

Framework for Collaborative Systems Assessment Based on Metrics

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Abstract: *The paper some issues regarding the requirements that must be met by an assessment system of the collaborative systems. A collaborative framework and the main characteristics of a collaborative system are presented as they are depicted in literature. Development process of an assessment system for collaborative systems is summarized through its characteristics, types of measurement scales, requirements that must be met, template for defining and documenting measures and a methodology is suggested. Finally, the way in which an assessment system based on metrics must be implemented is presented. A metric process model is depicted together with its stages. Also, an implementation process for collaborative systems assessment is highlighted.*

Keywords: *collaborative system, assessment, metric, measure, development process.*

1. Characteristics of the Collaborative Systems and Processes

Term of collaboration represents is a recursive process where two or more people or organizations work together in order to achieve common goals. This process means to share knowledge, learning and to build consensus [13].

A collaborative system is based on collaboration processes. This system is composed by people or entities working together by sharing knowledge and learning.

In [3], the collaborative environment is defined as “*system which supports users in performing tasks collaboratively*”. As collaborative capabilities, there are included: human communication, persistent shared object manipulation, archival of collaborative activity and so forth [3].

A collaborative framework is depicted in [3]. According to [3], the framework has the following levels:

- *Requirement* – is divided in four parts: work tasks, transition tasks, social protocols and group characteristics; this level describes the characteristics of the group in accordance to the tasks performed by the group;
 - *Capability* – offers the functionality necessitated by different requirements; functionality is obtained from service level of the collaborative level;
 - *Service* – describes services used to support capabilities; such services can be e-mail, audio/video applications, application sharing and so forth;
 - *Technology* – describes implementation of the services;
- At requirement level, the *work tasks* are divided in the following classes [3]:
- *Planning tasks* – the group has an goal and it must develop a written plan containing the steps to reach that goal;
 - *Brainstorming and group creativity* – members of the group are asked to brainstorming ideas on a particular topic;
 - *Intellective tasks* – the group must solve o problem for which there is a solution;

- *Decision making task* – members of the group must develop consensus on issues for which they do not have correct answers;
- *Cognitive conflict tasks* – the group must take a decision although they have different viewpoints;
- *Mixed motive tasks* – range of tasks differentiated by the degree to which a group member's outcome is affected by a combination of his own actions and the group's outcome [3];
- *Competitive performances* – regards competitions between groups; each group has the goal to win over the paired group;
- *Non-competitive contests* – execution of the plan by the group;
- *Dissemination of information tasks* – distribution of the information among the group members.

The *transition tasks* are used to move between work tasks and they contain the following: outcome of the last task, assigning items to group members, deadlines [3].

Social protocols establish the ways to conduct the collaborative sessions. They aim communication between group members, group activities, meeting conduct, awareness support [3].

The group characteristics are given by some requirements as time, group type and computer requirements [3].

To ensure the quality of collaborative systems, the following measures should be taken [9]:

- Establishing the quality requirements;
- Ensuring compliance of collaborative systems with the specified requirements.

Quality paradigm is based on the ability to measure the quality. Physical properties of manufactured products are easy to be quantified numerically. To determine the quality of collaborative systems, other ways must be identified [9].

Quality characteristics of collaborative systems must be known both to those who build bodies and those whom they are intended. There must be a clearly defined system for making of system manufacturers and users of these systems.

Quality of collaborative systems is planned to determine the resources needed to develop such kind of systems. Quality is built during development process of a collaborative system. When the level of quality characteristics for intermediate stages of development process is lower than the planned one, it proceeds to change it until the planned quality levels are reached [9].

In [11], the main quality characteristics of the collaborative systems are presented, as it follows:

- *Correctness* – represents the degree in which a collaborative system is exact, being certificated without errors [9]; there are some issues regarding the correctness, as it shows in [6]:
 - Correct system is unknown;
 - Standard system is not correct;
 - Standard system has more versions;
 - Correct system is not defined.

Correctness of a collaborative system is measured through correspondence between the real collaborative system and standard system assumed as being exact.

In [11], the correctness is evaluated through the following methods:

- Mathematical demonstrations and specialized software;
- Tests on large data sets.

