Chapter 6

Informal Conversation Environment for Collaborative Concept Formation

Kenji Mase
Yasuyuki Sumi
Kazushi Nishimoto

6.1 Introduction

We spend a lot of time every day engaged in informal conversations in various situations such as everyday chatting with neighbors and colleagues, informal talking after a business meeting or in a coffee break during a conference. Such informal conversations are in many instances very important in forming various kinds of communities because they establish the *common ground* among people necessary for the community. The informal exchange of ideas and thoughts can establish common ground, such as common interests and mutual understanding. While they may be initially immature, they are indispensable for further joint and collaborative activities. They are essential in starting and maintaining discussions in a *pre-collaborative group* that will later become a community.

Community in Its Early Stages

One scenario of establishing a community involves the stages of (i) gathering or assembly, (ii) common ground, (iii) sharing mutual interests and understanding, and (iv) agreeing common needs and/or goals. At first, people get together either by chance or on the basis of an implicit common interest or objective. However, they are not initially aware of the possibility of forming a new community. During conversations, they may find that common ground exists among them, focusing on several topics that may later be seen as mutual interests, and, thus, attain a better understanding of each other through this process. After that, they may be drawn to working together, for instance, to solve common problems.

In the course of this scenario, however, many communication problems may occur. For example, the meaning of a word may not always be universally understood, which can lead to misunderstanding and/or confusion. This problem often occurs due to difference in personal background, specialty, need, and/or interest, and as such frequently arise within a *pre-community group*. This naturally will not help the smooth communication between people but rather hinder it. A typical example can be seen in some so-called "flames" in discussions on electric news groups and/or mailing lists on the Internet.

Another problem we may observe during the gathering of a group is that some potential members may be unaware of the common needs and goals which may exist, and the potential they share to tackle problems together. Even though they can reach that stage of assembly and gathering, it is still difficult to plan joint actions if they don't know each other well enough to share the roles for a common goal.

6.1.1 Community Computing for the Internet Age

Computers and computer networks are becoming an integral part of our life, especially in business, with the common availability of such features as for sending e-mail, chatting, and/or meeting over networks. However, to what extent does a computer or network environment for the content of such correspondence benefit from the fact that it is being conducted on a computer via a network? Global networking, for instance, makes our communication free from the limitation of time and location. Telephone services overcome the problem of distance, and e-mail and fax make asynchronous communication possible. This is wonderful, of course. However, these telecommunication services only provide a transparent environment for face-to-face communication; they are far from enhancing or augmenting it. Furthermore, they cannot provide a completely transparent environment due to the limited channels over a network. Similar things can also be said of the computing environment. For instance, existing groupware systems replaced the pen, paper and white-board environment with networked computers, but remained behind truly-transparent systems. Again, they are far from enhancing or augmenting the conventional group working environment.

We may say that these telecommunication and computing systems provide the opportunity to resolve important issues through communication, e.g., through mutual understanding, common concept building, and sharing common ideas. These are all important objectives in communication and are necessary for community formation. However, they only provide an appropriate environment, and therefore the chance to resolve issues, but do not truly assist.

Mutual understanding and common concepts are very important core ideas in forming and maintaining a community. Networking and computing systems can, we believe, provide a novel aid as well as chances for enhanced communication, to support a pre-community group in forming a community. Community computing systems should be designed to include functions that facilitate mutual understanding and the development of common concepts. This leads to the question of how computers and networks can enhance communication for the pre-community group. The abilities of computers to visualize data of any kind and to reproduce and reuse situations are favorable features for this purpose.

Visualization using computer graphics techniques is well accepted today in many areas, such as medical simulation, flow dynamics simulation, and virtual reality. A computer can visualize the data in various ways once it is stored in a database with a well defined visualization algorithm. Data visualization objectifies the content by means of "computer's aspect" embedded in the algorithm. The aspect may include the data structure, the relations among data, the representation of data, and so on. This is applicable not only to data used in physics, but also to that relating to the contents of discussions. We will show in this chapter that the content space of chat and talk can be visualized in such a way as to be accessible using a computed metric. Once visualization has been performed, people in pre-community groups can identify common ground for discussion through which they can explore such forums as those involving inconsistency of wording, disparity of opinion, agreement of concept, or intimate company. Visualizing the conceptual space of chat or of discussion is one of the steps in community formation, and as such the concept visualization is an indispensable function of community computing.

Reproducibility and re-usability of data are also useful features of computers. Once a database has been provided with its "universal representation" in the computer, we can use it again and again for different purposes. We can also manipulate the data to modify it in a trial-and-error manner, if necessary, without affecting the original. The possible and desirable manipulations include, for instance, the crystallization of a topic and/or an idea, the visualization based on one's own perspective on a topic or on someone else's point of view, overlaying several aspects, and incorporating new knowledge or information from outside the on-going communication session. The universal representation makes it possible to distribute the data to others. In other words, if we can define the representation of communication contents well, it can be manipulated and shared with others. Consequently, it is useful for the people in a pre-community group to be able to manipulate and pass each other the knowledge and the viewpoint. The universal representation and re-producibility are thus essential functions in visualization of community computing.

In this electronic age, the Internet and the World Wide Web environments should not be disregarded as a means for community formation. We often come across some home pages that have been designed as "meta pages" for collecting other pages that can be classified within some context. These can prove to be valuable resources for many people. Some are extremely large collections specializing on a particular field and have been make available to the public on the basis of collector's subjective aspect. They may offer some ideas or viewpoints to people who have similar interests, and they help people forming a new community, providing an aid for encounters on the network. The structured presentation of the collection, which may be given by a concept visualization method or similar, will play a role of mate-making on the network. This may be also a picture of future computing systems in community.

6.1.2 Informal Discussion Environment for Community Computing

We have been developing a group-thinking support system, called AIDE (Augmented Informative Discussion Environment), as a conversation support environment that provides functions to manipulate communication content as previously outlined. AIDE is an online chat system that can facilitate daily and informal conversations in "conversation spaces" to be shared by various users. The conversation environment is integrated with the techniques for visualizing structured information space containing utterances from conversations, for personalizing information by means of crystallization, and for manipulating the aspects of the topic.

The conversation space of the AIDE is automatically represented in the *discussion viewer* by a method that statistically structures conceptual spaces containing text-objects and their keywords. The visualized map of the conversation space is very useful in that it allows users to instantly assimilate its content and the relation between participants through the perceptual process in spatial segmentation.

AIDE also employs an intelligent *conversationalist* agent that autonomously joins in with the conversation as a computer participant, providing text segments, from the information text-base. This can help to enhance the structure of conversation. The computer participant is an agent that sometimes behaves like an outsider to the group members, shaking ambiguous agreement in the pre-community group.

Each collaborative participant is also able to personalize information, simply by gathering and organizing it on a *personal desktop*, which is a seamlessly copied space of the conversation. In order to flexibly exploit shared information in this way, including modifying the information to adapt to facing problems and accommodating distributed and asynchronous environments for collaboration, personalizing information (gathering and organizing information) by each collaborative participant is an essential technique [Sumi *et al.* 1997b]. That is, one possible approach is to have all participants improve the quality of information through personalization, and acquire viewpoints that would facilitate understanding of others and the relationships among them. We also present a method of visualizing the relationships between multiple participant viewpoints acquired from these personalized information spaces.

Our fundamental intentions are to mediate communications between people pre-engaged in collaborative work, to extend our thought spaces during concept formation, and to seamlessly integrate our daily activities such as individual thoughts and group meetings with the technique of information retrieval. Our system assumes a conversation environment on networked computers, since we have become accustomed to electronic conversation environments, e.g., e-mail and online news, with the recent spread of the Internet. These media release communities from temporal and spatial restrictions, and raise the possibility of reusing accumulated results from their collaborative work.

Chapter Outline

The following sections of the chapter focus on the early stages of community establishment. In Section 6.2, a model of the group thinking process is presented, which is then applied to a case of activity transition in a pre-community group to form a community. Based on our model, we have been developing a system for online chat and discussion called AIDE that facilitates our daily and informal conversations in conversation spaces shared with other users. Section 6.3 describes the structure of the AIDE system. The online conversation space can be regarded as a public arena or a "common place" in the global electronic information age where a community can readily be formed within the environment as interaction proceeds. The system provides the forum and opportunity to form a community, and, more importantly, it can provide people with the functions and capabilities to actively support and enhance the community formation process. In Section 6.4, a few conversational examples of how the AIDE system can support communication between people will be presented. The examples are not specifically designed to explain the support process for community formation, but rather for group thinking itself. However, we believe that the examples will illustrate its potential capabilities for supporting community formation. Lastly, in section 6.5 we will discuss the AIDE system as a community information system as well as its various applications such as promoting the creative aspect of group thinking.

6.2 Conversation, Common Concept, and Community Formation

6.2.1 Group Thinking Model

In this section, we propose a universal model of group thinking. Even though the manner of group thinking varies according to the particular characteristics of a group, common structures exist in any group, i.e., its members and their interactions.

The foundation for group thinking is the thinking of each constituent member. However, group thinking cannot be realized merely by collecting the individual thoughts of members. It is the interactions among the members and their collaborative actions that make group thinking possible. Paying attention to the fact that the "mentality" of a thinking entity differs between individual member activity and the overall group activity, we modeled the group thinking process in terms of the following three modes:

- individual thinking mode
- cooperative thinking mode
- collaborative thinking mode

Figure 6.1 illustrates the relationship of the modes and the general idea of the group thinking model.

There is no interaction between the members while in the individual thinking mode. Each member develops thoughts in isolation, which enables personal opinion to be established and facilitates the creation of individual ideas. Deep thinking is easier in this mode than in the others.

The cooperative thinking mode is also referred to as the communication mode. In this mode, members work together cooperatively to understand each other through their interaction. In this way, they can understand the ways other members think and behave to exchange opinions, positions, and ideas correctly and understand them. Through these interactions, individual thinking merges to a unified "intention." The mode is preparatory for the collaborative mode.

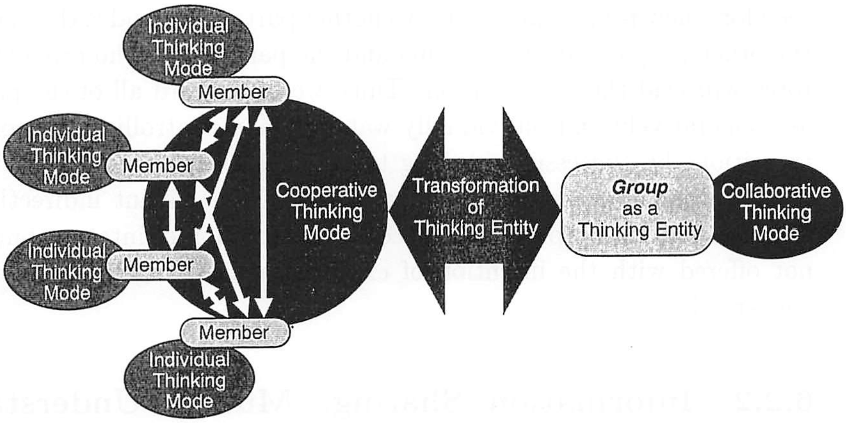


Figure 6.1: Group Thinking Model

In the collaborative thinking mode, members think together. The group sometimes behaves like a persona in thinking. In this case, the state of the group may be called a group-persona or a meta-persona. The objective of this mode is to establish the group opinion and position and to create unified group ideas.

