Agent oriented modeling of business information systems

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Abstract:
Enterprise modeling is an abstract definition of processes running in enterprise using process, value, data and resource models. There are two perspectives of business modeling: process perspective and value chain perspective. Both have some advantages and disadvantages. This paper proposes a combination of both perspectives into one generic model. The model takes also social part or the enterprise system into consideration and pays attention to disturbances influencing the enterprise system. Due to heterogeneous nature of the enterprise processes the outline proposed is oriented on the modeling using agents. Several types of agents are defined for the simulation model. The agents are structured into several layers. Well known JADE platform is proposed as the modeling framework. Further research directions are summed up in conclusion.

Keywords: process model, value chain model, business pattern, agent, control loop, feedback, JADE platform.

JEL Classification: L15, L23, M11, O21.

1. Introduction

Business applications using IT need typically several different perspectives: IT system perspective, business process perspective and business value perspective. The business process perspective aims for business processes description, information flows needed to accomplish the business targets and the process sequences and workflows. Corresponding business process models represent the operations inside the company. Here are the main issues control and data flow, resource handling and co-ordination of cross-operational processes. Resulting business process models depict the sequence of operations inside the company and process states, what is the main advantage of this perspective. On the other side, the value chain perspective illustrates the value flows among process participants inside and outside the company. Value chain based models represent the actual aim of the business – value exchange between the company and the environment. Distinctly from business process, value chain based models do not depict sequences in which these exchanges take place. The main advantage of value chain models is that they capture cross-concern activities and repeated business patterns as the value exchange always has some common features. Both perspectives can be modeled using well known approaches, but they seem difficult to interconnect. Combination of both perspectives leads to a generic company model using a general control circuit as a template. However, business process does not include a process or value factors only. A company can be seen as a social system, too. A social part of the business system brings some local intelligence into consideration. In this paper we analyze shortly business and value chain perspectives of business modeling and propose to include the local intelligence part by means of agent approach. The paper is structured as follows. Firstly the process models are generally described. The comparison of process and value chain perspective is presented in the following section. The agent paradigm and one of well known platforms namely the JADE framework is presented. Simple example of agent oriented simulation based on a part of generic company model in the next section shows the possibilities of agent approach. In the last part a general discussion and future research possibilities are presented.

2. Process oriented models

Model generally is understood as a simplified description of some object. It can be a real object or a proposed concept. Only most important features of reality are modeled what is based on the target to be accomplished. Other properties of the object can be neglected to some extent to obtain sufficiently clear and simple model, or because the modelers cannot analyze them to sufficient extent.

Process oriented models use following principles:

The objects of exploration are material or information processes in the company;
During the process exploration and model composition the models of various process life cycles are created: past or present state or future (target) state.

The basic elements of a process model are (REP 2006):

Process;
Activity;
Initiative or instigation;
Relations among processes and activities.

Process oriented modeling results in a structure of interconnected activities. Each activity can be looked upon as a process and decomposed into further activities until the single activity is reached. The activities do not come into being or exist independently from the environment. They are instigated by defined external or internal impulses or reasons.

The activities are interconnected by relations or dependencies. The interconnections results in a defined structure -process model. However, the process models do not depict ownership or resource control and value. This is the domain of the value chain oriented perspective.

Process modeling methods are dealt with by several authors e.g. [BPM 2008], etc .Řepa [REP 2006] in his publication analyzed several methodologies including MMABP being developed at VSE Prague for a long time. Dealing with activities, decision processes and functions in a company is the main aim of methods set IDEFxx developed for US Department of Defense [IDEF 2008]. Main modeling elements of IDEFxx methods are activities connected with inputs, outputs, control signals and mechanisms which enables descriptions of various company activities. Their main limitation of results achieved is in our opinion the fact that they are not usable for economic calculations.

