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Some Considerations on Essential Requirements of Intelligent Human Interfaces

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SOME CONSIDERATIONS ON

ESSENTIAL REQUIREMENTS OF INTELLIGENT HUMAN INTERFACES

--- Towards Office Information Systems for Intellectual Work ---

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ABSTRACT

What contribution will computers and computer networks, including so-called fifth generation computers and the INS network, make to human creative activities and intellectual work ? At first, fifth generation computers will possibly be used for intelligent office automation systems or office information systems.

Office information systems will support or improve not only human communications within offices, but also human intellectual work. Yet the development of intelligent systems which automatically undertake high-level human intellectual work is still in the distant future. So, it is reasonable to aim at realizing support systems for promoting intellectual work and creative activities by augmenting the creativity and imagination of human beings. Therefore, the importance of human interfaces should be even more emphasized.

This paper discusses some requirements of intelligent human interfaces of office information systems for knowledge workers.

1. INTRODUCTION

What contribution will computers and computer networks, including Fifth Generation Computers [Yok1] and Information Network Systems [Kih1], make to human creative activities and intellectual work? (*1) The following examples are cases in which computer-aids are effective in amplifying human creativity and imagination.

- .Solving solid-geometry problems by using computer graphics
- .Setting forth hypotheses by using computer simulations
- .Developing software by rapid prototyping [Ber1, Zav1]
- .Learning actively and voluntarily by playing the LOGO turtle [Pap1]

At first, fifth generation computers will possibly be used for intelligent office automation systems or office information systems, especially for providing more advanced human interfaces (man/machine interfaces). It should be pointed out that intelligent knowledge processing, as aimed at in the FGCS project, is essential for achieving this goal, e.g., for a database query system using voice [Wil1].

Various office automation systems or office information systems have been proposed. Most of them are, however, aimed only at reducing the user's burden by undertaking routine tasks or clerical work rather than at providing essential environments for human intellectual works. For example, a word processor is primarily used for making a fair copy of a draft of an article in offices (especially, in Japan) rather than for constructing or polishing the article; the former is just a kind of clerical activity, while the latter can be said to be intellectual work.

Office information systems are aimed not only at improving human communications within and between offices (e.g., electronic mail or teleconferencing), but also at developing creative office environments for intellectual work as referred to in [Sug2, Tam1], where various kinds of knowledge bases would be accessed through networks/LANs. Sugita also says that the FGCS project would rather focus on developing computers as tools to aid in thinking or in setting forth hypotheses [Sug1].

This paper focuses on discussing the intelligent human interfaces of office information systems for such intellectual work. Here, offices include programming offices, architectural design offices, law offices, laboratories, and so on rather than usual business offices (clerical offices).

(*1) Fifth Generation Computer Systems (FGCS) and Information Network System (INS) are both well-known national projects of Japan. ICOT (Institute for New Generation Computer Technology) is the central organization of the FGCS project.

2. EXAMPLES OF INTELLECTUAL WORK

What is intellectual work? How do we perform creative work? For realizing intelligent office environments, further research is required into the processes of various kinds of human intellectual activities, as described briefly below.

Most types of intellectual work have much in common with each other. In [Tag3, Tag4], some resemblance between writing processes and Warnier's programming process ([War1]) is discussed. Fischer also says in [Fis1], "Making complex designs in software engineering which are implemented over a long time and continually modified in the course of implementation has much in common with other creative activities (like writing, painting and composing)." Traditional techniques and tools used in the processes of these types of intellectual work should be studied and computerized (i.e., simulated on computers, as A. Kay says in [Kay1]). As A. Kay also says in [Kay1], such computerized tools equipped with diverse facilities, such as word-processing, graphics, simulation, information retrieval and human communication, will be available in the near future in place of traditional ones, such as paper, scissors, paste and pencil.

