Collaborative Systems Orthogonality

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Abstract: *The paper presents definitions of collaborative systems, their classification and the dynamics of collaborative systems. It describes the key concepts of decisions taken in collaborative systems. There are listed main properties and quality characteristics of collaborative systems. It analyzes the application for the assessment of text entities orthogonality within a collaborative system in education, represented by a virtual campus.*

Keywords: *collaborative system, orthogonality, virtual campus, evaluation.*

1. Collaborative systems

Collaborative systems have become an important research topic of the knowledge based society, most activities performed by people being related to this area. Any human activity is best realized if people work together in order to achieve a common goal.

A collaborative system is defined through a construction having the form:

< *activity, place, material resources, people, energy resources, procedures, flows* >

These elements build the four components of a collaborative system: the material component, the human component, the energy component and the information component. The *material component* is represented by the elements *activity*, *place* and *material resources*, the *human component* is represented by *people*, the *energy component* is shown by the *energy resources*, while the *information component* is presented by *procedures* and *flows*. Collaborative systems are ordered systems, meaning that includes a set of procedures, uniform governing relations between components.

A collaborative information system is represented through many software programs, running on a network whose nodes consist of computers, multi-processors, massive parallel processors or workstations, each having access to its own memory or to some common shared memory. [1]

Collaborative systems must work better than other types of systems. In [2] is defined the collaborative information system such as a distribution company whose objective is to sell increasing quantities of his products. In a collaborative system, between users and agents are permanent channels of communication, agents interests are not antagonistic, system components using shared resources in order to fulfill their own goals and their common objectives.

In [3] are presented the quality characteristics of collaborative systems, structures of collaborative systems and estimation of their quality. Through the quality characteristics studied in the literature, are highlighted: complexity, reliability, maintainability, portability, stability, integrability and functionality.

Science has led the development in practice of many types of collaborative systems, encountered in all activity fields. In [4] is described a communication architecture for cooperative systems in Europe, using wireless communications for intelligent transport systems.

Collaborative systems are designed to process the information they receive, turning them into outputs with value for system components. In a collaborative system enter raw and unprocessed data, following that the system to synthesize this data and transform them into meaningful data, with a certain importance.

Collaborative systems are characterized by a lot of states $S_1, S_2, \ldots, S_n$, the transition of the system from one state S_i to another state S_j is accomplished through an order or information. Switching from one state to another involves the provision by the system of an output. For a usual collaborative system is not possible the transition from the state S_i to the state S_j for whatever i and j in the range $1..n$. The system pass from one state to another, but fails passing from every state in all other states.

2. Dynamics of collaborative systems

The collaborative systems are an interdisciplinary field at the intersection of economy, informatics, management, and sociology. Collaboration involves organizations that have a common mission and join together to form a new structure. A collaborative informatics system is also a distribution company whose goal is to sell increasingly quantities of his products.

The collaborative informatics systems represent, from the implementation viewpoint, software entities that are developed during a life cycle process that starts with the problem analysis and ends with the implementation of a fully functional software system.

The systems consist of components and interactions between them. When collaborative systems are used voluntarily, one of the key drivers to success is how users feel that their experience with the system: if they like, if the system offers them what to expect from him, if they are able to communicate freely and naturally with other participants and whether to recommend it to others.

Collaborative systems are classified according to the following criteria:

a) *level of complexity*, and by this criterion are identified:

- *collaborative systems with low complexity level*, have few components and the number of relationships is limited;
- *collaborative systems with medium complexity level*, have small number of components, but do not have large number of streams or *systems with large number of flows* and which have large number of components;
- *collaborative systems with large or highly complexity level*;
- *collaborative systems extremely complex*, have many components and many streams: banks, police, internal chain of hotels, airline transport; the banking system is among collaborative systems with very high level of complexity, because it consists of many components and is characterized by a large variety of links between them.

b) *type of application*, criterion which groups systems in:

- *collaborative systems in education*;
- *collaborative systems of defense*;
- *productive collaborative systems*.

c) *method of organization*, criterion which divide systems into:

- *linear systems*, in which subsystems interact with each other in both directions;