For numerical data, measurement of the correctness characteristic is a possible operation with a less or more complexity degree. The correctness of numerical data is determined by the difference between measured values and the standard ones.

For a collaborative system, correctness refers the correspondence between the content of such system and standard specifications of the addressed domain. Standard specifications means all of concepts, hypotheses, models defined and elaborated in an area and which were accepted by the scientific community as being fair [9].

- *Flexibility* – represents the ability of a collaborative system to expand or contract in order to adapt to the demands of a domain or another; this ability means that a collaborative system can be changed as content and structure when external changes occur; in [11], there are highlighted some issues to achieve flexibility in design stage during its development process:
 - High generality of the system to solve a large range of problems;
 - Reusing components developed for other systems that demonstrated their generality;
 - Possibility to add new features to the collaborative system;
 - Fast integration of the new components in old collaborative systems.
- *Interoperability* – is ability of a collaborative system to interact with one or more systems through exchange and use of information; some ways to assure the interoperability for a collaborative system are presented in [11]:
 - Use of generic protocols;
 - Testing of components to establish their limits before integration in collaborative system;
 - Compatibility of components to other components in collaborative system;
 - Logging procedure to trace all inputs and outputs by developers and testers;
- *Maintainability* – is ability of a collaborative system to be changed; the reasons of changes are defects, new requirements, environment changes, improvement of the future maintenance, input data structure; measuring the maintainability depends on reliability of the collaborative system; maintainability is measured in terms of elapsed times (corrective and preventive maintenance), labor hours and rates, maintenance cost and frequencies, logistic factors;
- *Reliability* – represents the ability of a collaborative system to perform its functionalities under stated conditions for a specified period of time [14]; also, reliability is probability to accomplish the functions without occurrence of errors [9]; some issues regarding measuring the reliability are presented in [9]:
 - Probability to accomplish the functions without errors under stated conditions during a period of time;
 - Ratio of accomplished functions to designed functions of the collaborative system.
- *Testability* – ability to simulate the real running of a collaborative system or a component of this one in certain conditions established by testing team; without this characteristics, the failure probability of the system or component increases, altering the reliability of the collaborative system; testing team analyses the results and validates or rejects the launching or integration; testability offers an overview regarding the quality of the collaborative system.

In addition of the above characteristics, in [9] are presented quality characteristics for abstract construction that can be adapted to collaborative systems, as it follows:

- *Consistency* – concerns absence of conflicts between collaborative systems; there two forms of consistency: semantic consistency and structural consistency. Semantic consistency presents the real world in a clear and unambiguous way.

Structural consistency involves providing the same basic structure for collaborative systems and attributes that made representation for.

It is considered the data collectivities K_X and K_Y . There is the possibility that the two data sets to contain common elements, as it is depicted in figure 1.

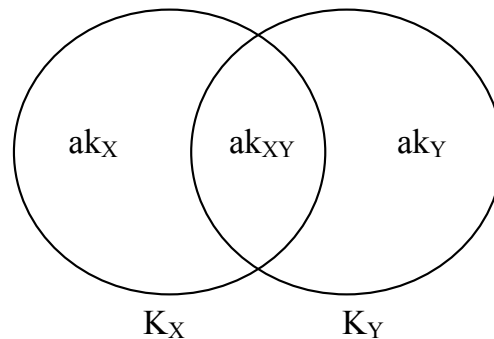


Fig. 1. Junction of X and Y data sets

Significances of the above notations are:

- ak_X – attributes of collectivity X;
- ak_{XY} – common attributes of collectivities X and Y;
- ak_Y – attributes of collectivity Y.

Consistency of collaborative system is achieved by ensuring of identity junction attributes. Consistency is ensured by inter-correlation of data.

A collaborative system is consistent if its assessment follows a set of restrictions on formal rules, logical requirements, requirements related to other data.

- Completeness – aims the degree in which the attributes are assigned values; a collaborative system is not complete if the measure of an attributes lacks; the values of the attributes are expressed quantitatively as a numerical form or qualitative as a textual form.

