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Emergent Media Environment for Idea Creation Support

Kozo Sugiyama, Kazuo Misue, Isamu Watanabe,
Kiyoshi Nitta and Yuji Takada

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Institute for Social Information Science,
FUJITSU LABORATORIES LTD.

Numazu office
140 Miyamoto, Numazu-shi, Shizuoka 410-03, Japan
Telephone: +81-559-23-2222 Fax: +81-559-24-6180

Tokyo office
9-3 Nakase 1-chome, Mihama-ku, Chiba-shi, Chiba 261, Japan
Telephone: +81-43-299-3211 Fax: +81-43-299-3075

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Kozo Sugiyama, Kazuo Misue, Isamu Watanabe, Kiyoshi Nitta and Yuji Takada

Institute for Social Information Science, FUJITSU LABORATORIES
{sugi, misue, isamu, nitta, yuji}@iias.flab.fujitsu.co.jp

ABSTRACT

An interactive computer system for supporting early or emergent stages in human intellectual activities is developed. In the system it is intended to integrate facilities for supporting generation/collection, organization and presentation of ideas and advising divergence/convergence of ideas. The Facilities of the system are explained and some experiences are described.

1. Introduction

Our major concern of this paper is to develop a highly interactive computer system for supporting early, emergent and usually creative stages in human intellectual activities such as research planning, conceptual design, software requirement analysis, knowledge acquisition, problem solving, decision making, counseling, motivating and so on. We can often observe common procedural steps in the emergent stages of the activities;

(i) encountering or finding a problem,

(ii) generating segments of ideas and/or collecting piece wise information relating to the

problem,

(iii) organizing them into a structured form to understand or solve the problem,

(iv) presenting the structured form as a document (or a speech) to the people.

The process consisted of these steps is called an *emergent process* in general or an *idea creation process* more specifically where the term 'idea' means understandings, insights or solutions of the problem. Figure 1 shows a model of the emergent process.

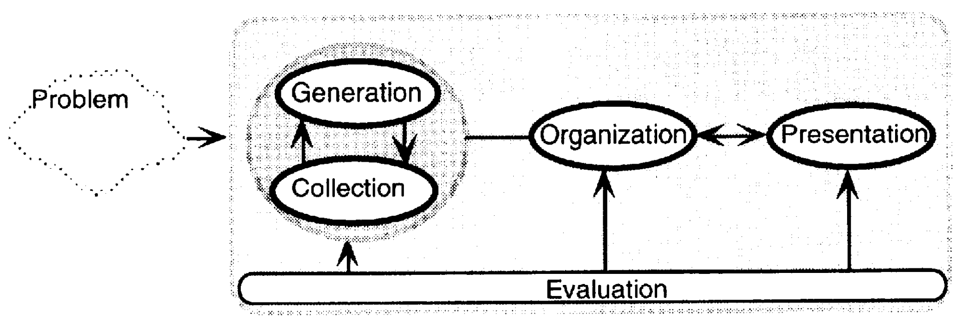

Figure 1. A model of the emergent process.

As an emergent process proceeds, information treated in each step is gradually elaborated from vague, informal, non-structured(or piece wise), personal and small-sized one to more precise, formal, structured(or well-organized), public and large-sized one. We call information methods to express "idea" in the emergent process *emergent media* and we can identify three chunks of the emergent media;

(i) ***card*** : medium suitable for expressing piece wise information (memos, sketches, messages, etc.), which is mainly used in the generation/collection step

(ii) ***diagram*** : medium suitable for organizing a set of piece wise information into structured forms (lists, clusters, trees, various types of graphs, etc.), which is mainly used in the organization step

(iii) ***document*** : medium suitable for expressing more precise, formal and large-sized information (concepts, idea, etc.), which is mainly used in the presentation step

Figure 2 illustrates the chunks of the emergent media.

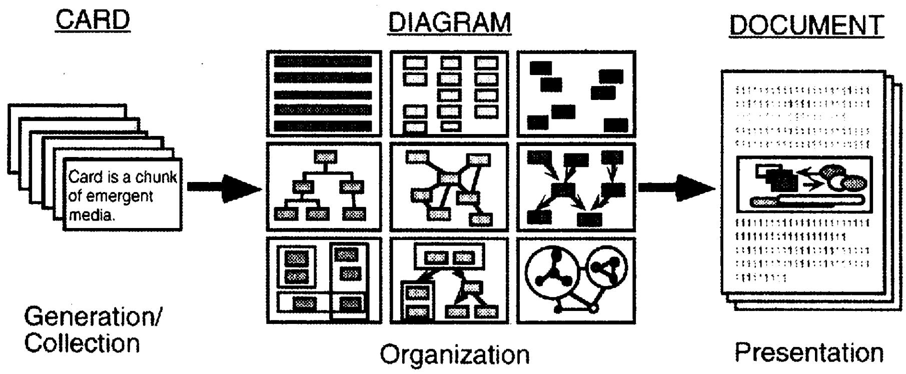

Figure 2. Chunks of the emergent media.

An *emergent media environment* (EME) is defined as a set of emergent media-based facilities to support the emergent process effectively on the basis of a more basic environment such as hardware, basic software, multimedia, networks and so on. Such the environment should be highly interactive and provide facilities for aiding human thinking on each chunk of the media and converting the chunks flexibly one to another as the process proceeds. To perform an idea creation we should specify a *methodology* which gives how to utilize the facilities provided by EME. In developing an experimental version of EME where we refer to KJ-method [1] (see Appendix) as a methodological basis.

There are some other related works: Marshall et al.[2] classified current spatial hypertext systems into four categories; permissive, emergent, descriptive and prescriptive. Our work is relating to an emergent spatial hypertext. Our term "emergent media" relates to the term "knowledge media" proposed by Stefik[3]. Haake et al.[4] developed a hypermedia prototype where idea transformation from informal to formal is considered.

In this paper facilities that current EME provides are outlined. The reminder of this paper is organized as: Section 2 presents an overview of major facilities implemented and Sections 3-5 explain each facility in more detail. Section 6 describes concluding remarks and planned future research.

2. Overview of Current Emergent Media Environment

In developing the experimental EME our efforts have been made in various dimensions as follows:

(1) In order to attain *integrated support* from the generation/collection step to the presentation step, we have developed user-friendly user interfaces for handling information in each chunk of the emergent media and for converting information from one chunk to another flexibly.

(2) In order to concentrate to thinking itself, we have developed facilities for *avoiding chores* or unpleasant jobs in arranging cards and drawing diagrams and so on.

(3) Computer-aided techniques have been applied for *idea divergence advising* in the generation/collection step and *idea convergence advising* in the organization step.

(4) *Networks* have been employed for idea collection and treatment of *multimedia information* have been implemented for idea representation in each step.

(5) Both *personal use* and *group use* should be supported. Current version is mainly personal-use oriented and a distributed brainstorming by group is partly supported for idea generation.

The current EME provides the following facilities :

(i) Generation/collection step
- instant idea memorizing anywhere and anytime
- distributed asynchronous brainstorming (under development)
- information collection via e-mail, netnews, WWW, database etc.

(ii) Organization step
- supporting a generic class of diagrams
- user-friendly and highly interactive interface for incremental diagram editing in an menu, direct-manipulation and animation environment
- automatic diagram layout for avoiding chores of manipulations
- flexible viewer of diagrams by fisheye views, information hiding etc. in order to overcome the limited size of a computer screen

(iii) Presentation step
- diagram conversion into a style being adequate for documentation
- multiple outline mode support in graphic and textual views.

Besides the above-mentioned facilities several advising facilities are prepared:

(iv) Advising in the generation/collection step
- automatic construction of associative database (nets of relationships among keywords and/or documents)

• idea diverging advisor with associative retrieval to associative database

(v) Advising in the organization step

• combining or deleting segments of idea by sorting with keywords

• idea convergence advising by grouping (or clustering) cards, linking cards and title-making of a group of cards.

Figure 3 shows an overview of the process, tools and facilities of the current EME.

