Metrics of Collaborative Business Systems in the Knowledge-Based Economy

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Abstract

There are already accumulations in the business-oriented collaborative informatics systems that require switching to a new generation: data acquisition, increasing the diversity of people that access them, generalization of databases use, multimedia application development, the use of touch screen-friendly interfaces. This paper aims to define the characteristics of the new generation of collaborative business systems, combining semantic with artificial intelligence based on intelligent analysis of content. An architecture of business collaborative systems is presented and metrics are defined in order to realize a quantitative analysis of semantic-oriented business collaborative systems. Experimental results are analyzed to determine the systems behavior in the context of knowledge-based economy evolution.

Keywords: collaborative systems; business; semantic; metrics; knowledge.

1. Business Informatics Systems

Business-oriented informatics systems represent a class of highly complex software products, because:

• economic processes at the microeconomic level are extremely dynamics;

• businessmen have high heterogeneity in terms of objectives, size of business and expectations level regarding interaction with these informatics systems;

• the structural changes in the economy are found in the businessmen behavior, which may influence the functions of business-oriented informatics systems; the more it progresses in time, the greater is the need for real time information in order to base decisions;

• every businessman need some information, at some point, with some degree of aggregation and, especially, containing exactly those elements which are required for taking the decision.

The business informatics system architecture includes those components that target the functions of organizations, regardless of their specificity, as through a customization process are enabled precisely those functions that reflect the needs of every businessman. In composing the architecture are included the following components:

• the entity assigned to storage processes with raw materials and subassemblies;

• the entity that ensures from informatics point of view the full coverage of human

resources at the organization level;

• the entity that concern the know-how elements of the organization taking into account the technologies, manufacturing prescriptions and management of intermediate stages and recovery;

• the entity dedicated to planning, programming, launching and tracking of production processes, where the problem of automatic data acquisition is the key to ensuring full operation, as starting from the quantities and assortment to be carried at terms, the calculation of necessary is made, the production ordering and workflows following;

• the entity dedicated to quality management of processes and products that are made in the organization;

• the entity concerning the management of stocks of finished products in the context of respecting delivery requirements included in contracts with business partners.

The organization collaborative system, as a business collaborative system, is decomposed into subsystems that constitute:

• the synchronous structure, where the set of inputs and outputs is decomposed into pairs of inputs and outputs, so that each pair represents a subsystem with the same functions as the system from which belongs, Figure 1;

• the diachronic structure, where the subsystems perform different functions in relation to the system they belongs, Figure 2, inputs of $SSCI_j$

The design and implementation of business systems is looking to boost performance in doing business, and creating new facilities to determine changes in the approaching decision making processes. The business informatics systems, as highly complex constructions, require that since the establishment of the achievement of their objectives to take into account that level of resources that ensure a high quality level, thereby obtaining all the features that satisfy the must exigent demands of the businessmen.

The essential aim of the business-oriented informatics systems is to provide all information requested by businessmen. Between the objective of business informatics system and businessmen objectives there is a high coverage of their information needs. When designing a business informatics system, an important role is for the communication subsystem through the interfaces that are defined to allow getting everything asked directly, without a special effort, as the new informatics system first entirely reproduces what provides current systems, at which new features are added, plus a significant increase in quality.

In terms of an evolved resources management determining the business quality, the specialized informatics systems must be redesigned in order to answer to new paradigms specific to the latest generation of database management systems and to data modeling and software development techniques and methods.

Changes in the management of innovative IT projects must be reflected in the structure of business information systems architectures.

The issue of interactivity from the development level now goes to the user level, every businessman disposing of enough intuitive tools that incorporates many elements of artificial intelligence, in order to adapt the informatics system to specific requirements through automated data collection.

2. Collaborative Systems for Business Performance

It appears the necessity of building architectures which using data acquisition, build users profiles, the businessmen being also treated as users for which the aggregation level of data is much higher.

The quality characteristics of collaborative business systems are the followings [1, 2, 3, 4, 5, 6]:

• *reliability*, which is determined by analyzing the number of problems solved by the system and the total number of specified problems;

• *portability*, representing the system ability to being translated from an environment to another;

• *continuity*, meaning the acquisition of structures interfaces from well-known products, so that the user goes directly to functions using known products experience;

• *functionality*, meaning the ability to provide to customers real-time resources;

• *customization*, it gives to customers exactly what they need, because their activated functions are stored and it builds the profile of each client. They have the advantage that it works on directly addressing of usual stuff and the disadvantage that for new requirements are made slower searches;

• *interoperability*, determined the system's ability to communicate and to exchange information between them via inputs and outputs of every system.

Specific database of business-oriented informatics systems contain two types of data:

• data describing entities, activities, processes;

• automatically acquired data that describe the information flow in the system.