The group cannot initially shift directly from the individual thinking mode to the collaborative thinking mode. Once it obtains some common ground in the cooperative thinking mode, the transition can then proceed smoothly. Furthermore, group thinking proceeds even while it switches back and forth between the modes. It is not necessary for all the members of a group to join in with each mode's activity, but instead members of sub-groups can be engaged in one of the modes.

Group Conversation and Community Formation

We can apply the group thinking process model to community formation. For some informal conversation situations such as in chatting, or during coffee breaks, people are involved initially just in an informal gathering. As the conversation proceeds, however, they will gain an understanding of each other, share information, and establish a common ground as in the cooperative thinking mode. This can be labeled as a pre-community group. Such a group may eventually want to work together to achieve a common goal and shift into the collaborative thinking mode, thus forming an established community.

As we are dealing with informal conversations, neither the number of participants nor the topic domain are restricted, and the goal of a conversation need not be evident. In daily conversation (i.e., without a moderator), a participant will often lead the conversation by focusing on a certain topic. If a seed for a new topic is provided by another participant and is then accepted by the others, topic transition occurs and the participant who provided the new topic will lead the conversation. Thus, we can regard all of the participants as cooperatively and individually watching and controlling the conversation transitions by successively taking turns as the leader. Moreover, this cooperative work emerges unintentionally. Each participant indirectly controls the conversation by providing pieces of information of interest, but these are not offered with the intention of explicitly controlling the direction of the conversation.

6.2.2 Information Sharing, Mutual Understanding, and Agreement for a Common Concept

As mentioned above, the cooperative thinking mode is indispensable in shifting group thinking to the collaborative thinking mode. This is also true for community formation. A gathering cannot become a community without passing through the cooperative thinking mode to establish common ground.

Group members may or may not find the group or the others behave in a way that is consistent or inconsistent with their own individual interests. Members exchange a variety of information from the trivial such as seasonal compliments, personal family information, and entertainment issues, to serious issues such as employment and private problems, as well as matters of specific interest such as criticisms of the presentations. Thus, they are able to share information and come to know each other better.

After getting to know each other, they proceed to the stage of accepting each other, i.e., accepting each other's ideas and opinions. For mutual understanding, agreement is not even necessary. Sometimes members are required to simulate how their own thinking is viewed by the others in order to achieve mutual understanding.

The ideas and opinions, or general *intention*, of members can be represented in terms of *viewpoint* and *knowledge*. Here, viewpoint is either a framework to structure information or the structure itself, and knowledge is a set of information fragments, either disorganized or organized in structure. Then, the task of thinking is to overlay and/or apply this viewpoint and knowledge in the cooperation mode, in one of the three following ways:

- overlaying between viewpoints
- applying a viewpoint to some knowledge
- overlaying between the knowledge of individuals

Consequently, we need a computer and network system that supports these tasks if we want to develop a support system for group thinking or community formation. We believe the most important information in group thinking is the information representing a viewpoint and knowledge. To shift between thinking modes, we need mutual understanding, which is not possible without exchanging viewpoints and knowledge.

6.2.3 Issues and Directions for Electronic Group Thinking

Colab [Stefik *et al.* 1987] is a pioneering system for electronic conferencing. The system's objectives are to induce brainstorming in electronic conversation environments, organize fragments of ideas extracted there, and share information; these are similar to our own aims. Colab, however, cannot effectively utilize computers to create a novel form of collaboration, as it would only reproduce meetings using traditional tools such as a pen, paper, and chalkboard, in some electronic form. However, we set out to create a new form of collaboration with an environment where computers positively offer information that cannot be offered by the traditional passive tools.

Some systems that help coordinate conversation have been proposed; see, e.g., [Conklin and Begeman 1988, Winograd 1988]. The aim of these is to support information-sharing among groups by processing the relationships between the words given and the positions of the participants during conversation in collaborative work. However, these systems force their users to follow some predetermined conversation models prepared by the system designers. That is, the users must attach additional information to all utterances relating to their own position or relationships with others. Our system does not require the users to specify any extra information during a conversation; in contrast, it offers provides useful information to the relationships among utterances.

Establishing permanent common ground [Bobrow 1991] satisfactory to all participants, for shared information in collaborations, is actually impossible in distributed and asynchronous environments on networked computers. Even if it were possible, the results would lack adaptability to variable situations. One possible approach, which we take in this chapter, is to have all participants improve the quality of their information through personalization, acquire viewpoints helpful in understanding the others, and understand the relationships among them, in such a way that the participants effectively use the personalized information in collaborative work.

The authors have proposed several computer tools for communication support, such as on *outsider agent* [Nishimoto *et al.* 1996], *CAT1* [Sumi *et al.* 1997a], and *CSS* [Sumi *et al.* 1996b]. These are the base of the

AIDE system, providing a new direction to make the system positively offer new information, to allow informal conversation space, and to provide manipulation handles on viewpoints and knowledge. An example is the Discussion Viewer, a main feature of AIDE, which visualizes the thought space with a method that statistically structures conceptual spaces. The method was first implemented for CSS as proposed in [Sumi *et al.* 1996b].

6.3 AIDE: An Informal Conversation Environment

6.3.1 System Overview and Configuration

AIDE is basically a client-server type chat and discussion system. This system can be centralized or distributed, and it can be synchronous or asynchronous. Furthermore, the number of participating users in a session is arbitrary. AIDE is implemented under the X Window System on a UNIX workstation, and offers a user interface with multiple windows. AIDE is characterized by the following three subsystems.

1. **Discussion Viewer**: This displays discussion spaces that visualize the structures of conversations. These spaces are information spaces shared among all the participants in conversations.

2. **Conversationalist**: This is a virtual participant who automatically extracts text relevant to the conversation from an external text-base and autonomously introduces them into the discussion spaces.

3. **Personal Desktop**: This is a local desktop in which users can enter to the phase of individual thought. The users can personalize shared information by duplicating and modifying the discussion spaces with the desktop.

Figure 6.2 illustrates the system configuration of AIDE, and Figure 6.3 depicts a scene in which two users are using AIDE in the face-to-face synchronous mode. Figure 6.4 is an example snapshot of the common screen image, which is also viewable on each user's client machine.

The main window of AIDE is shown on the left of Figure 6.4, and consists of a submission window with which a user can submit his/her utterances and a text utterance window that lists all collected utterances. The right-hand window is the Discussion Viewer, the common visualized discussion space. The server machine manages both information relating to users' utterances and discussion spaces that visualize the structures. When a user submits an utterance, the server automatically extracts keywords from the text along

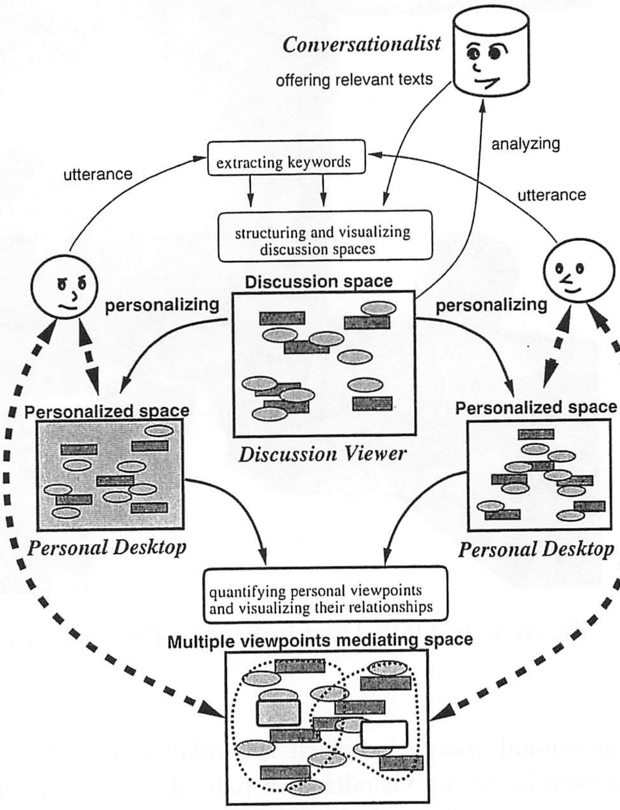


Figure 6.2: Configuration of AIDE, and Viewpoint Sharing among Participants Using AIDE

with their importance values, and, according to the updated information, calculates and redisplays the discussion spaces on all of the users' client machines. The Personal Desktop is not shown in the figure, however, it is an extended form of the displayed screen shot. The difference is that users can modify and manipulate the discussion content locally.

6.3.2 Discussion Viewer: Shared Visual Discussion Space

In the discussion spaces, icons are used to indicate the various utterances up to that current point and their keywords, which are automatically extracted by morphological analysis, and are then mapped.[1] The discussion spaces are

[1]Each user can decide whether or not the icons for utterances and keywords are simultaneously displayed.

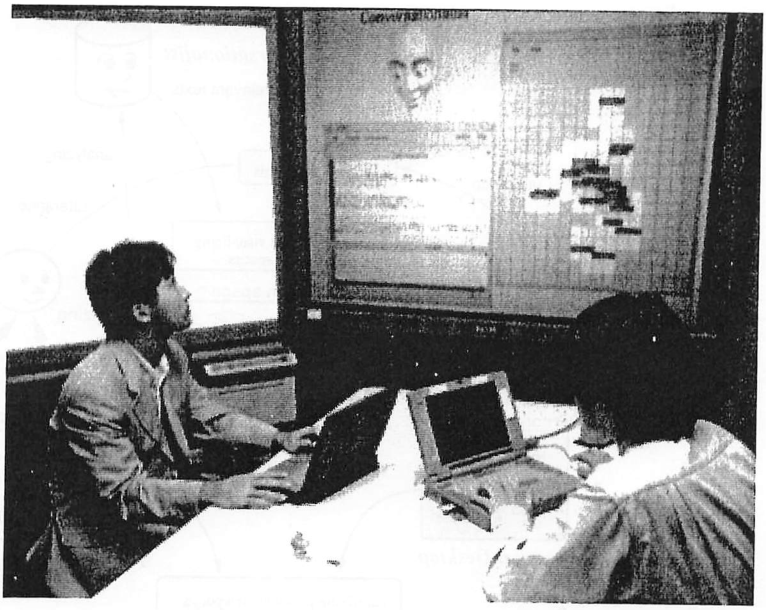


Figure 6.3: AIDE Used in Face-to-Face Synchronous Mode

two-dimensional spaces in which the relationships between utterances and their keywords can be visualized; a pair of utterances with more commonly used keywords are located closer together and these common keywords are mapped between the pair.

A discussion space can be regarded as a joint *thought space* for the participating people, like an externalized mental space consisting of fragments of ideas or knowledge and the relationships among them established in thinking activities. If we see some clusters or blanks in the space, we may try to find the reason, creating a concept personally or jointly. Visualizing snapshots of the topological structures of a user's thought space also assists in forming creative concepts.

