Socialization of Enterprises in the Innovative Economy and Ontology Automated Modification

Victor Romanov, Daria Novotoskih, and Cyrill Dutov

***Abstract*—New trends in modern understanding of the enterprise concept is associated with enterprise evolution in time, changing its structure as result of adaptation to dynamic environment, establishing connections with other organizations and enterprises. In that case, the ontologies play essential role as a mean of "multicultural" (in the technical sense) communications between systems. At this paper the problems of ontology merging and splitting are considered as a necessary condition for the survival of enterprises. As example of commercial bank's ontology was taken and formal concepts analysis was applied for justifying the right way merging with global finance ontology.**

***Index Terms*—Enterprise trends ontology merging, formal concepts, automated ontology creation.**

I. Introduction

In speaking about socializing of enterprises we mean not only new ways of marketing using social networks but in a broader sense that modern enterprises exists like living organisms. It may enter in relations such as merge and acquisition or collaboration with others enterprises. It can split into separate part, each of which continues to live its own life, it can evolve, grow up and die. They can adapt to the changes in their environment. Despite the fact that these ideas have been expressed long enough time ago, their significance for the design methodology of enterprise information systems has become particularly clear only in recent years. We will show further some of essential features and trends of modern enterprises including possibility to become members of some kind ''technological society", consisting from other enterprises. In such condition the existence of efficient tools for translating at semantic level the content of messages in the process of communication between members of "society" become inevitable. Operations of merge partners' local ontologies into global common ontology as well as split common ontology at local ones, will be crucial component of the communication process. The rest of paper is organized as following. Section II contains the review of related work mainly concerning several directions of evolution modern enterprise.

In Section III the requirements for an information system that meets the needs of advanced enterprise are discussed. The problems of ontology development in condition of dynamic enterprise structure and activity cooperation in the collaborative networks are considered in the Section IV. Section V is devoted to some examples of merging and splitting local banking ontologies and the Section VI contains propositions on future works and conclusion.

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II. Related Works

A. Enterprise as Living Organisms

As concerning of living enterprise modeling the authors note that a stable living system under stress will move in that direction which tends to minimize the stress. There are three levels of modification: adjustment, adaptation, and evolution. Adjustment signifies minor modifications of inputs and outputs to existing activities. Adaptation is the development of new capabilities to respond to the change. Evolution is change in the genetic structure of the model. So the enterprise from formal point of view may be considered as complex nonlinear adaptive system.

Reconfigurability provides a key competitive advantage in a turbulent global economy in which companies must be able to react to changes rapidly and cost-effectively. Reconfigurable Manufacturing Systems (RMS) are designed at the outset for rapid change in structure, as well as in hardware and software components, in order to quickly adjust production capacity and functionality in response to sudden changes in market or regulatory requirements.

RMS enable to change constantly during its lifetime, ''staying alive'' despite changes in markets, consumer demand, and process technology. Implementing RMS characteristics and principles in the system design leads to achieving the ultimate goal - to create a ''living factory'' that can rapidly adjust its production capacity [1].

B. Virtual Enterprises

Virtual enterprises are based on stable business networks or 'virtual communities' from which project specific, temporary collaborations of real enterprises are formed.

A key implication of virtual enterprises is that they are more reconfigurable and their boundaries are considerably more blurred than traditional networks. The glue among these autonomous business units is represented, at the higher level, by a deep result-orientation and, at the operational level, by the adoption of standard platforms and by information systems integration. A virtual enterprise is flexible, dynamic, proactive and not constrained by pre-defined structure.

C. Collaborative Enterprises Networks

The first stage of companies' socialization had been social CRM when companies began widely use social media for advertising purposes, promotion their products and services and creating their representatives at social networks. The leading companies felt they had the tactics to transform their traditional marketing campaign into a social media campaign. Social media became not just a new marketing channel, but of environment where enterprises more and more integrated into. By inviting customers to make suggestions and have some of them be incorporated in products, they turned these customers into invested advocates and enrich the team of product developers [2].

The next stage of companies' socialization is collaborative networks. Collaborative networks have emerged over the last few years because of the challenges faced by both the business and scientific worlds, since collaboration has become the key issue to rapidly answer market demands in manufacturing companies, through sharing competence and resources.

In the innovation economy in addition to the collaborative benefits, the dramatic increase in the remote and mobile workforce along with the expansion of cloud technologies, have also driven enterprise socialization — and vice versa. Remote work can significantly improve corporate-wide efficiency by enabling team members to remain engaged in a project even while they're away on travel, and it can dramatically reduce overhead by reducing the need for office space and other infrastructure [3].

