GLOBAL MANUFACTURING IN NETWORKS
A METHOD TO MODEL VALUE-ADDED NETWORKS BASED ON BUSINESS CAPABILITIES

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Abstract: The challenge for globally operating companies is to configure, operate and dynamically reconfigure the global network with respect to market penetration, business processes and capabilities at the different partners. This paper outlines the application of a specific, flexible method of applying service-oriented architecture (SOA) principles to business interactions utilizing the unique business capabilities of all involved partners in a value-added network. The method draws upon the vast knowledge and experiences gathered in the networking communication area and apply those principles to business interactions using services as the means of communication.

Keywords: Reference Architecture, Manufacturing, Production Control, Decision Making

1. INTRODUCTION

Companies of the information age are showing completely different principles of added value [Grabowski 2003] due to the globalisation, the increasing pressure of time and cost and the information technology's progress. New promising and prospering markets most often in connection with local content requirements, significant differences in wages in the individual countries and regions as well as increasing competition are demanding the companies to rethink their strategies and to partly implement radical changes. Saturated markets are requesting customized products and problem solving [Höbig 2002].
This means a significant increase of required competences and capabilities in order to meet the different customer's requirements. Often these competences and capabilities cannot be kept and used within one company economically. This leads to reflect on core competences and a service provision in value added networks [Wiendahl 2003], which are arising from classical chains of subcontractors by the generated outsourcing of competences to partners as well as the composition of local sites. These value added networks are not only including the production (classical production networks) but all value added business processes (i. e. commercial business processes, research & development) for the generation of a physical good or a service.
Business processes are chains of activities as a logical result of the capabilities' use (business capabilities (BCs)), which are executed by different organizations and organization elements [Homann 2004]. The development of "optimal" business processes in value added networks is requesting a management of BCs and the herewith related information and the knowledge of workflows, structures and experiences [META 2005].
In value added networks many elements are interacting whereby the complexity is being increased. Thus due to the increasing need of coordination and reduced transparency the danger exists to become more inflexible and consequently slower on the market. However, agility and flexibility i. e. adaptability of business processes are actually more than ever requested [Heinrich 2003,

Bley 2003]. Consequently a significant importance is coming up to the complexities' management under consideration of transaction costs which represents a significant cost element besides the internal cost of the individual elements [Intra 2004]. Thus the goal is to flexibly and cost oriented divide these business processes in value added networks under consideration of restrictions and complexities' reduction.

Underlying all the hype is a paradigm shift of how enterprises conduct business with their customers, suppliers, and partners:

- The Internet has provided general connectivity between businesses and with customers to the degree that an enterprise can assume that online access is available as well as phone and fax services.
- Standard Internet formats and protocols have made it easier to exchange messages between business partners who treat the Internet as a trading network.
- Line-of-business applications (ERP, CRM, SCM) have been increasingly Internet enabled, exposing business processes previously locked up in proprietary systems.
- Enterprises are making use of the Internet to gain competitive advantages by changing business processes and models to incorporate online business collaboration and services.
- The enterprise software landscape is changing from batch-oriented business processes to real-time execution to support direct customer interaction and business-to-business collaboration over the Internet.
- Companies integrate all touch points with customers, partners, suppliers, and employees into corporate portals with the goal of providing an integrated, consistent, and branded presence to everyone and everything.

This paper asserts that business process management inevitably requires BOTH automation and Information Worker) (IW) interactivity. Therefore, business process management solutions are inadequate if they only support automation. Empowered Automation is not possible if IWs are excluded from adding value to business processes. The IDC definition of Business Process Integration recognizes the involvement of the IW and defines it as "two or more activities that are performed in sequence by either an automated system or a human being and collectively serve some broader business purpose. The set of steps may be documented and rigorously followed or may be ad hoc." This is very consistent with our on-site observations for IWs moving fluidly between systems and structured and unstructured processes.
Companies have a need to manage the end-to-end business processes that are involved in doing business with one another. Even though business processes may consist of repeatable patterns variations arise when information workers (IWs) are direct participants in the process flow. IWs interact with these processes to implement business decisions, negotiate and clarify expectations and handle business exceptions when these expectations are not met. These workers require the flexibility to be able to guide business process through their life-cycle affecting the paths these processes take and controlling the business communications that occur within these processes.

