# Computerized Collaborative Support for Enhancing Human's Creativity for Networked Community*

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**Abstract.** The rapid development of computer and Internet enables people who have common interests to build loosely coupled networked communities. Through stimulating individual's creativity to augment community's communicative and collaborative abilities for acquiring new ideas and knowledge is becoming highlight research and achieving more and more experts' attentions. In this paper, we focus on exploring effective computerized collaborative support for enhancing human's creativity for networked community. Versatile aids are explored, such as visualization of expert opinion structure, clustering of contributed opinions for concept formation and idea/knowledge detecting and growing, etc. all integrated into a group argumentation environment (GAE) with a simple example.

**Keywords:** Creativity, Networked Community, Dual Scaling Method, Centroid.

## 1 Introduction

In daily life, many interesting phenomena can be described and explained through network. For instance, scale free network [1], such as World Wide Web, actor connectivity and science coauthorship, can aid to solve practical problems better. Also, social network has become one of highlights in academic research. Social network analysis (SNA) pays more attention to the relationships between people, and their roles played in the network [2]. Above all, computers and computer networks as advanced information techniques has been becoming an integral part of our life. It promotes and facilitates the research on network and its phenomena, such as powerful development and advancement on electric business, networked economy and knowledge networking, etc. Via the network, people who gather with common interests, form common ground and consensus. That builds the funentmental organization as a vitual team, networked group or community, even society. Global networking provides the convenient way to facilitate communication and interaction free from the limitation of time and location.

In general, community as a group allows free discussion, speech, brainstorming, dynamic data/information/knowledge sharing and transferring [3]. Debate, negotiation,

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argumentation and consensus building are common communicative and collaborative activities for community. Collaboration and technical support collaborative tools are key elements for productivity of improvement in both physical and networked settings. Nunamaker divided collaboration into three levels toward problem solving: the first one is collective level, in which individuals are independent and uncoordinated. Community starts from individuals, while an individual is a potentially unique community. The second one is coordinative level. All community's individuals are limited to share their information in this level. The highest level is concerted level in which collaborative communities are established [4]. In our opinions, accordingly, some technical applications can be easily found to match the three levels. Personal Web homepages, advertisements, etc. can work as collective level; BBS, forum, messager, etc, for information sharing can represent the coordinative level; The highest level tools may include group support system (GSS), computer supported cooperative work (CSCW), etc. Similar to Nunamaker's view, Mase et, al also provided three modes from the group thinking perspective. Individual thinking mode as the foundation for group thinking is the thinking of community's each constituent member. There is no interaction and individual's deep thinking in isolation. The cooperative thinking mode is also referred as the communication mode. Individuals as pre-community work together cooperatively to understand each other through their interaction. Furthermore, community can not only share their information and ideas, but create new things all together in collaborative thinking mode [5]. New creation and favorable collaborative tools are the important factors to build and maintain a positive and active networked community.

Based on the different type of communities, new creation can be new design, new products and new theories, etc. Expert community through distributed argumentation, pays more attention to the created and emerged new ideas, new knowledge, even their wisdoms. For that, how to effectively and efficiently exploit individuals' implicit knowledge, externalize their mental models, stimulate his/her intuition, insight and creativity, and augment their communicative and interactive abilities together with computerized support is a major concern. The content or platform for group collaboration for the networked community also can be called '*ba*', a Japanese word, where idea/knowledge is created, shared and exploited for different domains' experts for creative problem solving [6].

In this paper, we concentrate on computerized collaborative support for enhancing human's creativity for networked community during argumentation process. Versatile computerized aids have been developed, such as visualization of expert opinion structure, clustering of contributed opinions for concept formation and idea/knowledge detecting and growing, etc. all integrated into a group argumentation environment (GAE), to support the emergence of a *ba* for knowledge creation.

## 2 Computerized Support for Enhancing Information Sharing and Knowledge Creation for Networked Community

To facilitate group argumentation for enhancing information sharing and knowledge creation for networked community, heavy endeavors have been engaged in computerized support with tremendous advances of information and network

technologies. Absorbing some ideas from AIDE [7], AA1 [8], the architecture of we developed versatile aids for community is given.

### 2.1 Architecture of Computerized for Group Argumentation

Fig. 1 shows the four layers of the architecture of the integrated group argumentation environment (GAE) which is based on client/server framework and mainly includes an online electronic brainstorming argumentation room (BAR).