All users can participate in conversation and understand the global structure and relationships among multiple topics (clusters of icons in the space) by viewing the shared discussion spaces. The discussion spaces visualize the relationships among the utterances on the basis of such objective and simple information as the co-occurrences of keywords; this has the effect of making users notice new relationships instead of temporal relations.[2] Hence, the Discussion Viewer and record of utterances on the main window are complementary.

[2] It is possible to employ the temporal dimension into the display using a three- or higher-dimensional display.

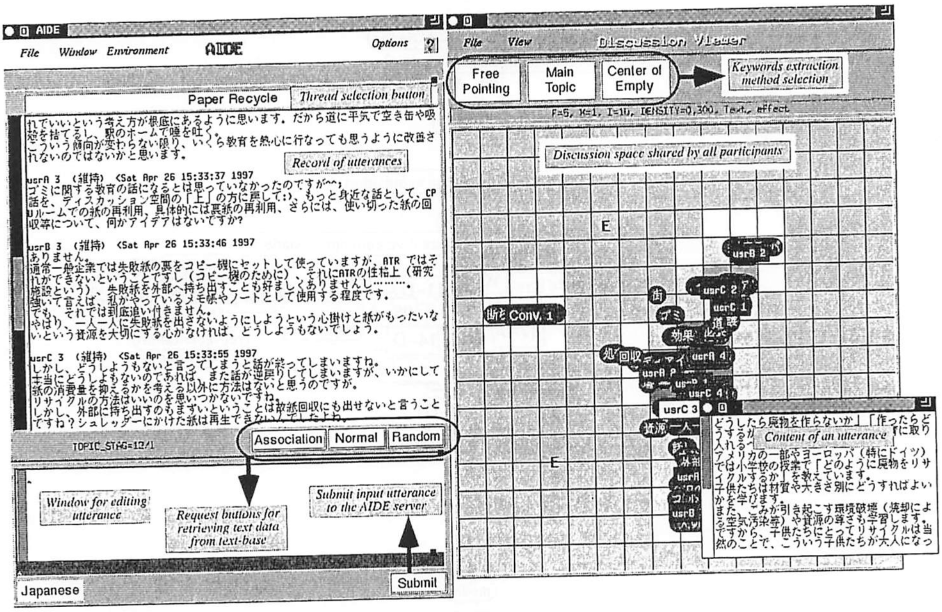


Figure 6.4: Usage of AIDE

The Discussion Viewer is used for individual reflection and shared understanding in groups working collaboratively. It works successfully to visualize the global structure of a user's thought space. These visualizations encourage the user to further his/her thinking, such as finding the axes of a semantic structure in the presented space, or finding new ideas in empty regions in the presented space. It also has the potential to display a user's subjective ideas and views to his/her colleagues.

Figure 6.5 shows an example view of the Discussion Viewer for a group discussion. In this group discussion, four people have joined to discuss "a knowledge-based system for design," which is not a previously articulated idea. The rectangular icons are text-objects, which show statements posted via on-line news systems. For instance, "12-A" indicates that this statement was posted 12th, by a participant A. The oval icons are keywords that have been articulated by the participants. The two-dimensional space visualizes relationships among the participants, topics, and their keywords. This visual information is useful for the participants, allowing them to realize their positions as well as for outsiders to grasp an overview of the discussion.

The computation to spatially allocate the utterances and keywords in the two-dimensional space employs the *dual-scaling method*, which is a multivariant statistical analysis method [Nishisato 1980]. It provides the principal components for given relations between keywords and utterances containing

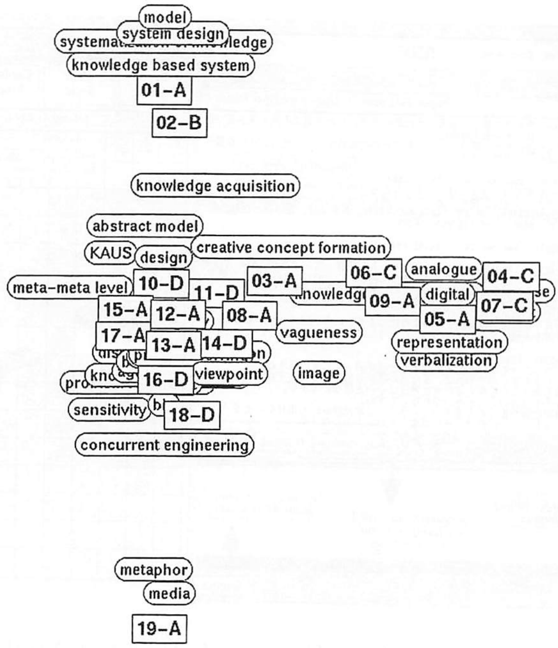


Figure 6.5: Snapshot of the Semantic Structure of an On-Line Discussion Using Discussion Viewer

them. Thus, the relations between concepts (i.e., utterance-objects) and elements of concepts (i.e., keywords) are represented by spatially arranging the concepts and the elements.

The dual-scaling method represents the relations of the attributes shared among the objects and the co-occurrent relations among the attributes as spatial relative relations, by quantitatively grading the object set and the attribute set. For this method, it is assumed that a text-object set consisting of plural quantification attributes is a given. We assume that keywords are automatically extracted by the utterance-processing module (see the next section) as attributes of utterance-objects, and that the weight of each keyword is regarded as its attribute value. As a result, the conversation-structure space that represents the relations between all of the utterance-objects and all of the keyword-objects (a keyword-object consists of a unique keyword) was obtained.

Space Visualization with Dual-scaling Method

The actual computation of the method is illustrated as follows. An $n \times m$ array of n text-objects and m keywords is given:

	keyword$_1$	keyword$_2$	...	keyword$_m$
object$_1$	2.0	—	...	1.5
object$_2$	—	2.5	...	1.0
⋮	⋮	⋮	⋱	⋮
object$_n$	—	1.5	...	—

where value expresses that the corresponding keyword is used in the corresponding text-object (the value is automatically set by the system), and where a blank slot represents the absence of a keyword in the corresponding object. Most of the slots are blank for real data.

The dual-scaling method first defines the score vector for each data-object (text-object) and its attribute (keyword) in the following equations:

$$\boldsymbol{x} =^t (x_1, x_2, \ldots, x_n), \quad \boldsymbol{y} =^t (y_1, y_2, \ldots, y_m)$$

where t indicates the transpose. Then, it determines them so that data-objects that have similar sets of attributes obtain similar scores and that attributes belonging to similar sets of data-objects obtain similar scores. That is, if an $object_i$ has an $attribute_j$ ($keyword_j$), they are paired as (x_i, y_j), and then the vectors $\boldsymbol{x}$ and $\boldsymbol{y}$ are determined, maximizing the correlation coefficients using the set of (x_i, y_j). The matrix can be written as follows:

		attribute$_1$	attribute$_2$	...	attribute$_m$
		y_1	y_2	...	y_m
object$_1$	x_1	2.0 (x_1, y_1)	—	...	1.5 (x_1, y_m)
object$_2$	x_2	—	2.5 (x_2, y_2)	...	1.0 (x_2, y_m)
⋮	⋮	⋮	⋮	⋱	⋮
object$_n$	x_n	—	1.5 (x_n, y_2)	...	—

The correlation between the object set weighted by $\boldsymbol{x}$ and the attribute set weighted by $\boldsymbol{y}$ is given by

$$\frac{\text{covariance between objects and attributes}}{\sqrt{\text{variance of objects}}\sqrt{\text{variance of attributes}}}$$

Then, if $\overline{\boldsymbol{x}} = \overline{\boldsymbol{y}} = 0$, the correlation becomes

$$\frac{{}^t\boldsymbol{x}F\boldsymbol{y}}{\sqrt{{}^t\boldsymbol{x}D_n\boldsymbol{x}} \cdot \sqrt{{}^t\boldsymbol{y}D_m\boldsymbol{y}}}$$

where F is the matrix of the data, D_n is the matrix with row marginal distribution of F as its diagonal term, and D_m is the matrix with column marginal distribution of F as its diagonal term.

The problem of obtaining the ($\boldsymbol{x}$, $\boldsymbol{y}$) that maximizes the equation above reduces to an eigenvalue problem, details of which should be referred to in

[Nishisato 1980]. The interesting aspect here for the dual-scaling method is that x and y are determined uniquely and they are interpreted as the same measurement. The Discussion Viewer uses two sets of values for (x, y), which correspond to the two dominant eigenvalues, as the coordinates of the visualization space.

6.3.3 Conversationalist: A Computer Participant Agent

Next, we explain the virtual participant called the Conversationalist. This subsystem is implemented for information retrieval, but also features several other functions such as calculating the timing of utterances and evaluating the contents of utterances, possibly by analyzing them in comparison with other utterances during a conversation [Nishimoto *et al.* 1998].

The Conversationalist has text-bases containing text indexed with keyword vectors beforehand.[3] Segments of text and their keywords are also brought in the discussion spaces by the agent, and this causes a reconfiguration of the spaces. These results may be effective in leading human participants to a wider thought space and new ideas.

Daily conversations are not necessarily well-structured, often spreading over several domains. Consequently, it is not realistic for the conversationalist to have frame-knowledge of the conversation transitions or contents beforehand. Therefore, we apply a method of processing conversations on the basis of the surface information of each utterance.

Figure 6.6 shows the software structure of the conversationalist. The utterance processing module morphologically analyses each input utterance and extracts weighted keywords with respect to the history of each keyword in a conversation. The conversation structuring module arranges each utterance and keyword in two-dimensional space based on the dual-scaling method. These modules are shared with the Discussion Viewer.

Then the *topic development recognition module*, searches for main topics and empty spaces in topics by using the space obtained by the *conversation structuring module* which employs an image processing method. On the other hand, the *topic transition observation module* observes topic transition by evaluating cohesion among utterances. If stagnation is detected in a topic, the *topic seed provision module* is invoked and a piece of information is extracted that can form the seed of a new topic based on the topic development situation obtained by the topic development recognition module. As a result, the conversationalist can introduce a new viewpoint and a new direction.

[3] Currently, this text-base contains articles from a contemporary Japanese language encyclopedia. The number of articles is about 10 000, with about 40 000 keywords extracted beforehand.

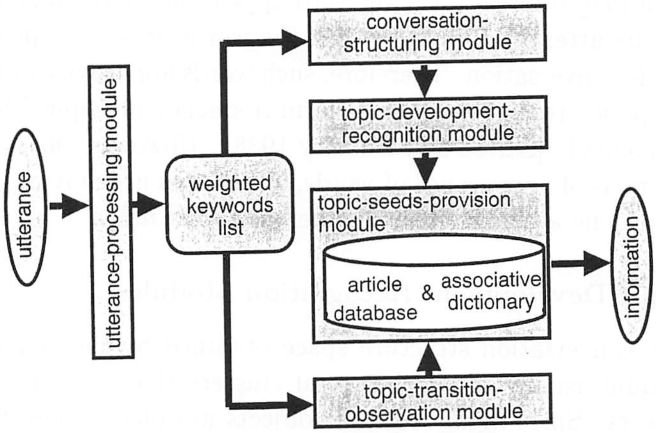


Figure 6.6: Software Structure of the Conversationalist Agent

In the following, the processes of the utterance processing module, the topic development recognition module, the topic transition observation module, and topic seeds provision module are described in detail.