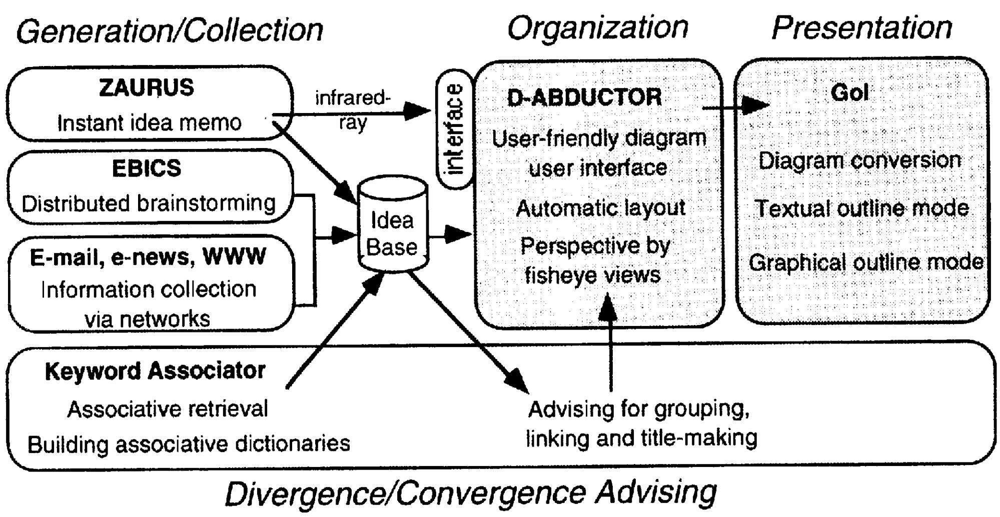

Figure 3. An overview of the process, tools and facilities of he current EME.

3. Facilities for the Generation/Collection Step

3.1. Instant idea memorizing and transferring

Ideas often come to mind suddenly when we are in bed, walking on a street, driving a car or at the desk. Unless we memorize them instantly, they tend to disappear within a minute. Therefore an instant idea capturing or memorizing facility anywhere and anytime is most important for the generation/collection step. Further it is desirable that such memorized ideas should be easily and smoothly transferred to the organization step. For this purpose we used a portable, pen-based computer called ZAURUS and connected it via infrared-ray transmission to an idea organizing tool called D-ABDUCTOR in a PC or Work Station. Figure 4 shows an illustration of instant idea memorizing and transferring facilities. Figures 5 and 6 are examples of screens of D-ABDUCTOR where cards expressing idea segments are spread uniformly on the screen. In Figure 5 we can see a mixture of cards with texts and hand-written images memorized by ZAURUS and a photo took with a digital camera. Figure 6 presents an example in a real situation (hand-written memos recorded when one of the authors attended some lecture).

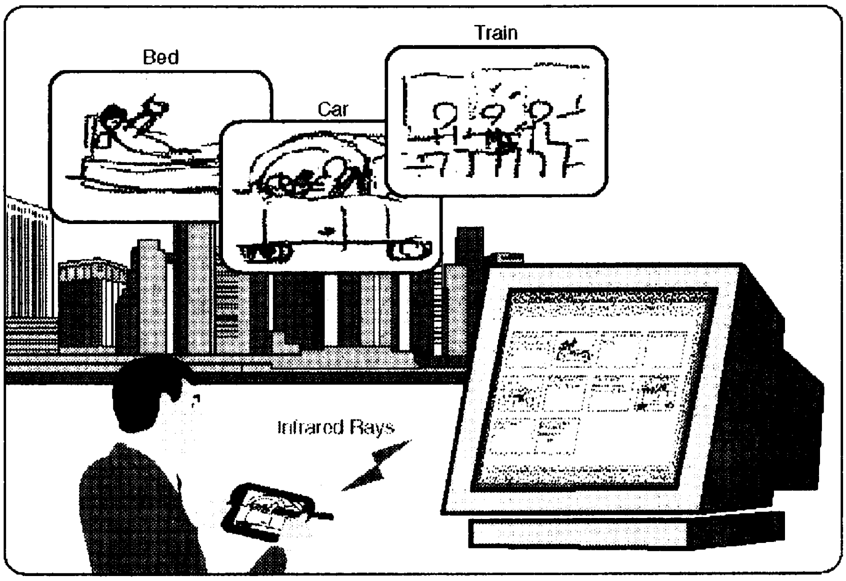

Figure 4. Instant idea memorizing and transferring.

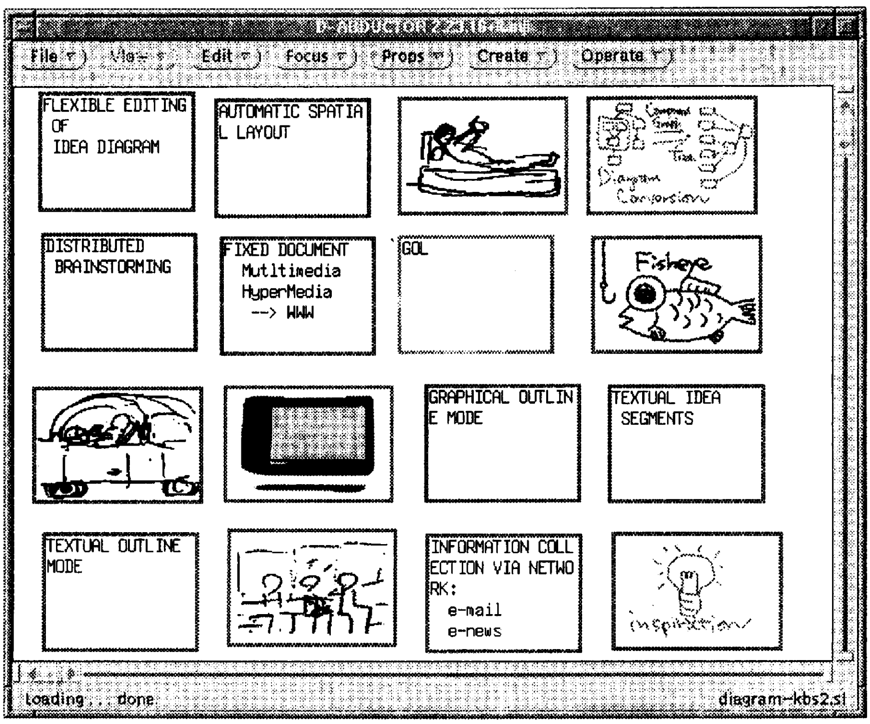

Figure 5. An example of cards (collected idea segments) with texts and images.

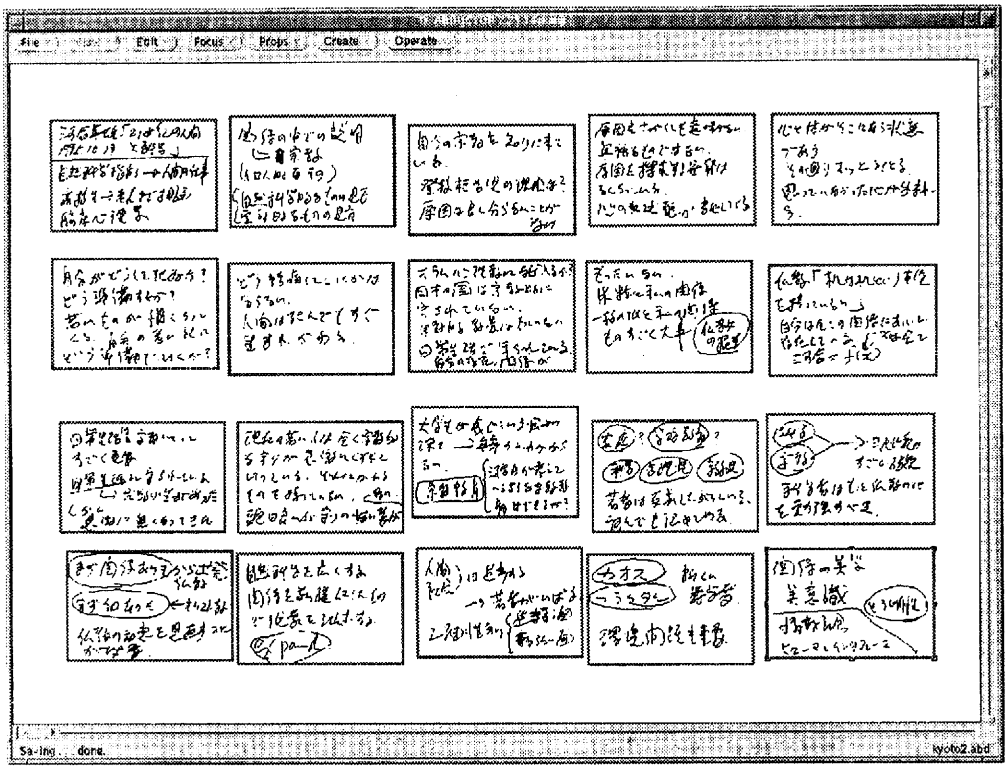

Figure 6. An example from a real work. Cards with handwritten memos are spread on a screen.