The main benefits of Enterprise's Socialization are more connection, engagement, more innovation, more transparency. A collaborative network involves a group of companies or actors in the network, together with another group of clients, supported by an appropriate platform and infrastructure.

At the Fig. 1 we have accumulated the main benefits of enterprise's socialization in form of adaptive, reconfigurable and collaborative EIS, with rapid response to the dynamic environment, containing all this subsystems.

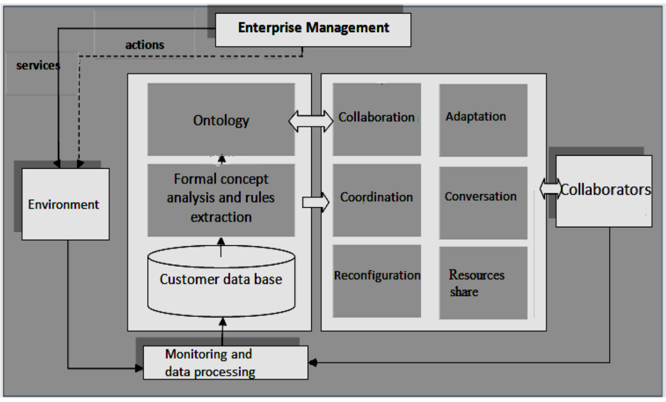

Fig. 1. Adaptive, reconfigurable and collaborative EIS, with rapid response to the dynamic environment.

III. Advanced Information System Meets Enterprises' Challenges

Specific Features of Collaborative Information System

In collaborative network the information system must expand over organizational frontiers and due to this became Inter-organizational.

Collaborative Information System is based on semantic transformer which plugged into the partners' is responsible for the collaboration by driving and controlling collaborative processes, by managing calls of applications from partners and by carrying and translating data from one partner to the other (when it is necessary and legitimate according to global processes). The functions of semantic transformer include syntactic and semantic data conversion, possibility to manage external accesses to collaborator's applications, orchestration of services that make up collaborators' processes [4]. So we can to say that dynamic inter-organizational business processes must satisfy the next conditions: autonomy, flexibility, scalability, service independence, service extensibility and possibility of including new services, as result of evolution.

IV. The Enterprise Ontological Metamodel Development

The enterprise metamodel is based on the ontology that should obey some conditions [5]: integrality, no contradictory, completeness, irredundancy, consistency with the problem area. Based on the enterprise ontology, one then can identify the business profile components such as nomenclature products and services, operations, work centers and processes, resources and constraints, business rules and production capacity. A business profile model constitutes the basis for the making the enterprise more flexible and adjustable to the business needs.

The ontology also contains concepts, relations, properties and data types, semantic issues are important.

To solve enterprise interoperability problem, data heterogeneity must be considered from two aspects: structural/schematic heterogeneity and semantic heterogeneity. Structural heterogeneity may be caused by type conflicts, labeling conflicts, aggregation conflicts, and generalization conflicts occurring in different databases/information systems.

Collaborative business processes are divided into three types: internal process, coordination process, and cooperation process. In practice, if there is a core cooperator, the core cooperator who will not negotiate with any other cooperator creates the cooperation (collaborative) process; if there is no core cooperator, the cooperation (collaborative) process is created through the negotiation of all the cooperators.

The global ontology is created, managed and accessed by all cooperators, and provide the syntax and the semantics of the collaborative processes. The business expressions of all elements of a collaborative process must also respect the definitions in the global ontology. The global ontology must also contain the collaborators' information. Collaborators should be able to discover, invoke, compose, and monitor network resources offering particular services and having particular properties, and should be able to do so with a high degree of automation if desired. OWL-S, the ontology having three main parts: the service profile for advertising and discovering services; the process model, which gives a detailed description of a service's operation; and the grounding, which provides details on how to interoperate with a service, via messages.

The Service Profile provides the information needed for an agent to discover a service, while the Service Model and Service Grounding, taken together, provide enough information for an agent to make use of a service, once found. Using strict and formal concepts definition OWL-S, the collaborators have possibility to construct global ontology from local ones.

V. Mergers and Splitting Structure of the Bank Based on Ontologies

We decided to apply formal concept analysis that was primary proposed by R. Wille in 1982 [6], for discovering dependencies to make recommendations how transform the structure of the commercial bank, when two banks are merging. Aside from selection departments group and its visualizing this method provide possibility for searching attribute dependencies in form of implications.

