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Collaborative systems assessment

1. INTRODUCTION

Collaborative systems represent a new interdisciplinary domain at the intersection of economics, computer science, management, sociology, etc. From the implementation viewpoint, the collaborative systems represent 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. Implementing a collaborative system is accomplished using software instruments that allow the development of distributed software applications.

The informatics collaborative system is like a distribution firm that has the objective to sell more and more quantities of their products and for that has commercial agents which go to various retail shops in order to convince them to close a distribution contract.

A collaborative system is one where multiple users or agents are engaged in a shared activity, usually from remote locations. In the large family of distributed applications, collaborative systems are distinguished by the fact that the agents in the system are working together towards a common goal and have a critical need to interact closely with each other.

The collaborative systems assessment is an important problem of our days, and an important part of the human activities is involved in this problem. The complexity of this subject, but also the huge number of the applications makes impossible to have a large presentation in a note, but we would underline some of the main aspects.

Science has great impact on the development of different types of collaborative systems from various activity fields. One important domain that was one of the first fields presenting great interest in implementing complex collaborative systems is the military. The complexity of exercises and military deployment of forces involves the coordination of many resources. The

collaboration between different system components has a significant effect on achieving final objectives. Otherwise the results may conduct to a disaster.

Another example is given by the medical field in which modern communication technologies allow doctors from around the world to work on the same patient. In a chirurgical operation each person from the group of doctors has distinct roles. In this example it is analyzed a collaborative system model representing a training on different chirurgical activities that is done in a virtual medium. The training is based on the scenario in which the instructor and the trainee are on different locations. The instructor and the trainee share a common virtual space that contains various three-dimensional anatomical models. Each person interacts with the other one through the virtual space and a medical simulation engine describes the physical and logical behavior of objects present on the virtual scene. The interaction is maintained by a multi-modal interface that uses visual 2D and 3D data, voices and audio simulation. Each person is in front of a working table that has a monitor and stereo active pair of glasses. All of these generate a three-dimensional desktop. For collaborative use, it has been implemented a mini broadband system that allows creating a videoconference between persons.

The interaction between the instructor and the trainee is based on voice, gestures, chirurgical demonstrative actions, step by step tutorial and simultaneous actions.

The chirurgical training from this example, suppose a high level of interaction between the two persons. In opposition with training systems developed only for chirurgical dexterity, this process is concentrated also on procedures that target the understanding of the patient anatomy. The learning process is enhanced by the demonstration, the dialog and the show how activities.

2. INDICATORS FOR COLLABORATIVE SYSTEMS CHARACTERISTICS ASSESSMENT

The analytical forms of the indicators must be built such as the indicators simultaneously assure the following conditions. They must be:

- *sensitive*, that is at small variations of the influence factors the result variable has small variations; at big variations of the influence factors the result variable has big variations;
- *non-compensatory*, that is at different variation sets of the factors, small values of the result variable are not obtained;
- *non-catastrophic*, that is at small variations of the factors, big variations of the result variable have not to obtain;
- *representative,* it represents the quality to be accepted by users in analysis making assuring the significance of the results.

The analytical form of an indicator used to measured quantitative levels for collaborative systems qualitative characteristics is based on

$$y = f(x_1, x_2, \ldots, x_{nfc}),$$

where:

- ***nfc*** – number of identified factors which have impact on the evolution of analyzed phenomena;
- x_i – measured level for the ith influence factor of the case study;
- ***f( )*** – an analytical real form used to represent the dependency between the influence factors and result variables; it is used to describe and to study the phenomenon;
- ***y*** – result variable that describe an existing situation in the phenomenon evolution.

In case of the type **I** indicators, that have analytical forms as:

$$I = \frac{A}{B}$$

the catastrophic character is the result of the very high variation of metrics value while the value of B factor is converging to zero.

