Towards a Collaborative Planning System

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Abstract

This article begins by exploring the problem of combining the elements of group cognition, access to media, and access to tools into a holistic planning process. It then discusses a way in which technology can be used to help combine these activities by incorporating graphical interfaces, associative information structuring, and computer-supported collaborative work into a microcomputer-based Collaborative Planning System (CPS). Methods for the development of a CPS are proposed and two systems are explored as examples. It is concluded that increased access to relevant information, aided by the implementation of a CPS, can ultimately lead to greater communication amongst participants in a group planning situation. This will ultimately have a positive effect on the quality of plans and decisions.

INTRODUCTION

The quality of plans and decisions is dependent upon the amount of relevant information used during the formulation of problems, development and evaluation of alternatives, and the making of decisions. This relevant information may manifest itself in a number of different forms. Among these are various types of forecasts, analyses, models, documents, news clips, interviews, and observations. These forms of information may be combined with other information types such as practical experience and political savvy expressed through collaboration to form the relevant information planners take into consideration when facing a problem.

When considering the vehicles typically used for the delivery of relevant information, one could generalize that forecasts, analyses, and models are provided by various types of analytical **tools**. These tools often deal with quantitative information and are frequently implemented with the aid of the microcomputer. Documents, news clips, and interviews are often provided through both printed and electronic forms of communication that manifest themselves as various types of **media**. Finally, observations, practical experience, and political savvy are usually delivered in a less formal manner through **collective cognition**.

Cognition is typically defined as the mental processes by which knowledge is apprehended (attention, creativity, memory, perception, etc.). In this context, I am defining collective cognition as access to knowledge stored in the minds of a group of people. This cognition is typically facilitated through interpersonal communication. Thus the three delivery vehicles for relevant information are identified here as tools, media, and collective cognition.

It is currently quite difficult to integrate tools, media, and collective cognition into a cohesive planning process. Typically one element is mastered at the expense of the others. Figure 1 is represented as a three dimensional model of information use in planning situations. In viewing Figure 1, we can see that typical planning situations, (represented by points **A**, **B**, and **C**), often access one form of information at the expense of others. Our goal is to move towards point **D** where there is greater access to tools, media, and collective cognition.

For example, point **A** represents a technician using a computer to access analytical tools. Because analytical tools are often implemented using computers, it is typically cumbersome[1] to bring tools into meetings and libraries for group interaction. The individual orientation of tools may serve to isolate the technician from the benefits of access to qualitative information in the form of media, as well as the benefits of collective cognition. Thus, the problem of bringing tools to collaborative work sessions and media centers (libraries) is the individual orientation of the tools' delivery mechanism which is most often represented by computers.

[1] The development of portable and laptop computers makes this less of a physical issue. However, functional difficulties still exist as interaction with tools in these environments can still prove to be challenging —especially for more than one individual at a time.

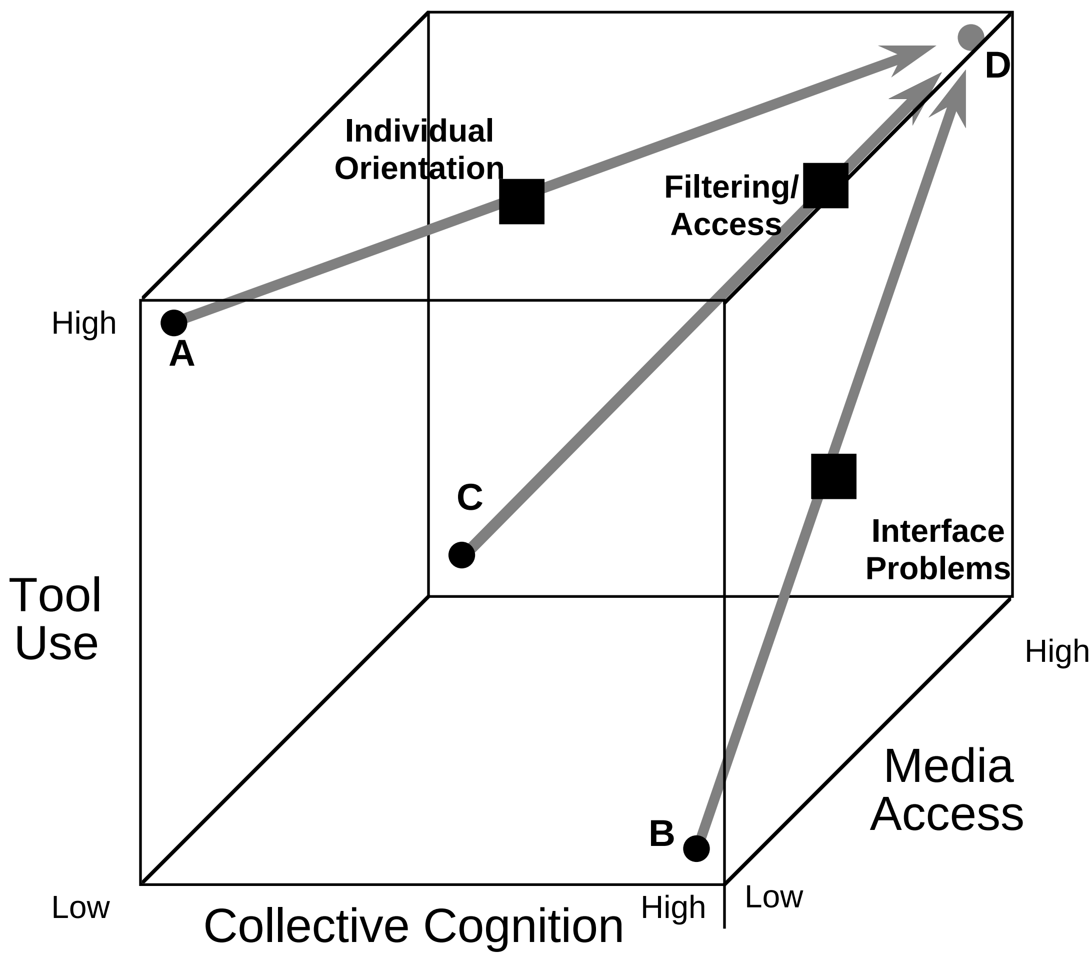

Figure 1: A three dimensional diagram of information use in planning situations.