Utterance Processing Module

The input data is text data of the human participants' written utterances on-line. We call the text data of each utterance an "utterance-object." This module analyzes an input utterance-object morphologically and determines the part-of-speech of each word. Nouns and unknown-part-of-speech words are then extracted as keywords of the utterance-object.

The weight $W_{w_i,n}$ of the keyword w_i at the nth utterance is calculated by the following equation:

$$W_{w_i,n} = \left(1 + \frac{1}{1+e^{-f_{w_i,n}+F_l}}\right)\left(1 + \frac{1}{1+e^{-i_{w_i,n}+I}}\right) \Big/ \left(1 + \frac{1}{1+e^{-f_{w_i}+F_g}}\right)^2 \qquad (6.1)$$

where f_{w_i} is the number of utterance-objects that include the word w_i until the $(n-1)$th utterance-object, $f_{w_i,n}$ is the number of the word w_i in the nth utterance-object, and $i_{w_i,n}$ is the blank duration, in terms of the number of utterances made, since w_i last appeared. The terms F_g, F_l, and I are constants. The weighting policy is as follows. Keywords appearing frequently throughout an entire conversation are very general words used in all kinds of conversations or words related to the global topic of the conversation. Therefore, such words are not important for the utterance-object and are lightly weighted. On the other hand, keywords frequently used in a certain utterance-object and keywords appearing in an utterance-object after a long interval (or a keyword appearing for the first time) are important for the utterance-object, even if the words appear frequently throughout the whole conversation. Therefore, such words are heavily weighted. This weighting policy resembles $tf \cdot idf$ (term frequency multiplied by inverse document frequency) [Salton and Buckley 1988]. However, our method considers the intervals of appearance of words, and makes use only of utterances that have been done already, which is different to $tf \cdot idf$.

Topic Development Recognition Module

The conversation structure space obtained by the conversation structuring module usually provides several clusters that consist of several utterance-objects. Since highly relevant objects are placed close to each other in the conversation structure space, we can assume that a cluster corresponds to certain content. Therefore, we can know the composition type of the conversation, and the main content from the conversation structure space. However, there are often "empty spaces" where no utterance-objects exist in the conversation structure space.

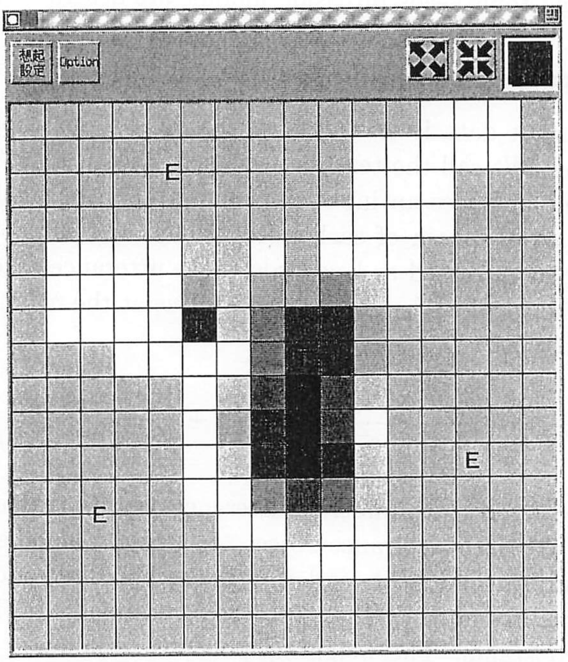


Figure 6.7: Topic-Development Structure Based on Conversation Situation

This module divides the conversation structure space into 16-by-16 cells as shown in Figure 6.7. The number of utterance-objects is counted for each cell by smooth filtering, and this is regarded as the weight of each cell. After each utterance, this module searches for peaks in the cell weights, and regards these peak cells as the main content. At the same time, the distance of each zero-weighted cell from the boundary of clusters of non-zero-weighted cells and that of the conversation structure space are calculated on the basis of the Euclidean distance transformation method [Saito and Toriwaki 1994]. If there are any clusters of zero-weighted cells that exceed a threshold distance (currently, a distance of two cells), this module regards them as empty spaces of the conversation at that time and regards the most distant region as the main empty space.

Topic Transition Observation Module

This module detects topic transition points in real-time by using two kinds of utterance cohesion—micro cohesion and macro cohesion—obtained from morphological data and time transition data from the utterances. The micro cohesion is determined by whether or not several specific expressions (e.g., clue-words, indication-pronouns, synonyms, antonym) are included in an utterance. The micro cohesion quantifies the cohesion between an utterance and the preceding utterance as strongly connected, weakly connected, or strongly disconnected. The macro cohesion is determined by the frequencies and intervals of nouns and synonyms included in utterances, and by the time elapsed since the last topic transition. The macro cohesion at each utterance quantifies the tendency to maintain the current topic.

Topic Seeds Provision Module

This module provides a piece of information as the seed for a new topic, when it detects stagnation in a conversation in the topic transition observation module. This module has a text-object database that consists of many text objects and retrieves the information from the database.

According to subjective experiments in thought-space visualization, people often find new topics in the empty spaces of the conversation structure space. The criteria of retrieving information is such that the module first finds an empty space in the conversation structure space, and then it searches for information that could fill the empty spot. As shown in Figure 6.7, the conversation structure space is divided into 16-by-16 cells and the empty spots are indicated by "E" in the figure.

Once an empty spot is identified, a query keyword vector is constructed in the following way. First, a constant number of keywords are obtained by collecting keyword-objects in order of their distance from the center of the main empty space, and, from which a query keyword set W_q is generated. The weight I_{w_i} of each keyword $w_i (w_i \in W_q)$ is calculated by the following equation:

$$I_{w_i} = \frac{min(d_{w_j}; w_j \in W_q)}{d_{w_i}} \tag{6.2}$$

where d_{w_i} is the distance between the center of the target empty space and the keyword-object w_i. A query keyword vector **Q** is generated from the query keywords and their weights.

The retrieval result is then determined by calculating the inner product of the query keyword vector and each keyword vector of each text-object of the text-object database. This results in the text-object that has the highest inner-product value. Such a piece of information can be expected to be located in the main empty space ready to introduce a new topic.

6.3.4 Personal Desktop: Information Personalizing Desktop

Lastly, we will explain the Personal Desktop. Each user can enter an individual-thought phase with this at any time while participating in a conversation. Since the presentation of information and the method of visualizing this information are the same as those for the Discussion Viewer, the transition from collaborative thinking to the personal thought, and vice versa, is very smooth. Users are not allowed to manipulate objects in the Discussion Viewer, except for submitting a new utterance. On the other hand, on the Personal Desktop, users can freely manipulate the discussion space, such as by moving icons, or by removing or modifying utterances and keywords, with regular utterances adding new texts, such as private memos, locally into the personalized space. This manipulation should assist the users in the deep thought process to help them crystallize their ideas.

One scenario using the Personal Desktop is to merge two or more people's refined thought spaces and observe the difference in ideas and concepts. For example, if two people are using the same keyword but with different meaning, it can often be difficult to quickly notice the difference through the conversations. With this system, differences between the users' thought spaces reflected by their viewpoints or backgrounds can be revealed, and the users are spared from communication gaps due to unconscious differences in personal knowledge or viewpoints. This enables, for example, users to contrast one individual's use of "media" with another's "media" in a merged space. An example of this is illustrated in Figure 6.8.

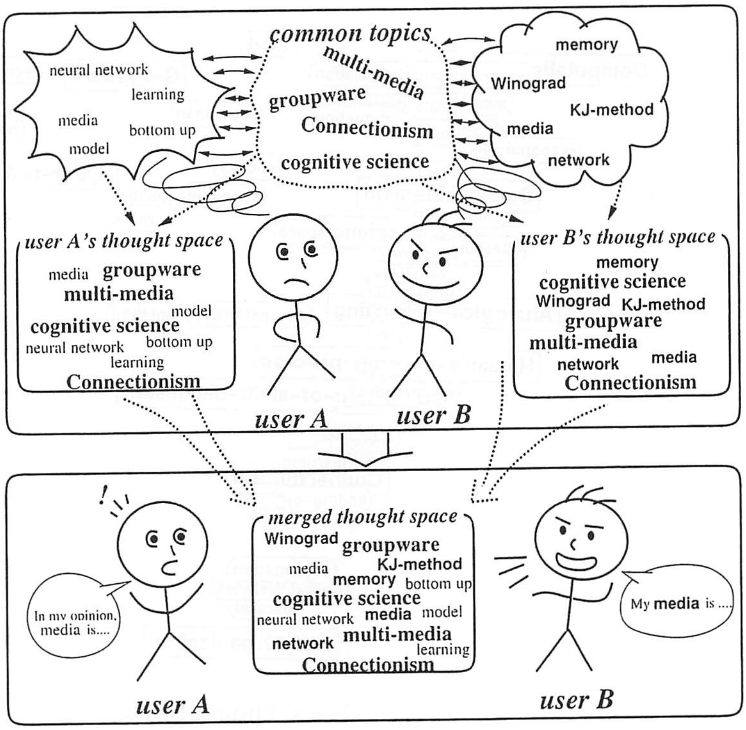


Figure 6.8: Merging Multiple Users' Personalized Spaces

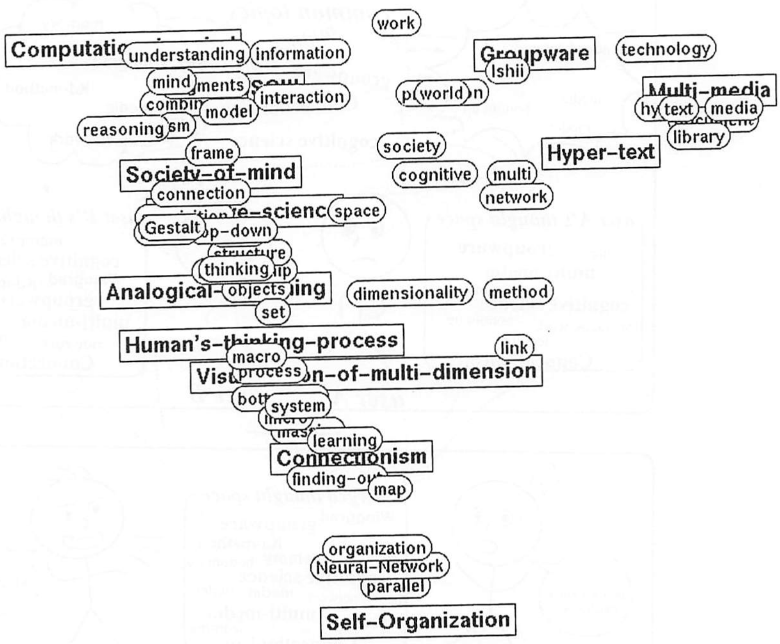
6.4 Examples of Using AIDE

6.4.1 Mutual Understanding

Revealing Differences Between Subjective Views of Multiple Users

From the viewpoint of concept formation, one of the main processes of human creative activity is *divergent thinking* in which broad alternatives are sought. Another process is *convergent thinking* in which a unique solution is sought [Imai *et al.* 1984]. Divergent thinking is indispensable especially in the early stages of creative activities, while both of these two processes must be repeated in concept formation. For this reason people involved in closed personal thought will communicate with others to search for alternatives to their ideas. This is an important aspect of collaborative work for human creativity.

