

Collaborative Educational System Analysis and Assessment

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Abstract — The paper presents definitions of collaborative systems, their classification and the study of collaborative systems in education. It describes the key concepts of collaborative educational systems. There are listed main properties and quality characteristics of collaborative educational systems. It analyzes the application for the assessment of text entities orthogonality within a collaborative system in education, represented by a virtual campus. It implements a metric for evaluating the orthogonality.

Keywords — collaborative system; education; virtual campus; evaluation; orthogonality;

I. 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 that build the four components of a collaborative system are: 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 that include 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 presented an example of collaborative information system, defined as a distribution company whose objective is to sell increasing quantities of its 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] the quality characteristics of collaborative systems, structures of collaborative systems and estimation of their quality are presented. 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 the system to synthesize these data and transform them into meaningful data, with a certain importance.

Collaborative systems are characterized by a lot of states S_1, S_2, \dots, 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 the transition from the state S_i to the state S_j is not possible for whatever i and j in the range $1..n$. The system passes from one state to another, but fails passing from every state to all other states.

The structure of the paper include the analysis of collaborative systems in education, the evaluation of text entities orthogonality within a collaborative system represented by a virtual campus and the implementation of metrics for orthogonality evaluation.

II. COLLABORATIVE SYSTEMS IN EDUCATION

The collaborative systems need new educational standards. Using the type of application criterion, collaborative systems are classified into several categories, one of which is collaborative systems in education. Such systems are applied in the educational field and have the objective to evaluate and increase the performance of the educational process.

In [5] is proposed a web-based collaborative educational

system that promotes the use of high-quality, open-source code examples as teaching materials to connect theories and practices of software engineering and computer science.

The educational system is a collaborative system. It considers the lots: T - the set of teachers, L - the set of learners and S - the set of students. There is collaboration between elements of sets T and L, between elements of sets T and S and between elements of sets T, L and S. The collaborative systems design is oriented to all partners: teachers, learners and students. A significant example of collaborative system in education is the virtual campus.

A virtual campus is a collaborative educational system serving to develop processes in which teachers post lessons and courses, realize databases of tests, organize the schedule of evaluations. In a virtual campus, a student signs up for certain courses, takes exams and receives credits. [6]

The virtual campus refers to an effective collaborative system in which people and equipment cooperate in order to achieve certain objectives. This is about Human-Human Interaction and Human-Computer Interaction.

The virtual campus has internal components, like: databases and portals, and external components, such as: teachers, students and computers. In Figure 1 are presented the external components of the virtual campus:

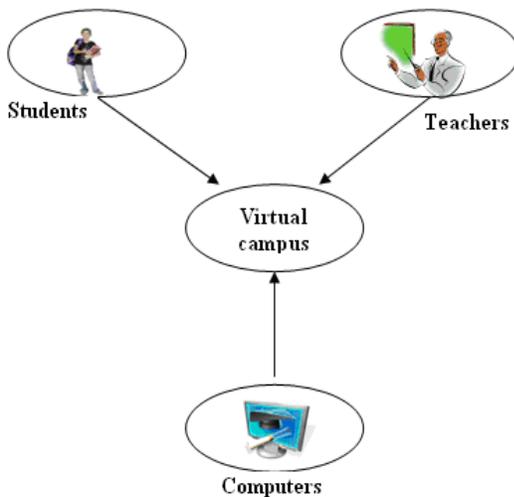


Figure 1. The external components of the virtual campus [7]

The university virtual campus is an organization with structure of collaborative type, in which interacts 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.

The objectives of the virtual campus are:

- developing and diversifying the online education for all the educational forms, activities held on the e-learning platform of a university;
- providing logistical support;
- monitoring the e-learning activities;
- training the participants;
- developing student and teacher's online guide.

The improvement in the education caused by using a collaborative system, as a virtual campus, is given by the Human-Computer interaction, which is more powerful, and the educational system is more efficient.

The increasing of the educational process' quality and of the virtual campus, designed as a collaborative system, is achieved through *diversification*. This means that the assessment methods should not be the same for all the courses. Are supported not only tests with multiple choices, but are also solved certain problems. If is given a linear system of differential equations, the student solves it, submits the solutions and, if these are correct, he gets points. Another example of diversification of assessment methods is that in which the student is given a problem, he solves it, enters the results on the platform, the system displays an option to solve it and if its results are invalid, then it learns how was the correct way to do. Diversification is achieved also through the use of smart books, in which the student is tested before and, depending on the points that he gets, it provides more complex or simple material. [6]

III. EVALUATION OF TEXT ENTITIES ORTHOGONALITY WITHIN A COLLABORATIVE SYSTEM

The problems analyzed by means of virtual campuses are processed and stored using structured entities. The virtual campus is a collaborative system that is treated with structured entities. The assessment in the virtual environment is achieved through:

- tests with multiple choices, 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 a 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. [8]

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 analyzes the degree of similarity between two or more entities. Through this quality characteristic is determined the measure in which the entities differ one from each other.

The measure in which two texts are different depending on the length of vocabularies is highlighted by the following indicator:

$$H_{LV} = \frac{\min \{LG(V_1), LG(V_2)\}}{\max \{LG(V_1), LG(V_2)\}},$$

where:

$LG(V_1)$ – the number of distinct words used in the text T_1 ;

$LG(V_2)$ – the number of distinct words used in the text T_2 ;

The orthogonality of structured entities is calculated according to the time at which they are uploaded into the ORTOES application: the user that uploads 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 processes, 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.ase.ro.

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. All tests are part of the first case of testing, the second case of testing being that with specifications.