The departments may be regarded as objects and their functions as attributes, which departments have. Upon this data, the set of departments with common attributes values may be discovered. The data are presented as formal context as a table, the rows of which correspond to object and the columns – to attributes. If some object has definite attribute value then at the intersection is placed one (or cross). The essence of the method consists in the next. Formal context $K:=(G,M,I)$ consists from sets G,M and a binary relation $I \subseteq G \times M$, where M –attribute set, G –objects sets, expression $(g,m) \in I$ - signifies that object g has attribute m. Formal context may be presented as binary matrix, rows of which correspond to object and column – to attributes values. Let us define the mappings for $A \subseteq G$, $B \subseteq M$:

$$\phi: \ 2^M \rightarrow 2^G \ \text{ and } \ \psi: \ 2^G \rightarrow 2^M$$

$$\phi(A) = \text{def } \{m \in M \mid gIm \ \forall g \in A\},$$

$$\psi(B) = \text{ def } \{g \in G \mid gIm \ \forall m \in B\},$$

$$A \subseteq G, B \subseteq M.$$

If $A \subseteq G$, $B \subseteq M$, then

pair(A,B) - is named as a formal concept of context K, if $\phi(A) = B$, $\psi(B) = A$.

In practice, in our work we use A. Yevtushenko's system of data analysis "Concept Explorer" [7]. It is convenient to use this method for visualization of the management structure of the commercial bank that gives the chance to draw conclusions on their crossings, the general signs and existence of some other regularities.

In our experiment, we have selected the banks, where departments are subject to a merger or split. We analyzed the commercial structure, documents, and management requirements of three banks and found out that the common function for departments of banks. The article contains the proper instruction of employees on four specimens from each bank. These function and links between them we described in the separate Excel document. These documents relate to the divisions of the bank credit individuals and legal entities, as well as the economic department. Departments of bank can be considered as objects, and their functions as attributes.

The context for our example with commercial bank is depicted at Fig. 2, where functions of the department are contained.

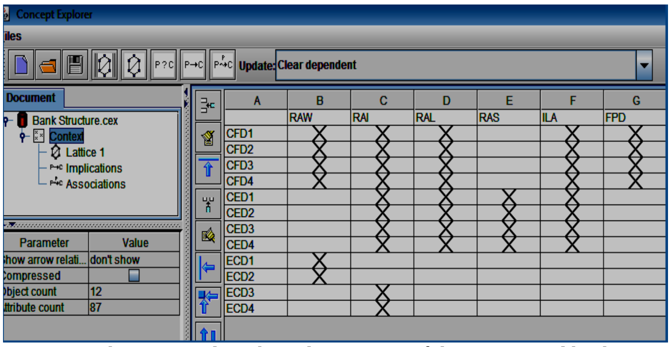

Fig. 2. The context, describing departments of the commercial banks.

The concept lattice for our case is presented at Fig. 3. This lattice provides us an opportunity to explore and interpret the relationship between concepts.

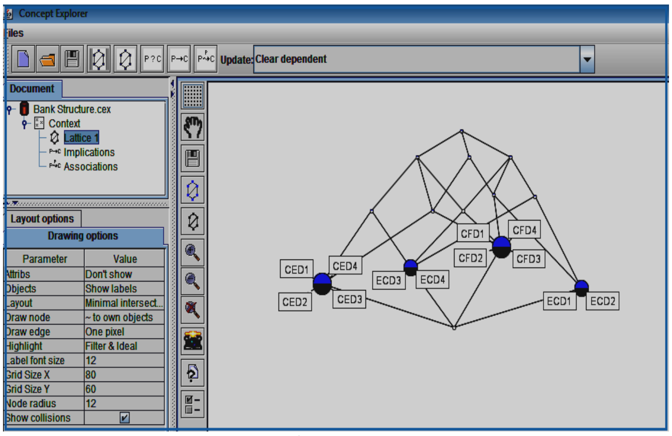

Fig. 3. Concept lattice of commercial bank departments.

Further on a set of such couples of look (objects, attributes) called by formal concepts the partial order on the relation of an investment of the first components is set. This relation defines a lattice of concepts.

The implication means that all objects of context, which contain attributes P also contain, attribute C. That is in the situation P manager must make decision C.

Our method accepts as basic data twelve objects (CFD1, CFD2, CFD3, CFD4, CED1, CED2, CED3, CED4, ECD1, ECD2, ECD3, ECD4) and a set of attributes (count 84). Attributes have to be relevant to objects and have to contain the terminology containing in these concepts.

The main algorithm makes merge of six of the twelve concepts and calculates a lattice of concepts for the integrated contexts.

We are isolated by defining the concept of formal analysis of the business processes of each bank and decide to merge o to split of the structures of the bank in these divisions. According to lattice we can noticed that there are two different groups of objects, which are grouped in separated sets: CFD, CED, ECD1, ECD2, ECD3, ECD4.

