Composite Indexes as Metrics of Cooperative Activity

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Abstract: This paper proposes a method based on composite indexes to reflect the level of computer–supported cooperative activity. This approach is innovative in the sense that it extends a purely quantitative approach with some qualitative contextual elements. Indeed, the indexes integrate two basic features of the computer-supported interactions within a group: the number of occurrences and the cooperative nature of the interactions. The paper describes the design of the indexes and shows their interest with simulated cases.

1 Introduction

In most of the professional and private situations, individuals are requested to cooperate in order to achieve a goal that they could not obtain alone. The contemporary computerization of life leads an increasing number of these cooperative situations to rely on the information and communication technologies. In the mid-eighties, the scientific community began to investigate some issues specifically raised by such situations. This then new research field is nowadays known as computer-supported cooperative work (CSCW). Summarizing some definitions proposed in the literature [BS91], [EGR91], [DNS97], [OO03], [Lo03], we can define this discipline as '*the study of how people work together with the support of the information and communication technologies*'. Among the numerous issues raised in the CSCW domain is the question of how to evaluate the influence of a new CSCW tool on the level of collaboration within the group. This paper proposes an innovative method to tackle this issue.

2 Evaluation of CSCW systems

The evaluation of CSCW software is unanimously considered in the literature as a complex issue [Gr99], [Gr94], [HPS04], [NCR04] and no clear consensus has emerged yet for determining which methodology is the most appropriate to situated circumstances [Gr99], [Hu03], [PG00]. Nevertheless, it seems quite accepted that the evaluation of collaborative systems has a higher order of complexity than the evaluation of single user systems [Da99], [NCR04]. In addition, a serious lack of inexpensive methods for CSCW evaluation has been noted [BGG02].

Research in CSCW assessment encompasses various categories. Some works draw a conceptual framework that points out the different aspects that can/should be evaluated (e.g. [Gr02], [MSB02], [Ra96]). Other approaches adopt a more pragmatic viewpoint and define operational tools, like usability heuristics (e.g. [BGG02], [Gr99]). In the literature we also know some reflections on the evaluation design process, such as how to derive operational measures from general evaluation purposes (e.g. [SP04]) or which successive steps the evaluation encompasses (e.g. [Hu03]). In conclusion, this research field regroups numerous issues and can be tackled from different viewpoints.

In the context of this paper, we would like to draw the attention to one of the classification axes of CSCW evaluation methods: quantitative vs. qualitative approaches. The former regroups research works that use input data such as the length of threads in discussion forums, the number of reply/forward operations in e-mail conversations or the duration of user connections to shared resources (e.g. [FPD04]). In contrast, interviews, ethnographic studies or field observations underpin the latter approach (e.g. [MD03]). Like many other researchers, we believe that both quantitative and qualitative methods must be combined in CSCW evaluation to provide worthwhile results. This assertion founds our research work that aims to design and develop a new methodology that integrates qualitative aspects into quantitative methods.

3 A model of cooperation

First of all, we must explain which situations our reflection targets and on which model our approach relies. This work concerns CSCW, so cooperation is at least partially supported by electronic means. An international research consortium managed through a web-based cooperation platform; and a '*wiki*' web site used to collectively write and publish some articles, are two examples of such situations.

From a general point of view, our reflection relies on modeling the cooperation as a set of *interactions* among *entities*. In this context, an entity can be a person or a resource (e.g. document management system, shared agenda…) and an interaction is defined as '*any exchange of information among entities*' (e.g. phone call, electronic message, upload of a document on a web site…). In our model, the creation of a new interaction by an entity is called '*interaction instantiation*'. An interaction can target one or many entities. For instance, if the interaction is an e-mail, the targets are the receivers and if the interaction is an invitation to a meeting in a shared agenda the targets are the meeting invitees.

This definition of '*interaction*' does not refer to the nature of the interaction in itself or to the communication media. It encompasses all kinds of interactions (e.g. electronic and physical, synchronous and asynchronous, co-located and distant…).