The group meeting/brainstorming session at point **B** on Figure 1 often occurs at the expense of direct interaction with useful analytical tools, as well as access to information in its physical forms (media). Few libraries are tolerant of the necessary verbal exchanges that occur during group meetings. While virtual libraries of relevant media are now available in the form of CD-ROM to supplant the need for library visits by groups, these still lack the necessary interface for group interaction. Thus, the problem becomes one of a lack of an adequate group-information interface.

Finally, if we consider the researcher in a library environment at point **C** on Figure 1, it becomes apparent that access to media often occurs at the expense of group planning situations and access to analytical tools. This is largely attributable to information access and filtering difficulties.

In summary, increased access to tools, information, and collaboration faces three barriers: 1) the ergonomic difficulties in using tools often caused by inadequate human/machine interfaces, 2) difficulties in filtering/accessing the vast amounts of information available from a variety of media, and 3) the individual orientation of most analytical tool implementations. While it is acknowledged that other factors, (political, organizational, economic, etc.), are likely to hinder access to tools, cognition, and media, this article will focus on overcoming the three barriers identified here because they are more tangible and universal in nature.

BARRIERS

This section will explore the nature of the barriers identified above as inadequate human/machine interfaces, information filtering/access difficulties, and individual tool orientation and propose how they may be respectively overcome using graphical interfaces, associative information structuring, and computer-supported collaborative work.

Human-Computer Interface

Analytical tools have the potential to be tremendously useful to planners for providing forecasts and modelling various phenomena. Yet they can be practically useless to individuals who may not understand how to implement such tools properly. The difficulties encountered in mastering these tools often cause less technically-oriented people to be excluded from the planning process. This may lead to less than satisfactory outcomes to planning problems as well as political, ethical, and psychological difficulties for both the planners and the planned-for (Rouse and Morris, 1976; Forester, 1980). Thus a need exists to make analytical tools and their outputs more visually (or audibly) appealing, so that information that would normally be meaningless and intimidating can be made understandable. A recent technological trend that addresses the need for usable tools has been the movement from "command-driven" to **graphical interfaces** for human-computer interaction.

Graphical interfaces overcome the need to memorize computer commands by translating the user's actions into commands that can be understood by the machine. This is accomplished by providing a human-computer interface displayed in a form that matches the way humans think about a problem. By doing this, the user can make "rapid incremental reversible operations whose impact on the object of interest is immediately visible" (Hutchins, Hollan, & Norman, 1986, p. 91). An example of a graphical interface is the input of values using sliding bars that immediately interact with an algorithm which, in turn, displays a graphic image to signify the output of the model being used. Rather than implement analytical models by typing cryptic code or numbers, planners can point to maps and photos, slide graphs and bars, and push on screen "buttons" using a direct-manipulation interface in order to elicit a response from the computer.

Graphical interfaces can also influence the output characteristics of the machine so that they are more readily understood by users. This involves designing computer displays so as to present information in a manner that allows for "pleasurable engagement" (Laurel, 1986). Pleasurable engagement is the ability to make the human-machine interaction so engaging that the machine essentially becomes "transparent" to the human. In other words, humans become so engaged in the activity of working with the information that they forget that they are using a computer. Pleasurable engagement incorporates concepts such as "visual presence" and "multiple representations".

Visual presence aids the user by providing visual reminders of what has been done. For example, grayed-out text could be used to signify portions of a plan that were already read or alternatives recently made redundant. Multiple representations of a problem (Rasmussen,1986) enable the user to view information in several different contexts thus offering the potential to generate alternative approaches to a problem. An example of this would be highlighting the impact of a proposed transit station on a surrounding neighborhood through the use of one graph to display the change in land values, another graph to reflect shifts in demographics, and a video to display physical changes. In this manner, users have the ability to visualize a situation from several different perspectives in order to gain a better understanding of the information conveyed.

Information Filtering/Access Difficulties

Planners are bombarded with a rapidly expanding information base that includes statistical data, slides and video images, maps, newspaper clippings, broadcast news stories, etc. While many of the more sophisticated database management systems (DBMS) and geographic information systems (GIS) support the organization of multiple media in a hierarchical or relational form, this organization often looses the rich network of interrelationships that underlie the information when it is decomposed into isolated records. For example, if a television news clip is related to an earlier news clip as well as several geographic regions, drawings, and documents, it is often difficult to impose a hierarchical or relational structure on the information without arbitrarily breaking it up into isolated records. This inability to adequately reflect the interrelationships amongst information from a variety of media can potentially hinder the planning process as planning situations often require a sequence of interrelated decisions based on associated information.

Associative information structuring allows one to incorporate information in its natural form without the need to break it up into individual records. In this manner, information that defies classification, such as the political climate surrounding a set of issues and geographical areas, can be incorporated into the system. While the application of organizing information in this manner is relatively new, (due to recent technological advances), the concept has more historical roots. In 1945 Vannevar Bush, science advisor to President Roosevelt criticized the artificiality of the information indexing systems of the time. Noting that most information was stored either alphabetically or numerically in a series of subclasses, Bush (1945) commented that:

> The human mind does not work that way. It operates by association. With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain.