The indicator $K_T = N_1 log_2 N_1 + N_2 log_2 N_2$ is sensitive, because the variations from N_1 to $N_1' = N_1 + \gamma$, respectively from N_2 to $N_2' = N_2 + \Delta$ determines:

$K_T' = N_1' \log_2 N_1' + N_2' \log_2 N_2' = (N_1+\gamma) \log_2(N_1+\gamma) + (N_2+\Delta) \log_2(N_2+\Delta) =$
$N_1 * \log_2(N_1+\gamma) + N_2 * \log_2(N_2+\Delta) + \gamma * \log_2(N_1+\gamma) + \Delta * \log_2(N_2+\Delta) > K_T + \gamma * \log_2(N_1+\gamma) + \Delta * \log_2(N_2+\Delta)$

In the case of **n** variables $\mathbf{x_1}, \mathbf{x_2}, \ldots, \mathbf{x_n}$, a generalized indicator for collaborative systems are:

$$I_n = f(x_1, x_2, \ldots, x_n) = \frac{\min\{x1, x2, \ldots, xn\}}{\max\{x1, x2, \ldots, xn\}}$$

For this indicator, the maximal value are **1** when $\mathbf{x_1=x_2=\ldots=x_n}$, with the condition that $\mathbf{x_i>0, i=1..n}$. The sensitive property for this indicator are verified, but the non-compensatory property is not verified, because at different variation sets of $\mathbf{x_1}, \mathbf{x_2}, \ldots, \mathbf{x_n}$ factors, the $\mathbf{I_n}$ value is the same.

To study the sensitive property for the indicator:
$\mathbf{Y = p_1 * \min\{A, B\}/\max\{A, B\} + p_2 * \min\{C, D\}/\max\{C, D\}}$, where $\mathbf{p_1 + p_2 = 1}$, seven cases are take into consideration:

Case I: the variable **A** grow with the value **θ,** where **θ>0.**
Result: $\mathbf{Y1 = p_1 * \min\{A + \theta, B\}/\max\{A + \theta, B\} + p_2 * \min\{C, D\}/\max\{C, D\}}$
a) $\mathbf{A + \theta < B}$ and $\mathbf{A < B}$, result $\mathbf{Y1 = p_1 * (A + \theta) / B + p_2 * \min\{C,D\}/\max\{C,D\}}$ and $\mathbf{Y = p_1 * A / B + p_2 * \min\{C, D\}/\max\{C, D\}}$
In this case, $\mathbf{Y1 = Y + p_1 * \theta / B}$.
b) $\mathbf{A + \theta = B}$ and $\mathbf{A < B}$, result $\mathbf{Y1 = p_1 + p_2 * \min\{C, D\}/\max\{C, D\}}$ and $\mathbf{Y = p_1 * A / B + p_2 * \min\{C, D\}/\max\{C, D\}}$
In this case, $\mathbf{Y1 = Y + p_1 * (1 - A / B)}$.
c) $\mathbf{A + \theta > B}$ and $\mathbf{A < B}$, result $\mathbf{Y1 = p_1 * B / (A + \theta) + p_2 * \min\{C,D\}/\max\{C,D\}}$ and $\mathbf{Y = p_1 * A / B + p_2 * \min\{C, D\}/\max\{C, D\}}$

In this case, $\mathbf{Y1 = Y + p_1 * (B / (A + \theta) - A / B)}$.
d) $\mathbf{A + \theta > B}$ and $\mathbf{A > B}$, result $\mathbf{Y1 = p_1 * B / (A + \theta) + p_2 * \min\{C,D\}/\max\{C,D\}}$ and $\mathbf{Y = p_1 * B / A + p_2 * \min\{C,D\}/\max\{C,D\}}$
In this case, $\mathbf{Y1 = Y + p_1 * (B / (A+\theta) - B / A)}$.
e) $\mathbf{A + \theta > B}$ and $\mathbf{A = B}$, result $\mathbf{Y1 = p_1 * B / (A + \theta) + p_2 * \min\{C,D\}/\max\{C,D\}}$ and $\mathbf{Y = p_1 + p_2 * \min\{C, D\}/\max\{C, D\}}$
In this case, $\mathbf{Y1 = Y + p_1 * (B / (A + \theta) - 1)}$.

