Multimedia Project Control and Documentation System

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ABSTRACT

Construction experience and knowledge are omnipresent yet difficult to capture at the project site. Many problems and innovative solutions cannot be effectively documented because of the lack of proper tools to collect and organize the as-built information. In claims or disputes, many issues involving site conditions cannot be thoroughly analyzed because of the lack of information. This as-built information may exist in diverse formats such as text (reports, daily logs), sound (meeting recordings, discussions), and video (site walk through, inspection records). Using multimedia technology, these diverse formats of as-built information can be integrated with project scheduling and control systems to provide an environment not only to control and document project information but also to elicit and study construction experience and knowledge. Such information could also be very valuable for facility operators/maintainers in the later stage of the facility life cycle. This paper presents the design and the operation of a multimedia project control and documentation system (MULTROL) under development at the University of Illinois and Construction Engineering and Research Laboratory (CERL). This system allows the users to document and retrieve the as-built project information in the form of text, sound, image and video associated with construction activities. The current version of MULTROL is developed for the PC platform and runs under Microsoft Windows™ operating environment. This system uses graphical user-interface for all operations, creating a user-friendly environment for construction personnel. The retrieval of the as-built information

is further assisted by user-definable queries to support different needs of construction management.

Key Words
project control; construction management; information system; multi-media; as-built project information

INTRODUCTION

The as-built project information represents how construction is actually performed. Designers/Engineers want this information to improve their design. Construction engineers want to know areas where productivity can be improved. Contractors would like to keep this information for their future job and bidding. Owners want the information documented as a basis for payments and claims. All these point to an obvious need, to collect and establish a complete and accurate as-built project information.

Currently, however, few projects have well-documented as-built information because the effort needed to collect and organize this information is enormous. As a result, in claims or disputes, engineers are forced to make judgments based on incomplete information, leaving much room for lawyers to maneuver on behalf of their clients' interests. On the other extreme, many contractors and owners are trying to document almost everything lest they be sued someday. The results are piles of documents which cannot be efficiently transformed into useful data for decision-making. There is a need to develop a system to easily store and retrieve the as-built project information.

The as-built project information exists in many diverse formats, such as text (reports), images (pictures), video (site walk-through), and sound (meeting and discussions). In many cases, information must be processed before it is stored, which inevitably causes some data loss. For example, inspectors usually need to describe the site condition and progress in writing. Due to the fact that each person will describe the same condition differently and the imprecise nature of human language, many facts and details are lost and will never be recovered. Images, video and sound can provide a richer format for preserving information. With the advent of multimedia technology, many diverse formats of as-built project information can be preserved in their original formats with minimum loss of facts. Later, with a multimedia information system, these diverse formats of information can be retrieved quickly and played back in their original formats directly on the computer.

This paper presents the operation and the design of MULTROL, a multimedia information system for project control and documentation. This system is under development by the University of Illinois at Urbana-Champaign and USA-CERL (Army Corps of Engineers Construction Engineering Research Laboratory). A prototype version of MULTROL was developed for the PC platform by using an object-oriented programming language. The system, running under Microsoft Windows™ 3.x, allows the storage and retrieval of information in the format of text, image, video, and sound. Special considerations were

made to create a friendly environment for construction personnel with minimum hardware and software requirements. The system design uses object-oriented programming to achieve maximum flexibility needed during the development phase.

AS-BUILT PROJECT INFORMATION AND CONSTRUCTION PLANNING AND PROJECT CONTROL

The as-built project information plays a vital role in project planning and control. People responsible for schedule updates and adjustments need access to the as-built information to evaluate the productivity and progress. Problems, conflicts, and interferences during construction must be identified so that costly delays and overruns can be avoided. This as-built information also provides feedback to designers and planners. Millions of dollars can be saved from costly rework and change orders if construction problems can be identified early. Two issues are of particular importance to establish useful as-built project information: (1) the collection and storage of information and (2) the efficiency of information retrieval.