This associative nature of the brain has since been observed in many contexts and has been formalized in several models of human memory (Collins and Loftus, 1975; Murdock, 1982). The organization and representation of an associative information structure from multiple media can be facilitated using a technology known as “hypermedia”. The term *hypermedia* comes from a merging of “hyper” which many mathematicians and scientists use to describe “extended and generalized” (Fraase, 1990) and “media” —a general term commonly used to describe methods of information presentation. The term itself is derived from Ted Nelson’s (1965) concept of “hypertext” that is used to describe nonsequential writing and perusal. In 1971 Nelson extended the concept of hypertext to include other forms of media such as graphics and moving images. Hence the term “hypermedia” was developed to describe the concept of organizing and displaying associated information in a manner that allows users to define the sequence and depth of information that is best suited to their needs.

It is important to draw a distinction between hypermedia and “multimedia” at this point. As mentioned above, hypermedia is viewed as the organizational structure behind the information. It is the method of organizing information of different forms (media), in an associative manner. Multimedia, is simply the display of this information. Multimedia does not have any underlying organizational structure per say. “Interactive multimedia”, on the other hand, possesses the ability to navigate amongst information of various media, but lacks the richness of a hypermedia system’s underlying associative structure.

With hypermedia technology, planners can combine a variety of information types into a format that allows for the fast cross referencing of numerous concepts. Thus a variety of planning related information, such as maps, written documents, statistical data, sounds, and video clips, can be organized by association. The most distinctive attribute of hypermedia is its ability to trigger the recollection of associated concepts with the aid of the computer. This process can be a complementary one. On one hand, the computer can help the human identify associations by exposing him or her to a variety of stimuli. On the other hand, the human can identify associations for the computer thereby enriching the knowledge base for future users. Through this process, associations in both the computer and the human can evolve.

Individual Tool Orientation

While tools designed to aid in the planning process can be brought into collaborative environments, they are often usable by only one or two individuals to the exclusion of other meeting participants. Many of these tools have been implemented using computer-based decision support systems (Brail, 1989) and most of the computer systems in use today aid the work of separate individuals rather than their work in groups (Stefik, et.al., 1988). Thus a breakdown in collaboration and group cognition can occur with individual tool use during the planning process.

Computer-supported collaborative work addresses the drawbacks associated with individual computer usage by placing computer-oriented tools into meeting environments that may be physical, as in small group meetings; distributed, as in local area networks; or virtual, as in “meeting rooms” found on electronic bulletin board services (BBS). This article is concerned primarily with small physical meetings of four to ten people.

Lowe, (1985) addressed computer-supported collaborative work as it applies to conceptual meeting environments when he envisioned a system that would be able to “encode knowledge in the argument structures themselves”. Lowe’s method is based upon the use of a structured representation for reasoning and debate, in which conclusions are justified or negated by individual items of evidence. “Through debates on the accuracy of information and on aspects of the structures themselves, a large number of users can co-operatively rank all available items of information in terms of significance and relevance to each topic” (Lowe, 1985). Such a system can be conceptually compared with rest room graffiti or electronic bulletin board services where one idea or comment is followed by another and so on. This makes it possible to trace an argument in such a way as to follow the line of reasoning. Thus, the accuracy, integration, and accessibility of information can be improved.

Computer-supported collaborative work applies also to physical meeting environments. The psychological benefits of these types of interactions for the participants have been noted as humans are identified as “social animals [with] face-to-face interaction, including the exchanging of job-related stories, [being mentioned as] an important and usually underestimated means of gaining information” (Rouse and Morris, 1976, p. 969). Stefik et al, (1988) also espoused the benefits of collaborative computer systems when they noted that computers are often left behind in favor of more passive media like chalkboards and flipcharts when meetings are held. Their development of the Colab at the Xerox Palo Alto Research Center (PARC), represents an attempt to demonstrate the collaborative capabilities of computers using a prototype meeting room.

Thus, in order to integrate tools, media, and group cognition into a cohesive planning process, a need exists for a system that can: (1) provide tools in a form that enables those who may not be technically adept to interact with them effectively, (2) access and filter large amounts of relevant information from a variety of media so that it can be presented in a variety of contexts, and (3) execute this in an environment that encourages group interaction and cognition.

COLLABORATIVE PLANNING SYSTEM

Recent advances in technology, now make possible the development of a Collaborative Planning System (CPS) that combines the activities of tool usage, information access, and collaboration. Such a system could make use of graphical interfaces, associative information structuring, and computer-supported collaborative work.

By exploring a CPS consisting of information added over a number of years, planners and public officials can identify relationships, create links, and append information. Therefore, it is possible to have input not only from all those present at a particular meeting, but also from as many people who may have interacted with the system since its development. Thus, CPS represents a move towards an open technology in that it stresses a participative form of information organization with an emphasis on the notion of people working together in an exploratory way. A CPS would also be able to act as a tool box from which the user could access various models for forecasting and performing general "what if" analyses. The hypermedia component of a CPS could also do a more accurate job at illustrating urban relationships than standard systems (spreadsheets, databases, etc.) because of its ability to organize and present spatial, political, economic, and other related information using animation, sound, graphics, video, and textual methods of representation. Furthermore, by providing multiple representations of a problem, a CPS can enable the user to view the information in several different contexts, thereby offering the potential to generate alternative approaches to a problem by viewing the information in a "new light".