Due to the growing globalisation caused by booming markets with good prospects, often in combination with local content requirements as well as differences in wage level in the individual countries and regions, enterprises face the task of organizing their added value within a global network. As a result of building up additional sites in attractive markets and the global sourcing classical supply chains are growing towards complex value-added networks. The nodes in these networks are either own sites or partners. Because of fast and frequent changes in markets and environments of companies, these value-added networks show a very dynamic behaviour.

2. Business Capabilities

The challenge for globally operating companies is to configure, operate and dynamically reconfigure the global network with respect to market penetration, business processes and capabilities at the different partners/sites. Especially for the manufacturing planning (design, production and services) the requirements of the business processes and the capabilities of the different enterprises or organizations are of utmost importance. The difficulty is to create transparency regarding performance, capacities and capabilities of the different sites. Main parameters to describe capabilities are efficiency, transaction costs and quality aspects.

Concept of Business Capabilities:
The Oxford Advanced Learner's Dictionary is describing capability as "quality of being able to do something; ability" [Hornby 1995]. This is a very general definition as "capability" or its plural "capabilities" are being used in every day's language. Therefore a more specific explanation is required.

Many definitions can be found in literature for capabilities. Collis [Collis 1994] is dividing these definitions into three categories. The first reflects the companies' ability to execute functions more efficient than the competitors. The definitions of the second category are having the dynamic amelioration of companies' activities as a subject. The third category is similar to the second. It comprises the metaphysical strategically perceptions, which enable a company to identify other resources' value or to develop new strategies prior to their competitors. Collis [Collis 1994] summarises the three categories to the following definition: Capabilities are "the social complex routines that determine the efficiency with which firms physically transform inputs into outputs".
Bredemeyer [Bredemeyer 2005] defines BCs in the context of enterprise architecture. He is seeing BCs as a combination of process, technology, economic goods and persons. Here the BCs are constructing the modules of an enterprise which are interacting as well as having relations to the outside world. Verona [Verona 1999] is separating capabilities into „functional and integrative capabilities". Functional capabilities allow the enterprises to deepen their technological knowledge. Integrative capabilities are serving to gain critical knowledge

from external sources and to combine the functional BCs.
Bernus et al. [Bernus 2003] are defining capabilities as „a firm's ability to execute business processes and activities to produce and deliver a required product through the deployment of the firm's resources. Therefore, a capability is a permanent or temporary aggregation of non-specific and/or specific assets needed to execute certain business processes". For this Bernus et al. developed the following model: organizations comprise many correlating business processes and activities which are supplying a final product to a market. Each of these processes and activities is supplying an output, which can present inputs for subsequent processes, resources for subsequent processes or a final product.

Key assumptions of the Capability Maturing Model (CMM) are: In a mature organization, managers monitor the quality of the products and the processes that produce them and they produce quality products or services effectively and consistently - immature organizations don't perform consistently [Curtis 2002, SEI 2005].
Resources are in the company's property or are acquired externally. They respectively assets divide it into specific and non specific. Their temporary or permanent aggregation is providing the basis for the capabilities which are being used to execute the business processes. In this approach Bernus et al. [Bernus 2003] is complying with Verona [Verona 1999] the two capabilities' directions, however, is adding a third kind of capabilities the cross functional capabilities. They represent identifiable business processes which are characterised by their multi functionality.

Transparency is a fundamental condition to design complex systems, particularly transparency in required BCs to achieve a predefined result or to generate a designated achievement. Examples are to plan a new plant or to develop, to produce and to market a product.
What's the intention of the BCs and why show the BCs such significance? Productivity, flexibility, connectivity and finally transaction costs are determining agility and performance. In value added networks, partners, sites and employees will execute routine jobs less and less, but more high-class activities, in which specialized competences are needed. Thus to optimize the added value the whole network should be focused concerning BCs, but not only several parts of it. In doing so, much non-productive work has to be avoided. Due to this, all involved, existent, needed, but also unnecessary BCs have to be known and describable in transparent form, what mean:

- A BC defines a special ability or characteristic, which is needed to achieve a specific goal
- To use the potentials of all involved BCs in optimal way, enterprises need a model, which describes these BCs.
- It is necessary, to have a complete and profound comprehension, which BCs will be needed when, how, where and for what.
- Such a model has to describe the linkages and relations between the BCs transparently.
- BCs are achievable and integrable in business processes for example via XML-based Web Services

Fundamental is a focus of an external viewpoint of the considered ecosystem, which allows to analyze and to model needed and existent BCs and their relations. These relations based on Meta data for example of organizations, services, information objects or performance indicators. Due to this an adaptive, situational and demand specific use of BCs and configuration of business processes based on these BCs is possible.Currently there are many approaches for network configuration under investigation. Most of them however cover only a limited range of targets, tasks and constraints and without any focus to support this with software concepts.