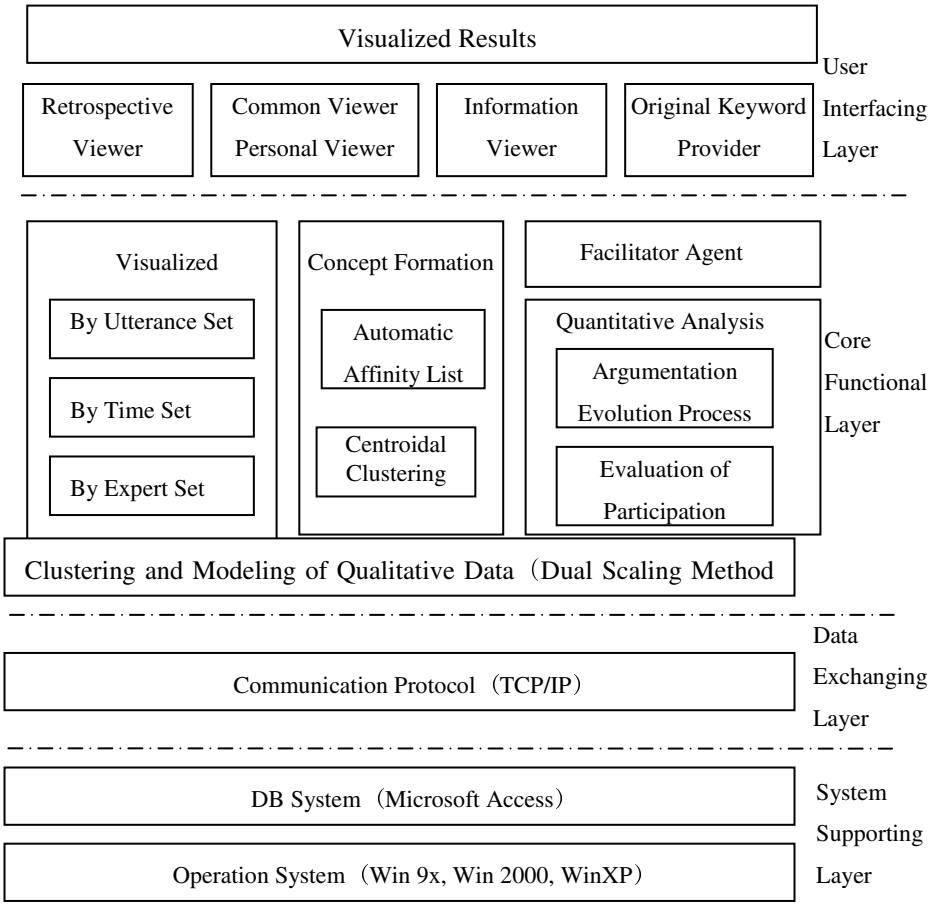


**Fig. 1.** Architecture of Group Argumentation Environment

Both user interfacing layer and core functional layer show what can be achieved at client window of BAR, though some services provided by server. Firstly, GAE can be regarded as a '*ba*' for networked community. Furthermore, by providing visualized thinking structure during the group working process together with a variety of

analytical mechanisms about the process and participants, it aims to support emergence of creativity, even wisdom. Follows introduce some salient functions.

### 2.2 Visualized Shared Memory for Group Argumentation

As shown in Fig. 2(a), the main client window for visualized shared memory is consisted of event record area, dialoguing area and visualizing area.

Visualized analysis transforms qualitative knowledge into a 2-dimenstional map, which helps the participants to understand community's others' opinions easier, find common interest, stimulate further thinking, acquire intuition and insight, facilitate knowledge sharing and new ideas generation. Following are two visualized viewers:

*Common viewer*, a discussion space as a joint thought space for all participants of community. Via the 2-dimensional space, the idea association process to stimulate participants' thinking, idea generation, tacit knowledge surfacing and even wisdom emergence is exhibited based on the utterances and keywords from participants. The global structure and relationships between participants and their utterances are shared by all participants in the session. It helps users to acquire a general impression about each participant's contributions toward the discussing topic, and understand the relationships of each thinking structure about the topic between participants.