System Development

There are two methods for organizing the development of a CPS: “comprehensive” and “iterative”. Comprehensive development is best suited when there is a well-defined problem and data are plentiful. This method is an attempt to gather as much information as possible about a particular topic or area so that it will be on hand when needed. The drawback of comprehensive development is that it typically requires a long time to develop a usable system. It also tends to be costly due to an extensive amount of data collection. Furthermore, large amounts of data may also go unused and the initial problem focus may be lost during comprehensive development.

Iterative system development works best for problem areas that are not well-defined. This method begins development with a map and image base. From here, areas of interest are identified and further information is gathered as needed. Since the initial development of an iterative system entails linking a map to descriptive graphics and text, development time is short for a usable system. The benefits of this development method are that it keeps the problem area in focus and very little information goes unused. This makes iterative development quite cost effective. The drawbacks are that it may be difficult to anticipate future data needs. Furthermore, iterative development may be handled in an overly conservative manner that may result in a hypermedia knowledge base that is too limited.

The development of a CPS is an extremely personalized process based on the specific requirements of the entity developing the system. The components incorporated into the system will vary based on the types of information used and budgetary constraints. Such components can include maps, text documents, CAD drawings, various types of analytical tools, motion and still video images, animation, sound, and a variety of other elements.

Programming

The CPS can be programmed using an object-oriented method that allows for iterative development. Although this method of programming has been available for some time using languages such as “C”, it has recently been popularized for microcomputers by authoring systems such as ToolBook™ on the IBM PC, and Hypercard™ and Supercard™ on the Macintosh™.

Object-oriented programming differs from traditional programming in that, rather than writing out a long list of programming code to construct one computer application or program, one simply writes a series of “scripts” that are tied to particular “objects” such as buttons, fields, cards, windows, and menus. These scripts can be considered subroutines that have the ability to pass messages along to other subroutines in a set hierarchy. One of the greatest benefits of the object-oriented approach to programming is the ability to construct a system using a modular approach much the way one would work with Lego™ building blocks. Objects can be copied and pasted among windows and their associated scripts are duplicated and carried along with them.

One of the most important aspects in selecting an object-oriented authoring system is the ability to easily incorporate revisions to programs. In the CPS prototypes that have been developed and tested, Supercard was selected as the development environment. The criteria for choosing Supercard included the ability to incorporate maps made up of either objects or bit-mapped images, the ability to link information to irregularly shaped objects within these maps, and the ability to display these maps within large sized windows. Additional criteria for selecting Supercard included the ability to display color, digitized video, incorporate sound, and animation.

An important aspect of a CPS is the ability to visualize dynamic processes such as population growth, changes in traffic flow, or various stages of development. Visualization can be accomplished using animation techniques. Software applications such as Autodesk's Animator™ and Macromind's Director™ represent popular animation environments for microcomputers. Director animations can be linked to Supercard scripts. For example, an analytical model could be used to drive animation A if the output of the model is A' and to drive animation B if the output of the model is B'. The use of animation can therefore help the users(s) to visualize the effects of the model's output upon the physical environment.

Hardware

The central piece of hardware necessary for the development of a CPS is a microcomputer. While the number and scope of microcomputer configurations available is in a constant state of flux, several criteria need to be taken into account when selecting a platform for CPS development.

First, it is important to select a microcomputer platform that can translate existing electronic files for inclusion into a CPS. Fortunately, this criterion is easy to meet with almost any current computer platform due to recent advances in file sharing and data translation.

Second, it is important to select a platform that represents the state-of-the-art in graphic display and manipulation since much of the proposed system makes use of sophisticated graphics such as real-time video and animation.

Third, it is important to select a platform that provides consistency of operation across the hardware and software components necessary for the construction of a CPS. Software and hardware peripherals are often incompatible within many microcomputing platforms. This has been due to variations in hardware configurations, a lack of interface standards, and incompatibilities amongst various external device drivers. Several computer manufacturers specify strict compatibility standards for third party hardware and software developers. Where these standards are met, it is possible to include many of the elements needed to construct a multimedia decision support system while minimizing technical effort.

Finally, it is important to select a platform that provides the speed, storage, and memory requirements to be able to handle the extensive graphic and sound manipulations necessary to the operation of such a system. A less powerful configuration could possibly obscure the relative benefits of hypermedia and graphical interfaces by causing extended delays.

The display requirements of a CPS are directly related to the number of participants in the working group. A video projector will be required if the system is to be used by more than five or six individuals at a time. For smaller groups, a color monitor capable of displaying high resolution graphics and a second monitor capable of displaying output of an analog video source such as a laserdisc or a camcorder, should be sufficient.

In addition to the system's display requirements and central processing unit, several peripherals will be needed. The ability to capture video images and display them in color on the computer display screen for navigation, manipulation, or archival purposes will necessitate the acquisition of a video frame grabbing device. Likewise, the ability to overlay computer graphics and animations onto motion video for visualization purposes will require the use of a video overlay board. Other hardware peripherals that will be needed include a high resolution video camcorder for the capture of video images, a sound digitization device for the capture of audio information, and a large scale storage device such as a magneto-optical drive or high capacity hard disk for the storage of captured information. Finally, a pointing device and a keyboard will need to be connected to the system using infrared technology or long cables so that they can be easily passed among participants during the planning sessions.

Implementation

The implementation of a system typically begins with a definition of the problem area, and the initial collection of information. The initial information to be collected in the system will typically be existing maps of varying scales and visual images of selected sites. The scale of the maps would be dependent upon the project scope and the amount of information available for each area. These maps can be adapted from existing information systems, or scanned in from hard copy. Images of specific focus areas would then be collected in order to help visually familiarize the users of the system with locations of interest. The images could be in the form of slides, photographs, or video tape that could then be digitized and linked to the maps.