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

<i>Entity</i>	<i>Share</i>
<i>Structured entity project T_1</i>	78%
<i>Structured entity project T_2</i>	55%
<i>Structured entity project T_3</i>	63%

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

TABLE 2. THE SHARE OF ORTHOGONALITY LEVEL

<i>Entity</i>	<i>Orthogonality between [0;0.75)</i>	<i>Orthogonality between [0.75;0.85)</i>	<i>Orthogonality between [0.85;1.00]</i>
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

<i>Entity</i>	<i>Share</i>	<i>Frequency</i>
T_4	24.32%	36
T_5	68.91%	102
T_6	0.02%	3
T_7	0.02%	4

T_8	0.027%	3
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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	Orthogonal ity between [0;0.75)	Orthogonal ity between [0.75;0.85)	Orthogonal ity between [0.85; 1]
T_4	2	0	34
T_5	0	0	102
T_6	0	2	1
T_7	0	2	2
T_8	0	0	3

If there were performed reintroduction of texts in order to increase the orthogonality level, than these 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	Orthogon ality between [0;0.75)	Orthogon ality between [0.75;1]
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, \dots, 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 6, for any specification for which were not 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 orthogonality, value obtained because the solutions appropriate of this specification are more extended, their complexity being very high.

In [9] 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.

Through the benefits of evaluating text entities orthogonality in a collaborative educational system is included the possibility to increase the originality of materials and projects realized.

The ORTOES application has a database that stores information about user behavior: when they enter in the application, the options that they access, when they exit. The application contains a number of counters for the information analysis on user behavior. The values are 0 for all counters when a user enters into the application. As the user accesses certain features of the application, the counters associated with these options are activated and takes the value 1. Introduction of these counters is to develop an automatic restructuring of the application, according to the

most frequently options accessed by users. They intend to maintain the collaborative system complexity in certain operating limits.

IV. METRIC IMPLEMENTATION FOR ORTHOGONALITY EVALUATION

Software metric is a mathematical model developed around an equation. Metrics use analytical expressions of the form $y = f(x, z, w)$, where x, z and w are variables of influence factors, and y is the result variable. A software metric must be characterized by the following properties: sensitivity, not compensatory character, not catastrophic character, representativeness.

In order to establish the orthogonality H , of two C++ source files, S_1 and S_2 , is used the indicator:

$$H = 1 - \frac{NCC}{\max(LG(S_1), LG(S_2))}$$

where:

NCC – number of common words;

LG() – length of solution, represented as a number of component words.

To implement the metrics for analyzing the application for orthogonality's evaluation, are developed procedures written in the languages C#.NET and ASP.NET, integrated into an application, SMSC, available at <http://collaborative.brinkster.net>. The application objective is to calculate indicators associated to collaborative systems and establish correlations between them. SMSC allow assessing several types of collaborative systems by determining the four indicators specific of each system: complexity, reliability, portability and maintainability.

For characterization and classification of a collaborative system into a certain category in terms of complexity, reliability, portability and maintainability, the application provides to the user the possibility to determine an indicator of metric refinement, applied to that system.

Refining the metric for the evaluation of a collaborative system, represented by ORTOES application, is a transformation process of a system with complexity C in another system with complexity C' , where $C > C'$ and the levels of representativeness of the two systems are not significantly different. The metric refinement indicator I , of a system in the case of four influence factors, is calculated according to:

$$I = \frac{\min\{a, b, c, d\}}{\max\{a, b, c, d\}}$$

where:

a – the complexity level;

b – the reliability level;

c – the portability level;

d – the maintainability level.

The metric refinement indicator takes values between 0 and 1, the 0 value showing the best results. In order to determine the values of variables a, b, c and d are taken into

account the following characteristics of the ORTOES application:

- has a number of 4 modules, consisting of several functions;
- the successfully operating rate of the applicaton in one day is 95%;
- to ensure the portability of the application from one server to another, at a number of 100 instructions of the application will take place: adding 10 instructions, eliminate 15 and modify 5 instructions;
- the time needed to perform changes in the application in order to keep it in use is 85 units of time, and the time needed to application development is 100 units of time.

The maximum complexity value of the application ORTOES determined with SMSC is 10, the reliability indicator is 0.95, the value obtained for the portability indicator is 0.70 and the value of the maintainability indicator is 0.85. In Figure 2 are presented the results for the variables a, b, c and d :

Complexity:	10
Reliability:	0.95
Portability:	0.70
Maintainability:	0.85
Refinement:	0.07

Figure 2. The values of the indicators calculated with SMSC

Depending on the values calculated for the four indicators, with the SMSC was obtained a value of 0.07 for the metric refinement indicator. This value is very good and proves that the ORTOES application needs minor changes in order to be refined from the point of view of influence factors.

In order to measure the quality of a collaborative system, represented by ORTOES application, and assess its performance is used the indicator:

$$Q = p_1 * \frac{\min(x, y)}{\max(x, y)} + p_2 * \frac{\min(z, w)}{\max(z, w)},$$

where:

x, z – the planned values for two quality characteristics;

y, w – the realized values for two quality characteristics;

p_1, p_2 – the share of each quality characteristic ($p_1 + p_2 = 1$).

In [10] are presented methods of genetic algorithms, which are retrieved directly in refining the metrics of collaborative systems.

V. CONCLUSION

In designing an educational system should be taken into account the context in which it will be used and the views of the social group that will use it. Learning should be seen not only as a process of information transfer from teacher to student, but as knowledge-building process while

interacting with other participants of the group to a specific educational activity. [11]

The development of collaborative systems conducts 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 informational 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.

Another benefit of evaluating text entities orthogonality in a collaborative educational system is the creation of a collaborative teaching and learning 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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