1) Writing

Writing can be viewed as the most typical intellectual activity. We human beings, think using our native language. Writing an article is not only for communicating one's thoughts, but also a means of developing them by accessing various knowledge bases, such as dictionaries, encyclopedias, books, research papers and the findings of investigations and experiments. In particular, a fundamental study of writing processes in a foreign language will hold clues for the direction of future research into the essential nature of intellectual work and into creative support environments. The effect of computer aids will come to be even clearer, since a language other than one's native language is constraining and inconvenient. There are two things helpful for writing in non-native languages:

- First, reducing psychological pressure so as not to suppress human creativity; this means to encourage thinking a little within the logical framework of the foreign language from the start
- To support the translation process; e.g., spell checkers and on-line dictionaries (especially, a "thesaurus")

Figure 1 shows various processes for producing (writing or translating) an article in a foreign language. In process (a), computer aids, such as screen text editors, are not well utilized in the thinking phase. Moreover, the translation of an article completely organized in the logic of one's native language into another language is quite difficult; it seems to be much easier to translate dynamically sentence by sentence (or paragraph by paragraph) in parallel with thinking or composing the whole article, as shown in Figure 1 (b). Process (b) takes advantage of the interactive computer aid for feedback between thinking and writing: that is, not only in composing an article but also in the thinking process itself.

2) Programming

Another example of intellectual work is programming. As Wulf says

in [Wul1], a programming language is a design tool and a vehicle for human communication; Knuth also says in [Knu1], "Instead of imagining that our main task is to instruct a computer what to do, let us concentrate rather on explaining to human beings what we want a computer to do." Programming involves not only giving instructions to a computer, but also creative thinking. At the beginning, a problem solving procedure is generally still vague even to the programmer himself [Fut1]; as so often the problem itself is too. He must repeatedly break down the vague problem solving procedure into sub-procedures until they can all be described clearly.

MacDonald says in his proposal for "Visual Programming" ([Mac1]), "One way to ease the programmer shortage is to simplify programming and let the users do it themselves." It should be pointed out that, especially in future computerized offices, "programming" will become one of the common, fundamental and primary tasks along with "writing". At least, those who intend to make good use of computing facilities in their intellectual work will be required to do "programming" in order to tailor (or personalize) their computerized tools for thinking ([Nan1]), or to fix their knowledge bases, just as a carver sharpens his knives for himself before creating his work of art.

"Programming" may well become much broader than, or far different from, the traditional concept of procedure-oriented programming. Recently, new very high level languages, called "Fourth Generation Languages", have been proposed or experimentally used. They are, let us say:

.non-procedural/declarative, and so easy to use,

.equipped with database interfaces, especially relational database interfaces,

.useful for developing distributed processing systems, and so on.

Moreover, one future principal programming style will be "knowledge programming", as evolved from logic programming. This will involve constructing a model or a program while accessing a number of knowledge bases, such as program libraries and document files. Logic programming means describing declaratively logical relations and conditions inherent to the problem to be solved, instead of specifying the solving procedure [Kow1]. Most future programming styles, including those listed below, will probably bear a greater similarity to writing or composing an article.

.literate programming [Knu1]

.rapid-prototyping in executable specification languages

.object-oriented programming

.UNIX SHELL programming language

3) Creative Group Thinking

Another category of creative processes includes those which are performed by a group, that is, "Creative Group Thinking". Some procedures for enhancing creativity or idea generation have been developed: e.g., brainstorming (A.F. Osborn), the KJ method (J. Kawakita), and walkthrough ([You1]). Tools and setting, including blackboard, OHP and so on, should be computerized and integrated into human interface systems in future intelligent office information

systems; these would be effective in eliciting all expertise, ideas and opinions from group members, and in synthesizing or combining them by extending the imaginative range of group members.

Walkthrough is a kind of design review technique in software engineering. Weinberg and Freedman say in [Wei1], "In some cases, the walkthrough is very close to a lecture about the product." Teaching is thinking: the lecturer could himself better understand what he teaches through his lecture for his students. So, walkthrough, properly performed, is more than design inspection. It can be regarded as creative group thinking for software development.

3. SOME ESSENTIAL REQUIREMENTS OF CREATIVE ENVIRONMENTS

Although future intelligent support systems will gradually be equipped with the capabilities necessary for undertaking high-level human intellectual work, existing automation systems are not aimed at executing the kinds of high-level intelligent activities. It is clearly reasonable to aim at realizing systems for supporting intellectual work by augmenting the creativity and imagination of human beings. This means developing the totally optimum man-machine system, where two kind of information processing systems, human beings and computer systems, would be combined under optimum conditions. In order not to constrain the imagination and creativity, the increased computing power of personal computers will be devoted to realizing sophisticated natural human interfaces (man/machine interfaces) [Tag1]. The design philosophy of the "Dialogue Management" basic interface system, based on the multi-window display, of the PSI personal inference machine being developed at ICOT is discussed in [Tsu1]. More sophisticated discourse models, taking advantage of new advanced interface hardware (e.g., "voice recogniser/synthesiser" or "mouse"), will be essential along with advanced interface vehicles (e.g., natural language, voice and graphics). As M. McCluhan says, "The medium is the message"; the medium is itself a good stimulant to the human imagination.

