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From the Editor

Along with the progress towards a more information-oriented society in recent years, large amounts of various types of information have come to be used in home life as well as in industrial and social activities. The volume of information generated has also been increasing sharply as a result of the diffusion of word processors, personal computers, and workstations brought about by advances in information technologies. Since the volume of such information is expected to increase further from now on, finding ways to find needed information quickly will be an important challenge both for the support of individual intellectual and creative activities and for the determination of corporate strategies. However, information as it is now generated is in a variety of forms such as images, graphics and voice as well as numerals and characters. For example, images include drawings showing statistical data, design drawings, and cardiograms. Graphics include nature documentaries, experimental observations, and sports. Voice includes the sounds of natural phenomena such as wind and rain as well as the sounds of conversation, lectures, and speeches. For expressing such a variety of information, it has traditionally been necessary to convert the information into the form of numerical values or text. But the progress of computer technologies is making it possible to handle images, graphics and voice in their original forms. As a result, not only is the scope of computer applications widening, but there is also a rapid rise in the desire to process various forms of information by computers. Words such as "multimedia" and "hypermedia" have become highlighted in recent years. This is apparently because there has been a rapid expansion of needs and demands and because there have been steady improvements in the technologies and products to meet those demands.

Today it is becoming possible to use so-called "multimedia information," that is, the information accumulated in a variety of media. Partly because of this development, the concept of "information processing adapted to the user's thinking" has arisen. This is the concept that the user should be able to make integrated use of diversified media without having to pay attention to the media used to store the information.

The idea of making integrated use of information media means that people can freely use various information in writing and conversation in concert with the thinking process. With conventional computers, the information media that could be handled had to be limited in advance. Besides, it was difficult or economically impracticable to handle image and voice media in the same way as characters. Behind the growing interest in multimedia in recent years is the fact that multi-media products that can be used as easily as personal computers are now available at fairly reasonable prices.

Progress in information technologies has been furthering the development of culture, causing rapid change from time to time. Multimedia have traditionally been used by people without any particular awareness of the information media involved. But now it is becoming possible for computers to handle multimedia. This development is expected to have a great deal of impact in a wide variety of fields, including culture, society and private life.

A hypermedia system is a system in which information is organized in accordance with the structure of human association and conveyed or recorded in a form that includes relations among different pieces of information, so that the information can be used in a more diversified way. Intelligent hypermedia systems, which will be created by adding intelligence to hypermedia systems for improved affinity with the human being, are expected to receive a lot of attention in the future. The intelligent hypermedia system will be positioned as a powerful tool of intellectual activity. Therefore, by ensuring the supply and use of abundant information in such fields as private life, society, business, and academia, this tool will help materialize an advanced information-oriented society and create a new culture or civilization.

The use of hypermedia is expected to spread in the future to social activities such as operation of museums as well as education, and medicine, etc. In addition, new business opportunities will arise from the activation of existing industries, increases in added value, new technologies, and new products. This will in turn contribute to increased employment opportunities and industrial or economic growth.

But a number of problems have yet to be solved to ensure the sound growth of hypermedia. For example, specialists have to be trained and problems related to standardization and intellectual property rights must be solved.

This issue describes basic hypermedia concepts, cases of application in this country, new developments and so on. We hope the articles will be of use to our readers.

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R&D Trend of Hypermedia

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1. What Is Hypertext/Hypermedia?

Our life is now surrounded by an enormous amount of information. We are highly concerned with how to use it. For the multilateral utilization of information, it is important not only to collect separate and fragmentary pieces of information, but also to recognize the relationships and similarities between them and to connect the related information. Database systems and information retrieval systems are based on conditional retrieval. They have no function for connecting related information or supporting associative retrieval. Hypertext is a system which does not simply accumulate fragmentary information, but constructs an associative network by connecting related information and enables associative retrieval by tracing this path.

An ordinary text has a unit called page. A text has a linear structure consisting of sequential pages. The linearity of a text structure often becomes an obstacle to its use. We do not necessarily read a book or a magazine sequentially. We sometimes look at pages ahead or go back to check, refer to footnotes or notes at the end of a chapter or a book. We freely go from one page to another. We look up a dictionary or an encyclopedia or refer to related documents while reading a book.

Hypertext enables the formation of an advance connection link between the starting point and the target of skipping with regard to the act of skipping in the act of reading. A reader can skip to a related location directly and return to the original position directly. The starting point and the destination of skipping are called the source anchor and destination anchor, respectively. Hypertext uses a card as its unit of information instead of a page. Anchors can be set for any items such as a phrase or illustration in a card. A link can be formed from an item in one card to an item in another card as illustrated in Figure 1. This card is called node of a hypernetwork formed by card linkage.

Similarly, the process of text production is not necessarily sequential. Document production involves work, such as conception, planning, and elaboration, which by their nature cannot be carried out sequentially according to the sequence of chapters and sections. Furthermore, text production cannot be thought of independently of text utilization because document production generally requires literary study.

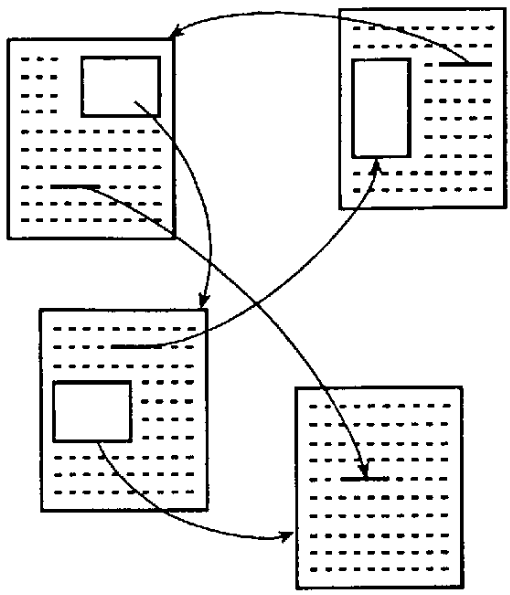

Figure 1 Connection Structure of Hypermedia

Hypertext is a system for producing, accumulating, organizing, and utilizing information and is characterized by the use of a non-linear structure for organizing text information using a new medium called computer.

The term "hypertext" was coined by directing attention to textual information only. However, it began to be replaced by the term "hypermedia" as multi-media nodes become common along with the diversification of computer-supported media. Furthermore, there is a new attempt to give integrated support to information processing by the use of the hypertext or hypermedia framework. This attempt regards not only multimedia documents, but also tools such as spread sheets and charts, service systems such as a database and electronic mail, and even various application programs as visible objects having a paper image.

This paper describes the research trends in hypertext and hypermedia, and explains the characteristics of R&D in this field in Japan.

2. History of Hypermedia

The research history of hypertext is the research history of mind tools which try to apply computers for amplifying man's memory and thinking. This history began a long time ago. The prototype of the concept of hypertext can be seen in V. Bush's 1945 paper, 'As We May Think'. V. Bush conceived an imaginary device named MEMEX. A MEMEX is a micro film reader having extended functions. It can write in the margin of a called book, display two articles side by side simultaneously, form a connection link between any two items in these articles so that an associative search path can be defined. A button is assigned to a connection link so that the related item can be called immediately by pressing the button when one of these items is displayed for later use.

Stimulated by V. Bush's paper, D. Engelbart developed the NLS. The objective of the NLS was to store all the specifications, plans, designs, programs, documents, reports, memos, literature and comments that a group of researchers needs in a computer and to enable various operations such as document production, planning, designing and debugging, as well as communications between researchers via a console. The NLS supported a mouse for the first time, had a multi-window display function, and implemented a document system that could form cross reference links such as hypertext and electronic mail functions. The NLS was demonstrated in 1968.

At the beginning of the 1960s, T. Nelson proposed a system that supports an access to all the information on the earth as well as the production and publication of new information. It was named Xanadu. Xanadu is a global electronic publication network. Its users can freely retrieve and use all the kinds of information and are charged automatically. A user writes a document on this network. When he wants to quote another document, a pointer is extended to the original instead of copying it. The display displays the quoted information as if it were copied. The copyright of the original document can be protected because no copy exists. By publishing all documents on this network, a network of connection links is formed between information. Thus, the systematization of information is automatically promoted.

Taking a hint from S. Papert's attempt to have children use a computer, A. C. Kay conceived a concept called Dynabook. Thus, the development of a computer for individuals, and a new programming language for it, was started at Xerox PARC (Palo Alto Research Center). As a result, the Alto machine and Smalltalk-72 were developed in 1973 and 1972, respectively. Smalltalk was improved subsequently and released as Smalltalk-80 in 1980. This language made a large contribution to the object-oriented programming paradigm. The MVC programming style of this language became the foundation for today's window system and GUI (graphical user interface) architecture.

S. Jobs, who founded Apple Computer and later established NeXT, visited PARC and was impressed by Alto. Thus, Lisa was born and followed by Macintosh. In 1987, B. Atkinson developed HyperCard as a bundling software for Macintosh. HyperCard is a programmable hypermedia developed by adopting the idea of object oriented programming. It adopts the event driven type language HyperTalk, as a simple programming language. HyperCard can display one card on one screen and manage information by card units. Information, such as documents, images and voice, can be freely stored in each card. Another card can be called by clicking the button that is assigned to it in advance by using the mouse. HyperCard has become a platform for developing multi-media information systems by providing standardized display forms and a standard access protocol for a large variety of multi-media information.

On the other hand, Xerox developed Star workstations using the desktop metaphor and icons. In 1985, they announced NoteCards, which is a hypertext system having a large variety of programmable functions using the Interlisp-D language. NoteCards was developed originally as an idea processor. Card sets are mutually connected by various types of links. Cards are defined by functional classification and form a class hierarchy. A property inheritance mechanism is employed along this hierarchy. A number of cards can be displayed simultaneously and the card size can be changed freely. A link is displayed in the form of a symbol called a link icon on a link source card. The card of the link destination can be called by clicking this icon. NoteCards has a browser that displays the network structure of links as a graph. A card called file box is in charge of filing to the secondary storage of a large network, and has saving and loading functions.

IRIS (The Institute for Research in Information and Scholarship) at Brown University has been engaged in research on hypermedia for more than 20 years. The first system they developed in 1968 is a hypertext editing system. It was used for producing documents relating to the Apollo Project. The current hypertext system is called Intermedia. This system supports both text production and utilization and was developed for use for research and education at the university. Intermedia has a mechanism called a web which enables a user to view only a specific partial network of a hypertext link network like a view definition of a relational database.

Analyst, developed by Vista Lab. of Xerox Special Information Systems is an integrated system that supports a large variety of jobs at a business office both multi-laterally and comprehensively. Analyst was originally developed as a military strategy support tool. It was developed using Smalltalk and has a desktop publishing function, business graph function, spread sheet function, composite document definition function, outline processor function, image editing and formation function, database function, map support function, printing function, linking function, expert system function, etc. A unified user interface is provided for these functions. Analyst supports maps and has functions for automatically producing a map from a geographical database, displaying overlaid geographical information, and automatically relating it with geographical information in a database in addition to magnified and reduced display functions. The spread sheet function of Analyst can display various objects, such as matrices, fractions, images, databases, or charts in cells.

Analyst can systematically store an enormous amount of data in a file called an information center. The information center has a retrieval function. Users can retrieve information by specifying a keyword, a data type, a text string, etc. Associative links can be defined between pieces of information stored in the information center. A user can define a new link type. He/she can automatically form new links or automatically delete old links by giving inference rules for links. A subsystem called Humble provides the expert system function. It is the E-Mycin developed using Smalltalk.

3. Development Trends in Hypermedia

The last chapter was concerned with the R&D history of hypermedia. This chapter is concerned with its future direction. Research on hypermedia is being developed in the following directions.

