# A Metrics Approach for Collaborative Systems

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*This article presents different types of collaborative systems, their structure and classification. This paper defines the concept of virtual campus as a collaborative system. It builds architecture for virtual campus oriented on collaborative training processes. It analyses the quality characteristics of collaborative systems and propose techniques for metrics construction and validation in order to evaluate them. The article analyzes different ways to increase the efficiency and the performance level in collaborative banking systems.*
***Keywords:*** *collaborative system, collaborative learning, virtual campus, banking, metric.*

## 1 Types of collaborative systems

A collaborative system is one that works with people and other systems to get jobs done faster. Each person and each software program has various strengths and weaknesses. Working alone they can only accomplish so much. Working together, strength combines with strength to increase the likelihood of success. [15]

Collaborative systems are an important subject of knowledge-based society and an important part of the human activities is involved in this field. Science has great impact on the development of different types of collaborative systems from various activity fields. There are many criteria for collaborative systems classification. After the criterion type of application, collaborative systems are:

- *collaborative systems in education*: they are applied in the educational field and aimed at evaluating and enhancing the educational process performance;
- *collaborative systems of defense*: they are encountered in the military field and are characterized by strict rules of organization and functioning;
- *collaborative systems in production*: designed to increase production capacity and product quality in different units producing goods and services;
- *collaborative banking systems*: they are analyzed to determine factors affecting the banking system and its components. [18]

After the criterion of the organization, collaborative systems are:

- *linear*:

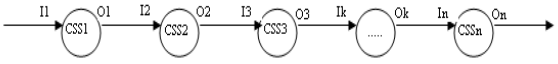


**Fig. 1.** Linear structure

In the linear collaborative system shown in figure 1, initial entries are $I_1$ and final outputs are $O_n$. At intermediate levels, the outputs of *k-1* subsystem are the entries for *k* subsystem. These types of collaborative systems are encountered in the field of education, each subsystem representing a graduate school.

- *tree*:

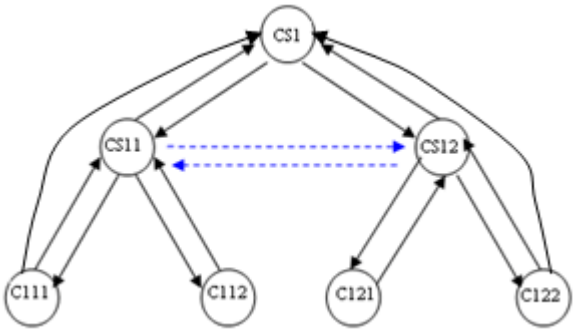


**Fig. 2.** Tree structure

In the tree collaborative system the messages move between subsystems in hierarchical sense that means a message from the level two will reach the top level only if it passes first to the level one. In the example shown in figure 2, each subsystem has many entries and many outputs and the information flows move in both directions. In the collaborative systems with tree structure there are also exceptions, like in figure 2, where a message from the level two can reach the top level without passing first to the level one. The information flows exchange can be done also on the same hierarchical level, in the given example between *CS11* and *CS12*.

Systems of this kind meet in organizational management and public administration.

- *network*:

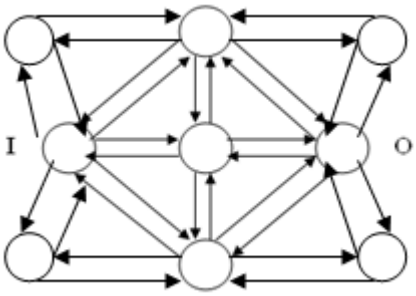


**Fig. 3.** Network structure

In the case of a collaborative system, network type, subsystems are all interconnected, that all transfers are interrelated. In such a system, messages circulate between all components without any restriction. Network type collaborative systems meet in the field of production and banking. [1]

There is about the collaborative systems writing of a well developed specialty. In *Collaborative Multi-Agent Systems* [2], the book most often cited in articles and presentations at conferences are considered the following issues:

- agents - key concepts;
- fundamentals of agents interaction;
- formal models of collaboration;
- agents-oriented to the methodologies of software engineering;
- developing agent systems;
- agents based on personal tools of collaborative search.