In the following, some essential requirements of intelligent human interface systems (especially of a sophisticated discourse model) that will augment intellectual faculties are discussed, taking into account some characteristics of intellectual work explained in Section 2. Of course, they have very much in common with each other, and 'Simplicity is best' is also true here.

1) Quickness

Concentration is very important for human creative activities. To accelerate concentration, "quickness" may be essential; human creativity and imagination will thereby be psychologically amplified.

The virtue of "quick response" or "quick interaction", realized only by computerized tools equipped with convenient interface devices (e.g., "voice recogniser/synthesiser" or "mouse"), is that they remove certain obstacles (e.g., time-lag) that tend to ruin concentration, for thinking generally proceeds much faster than handling traditional tools like pencil and paper.

2) User-initiative (Mode-less)

Attention to the information will be more valuable and creative than the information itself. Although future intelligent support systems will gradually be provided with meta-knowledge on how to use various kinds of knowledge bases necessary for undertaking high-level human intellectual work, which information to pay attention to would best be entrusted to the creativity and imagination of human beings. It is the user himself who has intelligence; it is important that tools and environments be natural and moderate (not forcible) so as not to impede human creativity and imagination. Human interfaces should be designed only to provide the user with moderate hints [Kay1]. Scott and Scherlis say in [Sch1], "We believe that programming, like other areas of creative endeavor, should not be too heavily shackled by form or method. Tools or vehicles for programming, therefore, must be constructed in such a way that programmers will

still feel the freedom to explore in unfettered fashion."

Therefore, "user initiative" is an essential requirement of a creative environment. For example, the mode-less interface model concept of Xerox's STAR [Smi1], based on a multi-window display, gives the user the initiative rather than making him dependent on the caprices (unnecessary modes) of the computer. The user can focus attention on any aspects of the computer's operation. He can pay attention to several pages or documents of interest to him at the same time in writing articles under favor of the multi-window system. Ellis says that the sensation of working in the environment which enables the style called "modeless" in Xerox's Smalltalk, giving the user the sense of seamlessness, is like the sensation of cooking in a well-organized kitchen [Ell1].

3) Interactiveness

For creative activities, top-down (global) and bottom-up (detail) approaches are both necessary, as Knuth remarks in [Knu1], "I had the feeling that top-down and bottom-up were opposing methodologies; --- But after gaining experience with WEB, I have come to realize that there is no need to choose once and for all between top-down and bottom-up, because a program is best thought of as a web in stead of a tree". They mutually enrich each other amplifying human imagination: 'analysis by synthesis' is the basis of high-level decision-making by human beings. Trial-and-error (feedback) is an essential characteristic of creative activities; an interactive environment is obviously helpful for trial-and-error approaches. "Design without final, precisely definable goals is possible and in many cases inevitable." [Fis1, Sim1] This is the same situation as in the example cited previously: at the beginning of programming, not only the problem solving procedure but also the problem are often vague even to the programmer.

Various human activities, such as planning and designing, are also performed in the way described above. Figure 2 shows a typical process of travel planning. The travel planning consists of picking up spots (that is, details) to visit during the trip and scheduling them taking into account geographic (that is, global) conditions.

Certain Japanese researchers in the social sciences use the method, called "Kyoto University Card System", for researching and writing articles. In this method, as Figure 2 (b) shows, taking into account the global context, researchers basically compose their articles and set forth their hypotheses by synthesizing individual data and flashes of ideas written down on cards.

It is interesting that Warnier's programming methodology (especially, its mapping concept) bears some resemblance to the synthesizing process in writing. In Warnier's methodology, programming becomes more tractable by dividing programming into two subworks, the design of a program framework (global control structure) and the selection of actual instructions. In this approach, as shown in Figure 2 (c), a program is completed by mapping individual instructions onto a global frame of the program.