Case II: the variable **B** grow with the value $\boldsymbol{\varepsilon}$, where $\boldsymbol{\varepsilon > 0}$.
Result: $\mathbf{Y2 = p_1 * \min\{A, B + \varepsilon\}/\max\{A, B + \varepsilon\} + p_2 * \min\{C, D\}/\max\{C, D\}}$
a) $\mathbf{A < B + \varepsilon}$ and $\mathbf{A < B}$, result $\mathbf{Y2 = p_1 * A / (B + \varepsilon) + p_2 * \min\{C, D\}/\max\{C,D\}}$ and $\mathbf{Y = p_1 * A / B + p_2 * \min\{C, D\}/\max\{C, D\}}$
In this case, $\mathbf{Y2 = Y + p_1 * (A / (B+\varepsilon) - A / B)}$.
b) $\mathbf{A = B + \varepsilon}$ and $\mathbf{A > B}$, result $\mathbf{Y2 = p_1 + p_2 * \min\{C, D\}/\max\{C, D\}}$ and $\mathbf{Y = p_1 * B / A + p_2 * \min\{C, D\}/\max\{C, D\}}$
In this case, $\mathbf{Y2 = Y + p_1 * (1 - B / A)}$.
c) $\mathbf{A > B + \varepsilon}$ and $\mathbf{A > B}$, result $\mathbf{Y2 = p_1 * (B + \varepsilon) / A + p_2 * \min\{C,D\}/\max\{C,D\}}$ and $\mathbf{Y = p_1 * B / A + p_2 * \min\{C, D\}/\max\{C, D\}}$
In this case, $\mathbf{Y2 = Y + p_1 * ((B+\varepsilon) / A - B / A)}$.
d) $\mathbf{A < B + \varepsilon}$ and $\mathbf{A = B}$, result $\mathbf{Y2 = p_1 * A / (B + \varepsilon) + p_2 * \min\{C, D\}/\max\{C,D\}}$ and $\mathbf{Y = p_1 + p_2 * \min\{C, D\}/\max\{C, D\}}$
In this case, $\mathbf{Y2 = Y + p_1 * (A / (B + \varepsilon) - 1)}$.

Case III: the variable **C** grow with the value $\boldsymbol{\eta}$, where $\boldsymbol{\eta > 0}$.
Result: $\mathbf{Y3 = p_1 * \min\{A,B\}/\max\{A,B\} + p_2 * \min\{C+\eta,D\}/\max\{C+\eta,D\}}$
a) $\mathbf{C + \eta < D}$ and $\mathbf{C < D}$, result $\mathbf{Y3 = p_1 * \min\{A, B\}/\max\{A, B\} + p_2 * (C+\eta)/D}$ and $\mathbf{Y = p_1 * \min\{A, B\}/\max\{A, B\} + p_2 * C / D}$
In this case, $\mathbf{Y3 = Y + p_2 * \eta / D}$.
b) $\mathbf{C + \eta = D}$ and $\mathbf{C < D}$, result $\mathbf{Y3 = p_1 * \min\{A, B\}/\max\{A, B\} + p_2}$ and $\mathbf{Y = p_1 * \min\{A, B\}/\max\{A, B\} + p_2 * C / D}$
In this case, $\mathbf{Y3 = Y + p_2 * (1 - C / D)}$.
c) $\mathbf{C + \eta > D}$ and $\mathbf{C < D}$, result $\mathbf{Y3 = p_1 * \min\{A,B\}/\max\{A,B\} + p_2 * D / (C+\eta)}$ and $\mathbf{Y = p_1 * \min\{A,B\}/\max\{A,B\} + p_2 * C / D}$
In this case, $\mathbf{Y3 = Y + p_2 * (D / (C+\eta) - C / D)}$.
d) $\mathbf{C + \eta > D}$ and $\mathbf{C > D}$, result $\mathbf{Y3 = p_1 * \min\{A, B\}/\max\{A, B\} + p_2 * D/(C+\eta)}$ and $\mathbf{Y = p_1 * \min\{A, B\}/\max\{A, B\} + p_2 * D / C}$
In this case, $\mathbf{Y3 = Y + p_2 * (D / (C + \eta) - D / C)}$.
e) $\mathbf{C + \eta > D}$ and $\mathbf{C = D}$, result $\mathbf{Y3 = p_1 * \min\{A, B\}/\max\{A, B\} + p_2 * D / (C+\eta)}$ and $\mathbf{Y = p_1 * \min\{A, B\}/\max\{A, B\} + p_2}$
In this case, $\mathbf{Y3 = Y + p_2 * (D / (C + \eta) - 1)}$.