The book *Collaborative Multi-Agent Systems* is centered on collaborative multi-agent systems in terms of technologies activation, concepts, methods and instruments. Fundamentals of collaboration are necessary when defining the new societies of any kind (human or artificial). The main conclusion of this work is that multi-agent systems represent a new paradigm for modeling the social realities and for acquiring software development. [3]

## 2 Virtual campus – an application of collaborative systems

Cooperation and collaboration can facilitate and encourage learning and social interaction among distance learning students in a virtual learning environment, which can be designed like a collaborative system. [4]

Virtual campuses are already a reality with the advances in e-learning and web technologies, distributed and collaborative systems and broadband communication, as well as the emerging necessities of distanced universities for collaboration on offering common programs. [5]

The virtual campus is developing through the evolution of computers number and students' number in the university educational field. The number of computers in the universities from Romania, between 2001 and 2007, is shown in figure 4:

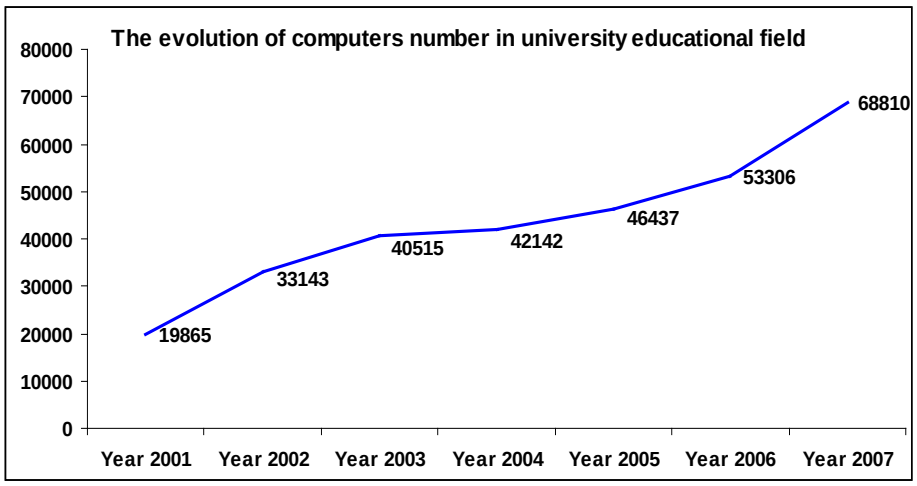


**Fig. 4.** The evolution of computers number in university educational field [13]

The number of students in the universities from Romania, between 2001 and 2006, is shown in figure 5.

The virtual campus is a virtual organizational structure of collaborative type in which interact five target groups:

- the *target group of students*, composed by participants in tele-activities of training, testing, elaboration of homework, documentation, participation in online meetings, forums communication, banking transactions for study fees payment;
- the *target group of teachers* who complete multimedia teaching materials for virtual campus training, evaluates papers submitted online by

students, update databases proper evaluations;
- the *target group of people outside* the virtual campus, which informs about the performance on campus, interact conveying information allowing the selection of students;
- the *target group of organizations* which demands for workforce specialists, requiring new training courses;
- the *target group of campus management*, which defines development strategies, moderate discussions on forums, study the labor market, select teachers for the courses who will take place, establishes specific program costs.