We require personal background knowledge and subjective views to be conveyed to others during the early stages of collaborative work since this information depends on each participant even if common topics are be-



(a) Alice's Thought Space

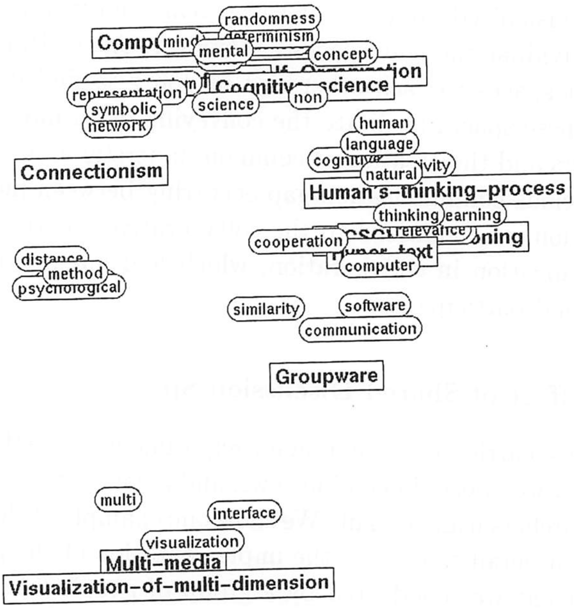
Figure 6.9: See facing page

ing discussed. We investigated this using the Discussion Viewer on the Personal Desktop. This work was originally conducted by using an early version of the AIDE system, named the Communication Support System [Sumi *et al.* 1996b]. However, since they have the same functionality, we have not discriminated between them in this chapter unless necessary.

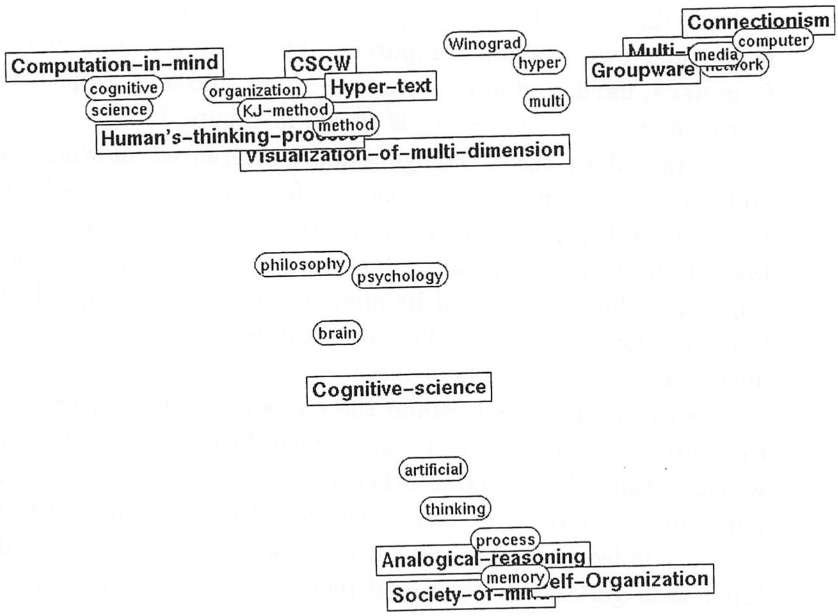
The experiment was conducted by three researchers, who we shall refer to as Alice, Bill and Chris, who had common interests. The three were given several topics[4] relevant to their common interests, and they independently built their thought spaces containing these topics as text-objects. Content and keywords of the text-objects were freely determined by each user. In order to simplify the their work, we let them designate 1 as the weight values for all keywords.

Figure 6.9 shows that, with the Discussion Viewer, the relationships among the concepts and their micro concepts forming each thought space

[4]The given titles of the text-objects correspond to 12 topics, namely, "CSCW," "Connectionism," "Hypertext," "Multi-media," "Society of mind," "Analogical reasoning," "Groupware," "Visualizing multi-dimensional spaces," "Cognitive science," "Computation in mind," "Human thinking process," and "Self-organization."



(b) Bill's Thought Space



(c) Chris's Thought Space

Figure 6.9: Example of Clarifying Differences in Thought Spaces between Three Users

can be visualized, and that it can reveal the differences in the structures of the individual thought spaces. Moreover, Alice, Bill and Chris show their thought spaces to each other and in doing so find differences and similarities. These spaces facilitate the conveying of an individual's mental content to others and the creation of common understanding. This can eliminate the unconscious communication gap occurring between members working in collaboration, and can lead to the collaborative creation of new ideas through communication in collaboration, which had not previously been noticed by individual participants.

The Effect of Shared Discussion Space

Next, we carried out preliminary experiments on AIDE with sets of articles such as those posted in online news, and records of discussions by a close group of researchers using e-mail. We show one example of the experimental usage of AIDE in detail to explain the implementation of the proposed method. This experiment was conducted by a group of people from a single organization; we will call them `usrA`, `usrB`, and `usrC`. The subject of the conversation was "recycling used paper in our office." This experiment was conducted over a single day, and they participated in the conversation in their spare time using their own desktop computers. The numbers of submitted utterances from `usrA`, `usrB`, and `usrC` were four, three, and four, respectively. The final status of the discussion space is shown in Figure 6.10.[5]

Rectangular icons in the figure imply utterances, showing who made them and the submission order. "`Conv.`" refers to an utterance by the Conversationalist. In this experiment, we inactivated the automatic submission function of the Conversationalist, but used its manual information submission function. Thus, it provided its opinion only when prompted by human participants. Oval icons imply keywords automatically extracted from the utterances, and there were 208 of these.

We can roughly understand the contents of the conversation by viewing the clusters of utterance icons and keyword icons scattered around them, and we can intuitively understand their topological relationships. For example, as noted in Figure 6.10, we can understand that the topics of the conversation were expanded from "recycling used papers" to "environmental problems related with garbage disposal and recycling," and "educational issues." The manual information submission function was used twice during the conversation. After each user input one utterance, this presented an utterance `Conv.:1` (an article on "garbage tax") in response to a request from one of the users. `usrB` was aware on this utterance and the social aspect of this

[5]This experiment was done in Japanese. The following examples in this chapter have been translated by the authors.

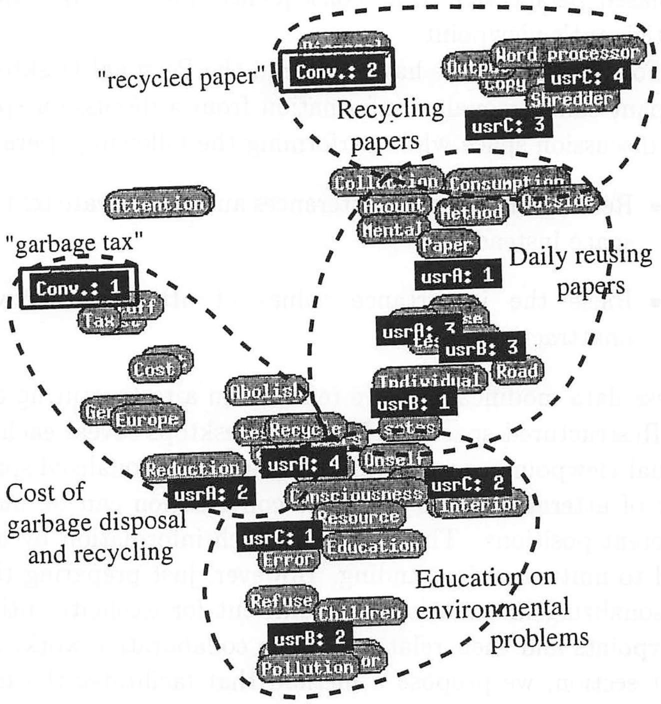


Figure 6.10: Example of Discussion Space on the Subject "Recycling Paper"

problem and mentioned an educational issue concerned with environmental problems, which lead to a responsive discussion on this topic.

Since the focus of the conversation was a little displaced, the manual information submission function was used, and then `Conv.:2` (an article on "recycled paper") was given. This made the focus go back to the original subject, i.e., effectively reusing papers. Moreover, a description about the "cost of garbage disposal and recycling" in `Conv.:1` gave stimuli to `usrA` and led to the further discussion.

6.4.2 Information Crystallization

Personalizing Discussion Spaces

Since emerged clusters of utterances with many common keywords in the discussion spaces display the global structure and local information of the conversation simultaneously, not only the participants themselves but also outsiders can easily browse the conversation. While the discussion spaces visualize the structures of the conversation from an average viewpoint, or unbiased perspective, they consequently may not be suited to a particular participant's viewpoint.

For this reason, we have prepared the Personal Desktop, where each participant can personalize information from a discussion space by duplicating the discussion space while performing the following operations.

- Remove unattractive utterances and add private text to the personalized space instead.
- Raise the importance values of attractive keywords and remove unattractive ones.

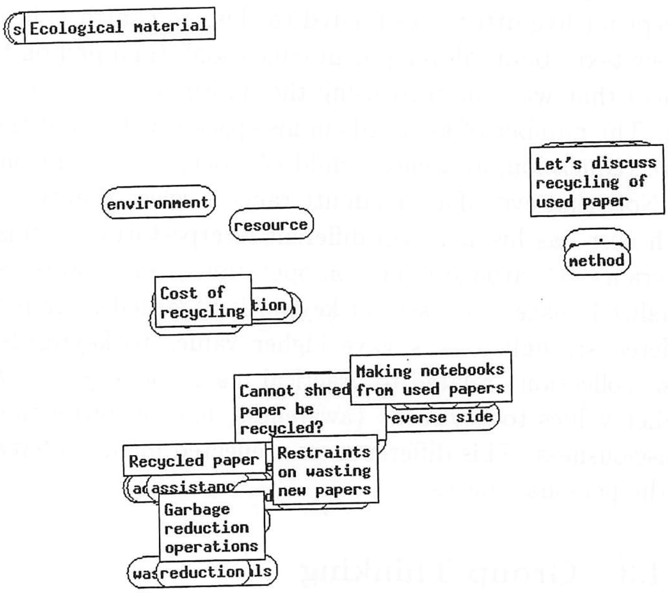
These data modifications are reflected in a restructuring of the space.

Restructured spaces in Personal Desktops reveal each participant's individual viewpoints, namely, in the different personalized spaces, even the same pair of utterances from the same conversation can be mapped at relatively different positions. The sharing of such information by all participants can lead to mutual understanding. However, just preparing the environment for personalizing information is insufficient for explicitly utilizing the personal viewpoints and their relationships in collaborative work. Accordingly, in the next section, we propose a method that facilitates the mutual understanding of personal viewpoints by quantifying the personal viewpoints revealed in personalized spaces and visualizing their relationships.