1. Interface construction tools
2. Document production support tools
3. Information management tools based on associative structures
4. Information organization tools
5. Integration tools for various information and tools
6. Multi-media tools
7. Cooperative work support tools
8. Open platforms

<u>Interface construction tools</u>

There have appeared new attempts to use hypermedia as an interface of an expert system or a database system using its interface constructing ability. This movement, and the standardization trend of user interface construction tools and kits for window systems, will influence each other and promote the development of hypertext or hypermedia tool kits.

Document production support tools

Also, there are new attempts to extend the non-sequential writing support function of hypertext and apply it to concept and planning support. An idea processor and a KJ method support tool are such examples.

Information management tools based on associative structures

By extending the information management function based on the associative structure of hypertext, it will be possible to introduce associative inference and analogical inference functions just as in a semantic network. It is possible to use not a card, but a more fragmentary concept, a phrase, or a statement as the unit of information. Hitachi's concept browser indicates such a research trend.

Information organization tools

Attempts to support an integrated environment for publishing, accumulating and utilizing documents by a global network system and to systematize the information accumulated by users' intelligent activities in this environment, as indicated by Xanadu, can be thought of as applicable to document management within an enterprise or a small research group or even to personal document management. T. Nelson proposed Little Xanadu as a personal document management application. Research in this direction is largely nonexistent at present, but will grow in the future.

Integration tools for various systems

Neptune developed at Tectronics, has an interface based on Smalltalk-80 at the front end, and a hypertext model called Hypertext Abstract Machine (HAM) at the back end. This system has a function for defining an attribute value in a node as a predicate logic expression and obtaining a value by evaluating it. Using this function, a user can set a node value by a database access, and build a node which functions as a database access path into a hypertext network.

This function enables accessing to databases of different attributes on an identical node. As a result, heterogeneous data stored in heterogeneous databases can also be integrated at the view level. Fuji Xerox adopted this idea for document management in EDMICS.

This concept will be developed into hypermedia as the open platform in 8. This will be discussed in the next section.

Multi-media tools

Using multi-media storage media like CD-ROM or laser disk, virtual media can be implemented on a computer display. Information, such as images, voice, and video, is kept in its original state, but can be directly edited by a user by changing the access sequence to these fragmentary pieces of information by programming as if media that can be edited freely existed. Hokkaido University's Transmedia was developed by applying this idea to image text documents. Stanford University and the MIT Media Laboratory have applied it to research on interactive video.

Cooperative work support tool

Research on group-ware for CSCW (Computer-Supported Cooperative Work) has suddenly become active in recent years. Media metaphors are widely used in this field because of the need to intuitively grasp a place of cooperative work. A non-linear structure is often used for information management. Functions like simultaneous access control and version management are necessary for applying hypertext to CSCW. Functions like distributed processing, multi-processing and object management must be implemented as implementation technologies.

A cooperative work support tool is being developed into a networked virtual reality system.

4. Hypermedia as an Open Platform

4.1 Closed Integration and Open Integration

The framework of hypermedia is suitable for integrating various systems. This characteristic is seen in Analyst, for example. Under Analyst, systems must be defined as a node type before they can be integrated, and a system of a new function cannot be introduced. Such integration is called closed integration. In contrast, system integration that allows introduction of a new system is called open integration. Increasing importance is attached to the development of open platforms based on the hypermedia framework because the open system approach in various senses of the word is demanded at present. This trend can be seen in various attempts to extend node and link functions.

4.2 Extension of Node Functions

Hypermedia consists of a set of nodes corresponding to a card configuration, and a set of links that connect different node items. Both node functions and link functions are being extended. The trend to extend node functions is outlined here. An expression using a card configuration is called the adoption of a media metaphor. The progress of the media metaphor is nothing but the history of the node functions in hypermedia systems.

As shown in Figure 2, the history of the media metaphor began in computers with DTP (Desktop Publishing). DTP enabled production and printing of documents in which graphs, tables, drawings, and images are freely laid in text. Languages like PostScript which control printing formats were developed and enabled displaying in a print-out format. This promoted the design philosophy of WYSIWYG. Display PostScript, which describes animation in a print-out format, was developed. As a result, it became possible to embed animation in a composite document and send it by electronic mail.

Various enterprises announced video boards which feature the coexistence of video and other windows on a display screen. There are new attempts to embed voice and video clips in a composite document for use in presentation. This was the beginning of DTPR (Desk Top Presentation).

Then, researchers began to search for a means of integrating elements of different types. This led to an object-oriented system development methodology under which not only various multi-media objects, but also application programs can be handled uniformly as objects. It became possible to embed even

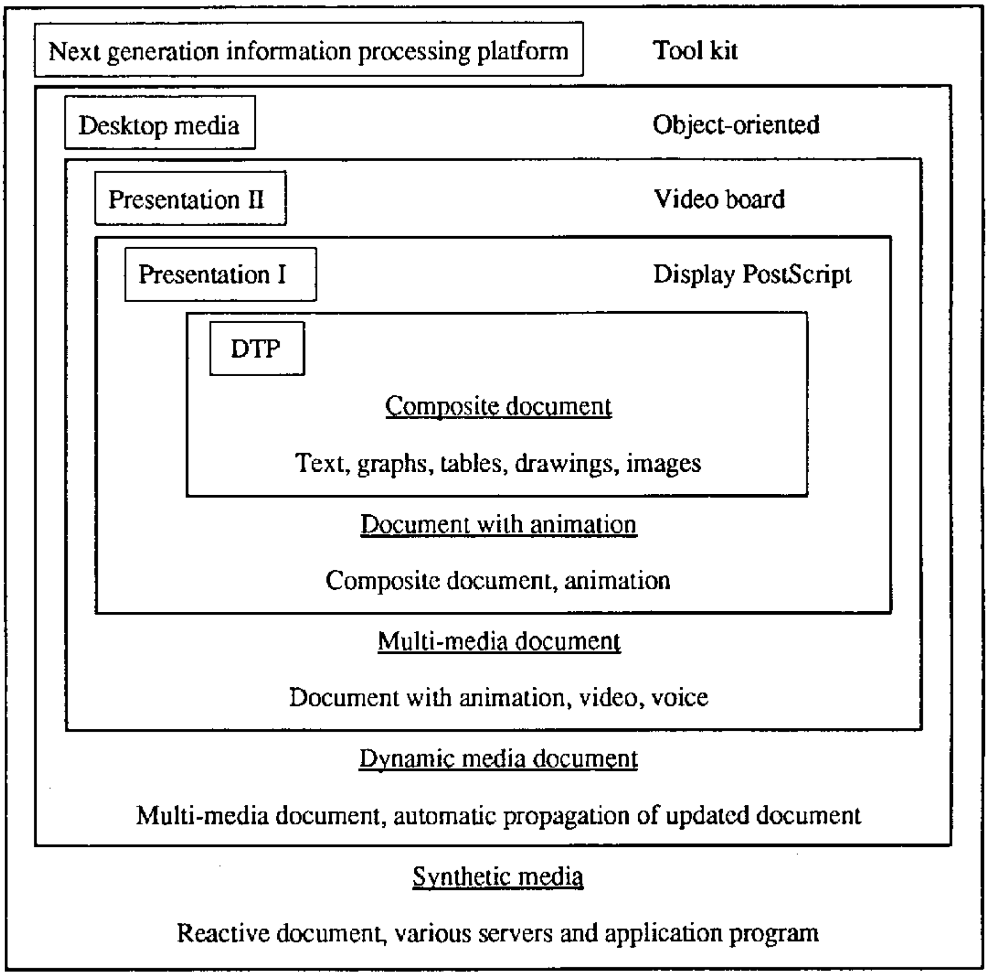

Figure 2 Transition of Media on Computer

programs as elements of a composite document.

Such attempts were developed for general use so that composite documents may have elements that make a status change in response to user operations. Such a composite document is called a reactive document or dynamic media document.

The object-oriented synthetic programming paradigm produced the various GUI tool kits of the windows system in the middle of the 1980s. They include MIT's Xt, CMU's Andrew Toolkit, OPEN LOOK Toolkit and Motif Toolkit. Against this background, attempts to produce dynamic media tool kits were started. This is synthetic media. Hokkaido University's IntelligentPad is an example of this.

4.3 Extension of Link Functions

The functions of links, which are hypermedia structural elements along with nodes, are being extended. Originally, hypertext/hypermedia links were navigation links (search link) that were used for searching related information.

As nodes began to support not only static documents, but also dynamic media documents, updating and propagating functions began to be given to links in addition to the search function. In a system in which links have updating and propagating functions, the following operation takes place. When the state of an object defined as a source anchor is updated, the fact that updating has taken place is reported to the destination anchor. A link having a function for automatically and unconditionally executing updating and propagation is called a hot link, while a link having a function for propagating updated information only when demanded by the destination is called a warm link. A navigation link is called a cold link.

The concept of linking and connecting independently developed application programs is reached by extending the link function to enable message exchange between two objects along a link. Such a mechanism is found in HP's NewWave and SUN's Link Server. An operation linkage link integrates functions by operation linkage.

5. Characteristics of Hypermedia Research in Japan

In Japan, a higher interest is found in multimedia technology than in the integrated architecture called hypermedia. Many of the hypermedia products developed by enterprises are intended for application to OIS, such as drawing management and document management. Multi-media presentation systems are being actively commercialized, but most of them have a simple link function, that is, links that are not regarded as hypermedia. In R&D, research which relates hypermedia with groupware is being conducted at various organizations (NTT, NEC, Hokkaido University, etc.). Research into application of hypermedia to CAI is being conducted as well (Kyushu Institute of Technology, etc.). Multi-media component research that in progress includes a study on video search technology (Hitachi, NTT) and a study on multi-modal I/O (Waseda University, etc.). Some database researchers are engaged in theoretical research on a hypermedia database (Kobe University, Osaka University, etc.). The R&D for IntelligentPad (Hokkaido University) is research on hypermedia as a platform.

As for national projects, metaphor technology and agent technology for human interfaces are being studied under Friend21. However, no special emphasis is being placed on hypermedia. The knowledge archive project proposed by Mr. Yokoi of EDR and the OPERA project of Mr. Matsuoka at Editorial Engineering Laboratory are being proposed. They are expected to bring new perspectives to hypermedia research.

Examples of Hypermedia

(1) IntelligentPad

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1. Introduction

Dr. Naffah of the Bull Co. states that trends in office information processing support technologies since the 1970s can be classified into three generations. The first generation was the 1970s, which was the age of text processing and billing slip processing support. DTP (Desktop Publishing) systems were propagated in the second generation of the 1980s, so this could be described as the age of complex document creation support. He forecasts that the third generation of the 1990s will be an age of integrated support using "hypermedia".

With the use of a hypermedia framework, attempts to find new ways to provide comprehensive support for office information processing have begun. In the hypermedia framework all intellectual resources, including (1) documents, (2) multi-media (such as graphics, images, animated pictures and voice), (3) system service programs (such as data base systems, mail systems and editors and (4) application programs, are handled in an unified manner as media objects (visible objects with a paper image), making integrated management possible. Associative connections and dynamic linkages between media objects can be set up by providing links between media objects. As the nodes of such networks, first generation and second generation tools can be organically linked to other tools and application programs. Users can utilize processing support for all aspects of office information processing in a comprehensive support environment, without being aware of the processing linkages between these aspects. Such an environment is called an "Overall Integrated Environment."

If the hypermedia framework is viewed as an integrated environment, a conventional system is one in which we cannot add new functional modules freely or use them in organic combination with existing modules. Such a system is called a "closed system". In the future, it will be desirable to develop an open overall integrated hypermedia architecture that can be positioned as the next-generation information processing system platform.