Originally in German speaking countries but gradually everywhere, where the SAP deployment was envisaged, the ARIS system proposed and defined by Scheer (see e.g. [ARIS 2008]) is being used. In this system the company reality is statically depicted by data, organization and activities view. The static views are interconnected dynamically by process view which describes the process behavior in time. From the detail level point of view there exists a logical concept, data processing concept and implementation concept. Mutually bundled methods are assigned to each level and view.

Process interaction with company environment is the target of other model definitions as e.g. Process Modeling Language, which can be defined as a supplement to graphical process description tool - Business Processing Notation [BPM 2007].

The main advantage of process modeling is the orientation on actual activities what helps by process re-engineering. However, the process models are not typically oriented on cross-cutting concerns and repeating activities (patterns). This makes some features of models redundant or leads to stove-pipe solutions.

3. Value chain oriented models

The alternative to process oriented approach is orientation towards value chain patterns in the enterprise. What can be understood under value chain? A general enterprise value system can be presented as follows. The enterprise produces goods and services for customers and receives cash in the value of the goods and services delivered. Working capital (cash) comes from the investors or creditors, goods and services process. This general value system can be expanded into more specific value chain. The company produces goods during conversion (manufacturing) process. Resources like raw materials, tools, third party services etc. are needed to accomplish the conversion. They are obtained and paid for during the acquisition/payment process. In the manufacturing also human resources are needed to produce and supervise the process. Labor is procured and paid for in the human resources and payroll processes. The payments are effected by finance process. The money for the payments is collected from revenue (sales) process.

Continuing the expansion down to the process level we do not obtain processes from the workflow but from the value point of view. Following this way we can define several basic transaction cycles. These transaction cycles can be generally presented in a form of business patterns, bearing enterprise value system and value chain in mind. The business patterns can be used for knowledge and functionality sharing similar to the well known services oriented architecture of information systems. On the last (lowest) decomposition level the tasks actually performing the transactions can be identified. Here we are again close to the process approach. Nevertheless, a more general perspective can be obtained by using the value approach, as the basic cycles and relations are principally the same for all transaction types. The value chain approach was presented in many papers already. ([DUN 2005], [MCC 2008], [HRU 2006] etc) We reported on usage of value chain perspective in e.g. [VYM 2008]. The value chain approach has also some disadvantages. There are no time dependencies in the model. So, for example, it cannot be defined who started the value exchange (instigation event). It is also difficult to add some joins, forks or conditions into the value chain model. Some combination of process and value chain perspective is necessary to obtain really consistent model. It can be shown, that this combination, that we call dynamization of value chain oriented model, helps to achieve this. [VYM 2009]