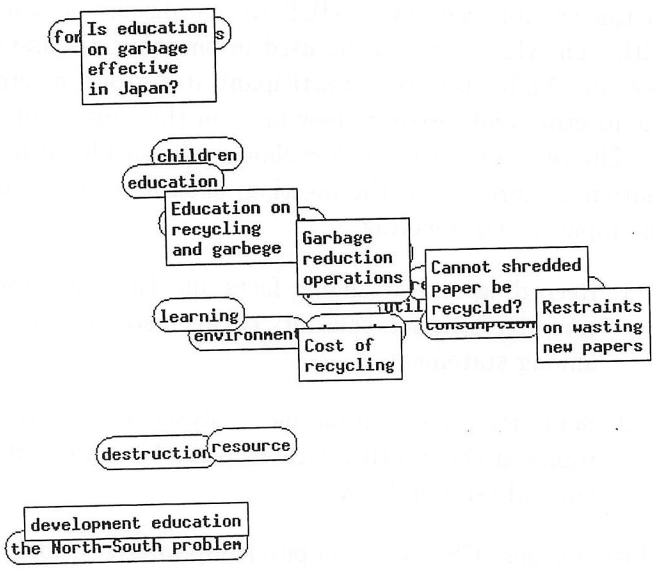
Personalized Spaces with Different Viewpoints

We show an example of personalized spaces being constructed by two users, `usrA` and `usrC`, derived from the discussion space shown in Figure 6.10. Figures 6.11(a) and (b) show the respective results. The tags of the utterance icons are changed, by a function in the Personal Desktop, to phrases indicating the utterances by the authors. The same utterance appearing in both Figures 6.11(a) and (b) is given the same tag.

In the case of `usrA`, the discussion space was personalized with the viewpoint of "means of recycling." As a result, utterances concerned with an educational issue were removed from `usrA`'s personalized space, and, in contrast, a text about "ecological material" (mapped at the upper left of the space) was newly added. Here, this text was obtained as a related text to `usrA`'s personalized space by the information retrieval function of AIDE. But this does not mean that texts added to personalized spaces are always obtained using this function. The number of keywords remaining in `usrA`'s space was 68. The keywords that have relatively high values of importance were {recycling, waste materials, nature, environment, cost}, which would be used as the keywords of `usrA`'s viewpoint-object afterwards for viewpoint overlay with other keywords.



(a) usrA



(b) usrC

Figure 6.11: Personalized Spaces of usrA and usrC with the Viewpoints of "Means of Recycling" and "Raising Public Concern"

In the case of `usrC`, his personalized space was built with the viewpoint of "raising public spirit," and, consequently, many utterances were removed except for five utterances related to this. In contrast, he selected and added a new text about "development education" (mapped on the lower left of the space) that was obtained using the information retrieval function like `usrA` did. The number of keywords in his space was 69, and the priority keywords were {education, awareness, children, society, foreign countries}.

Note that even if a certain utterance is selected in two personalized spaces, each user has his/her own different interpretation of this. Specifically, four utterances ("garbage reduction operations," etc.) were selected in both personalized spaces, but sets of keywords regarded as important in the spaces differed strongly: `usrA` gave higher values to keywords {paper, shredder, cost, collection} related to practical means of recycling; however, `usrC` gave higher values to keywords {awareness, nature, protection} related to social consciousness. This difference was reflected in the difference of the structure of the personal spaces.

6.4.3 Group Thinking

Supporting Group Meetings

In this section, we apply AIDE to free discussion among groups of people. Although AIDE can also be used in on-going discussions, this time, we will describe AIDE used by a participant at a group meeting who looks back at the meeting and discovers new ideas in the content of the discussion.

The two approaches below should be considered in structuring the information acquired from the meeting, such as statements by participants and the topics at the meeting.

1. Recording and arranging facts and their superficial relationships, i.e., *who* uttered *what*, causality between statements, temporal relationships among statements.

2. Supporting recognition and analysis of semantic relationships between topics at the meeting without being bound by information about speakers and temporal flow.

Most former CSCW (Computer-Supported Cooperative Work) of systems organizing statements by participants at meetings focus on the first of the above approaches. For example, [Winograd 1988] and [Conklin and Begeman 1988] employed a method that required users to explicitly specify the placement or causality of each statement (e.g., argument, counter, acceptance, support, response) whenever users made a statement. On the other hand, the second approach requires topics of a discussion to be organized at the semantic level. In other words, we could say that the second approach is aimed at external media as a projection of the users' thoughts that can be manipulated by them at any time, while the first approach is aimed at external storage of information input by users. Our target is the second approach.

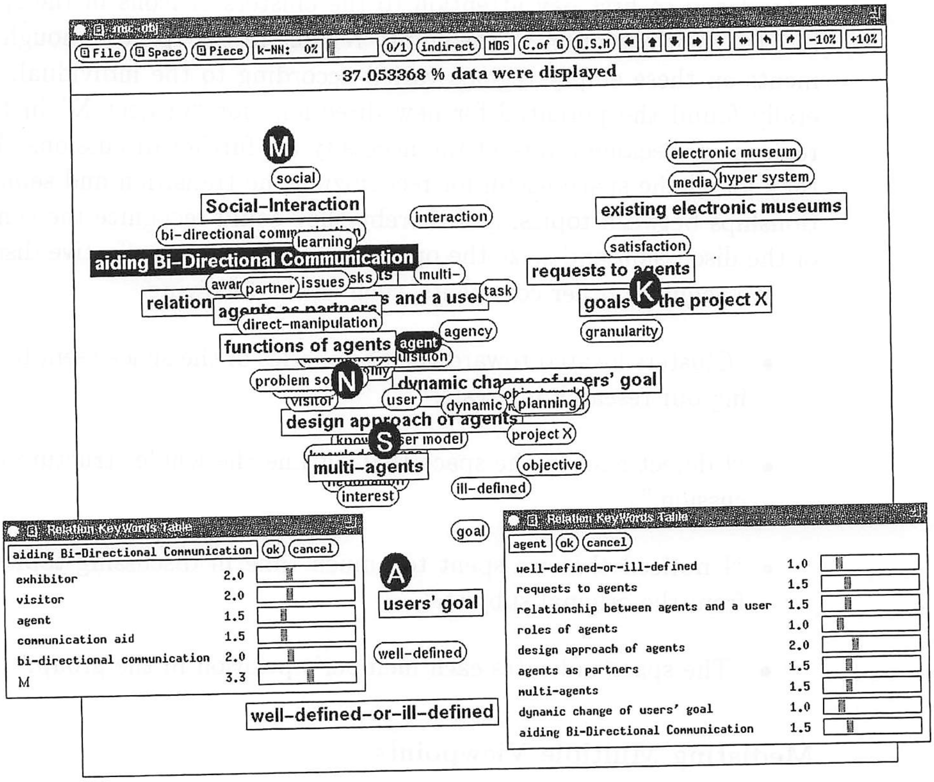


Figure 6.12: Example of Using Discussion Viewer in a Group Discussion

We conducted an experiment to visualize the relationships between topics and participants at a meeting. There were five participants at the meeting, and the number of topics extracted was 13. The extraction was performed by one participant. The meeting was to discuss "project X," whose objective and approach was yet to be decided in a brainstorming style. At the meeting, a wide range of topics on each participant's interests and many technical issues were discovered.

Figure 6.12 shows the space that one of the participants at the meeting built using Personal Desktop. The rectangular icons in the space indicate text-objects corresponding to the topics extracted by the user, and the oval icons indicate their keywords. The elliptical icons indicate the names of the participants. In this experiment, we also defined the name of each participant as a kind of keyword, and the user declared each participant's name as the keyword for text-objects corresponding to topics keenly participated in by him/her. This method visualized the relationships between not only topics and their keywords but also the participants.

The resulting space was shown to the other four participants. They had a tendency to first pay attention to the clusters of icons in the space, then to turn their attention to the empty regions in the space. Though the comments on these empty regions varied according to the individual, they generally found the potential for new directions for "project X" in the empty regions, or became aware of the necessity for further discussions. Moreover, they found the space useful for recognizing the transition and semantic relationships between topics, and thereby they could recognize the central topic of the discussion and seize the opportunity for further effective discussion.

We acquired other comments, such as the following.

- "Clusters located toward the peripheries of the space seem to be opposing our research interests."
- "I detect axes in the space that outline the whole structure of the discussion."
- "I noticed that we spent too much time in discussing topics different from the original subject."
- "The space indicates each member's position in the group."

Mediating Multiple Viewpoints

Let us go back to the example of the discussion with three people as given in Section 6.4.2 and illustrated in Figures 6.10 and 6.11. Figure 6.13 shows an example of mediating multiple viewpoints, automatically created from the personalized spaces of `usrA` and `usrC`. Mapped icons of utterances and keywords are the sum of those in the two users' personalized spaces, and there are 11 and 111 of them, respectively. The mediating space also includes viewpoint-objects that imply the two users' individual viewpoints.

We can read several effects of the mediating spaces from the example shown in Figure 6.13. Firstly, we notice that the space is not a simple amalgamation of the two personalized spaces, and its structure differs distinctly from that of the initial discussion space shown in Figure 6.10. The mediating space reveals different and shared parts between viewpoints of `usrA` and `usrC`. Moreover, while the initial discussion space also includes insignificant information for both of the two users, since it contains all information from the

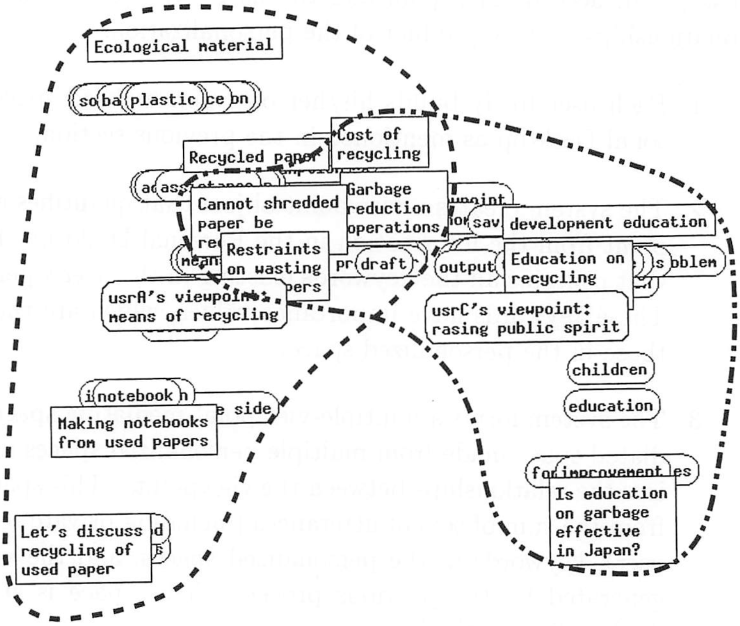


Figure 6.13: Example of the Relationship between Space Visualizing Viewpoints of Two Participants, `usrA` and `usrC`

conversations, the mediating space can be regarded as refined new common ground for the two users.