Therefore, in order to restrict the concept to the situations that we intend to study, we introduce the concept of '*computer-mediated interaction*' (CMI), defined as '*any electronic exchange of information among entities*'. In some degree, it can be considered as an extension of the well-known concept of '*computer-mediated communications*' (see [CMC] for further explanation of this concept). CMI includes both 'person-to-person' and 'person-to-resource' interactions.

The concepts described in the paper can theoretically be also applied to physical or mixed interactions (i.e. combination of CMI and physical interactions). As we focus on CSCW, we have deliberately limited our scope to CMI. This decision offers the advantage, among others, to allow collecting the needed rough data quite easily and inexpensively.

For reasons of concision, the term '*interaction*'is often used in the next sections of this paper but it must be understood as '*computer-mediated interaction*'.

4 The global issue of metrics

4.1 Identification of the metrics to be designed

We face thus the non-trivial issue of designing a metric representative of the level of electronic cooperation within a group. In this context, we adopt Scholtz and Potts Steves's definition of metrics: '*the interpretation of one or more contributing elements […] corresponding to the degree to which the set of attribute elements affects its quality*' [SP04]. The interpretation step aims to determine the importance of each attribute and may result, for instance, in a weighted sum of values. In addition, we want to design metrics that can be automatically computed in order to avoid the well-known issue of time and cost required by manual data collection methodologies. The basic idea consists in collecting quantitative data that is enriched by qualitative indicators.

To make the reading easier, let's start by giving this index a name: *Glocoopex* (*Global electronic Cooperation Composite Index*). This index is intended to allow comparing two similar cooperative situations. Obviously, the *Glocoopex* index will not reflect the whole complexity of a cooperative situation but will rather provide a global overview. It must be considered as a tool among others, just like the '*Dow Jones Industrial Average*' index, which does not render the diversity of all transactions on the New York Stock Exchange. The purpose of the *Glocoopex* is to show some trends in the evolution of a cooperative situation and/or to point out some major differences between two comparable situations.

We consider that the level of cooperation within a group is composed of two basic elements: the number of interactions and the cooperative nature of these interactions. This approach makes the *Glocoopex* index conceptually original as it goes beyond the purely quantitative approach and integrates some indicators of the quality of the interactions (from a cooperative viewpoint). However, this index remains computed on the basis of automatically collected data. Therefore, the aim is not to provide some results as rich as the qualitative methodologies can do.

The *Glocoopex* index is built by combining two simpler indexes: the *Coopadex* index (*electronic Cooperation Activity Composite Index*) which is representative of the number of interactions and the *Coopidex* index (*electronic Cooperation Interest Composite Index*) which renders the cooperative nature of the interactions.

Glocoopex = f(*Coopadex*, *Coopidex*)

4.2 The issue of time

When a situation of cooperation is analytically observed, time is an essential factor to consider. The comparison of mean levels of cooperative activity makes sense only if they relate to comparable situations. The most obvious element that may justify the comparability of different situations is the absolute duration of the periods under examination (e.g. periods of three months). Nevertheless, in certain circumstances, other features may be more appropriate to evaluate this comparability. For instance, let's imagine that we want to compare two software engineering projects, which include both a requirement analysis phase (I), a development phase (II) and a test phase (III) (cf. Fig. 1).

In this case, is it more significant to compare the two first months of each project or their requirement analysis phases that have different durations? In theory, both approaches can be acceptable but the critical interrogation of the evaluator about the similarities of the situations is of outmost importance. If the situations are by nature composed of successive phases, those phases are probably the best reference periods to compare. If the study targets some regular situations that cannot be split easily in several parts, then the absolute duration of the periods should be preferred.