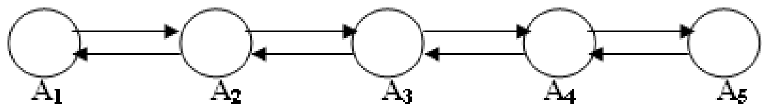

Fig. 1. Linear collaborative system

Between activities $\mathbf{A_1}$ and $\mathbf{A_2}$ is changed the message $\mathbf{M_1}$, between $\mathbf{A_2}$ and $\mathbf{A_3}$ is changed the message $\mathbf{M_2}$, between $\mathbf{A_3}$ and $\mathbf{A_4}$ is changed the message $\mathbf{M_3}$, and between $\mathbf{A_4}$ and $\mathbf{A_5}$ is changed the message $\mathbf{M_4}$.

These types of collaborative systems are encountered in the field of education, each subsystem representing a graduate school.

- *tree systems*, organized by levels, as in figure 2:

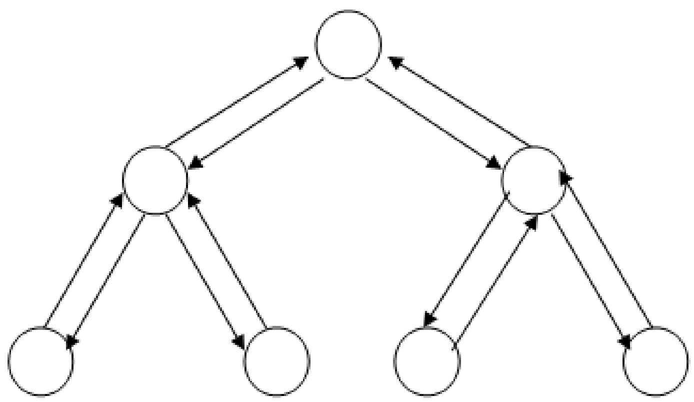

Fig. 2. Tree collaborative system

In a tree system, messages are moving between activities in a hierarchical manner, a message from the second level will reach the level zero only if he move and at level one, and a message of basic activity, represented by the tree root, will be propagated only to activities on the immediately below level. From this level, the message will be forwarded to the activities represented by child nodes of the nodes from level one;

Considering the collaborative system as a tree structure, there are taking into consideration:

- the degree of vertical collaboration as the number of links between components from level k to the ones on level $k+1$;

- the degree of horizontal collaboration as the number of links between components on same level.

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

- *network systems*, the components communicate with each other regardless of the level that is;

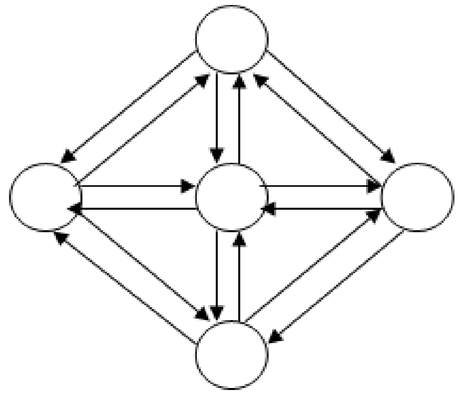

Fig. 3. Network collaborative system

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.

The business collaborative system works under the black box principle set out by Zadeh, the entries being given by raw materials and information and the outputs being materialized in finished products, services and other information which turns into costs for that business.

Dynamics of collaborative systems concern changes regarding the quality, structure, functions, size, their procedures and standards. Dynamics of collaborative systems are studied using mathematical analysis, providing long-term behavior of each major systems, winning a look inside the system design: which parameters determine the group behaviour and how the system characteristics are affected. Is developed a class of mathematical models which describe the collective dynamics of the collaborative system and which illustrates the approach by applying to several case studies, including both software agents and robots. For each system, is transformed a set of equations that describe how the system is changing in time and analyze their solutions. Finally, is shown what say these solutions about the collaborative system behaviour.