Secondly, the mediating spaces include each user's private text that shows their interests and viewpoints; for example, the space shown in Figure 6.13 has `usrA`'s "ecological material" (upper left icon in the space) and `usrC`'s "development education" (upper right icon). Such visual information facilitates users in intuitively seeing their companions' intentions and in sharing personal knowledge.

Lastly, we point out the effect of reducing the number of keywords by removing worthless keywords, and that the number of keywords is reduced in the mediating spaces. This refines the structure of the spaces, which can be new common ground for users. It is noteworthy that all that is needed to obtain a mediating space is each individual's operation of personalizing a shared discussion space; this method does not require any special operation for negotiation or coordination between users.

Now, we will describe how to quantify the personal viewpoints revealed in the Personal Desktops and visualize their relationships in the mediating space. We propose the following procedure, which does not postulate any special operations except the personalization of the discussion space of each user, and, accordingly, quantifies the users' viewpoints and visualizes their relationships as a by-product of the personalization.

1. Each user freely builds his/her own personalized space using the Personal Desktop as mentioned in the previous section.

2. The system creates a viewpoint-object that quantifies each user's viewpoint from the information in the Personal Desktop. This is an object that contains all the keywords existing in the user's personalized space. These keywords have importance values, which are the mean values of those in the personalized space.

3. The system forms a multiple-viewpoint mediating space, which is a mediated space made from multiple personalized spaces and which visualizes the relationships between the viewpoints. This space is constructed from the sum of sets of utterances (including private text given by each user), keywords in the personalized spaces, and the viewpoint-objects generated by the previous process. This space is structured by the dual-scaling method.

The multiple-viewpoint mediating space has utterances and keywords commonly inherited from the discussion space. The space visually mediates the multiple users' viewpoints and leads to mutual understanding. Moreover, the space including private text given in the personalized spaces encourages the users to mutually exchange and share personal knowledge and ideas.

6.4.4 Community Formation

In this section, we are proposing a system that encourages a novel type of communication, not yet seen in the real world. With the advantages of the Internet, encounters in a networked society via third persons' personalized views will be possible. The proposed method makes it possible for a user accessing the WWW to encounter other people who have similar interests. For a virtual place where they can meet, this method appropriates a third person's already-existing home page, which has several reference links to other pages, including the user's. The page is taken and used by the system for these people. Such encounters distinctly differ from those in the real world in terms of the following features.

- Encounters are not restricted by spatial and temporal coincidence.
- Encounters are made not through personal relationships, but by the relevance of personal interests.

Asynchronous Encounters from Third Persons' Personalized Views

This section describes the idea of asynchronous encounters, which uses the personal viewpoint of a third person and gives users the chance to make acquaintances based on their interests.

As places for possible encounters, we exploit personal pages on the WWW having several links to other people's pages that are related to each other in some context. These personal pages have the potential to provide effective stimuli to people whose pages are referred to by them.

However, on the current WWW, users whose pages are referred to by other persons' pages are unable to know who made these links. If they could notice that someone else's page is referring to their page, they could learn of people who have a similar relationship from the third person's viewpoint. These encounters would be distinctly different from existing communications in the real world, in the sense that they could not meet with these people unless there were personal connections.

There are two options to force users to notice the possible connections.

1. A person who edits a page having several links to other pages could contact and report these links to those who provide these pages. Otherwise, some software agent could automatically inform providers of the fact that a certain page is referring to theirs.

2. Users who are keen for new encounters with people having similar interests could take action by themselves. This would necessitate some technologies that search for pages referring to their own personal pages by pursuing links with opposite directions.

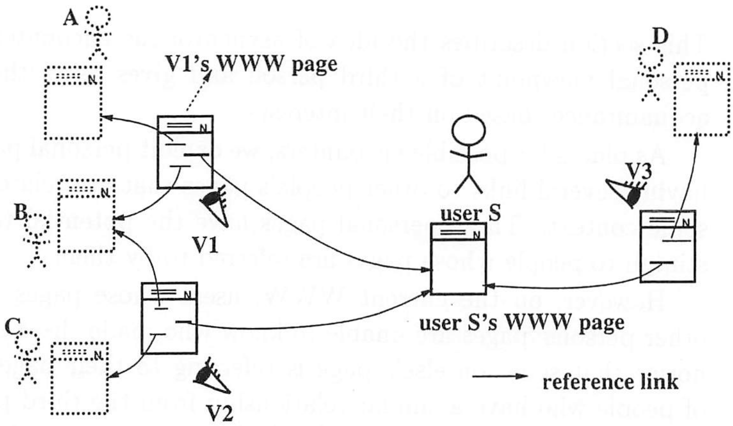
Currently, we think that the first strategy is impracticable for general users. Therefore, we select the second strategy. In order to achieve this approach, we propose using existing search engines to search for opposite links (e.g. Senrigan ("clairvoyance" in Japanese)[6] and RCAAU[7]). These search engines collect information on links on the WWW comprehensively to gather information about pages that will be queried by users. Here, we utilize information on links to search for pages linking to the same page.

Below is the procedure for encounter in a third person's page on the WWW (see Figure 6.14).

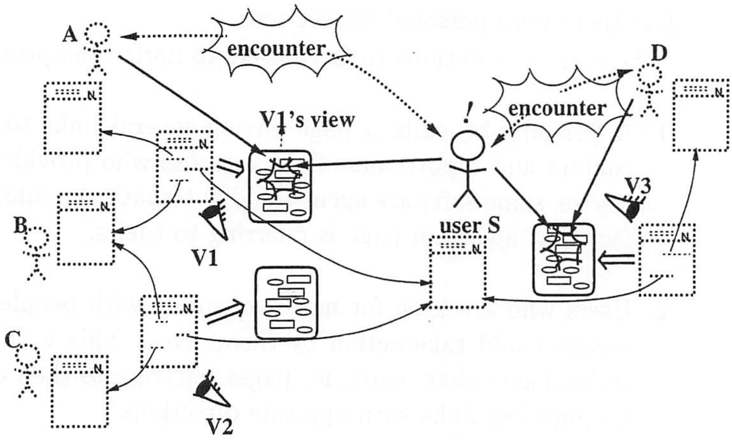
1. User S takes action to seek people on the WWW who have similar interests.

[6] http://senrigan.ascii.co.jp/index-e.html

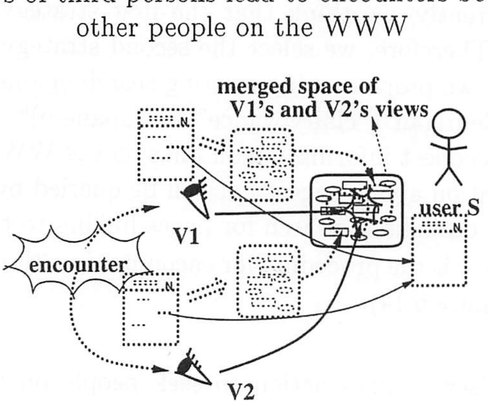
[7] http://www.kuamp.kyoto-u.ac.jp/labs/infocom/mondou/index_e.html



(a) A web of reference links on the WWW



(b) Personal views of third persons lead to encounters between user S and other people on the WWW



(c) Encounter between V1 and V2 caused by user S's action

Figure 6.14: Emergent Encounters on the WWW Caused by Third Person's Views

2. The system generates a list of pages referring to user S's page by searching a database consisting of information on links. In Figure 6.14(a), V1's, V2's, and V3's pages have links referring to user S's page.

3. The system provides places to facilitate encounters by visualizing each creator's view along with his/her page's content consisting of information on links. Here, we expect that Discussion Viewer is suitable as virtual space for the encounters.

4. User S gets to know several people over the network by looking at visualized spaces. In Figure 6.14(b), user S encounters users A and B in V1's view.

5. Using AIDE to merge multiple spaces representing personal views encourages other encounters between people referring to user S's page. That is, user S's action enables encounters between people who have an interest in user S's personal page. In Figure 6.14(c), V1 and V2 encounter in V1's and V2's merged space. This encounter enables them, who are not yet acquainted, to get to know the relevance between their viewpoints.

6.5 Discussion

The volume and the range of information available on the Internet continues to expand. From the viewpoint of human communications, the Internet has several attractive features.

1. It is world-wide.

2. It provides a means of bi-directional communications.

3. Whoever joins in it can play the main role in communications.

The first feature enables users to expand their thought spaces and knowledge on their collaborative fields on a world-wide scale. From the viewpoint of creative thinking, we can say that one of the major processes fostering human creative activities is divergent thinking, in which broad alternatives are searched for. Another is convergent thinking, in which a unique solution is sought. Although these two processes must be invoked repeatedly, divergent thinking is indispensable, especially in the early stages of creative activities. Use of the Internet can broaden one's thought spaces, and encourage divergent thinking. Thus, there have been several works on computer-aided thinking using information on the Internet. For example, [Gaines and Shaw 1995] links a personal hypertext world-wide, and [Ohmi *et al.* 1996] have proposed card-based Internet resource accessing tools.

Human communications are basically bi-directional and interactive. However, much of the media, such as newspapers, radio stations, and television networks provide only a one-way flow of information, i.e., broadcasting. The second and third features of the Internet are important in this respect. Yet, the conventional usage of the Internet, such as mailing-lists and BBS (Bulletin Board Systems), is a form of broadcasting, and distinguishes providers of information from receivers. Currently, the WWW (World-Wide Web) too only provides a one-way flow of information.

The WWW has a strong feature that enables navigation from one personal page to another. People accessing the WWW can find information by following the successive links made by others. This feature has led to a new kind of search strategy in the context of computer networks — it is an old and familiar way of finding things out in the real world [Erikson 1996]. However, there is a definite difference between navigation in the WWW and in the real world, since current information flows over the WWW are limited to one way. Therefore, no interaction has been occurring between providers and receivers. Consequently, providers of information are unable to obtain feedback, e.g., (1) of who of all the receivers have visited or given links to their pages in the receivers' contexts, (2) of what these contexts are, and (3) of how the information being provided is contributing toward new information. Besides, when providers create new pages on the WWW and wish to communicate with other people on the Internet through these pages, they must announce the openings through other broadcasting media such as a BBS.

When we regard the Internet as a world-wide knowledge-base, the KB consists of pages of contents and hyper-links, in the case of the WWW. As the contents are produced independently and the hyper-links are established sequentially, the net has the characteristics of the distributiveness and the asynchronousness of knowledge, which are also important advantages. Under this consideration, in order to make the best use of these advantages for personal and collaborative work, we should utilize the Internet not only as a medium for broadcasting but also as a space where we can convey personal information to others interactively, i.e., the interaction of provider and receiver.

Linking AIDE to the World-Wide Web

AIDE successfully works to visualize personalized information spaces and collaborative shared spaces. We are now connecting AIDE to other technologies in order to deal with world-wide collaboration and human communications on the Internet [Sumi *et al.* 1996a].