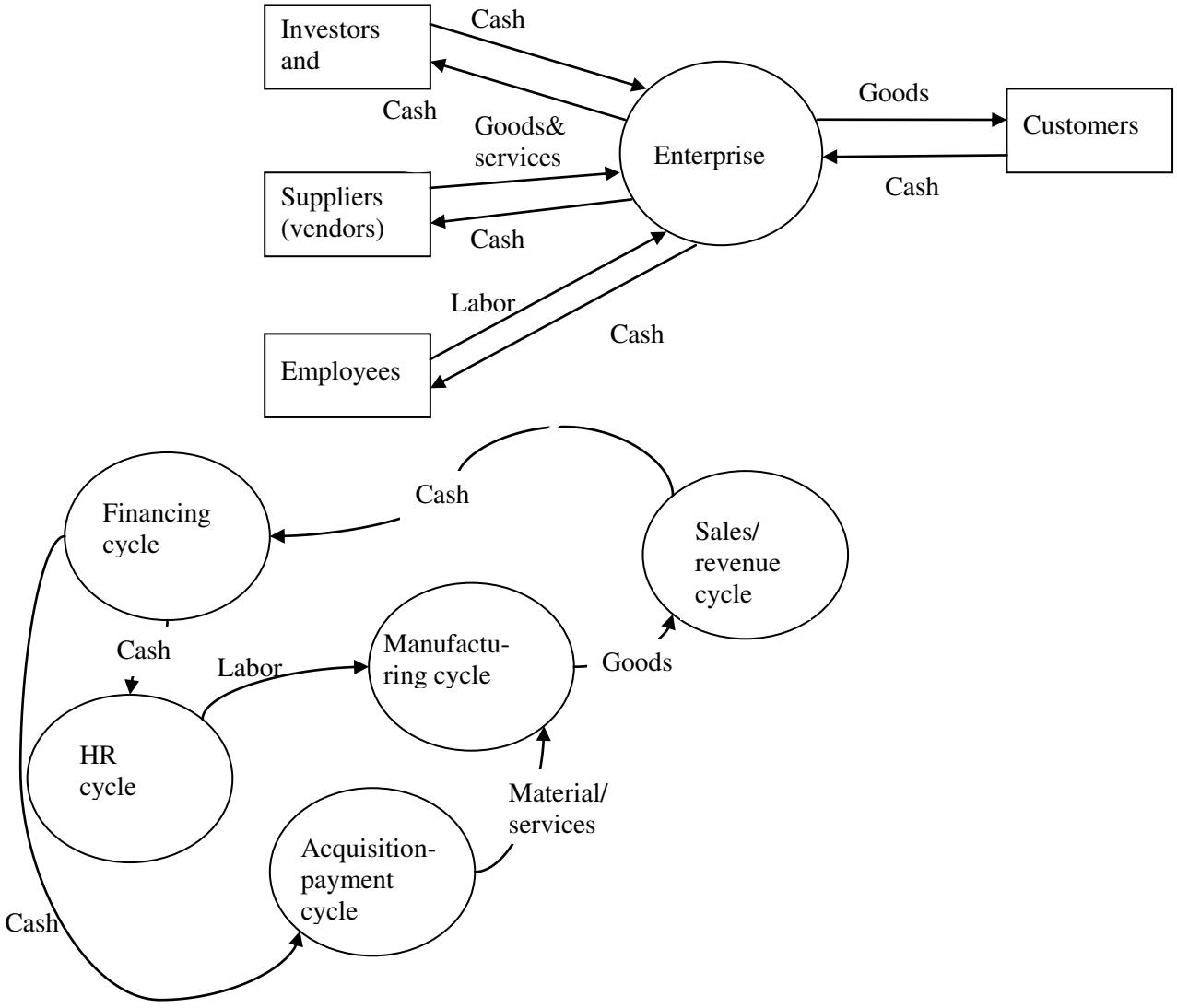

Fig. 1 Enterprise value system and value chain
Source: adopted from Dunn, Cherrington, Hollander 2005 [DUN 2005]

4. Generic model of a company

Process and value chain modeling in a firm still does not give a full picture of company management and control enabling flexibility of decisions. The need of risk management and decision flexibility is caused by quick market changes in global environment, instability of market and rapid development of new technologies. The external events and changes can be perceived as disturbances. On the other side, company has not only business targets. As a social system it has to follow some social aims and desires. These aims are reflected not only on the global company level but also down through the organizational units and individuals. The social aims and desires can be mutually interfered and thus form other type of disturbances. For exploring and simulation of such factors relatively static results of process and value oriented models might not be sufficient.

Using business patterns with the value chain paradigm gives the possibility to define a generic business model of a firm. The concept of modeling the company as a control loop is generally known. In our approach we use following concepts:

- definition or transaction cycles representing the main value exchange and conversion cycles or the firm;
- interconnection of transaction cycles (subsystems) by means of messages using typical or defined structure and contents (ontology);
- the transaction cycles form relatively independent control loops, the rest of the company and its environment is out of scope of the control loop;
- definition of generic company model based on the control loop – [perceiving the reality – measurement – steering action] using feedback.
- concept of disturbances affecting the loops, the disturbances represent the phenomena outside the company (external disturbances) or in other transaction cycles (internal disturbances).

Fig. 2 represents a simple generic model of two subsystems, namely the sales representing the value exchange transaction cycle and marketing subsystem, representing the supplementary overhead process and their connection to other transaction cycles of a company.