3. Decisions in collaborative systems

The decision system is very closely related to the information system. The link between the decision and the information systems is as follows:

- first of all, at the entry, the information system provides to the decision system the data which it needs and which it process giving them the appropriate form to be used in the decision process;

- second, the data, once processed and taken the decision, this is captured by the information system and directed to compartments where it must reach to be put into practice;

- thirdly, the decision system requires even inside it a interim circuit information under conditions in which the collaborative system is led through participatory management.

Decisions relating to collaborative systems are divided into:

- *current decisions*, that relate to daily decisions, contribute to achieving individual objectives and prevails at medium and lower management. Inputs and outputs of such decisions concern the daily problems taking place in a collaborative system. The costs regarding a wrong current decision are small and risks are also reduced;

- *short-term decisions*, which concern the decisions for periods of maximum several months and contribute to achieving the group objectives and prevails at medium and lower management. The costs incurred in making such decisions are higher than for current decisions;
- *medium-term decisions*, which concern the decisions for periods ranging from several months to a year, contributing to achieving the objectives of the group and prevailing at medium and high management. Costs and risks incurred when a medium-term decision is wrong are quite high;
- *long-term decisions*, that relate to decisions for periods ranging between 1 and 3 years, contributing to achieving the group objectives and overbear at high management level. A wrong decision of this kind involves very large risks and costs and have catastrophic consequences on the collaborative system involved;
- *strategic decisions*, that relate to a period between 3 and 5 years and contributing directly to achieving the fundamental or derivative objectives and aims the overall system activities or its main components.

Economic decision is the action line consciously chosen in the driving the system process, from a certain number of possibilities in order to achieve some objectives in an efficient maximum. The decision put the resources at work, establish and achieve the system objectives. Requires a training and preparation in which participate a large number of individuals and departments within the system.

Environmental decision consist in all heterogeneous and exogenous elements of a collaborative system, which make up the decision situation characterized by the expression of direct and indirect influences on the content and significant results of the decision. In environmental decision is an evolving contradictory: on the one hand are a number of changes likely to provide the best prerequisites for an effective decision process, and on the other, environmental decision tends to become increasingly more complex due deepening social division, reducing the life cycle of products and accelerating the pace of moral attrition. In decision making, these elements are expressed in a number of variables and limit conditions and in the involvement of interdependencies between these.

4. The orthogonality

The orthogonality studies the semblance degree between two or more entities. Through this quality characteristic is determined the measure in which the entities are different one from another.

The orthogonality is being studied on the basis of the orthogonality criteria. With the help of these criteria are highlighted the characteristics that have the same value for the studied entities and are being determined the semblance levels.

The comparison of two entities is reduced to relating one entity to the other entity, respectively to identifying the common parts and the parts that are different. In this way are compared the correspondent characteristics of the two entities. For the text entities, the frequency of the words' appearance as part of the entities has an important roll. Through frequency is being determined the importance of the words as part of the entities and is being determined the degree of using the words, the way how these influence the entities building.

For the orthogonality's study it is defined an orthogonality indicator included between the interval [0, 1], which takes the following values: 1, if the elements are orthogonal, meaning they don't have anything in common, respectively 0, if the elements are identical.

Therefore, it is followed the modality in which two entities are different or similar, both as frequencies of the words' appearance, content, and as signification of the contained data.

Another applicability of the orthogonality concept is that of identifying if certain workings belong or not to a reference domain. It is studied the similitude degree, the frequencies of using the words, and on the basis of the resulted indicator it is determined if the texts are similar or not. In the situation when the orthogonality indicator tends towards 1 that means the workings are completely different it is obvious that don't belong to the same domain. To identify precisely if two or more workings belong to the same domain, must identify the specialized words contained in the workings and their appearance frequencies, through constructing a thesaurus of words belonging to the domain.

To study the orthogonality are defined series of indicators which analyse the differentiation degree of the concepts and materials which make the object of the studied domain.

In the case of collaborative systems the orthogonality finds its applicability in studying the level of similitude of the information processed with the help of the collaborative systems and in establishing the way in which applications and implemented technologies cover the demand of presenting and adapting the information.

Through the implementation of the orthogonality concept is intended the growth of information processed' utility level

Constructing collaborative systems which don't find an activity object or which don't satisfy precisely the demanding which were made, although are respected the criteria which lay at the basis of their creation, leads to an reduced efficiency of the concept.