In order to materialize an open, overall integrated hypermedia system, it will be necessary to realize: (1) implementation of tool kits for media objects, (2) synthetic programming by assembly of components, (3) standardization and opening of platforms, (4) integrated management of all media objects, and (5) distribution mechanisms for media objects using online and offline media. Furthermore, in order to be able to immediately compose media objects through assembly of components without hindering the thinking process, (6) it will be desirable to be able to decompose and compose media objects using direct operations.

A media architecture that can satisfy all these conditions can be termed a "synthetic media architecture". Items (1) - (3) and (5), (6) will provide new forms of distribution for documents and application programs and will promote the formation of new media markets.

In this paper, I will explain "IntelligentPad", the framework we have developed with the aim of concrete realization of a Synthetic Media Architecture.

2. Overview of IntelligentPad

In IntelligentPad, a media object is called a pad. Links between media objects are defined using special pads called "link pads". A pad is expressed on the display as a window. Multiple pads can be pasted onto a pad. These operations can be directly performed on pads on the screen using a mouse. In this way, layout design can be performed freely, with functional composition of pads occurring simultaneously. A synthesized pad created by pasting pads together can be utilized as a single pad. A display hard copy of IntelligentPad is shown in Figure 1. The buttons, bar meters, pasteboards, and rectangular elements in the figure are all pads. Various tools and documents are created through combination of pasted pads.

In IntelligentPad, a number of basic components are prepared in advance as primitive pads. About 200 kinds of primitive pads have been prepared as of now, and additions can be made as required. Pads created through composition can be registered as re-usable forms. Users can take a shared copy or a non-shared copy out of any pad.

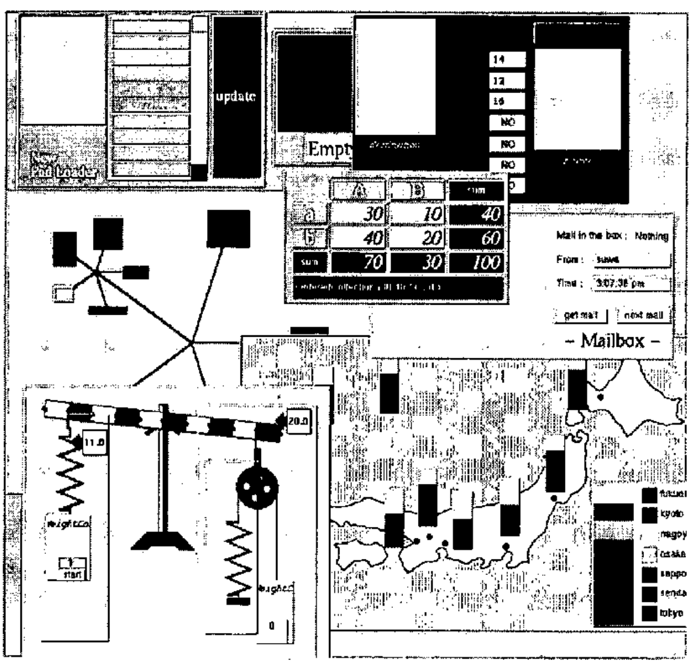

Figure 1 Display Hard Copy of IntelligentPad

3. The Open, Integrated Media Environment of IntelligentPad

Our IntelligentPad research is aimed at realization of a distributed, open, overall integrated platform as a next-generation information processing platform. In this system, information can be stored externally as integrated forms called pads, and pads are stored and accumulated in an object oriented data base called a Pad Base, in which integrated management is performed. Using retrieval functions, we can freely retrieve and excerpt any pads we need. Using mail functions, pads can be transferred to other sites via network. Various types of primitive pads and composite pads can be saved in offline media, distributed to various destinations in the world, or taken into a system and used as required. Retrieved composite pads can be processed by taking away pad components or pasting on other pads. In this way, we can edit documents and tools, and evaluate and utilize them from different viewpoints. Joint work can be done in a shared work environment using a shared copy of a special pad called a "FieldPad". Thus, integrated support can be provided for all actions, including external storage of information, recording, saving, distribution, joint sharing, quoting, and editing.

In IntelligentPad, apart from functional composition through pad pasting, we have already developed "StagePad" for regulation and control of multiple pads. A "Stage Pad" functions as a stage for multiple pads. We have also developed an event-driven script language that gives instructions for pad movement on the stage.

4. Pad Base

We developed our Pad Base using the GemStone object-oriented database management system. While an ordinary database is suited to management of large amounts of data of limited kinds, Pad Base must be able to manage and retrieve small numbers of many kinds of pads with a large total amount of pads. This type of object management requires new management and retrieval methods. Figure 2 shows an example of retrieval by Pad Base. On the left-hand side, part of the pasted structure of a target pad is shown as a retrieval condition. On the right-hand side, results of retrieval are shown as an assembly of composite pads.

5. Collaborative Work Support

Functions that enable joint sharing of the pad utilization environment by multiple workstations are required in order to support collaborative work. Three types of joint sharing are envisioned: model sharing, event sharing, and view sharing. Model sharing means joint sharing in which a shared status copy of the same pad is held by each workstation. Event sharing means joint sharing in which a shared copy of a detection field for a user event for the same object is held by each workstation. When this detection field is expressed as a pad, it is called a FieldPad. The FieldPad plays the role of a worktable. View sharing means joint sharing in which part of a display is shared by multiple workstations. The current system does not have view sharing functions, but realization of such functions will not be difficult.

Any number of any kinds of pads can be put on a FieldPad. When a shared copy of a FieldPad is taken out, the pads piled on that FieldPad are all copied at that time. User operation on any given copy will be applied to all copies. If these copies are distributed to different sites, multiple users will be able to perform collaborative work, sharing the same work environment. There-

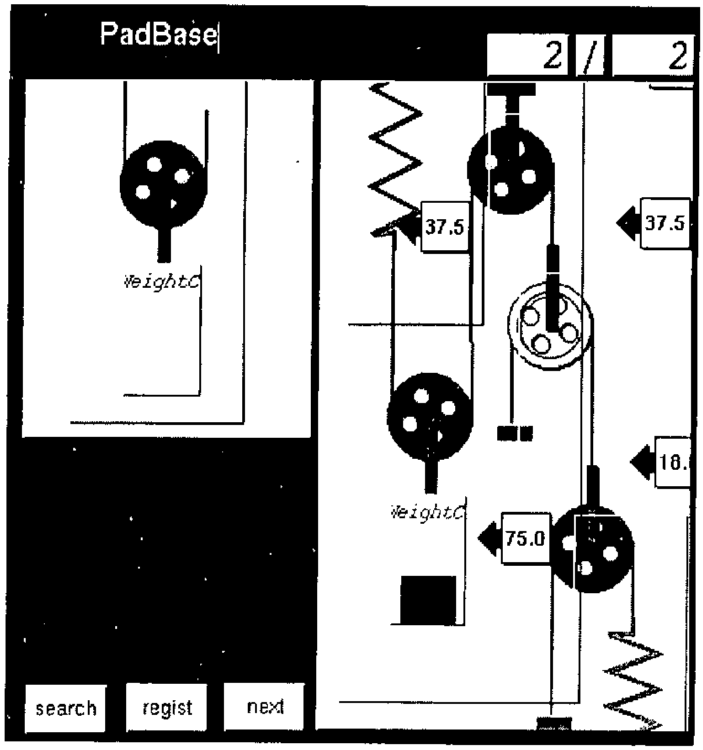

Figure 2 Retrieval Example using Pad Base

fore, any environment that can be defined by pad pasting can be changed into a collaborative work environment shared by multiple users.

Since a FieldPad is also a pad, we can paste one FieldPad onto another FieldPad. In this way, we can define a shared space with a nested structure. In Figure 3, User A and User B share the same space, but User C shares only part of the space with User A and User B.

6. IntelligentPad Realization Mechanism

Each pad of IntelligentPad is defined as a group of three kinds of parameters - M, V, and C. Model (M) specifies pad status and pad behavior. View (V) defines how pads are seen, and controller (C) defines how the pad reacts to user operations.

The model of a pad has a 'frame' structure composed of a list of slots. The slots can only be accessed by one of the following messages: 'set<slot_name><value>' or 'gimme<slot_name>'. Each message will start up the corresponding side of two procedures ($proc_{i,set}$ and $proc_{i,gimme}$) attached to the slot$_n$. The default procedure for procedure $proc_{i,set}$ is to set the parameter value to the slot. The default procedure for $proc_{i,gimme}$ is to return the slot value. The slot list and attached procedures define the internal mechanisms of the pad.

If a Pad P_2 is pasted onto another Pad P_1, an update transmission path for P_1 to P_2 will be created, and a message transmission path from P_2 to P_1 will be created. P_2 is called a sub-pad of P_1, and P_1 is called the master pad of P_2. If P_1 has more than one slot, one must select the slot to which P_2 should be connected. This selection is made by following a menu selection method, in which the user opens a window

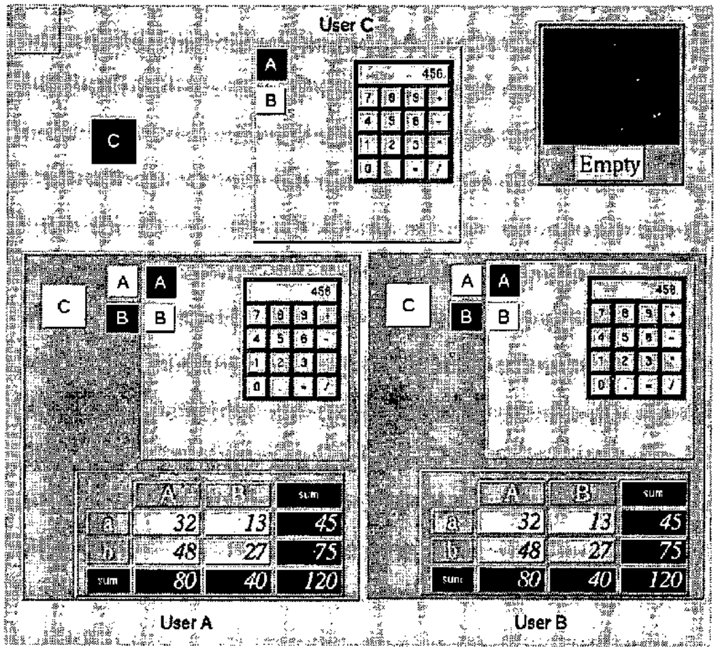

Figure 3 Nesting Structure of Shared Space

called a "connection sheet." The selected slot name is called the connect slot of the sub-pad, and is retained in a standard slot. A sub-pad can send a message of "set↑*connectslot*<value>" or "gimme↑*connectslot*" to the master pad. On the other hand, the master pad will send an update message to all its sub-pads if its own status changes. The upward direction arrow mark prior to "*connectslot*" means that the slot name retained in the "connectslot" will be sent as an actual argument. The programming of a sub-pad does not require prior knowledge about the master pad. IntelligentPad can independently enable or disable each of the three kinds of messages by indicating instructions on the connection sheet.

Besides these three kinds of standard messages, each pad can receive several standard geometrical messages that have already been provided. These include messages for move, copy, delete, hide, display, open, close, resize, paste, etc.

7. Example of an Application Pad

Figure 4 shows an example of a CAI System for Dynamics developed using IntelligentPad. This system is the materialization of a microworld as an educational tool for study of dynamics. A number of basic components have been provided as a construction kit. Students can define a complex pulley system by combining these components, and can observe changes in tensile force at each location by changing the deadweights. At a glance, the components may look like pulleys and springs tied together with ropes. However, these components are actually animations displayed on transparent pads. If a spring animation pad is pasted on a pulley animation pad, this is actually the connection of two component animations.