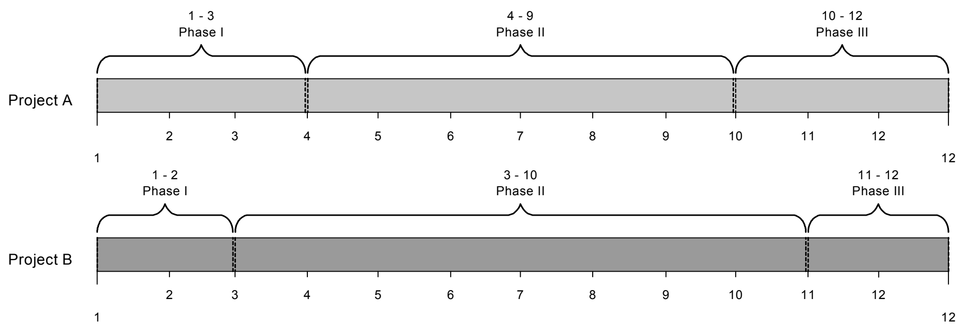

Fig. 1: Comparability of situations : the example of software engineering projects

In order to consider this duality, we introduce the concept of 'semantic duration'. The semantic duration is equal to the absolute duration (expressed in terms of usual time units: *months*, *date*, *hour*…) if some regular situations are compared and is arbitrarily set to the value: ‘*one*’ (expressed in the pseudo time unit: ‘*period*’) if the compared situations concern some sub-periods that cannot be divided. The underlying idea is the following. The indexes are mean values that result from the processing of some field observations. If it is acceptable to divide a given number of interaction occurrences by the duration of the period in the case of regular situations, it becomes really questionable to apply this method in the case of phased situations. For instance, in the software engineering example, a similar number of interactions during the requirement phase would lead to similar index values if the whole phase is considered but to significantly different values if this number were divided by the absolute duration of the period. Consequently, in this case, the absolute duration has probably few meaning and one should consider the phase itself as the time pseudo-unit. The resulting global rule states thus that two situations will be comparable if they have the same semantic duration. An obvious consequence of this rule is that the indexes cannot be used to compare a phased situation with a regular one.

A specific formalism has been adopted to make the definition of the indexes compatible with this concept of ‘semantic duration’.

$$\tilde{\Delta}T \text{ : semantic duration of the period}$$

$$\Delta T = (t_2 - t_1) \text{ : absolute duration of the period } [t_1, t_2]$$

$$\tilde{\Delta}T = \Delta T \text{ when a comparison of absolute durations makes sense}$$

$$\tilde{\Delta}T = 1 \text{ when a comparison of phases durations makes sense}$$

4.3 Theoretical constraints

In our undertaking of metrics design, we try to identify some interactions properties that are relevant for characterizing the cooperation level associated to a given situation. Before discussing those properties on an individual basis, it is important to reflect on the general constraints that all of them should satisfy in order to build a coherent model.

The experience shows how difficult it may be to categorize complex multidimensional data, such as the interactions within a group of people. In order to strengthen the validity of our approach, we have reflected on the theoretical constraints that are required to build a coherent classification framework. Three fundamental constraints have been identified.

1. First, we want to limit as much as possible the risk of imprecision concerning the input data of the model. Consequently, we impose that it must be possible to set indisputably the value of any property for any interaction, which we call the ‘*objectivity constraint*’.
2. Next, for each property, it must be possible to portion the set of all interactions in mutually exclusive subsets, according to the values allowed for this property. This means that, for each interaction, one and only one value is always set for any property. This defines the ‘*uniqueness constraint*’.

3. Finally, as our goal is to characterize the level of cooperation, we accept only some properties of which the allowed values can be ordered in terms of levels of cooperation. In other words, it must be always possible to determine, for each property, whether a given value is associated to a lower of higher level of cooperation than another value. This third constraint is called '*order constraint*'.

The following examples show that many of the potential interaction properties do not satisfy these constraints:

- the *feeling* associated to an interaction does not satisfy the 'objectivity constraint',
- the *name of the documents exchanged during an interaction* does not satisfy the 'uniqueness constraint',
- the *moment when the interaction occurs* does not satisfy the 'order constraint'.

This does not mean that such properties are meaningless. We simply believe that they cannot be used to define a simple, coherent and useful metric of the level of cooperation at the operational level.

5 Proposal of metrics

In this section, the precise definition of each of the three above-mentioned indexes is detailed.

