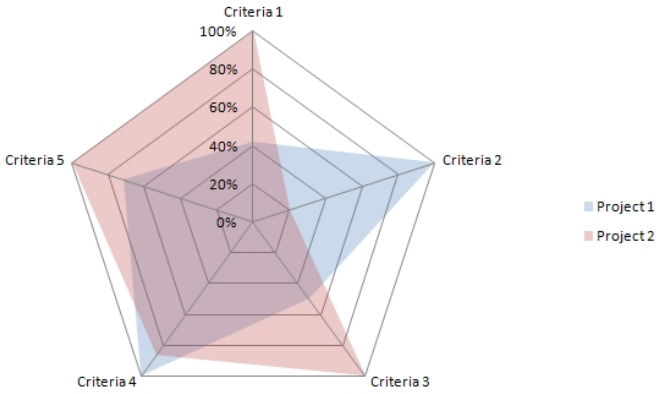


Figure 7: Sample radar chart using five different criteria

- It can be used for an arbitrary number of criteria larger or equal than three.
- The change of the scale does not change the result as all projects are measured against the same baseline.

In the next step the area needs to be calculated for each of the sample projects. To do so, the formula for calculating the area of a polygon is given by (see also [BOU98]):

$$\text{Area} = \left| \frac{1}{2} \sum_{i=0}^{N-1} (x_i y_{i+1} - x_{i+1} y_i) \right| \tag{11}$$

where N represents the number of edges in the polygon and x and y their coordinates. The last coordinate must be identical with the first one to close the area of the polygon.

To do the calculation with the items out of a radar chart, the data points need to be transformed into a two-dimensional co-ordinate system. In the first step x- and y-values of the data points are calculated taking the centre of the polygon to be the zero-point of the grid. This can be derived using trigonometric functions. Assuming – like shown in figure 7 – the line for criteria one is vertically aligned (what means 90 degree or $\pi/2$) the formula is defined as follows; let x_i and y_i be the x and y coordinates relative to the centre of the radar-chart for every relative value χ_i of the corresponding criteria β_i in the radar-chart where N is the total number of criteria:

$$x_i = \cos\left(\frac{\pi}{2} - \frac{2\pi\,(i-1)}{N}\right) \times \chi_i \tag{12}$$

$$y_i = \sin\left(\frac{\pi}{2} - \frac{2\pi\,(i-1)}{N}\right) \times \chi_i \tag{13}$$

The formula is derived the following way:

$$\begin{aligned} x_i &= \cos\left(\left(90 - \frac{360}{N} \times (i-1)\right) \times \frac{2\pi}{360}\right) \times \chi_i \\ &= \cos\left(\left(90 - \frac{360 \times (i-1)}{N}\right) \times \frac{2\pi}{360}\right) \times \chi_i \\ &= \cos\left(\frac{180\pi}{360} - \frac{720\pi \times (i-1)}{360N}\right) \times \chi_i \\ &= \cos\left(\frac{\pi}{2} - \frac{2\pi\,(i-1)}{N}\right) \times \chi_i \end{aligned}$$

The deduction is analogical for y_i. For the figures given in table 3.4, this gives the following coordinates and the area the projects cover:

		Criteria					
		1	2	3	4	5	Area
P1	x	0,00	0,95	0,29	-0,59	-0,68	1,15
	y	0,42	0,31	-0,40	-0,81	0,22	
P2	x	0,00	0,19	0,59	-0,51	-0,95	1,49
	y	1,00	0,06	-0,81	-0,70	0,31	

The result shows, what is expected when looking at figure 7: project 2 covers a larger area and has therefore the higher value compared to Project 1 in terms of measures that are influenced by it. As discussed already, this indicator can easily combined with the formula defined in (4) to calculate the value of an portfolio option based on all the projects contained.

3.5 Constraints within a project or a project portfolio

The last remaining issue not being addressed so far is the one of constraints within a project or a project portfolio. As a matter of fact limitations constrict the possibilities of projects to choose for a portfolio. Recent approaches try to formulate every constraint as a financial one arguing that anything else can be removed by monetary investments. In reality this is not the case as it was explained already in the description of weaknesses at the beginning of chapter 3 on the example of skills of human resources.