The orthogonality is studied on the basis of the orthogonality criteria. With the help of this criteria are emphasized the characteristics that have the same value for the studied systems and are determined the similarity levels.

The orthogonality criteria which are taken into account for studying the collaborative systems are:

- the informatics content delivered with the help of the systems;
- the applicability degree of the implemented concepts.

The informational content is studied in order to establish to what extent the information specific to each system were taken over and stocked in an accurate manner.

The applicability degree of the implemented concepts study the modality in which the collaborative systems succeed in realizing the demands for which were build. The concept implementation offer a general view over the manner of realizing the systems, over the manner of how interact the components and supply solutions for improving the application and for growing the integration degree of the component elements. The orthogonality identifies those components of the applications which must be revised in order to grow its efficiency, on the basis of the orthogonality criteria.

The orthogonality analyses the collaborative systems both from the point of view of the internal components, and through comparing with the external applications. The concept's implementation offers a general view over the manner of joining the component modules, over the manner of realizing the application, as well as over the manner of how the components interact and deliver solutions.

5. Evaluation of text entities orthogonality within a collaborative system

The assessment in the virtual environment is achieved through:

- tests with multiple choice, which offers the advantage of fast corrections; if the test is given on the paper, the correction work is carried out automatically by scanning;
- structured text entities, such as projects and software programs.

Structured entities are defined by the property of concepts inclusion and seek to create and implement storage and processing forms, which will be used for information management. Structuring the entities reflect the associations between data. A structured entity summarizes the grouping method of the characteristics and the links between them. [7]

For the analysis and evaluation of structured text entities orthogonality within a collaborative system, represented by a virtual campus, has been developed the ORTOES application. The ORTOES application is built to analyze the degree of differentiation between two or more structured text entities.

The orthogonality analyze the degree of similarity between two or more entities. Through this quality characteristics is the determined the measure in which the entities differ one from each other.

The orthogonality of structured entities is calculated according to the time at which they are uploaded into the ORTOES application: the user which upload the first the structured entity will have the maximum orthogonality level, because at that moment there is not a similar entity for comparison. Entities which will be uploaded after, will be reported to the entities already taken, this being highlighted by the results analysis, ordered by uploading time.

The ORTOES application consists of four modules: data acquisition, data analysis, results display and administration. These modules were built to ensure the interaction with users, processing data entered by them, displaying the results, both individual and aggregate, and administration of application functionality.

The application takes data from a text file in a queue-type structure, and based on implemented functions realize a series of processing, such as determining the number of distinct words, the number of words that have been repeated, determining the frequency of words occurrence and calculation of orthogonality indicators.

After uploading the file *.txt* type, containing the text entity, the user receives a validation message of upload, message which informs the user regarding to the number of project uploaded. The user receives a validation code for the project uploaded. The unique code is generated randomly and, based on it, the student proves that he meet the criteria required by the application in order to take over the entity.

After running, the module generates two files *.txt* containing the average orthogonality of stored entities, and information on the contents of files: number of common words, entities which have orthogonality values under the threshold of 0.75, the size of files analyzed.

The module for processing and analysis of entities take over the *.txt* files, store them using dynamic variables, analyze their content, calculate the average orthogonality and saves the results in some *.txt* files.

The ORTOES application is written in PHP, version 5.0, and use the MySQL for information storage. As web server, is used Apache, version 2.2. Users must have installed a web browser with which accesses the application options. During the tests, the application was hosted at the address: www.ortogonalitate.milodin.com.

The application is functional and used since October 2008. In concordance with the schedules for building the entities, the user access was provided according to the deadlines for uploading the structured entities.

The ORTOES application is tested taking into account datasets from users' collectivity, data received at two separate time moments, resulting in changes in the number of users involved.