An integrated method to configure and reconfigure value-added networks looking simultaneously at performance, transaction costs, efficiency and constraints like local-content requirements and to establish software methods, tools and (Web) Services still needs to be developed.

Such a method is currently under development for new concepts for modelling business capabilities in the understanding of Service Oriented Architecture Concepts. It is based on benchmarks of markets, products and sites, which are described by independent indices. The first index describes the attractiveness of the markets in general, the second is characterizing the fit of a given product to a dedicated market, the third defines the production requirements of the product based on the necessary value-adding activities and the fourth characterizes the capability of a site or a partner. The different value-adding business capabilities are structured in a hierarchical model. For each capability or value-adding-module as an aggregation of several capabilities resources as well as information and control information for their execution, measurement and change are needed. By matching the requirements and the capabilities of the individual sites and companies inside a network valid allocation of modules to sites and partners are calculated. They are described mathematically by matrices. Due to the modular description of the value-adding process through activities and value-adding modules, a fast configuration as well as reconfiguration is possible. This method allows a capability-oriented and dynamic selection of sites and partners. Also the need for development of further capabilities in the individual sites of the network and/or the demand of integrating additional sites or companies to the network can easily be seen. Further the deduction of corporate strategy and the comparison with "Best in Class" or "Next/higher performance in Class" is supported [Fleischer, Herm 2005].

3. Real Scenario

The growing complexity and near real-time communication/collaboration requirements with all participants any time, any place, using a growing number of channels and devices showed the company clearly that their existing systems were unable to cope. The new environment focused on communication and collaboration while at the same time deeply integrating the existing legacy.
The required, available or desirable business functions and their associated processes were unclear and non-transparent. It is important to note that the picture only

represents a single customer/supplier integration diagram for complaint management without the required integration into the suppliers (or the customers) associated business functions and systems.
Given the density and variability of relationships between partners and within any given company, as well as the complexity of the interactions it starts to become clear that simple, linear approaches will not be sufficient to solve complex, intricately interleaved structures and processes. Future strategy, planning and action requires not only to accept those networked relationships, but to seize the opportunity to derive and use understanding to act lastingly and with the appropriate consideration for the required flexibility and agility to stay in or even grow the business.
The transparency and borders of the involved systems, the available and required business capabilities with their associated business processes are essential prerequisites for success. If we further incorporate the diversity, complexity and volatility of the relationships and interactions with the partners involved in the value network, it becomes clear that the currently available approaches[1] to standardize business processes and interactions between business partners can only be partially successful. Business processes reflect the varying and individual relationships between partners [Hammer 1993]. Another facet limiting the broad value of standardized business processes is the rapidly growing trend and market pressure to create value within relationships by individualization and special treatment.
What is there to be done? How do we create an environment where the requirements of individualization, diversity and complexity can be handled without rapidly growing integration and interaction costs putting further pressure on the bottom line? How do we capture the growing automation, interaction and communication abilities of all actors in the partner network to bring marketable value?

The key lies in a two-step approach:

- Provide an abstraction that allows a systematic approach and coarse-grained view capturing the business requirements in its entirety, yet flexible enough to provide different views for the varying aspects of interest.
- Within the abstraction identify, capture and organize the 'stable' elements to satisfy the business case(s).

The approach taken in this solution is driven by two principles:

- Identification, isolation and grouping of capabilities and their relationships – regardless of actor[2] - required to satisfy the requirements.
- Description of all required or known business capabilities connected to the use case in a map[3] depicting the system as a whole.