The purpose for building the image base first is to enable the system's use at initial meetings during which planners often unfold maps, spread them out on a table, and try to visualize current conditions. In this case however, the work group could meet with the system projected on a screen and determine which areas of information need to be added to the system in order to make it more useful. It can be expected that additional visual images as well as relevant site descriptions, numerical data, drawings, sounds, and possibly video interviews would be specified for further information collection. At this point, the system's users actually work to shape the CPS by adding the appropriate information and tools to suit their needs.

A key component of the CPS is the ability to annotate the information contained within the system during meetings. This can be accomplished by typing text into a field linked to a specified element of information. Experience in implementing CPS has shown that collaborative environments can only accommodate minimal delay. Therefore, an audio annotation capability has been developed to minimize delay by allowing users to append verbal information to the existing text, graphics, or video. The tool creates an object, such as a polygon or icon, that can "store" sounds such as airport or traffic noises and users' comments. These objects can be attached to any element of the system including maps and photos (Figure 2). Verbal comments made during the meeting can later be transcribed and incorporated into a text field. Transcribing these audio comments helps to minimize disk storage requirements.

The revisions specified during meetings can be incorporated into the CPS through the method that is best suited to the task. For example, if comments call for the inclusion of an additional analytical tool, a new module is created using object-oriented programming techniques. This module is then tested for compatibility with the CPS. If the module works, it is appended. If incompatibilities arise, the module is revised and retested.

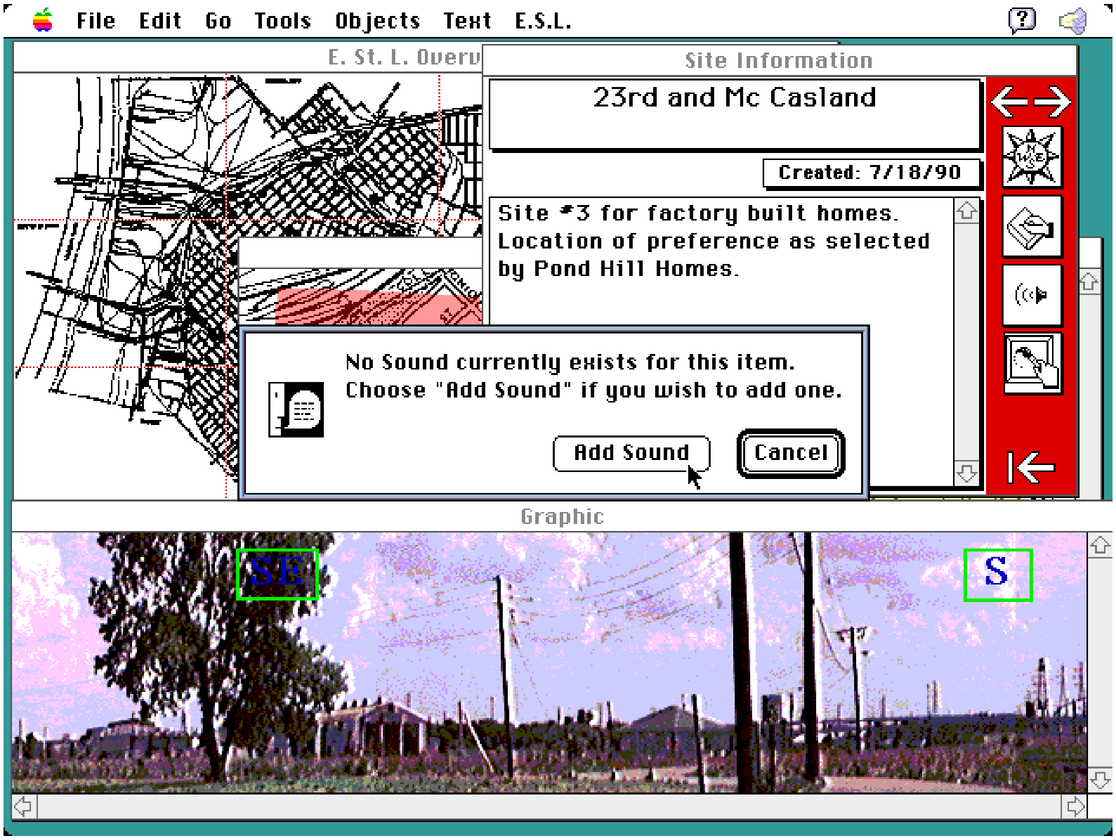

Figure 2: An example of an audio annotation device in use with a CPS.

CPS EXAMPLES

In order to evaluate the suitability of CPSs when applied to the planning process, several prototypes have been constructed. In this section two prototypes are briefly discussed: the St. Louis Riverfront CPS and the Crawford County, Illinois CPS. While these systems differ considerably in size and complexity, they contain many common elements of a CPS.

St. Louis Riverfront CPS

The St. Louis Riverfront CPS is derived from the "Riverfront 2000" project (Kindleberger, 1989; Wiggins and Shiffer, 1990). Riverfront 2000 was an endeavor to build an information system for the redevelopment of St. Louis's riverfront using hypermedia technology. While Riverfront 2000 was not originally designed to be a CPS, it has been adapted through the inclusion of components that support tool usage and group decision support. The St.Louis CPS consists of three components: an information base, a creation mechanism, and an evaluation mechanism.