Information Collection and Storage

It is desirable to collect useful information and store it with a minimum loss of facts. During construction, the collection of as-built project information has been the responsibility of the project control. Usually superintendents or site engineers fill out daily logs to document the progress and the site conditions. Other information is collected to create reports as required by the contract documents. Most of these logs and reports require judgment or interpretation of the site conditions. This judgment and interpretation are then transformed into textual reports. As we all know, people use different words to describe the same thing and human language is somewhat imprecise. It is difficult to collect a complete and unbiased information through written text only. Many facts and details are lost during the transformation and will never be recovered. Pictures on the other hand provide a richer format to document site conditions. Site photographs are usually taken periodically to complement the daily logs and reports when documenting the site conditions and progress. Nowadays, video cameras are becoming more and more popular to assist the collection of as-built project information.

Once collected, information is then indexed and stored for future reference. Computers are usually used to assist the indexing and retrieving stored information. To view the contents, users still have to go through thick reports or rummage through hours of video tapes to get needed information. With the advances in computer technologies, information can be indexed and stored digitally directly onto the computer, and later be retrieved and displayed on the computer screen as text, picture, video, and/or sound.

Information Retrieval

Timely information retrieval is the key to successful use of as-built project information. Schedule analysis, productivity evaluation, and payments all tie to the project progress documented in the as-built project information. The old methods of searching through logs and reports simply are not efficient enough to satisfy the growing needs for timely decision-making in construction. Computers are a powerful tool to assist the retrieval of information. They can not only retrieve the indexes of stored locations, but also, with proper hardware and software, can display the information directly on the screen as text, picture, sound and video—an information system called "multimedia information system."

MULTIMEDIA INFORMATION SYSTEM

Multimedia information system refers to information systems that are capable of storing and displaying multiple media formats, such as text, picture, sound, and video. Information systems handling large quantities of audio and video information became possible with the advent of videodiscs in the late 1970s. The random access capability of videodiscs allows computers to control and play back audio and video information stored in analog format. Because the high costs for reproduction, videodiscs have not been widely accepted. In 1985, a CD-ROM (compact-disc read-only memory), with a capacity of 650 Mbytes of digital information, costs less than one dollar to manufacture. This triggered wide-spread applications in the audio industry and eventually the computer industry. In digital format, data can be easily manipulated and communicated by the computers. The latest advancements in compression technology have made the digital storage even more cost effective. Digital data can be stored with less space and still can be played back efficiently. Multimedia PCs are rapidly becoming the main stream of the PC industry due to their low cost and the potential benefits of providing a lively information retrieval environment.

CHALLENGES OF DESIGNING AN INFORMATION SYSTEM FOR CONSTRUCTION PERSONNEL

It is a challenge to design a good information storage and retrieval system for construction personnel considering the users' level of expertise in computers. Many capabilities should be considered to make sure that such a system will be accepted by construction personnel. These considerations are summarized below:

1. The system has to be easy to use. No special computer expertise should be needed to operate the system.
2. The maintenance and administration of database should be equally user-friendly.
3. The user should never feel lost. On-line information should be available to guide the user when using the system.

4. The system design and its database should be independent of each other as much as possible. Major changes in one should not require much change in the other.
5. The initial implementation should be an open system that does not constrain its future capabilities.
6. The system should be as hardware-independent as possible making the system available for most existing desktop PCs in the construction industry.
7. The cost to set up such a system should be minimized, so that even small projects/firms can afford to use the system.

Given the above set of design considerations, MULTROL was developed for the PC platform and runs under Microsoft Windows™ 3.x.

MULTROL—MULTIMEDIA MEDIA PROJECT CONTROL AND DOCUMENTATION SYSTEM

MULTROL is an information retrieval system for documenting and retrieving as-built project information. MULTROL has two major functions, information storage and retrieval. Diverse information formats of text, images, video and sound related to a project can be stored and attached to the activities. These diverse formats of information, once stored, are compressed and indexed in a database. Later, when an activity is selected, the associated information can be decompressed and displayed in their original formats.