Collaborative systems must meet a basic set of quality characteristics [9]:

- Correctness – concerns absence of errors or acceptable limits specified by quality standards;
- Completeness – represents the degree in which values are present in attributes of the collaborative systems;
- Consistency – is the degree to which collaborative systems meet a lot of conditions; it is expressed through lack of variation and contradiction;
- Correlation – concerns reporting and comparison with other collaborative systems;
- Relevance – maintaining a collaborative system in a state that provides the ability to retrieve services required by user;
- Opportunity – providing services at a time, planned or not; it is the system capacity to satisfy the user service needs when these are required;
- Uniqueness – implies the absence of other collaborative system equal or equivalent;
- Validity – it is capacity of a collaborative system to produce the needed results.

A high quality level of collaborative systems reduces costs and increase client's availability to buy services of such system.

The forms of collaborative systems with low quality level are [9]:

- Redundancy – development costs are increased;
- Incompleteness or failure to update – determines negative effects on image of collaborative system framework;

- Poor definition – determines inefficient use of services due to incorrect values assigned attributes.

Establishing the collaborative framework is used to evaluate collaborative systems or to compare them. Also, identifying the characteristics of collaborative systems offers the possibility to improve them, having important advantages for developers and users of such systems.

2. Characteristics of the Development Process of a Collaborative Assessment System

Indicators represent the base of an assessment system. Indicators allow to create criteria, requirements, standards and to compare characteristics and results across components of distributed informatics systems [10].

The assessment system reduces the degree of subjectivity because the indicators offer an objective way to quantify characteristics or processes. Some problems regarding the assessment system aim the correctness, reliability, testing and validation of the mathematical models of the indicators and the way in which the input data are gathered and prepared must be attenuated [10].

An indicator represents a value on a scale of measurement derived from data series.

There is an assessment framework mapped on collaborative framework depicted in [3]. Assessment is made through defining data collection methods, metrics, measures, and human judgment.

In [3], a measure for collaborative framework is defined by the following items:

- Definition;
- Metrics and other measures – combination of metrics and other arithmetic formulas;
- Associated task types.

At requirement level, the following measures are defined in [3]: task outcome, cost, user satisfaction, scalability, security, interoperability, participation, efficiency and consensus.

The capability level measures evaluate the capabilities of the collaborative system and they include [3]: awareness, collaboration management, human to human communication, grounding, collaborative object support, task focus, transition.

The measures defined at service level of collaborative framework are classified in two groups [3]: breakdown and tool usage.

The technology level includes software and hardware components, interfaces and component connections. The measures aim the following issues [3]: usability and specific technology.

Metrics aim the observable data elements. They are single numbers or set of numbers. Metrics have interpretations to be used in building measures. For collaborative systems, the following metrics must be considered [3]: countables, length of turns, task completion, time, preparation cost metrics, expert judgments, user ratings, tool usage, turn overlap, repair activities, conversational constructs and so forth.

Data collection methods are used to gather metrics. They offer opportunities to obtain metrics that cannot be gathered in other ways. For metrics of collaboration systems, data collection methods include [3]: logs, direct observation, questionnaires/interviews/rating scales (open-ended, closed/fixed alternatives), tape recorder/transcription, video recorder/annotation.

The scales of measurement are classified in the following classes [7]:

- *Nominal scale* – classification is the lowest level of measurement; elements are sorted in categories in accordance to a certain attribute; also, the elements are jointly exhaustive and mutually exclusive;
- *Ordinal scale* – elements can be compared in order; more that nominal scale, the ordinal scale group elements in categories and order the categories;
- *Interval scale* – differences between measurement points are indicated; the arithmetic operators can be applied on this measurement scale;
- *Ratio scale* – it is the highest level of measurement; all operations are allowed to be applied on it; it represents an interval scale with an absolute or non-arbitrary zero point.

In relation to the reaching of the requirements of a collaborative system, the following classes are identified in [4]:

- *Success indicators* – they are used to establish if the goals are met;
- *Progress indicators* – they are used for tracking the execution of tasks;
- *Analysis indicators* – they assist the analyzing the outputs of the tasks.

