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► **To cite this version:**

Filipa Ferrada, Luis Camarinha-Matos. An Emotional Support System for Collaborative Networks. 6th Doctoral Conference on Computing, Electrical and Industrial Systems (DoCEIS), Apr 2015, Costa de Caparica, Portugal. pp.42-53, 10.1007/978-3-319-16766-4\_5 . hal-01343464

**HAL Id: hal-01343464**

**<https://hal.inria.fr/hal-01343464>**

Submitted on 8 Jul 2016

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# An Emotional Support System for Collaborative Networks

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**Abstract.** A particular challenge in the management of collaborative networks is the effective handling of the interactions among participants, especially in what concerns the management of “soft” issues that are not currently available in the execution processes of such networks. These issues can include inter- and intra-organizational abilities, problems in keeping team cohesion, leadership, among others. Moreover, one cannot forget that organizations are composed of people, and people have intrinsically associated emotions which are present in all interactions. In this sense, when not properly handled, some participant’s emotions might put in jeopardy the quality of the collaboration. On the other hand the collective emotional state of the collaborative network can also affect each participant’s emotions. As a contribution to keep the emotional equilibrium of the network, this paper presents the design of an emotional support system, including the identification and categorization of the most influencing positive and negative collective emotions and also the specification and prototyping of the sub-system services.

**Keywords:** Emotions, Collective Emotions, Collaborative Networks, Collaboration Health.

## 1 Introduction

Over the past decades there has been a great interest in the nature and role of emotions in community and work contexts, and a growing recognition of their centrality in facilitating or not connections between people [1]. In this line, the understanding of the role of emotions within networks of organizations is becoming a challenge due to its organizational, dynamic and “soft” nature. Furthermore, emotions might have a central role in the quality of communications and interaction among participants, in keeping network cohesion, in decision-making, in conflicts resolution, in leadership, among others. Having these considerations into account, it becomes interesting to understand to what extent having an emotional equilibrium in the network contributes to the health of the collaboration.

In this context the main research question for this work is: *What could be a suitable set of models, methods and tools to promote emotional health in collaborative*

networks, *namely allowing the diagnosis of the networks' emotional state and assisting in conflicts resolution?*

The development of effective supervision functionalities to monitor and manage the emotional climate/state – or the “collective virtual emotions” – of collaborative networks with the intention of maintaining the emotional equilibrium of the community, forecasting and attempting to *heal* potential conflicts among participants and external communities are important elements for the success of the network [2]. In fact, several studies reveal that emotions are very often the cause for misunderstandings and conflicts which, in some cases might lead to the failure of collaborative networks [3]. However, very little progress has been made in this direction. A particularly challenging issue is the acquisition, via non-intrusive methods, of multi-modal emotional input for achieving awareness of the participants' as well as the collective emotional state.

As a contribution to help keeping the emotional equilibrium of the network, this paper presents an emotional support system for collaborative networks developed on top of the GloNet platform. It includes the identification and categorization of the most influencing positive and negative collective emotions and also the specification and prototyping of the sub-system services. The remainder of this paper is organized as follows: Section 2 identifies the relationship of this work to cloud-based engineering systems; Section 3 gives a brief description of the related literature, namely in what concerns emotions in organizations and group-based emotions; Section 4 presents the emotions support system, its framework and prototype; and finally Section 5 concludes.

## 2 Benefits from Cloud-based Engineering Systems

Several research projects and business initiatives show trend to develop collaboration platforms on the cloud. The consolidation of this approach is likely to facilitate an increase of collaboration among small and medium enterprises (SMEs) as, in this case, they do not need to acquire and maintain complex computational infrastructures. The work presented in this paper is developed in such context in the scope of the GloNet project: networks of SMEs involved in complex service-enhanced products [4] are supported by a cloud-based platform. This platform not only facilitates the collaboration processes among participants but also allows the emotional support system to more easily access the information that is needed to assess and manage the emotional equilibrium within the collaborative networks.

Besides the benefits of freeing enterprises from the burden of keeping their own infrastructures, the scalability property of cloud-computing allows for greater agility, which is quite relevant in our use case on supporting the full life cycle of solar plants. Each solar plant (a complex product) and the associated business services to be provided along its life cycle are highly customized (one of a kind) and might involve the need to store increasing amount of data. On the other hand, security concerns, namely in terms of access to data and even direct access to the physical plant, are vital here. The solutions offered by cloud providers are more reliable than what could be guaranteed by proprietary development of a network of heterogeneous SMEs. On the other hand, even within a network of collaborating partners there are several levels of access to information that need to be properly defined according to the role played by

each participant. The GloNet platform provides the base mechanisms for specification of those access rights [5] and these need to be taken into account by the emotional support system in delivering different access to members and administrator.