In the first case, the initial collectivity of users consists of 482 items, of which for the structured entity consisting of the following T_1, T_2, T_3 texts, interdependent, orthogonality was checked as in the table 1:

Table 1. Users share in the orthogonality calculation

Entity	*Share*
Structured entity project T_1	78%
Structured entity project T_2	55%
Structured entity project T_3	63%

The orthogonality levels of the three entities, on ownership intervals, are presented in table 2:

Table 2. The share of orthogonality level

Entity	*Orthogonality between [0;0.75)*	*Orthogonality between [0.75;0.85)*	*Orthogonality between [0.85;1.00]*
T_1	10%	0,002%	89,998%
T_2	0%	25.6%	74,4%
T_3	0%	35.4%	64.6%

Concerning the final structured entities for which the orthogonality is analyzed, from a total of 148 entities generated, the share of users is:

Table 3. The share of structured entities in the orthogonality analysis

Entity	*Share*	*Frequency*
STDAT01	24.32%	36
CREARE	68.91%	102
CAUTAREREF	0.02%	3
CONVERSIE	0.02%	4
BIBLIOTECA	0.027%	3

It was noted that there are differences in the levels of orthogonality, as shown in table 4:

Table 4. Frequencies of entities by level of orthogonality

Entity	*Orthogonality between [0;0.75)*	*Orthogonality between [0.75;0.85)*	*Orthogonality between [0.85;1.00]*
STDAT01	2	0	34
CREARE	0	0	102
CAUTAREREF	0	2	1
CONVERSIE	0	2	2
BIBLIOTECA	0	0	3

If were performed reintroduction of texts in order to increase the orthogonality level, then were recorded the evolutions given in table 5:

Table 5. The evolution of the orthogonality of structured entity T_1

Number of reintroduction	*Number of users which have uploaded the entity T_1*	*Orthogonality between [0;0.75)*	*Orthogonality between [0.75;1.00]*
first reintroduction	54	4	50
second reintroduction	4	0	4

Result a synthetic approach obtained by modifying 54 entities, in 92.59% of cases at the first change was obtained the increase of the orthogonality over the 0.75 limit imposed, and at the second change was obtained the orthogonality growth in 100% of cases, respecting the limit that the orthogonality of T_1 entity rises the threshold of 0.75, which indicate the users orientation towards entities with a high level of orthogonality.

In the second case of testing the application, one starts from a series of specifications imposed to users. Thus are considered the specifications S_1, S_2, ..., S_6. Based on these specifications are built homogeneous lots of programs. The acquisition of lots of programs from users is performed using the ORTOES application.

The collectivity of users is composed of a total of 118 members. Of these, only 114 have met the requirements for uploading personal solutions of the specifications mentioned. In table 6 is presented the users arrangement according to these six types of problems to solve:

Table 6. The users arrangement according to specifications of problems to solve

Specification	*No. of members which have uploaded the solution*	*No. of members which do not have uploaded the solution*
S_1	96	18
S_2	96	18
S_3	93	21
S_4	91	23
S_5	81	33
S_6	103	11

As shown in table 1, for any specification do not were submitted solutions by all the members of the collectivity, the lowest number of students who brought the solution is 81, corresponding to the S_5 specification, and the highest number of solutions appropriate to a specification is 103, corresponding to the S_6 specification.

In table 7 are presented the highest and lowest values of the orthogonality indicator appropriate to the six specifications:

Table 7. The maximum and minimum values of the orthogonality

Specification	*Maximum value*	*Minimum value*
S_1	0.996	0.799
S_2	0.996	0.861
S_3	0.996	0.906

S_4	0.996	0.822
S_5	0.995	0.81
S_6	1	0.799

From the table 7 result that only for the S_6 specification was achieved the maximum level of the orthogonality, value obtained because the solutions appropriate of this specification are more extended, their complexity being very high.

In [8] is presented a method for assessing collaborative systems that allow novice evaluators to show pervasive observations on the systems they evaluate, at a comparable level with those of experts in certain situations.

6. Conclusion

It is important to assure a complete process for increasing the orthogonality level, being interested in finite-products, and while is being created the opportunity of modifying the component systems in order to increase the level of orthogonality, this process is benefic.

Regarding the collaborative systems it is important to assure a high level of orthogonality in order to process the information through all component systems at a high speed and precision. The resulting data must be unique and with a high degree of applicability.

Analyzing the collective systems through the orthogonality criterion has a big impact on the quality of the systems.

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