Ordering of capabilities in layers utilizing the discipline and principles of network technologies (TCP/IP, etc), ultimately leading to interchangeable implementations in the identified isolation layer without repercussions for the rest of the environment.
Back to the business problem: detailed analysis
Reviewing the project situation it becomes very clear presents a complex picture where one is hard-pressed to bring the level of transparency required to identify, isolate and group the required capabilities and their relationships.
The 'natural' reflex – often driven by shrinking budgets and project pressure – is to focus on narrowly defined areas or processes, adding to the already large number of special solutions to specific requirements. A manual, isolated and non-systematic approach will most likely lead to exaggerated and non-transparent cost situations.
An inspection of the problem using the approach outlined in system theory research appears as a plausible and practical solution. Starting from a number of differing points of view, Beer [Beer 1959] and others developed methods that support systematic analysis of complex problems such as the above described. The requirements of the business problem reflect high adaptation, maintenance and change costs, as 1:1 relationships between partners exist.

Detour: system theory
Relationships between companies are generally reviewed by the impact on the reviewing company and with the point of view of the reviewing company. System theory argues that relationships[4] need to be viewed holistically, with special focus on the connections between relationships. Vester [Vester 2003] in his report to the 'club of Rome' – "The Art of Networked Thinking - Ideas and Tools for a New Dealing with Complexity" – writes: "*The following factors increase the fear to study complex systems and their fundamental structures dramatically: Number and interrelation of the relevant influence factors for behaviour are growing at an alarming rate, further increasing the impression of complexity and zero transparency. Compounding the problem is the speed of change in an unprecedented measure: measurement data change almost on a daily basis.*"
Due to the complexity and speed of change the general approach to solve interaction demands is a one-sided view focused on the received or sends signals[5] in deep technical detail. This usually leads on an overload of information at a very detailed level. This level of detail

[1] E.g. EDI and others simply organize the transfer of information packaged as business documents. The context of the customer relationship, the associated functions and processes are not part of the standardization. RosettaNet has improved on that basic approach and defines simple partner interface processes for several business cases – it lacks the integration into the business system environment and support for the specific relationships between partners. Both are necessary parts to solve the interaction conundrum, but are not sufficient to completely provide the required solution.

[2] Arguing that the business functions provided are far more important than the provider of given functions – especially in light of growing communication abilities.

[3] Later referred to as the 'business capability map'

[4] Represented by communication between 'organisms'

[5] E.g.: documents or messages going back and forth between the interacting parties.

easily leads to a narrow view limiting the ability to capture the structure and business-related implications of the interaction in order to compare it with other similarly structured business problems.
Enabling recognition of the true complexity, identification of recurring patterns of interactions and resulting requirements to drive more structured solutions requires a different approach. Effective pattern recognition requires an objective, 'outside' view of the complete system. As participant of the system I have to temporarily 'step-out' of my role within the system and review the overall environment from the outside.

The solution approach therefore focuses on a holistic, end-to-end review of the customer complaint processes and decomposition into its basic, business-related parts: customer activity is triggered by defects of parts, missing parts, mislabelling of parts, etc.
A review of a number of associated quality management processes (e.g. Six Sigma, etc) led to the recognition of the following pattern:

- The customer identifies a problem with a delivery
- The customer files a complaint
- The supplier acknowledges the complaint
- The supplier researches the complaint and decides whether to accept the complaint. Part of the decision process might include request for more supporting information or evidence (photos, etc)
- Pre-established activities to manage the complaint are started:
- Root source analysis to identify the source of the issue and identification of solution to prevent repetition of erroneous behaviour
- Activities to evaluate the event and measure its impact on the relationship
- Actions to manage the financial and material impact of the complaint

In summary, the relationships are grouped as the following business functions or capabilities:

- The triggering complaint process activates the generic mechanisms associated with handling the complaint
- Customer and supplier use their respective capabilities (i.e. execute business processes) – human and/or IT – required by the previously mutually agreed upon quality management policy or contract
- Customer and supplier use their relevant capabilities to establish and execute a material compensation guided by the previously established compensation strategy or contract. E.g. financial interchanges, redelivery of product, etc.

4. Business capability map: transparency and structure

Once the business capabilities required by the interactions and their associations within the given organizations are identified, they can be structured and hierarchically described and documented. This structure and description provides the required basis for transparency, ability to identify commonality and drive isolation of common capabilities in interchangeable layers.