3.2. Distributed asynchronous brainstorming

Group works for the idea generation are classified into face-to face meetings, distributed synchronous meetings and distributed asynchronous meetings. Benefits of group idea generation through such meetings exist in: We have more information/knowledge and more view points than personal cases, and we can expect synergy effects among participants. We are developing a brainstorming tool called EBICS in a distributed asynchronous situation using multi-agent programming technologies. It consists of servers, clients (or participants to the meeting) and other related tools such as database management system. Clients and servers are implemented as agents in multi-agent programming language April[4] and data are managed by agent oriented distributed database engine AdB. Figure 7 shows the system configuration of EBICS and Figure 8 a sample screen.

3.3 Information collection via network

Retrieving or collecting information through the network (e-mail, e-news, WWW etc.) is another useful way in this step. We have experiences to apply our EME to collect and summarize user's comments on D-ABDUCTOR, questionnaire for market researches and so on. Network searcher, intelligent agents, WWWWorm will be used much more for this purpose in the near future.

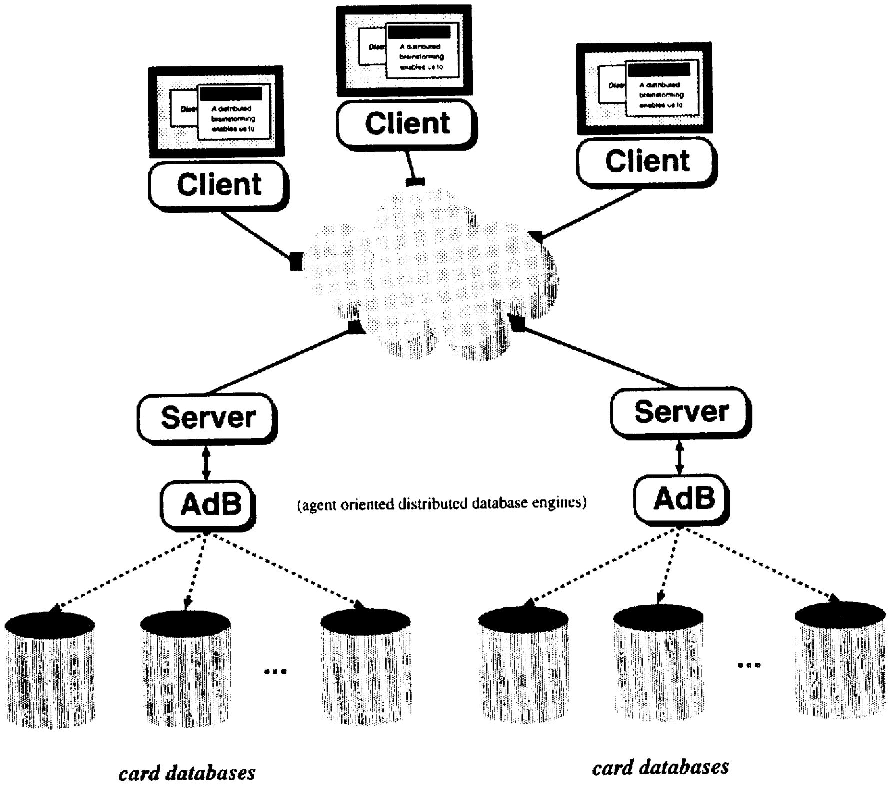

Figure 7. System configuration of a distributed asynchronous brainstorming.

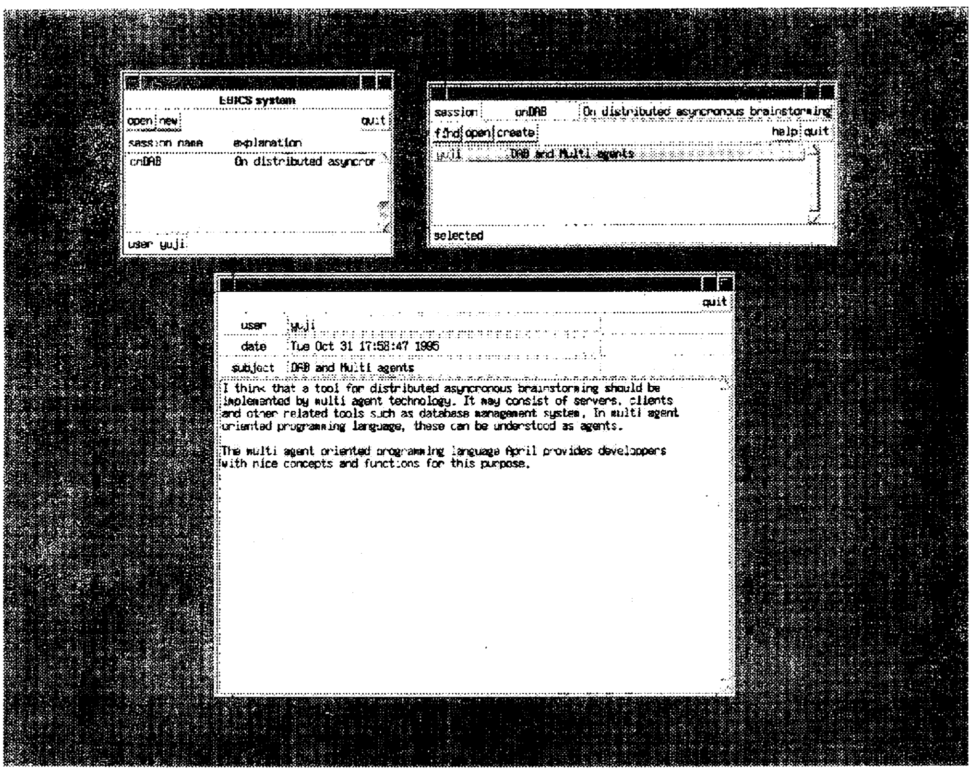

Figure 8. A sample screen.

3. 4 Idea divergence advising

We have developed an idea divergence advising tool called Keyword Associator [6,7] of which architecture is presented in Figure 9. There exist two major facilities provided by Keyword Associator: automatic construction of associative dictionaries called IdeaBase and user-friendly interface called IdeaBaseInterface for an associative retrieval of keywords from the associative dictionary.

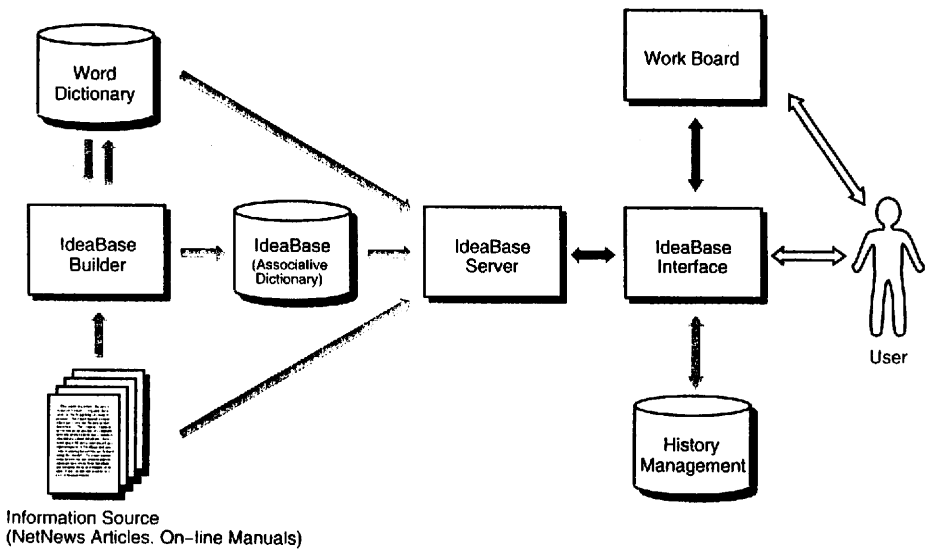

Figure 9. Architecture of Keyword Associator.