5.1 *Coopadex* index

The *Coopadex* index aims to be representative of the mean level of use of electronic tools supporting the cooperation. As, by definition, cooperation requires the presence of more than one person, we will consider the number of computer-mediated interactions (cf. previous definition) as a reliable indicator of the volume of cooperation.

The *Coopadex* index is defined as the mean number of computer-mediated interactions between group members for a given period. It can be easily computed by the formula:

$$Coopadex = \frac{\Sigma_j \left(I(G_j) \right)}{n \,.\, \Delta\tilde{T}}$$

where

- G is a group of *n* persons in a situation of cooperation,
- G_j is the j^{th} member of the group G,
- I (G_j) is the number of interactions in which G_j is involved,

- $\Delta\tilde{}T$ is the semantic duration of the period under examination.

The units of *Coopadex* are thus [interaction . person^{-1} . (pseudo) time unit^{-1}]

It must be noted that the denominator includes the factor *n*, i.e. the total number of members in the group G and not the number of members that are involved in the computer-mediated interactions during the period. This design choice was deliberate in order to build an index that is representative of the level of cooperative activity within the whole group. To be able to collect the data needed to compute the index, some boundaries must be drawn to delimitate the system under examination. For this reason the interactions with entities or objects outside the group are not taken into account in the index that consequently renders only the level of cooperation inside the group.

We must also detail how the number of interactions is computed. If an interaction is initiated by G_j and targets G_k and G_m, it counts as three interactions in the *Coopadex* index. This approach has been adopted to give an increasing weight to the interactions as the number of persons they involve raises.

5.2 *Coopidex* and *N-Coopidex* indexes

The *Coopadex* index reflects the mean rate of use of the electronic cooperation tools but it does not render the level of interest or motivation of the persons towards the cooperation. The *Coopidex* index has been designed to fill this lack. Its design relies on the observation that some interactions express a higher motivation to cooperate than other ones. For instance, an automatically generated e-mail that notifies a modification on a web site can reasonably be associated to a lower level of motivation to cooperate than an explicit invitation to a meeting in a shared calendar.

The challenge that we faced at this point was the evaluation of the cooperative nature of the computer-mediated interactions. Let's remind that the candidate properties must satisfy the objectivity, uniqueness and order constraints. After the analysis of several candidates, two properties were selected.

The first property indicates whether the computer-mediated interaction is optional or imposed.

- It satisfies the objectivity constraint because it is possible to determine whether initiating/being targeted by the interaction was an option or an imposed fact for the concerned entity. For instance, requesting some information by e-mail is optional in most of the cases while being forced to upload a document on a web site before a fixed date is a mandatory interaction.
- The uniqueness constraint is also fulfilled because an interaction cannot be simultaneously mandatory and optional. As previously described, an interaction must be counted as many times as a different entity is addressed. Due to this mechanism, a given e-mail, for instance, can be considered as an optional interaction for the sender and as imposed interaction for the receiver.
- Finally, this property satisfies the order constraint. Indeed, one may reasonably consider that the presence of optional interactions reflects a higher degree of

motivation for the cooperation than the occurrence of imposed ones as, in the former case, it results from a free and deliberate decision.

This reflection is integrated in the design of the *Coopidex* index by introducing two coefficients: α_o (optional) and α_i (imposed). These coefficients take a value in the range [0,1], depending on the importance given to this first axis of categorization of the interactions (cf. weighted values). In all cases, however, according to the previous discussion, α_o must be greater than α_i.

The active or passive nature of the computer-mediated interaction was identified as a second meaningful property. An active interaction is defined as an interaction that occurs due to an explicit action of the concerned entity (e.g. sending an e-mail). In contrast, a passive interaction does not require such an explicit action (e.g. receiving an invitation to a meeting).

- The objectivity constraint is satisfied because it is always possible to determine whether an interaction has required an explicit action of the involved entity or not.
- As an interaction cannot be simultaneously active and passive, the uniqueness constraint is fulfilled.
- We can legitimately consider that the active interactions indicate a higher level of involvement in the cooperation than the passive ones, as they require an effort for the concerned entity. Therefore, the order constraint is satisfied.