As discussed in section 3.3, all relevant indicators for the selection of projects are represented in the α- and the derived β-figures. This implies that also the relevant constraints for the portfolio can only hit one of these figures.

First of all, all the αs and βs from the projects and all their totals in case of combinations that could be started in t_0 based on their dependencies are summarized in a matrix together with their prioritization and constraints. The order of the projects is based on the total option value of the project (except for mandatory projects) summarizing all discounted option values it is the first project in. At the bottom of the matrix, all constraints for the indicators are filled in. Additionally every constraint needs to be marked, if the constraint must not be undercut (a minimum-constraint) or must not be exceeded (a maximum-constraint):

Project	Total Option Value	BSC					
		Input			Output		
		$B\alpha_1$	…	$B\alpha_n$	$B\beta_1$	…	$B\beta_o$
P_1	ov_1		…			…	
⋮	⋮	⋮	⋱	⋮	⋮	⋱	⋮
P_m	ov_m		…			…	
	$\sum$		…			…	
	Constraint		…			…	

The project-specific αs and βs are not displayed in this example for space reasons. Normally the matrix is extended at their right border by the project-specific αs and βs.

All totals of αs and βs need to compared with their respective constraints. For all of them which are violated, so called "discretionary" dependencies need to be added in the following way: the project with the lowest total option value is taken away from the portfolio of t_0 and given a dependency to the project finishing the earliest after the prioritization.

This is repeated until all constraints can be fulfilled. If this is impossible (so in the worst case, the project with the highest total option value cannot be executed) the topmost project causing the conflict is removed and the procedure is restarted with all the other projects. If this extended procedure does not direct to a meaningful portfolio, the constraints are too narrow to allow a prioritization. In this case, focus need to be set on widening the constraints.

3.6 The Final Portfolio

The portfolio developed is the one that contributes best to the strategic targets of the company under the given conditions. However, the prioritization itself is not a guarantor that the targets set for the projects are also achieved. For controlling the projects in a way to have tight control on the progress, there are methods available but they are outside of the scope of this paper – a detailed description can be found at [PMI05].

4. EXAMPLE: IMPLEMENTATION OF THE NEW APPROACH

4.1 Initial situation

This chapter deals with the exemplary implementation of the approach developed. The sample setup consists out of five projects taken out of a project portfolio of a bank:

#	Name
1	Data Warehousing (DWH)
2	Management Information System (MIS)
3	Customer Relationship Management (CRM)
4	Application Processing System (APS) for loans
5	Collection System (CS) for overdue loans

To fulfil the quantification requirements defined in section 3.3 the model needs to rely on a BSC developed for this company and on the respective input parameters to this BSC. The success factors defined for this sample BSC can be seen in figure 8.

The Cause-Effect model for this sample BSC is shown in figure 9. The detailed aggregation algorithms from the α-figures up to the calculation of the influence of the success factors is not discussed here in detail, as it is part of a BSC and for the algorithm in this example, only the input-figures and the output-figures of the BSC are of importance.

4.2 The distribution of the set of projects including their dependencies

Before the paper goes into detail on the α- and β-figures for this set of projects, the dependencies for this constellation are discussed. Following the formula given in (2), the complexity of five projects and their combinations give 31 possibilities to structure the portfolio in t_0:

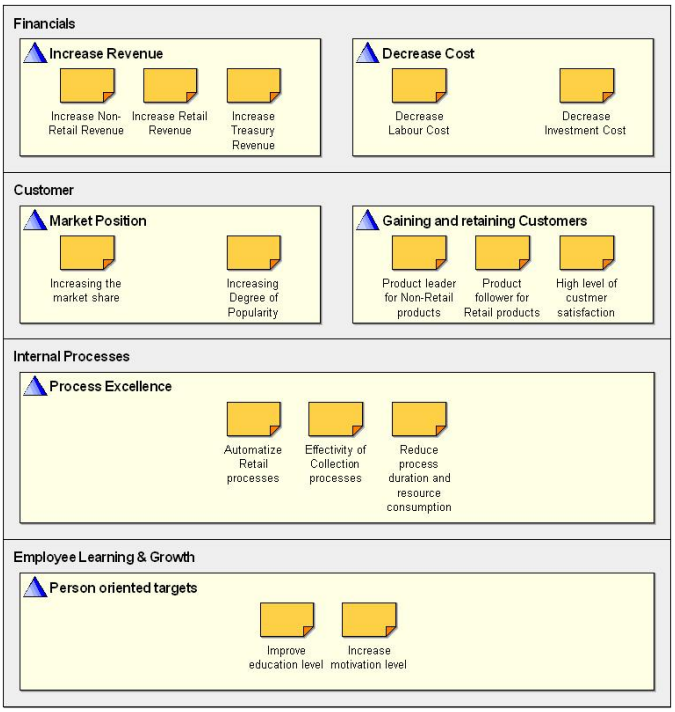


Figure 8: Success factors for the sample BSC – developed using ADOscore®

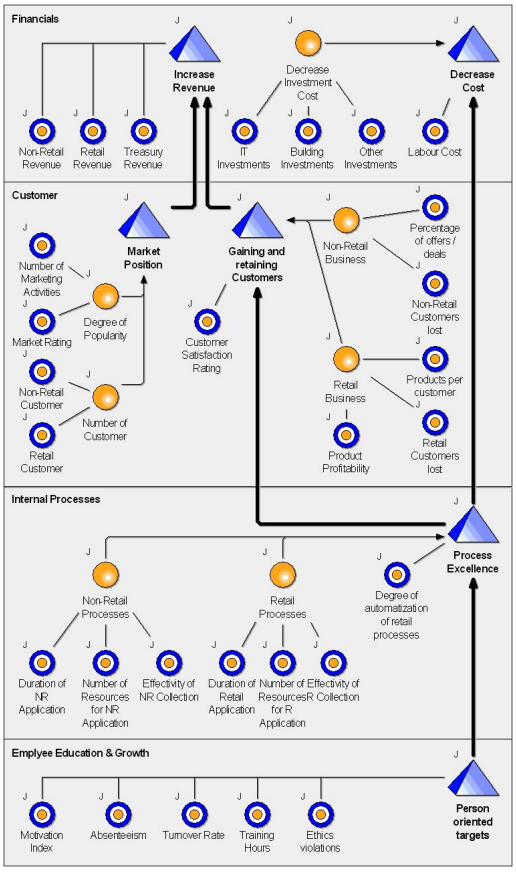
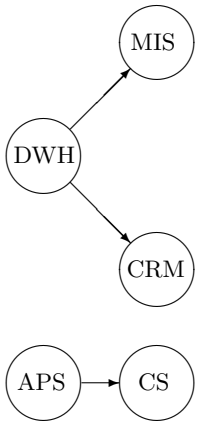


Figure 9: Cause-Effect model for the sample BSC – developed using ADOscore®

Combination	Possibilities
$\binom{5}{1}$	P_1, P_2, P_3, P_4, P_5
$\binom{5}{2}$	P_1P_2, P_1P_3, P_1P_4, P_1P_5, P_2P_3, P_2P_4, P_2P_5, P_3P_4, P_3P_5, P_4P_5
$\binom{5}{3}$	$P_1P_2P_3$, $P_1P_2P_4$, $P_1P_2P_5$, $P_1P_3P_4$, $P_1P_3P_5$, $P_1P_4P_5$, $P_2P_3P_4$, $P_2P_3P_5$, $P_2P_4P_5$, $P_3P_4P_5$
$\binom{5}{4}$	$P_1P_2P_3P_4$, $P_1P_2P_3P_5$, $P_1P_2P_4P_5$, $P_1P_3P_4P_5$, $P_2P_3P_4P_5$
$\binom{5}{5}$	$P_1P_2P_3P_4P_5$