Initially the system consisted of a riverfront video navigator that allowed the user to fly a conceptual helicopter up and down the riverfront while the corresponding location was highlighted on a map. Later, an information base was added to bring together information collected on a wide variety of subjects concerning the city's Mississippi riverfront. These subjects included: site specific descriptions of potential development, area businesses and industries, residential developments, recreational areas, environmental impacts, past proposals, and general plans. The areas of interest were organized using a "comprehensive plan" metaphor with each subject area represented by an appropriate "chapter". In practice, these chapters are presented as a series of windows. Each chapter consists of a number of "pages" containing relevant information. This information often includes a written description of a particular area of interest.

Using the system's information base, one can access information by: 1) a search of subjects or key words using the system's menu structure, 2) geographic searches for information by pointing to an area of an on-screen map and clicking with a mouse button, and 3) navigating around a site using an on-screen video. All of these procedures yield related information cards, a video image, and an indication on a map of the relevant geographical location.

The system's creation mechanism supports the generation of ideas using a multimedia "brainstorming" component. The interface of this component uses a sketchpad metaphor, where sounds, images, and text can be generated by the user(s) or retrieved from the information base. Also, nodes of relevant information can be retrieved from the information base and grouped together into associative structures for the identification of issues, problem areas, or strategies. The information nodes can be used to visualize a single, complex issue, or a set of different issues. Often, as a group of issues are identified it will become apparent that some of them are interconnected. At this point in the meeting, it may be necessary to take a conceptual step back and view the problem graphically (Figure 3). From this, a number of areas to focus on may become apparent to the meeting participants. Thus, a wide range of issues can be initially considered that are later narrowed into more specific focus areas.

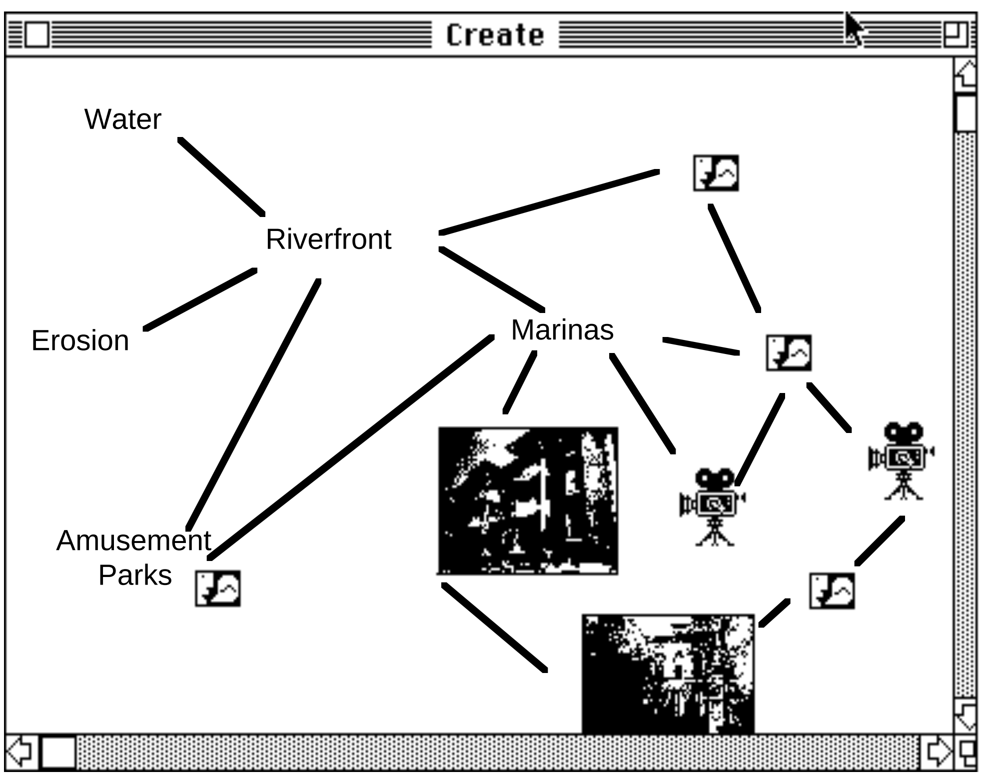

Figure 3: The window that contains the electronic sketchpad for "brainstorming".

The evaluation mechanism of the St. Louis Riverfront CPS is designed to ultimately support a variety of evaluation methods. The system currently makes use of a form of multiattribute analysis based on a Simple Multiattribute Rating Technique, (SMART) described by Edwards (1977). The interface for the evaluation mechanism makes use of digitized video and sound combined with direct manipulation graphics as illustrated in Figure 4. The digitized video is used to identify each alternative. Scores and weights are input by sliding a graphic bar. Sound can also be added so as to better describe an alternative's performance on a given attribute.