The *Coopidex* index is also influenced by this property of the interactions. Therefore, we introduce two additional coefficients: β_a (active interaction) and β_p (passive interaction). These coefficients also take a value in the range [0,1], depending on the weight given to this second axis of categorization. According to the previous discussion, β_a must always be greater than β_p.

Any interaction now falls in one of the four following categories: active-optional, passive-optional, active-imposed or passive-imposed. We can thus sum up the number of interactions in each category:

- $I_{a,o}$: number of active optional interactions
- $I_{p,o}$: number of passive optional interactions
- $I_{a,i}$: number of active imposed interactions
- $I_{p,i}$: number of passive imposed interactions

The *Coopidex* index can then be computed by the expression:

$$\textit{Coopidex} = \frac{\alpha_o\ \beta_a\ I_{a,o} + \alpha_o\ \beta_p\ I_{p,o} + \alpha_i\ \beta_a\ I_{a,i} + \alpha_i\ \beta_p\ I_{p,i}}{I_{a,o} + I_{p,o} + I_{a,i} + I_{p,i}}$$

Il must be noted that ($I_{a,o} + I_{p,o} + I_{a,i} + I_{p,i}$)= $\Sigma_j \left(I(G_j) \right)$ because the same interactions are concerned.

The value of the *Coopidex* index varies between the low limit ($\alpha_i\ \beta_p$) when all the computer-mediated interactions are imposed and passive and the high limit ($\alpha_o\ \beta_a$) when all the interactions are optional and active. This value may be difficult to interpret as it demands to know the value of the weights: α_i, α_o, β_a and β_p. In order to make it easier to understand, we normalize the *Coopidex* index with a projection on the interval [0,1]. This operation defines a new index, called *N-Coopidex* (*Normalized electronic Cooperation Implication Composite Index*), that can be computed by the expression:

$$N\text{-}Coopidex = \frac{(Coopidex - \alpha_i\ \beta_p)}{(\alpha_o\ \beta_a - \alpha_i\ \beta_p)}$$

According to the definition of the Coopidex index, this expression can be transformed as follows:

$$N\text{-}Coopidex = \frac{\left[(\alpha_o\ \beta_a - \alpha_i\ \beta_p)\ I_{a,o} + \beta_p\ (\alpha_o - \alpha_i)\ I_{p,o} + \alpha_i\ (\beta_a - \beta_p)\ I_{a,i} \right]}{(I_{a,o} + I_{p,o} + I_{a,i} + I_{p,i})\ (\alpha_o\ \beta_a - \alpha_i\ \beta_p)}$$

N-Coopidex varies between the value '0' (when all interactions are passive and imposed) and the value '1' (when all interactions are active and optional). The higher the *N-Coopidex* value, the more the members of the group take the initiative to instantiate some interactions and the higher the level of cooperation within the group.

For each interaction, the parameter values (α_o , α_i , β_a , β_p) are set according to general rules (R_i) defined by the evaluator. These rules specify how the parameter values depend on the communication medium (e.g. *e-mail*, *shared calendar*, *web page with news*…), the communication direction (e.g. *send-receive*, *upload-download*…) and potentially many other elements (e.g. *the hierarchical position of the interaction initiator*…). For instance, if an employee answers via a '*Reply mail*' to an e-mail received by his/her director, the set of rules may specify that this '*Reply mail*' must be considered as an *imposed active* interaction. Designing the set of rules R_i demands a preliminary good knowledge of the cooperative situation but once they are specified the indexes may be easily computed.

Let's note that both *Coopidex* and *N-Coopidex* have no dimensions (i.e. no unit). It may also be useful to point out that the comparison of these indexes demands that the same values of the coefficients α_o , α_i , β_a , β_p and some coherent sets of rules R_i were used to compute them.