Figure 5 shows an example of synthetic construction of pads into a tool to analyze sound fields created by sound sources and obstacles

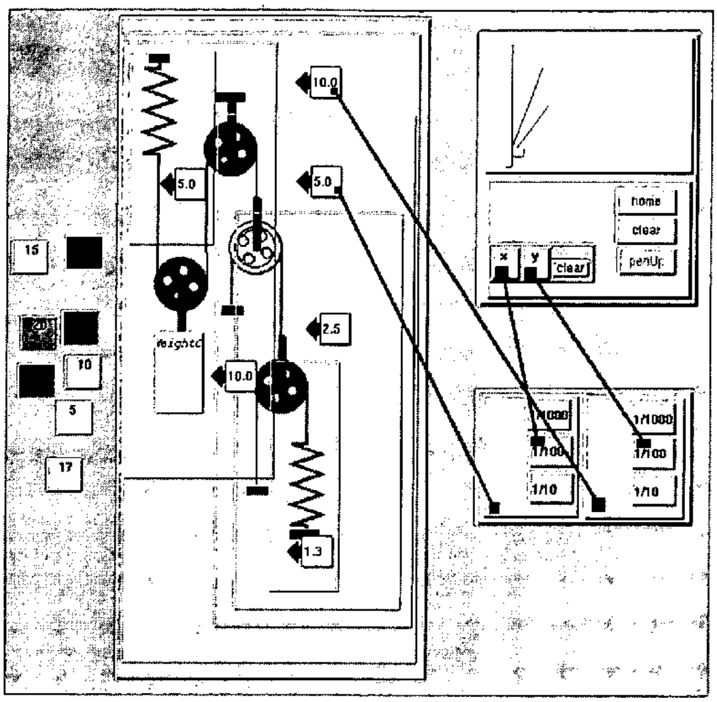

Figure 4 CAI System for Dynamics

using the Boundary Element Method. In the figure, the BEM Pad is what performs calculation using the Boundary Element Method. However, the actual calculation is done by separate high-performance computer. This pad acts as a proxy for the external object on the high-performance computer that actually performs the calculations. Using such proxy pads, various external objects can be represented as pads, and their functions can be integrated by pasting those pads together.

8. Conclusion

IntelligentPad is a media system that can perform three roles that media perform on information for all documents and tools - functional attachment, standard interface supply, and integration. With IntelligentPad editing is not only used to integrate information; it is also used to integrate functions. In this sense, IntelligentPad is a system that is an embodiment of synthetic media architecture. Handling of information and programs by putting them on media called pads will facilitate exchange, processing, control, and retrieval and will have the effect of promoting distribution.

The IntelligentPad Project was started at the end of 1986. So far, the fundamental architecture has been established, and system development has been pursued using Smalltalk. At present, research is under way regarding the index structure for the Pad Base, the development of a hypermedia system that also uses pads for links, and development of a "Concurrent IntelligentPad" that can perform concurrent operation of pads.

IntelligentPad has been developed using Smalltalk, but development of versions using C++ and standard GUI system aiming at open

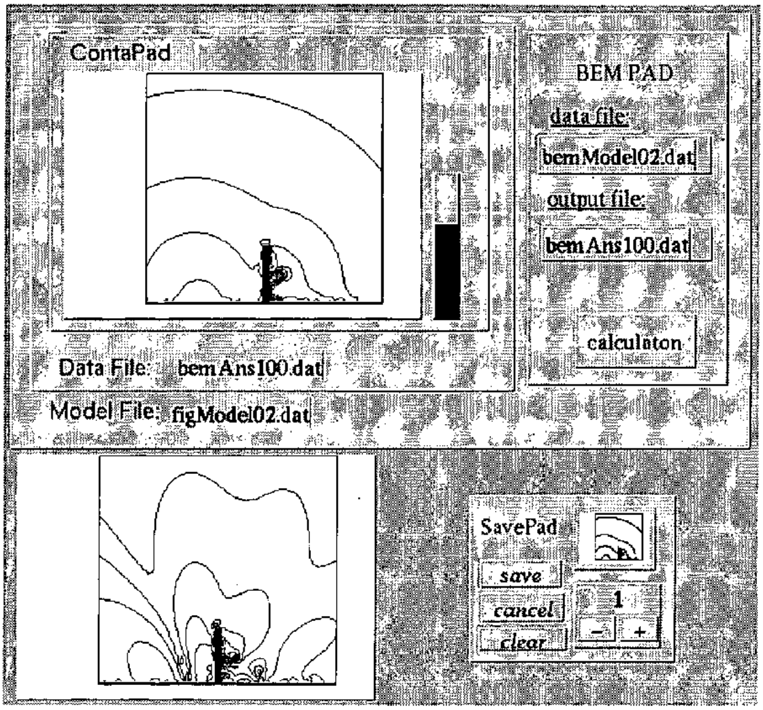

Figure 5 Analysis of Sound Field using Boundary Element Method

architecture of platforms is also in progress. Fujitsu, Hitachi Software Engineering, and other companies are participants in this project.

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Examples of Hypermedia

(2) EDMICS (Engineering Drawing Management and Information Control System)

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1. Background to Development

In today's manufacturing industry, "drawing" information serves as the know-how which forms the basis for enterprise activities. Drawings play an important role in many phases of engineering-related enterprise activities in the manufacturing industry. For example, drawings may be combined with performance information for marketing activities, with material and shape information for manufacturing activities, with cost and vendor information for material purchasing activities, with family tree information for stock management activities, or with shape information for maintenance activities. The effective utilization of drawings is truly essential for the success of an enterprise's activities. However, most conventional systems for managing drawings have had various problems, such as: ① Drawings could not be managed centrally since the original drawings were in a variety of different forms, such as manually drawn drawings, CAD drawings (drawings electronically stored in a CAD system), microfilm drawings, and optical file drawings. As a result, drawings have been difficult to store and retrieve. ② In many cases the drawings themselves and the related attribute data (information related to the drawings) have been managed separately, resulting in inconsistencies between drawings and attribute data when design changes are made. ③ Although drawings have been stored in the form of microfilm, electronic files or optical files, they have not been stored in systems that can function as databases that can be easily accessed by the departments that need the drawings, such as the manufacturing and purchasing departments. ④ Improvements in drawing-related operations have not kept up with the rationalization of design operations. EDMICS was developed in order to solve these problems through "unification of applications and functions".

2. System Concept

The basic system concepts adopted for development of EDMICS are as follows.

1) Integrate drawing information with other engineering information databases.

Drawing information (Manually drawn

drawings, CAD drawings, microfilms, optical files)
Drawing attribute information
Information about relationships between drawings (Family trees)
Catalog information, patent information, simple texts, engineering document information, modification history information

2) Centrally manage multi-media information and integrate its processing.

Synchronously manage drawings and related information en bloc.
View and handle drawings and related information as one unit.
Make user knowledge about the storage media unnecessary.

3) Utilize multiple database technology.

Improve the synchronous manageability, maintainability and reliability of information.

4) Adopt an object-oriented GUI.

Adopt a desktop environment and the icon method.
- Select processing objects, and use standardized instructions for selected objects.
- Adopt a modeless system to eliminate the burden of changing modes for each function.
- Be able to run other makers' software in the same environment.

Adopt the WYSIWYG (What You See Is What You Get) approach.
- Make it possible to operate the system through simple inferences based on an understanding of basic principles without having to know many functions.
- Enable users to operate the system easily even without any professional computer or word processing skills.

5) Distribute processing by the use of general-purpose workstations, servers, and LAN.

Adopt the open system approach and open architecture.
- UNIX, C, TCP/IP, RPC

Adopt industry standards and de facto mechanisms. Build a system made up of modules.
- CCITT/G4 (MMR), Indexed-RLC, JIS/ANSI, general-purpose RDBMS

3. Outline of System and Configuration of SW Modules

Figure 1 shows the relations between the open desktop environment software (ED-Desktop) and the multiple database management software (ED-Manager) that were adopted to implement the distributed database control functions of EDMICS and gives an overview of their functions. The following is a functional classification of the component software of EDMICS.

- Open desktop environment
  ED-Desktop

- Multiple database management
  ED-Manager, ED-Tree
  RDMS (Relational Data Management Service)
  OFMS (Optical Filing Management Serv-

ice)
RMMS (Removable Media Management Service)
RDMS/Batch Registration

- Drawing input:
ED-Scan, ED-Scan12, ED-ScanM

- Drawing editing: ED-Draw, ED-Shell

- Technical document editing:
ED-Doc,
ED-Doc(PCL)

- Drawing output: Plotting Service

- Inter-network communications: ED-Mail, ED-XNS

- Data conversion:
Vector Conversion (ILD, IGES, XIDS, DXF, BMI), Raster Conversion (Calcomp, HPGL, VPlot9, ILD), Format Conversion (Calcomp, HPGL, Postscript), Data Conversion (For E.D.I.S.)

- Other: ED-Fax, ED-Storage, Device Driver/ Library, Installation Software

4. Multiple Data Processing and Distributed Database Management

Multiple data, which are the units of processing in EDMICS multiple data processing, consist of raster data (image information mainly read by scanner or micro film reader), vector data (mainly CAD digital data), and text data (various kinds of attribute data related to drawings).

EDMICS hierarchically manages multiple data, the units of processing, as layers of raster data and vector data. It manages the attribute data for