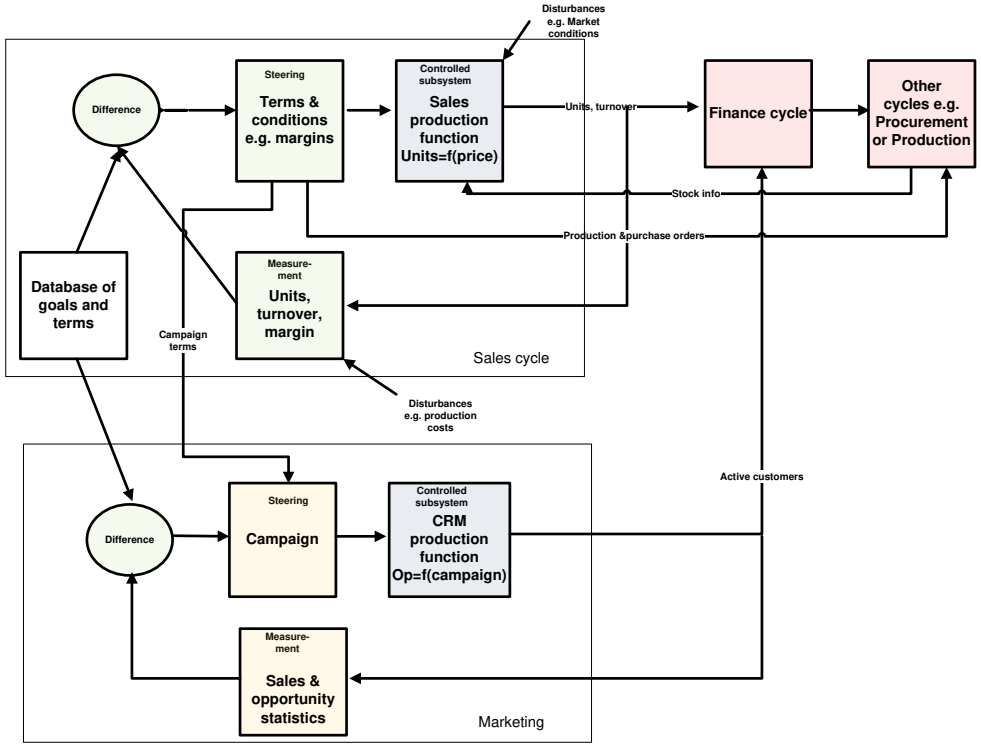

Fig. 2 Simple generic company model

The outputs of the sales cycle e.g. Units sold and turnover are measured and evaluated. As a part of evaluation the profit margin is calculated in the measurement item and compared with the target units, turnover and margin. The steering item changes the sales terms and conditions, e.g. the margin limits for the sales force. The sales force is simulated by sales production function. There can be several sales force units (salesmen) with a little different sales production function (capability to sell the product etc.). The environment – the market itself produces the disturbances, e.g. the prices of the competition that can be simulated by coefficients in the sales production function. As other external influence – disturbance the stock information message from the purchase/production cycle can be simulated. Production costs influencing the profit margin can be simulated as other internal disturbance to the sales cycle. Negative results of sales can bring other decision in the sales cycle control loop, namely the decision to start a marketing campaign, this decision is an external message to marketing steering item instigating the campaign. The results of sales e.g. turnover and profit margin are the input for the revenue cycle control loop.

The model presented in Fig. 2 can be expanded by other control loops, simulated disturbances both external and internal; it is thus open for more complex simulations. The question arises, how to accomplish the simulations using this model with its company targets, disturbances and social aims and desires. It is obvious that we are handling objects with considerable heterogeneities. It looks sensible to use loose coupling of individual control loops, local intelligence of the modules and basically asynchronous message structure. This can be accomplished by using software agents.