Many computerized interactive tools, such as display editors and incremental language processors (or check-out compilers), have been proposed. A computerized interactive screen editor for texts or program-diagrams would facilitate this mapping/synthesizing process. Such an interactive editor would truncate, insert, replace and shift the twigs and boughs of a program tree diagram or the sentences and paragraphs of an article. An experimental interactive PAD-editing

system is proposed in [Ham1, Mae1]; a PAD (Problem Analysis Diagram) is a two-dimensional tree-structured diagram (evolved from Warnier's program diagram) for describing the logic of programs [Fut1].

Ellis also discusses "interactiveness" of TOOLS comparing with "programmability" of UNIX, which emphasizes programmability and provides an environment providing little feedback to the user [Ell1]. He further says, "The TOOLS environment subordinates simple tasks to goals in a way that users find easy and natural." The advantage of the increased computing power provided by interactive environments or personal computers should be made use of more directly in thought processes (that is, thinking), not only for programming but also for a variety of human intellectual work.

4) Visuality

Imagination, especially association, may be the most essential factor of human creativity. To amplify mental association, "visuality" is one of the most important requirements of intelligent human interface systems besides the concept of user-initiative. For example, a desk surface is effective not only for "ordering and finding" but also for "reminding" [Mal1]; a bookshelf or filing-system could also serve a similar function. "Desk-top" and "icon" concepts introduced in STAR simulate well this facility of reminding on computers or computer-networks.

The visualization of the entire network, including knowledge bases distributed around networks, is also essential for realizing advanced network interfaces as well as so-called network-transparency which lets the user not be concerned how the accessed resources are distributed among the network. For network visualization, two multiplexing techniques, the multi-window display and the virtual circuit (or session), are primitive but essential materials required for developing basic models of man/machine and man/network interfaces. Figure 3 (c) shows how, with these facilities, the user may simultaneously access and consider several knowledge bases through the network so as to promote his creative works.

The communication group ([Tag2]), which evolved from virtual circuits, is a more elegant advanced concept for realizing visual interfaces by simultaneously inquiring and gathering knowledge through the network. In the near future, multi-communication-media providing integrated service networks (voice, graphics, image, text and so on) and more sophisticated multi-interface-media would provide more ideal visual human interfaces, such as so-called media room or media booth. In addition, an advanced discourse model of human interface will be essential to take advantage of such advanced interface media for developing various ideal human interfaces.

5) Knowledge-based Dialogue (Literate Terminology)

In dialogue, it is important to use terms with which the user is familiar. For example, assembly language is more inconvenient for writing numerical programs than FORTRAN, because human beings think out a numerical problem in a far higher-level representation or terminology than that of assembly language. The former forces the user to think in a low-level terminology that is convenient only to computers, and to break down a meaningful unit concept into meaningless details biased in favor of computers.

Similarly, in order to realize an optimum man-machine information processing system, more flexible human interfaces will be required,

based on some shared knowledge and on the capability of learning the user model. That is, knowledge-based dialogue, containing default-reasoning or common-sense-reasoning, would be required in place of the conventional instruction-level or data-level types. As an example, a structure-editor or syntax-editor has the capability for more high-level sophisticated dialogue in literate terminology than a text-editor, because the former has some knowledge concerning programming languages to be edited.

6) Computer-based Group Communication

The computer-based human communication facility (e.g., so-called video-conference) will be required in future office information systems. Moreover, future intelligent human interface systems should have some functions for intellectual interaction among several users through networks so as to improve the intellectual performance of a community or group [Sae1].

The design of computer communication systems and human interfaces affects the ability and performance of a group [Mur1, Mur2]. It will be more important to provide human interface systems, helpful to organize and coordinate creative group thinking as discussed in Section 2, taking advantage of new interface hardware and communication media. Murrel explored the impact of two communication interfaces on computer-based conferencing, such as brainstorming and group decision-making. One provides a multi-window display terminal as the discussion platform for each group member and the other uses a usual message terminal. She says, "Window system groups produced significantly higher quality decisions than groups using the less interactive message system." and, "A number of structures have been used to enhance face-to-face brainstorming. --- Any of these would be easy to incorporate into a computer conference."