### 3 Related Literature

#### 3.1 Emotions in Organizations

Organizations have been studied by several scientific areas as rationally designed and operated structures. Nevertheless, issues like bringing fruitful collective action, quality of interaction and relations between parties and incentives to motivate organization's participants to follow common goals were, for a while, treated as irrelevant or insignificant. Aspects of group dynamics [6] and factors of sociality were often disregarded such as the impact of complex social processes on organization's participants. However, they surely contribute for the ability that an organization has to integrate, create and reconfigure internal and external resources according to the changing environment. These "additional factors", to a large extent, form the "social glue" that keeps together the participants of the collective action [7]. Emotions started to be recognized as an important element of cognitive processes [8], a necessary component of individual activity motivation and have high importance in interpersonal communications. In other words, the influence of emotional factors provides significant impact for positive organizational dynamics. On the other hand, emotional factors might as well input some negative impacts in an organization [9, 10]. Namely, they can disrupt normal procedural flows, break working relationships, and disrupt reasoned judgment and decision-making.

#### 3.2 Collective and Group-Based Emotions

**Emotional Contagion.** Emotional contagion is "a process in which a person or group influences the emotions or behavior of another person or group through the conscious or unconscious induction of emotion states and behavioral attitudes" [11]. Emotions are "caught" by group members when they are exposed to the emotional expressions of other group members. Hatfield et al. [12] advanced that the degree to which emotional contagion occurs is mediated by attentional processes, with greater emotional contagion occurring when more attention is allocated. Zurcher [13] argues that displays of positive emotion in group situations constitute an essential ingredient necessary for the establishment of group cohesion. Furthermore, Lawler [14] claims that emotion is the essential social process in group formation and maintenance. This is because positive emotions strengthen feelings of control. As such, positive emotion is a necessary precursor of group cohesiveness. In the context of organizational work groups, George [15] has also shown that positive affection is a key ingredient for group effectiveness and satisfaction. Barsade [16] found that positive emotional contagion amongst group members affects individual-level attitudes and group

processes. Group members who experienced positive emotional contagion demonstrated improved cooperation, decreased conflict, and increased perceived task.

**Collective Emotions.** Collective emotions have been defined in a relatively general way as emotions that are shared by large numbers of individuals in a certain society [17], while group-based emotions are defined as emotions that are felt by individuals as a result of their membership in a certain group or society [18]. According to Bar-Tal [19], both concepts suggest that individuals may experience emotions, not necessarily in response to their personal life events, but also in reaction to collective or societal experiences in which only a part of the group members have taken part. But while the former concept suggests that group members may share the same emotions for a number of different reasons, the latter refers only to emotions that individuals experience as a result of identifying themselves with their fellow group members. A number of scholars have also pointed to the important behavioral implications of collective or group-based emotions when there are conflicts between groups and societies. Moreover, Bar-Tal [19] argues that the emotional element of context has great potential to influence emotional reactions and subsequent behavior. Furthermore, he proposed that, in contrast to individual emotions which are sometimes related to a dispositional system or physiological mechanism, collective or group-based emotions are solely formed as a consequence of experiences in a particular societal context. Society members experience collective emotions not only as a result of directly experiencing events that evoke particular emotion but also by identifications with the society as a collective.

**Emotional Atmosphere, Emotional Culture and Emotional Climate.** In the initial work of de Rivera [20], he suggested that it is important to differentiate emotional atmosphere from emotional culture and emotional climate: *emotional atmosphere* or *collective mood* refers to the collective behavior that a group or society may manifest when it is focused on a common event, rather than to the emotional relationships between members of the society. Such an atmosphere appears when those who identify with a group celebrate a collective success, lament a tragedy, or suffer a common threat. *Emotional culture* refers to the emotional relations that are socialized in a particular culture, while *emotional climate* is “an objective group phenomenon that can be palpably sensed - as when one enters a party or a city and feels an atmosphere of gaiety or depression, openness or fear”. This basically refers to the collective emotions experienced as a result of a society’s response to its sociopolitical conditions. Thus, in times of political repression, people are afraid of expressing their ideas in public; in times of ethnic tension, there is hate and/or fear toward other groups, and so on. De Rivera gives the example of Chile’s Pinochet regime that was under a climate of fear and now it has changed to a climate of hope. Emotional climate is more stable than emotional atmosphere and may be a useful construct for analyzing social dynamics in contexts of political violence [21].