In this example the MIS and the CRM project rely on the implementation of the DWH project; both systems are analytical ones and depend on various data loaded from different source systems. The APS project and Collection System project are independent from the DWH-project but the APS project is the mandatory predecessor for the Collection System (the bank could not collect overdue loans they do not have the data for). This information gives the following dependency map:



The dependency matrix for the projects is as follows:

Project	Dependencies
DWH	-
MIS	DWH
CRM	DWH
APS	-
CS	APS

Keeping the dependencies in mind the possible complexity of the portfolio reduces alreay from 31 to three possibilities in t_0 as defined in (3):

Combination	Possibilities
$\binom{2}{1}$	DWH or APS
$\binom{2}{2}$	DWH and APS

4.3 Quantifying measures

In our example the contribution to the input factors (already derived from α-figures) by the projects for the BSC were identified like this:

BSC Input Variables	DWH	MIS	CRM	APS	CS
Motivation Index					
Absenteeism					
Turnover Rate					
Training Hours	+1.600	+100	+200	+1.000	+150
Ethics Violations			-5		
Duration of NR Applications	-2			-5	
Number of Resources for NR Applications	-5			-10	
Efficiency of NR Collection	+5%		+5%		+10%
Duration of Retail Applications	-2		-1	-2	
Number of Resources for Retail Applications	-20		-10	-20	
Efficiency of Retail Collection	+5%		+5%		+20%
Degree of automatization of retail processes	+5%		+5%	+10%	+10%
Number of Marketing Activities	+25		+30		
Market Rating		+1		+1	+1
Non-Retail Customer			+100		
Retail Customer			+30.000		
Customer Satisfaction Rating	+1		+2	+1	-1
Percentage of offers/deals	+5%		+10%	+10%	
Non-Retail customers lost			-10		+5
Products per customer	+3		+3		
Retail Customers lost			-1.000		+500
Product Profitability		+10%			+5%
IT Investments	+500k	+100k	+150k	+150k	+150k
Building Investments	+100k				
Other Investments					
Labour Cost	+630k	+840k	+1.260k	+420k	+210k

The corresponding output figures (β-figures) for the BSC have been calculated and bring the results for the prioritization input:

BSC Output Variables	DWH	MIS	CRM	APS	CS
Person Oriented Targets	+16	+1	+2	+10	+2
Process Excellence	+28	+5	+7	+35	+7
Market Position	+25	+500	+430	+500	+500
Gaining and Retaining Customers	+500	+100	+610	+200	-5
Increase Revenue	1.568,6k	1.766,6k	2.049,0k	1.745,2k	1.503,4k
Decrease Cost	-1.306,0k	-957,0k	-1.416,0k	-575,0k	-393,8k

In table 4.3 it needs to be especially noted that the operational target of "Decrease Cost" has negative values as projects generate costs and therefore cannot contribute reducing their costs by themselves.

So far the BSC input- and output variables have been discussed. What is missing from the KPI point of view are the figures coming from the project input variables and their transformation to the output variables:

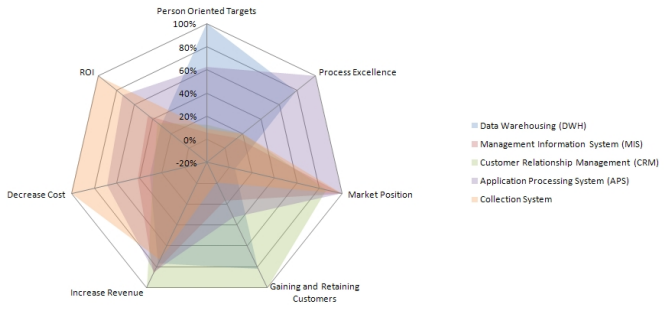


Figure 10: Radar-Chart for the data in the example

Project Input Variables	DWH	MIS	CRM	APS	CS
Rate: Skill 1	600	600	600	600	600
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
Rate: Skill s	1.500	1.500	1.500	1.500	1.500
Demand: Skill 1	800	400	600	200	100
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
Demand: Skill s	100	400	600	200	100
Investment Cost	600.000	100.000	150.000	150.000	150.000
Probability: Risk 1	10%	20%	15%	40%	30%
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
Probability: Risk r	50%	30%	10%	15%	10%
Impact: Risk 1	10.000	25.000	30.000	10.000	100.000
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
Impact: Risk r	150.000	40.000	15.000	8.000	38.000
Duration (in months)	12	8	10	18	12
Obligatory Project		Y			
Direct Dependencies		1	1		4
Operations Cost for 3 years	300.000	60.000	90.000	90.000	90.000