*Personal viewer,* a personalized space where records individual thinking process during discussion. It provides a personalized idea-gathering space where the relationships between utterances and keywords are visualized. Individual creativity may be stimulated through personalized work via this personalized space. It helps the user to understand how one piece of information (utterance) affects the group thinking process and understand the relationships between each participant's mental process.

Fig. 2(b) shows retrospective analysis which applies same mechanism as both viewers and provides participants to "drill down" the discussing process for visualized partial perspectives. Further analysis of pieces of discussion such as selected intervals of discussion or combination of any selected participants may be helpful to detect the existence or formulating process of a micro community and acquire further understanding about participants' thinking structure.

From the visualized structure about the discussion in the course, the standpoints of participants could be estimated based on distances between participants. All those are based on a $n \times m$ frequency matrix constructed by $n$ utterance-objects and $m$ keyword-objects (see the Table 1). In general, the matrix is a sparse matrix since keywords are only mentioned by some utterances. This frequency matrix is changing dynamically. As more utterances submitted, more rows and columns are appended. By the terms of graph theory, frequency matrix describes the relations between vertex (participants or utterances) and edge (sharing keywords).

In Table 1, where $w_{ij}$=0, when keyword *j* is not mentioned in utterance *i* otherwise, $w_{ij} = W_{ij}$. The weighting policy is as follows: keywords appearing frequently throughout an entire argumentation process are very general words, which are not important for the utterance-object and are lightly weighted. On the other hand, keywords frequently used in a certain utterance-object or referred again after a long interval are important for the utterance-object [9].

**Table 1.** Utterance sets and keyword sets

| Y \ X | keyword$_1$ $x_1$ | keyword$_2$ $x_2$ | ⋯ | keyword$_m$ $x_m$ | |
|---|---|---|---|---|---|
| utterance$_1$ $y_1$ | $w_{11}$ | $w_{12}$ | ⋯ | $w_{1m}$ | $y_1 = \sum_{i=1}^{m} w_{1i}x_i$ |
| utterance$_2$ $y_2$ | $w_{21}$ | $w_{22}$ | ⋯ | $w_{2m}$ | $y_2 = \sum_{i=1}^{m} w_{2i}x_i$ |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ |
| utterance$_n$ $y_n$ | $w_{n1}$ | $w_{n2}$ | ⋯ | $w_{nm}$ | $y_n = \sum_{i=1}^{m} w_{ni}x_i$ |

We applied an exploratory, descriptive multi-variant statistical method—dual scaling, to analyze and process the matrix [10,11]. Dual scaling has some of the characteristics of correspondence analysis and exploratory factor analysis. The math underlying dual scaling is based on calculations of eigenvectors and eigenvalues of a frequency matrix. As a result, a pair of utterances with more common keywords may locate closer in the 2-dimention space. In the common viewer, utterance object is the participants; participants who share more keywords may be within a cluster. Here share keywords may mean participants hold similar concerns toward those keywords.

Different from the topological graph, the above algorithm formed graph is an interpretable graph, which reflects the data's nature in the database. But the topological structures have been designed and the forms are structured. In our research, we want to cluster the utterances and keywords of the experts in networked community, and the aim is to externalize the mental process of the human thinking. Here, we think, the interpretable diagram is more suitable to embody the thinking activities than the topological graph.

### 2.3 Facilitator Agent

If fewer ideas are contributed by participants, the chairman can launch facilitator agent. Once every two minutes in default, the agent extracts the most infrequently posted keyword and submits it with the userID of "Conversation" if no more keywords are provided. It not only takes a more fervor environment, also stimulates participants' further thinking and interaction. As far as the most infrequent keyword is concerned, it effectively extends ideation of participants because they have to keep silence if no more new ideas can be produced after focusing heavily on one thesis for a long time. In a word, "Conversation" can help create new great ideas as a virtual participant. Appling facilitator agent participant in argumentation process also embodies the man-machine interaction.

### 2.4 Record of Original Keyword Provider

Boden distinguishes creativity into two senses: psychological creativity (P-creativity), and historical one (H-creativity). A valuable idea is P-creative if the person in whose mind it arises could not have had it before, no matter how many people may have had the same idea already. By contrast, a valuable idea is H-creative if it is P-creative and no one else has ever had it before with respect to the whole of human history [12]. We agree to Boden's claim that P-creativity is more critical than H-creativity. In group argumentation, if you are the original keyword provider, the keywords which represent your ideas are your P-creativity results, as shown in Fig. 2(c). The function of record of original keyword provider in GAE system is to assist the users in finding what they had not noticed so far (P-creativity) that could lead them to really creative work at last.