Automatic Construction of Associative Dictionaries

We have constructed an associative dictionary by using netnews articles since netnews is very adequate information sources: (i) the size of netnews articles is very large, (ii) netnews includes various subjects in various fields (computer science, social topics, etc.), (iii) netnews is always up-to-date, and (iv) getting netnews is easy.

How to construct an associative dictionary is explained in Figure 10 using a simple example. An associative dictionary is consisted of a set of keywords and three types of similarity nets (between keywords and groups, among keywords and among groups). In Figure 10 we consider three News Groups G_1, G_2 and G_3 and suppose that four different words A, B, D and E appear in G_1, A, D and E in G_2, and A, B, C and E in G_3. Procedures for constructing a dictionary are as follows:

(1) Occurrence probabilities of each word in the whole netnews ($P(i)$) and each group

($p(i,u)$) are calculated. For example $P(\mathrm{A})$=6/16, $P(\mathrm{B})$=3/16, $p(\mathrm{A},\mathrm{G}_1)$=2/6 and $p(\mathrm{A},\mathrm{G}_3)$=1/5.

(2) The significance of each word in each group ($s(i,u)$) is calculated by

$$s(i,u) = p(i,u)\log\frac{p(i,u)}{P(i)}.$$

(3) As the results we have

$$s(\mathrm{A},\mathrm{G}_1) = 0.017, s(\mathrm{B},\mathrm{G}_1) = 0.083, s(\mathrm{D},\mathrm{G}_1) = 0.009, s(\mathrm{E},\mathrm{G}_1) = -0.009$$
$$s(\mathrm{A},\mathrm{G}_2) = 0.011, s(\mathrm{D},\mathrm{G}_2) = 0.132, s(\mathrm{E},\mathrm{G}_2) = 0.006$$
$$s(\mathrm{A},\mathrm{G}_3) = 0.001, s(\mathrm{B},\mathrm{G}_3) = 0.006, s(\mathrm{C},\mathrm{G}_3) = 0.101, s(\mathrm{E},\mathrm{G}_3) = 0.006$$

(4) We extract words B, C and D as keywords for the dictionary since they are specific in respective News Group.

(5) The significance calculated in (3) constitute a similarity net between keywords and groups shown in the top of the right hand of Figure 10. Further we can obtain other two kinds of similarity nets; similarity net among keywords and similarity net among News Groups.

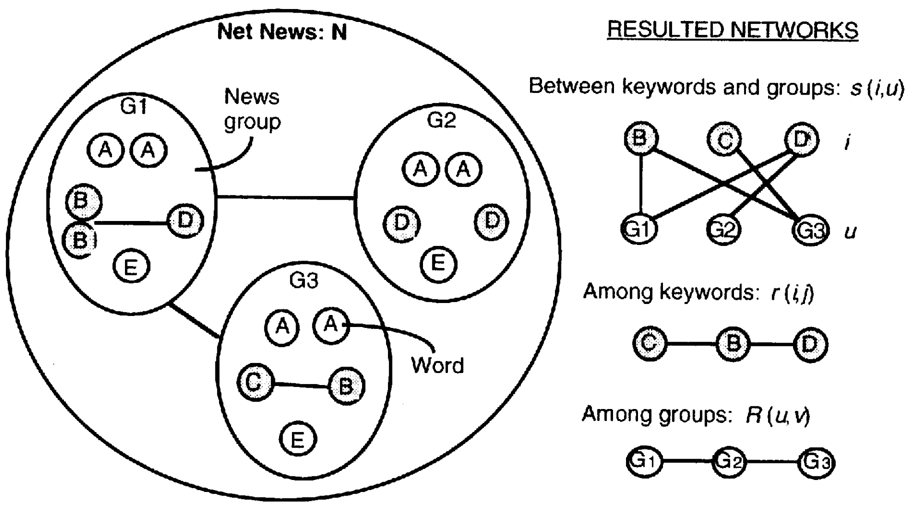

Figure 10. Explanation of construction of associative dictionary.

The items of current associative dictionaries we prepared are shown in Table 1. These dictionaries have been constructed from netnews articles during a month.

Table 1. Current associative dictionaries.

	English netnews	Japanese netnews
the amount of articles	~1.5GB	~100MB
the number of articles	~200,000	~15,000
the total number of words	~150,000	~110,000
the size of dictionary	~300MB	~20MB
time for retrieval	1sec - 2 min	1sec - 10sec

It should be noted that the same procedures described above can be applicable to other documents such as books, manuals and a set of cards, and we can construct other types of dictionaries. The method to use a set of cards will be used in Section 5.

Idea Divergence Support by an Associative Retrieval

Except group meetings we can point to analogy, metaphor, combination and association as effective methods for idea divergence. Keyword Associator serves for an idea divergence by association retrieval. When we give words and/or articles as input to Keyword Associator we can get words and/or articles relevant to them as output. We can choose a way of the associative retrieval among: (i) from words to words, (ii) from words to articles, (iii) from articles to words and (iv) from articles to articles.

Figure 11 shows the user interface of the Keyword Associator. The right window shows a tool for keyword association where the word "energy" is inputted and the top twenty words relevant to "energy" are listed up in the decreasing order of the relevance degree which is shown with slider bars in the right of each word. For this retrieval the associative dictionary constructed from netnews is used. Several combinations of inputted words such as "and", "or", "not" are possible. The left window shows a tool for idea editing canvas for expanding our images. We can put words in any place of the canvas and make links among them. We can take any words in both ways between the right window and the canvas with Drag-and-Drop operations.

Further, Keyword Associator has facilities for *user adaptations* and *filtering.*

(i) User adaptation (feedback through retrieval history)

Associative relationships that have already been used in previous retrieval history by the user are subtracted from the current associative dictionary because such associations are not stimulative to the user. Associative relationships extracted from a set of documents written by the user are subtracted from the current associative dictionary because such relationships also are not stimulative to the user.

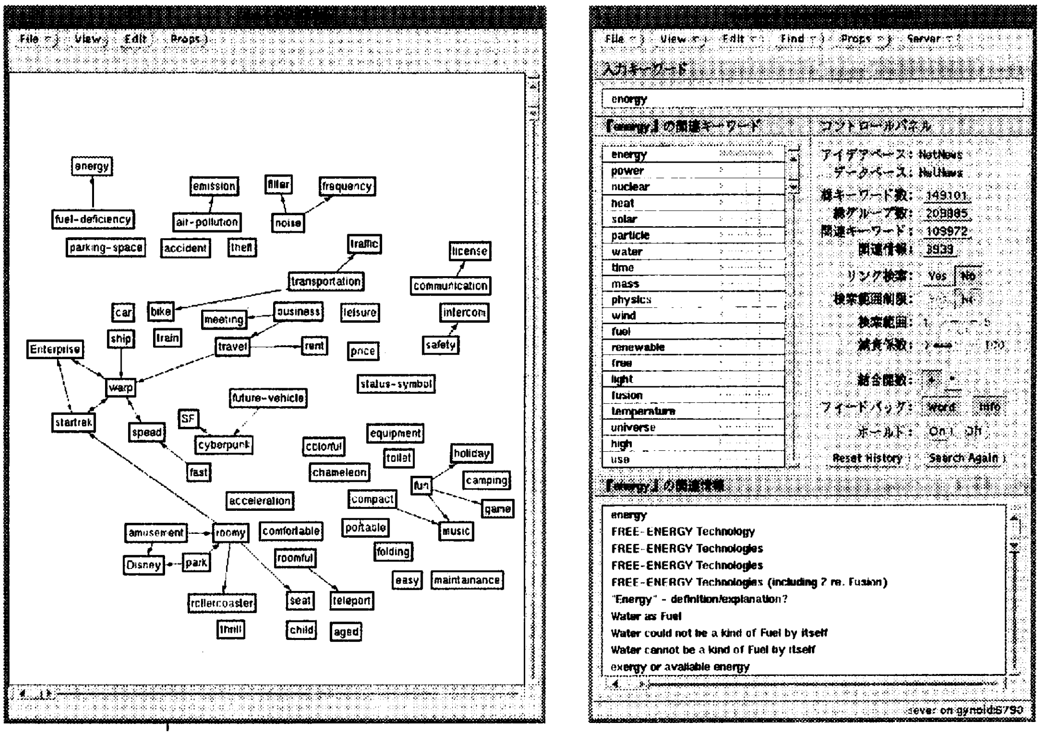

Figure 11. Interface of Keyword Associator.