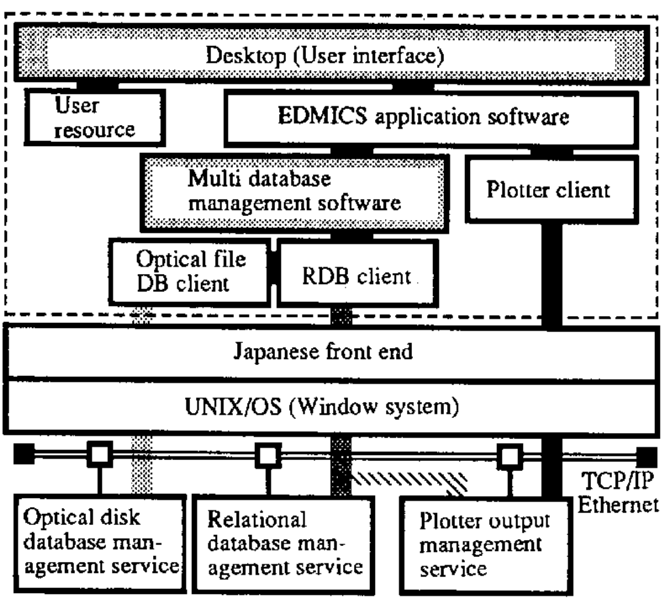

Figure 1 Configuration of Software Modules

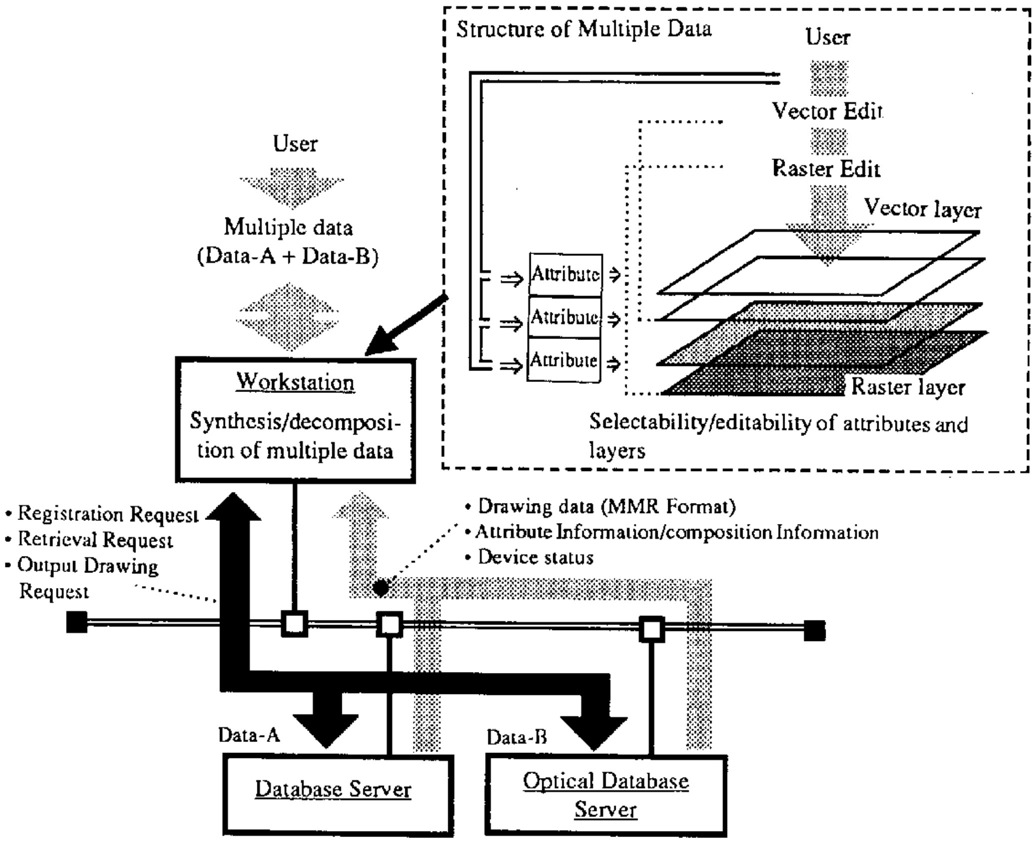

Figure 2 Decomposition and Synthesis of Raster, Vector and Text Data

each layer simultaneously. By inputting multiple data into the system, users can take out, decompose and synthesize multiple data at any time from various viewpoints without having to be aware of the form in which the data are stored or the storage location (See Figure 2).

Figure 3 shows the flow of multiple data in EDMICS and the EDMICS concept of distributed database management. It also shows the typical view points that the multiple data provide for the users. As the illustration shows, a conceptual distributed database termed a cabinet/drawer is provided as the view form in which the data is made visible to the users. There is no need for the user to be conscious of how the cabinet and drawers manage and integrate the multiple data.

5. Concrete Examples of Multiple Data Processing

1) Viewing drawings in a database

A list of all the drawings in a database can be referred to through a window called a "Drawer", which is an expression of the database in conceptual form. (This is called drawing list viewing.) When any drawing icon from this list is

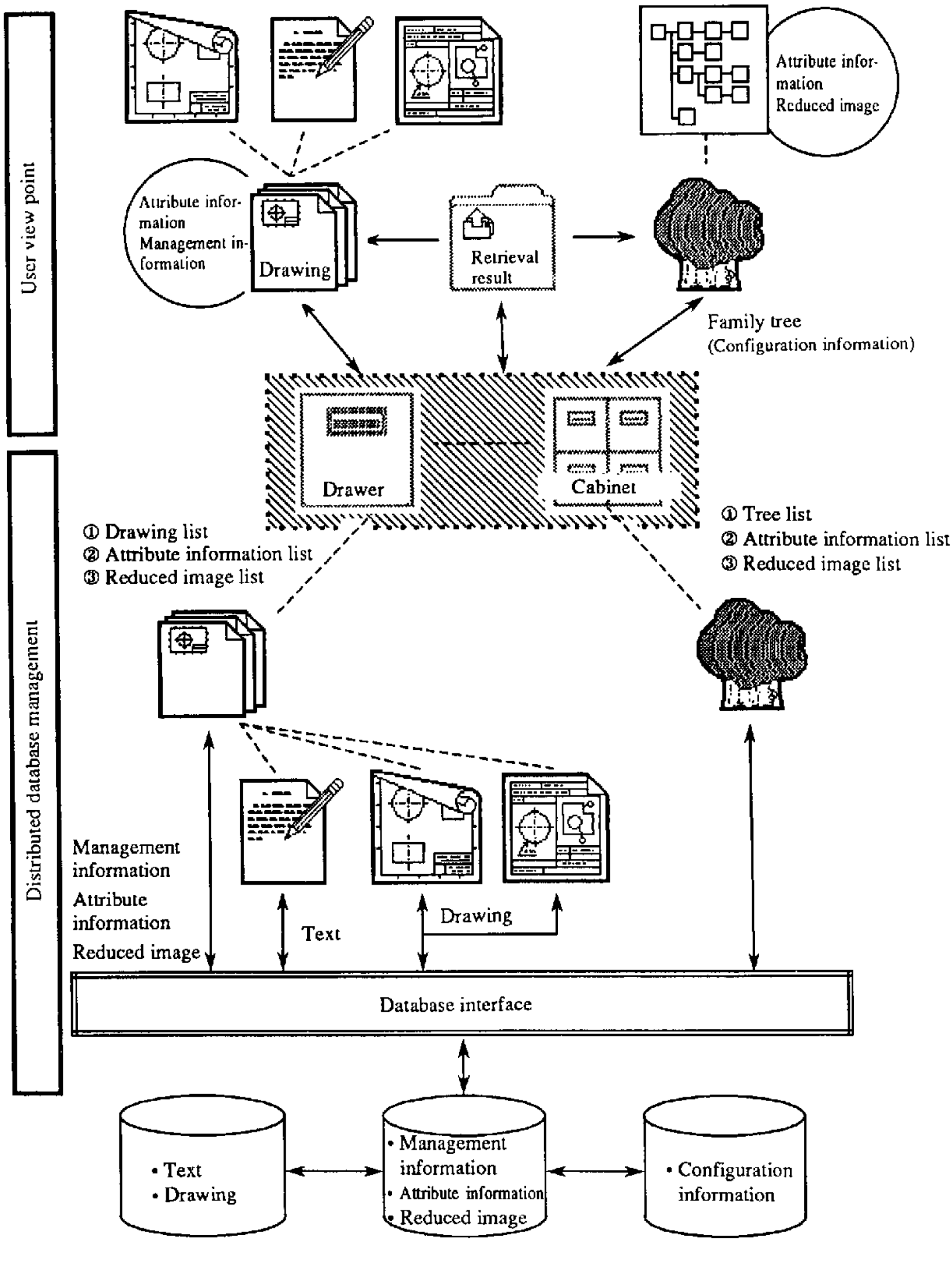

Figure 3 Flow of Multiple Data and Concept of Distributed Database Management

copied to the desktop outside the window, this means that all the link data information (linked object) that is managed as part of the multiple data is collected from the distributed database on the network and offered to the user as a restored multiple data set on the desktop. (This is called viewing by hyper information restoration.)

There is another method by which a user can refer to drawings in the database. This is the method of referring to drawings by displaying reduced images, possessed by the drawings themselves as one linked object. As shown in Figure 4, since the reduced image window of a drawing is displayed by selecting a drawing icon on the drawer window (or the retrieval result window or tree window explained later), the appearance of objects can be viewed at high speed. (This is called viewing of linked objects of hyper information.)

2) Viewing data from drawing relationships

One of the drawing management methods of EDMICS is to manage the drawings that constitute a specific assembly by using the parent-child relationships known as a "Family Tree". (Because of its effectiveness, this data management method will be adopted not only for drawings, but also for ordinary documents.)

Each drawing that is a component of a family

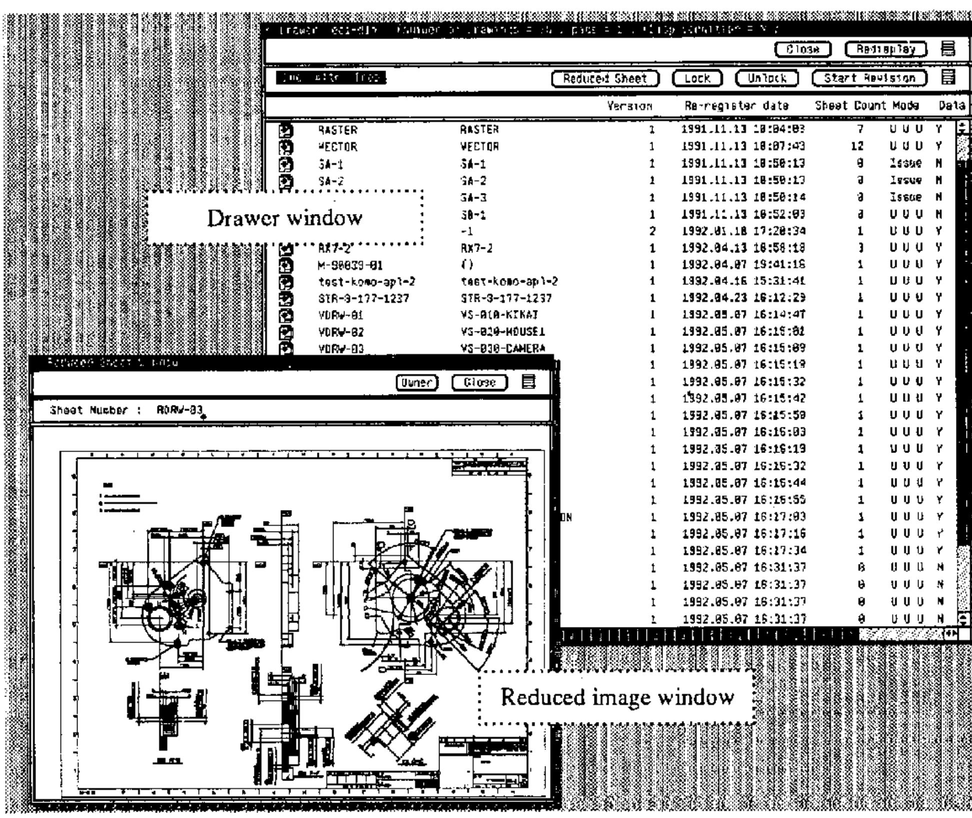

Figure 4 Reduced Image Window

tree includes location information about its parent drawing and child drawings. (The exceptions are the highest node of a tree, which is called a root node and has no parent, and the terminal nodes of a tree, which are called tail nodes and have no children.) This means that the family tree can be constructed merely by describing the child location information as the configuration information for each drawing. This system offers a means for referring to the contents of a database based on the drawing configuration information managed in the database. (This is called viewing based on drawing relationships.)

Figure 5 shows how a tree icon taken out of the cabinet and placed on the desktop is opened to visually display the family tree structure. Since a family tree is one of the means used for database viewing, it is possible to view the various hyper data of a node dynamically or to add or change node relations or attribute information.

3) Viewing data as hyperdocuments

EDMICS supports viewing data from documents produced by synthesizing hyper information managed in the distributed databases of the system or by synthesizing multiple views which are used for referring to information in external files and general purpose databases. (Hereafter, these are referred to as "hyperdocuments".)

A document consists of a combination of database interface views (called a BOX). Since a box is an object itself, it includes information about the box and the types and locations of the information that should be displayed on the box. The contents of a box can be viewed by synthesizing the hyperdata and dynamically accessing information from various databases at the same time. Since the user can access a box interactively, he or she can perform word processing and editing of the viewed information (raster, vector, text) in the box (See Figure 6).