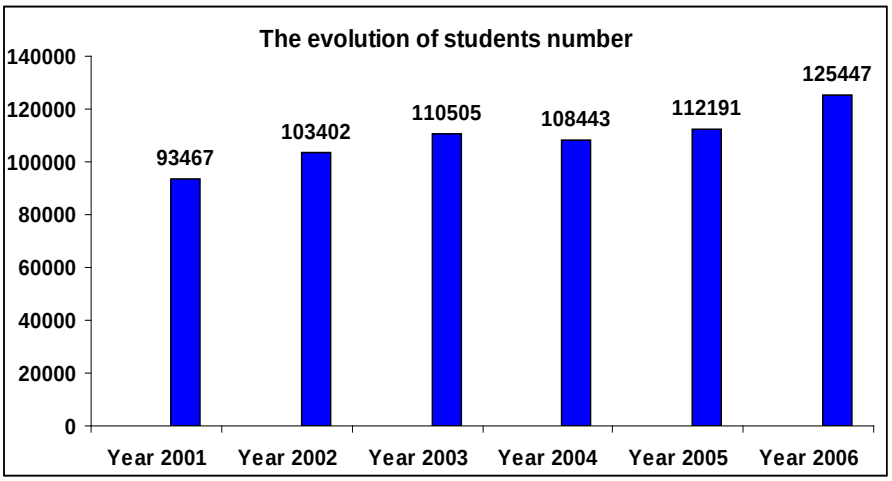


**Fig. 5.** The evolution of students number [13]

The main objectives of the virtual campus is the development and diversification of the online education for all the race, held on the e-learning platform of the university, providing logistical support, e-learning monitoring, training the participants and developing student and teacher's guide online.
The e-learning platform of virtual campus allows the simultaneous conducting of several online masters programs. For every education program there is a database of courses and a database of users. The student access to a particular course is based on key authentication. In the virtual campus of Bucharest Academy of Economic Studies is done online meetings, are posted messages on forums and are discussed issues related to the courses and not only.
The implementation of the virtual campus architecture is a long term aspiration, requesting the solution of many research problems, both in the educational and the technological fields.
The development of the virtual campus has been influenced by research in design science and is based on the concept of architectural design of the virtual campus, which is considered at three levels: the realization level, the representation level and the interface level. Identifying these levels provides a basis for the design of virtual worlds for professional and educational environments. The consideration of the representation level means that a person in the virtual campus can make use of the facilities in an intuitive manner. [6]

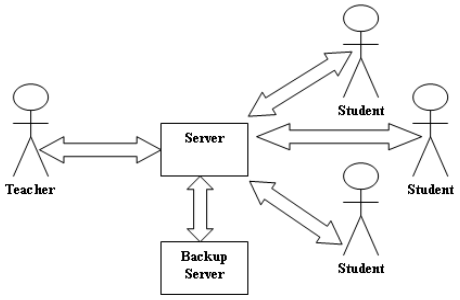


**Fig. 6.** Virtual campus architecture [8]

The virtual campus architecture includes five spaces for:
- *navigation and self-management*, to allow each user and particularly each learner to adopt methods appropriated to his/her specific learning style;
- *consultation*, to explore, collect and process the relevant information;
- *production*, to enable the learner to introduce new data in the active context of the consolidation of learning, and to present the results in original documents;
- *collaboration*, to gather the learners through computer conferencing, to support collaborative work and anchor the socio-cognitive dimension

of learning;
- *assistance*, by the way of online help and counseling, to accompany the student in his/her study project. [7]

The virtual campus architecture of a University of Economic Studies is presented in the figure 6.

The virtual campus has internal and external components, like: teachers, students, computers, databases, and portals.

The virtual campus internal components of a University of Economic Studies are designed in the figure 7:

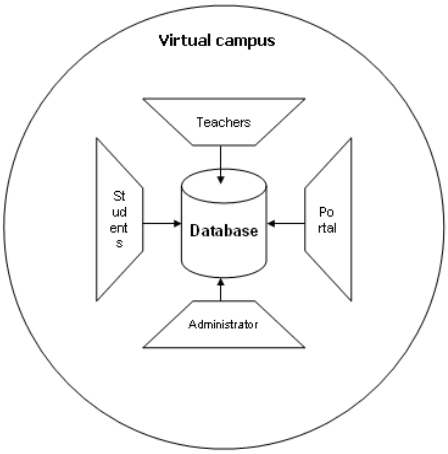


**Fig. 7.** Virtual campus internal components

The virtual campus external components are designed in the figure 8:

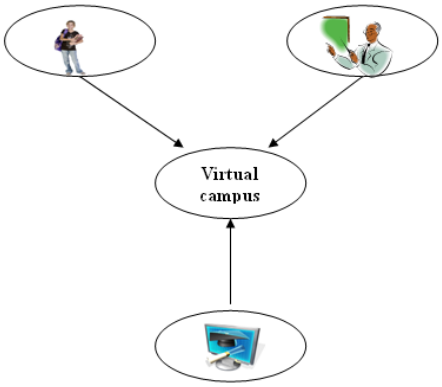


**Fig. 8.** Virtual campus external components

Virtual campus offers complete learning environment. The campus includes a personalized Internet portal through which each student can monitor credit hours, the status of their student account, course schedules, grades and assignments. The student home pages include daily postings of the news stories from their field of study and general campus wide announcements. Students also have the option to access a history of all the library sites they've visited at any time. [9]

## 3 Quality characteristics of collaborative systems and collaborative learning

The quality characteristics of collaborative systems are as follows:
- the *complexity*, which describe the density of fluxes between the components of the system and their links;
- the *reliability*, determined by analyzing the number of problems solved by the system and the total number of specified problems; reliability assumes permanent operation of the collaborative learning system, knowledge presented in the courses to be topical and, at the same entry, the system have the same behavior;
- the *maintainability*, measures the effort needed to make modifications on the collaborative system in order to make it suited for current needs;
- the *usability*, defined by the ability of a system to be useful for his agents or the capability of a system to be used easily;
- the *portability*, refers to the ability of a collaborative system to be transferred from one work environment to another;
- the *anywhere-anytime* characteristic and its potential to support interactive group learning have convinced many teachers to believe collaborative learning environments to be the promising next generation of educational tools for remote education;
- the *sociability* of a collaborative learning system is the extent the collaborative learning environment is able to give rise to such a social space;
- the *tele-proximity* is a term used to show that proximity is brought to a group of people via telecommunication systems and computer networks; social supplies in collaborative learning systems need to be based upon the concept of tele-proximity [10];
- the *automation* is another quality characteristic of collaborative learning systems; many of the processes are developed without human intervention; for example, it automates the measurement of the quality of tests in relation to the way in which the students responded; if the answer of tests developed to a question is a) and 100% of students give answer d), then it will analyze the cause;
- the *management* characteristic of collaborative information systems, which will mean diagnosing and troubleshooting by pulling documented problem/fix write-ups from any source available; when something goes wrong in the system, one of the best hopes is that someone else has already

encountered this problem and documented how to fix it; this works well with open source projects because mailing lists, blog posts, and FAQs are all on the web and have high traffic. [16]
Regarding the collaborative learning, there are three general types of team work: informal learning teams, formal learning teams and study teams. [11]
Collaborative learning is a relationship between learners that needs positive interdependence, individual accountability, interpersonal skills and reflecting on how well the team is functioning and how to function even better.

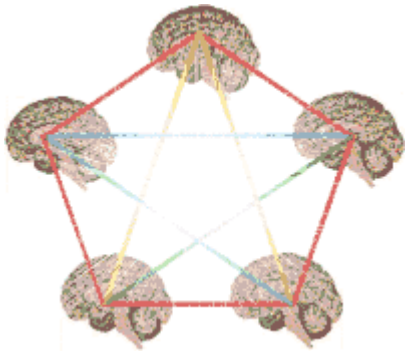

**Fig. 9.** Collaborative learning [12]

There are three key conditions for effective collaborative learning:
- *group composition*: one factor that determines the efficiency of collaborative learning is the composition of the group; this factor is defined by several variables: the age and levels of participants, the size of the group, the difference between group members, etc;
- *task features*: the effects of collaboration vary according to the task; some tasks prevent the activation of the mechanisms described above, while other tasks are appropriated; for instance, some tasks are inherently distributed and lead group members to work on their own, independently from each other;
- *communication media*: whatever task and group members have been selected, the collaboration may not work because the medium used for communication is not adequate; basically, most of current widely available Internet-based tools use text-based communication, synchronous or asynchronous, with mostly fixed graphics and images. [12]