5.3 *Glocoopex* index

In section 4.1, we explained that the *Glocoopex* index is defined as a combination of two simpler indexes: *Coopadex* and *Coopidex* (replaced by *N-Coopidex* to ease its understanding). Having defined them, we can propose the definition of *Glocoopex*.

$$Glocoopex = Coopadex \; . \; N\text{-}Coopidex$$

which can be developed as follows :

$$Glocoopex = \frac{\left[(\alpha_o \, \beta_a - \alpha_i \, \beta_p).I_{a,o} + \beta_p.(\alpha_o - \alpha_i).I_{p,o} + \alpha_i.(\beta_a - \beta_p).I_{a,i} \right]}{n \, . \, \Delta\tilde{}T \, . \, (\alpha_o \, \beta_a - \alpha_i \, \beta_p)}$$

The units of *Glocoopex* are [interaction . person^{-1} . (pseudo) time unit^{-1}].

In order to validate the adequateness of this index to render the modeled situations, we have computed its sensitivity to the different variables: n, $\Delta\tilde{}T$, $I_{p,i}$, $I_{a,o}$, $I_{p,o}$, $I_{a,i}$.

First, *ceteris paribus*, for a given number of interactions, it is trivial to show that the larger the size of the group (cf. variable *n*), the smaller the value of *Glocoopex*. The index renders thus the volume of cooperative exchanges among the members of the whole group.

Second, *Glocoopex* varies in inverse ratio to the duration of the concerned period (variable $\Delta\tilde{}T$). This behavior reflects that, for a given total number of interactions, the longer the period, the lower the level of activity.

The relative influence of the different kinds of interactions is worth being discussed with more details.

The *Glocoopex* index does not depend on the variable $I_{p,i}$. This is the consequence of the normalization of *Coopidex*. This result does not really represent a problem as it signifies that the involvement of the group members in passive imposed interactions is not considered as an indicator of a significant level of cooperative activity. For instance, the reception by the group members of automatically generated e-mails does not show that they are engaged in a dynamic cooperation.

The sensitivity of *Glocoopex* to the number of optional interactions is assessed by comparing the relative influence of passive optional and active optional interactions. On the basis of some quite simple mathematical developments, it can be proven that, considering the constraints on the weights α_o , α_i , β_a , β_p , the *Glocoopex* index is always less sensitive to a variation of the number of passive optional interactions ($I_{p,o}$) than to a variation of the number of active optional interactions ($I_{a,o}$). Similarly, it can be shown that *Glocoopex* is always less sensitive to a variation of the number of active imposed interactions ($I_{a,i}$) than to a variation of the number of active optional ones ($I_{a,o}$). These results are coherent with the intended significance of this index.

Another interesting question concerns the relative sensitivity of *Glocoopex* to some variations of $I_{p,o}$ and $I_{a,i}$. We hypothesize that the most important indicator of a high level of cooperation is the choice of the persons to participate. For instance, if the members of a group accept to be called via the chat system commonly adopted or agree to receive service information by the group mail, we consider that they are more motivated to cooperate than if they upload some documents on a website while they are forced to do it.

In our terms, this means that the optional/imposed factor must influence more the value of *Glocoopex* than the active/passive one. This statement implies that passive optional interactions are a sign of greater motivation than the active imposed ones, which can be expressed in mathematical terms as follows: $\alpha_o \ \beta_p > \alpha_i \ \beta_a$.

6 Simulated Cases

In order to validate the interest of the different indexes, it is essential to confront them to some observations. At the moment, the research project to which this work relates has not yet produced field observations. Some simulated cases were thus used to get a first evaluation of the potential of these new indexes. Of course, as soon as real field data will be available, new evaluations will be carried out on this more significant basis.

The indexes have thus been tested with typical cases that simulate different situations of cooperation. Among the various cases that have been tested, we will discuss four out of the most expressive ones: a low volume of homogenous activity, an intermediate volume of homogenous activity, a high volume of homogenous activity and an intermediate volume of activity with high motivation (cf. Tables below).

The values adopted for the four coefficients are the following: α_o=0,8 ; α_i=0,2 ; β_a=0,6 ; β_p=0,3 . These values satisfy the different constraints imposed on them. The size of the group has been set to five members ($\Rightarrow$ *n*=5) and the period concerned has duration of one (pseudo) time unit ($\Rightarrow \Delta\tilde{T}$ =1).