Development and implementation of an assessment system must take into account the following requirements [4]:

- Identifying the indicators based on a methodology;
- Specifying the goal of the assessment system;
- Indicator traceability back to the goals;
- Clear understanding of the type and purpose of each indicator;
- Small start point for assessment;
- Indicators for detecting the trends and hidden tradeoffs;
- Customizing the indicator template;
- Use of definition checklist;
- Dissemination of the unambiguous information;
- Privacy issues of the indicators;
- Respecting the needs of involved people;
- Identifying the adequate solutions available if there is no consensus;
- Using of pilot implementation;
- Planning some assessment on short term;
- Maximizing the relevant information and minimizing the collection effort;
- Testing of the assumptions;
- Taking into account the unintended consequences and the perspectives of different stakeholders.

A template for defining and documenting a measure is provided in [4]:

- Precise objective of the indicator – purpose of the indicator;
- Inputs – data used in indicator applying;
- Algorithms – combining data;
- Assumptions – business environment, business processes and so forth;
- Data collection information – description of how, when, how often and by whom data are to be collected;
- Data reporting information – responsibilities to report data;
- Analysis and interpretation of result –meaning of the different values for indicator.

A methodology to identify measures is presented in [4]:

- Step.1 Identifying the goals;
- Step.2 Identifying what it wants to know;
- Step.3 Identifying the sub-goals;

- Step.4 Identifying the entities and attributes;
- Step.5 Formalizing the measurement goals;
- Step.6 Identifying the measurement questions and indicators;
- Step.7 Identifying the data elements;
- Step.8 Defining and documenting measures and indicators;
- Step.9 Identifying the actions needed to implement measures;
- Step.10 Preparing a plan.

Validation is the process by which it is verified if the requirements and associated properties are met.

Metrics validation aims to accept or reject a metric. It is completed with explanations about the reasons of rejecting and modifications necessary to eliminate deficiencies. It is convenient to conclude the validation process with indicators superior to those undergoing the validation process.

Validated indicators must meet the properties regarding representativeness, generality, completeness, sensitivity, non-catastrophic character and non-compensatory character.

There are the following validation forms, as it is presented in [9]:

- Experimental validation – providing notes and acceptance / rejection of the metric by analyzing notes;
- Structural validation – consider the elements involved in development process of the indicators.

Development process of collaborative assessment system must respect a methodology to get measures (indicators) that are rigorous, consistent, reliable and significant for the field where they are applied.

3. Using Metrics for Collaborative Systems Assessment

Metrics bring value in any field where they are used. The added value by the metrics is higher as the metrics are identified, gathered and mixed in an appropriate way for the field where they are applied.

In [12], the value of the metrics is quantified as it follows:

- Improved performance of the overall collaborative system;
- Improved estimating for future collaborative systems;
- Validation of duration, cost, effort and quality objectives for the collaborative system;
- Identification and communication of best practices;
- Improved client satisfaction.

Metrics offer information about the ways in which designers of the collaborative systems do their tasks and how the things can be done better.

In collaborative systems, data are used to express content and structural items, and to quantify services implemented by these systems.

In [6], some ways to quantify the volume of data regardless of their form of representation are presented. Depending on representation and storage forms of the services implemented by collaborative systems, the volume of the services can have the following forms [6]:

- Values stored in a database – they are measures for a characteristic from a particular collectivity;
- Records in a database – they are quantifications of all characteristics for a particular collectivity;
- Scanned documents – they results from a translation process of the documents from the physical form to electronic one, having the same form and content;

- Tables – they are sets of characteristics having links between them; there more models to organize data in tables;
- Aggregation structures – part of the collaborative systems are aggregated in bigger structured;
- Fundamental units of data storage – they are measurement units of the volume;
- Colors used to transmit messages to developers and users of the system;
- Physical constructions – it supposes the existence of physical objects to express data dimension.

In previous chapter, some properties regarding the metrics validation were enumerated. An important role is played by sensitivity, non-catastrophic character and non-compensatory character of the metrics in order to be validated.

Sensitivity has the goal to highlight how the metric answers to the changes that are recorded from a data set to another. Sensitivity shows variations of dependent variables when it is recorded variations of independent variables. To be validated, the metric has not to be sensitive to quantitative changes [9].