## 3 Techniques for metrics construction and validation

For a quality characteristic, a lot of estimation indicators are built depending of work hypothesis and data gathering capability necessary for computation making. The indicator has an analytical expression easier or more complex depending of influence factors, influence intensity and reused structured of indicators with the behavior already known.
Also, the indicators for quantification of characteristic levels for maintainability, reliability, portability, complexity has a variety of analytical expressions, from homogeneous expressions to reports of homogeneous expressions, leading to constructions in which logarithmic and exponential function appear.
In order to measure the degree of knowledge management that a collaborative system has, is defined a knowledge management performance indicator, *KMPI*, as follows:

$$KMPI = \frac{KC + KA + KS + KU + KI}{5}$$

where:
*KC* - the knowledge creation indicator in a collaborative system;
*KA* - the knowledge accumulation indicator in a collaborative system;
*KS* - the knowledge sharing indicator in a collaborative system;
*KU* - the knowledge utilization indicator in a collaborative system;
*KI* - the knowledge internalization indicator in a collaborative system.
The integration capacity of a collaborative system is given by the ratio between the value of integrated system and the expenditure, which is made to ensure the integration:

$$KI = \frac{CIS}{VSI}$$ , where:

*KI* - the integration capacity of a collaborative system;
*CIS* - the expenditure made to ensure the system integration;
*VSI* - the value of integrated system.
If two banks merge by absorption, the absorbed bank must be integrated into the one who bought it, by determining it to function exactly as the parent bank. Because a subsidiary bank purchased to work after the parent bank rules, are made expenses for operators' trainings, equipment, furniture, software and support, business changing and others.
In this case, the integrity degree can be determined as follows:

$$GIB = \frac{CAB - CHB}{CAB}$$ , where:

*GIB* - the integrity degree;

*CAB* - the acquisition cost of the bank;
*CHB* - the costs incurred to ensure integration.
For the collaborative banking system is defined the indicator average amount of money traded by a person per unit time, according to the relationship:

$$VMBTP = \frac{VBT}{NPS}, \text{ where:}$$

VMBTP - the average amount of money traded by a person per unit time;
VBT - the total volume of money traded per unit time;
NPS - the average number of people served.
If are considered the collaborative systems $S_1$, $S_2$, …, $S_n$, it can build and other indicators for the implementation of quality metric of collaborative systems. For each system $S_i$ are collected the data $d_{i1}$, $d_{i2}$, …, $d_{im}$ regarding its dynamics. Through the intersection of $d_{i1}$, $d_{i2}$, …, $d_{im}$ values are obtained some data, which is common to all collaborative systems. These information are necessary to create new indicators $I_1$, $I_2$, …, $I_h$. It selects from these indicators some of them which must be sensitive, stable, representative. With the new indicators it can discover what is unique in collaborative systems. [1]
The metrics must be not too complicated because it will use lots of resources when implemented and also it must be not too simple because the measured levels will lose relevance. [17]

**4 Collaborative banking systems**

A collaborative banking system differs from a classical banking system by the following advantages: full transparency, perfect communication between employees, fostering teamwork, increased quality of services and rapid progress.
In a collaborative banking system are the following components:
- the material, which includes buildings, equipment and other property;
- the energy, consists of flows of electricity, internet and intranet connections, alternative channels of communication;
- the information, comprising all software and hardware resources available to the bank to conduct its business;
- the human, including human resources of the bank, the categories of personnel and the qualification levels of them.