Table 1

Case 1: low volume of homogenous activity			
Number of interactions	*Imposed*	*Optional*	Total
Active	10	10	20
Passive	10	10	20
Total	20	20	40

Value of the indexes

Coopadex	*Coopidex*	*N-Coopidex*	***Glocoopex***
8,000	0,225	0,393	**3,14**

Table 2

Case 2: intermediate volume of homogenous activity			
Number of interactions	*Imposed*	*Optional*	Total
Active	20	20	40
Passive	20	20	40
Total	40	40	80

Value of the indexes

Coopadex	*Coopidex*	*N-Coopidex*	***Glocoopex***
16,000	0,225	0,393	**6,29**

Table 3

Case 3: high volume of homogenous activity			
Number of interactions	*Imposed*	*Optional*	Total
Active	40	40	80
Passive	40	40	80
Total	80	80	160

Value of the indexes

Coopadex	*Coopidex*	*N-Coopidex*	***Glocoopex***
32,000	0,225	0,393	**12,57**

Table 4

Case 4: intermediate volume of activity with high motivation			
Number of interactions	*Imposed*	*Optional*	Total
Active	0	80	80
Passive	0	0	0
Total	0	80	80

Value of the indexes

Coopadex	*Coopidex*	*N-Coopidex*	***Glocoopex***
16,000	0,480	1,000	**16,00**

The numerical values illustrate the behavior of the indexes and can facilitate the understanding of the underlying formulas. *Coopadex* evolves as follows: the larger the number of interactions, the higher this index. The *Coopidex* and *N-Coopidex* indexes do not depend on the total number of interactions (cf. Cases 1, 2, 3) but are sensitive to the distribution of interactions among the four categories (cf. imposed/optional, active/passive). The total number of interaction being constant, if the number of active optional interactions increases, so do *Coopidex* and *N-Coopidex*, which indicates a higher level of motivation to cooperate (cf. Cases 2, 4).

The interpretation of the unifying *Glocoopex* index is subtler as it aims, by definition, to integrate different axes of analysis in one single value. Indeed, while it globally increases with the number of interactions, this growth is moderated by the nature of the interactions. For instance, the level of cooperation appears more intense in Case 4 than in Case 3 although more interactions occur in the latter (Case 3).

7 Conclusions

This paper discusses a new method to assess the influence of a new CSCW tool on the level of cooperation within a group. The approach is based on the design of a composite index, called *Glocoopex*, which tries to summarize some quantitative and qualitative aspects of the interactions among the members of the group. In fact, this index provides a global view of the mean level of cooperative activity within a group.

However, the *Glocoopex* index cannot be considered as an indicator of factors like the user satisfaction, the return on investment or the cooperation effectiveness. If a richer analysis of the situation is required, it must be completed with other evaluation methods, which can be either qualitative or quantitative.

The preliminary tests are based on simulations. Further works focused on the experimental validation of the indexes are still needed. On the theoretical level, the reflection will focus on the relevance to include other properties of the interactions to better reflect the reality of the cooperation.

Bibliography

[BGG02] Baker, K., Greenberg, S. and Gutwin, C.: Empirical Development of a Heuristic Evaluation Methodology for Shared workspace Groupware. In Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'02), New Orleans, Louisiana, 16th – 20th November 2002. ACM Press, New York, NY, 2002, pp. 96-105.

[BS91] Bannon, L. and Schmidt, K.: CSCW: four characters in search of a context, Studies in CSCW. Theory, practice and design. Bowers J.M. Benford S.D., North Holland, 1991, pp. 3-15.

[CMC] Journal of Computer-Mediated Communication, Internet address: http://jcmc.indiana.edu/, accessed 9th February 2006.

[Da99] Damianos, L., Hirschman, L., Kozierok, R., Kurtz, J., Greenberg, A., Walls, K., Laskowski, S. and Scholtz, J.: Evaluation for Collaborative Systems. In ACM Computing Surveys, 31, 2 (June 1999).