## 4 Emotions Supporting Health in Collaboration

As mentioned above, it might be considered that the emotional equilibrium of a collaborative network contributes to supporting healthy collaboration. Individual participants experience emotions not only as a result of directly experiencing events (that involve/evoke their own particular emotions) but also through collaborative interactions and by identifying themselves with the network as a whole. As a consequence, the emotional health of the collaborative network might depend of the intricate interactions between the various participants developing, in this way, a collective emotion which is influenced by each participant's dominant emotions and the network's global performance evaluation. From an intuitive point of view, it seems plausible that the more positive the collective emotion is, the healthier the collaborative network becomes.

### 4.1 Which Emotions

Human emotions are known and although not universally categorized and defined, some authors invested considerable research efforts on establishing theories for categorizing basic and inferred emotions, e.g. [22, 23]. However, when it comes to the context of collaborative networks it becomes understandable that the emotions that are “felt” are not at the level of an individual but rather of a “collectivity”. In this way, and under a simplified view of what should be the (collective) emotions that need to be further analyzed, the following examples can be considered:

- Excitement** Excitement is a positive emotion, “experienced” when the network as a whole feels excited, that might be triggered when the short- and/or long-term network objectives and partner's expectations and wishes are fully achieved. As a positive emotion, it maintains the network health calibrated ensuring, in this way, future successful interactions among network partners.
- Contentment** Contentment, like excitement, is a positive emotion, “experienced” when the network as a whole feels content, which might be triggered when the short- and/or long-term network objectives and partner's expectations and wishes were partially achieved. As a positive emotion, it indicates a successful achievement from the majority of the network participants and causes a slight alert to the network health to be regulated.
- Frustration** Frustration is a negative emotion, “experienced” when the network as a whole feels frustrated, that might be triggered when a partner's own actions, and/or others' actions in pursuit of the short- and/or long-term network objectives are mostly not achieved. As a negative emotion, it inhibits the achievement from the majority of network participants and down regulates the network health, increasing the chance of network “failure”.
- Depression** Depression, like frustration, is a negative emotion, “experienced” when the network as a whole feels depressed, hopeless, uninterested and unable to focus on normal activities. Depression might be triggered when a partner's own actions and/or others' actions in pursuit of the short- and/or long-term network objectives are a complete failure. As a negative emotion, it jeopardizes the network health, compromising the interactions among partners and potentially promoting conflicts.

## 4.2 Emotions Categorization

For both theoretical and practical reasons, some researchers define emotions according to one or more dimensions [24]. Dimensional descriptions capture essential properties of emotional states, such as arousal (active/passive) and valence (negative/positive). Emotion dimensions can be used to describe general emotional tendencies, including low-intensity emotions. In addition to these two, there are a number of other possible dimensions, such as power, control, or approach/avoidance, which add some refinement. Dimensional representations are attractive mainly because they provide a way of describing emotional states, which are more tractable than using words. A further attraction is the fact that dimensional descriptions can be translated into and out of verbal descriptions.

In the context of collaborative networks, we suggest that emotions can be defined according to three dimensions: Valence (positive/negative); Activation or arousal (active/passive); and Intensity (weak/moderate/strong).

## 4.3 Emotional Evidences/Information

In order to properly build an Emotional Support System, it is necessary to find (non-intrusive) mechanisms to measure/infer the emotion that the collaborative network is “feeling”. Therefore, emotional evidences (or emotional information) have to be defined and their sources identified. As collaborative networks are composed of organizations and people, each one of them can bring its own emotional tendencies to the network, helping in “producing” the network collective emotion. In this way two groups of emotional evidences/information are considered: the first concerning the information that will be useful for “measuring” each member’s emotional state and the second for “measuring” the collective emotion present in the collaborative network. The following tables illustrate the information envisaged, at this stage, for each group as well as were it can be collected. Due to the experimental nature of this work, this information might need to be revised later.

**Table 1.** Member’s Emotional Information

|                 | <i>Emotional Information</i> | <i>Sources</i>                                |
|-----------------|------------------------------|---|
| Individual Part | Needs & Expectations         | Survey / Questionnaire                        |
|                 | Performance Data             | Member Profile Performance Evaluation         |
|                 | Past Emotional States        | List of past <i>Estimated Emotional State</i> |
| Shared Part     | Member Satisfaction          | Survey / Questionnaire                        |
|                 | # of belonging Groups        | Member’s Groups List                          |
|                 | # of belonging VO’s          | Member’s VOs List                             |
|                 | # of Sharing Resources       | Member’s Shared Resources                     |

|               |   |                                       |
|---------------|---|---------------------------------------|
|               | Communication Data<br><ul style="list-style-type: none"> <li>▪ Member's Communication Flow<br/><i>(direction of member interactions, as a sender or receiver)</i></li> <li>▪ Member's Communication Intensity <i>(frequency of interactions)</i></li> </ul> | Social Network Analysis Tools         |
| Inferred Part | Estimated Actual Emotional State<br><ul style="list-style-type: none"> <li>▪ Name of emotion [EMOTION]</li> <li>▪ Valence [POSITIVE, NEGATIVE]</li> <li>▪ Activation [ACTIVE, PASSIVE]</li> <li>▪ Intensity of emotion [WEAK, MODERATE, STRONG]</li> </ul>  | Algorithm using the above information |