The banking system, seen as a collaborative system, consists of three subsystems:
- *the physically subsystem*:
  - consist of bank branches, ATMs, headquarters, money and last but not least, people;
  - there is a very good communication and cooperation between these elements, provided by the staff from bank branches and headquarter;
  - the staff from headquarter develop rules, procedures, circulars, on which employees from bank branches operate their activity;
  - from the customers' perspective, each branch is a separate unit of the bank, but from the bank employees, all operating subsidiaries works as a whole.
- *the informatics subsystem*, consisting of all software and hardware resources available to the bank to conduct its business. This subsystem is the most important in the banking system, because he controls the physical flow of money in the sense that it works with scriptural money.
- *the energy subsystem*, consisting of the flow of electricity, Internet and intranet connections, alternative channels of communication. If temporary fall part of this subsystem, the bank activity is compromised, since it is providing communication between branches and headquarter. Most banks have taken security measures to prevent this situation, meaning that computers and servers on which are the databases are equipped with UPS, which allows them to operate in case of a fall in electricity and the telecommunications is ensured in parallel by fixed and mobile phones.

In the banking system, the *reliability* of a bank, seen as a complex collaborative system, refers to the confidence that the customers have in the bank ability to work properly and normally in all conditions before established. A bank is reliable if it is sustainable over time. The reliability of a collaborative banking system assumes strict compliance with those principles, rules, standards and operating procedures of a bank to ensure the profits maximization for a long period of time.
*Portability* for collaborative banking system aims:
- *portability of printed documents*, refers to the degree of standardization and recognition at international level of models for each printed document: external payment disposition, payment order, payment sheet, etc.;
- *portability of management*, involves the transfer of a management model from a geographic area to another. Applying a different model of management at baseline performs restructuring of banks. This model can be new or adopted from other similar collaborative systems;
- *portability of procedures*, involves measuring the generality degree of the procedures developed in a bank and applying them in other banks or

collaborative systems, depending on circumstances;
- *portability of staff* refers to employees transferring from one branch to another and from one geographical area to another area. This portability is the movement of staff where the bank is opening new branches;
- *portability of processes*, refers to the possibility of carrying out operations in various other conditions of work than usual and by others;
- *portability of software* is the translation of various software components of the information system from a workstation to another.

A bank and the opens branches in different counties or cities in the country do an example of portable collaborative system.

The *integrity* characteristic of collaborative systems is well evidenced in the banking system, specifically in the case of commercial banks and its branches. Branches of banks are collaborative systems that fulfill a single function, namely, managing client accounts and transactions conducted by them. By integrating these branches result the large collaborative system, represented by the bank itself, which in this case fulfills many functions.

In the case of a commercial bank, regarded as a collaborative system, the *maintainability* refers primarily to maintain its information system. The banks information system is very complex and very clever, because it must manage client accounts. The bank existence to the market is limited in functionality and maintainability of its information system.

## 5 Using metrics for collaborative systems reengineering

The comparative analysis of the security metrics presumes a statistic approach, because the result must conclude if an indicator is more representative than another, that the accepted indicator is more suggestive there are minor risks in having confidence in the indicator when a decision is being made. [20]

In the collaborative banking systems are the following components:
- *the material*, which includes buildings, equipment and other property;
- *the energy*, consists of flow of electricity, Internet and intranet connections, alternative channels of communication;
- *the information*, comprising all software and hardware resources available to the bank to conduct its business;
- *the human*, including the bank human resources, the categories of personnel and the qualification levels of them.

Bank's financial results depend largely on the quality of staff and the efforts of each employee separately. For each position of the bank, the department of human resources is seeking people with a degree of training higher than required by the job in question. The goal of this recruitment is the elimination of cases in which an employee fails to meet certain requirements or to resolve certain issues related to its activity. Training of employees at work must be done at least every five years. During this period, an employee of the bank carries out one or more trainings.

Regarding the collaborative banking system, an indicator for increasing the efficiency is the level of staff training. Considering the qualifications period of five years, the minimum number of qualifications that get an employee is one in five years and the maximum number is one per year or five qualifications over five years. The maximum number of training sessions that the bank will finance, over a period of five years, is calculated according to the relationship:

$NT = 5 * NP$, where:

*NT* - the total number of training or qualifications supported by the bank;

*NP* - the numbers of people employed in the bank and are eligible for training.