Case IV: the variable **D** grow with the value $\boldsymbol{\delta}$, where $\boldsymbol{\delta > 0}$.
Result: $\mathbf{Y4 = p_1 * \min\{A,B\}/\max\{A,B\} + p_2 * \min\{C,D+\delta\}/\max\{C,D+\delta\}}$
a) $\mathbf{C < D + \delta}$ and $\mathbf{C < D}$, in this case, $\mathbf{Y4 = Y + p_2 * (C / (D + \delta) - C / D)}$.
b) $\mathbf{C = D + \delta}$ and $\mathbf{C > D}$, in this case, $\mathbf{Y4 = Y + p_2 * (1 - D / C)}$.
c) $\mathbf{C > D + \delta}$ and $\mathbf{C > D}$, in this case, $\mathbf{Y4 = Y + p_2 * ((D+\delta) / C - D / C)}$.
d) $\mathbf{C < D + \delta}$ and $\mathbf{C = D}$, in this case, $\mathbf{Y4 = Y + p_2 * (C / (D + \delta) - 1)}$.

Case V: the variable **A** grow with the value **θ,** the variable **C** grow with the value **η,** where **$\theta > 0$, $\eta > 0$.**
Result: **$Y5 = p_{1*} \min\{A+\theta, B\}/\max\{A+\theta, B\} + p_{2*} \min\{C+\eta, D\}/\max\{C+\eta, D\}$**
a) **$A + \theta < B$** and **$A < B$, $C + \eta < D$** and **$C < D$,** in this case, **$Y5 = Y+p_{1*} \theta / B + p_{2*} \eta/D$**
b) **$A + \theta = B$** and **$A < B$, $C + \eta < D$** and **$C < D$,** in this case, **$Y5 = Y + p_{1*} (1-A/B) + p_{2*} \eta / D$**
c) **$A + \theta > B$** and **$A < B$, $C + \eta < D$** and **$C < D$,** in this case, **$Y5 = Y + p_{1*} (B / (A+\theta) - A / B) + p_{2*} \eta / D$**
d) **$A + \theta > B$** and **$A > B$, $C + \eta < D$** and **$C < D$,** in this case, **$Y5 = Y + p_{1*} (B / (A+\theta) - B / A) + p_{2*} \eta / D$**
e) **$A + \theta > B$** and **$A = B$, $C + \eta < D$** and **$C < D$,** in this case, **$Y5 = Y + p_{1*} (B / (A + \theta) - 1) + p_{2*} \eta / D$**
f) **$A + \theta < B$** and **$A < B$, $C + \eta = D$** and **$C < D$,** in this case, **$Y5 = Y + p_{1*} \theta / B + p_{2*} (1 - C / D)$.**
g) **$A + \theta < B$** and **$A < B$, $C + \eta > D$** and **$C < D$,** in this case, **$Y5 = Y + p_{1*} \theta / B + p_{2*} (D / (C + \eta) - C / D)$.**
h) **$A + \theta < B$** and **$A < B$, $C + \eta > D$** and **$C > D$,** in this case, **$Y5 = Y + p_{1*} \theta / B + p_{2*} (D / (C + \eta) - D / C)$.**
i) **$A + \theta < B$** and **$A < B$, $C + \eta > D$** and **$C = D$,** in this case, **$Y5 = Y + p_{1*} \theta / B + p_{2*} (D / (C + \eta) - 1)$.**
j) **$A + \theta = B$** and **$A < B$, $C + \eta = D$** and **$C < D$,** in this case, **$Y5 = Y + p_{1*} (1 - A/B) + p_{2*} (1 - C / D)$.**
k) **$A + \theta = B$** and **$A < B$, $C + \eta > D$** and **$C < D$,** in this case, **$Y5 = Y + p_{1*} (1 - A/B) + p_{2*} (D / (C + \eta) - C / D)$.**
l) **$A + \theta = B$** and **$A < B$, $C + \eta > D$** and **$C > D$,** in this case, **$Y5 = Y + p_{1*} (1 - A/B) + p_{2*} (D / (C + \eta) - D / C)$.**