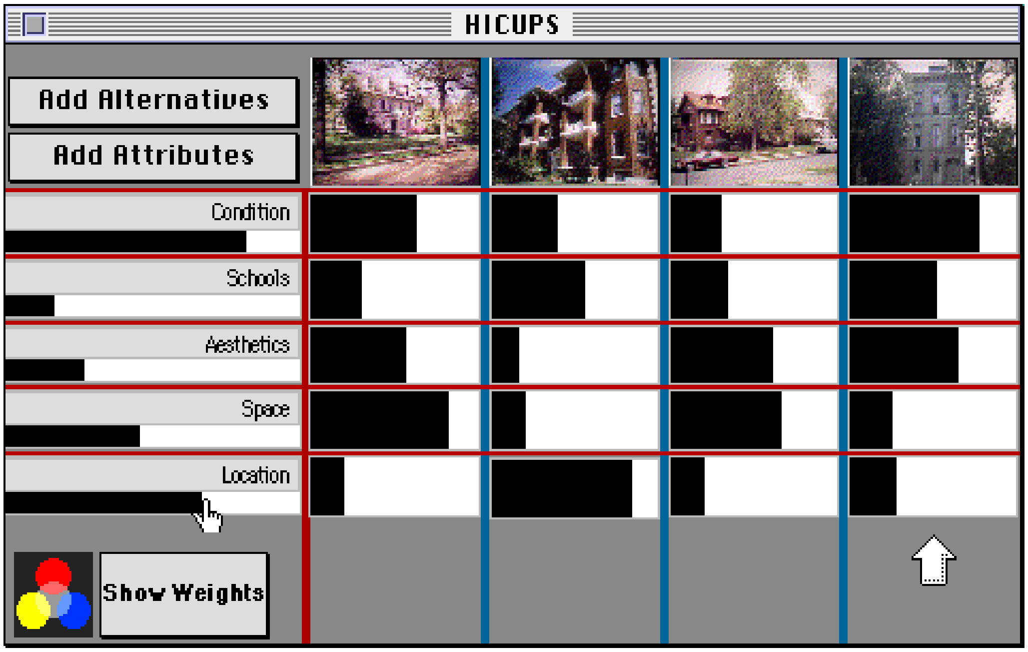

Figure 4: The window containing the multiattribute analysis portion of the evaluation mechanism. Weights and scores are input by sliding the bars with a mouse.

The St. Louis CPS was developed using the comprehensive method of development where as much information as possible was gathered about a specific area (in this case the St. Louis Mississippi Riverfront). This took a considerable amount of time and resources to get the system into a usable form. Start up time alone for the St. Louis system was approximately 150 hours. The textual data was collected primarily by CDA staff members and interns. The video and graphic information was collected primarily by a team of students under the direction of Dave van Bakergem at the Urban Research and Design Center of Washington University. An ad hoc committee chose the information for inclusion in the system. Since the system focused on riverfront planning, the information collected concentrated on sites abutting the river.

Crawford County Illinois CPS

The Crawford County CPS is an example of a simple implementation of a CPS. It consists of scanned maps at varying scales and digitized slides of specific areas. The system also incorporates video sketching tools and a linking and annotation capability for associative information structuring. The system was designed to support a historic preservation workshop of students at the University of Illinois at Urbana-Champaign. The system focuses on four small towns in Crawford County, Illinois. The project participants are primarily concerned with historic preservation initiatives in the town centers.

The Crawford County CPS has been developed using the iterative method. The start-up time of this system was initially five hours. This was considerably less than the start-up time for the St. Louis system which exceeded 150 hours. The system initially consisted of a map linked to photographic images. Text and audio descriptions of particular sites were later added to the CPS.

Development consisted of scanning existing USGS quad maps for each town along with an overview map of Crawford County. Transparent color polygons were overlaid on points of interest. In the case of the county map, a polygon was overlaid on each of the four towns being evaluated. Pointing to the polygon accesses the corresponding USGS quad map. The quad maps also contain transparent color polygons highlighting sites of interest in the towns. Pointing to these areas yield more detailed maps or site sketches that include arrows to represent camera locations and angles for corresponding photographic images. Selecting an arrow highlights it and displays the appropriate photographic image in a separate window (Figure 5). The users could also search through the photographic images for specific visual criteria and see the corresponding locations highlight on the map.

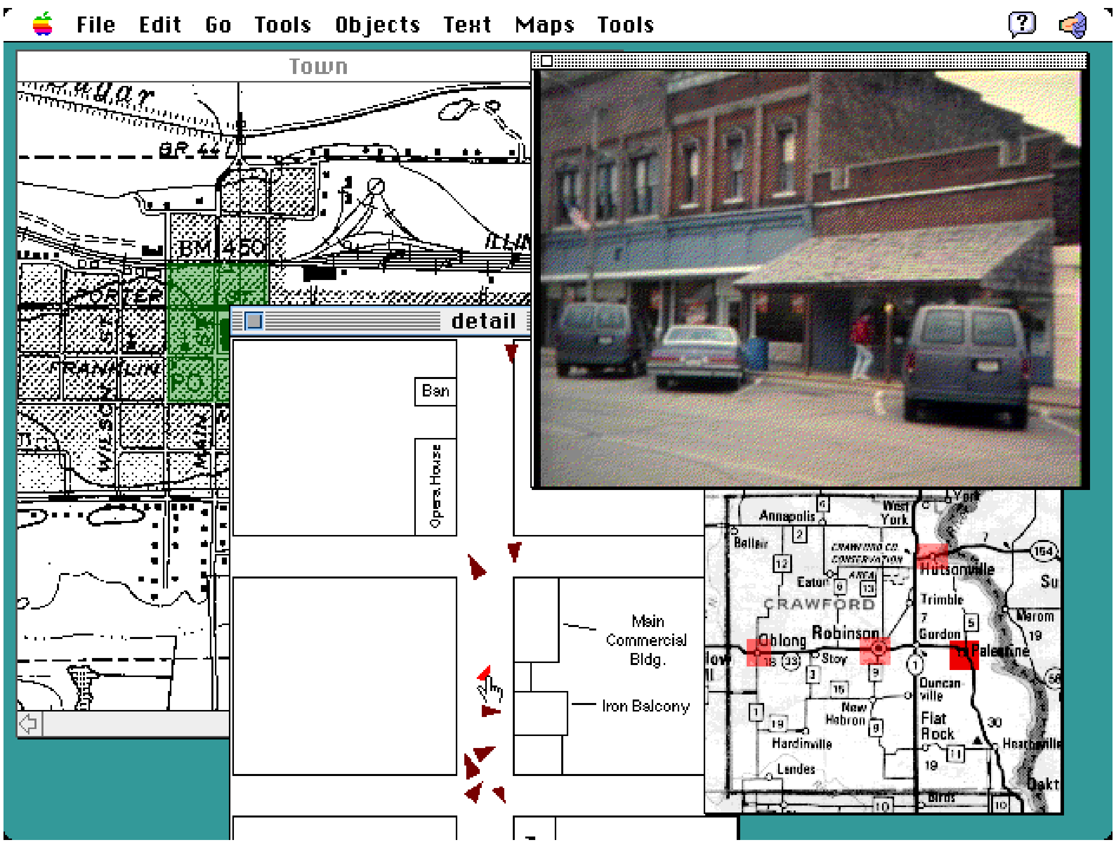

Figure 5: The interface of the Crawford County CPS.