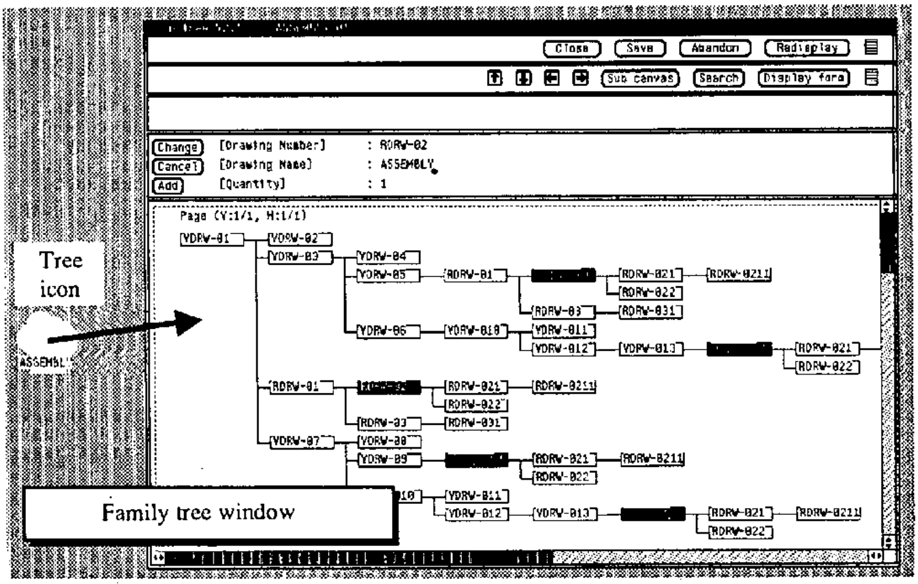

Figure 5 Tree Window

Synthesis of multiple data as hyperdocument

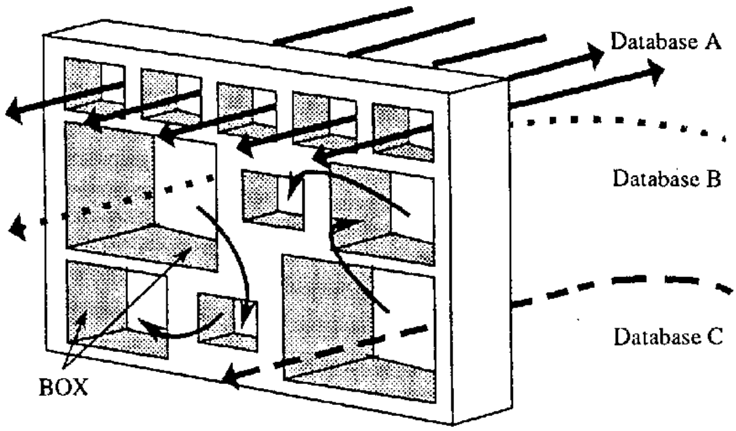

Figure 6 Database Linkage

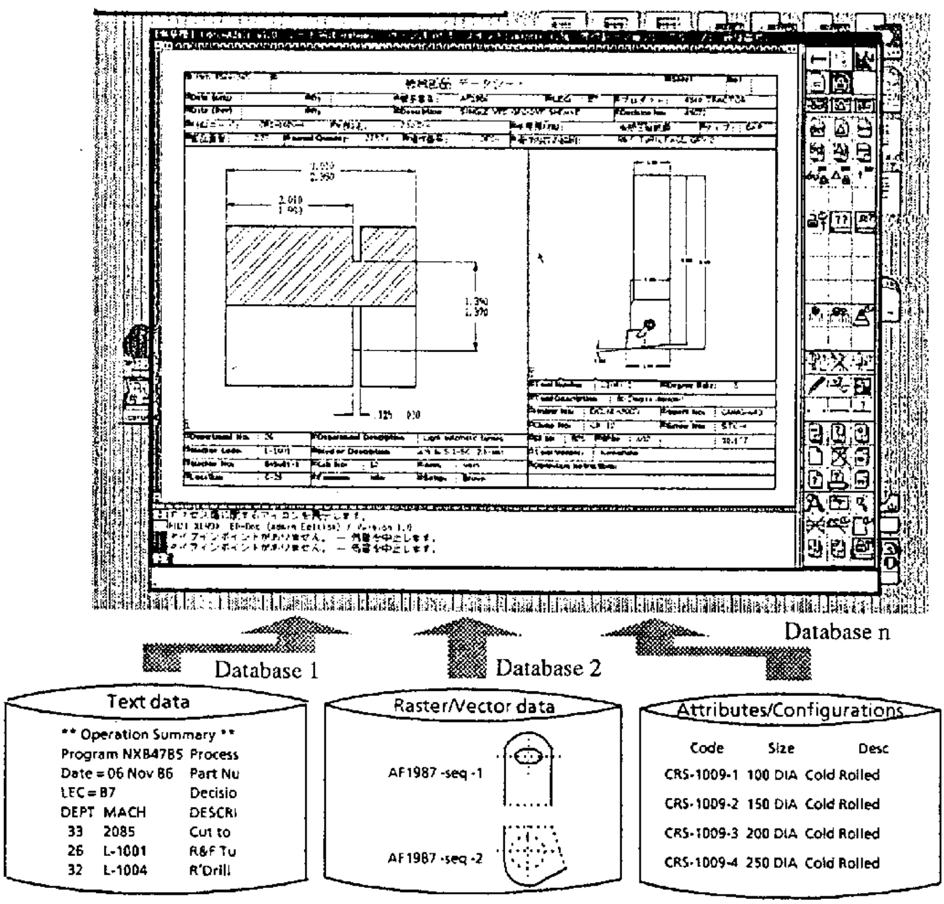

Figure 7 Synthesis of Multiple Databases through Use of Hyperdocuments

These functions make it possible to produce various engineering documents (such as maintenance manuals, assembly instructions and order instructions) based on hyper information managed in the system as well as on information in general-purpose databases outside the system.

When a box holds a large amount of information to be viewed, that data will be displayed only partially, but the complete data set is maintained outside the box at all times. Such a document can of course be loaded into or extracted from an EDMICS distributed database. This means that a completely new database world can be constructed on a document by synthesizing information from various databases into a single planar view (See Figure 7).

6. Summary

The EDMICS system consists of an environment for user operations (such as drawing input, production, editing, management, retrieval and extraction), a large capacity database server, a large capacity optical disk server and a plotting server. A number of stations and servers can exist on the same network.

Each of the functions in the user operation environment and each of the server functions are offered as independent software component modules. A number of component modules can be integrated on one workstation according to the requirements of the user application. Since the individual component modules are not dependent on the processor, any type of system can be constructed on a general-purpose EWS in accordance with the user application and its size. Therefore, EDMICS should be regarded not as a complete, ready-made product, but as an integration tool that can be used for implemention of flexible systems that suit the user application.

New Trends in Hypermedia

(1) Narrative Archetypes and Hypermedia How Have We Acquired Narrativity?

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Editorial Engineering Laboratory

Hypermedia is actually something that is inherently concealed within the human brain. Therefore, in the process of daily information processing, hypermedia-like thinking and communications are being performed all the time. It will be very important to observe the design of this closely and examine its mechanisms in order to develop new next-generation hypermedia and approach the secrets that lie behind our own thinking and communications.

The hypermedia-like mechanisms of our daily thinking and communications often use "narrativity." When we think about ourselves, when we recall the comings and goings of a town that we know, or when we write a business report or prepare a development plan, we utilize a type of narrative. I would like to propose that this type of narrative be applied to hypermedia. I would like to briefly introduce the philosophy in the background to the project called "The Opera Project" to provide a perspective on hypermedia in the future.

In many instances in our daily lives, we memorize and reproduce sequences of events by applying scenes to a certain plot and script, and build the scenery of spots based on units of scenes and the characteristics of speech and conduct of the characters involved. In other words, the information world is set up like a theater in which a kind of story is performed. Many complexly interwoven pieces of information are accurately edited while the particulars of scene development and character speech and action are quickly selected and carried out. Hypermedia features lie concealed in the narrative theater within the brain.

In the past, information was stored in an animistic form within the memory of the storyteller. The person of the storyteller was the information medium, and also the data base itself. These people knew the framework for storing information. By and by, writing and paper were invented. Stories as modes of information retention were conceived and compiled for the purpose of communicating information to laymen who did not have the special skills of a storyteller. Leon Cooper at Brown University, one of the AI connectionists, once said that "memory is the same as logic," but this was completely wrong. Memory has the hypermedia-like structure of a story.

Stories originally started in the beginning of the history of human information culture. Also, history started with the narrative. 'History' (histor, historia) has the meaning of "storytelling" in its etymology. However, the most important factor in the history of every people is that standards for information communication techniques, including human linguistic activity, were in reality developed and strongly promoted by stories. Stories have been hypermedia since ancient times.

For example, the standardization of the French language started with "The Romance of the Rose" and 'The Romance of the Fox," that of English started with the "Arthurian Legends" and "The Canterbury Tales," while that of Italian from the Florentine dialect began with "The Divine Comedy." In Japan, the standardization of Japanese started with "The Tale of the Heike" and the "Taiheiki." The standardization of languages was achieved only through the editing process. Whether in the East or the West, it was around the 11th century when the completion of the "narrative" as a mode for world history could be seen.

This birth of these kinds of tales can be likened to the human growth process. By around age 3, many children are able to narrate the day's events in chronological sequence, describing characters and scenes separately. There must be a sort of "narrative circuit" prototype in the human brain. After that, children come to describe a variety of information based on this form. Whether the description is a narrative or not can be confirmed particularly by coda (narrative conclusion words). A coda is the concluding remark for a narrative such as "... Then, they all lived happily ever after." or "And, they all graduated from the school."

Later on, children increase their number of narrative patterns through education and reading. They select only those patterns that suit them out of the patterns they encounter, and they become accustomed to using those patterns. Generally speaking, when the process of information editing seen in the diaries and conversation of adolescents is examined, it is found that they tend to use no more than one or two selected narrative patterns. However, we should be able to make use of more varied narrative patterns and enjoy information editing with greater freedom. We must utilize our "internal hypermedia" to a greater extent.

The action of reading narratives does not necessarily evolve only through literary texts. We can "read" narratives in a picture book, comic book, animation, movie, etc. Also, as in many ancient European and medieval architecture as well as medieval and modern gardens in Asia, interpretation of narratives has been frequently used in the art of architecture and gardening. Narrative as hypermedia is something that has been developed since early times just like "multimedia."

In this way, the widespread application of the narrative has developed due to the fact that narratives have mother types, and people have used these mother types as frameworks for information transmission.

For example, Dante's "The Divine Comedy" based its narrative framework on Vergil's "Aeneid." And, Vergil used many Greek myths as his mother types. Goethe's "Faust" used a number of medieval faust legends as its base, and the medieval legends are said to go back and employ "the Book of Job" of the Old Testament as a mother type.

The existence of this kind of "structure to produce a narrative based on a narrative," or "hyperlink between narrative knowledge" can be proven in a great number of cases. Moreover, if it is a very simple narrative, many people can tell which narratives resemble that narrative. More than 800 versions of the so-called Cinderella story have been collected around world. Once people know the Cinderella story, they can recognize that any of the versions has the same mother type when they hear it.

Now, the narrative has several remarkable features. That is, the structures that make up a narrative as a narrative have unique characteristics. By analyzing and grasping the characteristics of this narrative structure, we can surely gain a new perspective on hypermedia.

First of all, the narrative has a "world model." The world model is comparable to the "World Stage" in the time of Shakespeare and the "sekai = world" of Kabuki established in the Edo Period. This represents a common structure for the stage of a narrative. It is a macroscopic rule that restricts the world of a narrative. A narrative as a narrative is supported by this world model. This kind of world model is definitely lacking in the hypermedia appearing on the market today.