Non-catastrophic character consists of lack of particular values that lead to inability to obtain an outcome variable value. It highlights particular situations when the value of dependent variable is impossible to be determined from values of independent variables [9].

Some situations in which the catastrophic character appears are: denominator is zero, argument values of the logarithmic function are null or negative, square root of negative values and so forth.

Non-compensatory character concerns the effects of simultaneous changes of exogenous variables on endogenous variable. Thus, the change should not deprive the outcome variable when simultaneous variations of independent variables [9].

Some issues regarding the way in which an assessment system based on metrics and measures is applied to evaluate a system are presented at [12]:

- Collecting the metrics – it needs to collect the metrics mandatory for the organization and needed by the collaborative system that is evaluated;
- Value of collecting the metrics is worth the cost – process of collecting and managing the metrics costs; it must be a balance between the collecting cost of the metric and its benefits that will be gained from it;
- Reporting the metrics – information highlighted by a metric is understood by a small part of people; one way to expand the target audience of the metric is to report the metric along with the target;
- Training of the assessment team – removing the disconnections between the purpose and the value of the metrics and how these are perceived by the assessment team and client.

A metrics process model is presented in [1] to collect, report and analysis good metrics. The process has the following stages:

- Establishing and validation the goals – this stage aims what is important for organization and its customers; the objectives are validated together with customers, suppliers and top management and they are re-validated periodically;
- Creating a metrics plan – it validates the purpose of each metric; each metric has basic information associated to it to be use by right people at right time; this information is useful for all people who must know their role in collecting, reporting and making decisions based on metrics; information associated to the metric regards the following issues [1]:
 - Metric title;
 - Brief description;
 - Link to Goals/Objectives;

- Decision(s) based on analysis;
- Who makes decision(s);
- Who collects data;
- How is data collected;
- How often is data collected;
- Who reports data;
- How and to whom is data reported;
- How often is data reported;
- Who analyzes data;
- How is data to be analyzed (formulas and factors);
- Lowest acceptable values;
- Highest acceptable numerical values;
- Expected values;
- At what point will you stop collecting this metric;
- Reviewing metrics plan – the metrics plan is reviewing periodically to increase its opportunity through updating the information associated to each metric; also, new metrics are included in metrics database; decisions to add new metrics aim needs of management, environment changes, perceptions of decision makers about the existing metrics and so forth;
- Implementing metrics plan – it is the proof of the metrics plan; the stage include the following [1]:
 - Policy and process issues – policy is a document signed by high level responsible of the organization; it states logistical concerns in getting data and ensuring their consistency; the process of collecting metric data must be defined and published; this process is a consistent one and all data collectors must follow it;
 - Metric utilization by management – metrics represent a priority for management responsible when due-dates and justification for information collection and analysis are defined, and the importance of the metrics is understood by people involved in decision-making processes;
 - Reviews – are made to ensure an effective plan; they are useful to identify where some modifications will be made in the metrics process model.

Measures implementation process has the following stages as it is presented in [2]:

1. Creating or updating indicators;
2. Collecting data;
3. Storage data;
4. Analyzing and compiling data;
5. Reporting indicators;
6. Using indicators.

In [9], there is presented a measures implementation process to evaluate quality characteristics of the collaborative systems, as it follows:

1. Choice of quality characteristics in relation to which systems or parts of collaborative systems are quantified numerical;
2. Quantifying the fundamental quality characteristics of the collaborative systems;
3. Primary processing of collected or observed data;
4. Grouping of obtained information;
5. Aggregation of individual data.

Collaborative system assessment is a rigorous process that must be in accordance with the models and methodologies of assessment system based on metrics. There are some systematic ways to improve the applying of an assessment system depicted in literature and summarized above.

4. Conclusions

Quantitative ways to evaluate collaborative systems are very important. They extract valuable information regarding evaluation of the systems, their organization and services supplied to the customers. It obtains objective measures to quantitative and qualitative evaluation of the collaborative systems. Also, the assessment system offers the possibility to improve the collaborative system adjusting its quality characteristics and other services supplied by this one.

Implementation of an assessment system must meet requirements to ensure a high quality for this process in order to obtain valuable information for decision makers at management levels.

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