The Crawford County system also includes a video sketching tool that allows the user to create a copy of a displayed image for basic sketching and alteration. The original image remains on the screen while the copy is altered so that the group participants can compare the existing and modified images. As in the St. Louis CPS, annotations to information contained in the system can be either textual, audio, or graphic.

Both the St. Louis and the Crawford County CPS examples support associative information structuring by virtue of their hypermedia linking capabilities. Collaborative work is supported both through the systems' ability to be collectively viewed as well as rapidly annotated during the course of a meeting. In the future, collaborative support can also be incorporated into these systems by using algorithms that encourage the generation of alternatives. Tool usage is currently supported using the evaluation mechanism of the St. Louis CPS and the video sketching tools of the Crawford County CPS.

CONCLUSIONS

Due to the almost limitless potential to displaying information with a CPS, it helps to have both specific geographical and conceptual boundaries in order to maintain problem focus. It is also helpful to have an initial idea of the level or levels of detail that the system will contain. By making these decisions at the outset of system development, the CPS can more effectively meet its objectives. Likewise, time and money is not wasted by including information that is not relevant to the system.

Very few hypermedia systems peak in usefulness immediately after initial development. A process of "aging" or "maturing" occurs as many users interact with the system over time adding ingredients of knowledge by building links and relationships among the data. Thus, the more people that use a CPS, the more knowledge is added to it, making it even more useful in the future.

From the implementation of these systems and others like them, the benefits and drawbacks of CPS can be gauged. In order to assess the relative impacts of these systems on the planning process, it will be necessary to study human interaction with these systems more closely —especially in group decision making environments.

This article has addressed the three barriers of individual tool orientation, inadequate human machine interfaces, and information filtering/accessing difficulties. It has accomplished this by providing the development of a Collaborative Planning System as a method for overcoming the barriers so that planners will have easy access to relevant information in the form of tools, group cognition, and media. The increased access to relevant information aided by the implementation of a CPS can ultimately lead to increases in the quality of plans, number of alternatives generated, and the quality of decisions.

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BIBLIOGRAPHY

Brail, R.K. 1987. Microcomputers in Urban Planning (New Brunswick, N.J.: Center for Urban Policy Research).

Bush, V. 1945. "As We May Think," Atlantic Monthly 176: 101-108.

Collins, A. M., and Loftus, E. F. 1975. "A spreading-activation theory of semantic processing," Psychological Review 82: 407-428.

Edwards, W. 1977 "How to use Multiattribute Utility for Social Decisionmaking," IEEE Transactions on Systems, Man, and Cybernetics 7: 326-340.

Forester, J. 1980. "Critical Theory and Planning Practice," Journal of the American Planning Association 46: 275-286.

Fraase, M. 1989. Macintosh Hypermedia. Vol I, Reference Guide (Glenview, Il.: Scott, Foresman).

Hutchins, E. L., Hollan, J. D. & Norman, D. A. 1986. "Direct manipulation interfaces" in Norman, D.A. and Draper, S.W., eds., User Centered System Design: New Perspectives on Human Computer Interaction (Hillsdale, NJ: Lawrence Erlbaum).

Kindleberger, C.P. 1989. "Hypermedia Systems: Implications for State, Provincial, and Local Government" in Proceedings of the 1989 Annual Conference of the Urban and Regional Information Systems Association.

Laurel, B. 1986. "Interface as Mimesis" in Norman, D. A. and Draper, S. W. eds., User Centered System Design: New Perspectives on Human Computer Interaction (Hillsdale, NJ: Lawrence Erlbaum).

Lowe, D. G. 1985. "Cooperative Structuring of Information: The Representation of Reasoning and Debate," International Journal of Man-Machine Studies 23: 97-111.

Murdock, B.J. 1982. "A theory for the storage and retrieval of item and associative information," Psychological Review 89: 609-626.

Nelson, T.H. 1965. "A file structure for the complex, the changing and the indeterminate" in Proceedings of the ACM 20th National Conference.

Rasmussen, J. 1986. Information Processing and Human Machine Interaction: An Approach to Cognitive Engineering (New York: North Holland).

Rouse, W.B. & Morris, N. M. 1976. "Understanding and Enhancing User Acceptance of Computer Technology." IEEE Transactions on Systems, Man, and Cybernetics 6: 965-973.

Stefik, M., Foster, G., Bobrow, D., Kahn, K., Lanning, S., and Suchman, L. 1988. "Beyond the Chalkboard: Computer Support for Collaboration and Problem Solving in Meetings" in Greif, I. ed., Computer Supported Cooperative Work (San Mateo, CA.: Morgan Kaufmann).

Wiggins, L. L. & Shiffer, M.J. 1990. "Planning with Hypermedia: Combining Text, Graphics, Sound, and Video," Journal of the American Planning Association 56: 226-235.