5. Agents

The agents, in our paper the software agents are software modules that are based on the agents paradigm: (Bellifemine et al. [BEL 2003]):

> Agents are autonomous – they can control their own actions and under circumstances can take decisions
> Agents are proactive – they do not react in response only, but they can have own goal-oriented behavior and /or take initiative
> Agents are social – they are able to interact with other agents in order to accomplish their task and achieve the complete goal of the system.

The fact that agents are social invokes the question of their mutual communication. The agent communication, differently from Remote procedure call principle, is intrinsically based on Peer-to-Peer communication. This eventually brings problems with the speed of actions as the number of communication acts rises exponentially with the number of actions.

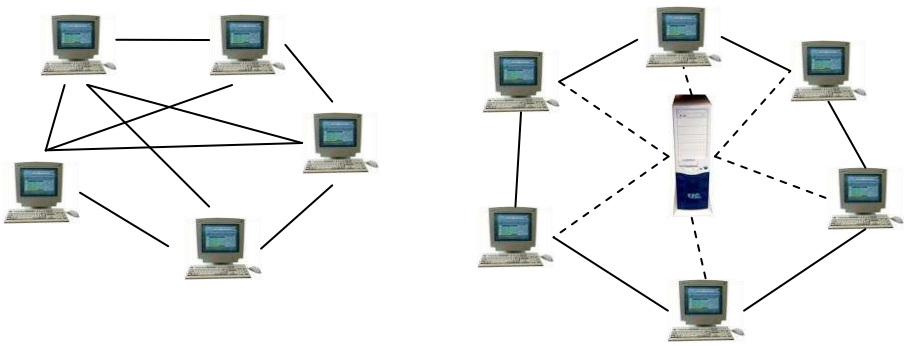

Fig. 3 P2P and Hybrid communication of agents

By Peer-to-Peer communication all agents communicate mutually. There is no control of the traffic. The hybrid Peer-to-Peer communication is partially controlled by a communication server able to set priorities, administer the message queues and agent addresses. This reduces the traffic substantially and saves resources used for communication. The agent communication is basically asynchronous.

The asynchronous message strategy enables agents to communicate with the other ones independently; the activities running on the agents are not bounded by the results of communication.

There exist many types of agents, their formal definition and usage. Well arranged agents classification and basics of formal description published Kubik [KUB 2004]. The multiple agent types and their communication methods could be a serious obstacle to their successful deployment in any business domain. This problem invoked several initiatives of standardization. The best known initiative is the Foundation for Intelligent Physical Agents (FIPA). FIPA published the reference model of agent platform in the years 2002 and 2004 [FIPA 2002, FIPA 2004]. This first part of reference model published in 2002 deals with abstract architecture specification, the second one describes the rules of agent communication using peer-to-peer model and defines the ACL – agent communication language.

In our model we prefer the hybrid communication of agents. The basic agent structure is mapped on the generic company model (Fig. 2) using control loops.

The core of simulation is represented by production function simulating the reaction of simulated transaction on the change of inputs and/or disturbances. This production function is generally described by formula

$$Y = F(k \cdot X),$$

where

Y – output,

F – actual type of function,

k – coefficient simulating the random deviances of disturbances with variance σ.

The control loop entities are simulated by several types of agents:

- measuring agent is transforming the outputs of the simulated systems into values defined in company target database;
- comparison agent calculate the deviation from the target values;
- steering agent calculates the action values representing the goal for the simulation agent;
- simulation agent realizes the production function represented;
- disturbance agent simulating the random values of coefficient k.

The agents use the distributed knowledge and goals database containing the goals of the system, the limits needed for correct functioning of the feedback and control loop (e.g. maximum or minimum profit margin and other settings). Strictly speaking, there are at least two more agents needed, namely the I/O agent for user interface and synchronization agent used for controlling the simulation time, simulated delays and agent synchronization.

Each agent can be looked upon as a layered software module schematically presented in Fig. 4.