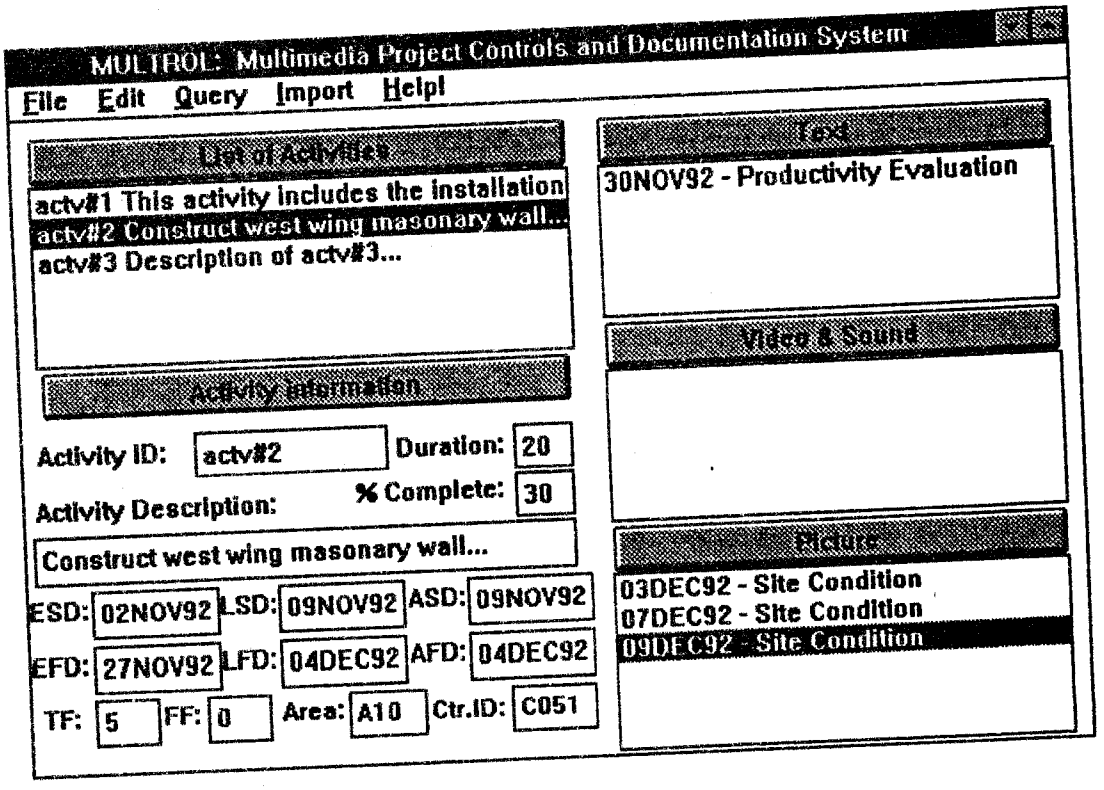

Figure 1. MULTROL Main Window

MULTROL is a standard Microsoft Windows™ application. It uses pop-up windows and a graphical user interface to provide a user-friendly environment for information retrieval. Figure 1 shows the main window of MULTROL. The main windows contains four list boxes and an activity information display area. The list box at the upper left displays a list of activities in a project schedule. The activity ID and portions of the activity description are shown in the list for easy identification during selection. When an activity is selected by the user, detailed activity information; such as the duration, description, early start date (ESD), early finish date (EFD), late start date (LSD), late finish date (LFD), actual start date (ASD), actual finish date (AFD), area, and contract ID; is displayed in the activity information area. The three list boxes to the right, text, video & sound, and picture, display the date and title of different formats of information that have been stored (associated) with that particular activity.

The menu on the main window has the following functions

File:
- Open: to open an existing schedule
- Save: to save changes made
- Save As: to save under a different name

Edit:
- Cut: to cut/delete an piece of information
- Copy: to copy information into clipboard
- Paste: to paste a piece of information into an activity
- Clear: to clear the activity display in the activity listbox

Query:
- Define queries for activity display. Select only the activities desired by the user by specifying dates, activity IDs, contractors, criticality, and areas

Import: to allow import of diverse formats of information into the system.

Help: to display help information

Data Requisition & Storage

The information requisition and storage of MULTROL center on the project breakdown structure. Each piece of information is associated with project activities. Textual information is stored by simply typing in the information with the keyboard or by importing existing files created by other word processors. Pictures, forms, records, and notes can be scanned into images and indexed through easy-to-use graphical user interface into MULTROL. Since video cameras store analog information (sound & video) on tape sequentially, it is difficult to index and retrieve this information efficiently using a computer. The analog formats of sound and video are, therefore, transformed into digital signals. These signals are then processed via video and sound processing systems to index and store the information properly. The voice recognition technology is used to detect simple spoken commands for building indexes. These commands will trigger the voice

recognition module to index and store in-coming signals into digital files. These files are then compressed to save storage space. The compressed video and audio data associated with an activity can later be displayed in full motion and sound.