For all information describing activities, products, events, processes, there are elements that refer to:

• moments expressly required by the content of documents with descriptivist character;

• moments when actions have been completed;

• moments when the actions are reflected in the informatics system.

There are identified the following situations:

• the effective moments preceding the moments required by documents, which means that the activity are in advance;

• the effective moments follows the moments that are contained in the documents, which means that delays occur;

• the moments that are contained in the documents are overlap with those that are effective, which means that conducting activities fully comply the requirements.

Also in the case of flows from business-oriented informatics system, are registered deviations in relation to the times recorded in documents or with internal rules specific of such systems.

Correspondingly, the new generation architecture of business informatics systems includes a new functional block containing:

• the function for acquisition and analysis of behavior data;

• the function of establishing the profile of businessman and partner profiles;

• the function that determines the corrections that take into account the perturbations induced by profiles of all those who interact, so the system to work properly.

Correspondingly, the interface will contain those elements that assist the businessmen by presenting the profile of partner interacting with. Unlike other approaches, business informatics systems are able to interact one with each other, thus succeeding in defining a global context more complete.

The elements of the new architecture allow developing the innovative side resulting in collaborative processes using methods oriented on semantic analysis.

The user profile is a concept that makes its way increasingly more in businessmen activity. The profile is an abstract construction that gets concrete forms from an user to another. Metrics are defined to measure the user behavior.

The indicators are concerning:

• the quantitative side of processes, the actions, the behavior of people which interacts in the system, counting the frequencies of demotions occurring or time overruns;

• the qualitative side that concern the effects generated by all deviations that occur through the actions that are reflected in the databases;

• the behavioral issues that shows determination in carrying out some activities or an hesitant character in front of decision making.

For all of these it is necessary to change the vision in structuring architectures associated to business informatics systems, introducing distinctly specific functions to the collaborative approach while making components that build profiles of the actors in the business world.

The interfaces must provide clear details on the procedures implemented for establishing profiles and to indicate the risks, respectively to show the advantages determined by the relationship with a new businessman, whose profile is constructed by analyzing the data coming from the global business informatics systems, which is a virtual system constituted by the interaction of business informatics systems that work independently one of each other.

The quantitative profile represented as a set of indicators that form a metric regarding a business collectivity and to another collectivity, the one of businessmen, has a counterpart in terms of quality, with appreciations on the performance of activities, namely, on the human qualities that has a person from the businessmen collectivity. Finally, it is reached the essence of the evaluation process by successive aggregations, obtaining the good or bad assessment, together with the probability of occurrence. The business informatics system

provides lists of partners, warns on the critical activities and events, but in the advanced structural form, it offers appreciations associated to collaborative profiles.

In [7] are presented the concepts of cloud computing and collaboration, and the technological revolutions impact on companies. It describes a new perspective on the company, due to the impact that has the collaboration on productivity growth. In this context generated by the mixing of software and services, it arise a new concept, that of social computing for business.

The collaborative production system, *SCP*, from the automotive industry is defined as follows:

$$SCP = (T, S, R, NMAT, MMAS, KOPE, X, PPRO, BBEN, F, \varphi, \eta) \quad (1)$$

where:

T – the set of time moments in which the system operates; S – the set of physical locations in which the system operates; R – the set of human and energetic resources that contribute to the activity achievement; $NMAT$ – the list of raw materials; $MMAS$ – the list of cars; $KOPE$ – the set of operations; X – the space of states, the set of state variable values; $PPRO$ – the set of finished products; $BBEN$ – the list of beneficiaries; F – the workflows; φ – the transition function of the system; η – the output function of the system.

In discrete manufacturing processes are considered the following distinct categories of collaborative production systems:

• collaborative production systems oriented on process, where there are made complex products, diversified and in small quantities; the statistical quality control requires validation of operations at each stage of the production process; due to the small size of sets of products, the conclusions arising from evolution of measured attribute values are used to validate the operations results and to correct production processes.

• collaborative production systems oriented on products, where there are obtained less complex or diversified products, but in large quantities; the statistical quality control aims to maintain the quality parameters of processes and products within accepted limits; the analysis of the series evolution values from deviations for the measured

attributes has a great importance; the collaborative production system has a great set of procedures for the processing and representation of the evolution of the measured values for each set of products; the database includes in its structure the data series measured for the range of validity of the set or for the command in progress.

The collaborative side of the production system concern the existence of databases for raw materials, workers, products, equipment, operations, beneficiaries, calendar, with which are built entries of planning, programming, monitoring and production optimization models.