(ii) Filtering

During the associative retrieval we can control the search region by filtering facility which restricts searching within specified fields and word classes. Figure 12 shows examples of retrieval sequences with word class and field filtering.

◆Example

[n→(hold)→a→n→a]

creativity→creative→essay→desert→
metaphor→cloudless→writer→novel→
book→reading→school→antitrust→
student→financial→aid→poor→people→
women→man→variant→answer→
suffocating

Figure 12. A sequence of associative retrieval when starting a word 'creativity'. 'n' and 'a' means noun and adjective respectively. (hold) means that this retrieval is restricted to search such articles that have word 'creativity'.

4. Facilities for the Organization Step

We often exploit diagrams when we think. One reason of using diagrams is that they are good media to represent and organize personal ideas, and to share ideas among persons on group works. However, editing, reforming, and redrawing diagrams, which are necessary on idea creation processes, are troublesome. Moreover they might be unessential for thought. In this section we describe an idea organizer that exploits diagrams effectively as media for human-computer interaction and for interaction among persons. We developed a diagram based idea organizer D-ABDUCTOR[8,9,10] where we were significantly affected by KJ-method in terms of methodology and procedures (see Appendix). We have integrated diagrammatic techniques with a menu, direct-manipulation and animation environment, and have supplemented communication facilities for group works, and multi-media facilities to deal with pictures.

4.1. Facilities of D-ABDUCTOR

D-ABDUCTOR provides an environment to deal with diagrams of a generic class of diagrams called *compound graphs*[11] which represent both adjacency and inclusion relationships among nodes (including both cards and groups of cards). The compound graphs are used in the KJ -method. D-ABDUCTOR provides the following facilities:

- **Fast automatic layout of compound graphs** : D-ABDUCTOR provides a fast automatic layout facility of compound graphs utilizing Sugiyama style extended drawing algorithm[11]. Certain operations chosen by the users can trigger the invocation of this facility for visual response.
- **Graph editing**: D-ABDUCTOR provides various editing operations from standard operations(e.g. create/delete a node or link, change color/width/shape of a node or link) to group operations(e.g. create/resolve a group node) in a menu and direct manipulation environment.
- **Collapse/Expand operations**: D-ABDUCTOR allows groups of nodes to be represented by one node (information hiding).
- **Fisheye view**: Our fisheye view facility called Diagram Dressing changes the size and visibility of nodes according to their importance[11]. More important nodes become larger, and less important nodes become smaller or omitted to overcome to small computer screen. Structure of diagrams, semantics of nodes and the specific user's viewpoint influence the importance of nodes.

• **Display with Animation**: D-ABDUCTOR can display the instantaneous visual change with an animation so that the user's mental map is preserved.

• **Communication**: Multiple set of D-ABDUCTOR can communicate with each other on a network to share database called Card Base consisted of diagram data, text data and images. D-ABDUCTOR can communicate with other applications through the language "Simple".

• **Language "Simple"**: The language Simple is designed to store the current graph and communicate with other processes. Graphs can be created, edited, loaded and saved through Simple. Furthermore, Simple has the capability to record working histories with D-ABDUCTOR and so we can replay the editing histories. D-ABDUCTOR works as an interpreter of Simple.

The system architecture and facilities of D-ABDUCTOR are shown in Figure 13. Sample screens of D-ABDUCTOR are shown in Figure 14. In Figure 14 some of menus and dialog boxes are opened and a small diagram with images is shown in the Main Window. Text can be placed into nodes by using a text editor(Create Menu). Graphic images can also be attached to nodes instead of text. Any node (whether a group node or leaf node) can be connected together with links(Mouse Operation). Each node has several handles allowing links to be attached. Predefined actions such as adding a new node or link can be set up to trigger the automatic layout facility and redraw the diagram (Layout dialog box). Diagrams can be oriented north, east, south and west (Layout dialog box). In Figure 15 a larger example is shown. The sizes of nodes in both diagrams are changed by the diagram dressing facility (Dressing dialog box).

Evaluation of D-ABDUCTOR from operational points of view were carried out [12]. Further we are distributing D-ABDUCTOR and collecting reports to evaluate it. Some early reports said that (1) D-ABDUCTOR was applicable to several practical tasks such as consideration of document structures, design of program structures, and design of database schema; (2) D-ABDUCTOR was useful to raise working efficiency; (3) changing layout could give the users good stimuli for thought[7]. The usage of D-ABDUCTOR other than idea organizations includes layout for documentation, outline processing, software engineering, WWW browsing, CAI design, database schema designing, network monitoring and so on.

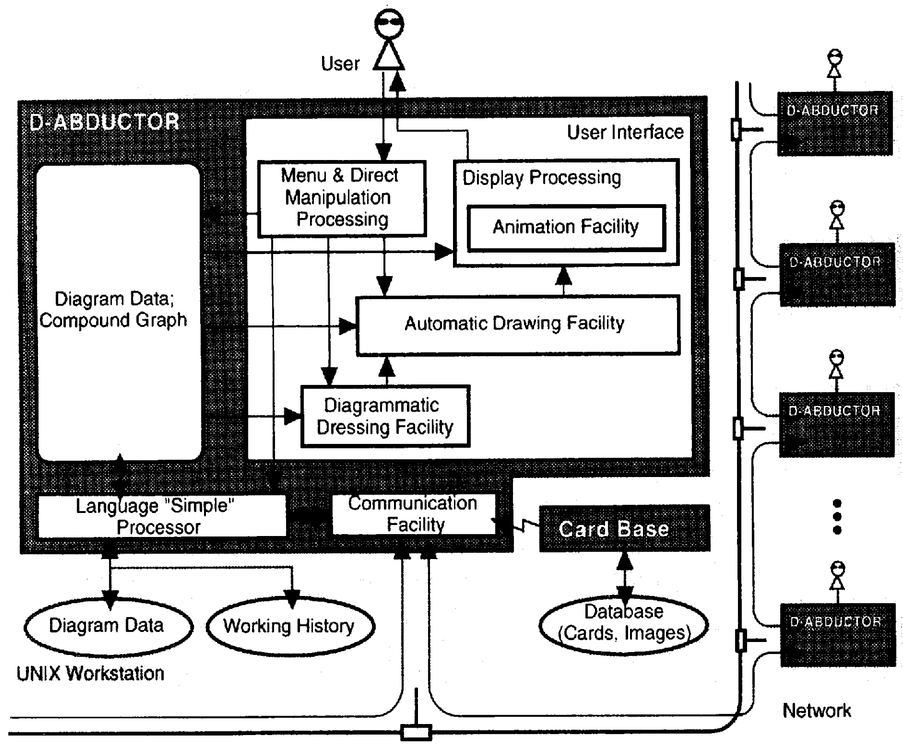

Figure 13. System architecture of D-ABDUCTOR.