### 2.5 Concept Formation

Concept formation means automatic summarizing and clustering of experts' utterances and detecting the typical keywords as meaningful groups or sub-communities of ideas based on visualized maps. The following are two methods to support concept formation:

1) Automatic affinity diagram (AAD): sometimes called the KJ diagram after its creator, Kawkita Jiro. AAD is to map the 2-dimension personal structure into 16×16 grids. As Fig. 2(e) showed, those utterances which fall into same cell are regarded as one cluster.

2) Centroidal clustering algorithm: centroid is the center of each set produced with cluster and given by $C_m = \frac{1}{n}\sum_{i=1}^{n} t_{mi}$ . Combining K-means clustering method [13], which equation is $m_i = \frac{1}{m}\sum_{j=1}^{m} t_{ij}$ , we use it to get $k$ centroids, where $k$ is an assumed number of clusters. The closest keyword to the centroid could be regarded as cluster label.

### 2.6 Idea/Knowledge Detecting and Growing During Argumentation Process

During group argumentation process, participants contribute and share their opinions (utterances, keywords) continuously. Locating and detecting current focuses and some representative ideas from the mass information with some quantitative methods may help stimulate experts' further thinking. For that, clustering algorithm of centroid is used to extract those typical keywords as ideas/knowledge based on the two-dimensional maps produced in common viewer of GAE. The concrete algorithm is shown in 2.5. Through recording series of extracted keywords at different given time, the process of idea/knowledge growing and evolution in group argumentation is explained well, as shown in Fig. 2(f).

The detailed introduction of other functions of GAE, such as evaluation of participation by calculation of eigenvectors about agreement matrix and dissimilarity matrix for further testing of some assumptions about individual impacts towards group behaviors, and information support for customized search, abstract and summarization, can see the reference [14].