7) Mobility (Remote-accessibility)

For human creative activities, it is desirable that tools and knowledge bases be accessible at any time and from any location, for ideas or data generally occur at any time, anywhere.

To realize this goal, a more advanced infrastructure, based on mobile-communication-systems (e.g., satellite-communication-systems and wireless-local-area-networks) and so-called multi-communication-media, is going to be vital as well as advanced portable or mobile interface-devices. For example, a cellular-radio network is intended for use as the basis of mobile-information-systems (e.g., mobile-office-facilities), which are one of the R&D themes in the UK's Alvey fifth-generation-computer project. This national cellular-radio network, planned in the UK, will comprise some 400 base stations (Electronics July 12, 1984). Taguchi also suggests some basic requirements of future knowledge communication networks as the infrastructure supporting intelligent computers, such as fifth generation computers [Tag5].

4. CONCLUSIONS

Existing office automation systems cannot execute high-level intelligent activities in place of human beings. It is in the distant future that intelligent systems will automatically undertake high-level human intellectual work. So, it is reasonable to aim at realizing support systems for promoting intellectual work and creative activities by augmenting the creativity and imagination of human beings. Intelligent programming support systems are required for this, rather than automatic programming systems (e.g., automatic program synthesis). Therefore, the importance of human interfaces should be even more emphasized.

In this paper, some requirements of human interfaces of intelligent support systems have been discussed. Among them, visuality might be said to be the most essential in interactive computing environments and network environments for allowing the user to freely pay attention to various knowledge bases. The rapid evolution of communication network technologies, such as multi-communication-media, will provide greater possibilities.

To realize ideal environments for intellectual work and creative work, further studies and sound understanding of the processes of human intellectual activities are required. The results of new research into the creative and intellectual functions of human beings, such as the work being done in cognitive psychology or cognitive science ([Fuc1, Nor1]), will surely contribute to such purposes, just as ergonomics (human engineering) has been making an important contribution in various fields of engineering and technology; e.g., in designing or installing equipment and work environments.

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(Note) *: In Japanese. Japanese titles are translated into English ones by the present author.