Personal pages being created on the WWW are blending the professional and the personal. At the same time, these personal pages have good accessibility and publicity for people accessing the Internet. Some pages are designed as meta pages that collect many pages and classify them in some context, which is useful for many people. Some are huge collections for common use, and some are personal collections due to the collectors' subjectivity. The latter may be nonsense for most others, but it may offer some ideas or viewpoints to people who have similar interests.

The objective of AIDE is to reveal personal ideas and viewpoints, and thereby encourage collaboration and communication in groups of people. Currently, AIDE mainly uses documents given by users themselves or a well-defined text database, and this information is used for collaboration only in organized groups explicitly. However, on the Internet, there are currently many electronic documents, and so asynchronous collaboration can also be expected between people who are not yet acquainted. Therefore, porting AIDE to enable it to integrate seamlessly with the WWW is a straightforward expansion strategy, and can be a community support system for global collaboration.

Encouraging New Personal Encounters in a Networked Society

Now, we point out our target, by referring to communication support systems on networked computers and classifying them along three axes representing the types of processed information (see Figure 6.15).

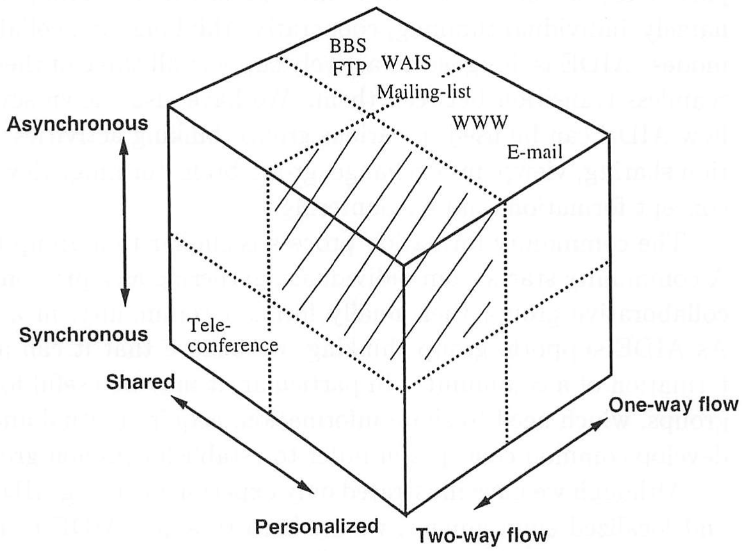


Figure 6.15: Classification of Communication Support Systems on Networked Computers and Our Target (Shown by Hatched Area)

- Our research focuses on a means of collaboration not limited to spatial and temporal synchronization. *Asynchronous* meetings provide more chances to meet and analyze a problem more deeply.

- Most existing systems that currently aid collaborative work on networked computers focus on providing common and shared spaces for their participants. Our interests shift to supporting the personalization of shared spaces for individual reflection and to collaboration in *personalized* information spaces.

- Most existing systems strictly distinguish the providers and receivers of information, and deal only with one-way flow of information. We are interested in the *bi-directional and interactive* flow of information. That is, some actions of the receivers, such as gathering information and editing, are given as feedback to the providers. This would lead to group thinking, and, thus, community forming.

6.6 Conclusions

We have proposed a universal model of group thinking and a conversation support environment, called AIDE, on the basis of our model that facilitates collaborative concept formation and information sharing in conversations. In particular, we have described three modes in the group thinking process, namely, individual thinking, cooperative thinking, and collaborative thinking modes. AIDE is designed to actively support all three of these modes and the seamless transition between them. We have also shown several examples of how AIDE can be used in various group thinking activities, such as information sharing, viewpoint exchange, group brainstorming, viewpoint overlaying, concept formation, and encountering.

The community formation process is similar to a group thinking process. A community starts from individuals, gathering as a pre-community and pre-collaborative group, then finally forms a community, in a typical scenario. As AIDE supports group thinking, we believe that it can also facilitate the formation of a community. In particular, it may be useful for pre-community groups, which need to share information, acquire mutual understanding, and develop common concepts in order to establish common ground.

Although we have illustrated only experiments using AIDE within a closed and localized environment, we are keen to apply AIDE to loosely organized conversations and between spatially distributed pre-communities and existing communities, via the Internet. We hope that AIDE already has the potential to be used by small pre-community groups. For a large group, additional technologies such as information filtering and information hierarchical organizing need to be incorporated, since the present AIDE would not provide meaningful discussion spaces if we had too many utterances. Manual spatial filtering on the Personal Desktop is currently the only possible method, which may be tedious work even though AIDE provides a group manipulation handler. Moreover, we believe it will be interesting to facilitate new encounters between people accessing the Internet who have similar interests to help earlier stages of formation of, and collaboration in, communities.

The authors' group has proposed the concept of the Meta-Museum [Mase *et al.* 1996], which is a new environment for knowledge sharing. The primary goal of the Meta-Museum is to create and facilitate communications between specialists (providers of information and knowledge) and visitors (receivers), thereby enabling a better understanding of museum exhibitions. The Meta-Museum is an example of one of the systems pointed out above. The Meta-Museum can be an example of a *knowledge medium*, proposed in [Stefik 1986], which is an information network with semi-automatic services for the generation, distribution, and consumption of knowledge. Future knowledge media will hold creative collaboration not only between human agents but also between any combination of human agents and intelligent machine agents. AIDE's Conversationalist is an example of an intelligent machine agent. In such knowledge media, communication between agents is a critical ingredient, and it can be facilitated by interposing a mediating agent [Bobrow 1991]. The multiple-viewpoints mediating spaces proposed in this chapter can be a mediating agent between the personal viewpoints of the participants in collaboration.

From the knowledge engineering viewpoint, we are interested in recording or classifying the emerging concepts and keywords in the spaces provided by AIDE into an ontology. It will then also be interesting to discuss the granularity and usability of the ontology in relation to the closeness or scale of the communities.

One important aspect of the objective of group thinking is creativity. Exchanging ideas and thoughts may help the group to obtain a breakthrough in solving a problem. A reason for forming a community may also be, we believe, to solve a unknown problem that is not solvable by individuals alone.

Acknowledgments

We thank Yasuyoshi Sakai and Ryohei Nakatsu for their support and encouragement throughout this work. Thanks are also due to the members of Department 2 of the ATR Media Integration & Communications Research Labs. for intensive discussions and valuable comments. We also wish to thank Osamu Sato for assisting in the implementation of our system, and Masanori Sugimoto, who developed the program for the dual scaling method.

Bibliography

[Bobrow 1991] D. G. Bobrow, "Dimensions of Interaction," *AI Magazine*, Vol. 12, No. 3, pp. 64–80, 1991.

[Conklin and Begeman 1988] J. Conklin and M. L. Begeman, "gIBIS: A Hypertext Tool for Exploratory Policy Discussion," *CSCW '88*, pp. 140–152, 1988.

[Erikson 1996] T. Erickson, "The World-Wide Web as Social Hypertext," *Communications of the ACM*, Vol. 39, No. 1, pp. 15–17, 1996.

[Gaines and Shaw 1995] B. R. Gaines and M. L. G. Shaw, "Concept Maps as Hypermedia Components," *International Journal of Human–Computer Studies*, Vol. 43, No. 3, pp. 323–361, 1995.

[Imai *et al.* 1984] K. Imai, I. Nonaka and H. Takeuchi, "Managing The New Product Development Process," *75th Anniversary Colloquium on Productivity and Technology*, pp. 28–29. Harvard Business School, 1984.

[Mase *et al.* 1996] K. Mase, R. Kadobayashi and R. Nakatsu, "Meta-Museum: A Supportive Augmented-Reality Environment for Knowledge Sharing" *International Conference on Virtual Systems and Multimedia*, pp. 107–110, 1996.

[Nishimoto *et al.* 1996] K. Nishimoto, Y. Sumi and K. Mase, "Toward an Outsider Agent for Supporting a Brainstorming Session — an Information Retrieval Method from a Different Viewpoint," *Knowledge-Based Systems*, Vol. 9, No. 6, pp. 377–384, 1996.

[Nishimoto *et al.* 1998] Kazushi Nishimoto, Yasuyuki Sumi, and Kenji Mase: "Enhancement of Creative Aspects of A Daily Conversation with A Topic Development Agent," in "Coordination Technology for Collaborative Applications – Organizations, Processes, and Agents," Lecture Notes on Computer Science, Vol. 1364, Springer-Verlag, 1998.

[Nishisato 1980] S. Nishisato, *Analysis of Categorical Data: Dual Scaling and Its Applications*, University of Toronto Press, 1980.

[Ohmi *et al.* 1996] Y. Ohmi, K. Nakamura, K. Kawai, N. Takeda and H. Ohiwa, "Pan-WWW: A Card-Based Internet Resource Accessing Tool," *Transactions of the Information Processing Society of Japan*, Vol. 37, No. 1, pp. 154–162, 1996.

[Saito and Toriwaki 1994] T. Saito and J. Toriwaki, "New Algorithm for Euclidean Distance Transformation of an *N*-dimensional Digitized Picture with Applications," *Pattern Recognition*, Vol. 27, No. 11, pp. 1551–1566, 1994.

[Salton and Buckley 1988] G. Salton and C. Buckley, "Term-weighting Approaches in Automatic Text Retrieval," *Information Processing & Management*, Vol. 24, No. 5, pp. 513–523, 1988.

[Stefik 1986] M. Stefik, "The Next Knowledge Medium," *AI Magazine*, Vol. 7, No. 1, pp. 34–46, 1986.

[Stefik *et al.* 1987] M. Stefik, G. Foster, D. G. Bobrow, K. Kahn, S. Lanning and L. Suchman, "Beyond the Chalkboard: Computer Support for Collaboration and Problem Solving in Meetings," *Communications of the ACM*, Vol. 30, No. 1, pp. 32–47, 1987.

[Sumi *et al.* 1996a] Y. Sumi, K. Mase and K. Nishimoto, "Facilitating Human Communications in Personalized Information Spaces," *AAAI-96 Workshop on Internet-based Information Systems*, 1996.

[Sumi *et al.* 1996b] Y. Sumi, R. Ogawa, K. Hori, S. Ohsuga and K. Mase, "Computer-aided Communications by Visualizing Thought Space Structure," *Electronics and Communications in Japan, Part 3*, Vol. 79, No. 10, pp. 11–22, 1996.

[Sumi *et al.* 1997a] Y. Sumi, K. Hori and S. Ohsuga, "Computer-aided Thinking by Mapping Text-objects into Metric Spaces," *Artificial Intelligence*, Vol. 91, No. 1, pp. 71–84, 1997.

[Sumi *et al.* 1997b] Y. Sumi, K. Nishimoto and K. Mase, "Personalizing Shared Information in Creative Conversations," *IJCAI-97 Workshop on Social Interaction and Communityware*, 1997.

[Winograd 1988] T. Winograd, "A Language/Action Perspective on the Design of Cooperative Work," *Human Computer Interaction*, Vol. 3, No. 1, pp. 3–30, 1988.

Community Computing

Collaboration over Global Information Networks

Edited by

Toru Ishida
Kyoto University, Japan

John Wiley & Sons
Chichester • New York • Weinheim • Brisbane • Singapore • Toronto