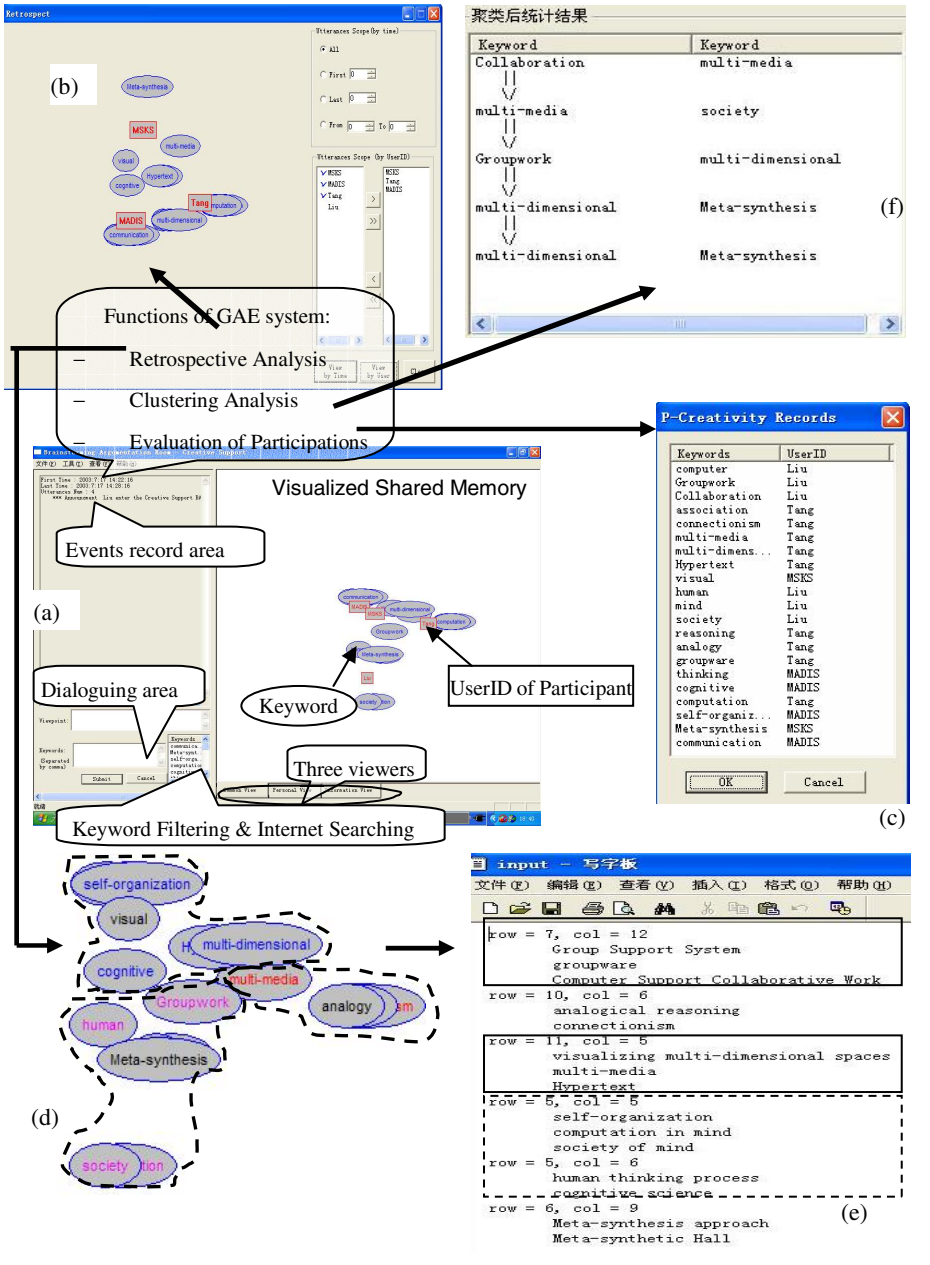


**Fig. 2.** Client Window of BAR (a) Main client window, b(b) Retrospective viewer, (c) Original keyword provider, (d) Clustering analysis (K=3), (e) KJ Editor (16×16), (f) Argumentation Evolution Process

## 3 An Example of GAE

In this example, the topic for discussion is about group support systems. Four persons whose registered IDs are Tang, Liu, MSKS and MADIS respectively participated the discussion and formed a networked community. Fig. 2 shows basic analysis taken in this test. Fig. 2(a) is a whole perspective of all concerned participants' contributions. It shows participants who share more common keywords locate closer in the 2-dimension space. Fig. 2(b) is the opinion structures of Users MADIS, Tang and MSKS as a subset community formed in retrospective viewer. Fig. 2(d) shows 3 clusters by K-means clustering method, where keywords 'visual', 'analogy' and 'Meta-synthesis' are acquired as the label (centroid) of each cluster.

Fig. 2(e) shows the affinity list based on personal viewer, which divides the whole utterance set into 6 cells according to their space relationship. It could be seen the utterances in one cell are related to each other. For example, all 3 utterances within Cell [row 7, col=12] are about GSS or similar tool systems, then that cell could be titled as group support system. On the other hand, all 3 utterances within Cell [row=11, col=5] exhibit concerns on man-machine interaction. Automatic affinity list could be regarded as a rough classification about participants' opinions during the brainstorming session. Further processing could be taken to acquire a more reasonable classification.

Dynamic visualized structures of the concerned topic may reinforce the stimulation and facilitate further thinking during community interactive process. The evolving diagrams may also help to find some hidden structures to aid communication and collaboration for community. Such a work is oriented to maintain an interactive *ba* and facilitate for idea emergence during group divergent thinking process.

## 4 Concluding Remarks

In this paper, we focus on computerized collaborative support for enhancing human's creativity for networked community. Research on creativity and knowledge creation together with computerized supports provides basis for our research [12, 15-17]. What we are exploring is not only a computerized support tool for communities' communication and interaction, but also expecting to support the emergence *ba* for creative problem solving. Our developed group argumentation environment exhibits our ideas, which acts as a virtual *ba* promoting members exchange ideas, stimulating their creativity and enhancing argumentation effects.

Our current work is still at very initial stage from both research and practice [14, 18-20]. From the research perspective, currently we mainly concentrate on cognitive modes and mental models for individual of community, and group communication and collaboration behaviors and responses. The aim of GAE is to support dynamic emergence of a knowledge creation environment (*ba*). Lots of further work are under exploration, such as better human-machine interaction, opinion synthesis in consideration of expert's background, and evolving process of keyword network to detect the pathway of knowledge creation, etc. More experiments, that is, building multi-communities, will also be undertaken for verification and validation of GAE in practice.

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