3. Context for Semantically Approach

Now there are many tools for semantic analysis. In [8] are presented a number of elements underlying the development of solutions based on these new techniques and methods. In [9] and [10] are presented insights into the use of ontologies and semantics of the institutional entities, and also building consensus through a collaborative space based on the semantic web. Switching to the semantic analysis of all elements of digital content that are stored in a business informatics system based on a collaborative architecture, where the profile is the basic

element, is the next step. Semantic analysis requires taking into consideration of specific business vocabulary, the typologies of activities that take place within the organizations and structure of classes of messages that accompany the activities. In this context, the current databases stores many documents, in which must be added elements that involve automated data acquisition, such as:

• moments of inserting documents;

• identification elements of people that operates;

• waiting time between consecutive input operations;

• pictures regarding the dynamics of activities accommodation;

• the establishment of complete cycles from raw materials to the end of cycle by passing the warranty period to the users;

• records originating from maintenance or adjustment processes and renegotiation;

• moments about the updates that are necessary due to downgrading or exceeding deadlines.

Semantic algorithms have as input diversity of data stored within a consistent time to give stability to analysis results. Thus are created sets of intervals which are refined over time, each interval being putted in correspondence with marks *good* or *bad*, and after refining processes are introduced and other more nuanced qualitative levels. The vocabulary gains after the semantic analysis meanings associated of each element, so switching to the methods of semantic processing, the final results to be complete and accurate, free from ambiguity.

In the context of social relationships, collaboration occurs when two or more people work together to create or to appropriate the same thing. A collaborative working system is an organizational unit that is established every time when collaboration takes place, whether formal or informal, intentional or unintentional.

In the knowledge-based society, the human component plays a particularly high role on the behavior of each element of the collaborative system. The knowledge-oriented collaborative systems, in current operation, require redesign in order to take the facilities offered by new technologies. In knowledge-oriented collaborative systems there are very large databases, complete and correct. Applying the data mining algorithms to extract relevant information lead their transformation into knowledge used to structure and classify the systems analyzed.

Using ontologies in collaborative portals make it possible to determine the specific terms vocabularies with which the system operates, so that the system can provide effective solutions tailored to the context and to user categories, based on the natural language through which the communication is realized. Having the knowledge base, populated in real time, by introducing genetic algorithms and neural networks, the collaborative system is able to deliver the best solutions to users.

In [11] is stated that the concept of collaboration is the key to building an organization connected, responsible and sustainable. The impact that collaboration concept bring on business productivity is manifested by reduced costs due to the addition of new applications in a collaborative infrastructure, and the combination of virtualization and open source software. Also, the mobile email has major impact on productivity growth, cooperation between individuals being preferably accomplished through chat and web conferencing.

Integrated collaborative systems offer a competitive advantage in the current economy by reducing costs, increasing the efficiency of operations and creating new relationships that lead to maximizing companies' profits.

An integrated collaborative system allows quick and effective collaboration between the component subsystems. Integrated collaborative systems have been implemented in education [12, 13, 14], to improve the university management or for efficiency of collaborative work, document management and processes management.

4. The Architecture of Semantic Collaborative System for Business

Unlike previous structures of business informatics systems, where an important role have the components concerning staff, inventories and deliveries conduct, in the context of finalizing contracts to build the

architecture of a business-oriented informatics system that has included the semantic component, it starts from what exists at the level of each organization and from the

objective proposed. It is desirable for obtaining such architectures to be done in stages, because of the complexity of the components to be built.

First, it must constitute the archive of organization by digitizing all documents, including the achievement of conversions so that documents to be directly processed.

Second, it must be set the vocabulary that must underpin the semantic analysis for all information flows reflecting the activities carried out in the organization.

Thirdly, it must be constructed the sets of intervals for variables evolution that appear in shaping the organization's activity.

Fourthly, it must be constructed indicators to allow giving the values in the intervals stated, by checking data quality, so that indicators to have analytical operational structures.

Fifth, through the semantic analysis it must be carried out mapping of intervals with qualitative levels.

Figure 3 describes the system architecture, which is based on three levels: data source input, data storing and processing and user interface.

The architecture includes components for data acquisition, such as very large databases, as number of records and as number of fields recorded. There must be studied the correlations between fields and indicators structures, which are built based on fields in which there are strong correlations. It starts from the reality where countless factors are, then are taken the strongest interactions, is built the model with those variables and the model turns to reality, where it is closely related.

The proposed architecture for the business information system is a collaborative one, because there are involved multiple processing nodes, institutions and organizations that are working together in order to achieve a common goal.

Collaborative information systems will represent the new generation of intelligent and auto-adaptive systems, which are encountered in many economic fields. The progress of technologies leads to the development of this new generation of collaborative systems.

The information system for automatic analysis of clusters is a collaborative system that accedes at the 3C rule, meaning communication, coordination and cooperation, which cannot be achieved without the interaction between agents or system components.