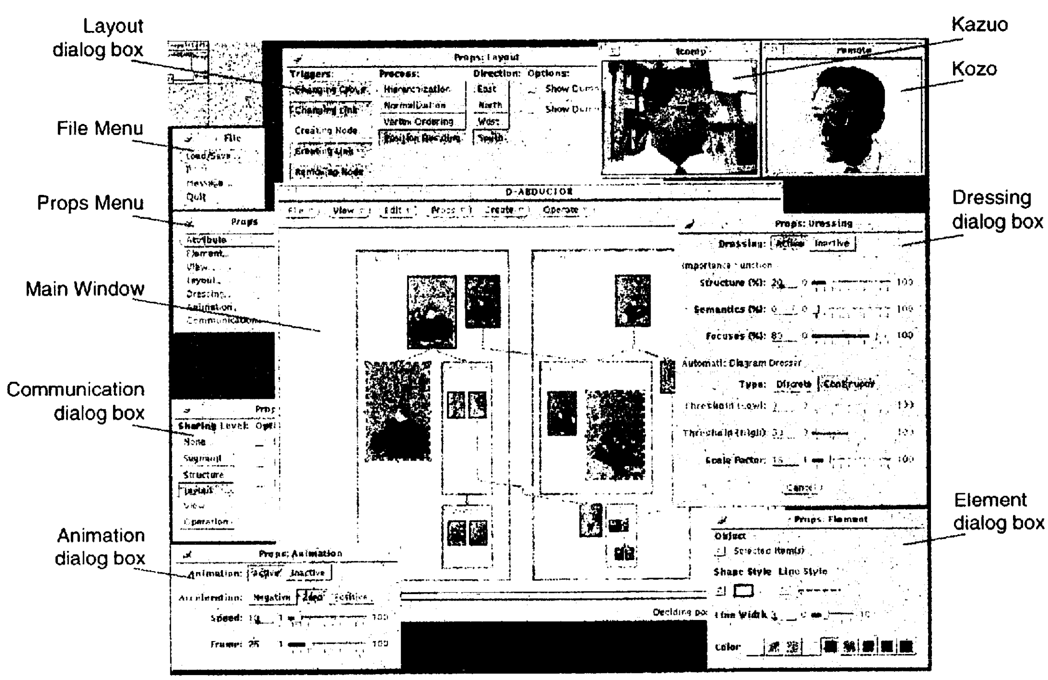

Figure 14. A sample screen: a small diagram with images, menus and dialog boxes.

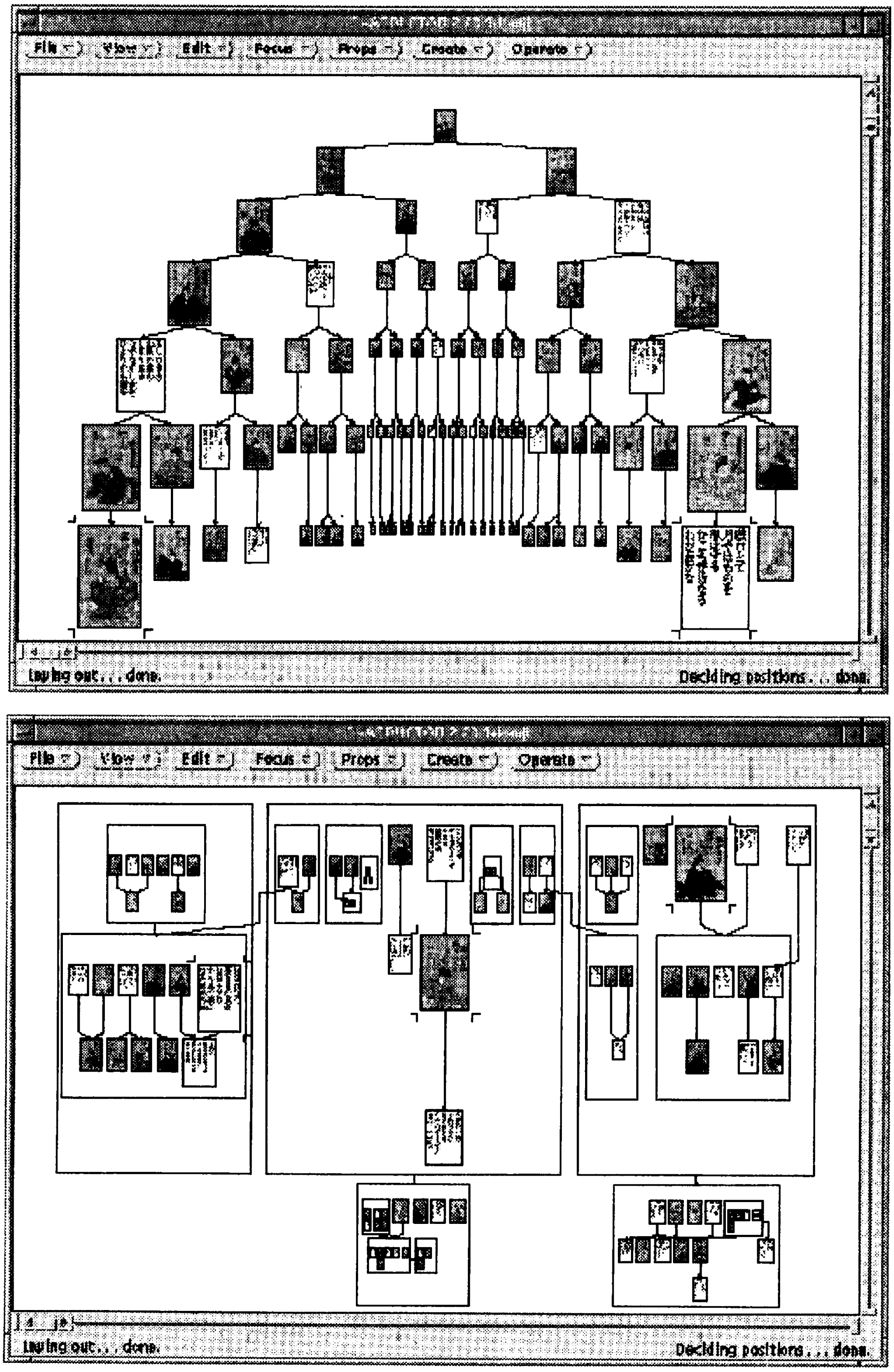

Figure 15. Sample screens of larger examples of a binary tree (upper) and a compound graph (lower). The number of leaf nodes in each diagram is 100. In both cases the diagram dressing facilities are utilized. Two marked nodes are focused in the upper diagram and three in the lower.

4.2. Idea organization by D-ABDUCTOR

We explain the use of D-ABDUCTOR for the idea organization using a simple example (see Figures 5, 16 and 17). The task in this example is to organize idea segments relating to "idea creation process" into an integrated conceptual diagram on the process. These idea segments were memorized using a portable computer. We first transfer the idea segments to D-ABDUCTOR on PC or Workstation and spread them as cards on the screen (see Figures 4 and 5). Here instead of the idea segments memorized on a portable computer we can utilize other data on a disc which are generated through brainstorming or collected via networks. Then we manipulate the cards (or edit a diagram) for grouping, title-making, linking and so on by a process of trial and error (see Figure 16). On the process D-ABDUCTOR facilitates the elaboration of the diagram effectively. Finally we obtain a conceptually well-organized diagram (see Figure 17) which express "idea creation process".

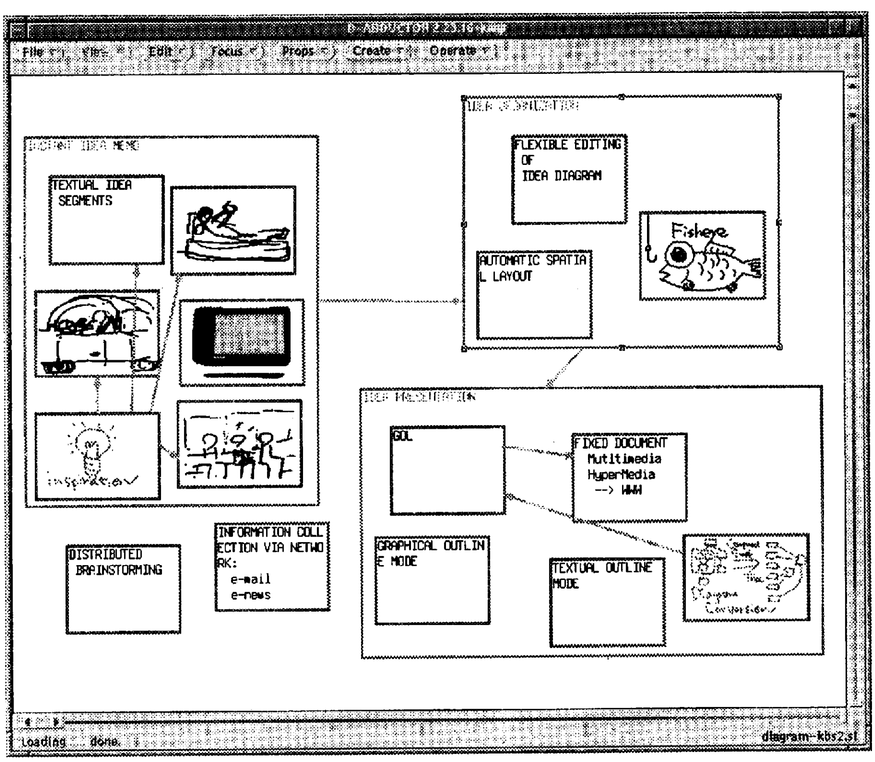

Figure 16. Intermediate stage of idea organization.