Case VI: the variable **B** grow with the value **ε,** the variable **D** grow with the value **δ,** where **$\varepsilon > 0$, $\delta > 0$.**
Result: **$Y6 = p_{1*} \min\{A, B + \varepsilon\}/\max\{A, B + \varepsilon\} + p_{2*} \min\{C, D + \delta\}/\max\{C, D + \delta\}$**
a) **$A < B + \varepsilon$** and **$A < B$, $C < D + \delta$** and **$C < D$,** in this case, **$Y6 = Y + p_{1*} (A / (B+\varepsilon) - A / B) + p_{2*} (C / (D+\delta) – C / D)$.**
b) **$A = B + \varepsilon$** and **$A > B$, $C < D + \delta$** and **$C < D$,** in this case, **$Y6 = Y + p_{1*} (1 - B/A) + p_{2*} (C / (D + \delta) – C / D)$.**
c) **$A > B + \varepsilon$** and **$A > B$, $C < D + \delta$** and **$C < D$,** in this case, **$Y6 = Y + p_{1*} \varepsilon / A + p_{2*} (C / (D + \delta) – C / D)$.**
d) **$A < B + \varepsilon$** and **$A = B$, $C < D + \delta$** and **$C < D$,** in this case, **$Y6 = Y + p_{1*} (A / (B + \varepsilon) – 1) + p_{2*} (C / (D + \delta) – C / D)$.**
e) **$A = B + \varepsilon$** and **$A > B$, $C = D + \delta$** and **$C > D$,** in this case, **$Y6 = Y + p_{1*} (1 - B/A) + p_{2*} (1 - D / C)$.**
f) **$A = B + \varepsilon$** and **$A > B$, $C > D + \delta$** and **$C > D$,** in this case, **$Y6 = Y + p_{1*} (1 - B/A) + p_{2*} \delta / C$.**
g) **$A < B + \varepsilon$** and **$A = B$, $C > D + \delta$** and **$C > D$,** in this case, **$Y6 = Y + p_{1*} (A / (B + \varepsilon) – 1) + p_{2*} \delta / C$.**
h) **$A < B + \varepsilon$** and **$A = B$, $C = D + \delta$** and **$C > D$,** in this case, **$Y6 = Y + p_{1*} (A / (B + \varepsilon) – 1) + p_{2*} (1 - D / C)$.**

Case VII: the variable **A** grow with the value **θ,** the variable **B** grow with the value **ε,** the variable **C** grow with the value **η,** the variable **D** grow with the value **δ,** where $\varepsilon > 0, \delta > 0, \theta > 0, \eta > 0$.