If those input figures become calculated by the formulas explained in chapter 3.3.2 the following output matrix can be determined – also for prioritization purposes, like the output matrix from the BSC:

Project Input Variables	DWH	MIS	CRM	APS	CS
Project Budget	1.306.000	957.000	1.416.000	575.200	393.800
thereof - Total Labour Cost	630.000	840.000	1.260.000	420.000	210.000
thereof - Total Investment Cost	600.000	100.000	150.000	150.000	150.000
thereof - Total Risk Budget	76.000	17.000	6.000	5.200	33.800
Duration (months)	12	8	10	18	12
Obligatory Project with dependencies	Y	Y			
Full Dependencies		1	1		4
Return on Investment (ROI)	128%	188%	145%	306%	418%

4.4 Building the quantification criteria

Of course the project budgets presented in this figure are equal with the negative decrease of cost in table 4.3. The χ-figures derived from the tables 4.3 and 4.3 are now used to build the radar-chart in figure 10. For the simplification of illustration not all criteria have been considered. The table with the base values looks as follows:

	POT	PE	MP	GaRC	IR	DC	ROI
DWH rel.	100%	78%	5%	82%	77%	30%	31%
MIS rel.	6%	14%	100%	16%	86%	41%	45%
CRM rel.	13%	20%	86%	100%	100%	28%	35%
APS rel.	63%	100%	100%	33%	85%	68%	73%
CS rel.	9%	20%	100%	-1%	73%	100%	100%

This data results in the following co-ordinates and values for the covered area:

		POT	PE	MP	GaRC	IR	DC	ROI	Area
APS	x	0,00	0,78	0,97	0,14	-0,37	-0,67	-0,57	1,48
	y	0,63	0,62	-0,22	-0,30	-0,77	-0,15	0,46	
CRM	x	0,00	0,15	0,84	0,43	-0,43	-0,27	-0,27	0,97
	y	0,13	0,12	-0,19	-0,90	-0,90	-0,06	0,22	
DWH	x	0,00	0,61	0,05	0,36	-0,33	-0,29	-0,24	0,83
	y	1,00	0,49	-0,01	-0,74	-0,69	-0,07	0,19	
CS	x	0,00	0,16	0,97	0,00	-0,32	-0,97	-0,78	0,79
	y	0,09	0,12	-0,22	0,01	-0,66	-0,22	0,62	
MIS	x	0,00	0,11	0,97	0,07	-0,37	-0,40	-0,35	0,40
	y	0,06	0,09	-0,22	-0,15	-0,78	-0,09	0,28	

Looking at the project itself without considering the possible portfolio options would clearly favour the APS project (1,48) compared to the DWH project (0,83). As described before the project on its own is not the driving factor – it is the option value of the different options that is important. Using equation (4), the results from table 4.4 and a discount rate of 5% shows the following results for the available options:

Option	Option Value
DWH	0,79
DWH - MIS	1,16
DWH - CRM	1,67
APS	1,42
APS - CS	2,13

Taking the projects being marked mandatory into the picture as well (see table 4.3) shows that the DWH-project needs to be executed for the MIS project having a obligatory status although the option DWH-MIS has the second-lowest value. Finally the following prioritization would be set:

Option	Mandatory	Option Value
DWH - MIS	Y	1,16
APS - CS		2,13
DWH - CRM		1,67
APS		1,42

The DWH-project is not given separately in table 4.4 as it is executed anyway because of the dependency.