The association rule Tab is presented at Fig. 4.

In association list, we see some sets on rules for credit departments:

- Rules with confidence 100% and which union 8 specimen of credit individuals and legal entities. Example: < 8 > RAL ACW PII =[100%]=> < 8 > RAI ILA GIW FCW FCI FCL FCC PGL MTR CCR PBC IGP ARC LNL PAS IBL ALW ALI ALS CGW CGT

CGS SNI RMS CCW CCI CUW CUI MOR CCT CCI FAL IWL;

- Rules with confidence 100% and which union 4 specimen of credit individuals or legal entities.
  Example: < 4 > ACW ACI PII =[100%]=> < 4 > RAW RAI RAL ILA FPD GIW GII FCW FCI FCL FCC PGL MTR CCR PBC IGP ARC LNL PAS IBL ALW ALI ALS CGW CGT CGS SNI SNS RMS CRW CRI CCW CCI CUW CUI MOR CCT CCI FAL IWL PNI CAA CFD.

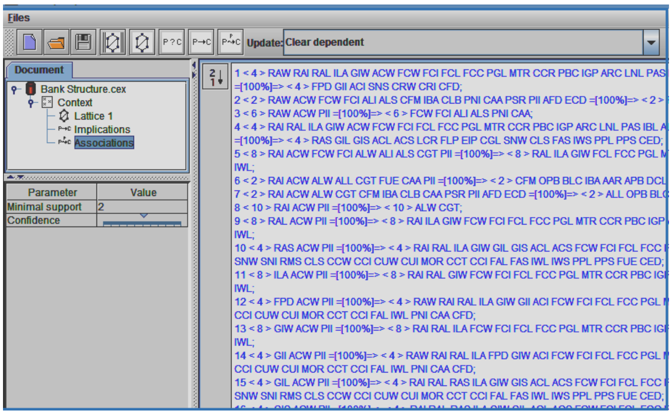

Fig. 4. Association rules.

We have rules so for eight specimen for both department as for four specimen for each department, but count for rules for eight specimen is high and our recommendation is to merge credit department in one on ontology diagram.

In implication list, we see some sets on rules for credit economic department:

- Rules with confidence 100% and which union 4 specimen of economic department.
  Example: < 4 > ACW PII ECD =[100%]=> < 4 > CFM IBA CLB CAA PSR AFD;

- Rules with confidence 100% and which union 2 specimen of economic department.
  Example: < 4 > ACW PII AFD =[100%]=> < 4 > CFM IBA CLB CAA PSR ECD.

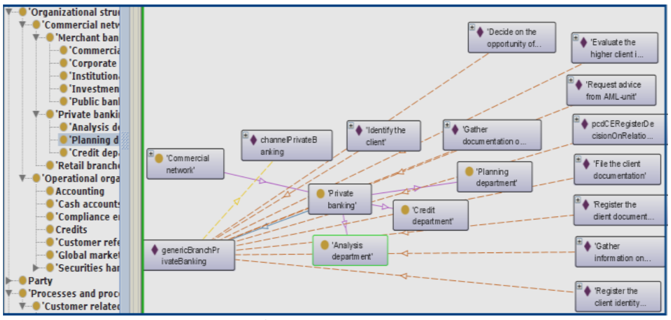

Fig. 5. Configured Financial ontology.

We have rules so for four specimen for economic department as for two specimen for department, but count for rules for two specimen is high and our recommendation is to split economic department to planning department and analytical department on ontology diagram.

In our work, we use "Protégé system" [8] as ontology editor.

After our experiment with formal concept, we see than on diagram there are more sub-classes Fig. 5.

Credit department, Planning department, Analysis department.

Environmental changes occur very often and quickly. Operation and modification of the ontology, socialized enterprises is very time-consuming because they require semantic information processing. We decided to apply the method of formal analysis concepts. Since it allows a certain degree of automation of the process.

VI. Future Works and Conclusion

Based on analysis of a large amount of literature, we conclude that modern businesses: adaptive, configurable, and collaborative.

All this makes it essential on the one hand changes in the structure of enterprises, and on the other side of their interaction with other companies and negotiations that simultaneously involves a change of the enterprise metamodel.

For this purpose, we have applied the analysis of the formal concepts that help us to determine the point of merge and split, based on the semantics of the enterprise.

As the next step of our research, we are planning to combine work on the merger and splitting of the concepts by means of formal concept analysis with work on the transformation of enterprise's business processes based on graph grammars. Just extend the scope of our method to other types of enterprises in particular to monitor the changes in the structure of our University, which is constantly loitering and expands at a constant absorption and merger of other institutions. To this end, we are going to use the AGG software.

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