Result: $Y7 = p_1 * \min\{A + \theta, B + \varepsilon\}/\max\{A + \theta, B + \varepsilon\} + p_2 * \min\{C+\eta, D+\delta\}/\max\{C + \eta, D + \delta\}$

a) $A + \theta < B + \varepsilon$ and $A < B$, $C + \eta < D + \delta$ and $C < D$, in this case, $Y7 = Y + p_1 * ((A + \theta) / (B + \varepsilon) - A / B) + p_2 * ((C + \eta) / (D + \delta) - C / D)$.

b) $A + \theta > B + \varepsilon$ and $A < B$, $C + \eta < D + \delta$ and $C < D$, in this case, $Y7 = Y + p_1 * ((B + \varepsilon) / (A + \theta) - A / B) + p_2 * ((C + \eta) / (D + \delta) - C / D)$.

c) $A + \theta = B + \varepsilon$ and $A < B$, $C + \eta < D + \delta$ and $C < D$, in this case, $Y7 = Y + p_1 * (1 - A / B) + p_2 * ((C + \eta) / (D + \delta) - C / D)$.

d) $A + \theta < B + \varepsilon$ and $A = B$, $C + \eta < D + \delta$ and $C < D$, in this case, $Y7 = Y + p_1 * ((A + \theta) / (B + \varepsilon) - 1) + p_2 * ((C + \eta) / (D + \delta) - C / D)$.

e) $A + \theta < B + \varepsilon$ and $A < B$, $C + \eta > D + \delta$ and $C < D$, in this case, $Y7 = Y + p_1 * ((A + \theta) / (B + \varepsilon) - A / B) + p_2 * ((D + \delta) / (C + \eta) - C / D)$.

f) $A + \theta < B + \varepsilon$ and $A < B$, $C + \eta = D + \delta$ and $C < D$, in this case, $Y7 = Y + p_1 * ((A + \theta) / (B + \varepsilon) - A / B) + p_2 * (1 - C / D)$.

g) $A + \theta < B + \varepsilon$ and $A < B$, $C + \eta < D + \delta$ and $C = D$, in this case, $Y7 = Y + p_1 * ((A + \theta) / (B + \varepsilon) - A / B) + p_2 * ((C + \eta) / (D + \delta) - 1)$.

The indicator is sensitive in case in which the levels associated to the influence factors have a variation such as it obtains the same general type of variation for the analyzed collaborative system.

3. SOFTWARE FOR INDICATORS IMPLEMENTATION

The software realized for the exemplification of the principals indicators of the collaborative systems has the goal to estimate the indicators like complexity, reliability, maintainability and functionality.

The McCabbe complexity was implemented in C#.NET language with the next function:

```
protected void Button1_Click(object sender, EventArgs e)
{
TextBox3.Text =
Convert.ToString(Convert.ToInt32(TextBox1.Text) -
Convert.ToInt32(TextBox2.Text) + 2);
}
```

The Halstead complexity was implemented in C#.NET language with the follow function:

```
protected void Button2_Click(object sender, EventArgs e)
{
int n1 = Convert.ToInt32(TextBox4.Text);
int n2 = Convert.ToInt32(TextBox5.Text);
TextBox6.Text = Convert.ToString(n1 * Math.Log(n1,2) + n2 *
Math.Log(n2,2));
}
```

The access in the application is obtained after the user authentication. To obtain access, the users of Collaborative Systems Site must enter a valid username and password, like in figure 1:

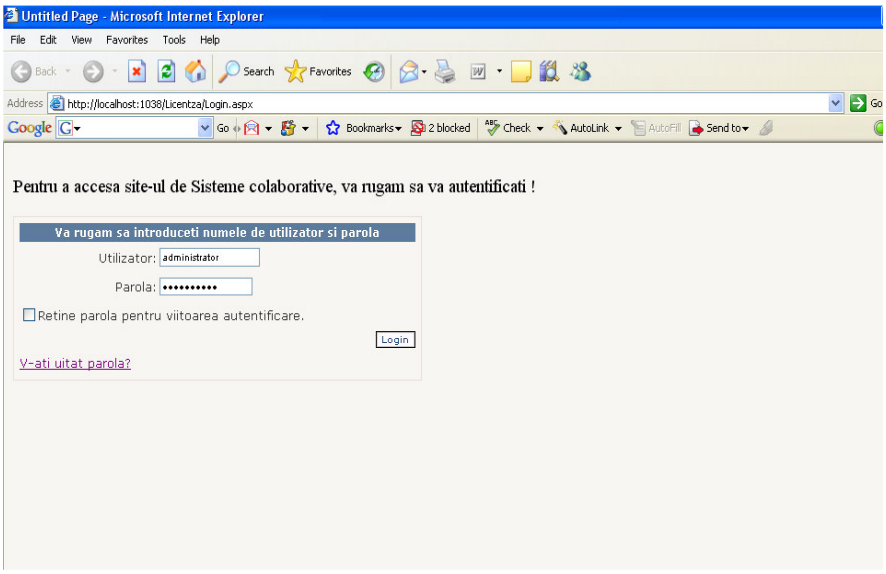
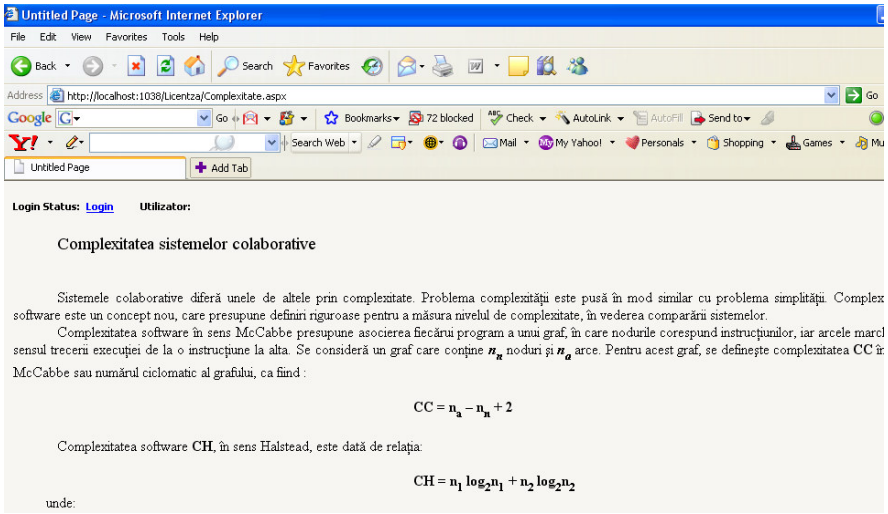


Fig. 1. Login page

The page for the calculation of McCabbe and Halstead complexity is shown in the figure 2:



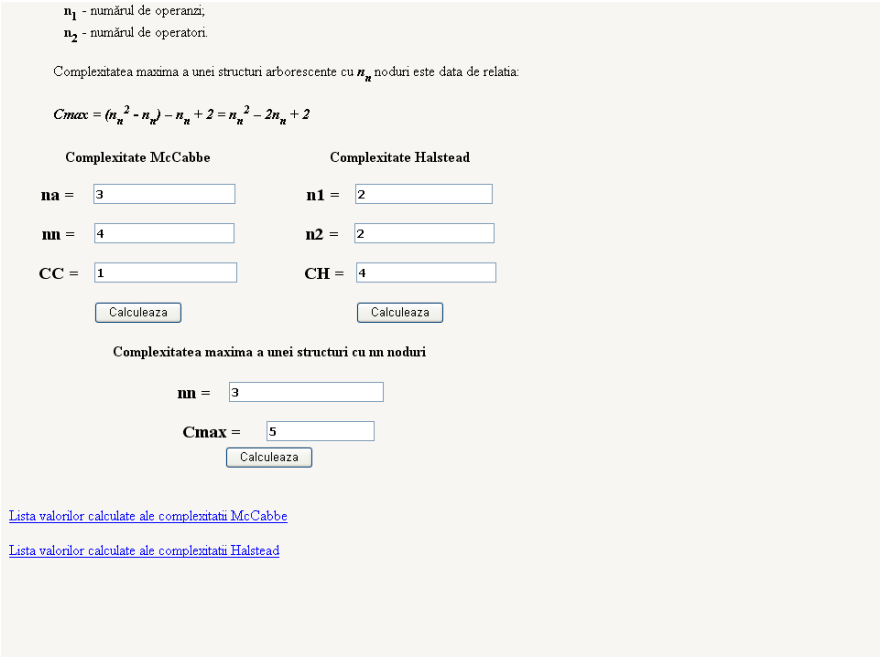


Fig. 2. The page for complexity calculation

The values of parameters *na, nn* and *CC,* for McCabbe complexity, and *n1, n2* and *CH,* for Halstead complexity, are inserted into two differents databases when the user press the associated button.