Secondly, a narrative has an archetype or a prototype. A tragedy has its own archetype or prototype; so does a love story; so does the success story of a businessman. Based on my own research and that of the Editorial Engineering Lab, we have concluded that are no more than 20 to 30 such prototypes. From several scores of prototypes, we have been able to extract several kinds of narrative archetypes. These are the "mother types."

Thirdly, a narrative always has four elements. These are a story or plot, scenes, characters, and narration by a narrator.

The story or plot is comparable to the "mythos" of Aristotle. It creates a narrative trajectory. The scenes strongly lend character to the narrative. As in picture books for children, a narrative can be edited into 10 scenes if it is compressed. However, for the people who enter into the narrative, mutual conprehensibility between scenes is important. The hypermedia software available today has been developed with sufficient recognition given to this. There is no particular necessity to explain the characters that move around in a narrative. However, it is here that the conspicuous characteristics of the characters, the network showing the mutual relationships between the characters, and the messages spoken by the characters are controlled.

Narrations that import an interactive atmosphere to a narrative have several narrator eyes, the viewpoints of which have either editorial omniscience, neutral omniscience, or multiple selective omniscience. These viewpoints are not created based on the actual experience of the people related to the narrative, but are established by integration of the viewpoints of the many narrators that have created the narrative structure. However, upon further investigation, it is found that the viewpoint of an omnipresent narrator and that of an omniscient narrator are best, when it is necessary to process a lot of narrative information evenly.

Fourth, narratives have a characteristic which I call the "self-editing system." The self-editing system is a mechanism to develop information in a narrative fashion, which is generally called a "narrative grammar." At present, the system software industry is seeking "self-awareness" and "self-management" in systems, but a narrative can completely cover these aspects through the self-editing system.

Fifth, a narrative itself constitutes a wonderful museum of knowledge. The myths of various peoples, the "Bible," "The Divine Comedy," and "Faust" have played the role of encyclopedias all by themselves. Encyclopedias were independently developed after that. However, real knowledge can be alive in a more resonant fashion if the knowledge is included in a narrative. In future hypermedia, which will enable knowledge to be utilized in an electronic system, I believe it is extremely important that the hypermedia have a narrative knowledge structure similar to the "Bible" or "The Divine Comedy" of the past.

Sixth, there are a variety of tools available for narratives. Maps, chronological tables, and genealogical tables are typical examples, for instance. Furthermore, there are illustrations and explanatory diagrams that evoke the visuality of narratives. There are tools that make narratives more hypermedia-like.

In the past, there was a field of study called "narratology" which focused on the structure of such narratives. This started with the study of old tales by Vladimir Propp, as well as with the linguistic theories of Roman Jacobson, and was succeeded by the study of narratives by structuralists Lévi Strauss and Roland Barthes. Their study of narratives examined narratives as existing at the roots of human cultural activities, and thus paved the way for narratology. In their studies, they tried to research the models of narratives, the grammar of narratives, the role of narrators, and the study of narrative time. However, once a certain level of results were achieved, narratology became stranded without showing any new achievements. This was because they only emphasized intrinsic, cultural value and could not find means for the utilization of other areas such as a mathematical, structural, and technical methods.

There have been several primitive studies in the area of electronic/technological approaches to narratives, starting with the attempts of Roger Schank and Robert Abelson. However, those attempts were not based on the premise of a narrative structure common to all mankind. They were merely attempts to add slight narrative elements to programs.

However, we have discovered that narratives and narrative mechanisms not only possess an important key to the process of information editing to supplement the instability of description by the human brain, but also that they will be a key to integrating new multimedia-like and hypermedia-like information culture technologies. A narrative is by nature a system that has a "work-flow language" and a "seamless user interface." Also, narrative itself has been the most important key to connecting "cultural technology" and "semantic technology." We have decided that the intrinsic elucidation of the narrative itself is the best method for reaching a revolutionary new paradigm.

In line with this rationale, "The OPERA Project"* was conceived as a "Narrative Navigator" to be used as an information composition support device derived from the structural features of the narrative. A "Narrative Captabase" is to be used as a large-scale knowledge base equipped with the world's universal narrative models.

* The OPERA Project has been initiated & directed by Seigo Matsuoka since 1992.

New Trends in Hypermedia

(2) Media and Very Large-scale Knowledge Base for the Knowledge Archives Project

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1. Media for Representing Knowledge

A shift is taking place in the kinds of media used to represent information on computers, from computer media such as programming languages and database languages to human media such as natural languages, formal languages, picture languages, images and sounds. This is the basis for the appeal of multimedia technologies, which are appreciated in terms of their knowledge and knowledge processing technologies. Needless to say, what is referred to here by the word "media" is not media and media uses for sensory purposes, it is rather media and media uses designed for the accurate representation, conveyance and accumulation of information.

So far, the aim of artificial intelligence research has been to realize black box-like intelligent systems, with painstaking efforts expended on ways to represent knowledge and give it to computers. Such research has currently become stalled at a point far from reaching its target. A wide variety of different efforts are now being made toward a fundamental reshaping of strategy. These efforts have started, as usual, with the pursuit of "key words", such as "logic", "fuzzy", "neuro" and "chaos". The pursuit of key words can certainly be a useful means, but a more definitive approach can be taken to this strategic reshaping. This is the viewpoint that focuses on "media and the very large-scale knowledge base". The three principal points to note about this approach are as follows:

① No progress will be made through leisurely philosophical discussion about intelligence in general. The approach that is needed is to close in on intelligence step by step, moving from objective observation to analysis, and then to experimentation. Media, media usage methods, and the information and knowledge represented by media are the tools which will make this approach viable.

② Knowledge is not expressed so as to be understood by computers. It is expressed so as to be understood by the humans who handle the computers. Knowledge must be understood by computers in part. However, this understanding is sufficient if it can function to support human understanding properly. The knowledge representation media used for human understanding include all the human media accumulated by human beings over their long history.

③ Humans expand and advance the sphere of human intellectual activity by using computers as a tool to reliably and rapidly process simple knowledge in large volumes. This division of roles between computers and humans is essential and will not change in the future. Computers cannot provide a high level of convenience by handling small amounts of knowledge in a somewhat more complex way. The utilization of a very large-scale accumulation of knowledge or massive quantities of information is indispensable to making computers realize their full potential. And since humanity has thus far represented and accumulated huge amounts of knowledge by use of "human media", the human being can express knowledge efficiently only by using human media.

A plan for a "Knowledge Archives Project" to solidify the viewpoint of "media and the very large-scale knowledge base" in tangible form has been proposed, and is now being carried forward. The main points of the project are described below.

2. Knowledge Archives – A Very Large-scale Knowledge Base to Serve as a Knowledge Foundation

A very large-scale knowledge base that forms a knowledge foundation has been given the name "Knowledge Archives", and will be the overriding common theme in the next generation of knowledge processing. It is called a "Knowledge Archive" because its aim is the archiving of knowledge.

The Knowledge Archives will be materialized through the research and development of the following technologies: technology for the automation (support) of the acquisition and collection of vast amounts of knowledge, technology for the self-organization of knowledge bases so that substantial amounts of knowledge can be stored systematically, technology which supports (automates) the creation of new knowledge by searching vast amounts of existing knowledge for necessary knowledge or technology which supports (automates) the development of appropriate and applicable knowledge bases which fulfil the needs of a variety of knowledge usages, and technology for the translation and transmission of knowledge to promote the interchange and common use of knowledge. In addition, the development of a basic knowledge base which can be shared by all these technologies will be necessary.

These technologies are all new knowledge processing technologies that are directly related to the knowledge itself. Until now, knowledge processing has only been concerned with knowledge processing devices, as in the research and development of computers and programming languages. The development of a Knowledge Archives will radically shift the perspective of knowledge processing to carrying out the research and development of new and high level technologies from the standpoint of knowledge itself.

Therefore, the Knowledge Archives is not merely a container for massive quantities of information, as in ordinary knowledge base (management) systems. Nor is it simply an electronic library for a massive accumulation of information. Of course, in the research and development of these new technologies, it will be necessary to tackle issues such as the improvement of knowledge containers and the collection of substantial amounts of knowledge and data in relevant fields.

Technology from the standpoint of the knowledge itself transcends the boundaries of knowledge processing, encompassing technologies related to knowledge, information and software. Natural language processing (especially text processing), knowledge engineering technology, multimedia (especially hypermedia), next generation databases (especially deductive databases and object oriented databases), and software engineering (especially specification description and reuse) will be used as the basis upon which the technologies for knowledge itself will be formulated.

The importance of this is that by intermingling within the larger framework of the knowledge technologies, work in each of the conventional technologies will uncover opportunities for new developments and breakthroughs. So far, the research and development of these technologies has often been carried out with little mutual interaction, or with rejection of mutual exchange in some cases. In consequence, though these technologies have yielded their own outstanding results, they also possess shortcomings which could have been overcome through mutual technological exchange.

The approach from the knowledge side is to approach everything from the viewpoint of the computer user. This means examining the fundamental question of what benefits computers are supposed to provide to humans. By observing their processing power, price, memory capacity and data transmission capacity alone, one can easily see that computers should be able to do a great deal for us. The efforts of the computer industry should guarantee growth in these basic computer capabilities at least over the next ten years. In terms of their hardware and software, computers have now reached a point of substantial maturity. This in turn means that the time has come when we can and must look at computers from a more user friendly perspective. That is, the time has come to demand true affluence and comfort from computerization.

Drastic measures must be taken in order to re-evaluate computers from the standpoint of the user. Simply improving the human interfaces to make them easier to use is no longer enough. After understanding the true nature of information, knowledge and their essential mechanisms, we must attempt to develop new technologies. Close joint research and cooperation with those who have long handled information and knowledge in the forefront of the humanities, social sciences, the media industry, and other fields, will be essential to this effort.

In more concrete terms the re-evaluation of computers from the human side means to re-evaluate computers from the application side. It is not enough to line up a number of individual applications. What is needed is to find a way to create a general framework that can define them all. The Knowledge Archives can be said to be the most universal application systems in this sense. The Knowledge Archives is also the most universal expert system as seen from the viewpoint of expert systems, which have received so much attention in recent years.

Therefore, it is meaningless to ask such questions as "What are the applications of the Knowledge Archives?" or "What are the uses of the Knowledge Archives?" That is because the Knowledge Archives is in and of itself an application — the realization of fundamental functions that have always been sought. In striving for the realization of the Knowledge Archives, computers can finally display the potential to grow to the point of serving solely as a tool.

One of the most important functions the Knowledge Archives is expected to perform from the beginning is to serve as a common basis of knowledge for international and interdisciplinary exchanges in research and technology. The research and development process for the Knowledge Archives can also help build up effective and cooperative international relationships. Bringing techniques peculiar to individual languages to international forums will enable participants to learn the techniques unique to other languages. The Knowledge Archives thus completed will provide a solid basis for international exchange of knowledge and information, something which is needed now and will be needed even more acutely in the future.

The Knowledge Archives project will not clarify every aspect of knowledge. It is a project for making a full-scale start into the clarification of knowledge. Continuing efforts are to be initiated toward the explication of knowledge and further the explication of intelligence. A very wide range of interdisciplinary cooperative relationships is crucial to the process of research and development of the Knowledge Archives. However, even after the project is completed, these cooperative relationships will have to be further strengthened and widened. The Knowledge Archives will be the very basis that will guarantee the possibility of such development.