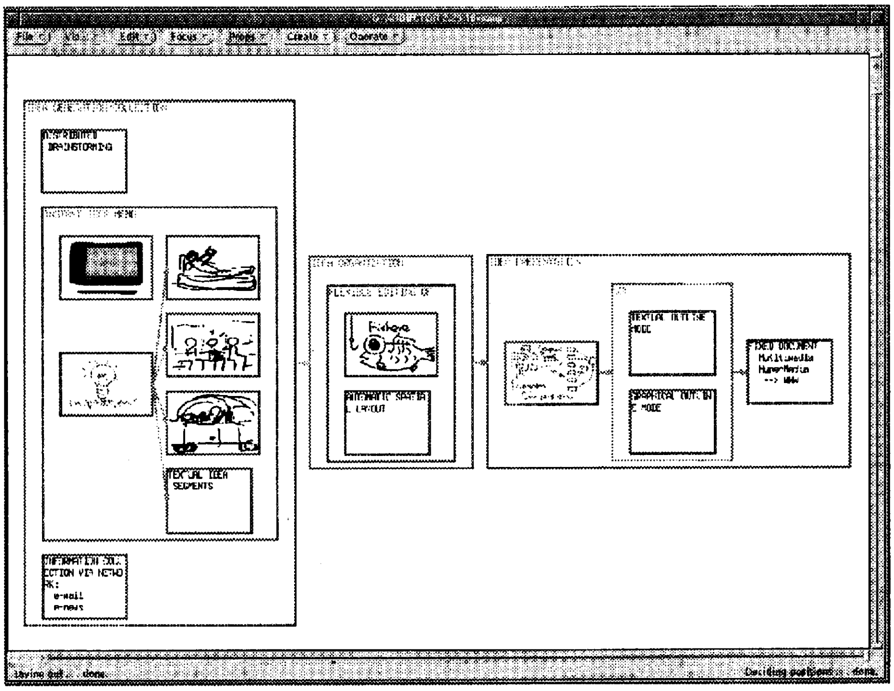

Figure 17. Final result of idea organization using D-ABDUCTOR.

4.3. Convergence Advising

Utilizing the facilities provided by the Keyword Associator described in Subsection 3.4, the emergent media environment can serve various kinds of advising facilities for the user to organize the idea cards into a well-structured diagram on D-ABDUCTOR[13]. Given a list of text contents of cards, Keyword Associator can calculate keywords and values of various relevance among cards such as similarities of cards, groups of cards by clustering, specific keywords characterizing each group and similarities among groups and cards. In this calculation we can employ the same method as shown in Figure 10 if News Groups are replaced with cards in Figure 10. These calculated results are displayed as diagrams or keywords lists on D-ABDUCTOR for aiding the user in various thinking phases in the idea organization step such as initial configuration, grouping of cards, title-making of each group of cards and grouping/linking of cards (see Figures 18 and 19). Though these advising facilities suggests the possibility to automate the organization step, they might be more effective in preprocessing before an interactive use for human considerations, especially when the number of cards are large.

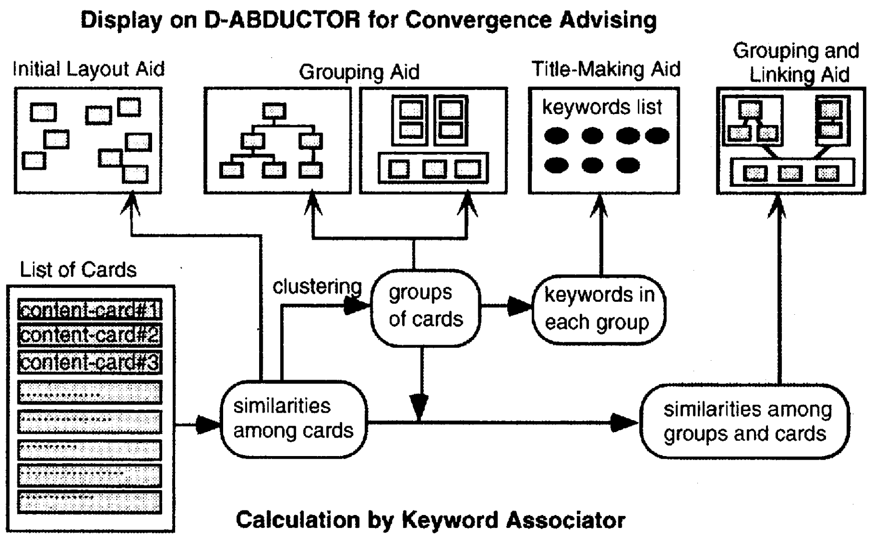

Figure 18. Various convergence advising facilities using Keyword Associator.

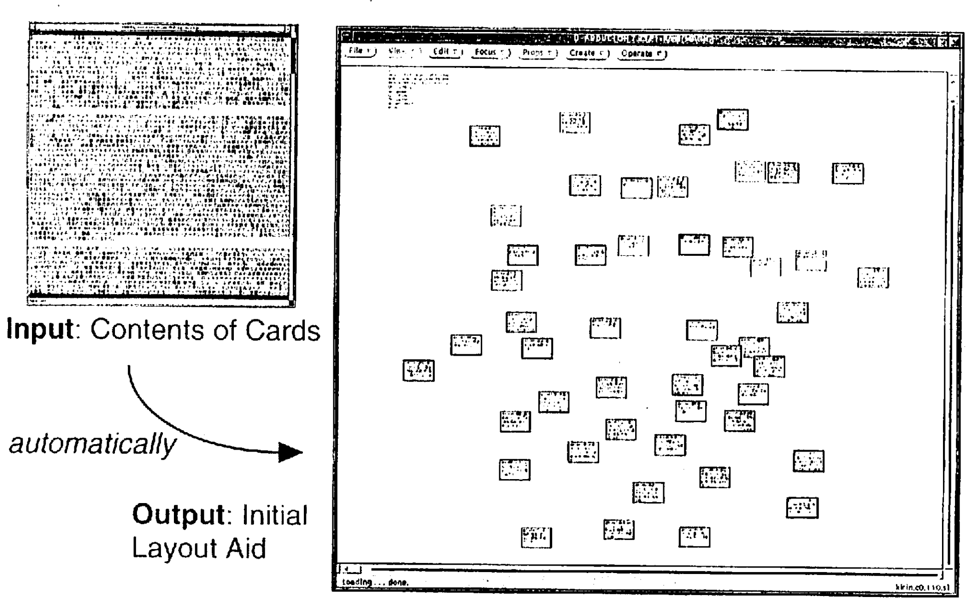

Figure 19 (a). An example of the initial layout aid.