In the next and also the last step the constraints need to be considered. Therefore a table is created as described in chapter 3.5. For the reason of clarity, the criteria already used in figure 10 and table 4.4 have been reused – the only difference to be noted is, that the ROI, the Increase in Revenue and Decrease of cost are removed but therefore an α-figure from the Project-αs is added: the demanded availability of a business analyst for the respective project measured in person days (PDs):

Project	Total Option Value	POT	PE	MP	GaRC	BA PDs
DWH-MIS	1,16	+17	+33	+525	+600	+550
APS-CS	2,13	+12	+42	+1.000	+195	+300
DWH-CRM	1,67	+18	+35	+455	+1.110	+500
APS	1,42	+10	+35	+500	+200	+200
	Total Constraints	+57	+145	+2.480	+2.105	+1.550
		Min (+25)	Min (+60)	Min (+1.000)	Min (+700)	Max (+700)

The table shows an obvious conflict with the person days for the business analysts needed (BA PDs). Following the

procedure described in section 3.5, the options need to be eliminated buttom-up following their total option values. If this is done in this portfolio, it ends up with the following status:

Project	Total Option Value	POT	PE	MP	GaRC	BA PDs
DWH-MIS	1,16	+17	+33	+525	+600	+550
	Total Constraints	+17 Min (+25)	+33 Min (+60)	+525 Min (+1.000)	+600 Min (+700)	+550 Max (+700)

The current status shows that the issue with the BA PDs could be solved but turned the project into conflict with lots of other constraints. Obviously the portfolio cannot be structured in a way that stay within the boundaries set. This leaves two options: the first one is, to take the portfolio above also implying that the stakeholders need to adapt the constraints given. The second option would be to include another project to optimize the number of limits being fulfilled and focus on adapting other limits:

Project	Total Option Value	POT	PE	MP	GaRC	BA PDs
DWH-MIS	1,16	+17	+33	+525	+600	+550
APS	1,42	+10	+35	+500	+200	+200
	Total Constraints	+27 Min (+25)	+68 Min (+60)	+1.025 Min (+1.000)	+800 Min (+700)	+750 Max (+700)

In the second option the constraint of the BA PDs is violated again with a very small backlog, which might be resolved. Therefore the other constraints could be kept and the portfolio could be adjusted in the best possible way. Most probably the company could resolve the BA PD issue and would go for the portfolio given in option 2.

5. CONCLUSION

The discussion in this paper showed that there are lots of improvements possible to extend the existing selection algorithms in a way to make them implementing the strategy of a company. If a company went already through the painful process of creating and implementing a BSC and is living the life-cycle process that goes along with it, the presented algorithm for the selection of appropriate portfolios is a spin-off product of the BSC and PPM. Naturally, the selection algorithm is only one part of various steps to successfully implement the strategy. Others, like the carefully planning and controlling of a project portfolio or the sustainable implementation of the project content are others that need to be dealt with seriously. Possible solutions in these fields are the Earned Value Methodology (EVM) for controlling the process or classical mechanisms for mid-term planing to compare the expected results from PPM with the realized benefits.

The challenge in the presented approach is definitely the quality of the BSC, the portfolio selection algorithm is based on. If the strategy is not described properly or the controlled measures are not the right ones to successfully achieve the vision of the company, the selected portfolio will fail the same way as the BSC will. Therefore the success of the implementation of this algorithm will heavily rely on the time that was spend for defining the strategy. This is also a lessons learned that should be taken away when project portfolios should be aligned with the strategy: the project portfolio can only be as good as the underlying strategy is.

The further steps for the PhD thesis will be the extension of the existing project portfolio life-cycle not only by the selection but also for the planning and monitoring phases. The target is to present a framework where the whole life-cycle is linked to the implementation of the strategy using BSCs. Further the scope is exclusively to focus on optimizing the project portfolio into this direction – it is true that projects that cannot be evaluated against their benefits but might deliver unexpectedly high results will never be selected with this methodology.

For the proof of concept (POC) data will be taken from an internationally acting bank and their project portfolio.

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