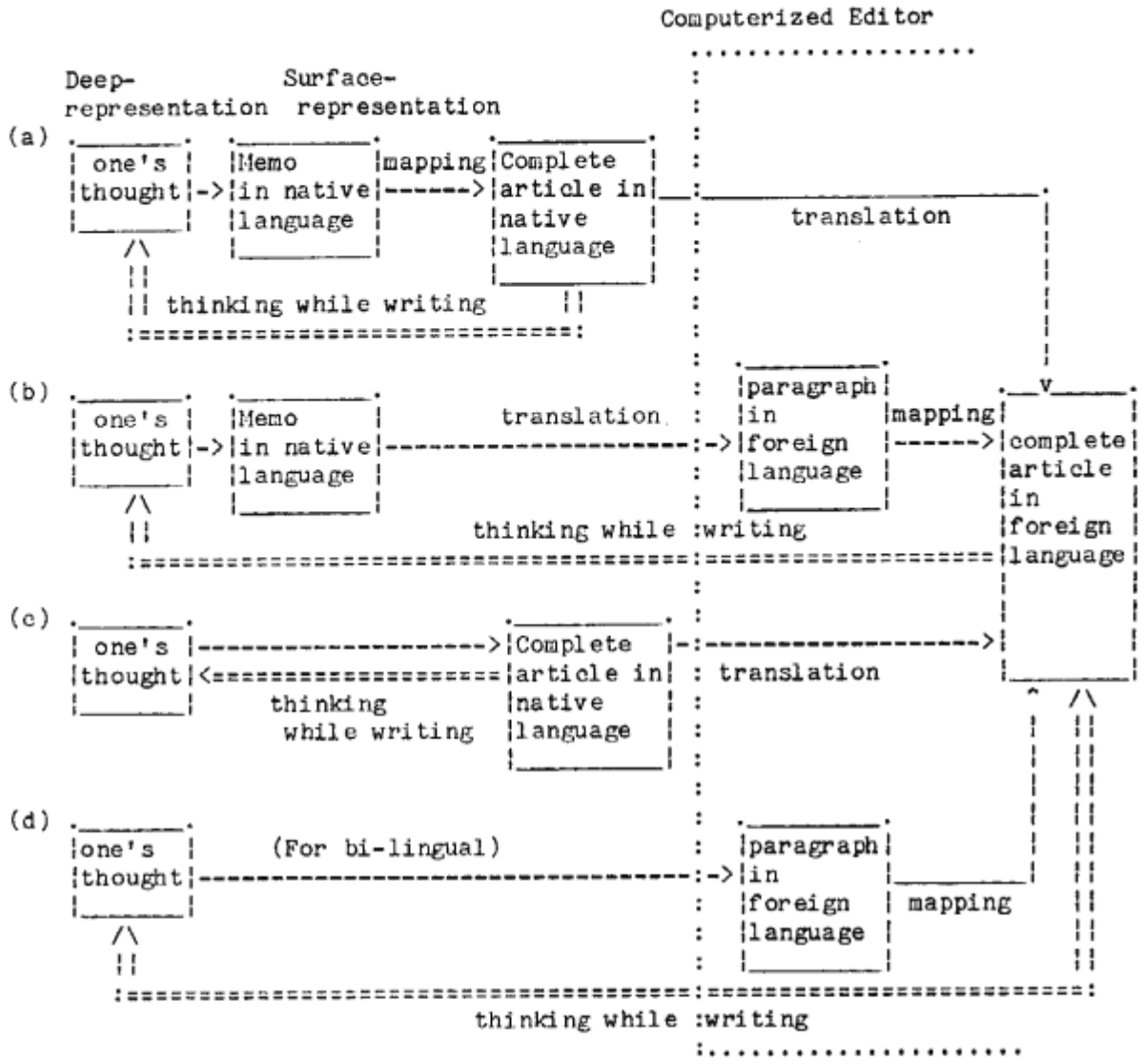
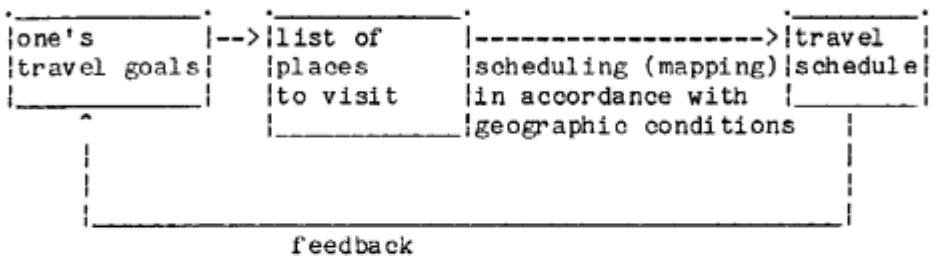
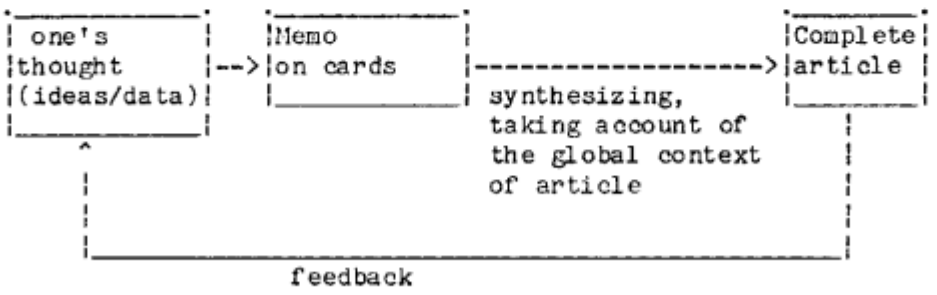