3. Knowledge in the Knowledge Archives

(1) Knowledge serving as a material

Only knowledge that can be represented explicitly and observed objectively will be used. The languages and media used to represent knowledge are called "knowledge representation media." The targeted knowledge is information having consistency as expressed by these knowledge representation media. Knowledge that will not be used includes knowledge which cannot fundamentally be expressed by the knowledge representation media, knowledge that is not sufficiently organized to be expressed, and knowledge that remains unexpressed due to the absence of appropriate knowledge representation media.

(2) Knowledge representation media

These include all media that can be used to represent information and that can be handled by computers. The media are to be handled at various levels, ranging from the level at which they are treated simply as data, to the level at which their contents are understood before being treated for a set purpose.

Knowledge representation media consist of natural languages, formal languages, picture languages, images, and sounds. Natural languages include a variety of foreign languages as well as Japanese. Formal languages include such artificial languages as algebraic formulas, legal formulas, and programming languages. This category also includes the knowledge representation languages in artificial intelligence and the format specification languages for the structural description of documents. Picture languages include representation media consisting mainly of diagrams and tables, such as architectural design drawings, electronic circuit diagrams and musical scores. Images include static images, dynamic images, and animation while sounds include speech (spoken language), music and other sounds in general. When properly combined, these knowledge representation media will display enhanced expressive capabilities.

Knowledge representation media play their respective roles, and each of them has its own irreplaceable function. Therefore, all of the media are treated equally in principle. From the viewpoint of knowledge processing, however, two of them have been selected as kernel media in consideration of the universality of their representation capability and the high level of their symbolization capability. They are a natural language (Japanese) as viewed from the human side and a knowledge representation language as viewed from the computer side. More precisely, they are modern Japanese, which is used with emphasis on high communication efficiency, and the system knowledge representation language which will be used by the Knowledge Archives in its knowledge base.

(3) Knowledge documents

"Knowledge documents" are made up of knowledge that is properly represented using knowledge representation media so that the knowledge can be observed and analyzed objectively.

Knowledge documents consist of represented knowledge, knowledge programs, and knowledge software created for humans and computers to use in combination. In other words, knowledge documents are knowledge expressed for use by a complex of humans and computers, a complex which works both as a processing system and as a comprehension system. Only part of the knowledge contained in the knowledge documents can be processed and understood by computers. How large that part is depends on the individual knowledge representation media. Some documents can be processed merely as data (raster data or vector data), others can be understood as syntactic structures, and still others can be understood as semantic structures. While computers can faithfully execute and process knowledge documents that are in knowledge representation languages, it is the role of humans to perform highly advanced processing in order to understand their overall meanings, make value judgements, and so forth.

As technology advances, the roles played by humans and computers with regard to the processing and understanding of knowledge documents are expected to shift more toward the computer side in terms of the volume of work. However, the division of roles between humans and computers is essential, and it will continue into the distant future.

All knowledge representation media will be handled equally. It will be necessary, however, to distribute the emphasis appropriately when actually conducting research and development. The following three steps are to be considered in the distribution of emphasis.

① Knowledge documents in natural languages

Knowledge documents using other representation media will be substituted for by knowledge documents in a natural language that have approximately the same meaning. All documents will be normalized thereby. The natural language will be Japanese, the kernel medium; both modern Japanese and, in some cases, controlled Japanese.

② Knowledge documents in natural languages and formal languages

Formal languages that will be considered are knowledge representation languages, programming languages, algebraic formulas and logical formulas. All major knowledge representation languages will be included in the knowledge Archives Project. One of these is the language based on constraint logic programming that is an outcome of the Fifth Generation Computer System Project. Processing and comprehension functions that bridge natural languages and formal languages are new themes in this project.

③ Knowledge documents in natural languages, formal languages, picture languages, images, and sounds

In general, the materialization of processing and understanding functions for picture languages, images and sounds is an aim that is beyond the range of this project. That is, it is a subject of study for the future. We will strive to create simple mechanisms that use the characteristics of the targeted knowledge documents.

4. Fields of Knowledge

The establishment of technologies for the Knowledge Archives requires the appropriate selection of fields representing the respective features of diverse forms of knowledge, and that research and development efforts be executed using substantially large amounts of knowledge documents in these fields. It is of utmost necessity to obtain the cooperation of experienced groups and organizations that possess such knowledge documents for the execution of the project. Our aim is to form new realms of research with such groups and organizations.

Knowledge documents can be divided into three main types: general texts, knowledge representations and programs, and data. For each type, at least the following knowledge documents will be targeted:

(1) Texts

Texts use natural languages as their main knowledge representation medium. They also use line graphics, images (photographs and paintings), and so on. Examples are:

Narratives
Newspaper articles
Scientific and technical papers
Patent documents
Legal documents and precedents
Manuals

(2) Knowledge and programs in knowledge representation languages

Formal languages such as knowledge representation languages and programming languages are the main knowledge representation media in such knowledge documents. Although specifications will also be targeted, knowledge representation media such as natural languages, formal languages (specification language, algebraic formulas and logical formulas), diagrams and tables will be used for these. Targeted knowledge documents will be chosen by selecting representative knowledge representation and programming languages. Examples of such targeted knowledge documents are:

Knowledge documents in system knowledge representation languages

Knowledge documents in constraint logic programming languages

Knowledge documents using expert system shells

Knowledge documents in general purpose programming languages

(3) Data

The knowledge representation medium in use for data is the formal language called a database language. Although the specifications of the database will also be a subject of study, natural languages and so on will be used. The main research theme here is the extraction of knowledge from a massive amount of data.

Current News

*** Sony to Join Hands with IBM for Multimedia Products**

Sony Co., Ltd. will tie up with IBM in the information-related electrical equipment business, in which computers and electrical equipment are combined. As a first step, IBM will develop software for a CD-ROM player developed by Sony and begin selling this product in the U.S.

The first product of this tie-up is the "Multimedia CD-ROM Player (MMCD)" developed by Sony. A palm-sized device that can process image, voice, characters and other information by using CD-ROM, it has already been marketed in the U.S. through Sony's sales network. The product will now be supplied to IBM through Sony America. IBM will sell it under the Sony brand name for the time being. In the future, however, IBM may switch to its own brand name by securing the product on an OEM (original equipment manufacturing) basis.

The software to be developed by IBM will primarily be designed for business use such as for employee training using images and voice. After building the software into the player, IBM intends to sell the player to corporate users through direct mail advertising and mail order.

The MMCD is an information-related device based on personal computer technology. It can hold 39,000 A4 size sheets of image data, such as photos and graphs, 300,000 A4 size sheets of character data, or 16 hours of voice data. It can reproduce the multimedia software for combination of these media. It is priced at around $1,000.

The development of information-related equipment requires both computer technologies and electrical equipment technologies. Recently, therefore, there have been successive announcements of tie-ups between Japanese electrical equipment makers and U.S. computer makers. For example, joint development of information-related electrical equipment by Apple Computer Inc. of the U.S. with Toshiba began in June 1992 and with Sharp Corp. in March 1992.

*** AT&T Ties Up with NEC and Toshiba for Development of Next Generation of Portable Terminals**

AT&T Microelectronics, the semiconductor business division of AT&T, has announced that it has joined hands with NEC and Toshiba for the development of next-generation portable terminals incorporating the AT&T-developed "Hobbit" microprocessor.

Hobbit is a 32-bit high-performance MPU. When compared with conventional products, it has higher throughput, is smaller in size and consumes less power. It also has communication functions. NEC intends to develop a pen-input type portable terminal using Hobbit and sell it to specific industries, such as the insurance and distribution industries. In addition, NEC has signed a licensing agreement for the manufacturing of Hobbit. Thus the Hobbit units manufactured by NEC will not only be used by the company for portable terminals but also sold to Toshiba. For the time being, however, Toshiba will purchase Hobbit from AT&T Microelectronics and NEC.

The three companies will initially work on the construction of a system that can send and receive characters and voice over public and other lines. In the future they plan to materialize a system that can send and receive animated images as well as a radio system.

* Sony to Sell Portable Telephone in the U.K.

Based on a business tieup with Cellnet, a company affiliated with British Telecom of the U.K., Sony will start selling cellular telephones through an AV sales network of 2,000 shops in the U.K. The BT group has recognized the Sony product as the first case of application of a new rate system established in an effort to expand private use. Under the new rate system, the subscription charge and the basic monthly charge are reduced to nearly half the charges applicable to business users while the service charge per minute is about twice as high. As a result, total charges are much the same as for business use.

The cellular telephone to be sold by Sony is priced at around £300, about half of the price of comparable products available at present. It is designed to be small enough to be held in one hand. The telephone number is set into each telephone set in advance, so it is no longer necessary for the purchaser to go to the trouble of concluding a line agreement and having a telephone number set up.

Cellular telephone service started in the U.K. in 1985. The number of subscribers has already exceeded one million and is still increasing at the rate of 150,000 to 200,000 a year. But most new subscribers are business users. Sony intends to cultivate private use in the U.K.

* Computer Production Records Double-Digit Drop for the First Time in 1992

The Japanese Electronic Industry Development Association (JEIDA) has announced that in 1992 the production of computers, including peripheral equipment, is expected to drop 10.2% from the preceding year, the first double-digit decrease in history. Production in 1992 is estimated at ¥5,460 billion. Of this amount, computers will account for ¥2,670 billion, down 9.1% from 1991, and peripheral and terminal equipment ¥2,790 billion, off 11.3% from 1991. By type, production of general purpose computers, office computers and personal computers will all decrease substantially from the previous year. The only exception is workstations, whose production is expected to increase nearly 20% due to the downsizing trend.

This will be the first time in 17 years that annual computer production has recorded a decrease from the previous year. In 1975, computer production decreased because of the effect of the first oil crisis. The semiconductor technology innovations that have materialized smaller size, higher performance, and lower-priced MPUs, the heart of the computer, have brought about smaller size, higher performance, and lower-priced hardware, with a great impact on computer makers. In addition, business corporation information investments have been stagnant because of the recent economic slowdown. Computer production has been substantially affected by the double shock of structural reform and poor economic activity.

JEIDA admits that computer production will continue to be tested by a severe environment in 1993. But the association expects production to increase 1.1% over the preceding year, as economic recovery can be expected to result from the Government's comprehensive economic measures.

* Hitachi and TI to Work Together for Development of 256 Megabit DRAM

Hitachi, Ltd. and Texas Instruments (TI) have agreed to cooperate in the development of a 256 megabit DRAM, the most advanced memory element for information equipment. The contents of the agreement include the joint design of a 256 megabit DRAM circuit, the development of common process technologies, and the development of standardized packages (exterior IC parts) with both parties contributing funds and engineers. The work will be similar to the joint 64 megabit DRAM development project agreed on between the two companies in November 1991. Hitachi and Texas Instruments are also scheduled to consider applying the technology for the design and manufacture of circuits with a line width of 0.2 to 0.25 microns used in the 256 megabit DRAMs to the most advanced MPU and logic products.

Two groups worked out international agreements for the joint development of 256 megabit DRAMs in July of 1992. One of the groups consists of Toshiba, IBM and Siemens, and the other is comprised of NEC and AT&T.

The memory capacity of the 256 megabit DRAM is 64 times as large as that of the 4 megabit DRAM now in widespread use. Each chip can hold information equivalent to 1,000 newspaper pages or about 4 hours of voice. At this point in time, NEC, Hitachi, Toshiba and Fujitsu have succeeded in making prototypes. Fujitsu has already announced plans to start commercial production in 1996. The development of a 256 megabit DRAM requires a huge outlay of funds and a large research staff. Therefore, one of the objectives of forming these groups is to reduce this financial burden by distributing it among the cooperating members. The establishment of these three groups is expected to spur on the competition for commercialization of products even further .

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