The architecture of the proposed information system will be refined according with the agreements established with the institutions and organization involved in this project. If some institutions will offer incomplete data sets, the data storing and processing module must not be affected and the data crawler agent must extract data that are missing from other sources.

5. Metrics of Semantic-Oriented Business Collaborative Systems

From large databases with many factors are extracted those factors that may influence

the dynamics of the system and generates a variety of analytical expressions, it is defined a criteria, such as the minimum sum of squared differences that allows the selection of the set of analytical expressions that satisfy those criteria.

Increasing the collaborative character of the business collaborative system is achieved by using metrics to determine levels of quality characteristics in order to identify new collaboration situations.

The following metrics are related to a collaborative informatics application used in a bank, which was adapted to be semantic-oriented in order to automatically predict user behavior and suggest relevant information to the users.

It is considered the indicator number of requests not completed by the analyst *k*, $NSNA_k$, defined as follows $NSNA_k =$

$NSINC_k$ $NSINR_k$, (2)

where: $NSINC_k$ – number of requests closed by analyst *k*; $NSINR_k$ – number of requests The frequency of realizing an registered by analyst *k*.

operation by analyst *k*, $FROA_k$, is determined as follows 15:

$FROA_k =$

NOP_{ik} $NTOP_k$, (3)

where: NOP_{ik} – number of *i* type operations carried out by analyst *k*; $NTOP_k$ – total number of operations realized by analyst *k*. The maximum number of operations performed on a workstation, *NMAXop*:

$NMAXop = \{\min_{i=1}^{npl} \{\max_{i=1}^{npl} Nop_i \cdot Nop_i\}\}$ (4)

where: Nop_i – number of operations performed by the analyst from the workstation *i*; *npl* – total number of workstations from which the analyst accesses the application.

For each indicator is established a weight *p* and with all indicators is built the aggregate indicator based on these indicators and weights:

$AI_k = NSNA_k * p_{NSNA_k} + FROA_k * p_{FROA_k} + NMAX_{op} * p_{NMAX_{op}}$ (5)

The weights are determined on a questionnaire realized on a bank personal about importance of these indicators. The weights calculated are presented in Table 1.

Table 1. Indicators weights Measurement Value $NSNA_k$ $FROA_k$ $NMAX_{op}$ 0.5 0.2 0.3 For the analyzed collaborative application are realized measurements presented in Table 2:

Table 2. Measurement realized Measurement Value $NSINC_k$ $NSINR_k$ NOP_{ik} $NTOP_k$ Nop_i npl 26 30 2 4 17, 13 2 With measurements from Table 1 is validated the software metric built for collaborative systems. For that the indicators values are calculated:

$NSNA_k = 30/26 = 86.0$, $FROA_k = 2/4 = 5.0$, $NMAX_{op} = 17/13 = 76.0$ (6)

With those values and the weights form Table 1, the aggregate indicator is calculated:

AI_k

$=$

$3.0*76.02.0*5.05.0*86.0 + + {}^{AIk}= 22.01.043.0$

$+ + (7)\ AIk=$

75.0

The experimental results obtained prove that the metrics defined are strong indicators that can be used to determine the systems behavior in the context of knowledge-based economy evolution.

Integration of the results obtained by the collaborative informatics system help to automate current operations carried out by the system, but also to provide strategic, tactical and operational information required in the decision-making process.

Practical experience is meant to influence the process of model validation. Validated models only go to conduct the refining step, controlling the loss of information.

The metrics helps to make a quantitative analysis of the collaborative systems from various economic fields. In order to evaluate a collaborative system, several metrics must be defined and analyzed from the point of view of following properties: sensitivity, not compensatory character, not catastrophic character, representativeness.

6. Conclusions

The business informatics systems are gaining the most varied forms and their open character is ensured through portals. In this context it is important to design informatics security subsystems particularly effective because:

• the number of people who access the portal of business informatics system is very high;

• the diversity of users is also very high, some just get informed, others perform some operations leading to firm orders and payments;

• there is a great variety of access types to organizational resources through portals, from simple emails to renting equipment and parts of the organization structure for the establishment of virtual organizations through information flows concatenation of the physical components of other organizations.

The inclusion in the portals structure of the latest elements provided by continuously developing information technologies ensures the premise of a consistent development of collaborative business informatics systems, where an essential role has the use of direct communication between objects using sensors to indicate stages and especially to allow calculation of aggregated indicators destined to appraisals of what happens with a business at a certain time. Only in this way, based on some complex information provided, are created the premises of businessmen intervention to positively influence

the conduct of a business or to change the terms of a project as part of management in order to increase the overall efficiency of the organization.