**Table 2.** Collaborative Network's Emotional Information

|               | <i>Emotional Information</i>  | <i>Sources</i>   |
|---------------|---|--|
| Network Part  | Performance Data  | Network Profile Performance Evaluation                   |
|               | Past Collective Emotional States  | List of past <i>Estimated Collective Emotional State</i> |
|               | List of Members' Emotional Information  | Members' emotional Information                           |
|               | Total Number of VOs   | Network VOs List   |
|               | Communication Data<br><ul style="list-style-type: none"> <li>▪ Communication Flows <i>(overall direction of interactions)</i></li> <li>▪ Communication Intensity <i>(overall frequency of interactions)</i></li> </ul>  | Social Network Analysis Tools                            |
| Inferred Part | Estimated Actual Collective Emotional State<br><ul style="list-style-type: none"> <li>▪ Name of emotion [EMOTION]</li> <li>▪ Valence [POSITIVE, NEGATIVE]</li> <li>▪ Activation [ACTIVE, PASSIVE]</li> <li>▪ Intensity of emotion [WEAK, MODERATE, STRONG]</li> </ul> | Algorithm using all the above information                |

#### 4.4 Emotional Support Sub-Systems

Having the above in mind, the Emotional Support System is divided into two sub-systems: the Member's Emotional State Support and the Collective Emotional State Support as illustrated in Fig. 1.



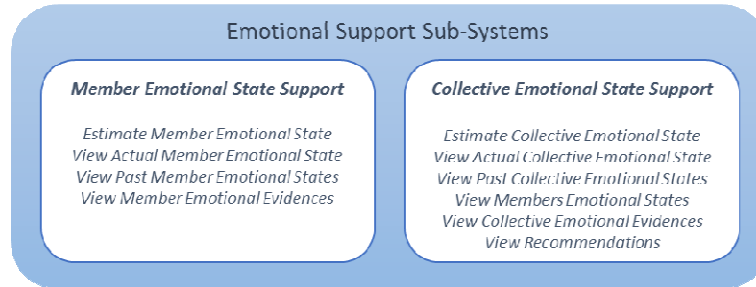


Fig. 1 – Global view of the Emotional Support System

**Member's Emotional State Support Sub-System.** The Member's Emotional State support sub-system aims to support gathering all the necessary information in order to estimate the current and past emotional state of a particular member.

Fig. 2 shows an adapted i\* Rationale Strategic model where the involved actors as well as their dependency objectives are illustrated. Within the boundaries of the Member Emotional State Support sub-system the respective associated tasks/functionality are presented.

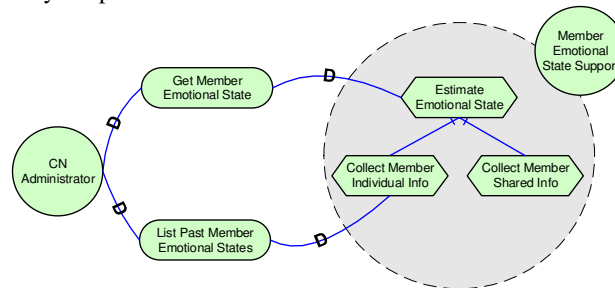


Fig. 2 - Adapted i\* Rationale Strategic Model for the Member Emotional State Support

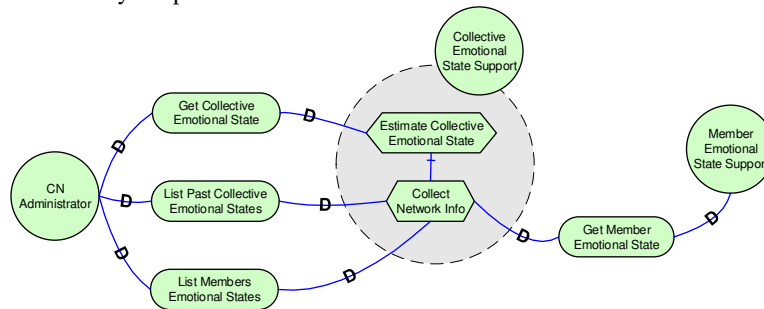
The main functionalities of this sub-system are included in Table 3.