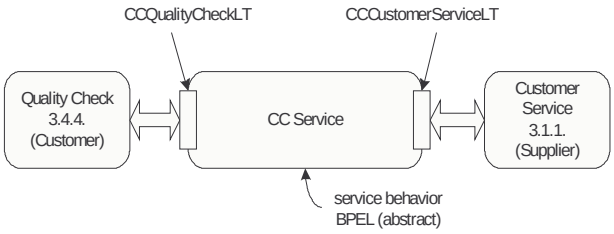

Figure 1: An extract of typical supply chain functions in a specific use case

A solution-wide classification system[6] allows the description of the individual, required capabilities and their display in graphical form as a system. Modelling can happen in a bottom-up or a top-down analysis process. Important is only the understanding of required capabilities and of relationships between business functions either in a containment relationship ("Handle customer interaction" is part of "Customer interaction") or in a connected relationship ("Customer interaction" is connected to "Order management").

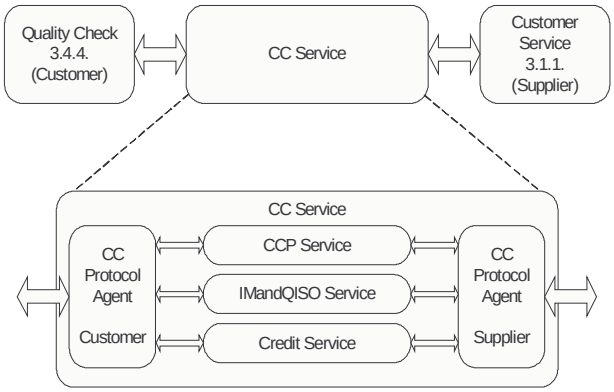

Figure 2: An extract of typical supply chain functions in a specific use case

As a second step, the actual use case(s) or processes[7] need to be layered on the above-modelled capabilities. Selecting a classification system and the different levels enables the required functions to be displayed in context and allows for a transparent overview of the used or relevant corporate functions.

5. Interchangeable capabilities: layers of functionality

The complexity of the living systems that represent these important relationships cannot be reduced. As a solution to the dilemma of complexity, science generally partitions the problem in appropriate parts or layers. Applying an appropriate classification scheme to the occurring business events groups related events, identifies connections between events and provides a way to associate significance of events. Thus identified

[6] That eventually can grow into a company-wide classification system of required business functionality.

[7] In this case the various complaint management processes – Six Sigma, ISO9000:2000, etc.

groups of events are layered based upon their significance:

- Primary business event – e.g.: a customer filing a complaint
- Supporting business event – e.g.: request for more supporting information or evidence (photos, etc)

Communication between layers follows the identified path of connections through the layers. The topmost integration layer manages the primary business events (e.g. complaint has been accepted) and is connected to the managing business functions (e.g. "Handle customer inquiries"). The lower layers are responsible for the details of the specific technique or process (e.g. Six Sigma) used in the concrete interaction.

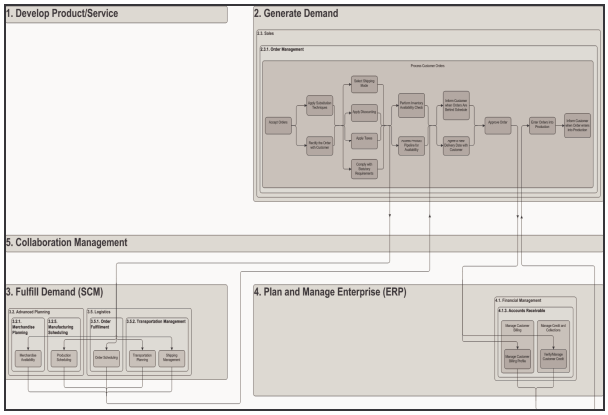

Figure 3: An extract of typical supply chain functions in a specific use case

4. CONCLUSIONS

The interactive nature of business processes requires some new approaches to process modelling and building business process management systems based on those models. It is not sufficient to build systems that prescribe process behaviours in a rigid manor. This may work for automating interactions between computers, but when Information Workers are involved, the variations that are introduced require models that are more flexible. The business process model, and the system that interprets it, need to be designed to allow for interactivity and allow the user to move the process forward in a flexible way.

There is a need for a process definition model that expresses processes in business analyst terms. This is required to render end-user views of process status and as a base to build authoring tools for the business analyst. We have chosen a business capability model based on definition and performance indicators and developed an XML schema and model engine to model interactive these business capabilities. This model provides the flexibility to handle the variations that arise when Information Workers are a part of the business processes.

We have developed this model by studying the needs of medium-sized businesses and global players in managing the order life-cycle. However, we believe that the concepts will apply to many other types of processes and to businesses of all sizes in different industries.

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