4. EDUCATIONAL COLLABORATIVE SYSTEM QUALITY ASSESSMENT

The collaborative systems needs new educational standards. Collaborative learning system represent a reculturative process that helps students become members of knowledge communities whose common property is different from the common property of the knowledge communities they already belong to.

The structure of an on-line testing application for the evaluation of students knowledge is shown in the figure 3:

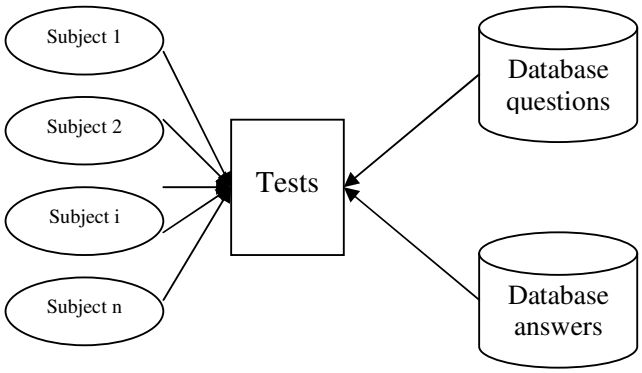


Fig. 3. The structure of the on-line testing application

The subjects answers for the tests questions can be centralized into a table like the table 1:

Table 1: Association between the subjects and the questions

	Question 1	Question 2	.....	**Question j**	.....	Question m
Subject 1				.		
Subject 2				.		
.....				.		
Subject i	**.....**	**.....**	**.....**	β_{ij}		
.....						
Subject n						

For any question in the test, the possible answers are a), b), c), d) or e). If the tests are right formulated, the results of the subjects evaluation has a normal distribution: 10% results are between 9 points and 10 points, 10% are between 3 and 4, and 80% results are between 5 and 9.

In this case, the follow situations are possible:

- all the subjects has submitted the answer a) and the correct answer was b). The conclusion is that the test was very difficult;
- all the subjects has submitted the answer b) and the correct answer is b). In this situation, the test was very simple.

The educational system is, by definition, a collaborative system. The collaboration exist between teachers and students, and between teachers - teachers and students - students.

In the figure 4 is shown the educational function of a collaborative system:

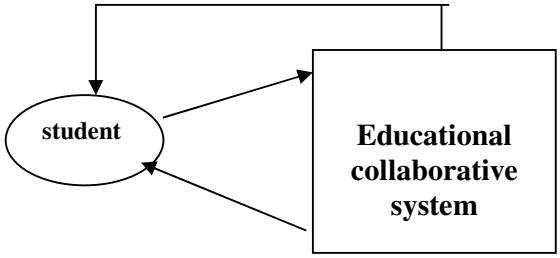


Fig. 4. The educational function of a collaborative system

The teacher offer to the student the information and the knowledge through the lesson. The student prove to the teacher that he has learned this information through the evaluation tests. Finally, the teacher offer the feedback through the score accorded to the student evaluation.

5. CONCLUSIONS

The field of systems evaluation is a domain that has many published papers and that has acquired in the last period a great volume of theoretical knowledge. This provides the methods and techniques to analyze the problem, to identify the resulting variables, the influence factors and in the end to define the model.

The complexity of the collaborative systems on which there will be applied the assessment has great impact on the number of factors and as result on the scale of the model. In the end, it must be reached equilibrium between the model dimension and its capability to give significant results. The assessment 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 loose relevance.

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