**Table 3.** Main Services of the Member's Emotional State support sub-system of Emotional Support

| <i>Service Name</i>             |        |           | <i>Service Description</i>   |
|---------------------------------|--------|-----------|--|
| Estimate Emotional State        | Member |           | Functionality used to infer the emotional state of an identified member taking into account the current available emotional information. |
| View Actual Emotional States    | Member |           | This functionality serves to show the last estimated emotional state of an identified member.  |
| View Past Emotional States      | Member |           | This functionality serves to show the list of the past emotional states of an identified member.   |
| View Member Emotional Evidences | Member | Emotional | Functionality that permits the visualization of the identified member evidences that were used to estimate the emotional state.          |

**Collective Emotional State Support Sub-System.** The Collective Emotional State support sub-system aims to support gathering all the necessary information in order to estimate the current and past emotional state of the network as a whole.

Fig. 3 shows an adapted i\* Rationale Strategic model where the involved actors as well as their dependency objectives are illustrated. Within the boundaries of the Collective Emotional State Support sub-system the respective associated tasks/functionality are presented.



**Fig. 3 -** Adapted i\* Rationale Strategic Model for the Collective Emotional State Support

The main functionalities of this sub-system are included in Table 4.

**Table 4.** Main Services of the Collective Emotional State support sub-system of Emotional Support

| <i>Service Name</i>             |            | <i>Service Description</i>  |
|---------------------------------|------------|---|
| Estimate<br>Emotional State     | Collective | Functionality used to infer the emotional state of the collaborative network taking into account the current available network emotional information. |
| View Actual<br>Emotional States | Collective | This functionality serves to show the last estimated emotional state of the network.  |
| View Past<br>Emotional States   | Collective | This functionality serves to show the list of the past collective emotional states of the collaborative network.                                      |
| View Members<br>States          | Emotional  | This functionality serves to show the list of the current emotional states of the CN members.   |
| View Collective<br>Evidences    | Emotional  | Functionality that permits the visualization of the evidences that were used to estimate the collective emotional state.                              |
| View Recommendations            |            | Functionality that according to the collective emotion suggests recommendations to the network administrator.   |

Fig. 4 illustrates the interface of the implemented prototype on the Administrators' side.

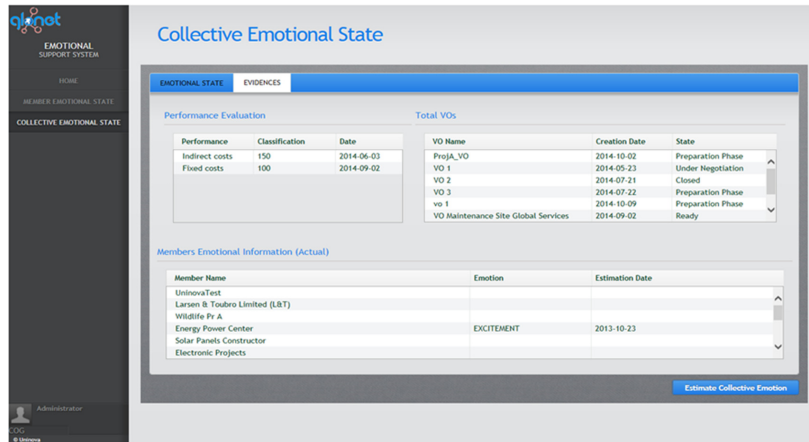


Fig. 4 – Developed prototype interface on the Administrators' side

This system is currently being evaluated and will be further validated in the context of the GloNet project, which addresses collaborative networks in support of complex service-enhanced products such as solar plants and intelligent buildings.

## 5 Conclusions and Future Work

Collective emotions are becoming an important element in the management of organizations. In the collaborative networks context its effect is also of extreme significance due to the virtual, dynamic and “soft” nature of the interactions among organization participants. Furthermore, it is also known that emotions might influence positively or negatively the network collaboration dynamics. Therefore, with the aim of maintaining the emotional equilibrium of the network, this paper presents the design of an emotional support system, including the identification and categorization of the most influencing positive and negative collective emotions and also the specification and prototyping of the sub-system services. Future work will rely on the progress of the emotional model that is used to estimate emotion according to the multi-modal non-intrusive evidences that were considered for the members and also for the network.

**Acknowledgments.** This work has been supported by the Collaborative Networks and Distributed Industrial Systems (CoDIS) Research Group of Uninova and partly by the GloNet project funded by the European Commission.

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