Fig.1 Processes of Writing an Article in a Foreign Language

(a) Travel Planning Process



(b) Writing Process in Kyoto University Card System



(c) Programming Process in Warnier's Methodology

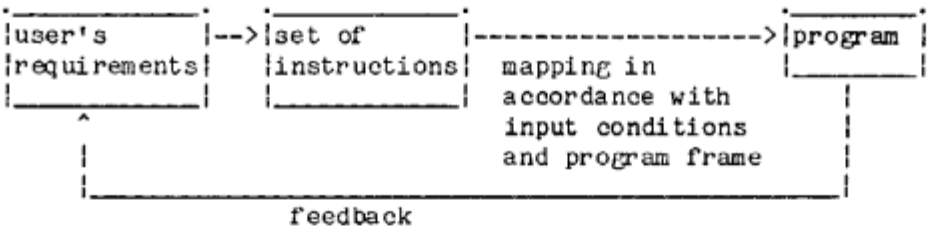


Fig.2 Processes of Travel Planning, Writing and Programming

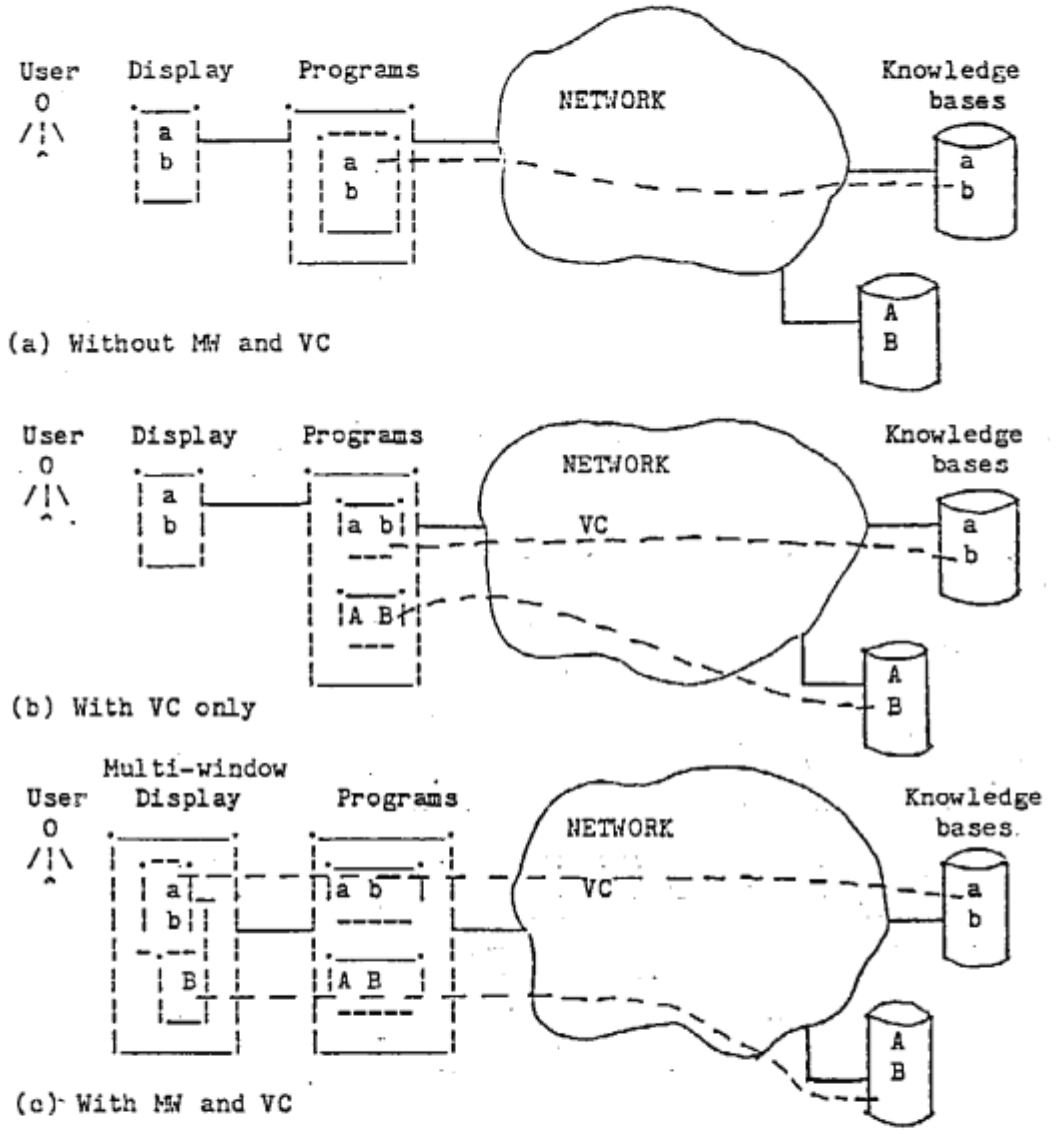


Fig.3 Visualization of Network Environment