If we take into account the duration of trainings, in the formulas for calculation of the indicators will appear another two variables:

*Dmin* - minimum duration of training, expressed in calendaristic months;

*Dmax* - maximum duration of training, expressed in calendaristic months.

In this case, the total number of training sessions supported by the bank within five years, expressed in calendaristic months, is given by the relationship:

$NT = 5 * NP * Dmax.$

The degree of increasing the level of staff training will be determined with the same formula, with the difference that the number of persons qualified in five years is weighted with the duration of qualifications for each person.

The personnel evaluation could take into account: education level, certification level, social abilities, experience, project team homogeneity degree and personnel productivity. [21]

The performance criterion specific to the banking system is the profit. As it is higher, the bank shall allow the number of branch expansion and attracting new customers. The market share of the bank and the credits offer varies depending on

the profit earned by the bank.
The measures which are taken in a bank in order to maximize profits are much more drastic than the measures that are applied in other companies. These measures aim at: reducing the number of personnel to ensure the correlation between productivity and wages paid to employees, periodic replacement of the bank management in order to increase the performance, and the most expensive and long-term measure, the replacement of the information system.
A banking information system is thus designed to automate a higher set of current bank operations and provide strategic, tactical and operational information necessary in the decision-making process.
The main feature of a modern banking information system is the connectivity level between the factors involved in the banking activity. From this point of view, the banking information systems development suppose the successive or directly implementation of the following types of information systems:
- *banking information systems without connectivity*, which are characterized by the existence of independent computers that run applications specific to certain departments: accounting, credit, etc.; the data transfer between computers is provided, usually through external supports; such information systems are encountered, especially in smaller banking units like branches and subsidiaries;
- *banking information systems with local connectivity*, which are information systems based on local computers networks;
- *banking information systems with global connectivity*, which are information systems based on wide area networks, which connects local networks of the banking units.
Currently, it follows to increase the quality of services offered by the collaborative banking systems, through the introduction of intelligent agents in order to help increasing the performance of these systems. [3]
Starting from the classical architecture of a collaborative system based on software agents, it is clear that it behaves as a poorly connected network of autonomous entities that collaborate to solve problems that can not be resolved individually, and which supports various transactions to achieve pursued common goals.
Intelligent agents are perceived as being autonomous, with capabilities for collaboration and learning from past experience. Referring to Brenner's cube, and taking into account criteria such as number of agents, mobility and intelligence of the agents, it can shape the field of multi-agent distributed systems, which are able to shape collaborative virtual communities.
Agents members of multi-agent systems presents, usually a BDI architecture (Belief-Desire-Intention), their behavior resulting from the actions they undertake in accordance with their beliefs, formed on the basis of perceptions, but also the wishes expressed. [14]

## 6 Conclusions

The cooperation involves communication and a specific kind of coordination. From these three elements result the development of a new paradigm of the collaborative activities. [19]
The development of virtual campus is accelerated, along with the wireless networks and, the quality characteristics become strictly related to the security characteristics.
Collaborative work can be successful if all members show goodwill and responsibility. Collaboration is necessary to deal with such large projects. The collaborative and essentially social character of work needs to be appreciated in undertaking interactive systems design.
The development of collaborative systems conduct to increase their complexity and the global character of the economy is designed to determine, also a global character for many of the collaborative systems. From the information point of view, to these global collaborative systems must correspond global performance indicators, procurement systems scratchy and data conversion procedures, to transform heterogeneous information into homogeneous entries for aggregate indicators, defined in the metrics of collaborative systems. Based on these aggregated indicators should decide appropriate to the global level, intermediate level and the execution level of any collaborative system organized into hierarchical levels.
A collaborative system creates a environment where people can work better together, can share information without the constraints of time and space, being characterized by three fundamental aspects: joint activities, sharing environment and way of interaction.

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