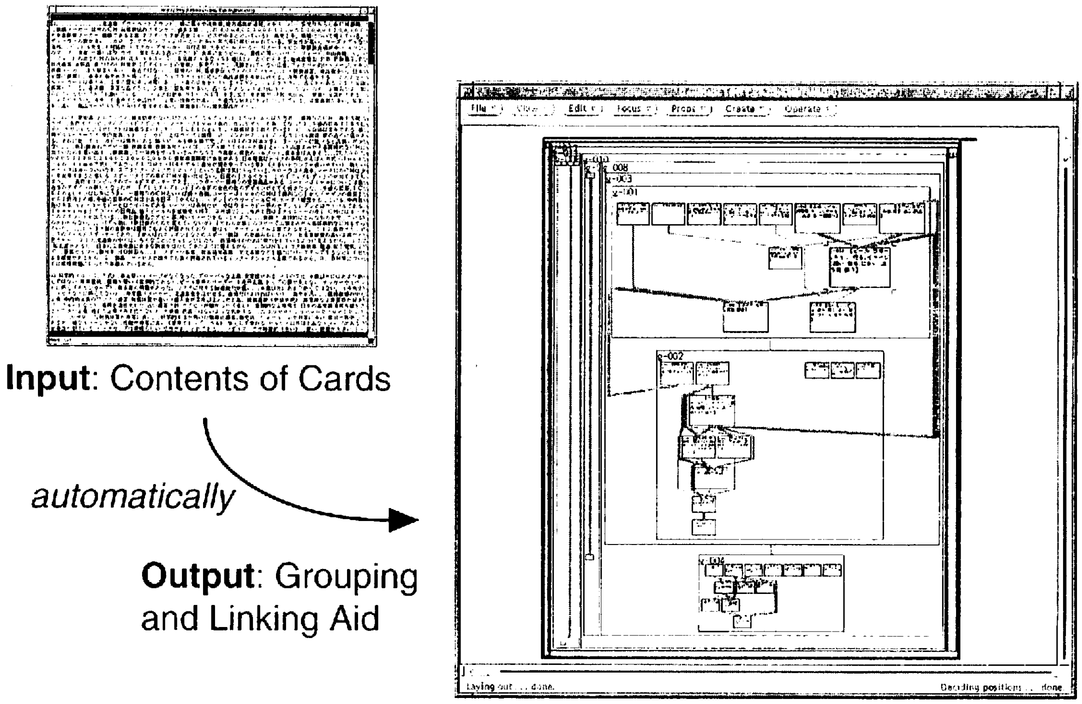

Figure 19 (b). An example of the grouping and linking aid.

5. Facilities for the Presentation Step

As the final results of the idea creation are presented as documents, we need a tool for effectively supporting the step for conversing diagrams produced in the idea generation step to documents. The primary difficulty exists in the fact that a diagram has a net structure while a document has a linear structure. So we should determine a description order among cards and groups in a diagram. The secondary difficulty is that when we write a document to elaborate what the diagram expresses more precisely, we often need to see the whole structure of the diagram and change the description order. To solve these difficulties we have developed a new type of outline processor called Gol [14] where both graphical and textual mode are utilized. A sample screen of Gol is shown in Figure 20. Processes in using Gol are as follows:

(i) Converting a diagram produced in the organization step into a new type diagram: For example the diagram shown in Figure 17 is converted into the diagram shown in the window on the upper right corner of Figure 20. Layout conventions of the new diagram are that the nodes in the first depth are arranged horizontally, the nodes in the second depth are arranged vertically and so on. This diagram can be edited (or a description order can be changed) easily with a direct manipulation like D-ABDUCTOR: This is called Graphical Outline Mode.

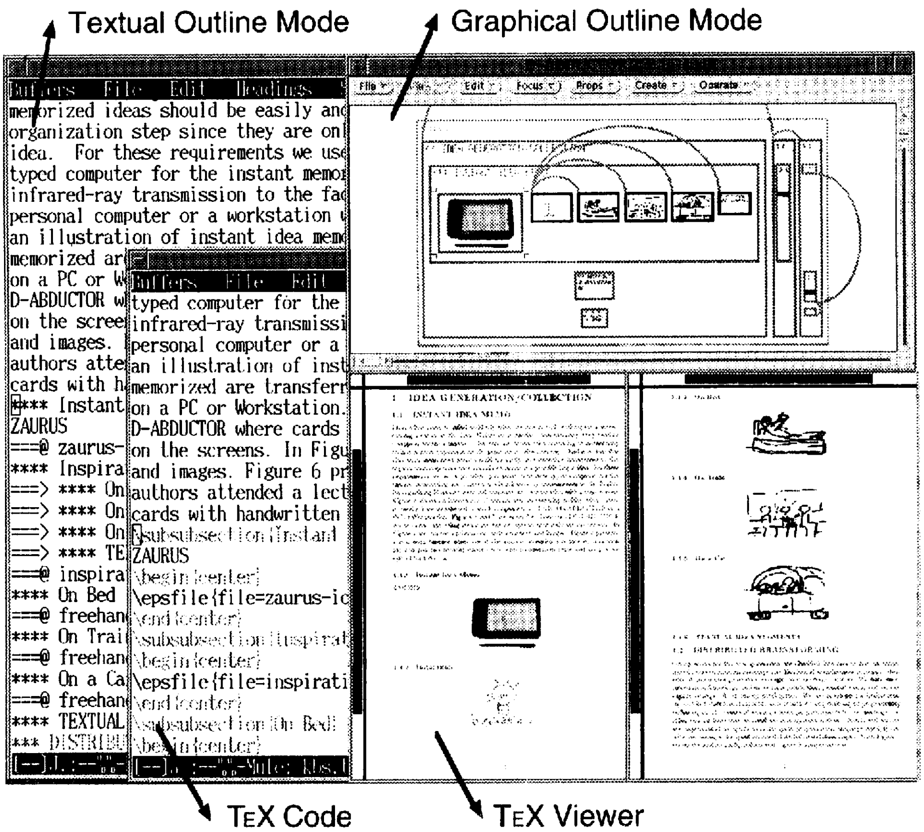

Figure 20. A sample screen of GoI.

(ii) We use an outline processor in EMACS. This is called Textual Outline Mode. Both Modes are connected in both ways or changes in a description order and outlines in one Mode always affect changes in them in the other Mode consistently. Using both Outline Modes we can proceed the process to elaborate a conceptual diagram into a document.

(iii) GoI has such facility to convert texts of Textual Outline into TeX code automatically. For example the window in the lower right corner of Figure 20 shows the final document which describe the diagram in the upper right corner precisely. It should be noted that this conversion is possible if the diagram includes cards with images.

6. Concluding Remarks

We have described facilities of our current emergent media environment and shown some examples of the idea creation process. Each facility is not integrated fully in the current version and the evaluation of the system is not sufficient. Therefore we need to make efforts to further integrate and evaluate the system through applying it to many practical problems. To make much progress the following studies are envisaged for future research:

1) multimedia portable equipment for instant capturing of photo, movie, sound etc.

2) recognition of handwritten texts and diagrams

3) how to use a big screen for the idea organization

4) various experiments by methodologies other than KJ-method on the environment.

Appendix: KJ-method

KJ -method[1] is very famous in Japan as an effective label-based method for organizing ideas and solving problems without computer support (word 'label' is used in KJ-method instead of 'card") . The main part of KJ-method contains four basic steps as follows:

(1) **Label Making**: We start with a supply of labels or note cards on which ideas or information (text or image etc.) relevant to our problem are written. We collect and record ideas until we feel we have exhausted all information necessary to solve the problem.

(2) **Label Grouping and Title Making**: The labels are shuffled well and spread on a large sheet. Then all the labels are read several times. If there exist such labels seemed to belong together, we make a team of the labels. This process is repeated. After about two-thirds of all the labels are arranged in teams, making titles for the teams is started. The titles should clearly describe the essence of all labels in the team. Once a title is made for a team, we put all the labels together in a pile with the title clipped on its top. Next, we arrange the teams in larger teams in the same manner. This iterative process of grouping labels may be repeated as many times as necessary. Usually it is terminated when the number of the teams is reduced to less than ten.

(3) **Spatial Arrangement and Chart Making**: We find carefully the arrangement of the final groups in which a consistent understanding of all the groups can be obtained. Then we proceed to arrange all sub-teams or elements in the same manner. After completing this spatial arrangement, we draw a chart in own handwriting by showing the relationships using various symbols and signs.

(4) **Verbal or Written Explanation**: To explain the chart clearly, we try to describe the chart verbally or in writing. As a general rule our explanation should proceed to a team adjacent to where it stated. The cumulative effect of idea generation will continue to increase as our explanation advances.

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