[DNS97] Decortis, F., Noirfalise S. and Saudelli B.: Distributed Cognition as Framework for Cooperative Work, Working Paper, COTCOS project, 1997, Internet address: http://www-sv.cict.fr/cotcos/pjs/, accessed 15th September 2005.

[EGR91] Ellis, C.A., Gibbs, S.J. and Rein G.L.: Groupware : Some Issues and Experiences. In Communications of the ACM, Vol. 43, N° 1, January 1991, pp. 39-58.

[FPD04] Furmanski, C., Payton, D. and Daily, M.: Quantitative Evaluation Methodology for Dynamic, Web-based Collaboration Tools. In Proceedings of the 37th Hawaii International Conference on System Sciences, Waikoloha Village, Hawaii, 5th – 8th January 2004, pp. 132-141.

[Gr99] Greenberg, S., Fitzpatrick, G., Gutwin, C. and Kaplan, S.: Adapting the Locales Framework for Heuristic Evaluation of Groupware. In Proceedings of the Australian Conference on Computer Human Interaction (OZCHI'99), Wagga Wagga, Australia, 28th – 30th November 1999.

[Gr94] Grudin, J.: Groupware and Social Dynamics: Eight Challenges for Developers. In Communications of the ACM, Vol. 37, N° 1, January 1994, pp. 92-105.

[Gr02] Grundén K.: An Evaluation Model for CSCW Systems. In Proceedings of the 9th European Conference on Information Technology Evaluation (ECITE'02), Paris, France, 15th – 16th July, 2002. MCIL Editions, Reading, UK, 2002, pp. 181-187.

[HPS04] Haynes, S. R., Purao, S. and Skattebo, A. L.: Situating Evaluation in Scenarios of Use. In Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'04), Chicago, Illinois, 6th – 10th November 2004. ACM Press, New York, NY, 2004, pp. 92-101.

[Hu03] Huang, P.H.: Using evaluation lifecycle to support development of collaborative environments. In Proceedings of the 10th European Conference on Information Technology Evaluation (ECITE'03), Madrid, Spain, 25th – 26th September, 2003. MCIL Editions, Reading, UK, 2003, pp. 339-348.

[Lo03] Lonchamps, J.: Le travail coopératif et ses technologies. Editions Hermes, Paris, 2003.

[MD03] McDonald D.W.: Recommending Collaboration with Social Networks: A Comparative Evaluation. In Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'03), Ft Lauderdale, Florida, 5th – 10th April 2003. ACM Press, New York, NY, 2003, pp. 593-600.

[MSB02] Mendes de Araujo R., Santoro, F. M. and Borges, M.R.S.: The CSCW Lab for Groupware Evaluation. In Proceedings of the 8th International Workshop on Groupware: Design, Implementation, and Use (CRIWG 2002), La Serena, Chile, 1st – 4th September 2002. Springer, Berlin, Germany, 2002, pp. 222-231.

[NCR04] Neale, D.C., Carrol, J.M. and Rosson, M.B.: Evaluating Computer-Supported Cooperative Work: Models and Frameworks. In Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'04), Chicago, Illinois, 6th – 10th November 2004. ACM Press, New York, NY, 2004, pp. 112-121.

[OO03] Olson J. S. and Olson G. M.: Computer-Supported Cooperative Work. In Encyclopedia of Information Systems, Vol. 1, Elsevier, Academic Press, San Diego, 2003, pp. 243-253.

[PG00] Pinelle, D. and Gutwin, C.: A Review of Groupware Evaluations. In Proceedings of the 9th IEEE Workshop on Enabling Technologies – Infrastructures for Collaborative Enterprises (WET ICE'00), Gaithersburg, Maryland, June 2000. IEEE Press, 2000, pp. 86-91.

[Ra96] Ramage, M.: CSCW Evaluation in Five Types. Technical Report CSEG/17/1996, Lancaster University, Computing Department, UK, 1996.

[SP04] Scholtz, J. and Potts Steves M.: A Framework for Real-World Software System Evaluations. In Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'04), Chicago, Illinois, 6th – 10th November 2004. ACM Press, New York, NY, 2004, pp. 600-603.