Each agent delivers its services by means reactive layer. The planning and co-operation layer are responsible for planning of services needed and co-operation with other agents using FIPA/ACL and other services existing during the agent lifecycle. The social behavior layer complements the services and message structure of the agent, but can also simulate other desires and priorities of the agent. All agent layers use the distributed (and hierarchical) knowledge database mentioned herein above.

The last but not least question is which platform should be used for the model. As the proposed approach follows the FIPA reference model, the most suitable platform seems to be the JADE framework developed by TILAB – a Telecom Italia laboratory. JADE – Java Agent Development Environment is a complete framework supporting the agent lifecycle functions, white and yellow pages service and communication based on FIPA ACL communication language. JADE can be seen as a set of APIs for agent integration with various Java interfaces. The framework is transparent for the programmer, places a set of graphical tools at user disposal. JADE properties, namely compliance with accepted FIPA standards, transparency of agents administration, communication tools based on FIPA/ACL, distant monitoring and control are the properties enabling modular and open architecture of simulation models using combination of process and value chain modeling of company business processes.

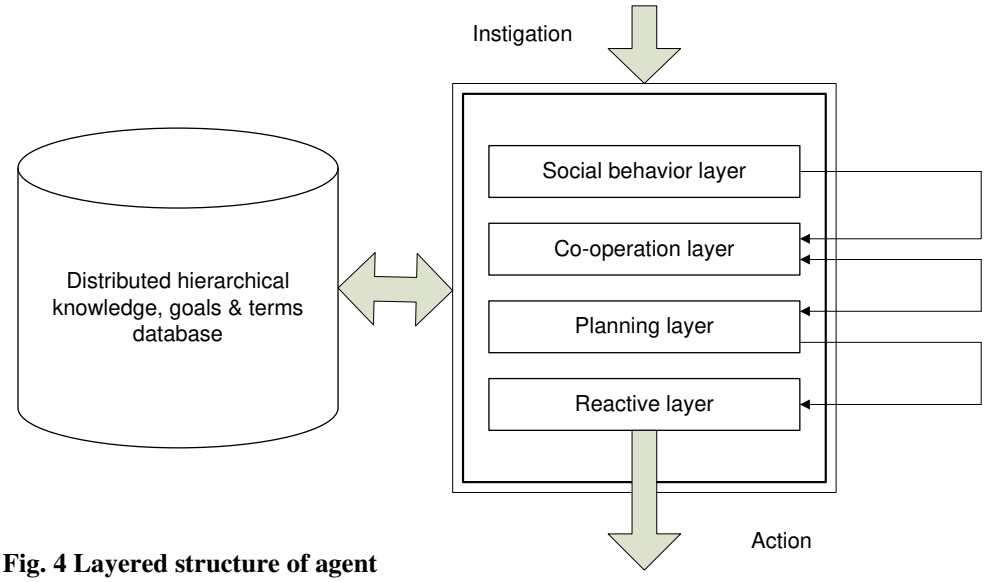

Fig. 4 Layered structure of agent

6. Discussion and closing remarks

Presented generic company model uses a combination of process perspective and value chain perspective. The individual transaction cycles of company value chain can be transformed into processes simulating control loop. The general pattern of control loop can be complemented by simulated disturbances both external and internal. Such approach can be looked upon as a general approach to control systems in business and also in production while the level of decomposition can be set based on the simulation goals and targets. The incorporation of social behavior part into the simulation model would enable to simulate also internal behavior factors and their influence on the company results. The tools proposed for the simulation use agents paradigm and FIPA standards.

However, several questions are open and subject for further research. Firstly, the concept of production function simulating the actual real process is still too simple. It needs further research on production function properties. Secondly, more complex and formal definition of the feedback function is to be done in order to evaluate the stability of loops modeled. Thirdly, the concept of disturbances should be formally defined in order to accomplish real disturbance absolute value and its variances for disturbances to be modeled. The time slices model has to be defined in order to obtain dynamic characteristics of the whole simulation. These opens issues and possibilities of their solution are subject to further research in future.[1]

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