Information Retrieval

Similar to information storage, the retrieval of information centers on activities in a project. Users can define different queries to extract or locate the desired activities, and then retrieve the associated text, pictures, video and sound. For example, a user can extract activities in a certain area to evaluate the progress of that particular area. Alternatively, the user can extract activities associated with a contract and assess the performance of certain contractors to predict trends in productivity and performance. This mechanism provides the flexibility of retrieving information for different purposes. As a result, MULTROL can be used not only as a documentation system but also as a project control and analysis tool. Figure 2 shows the display of a paragraph of text and a picture in the windows of MULTROL.

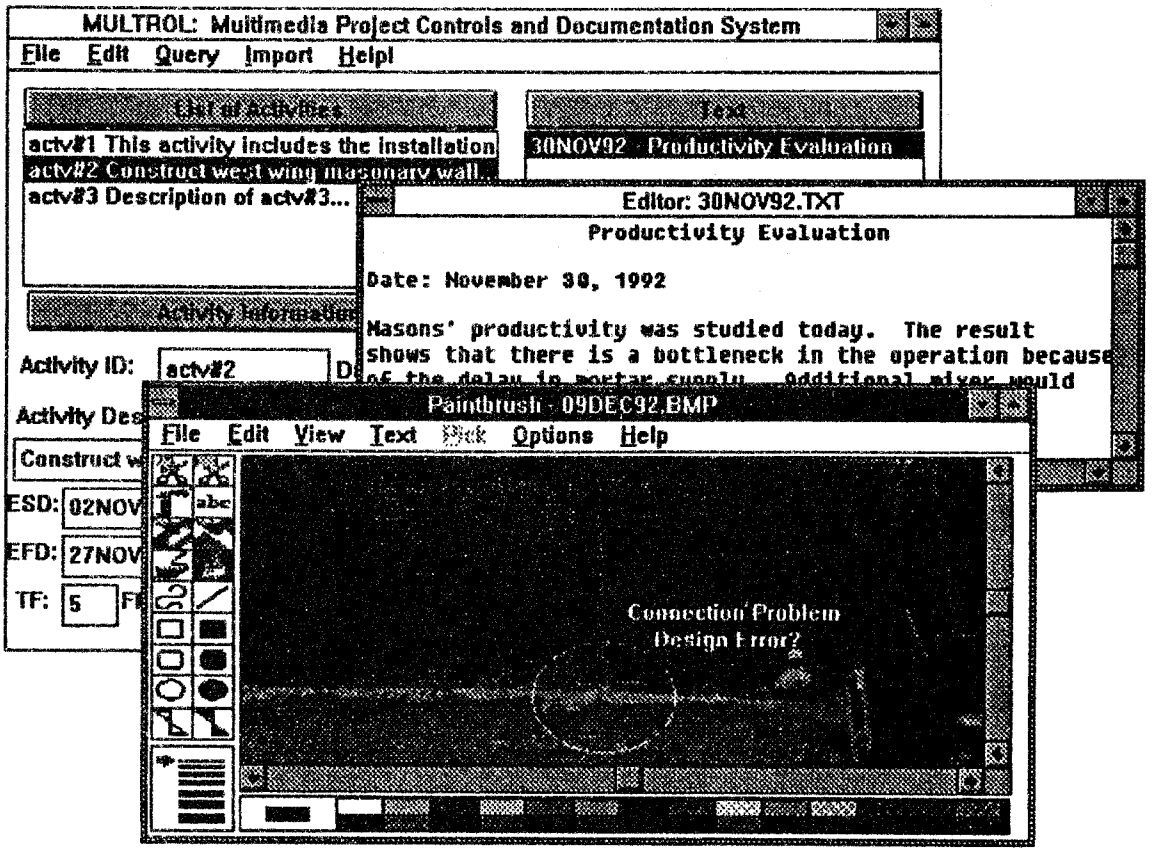

Figure 2. MULTROL Operations

Figure 2 shows three activities in the project: Actv#1, Actv#2, and Actv#3. When the user selects Actv#2 (highlighted), the display list box under Text, Video & Sound, and Picture will show the pieces of information that have been stored for Actv#2. Subsequent clicks on the information items will trigger decompression of digital file and display the information in its original format, displaying text, picture, or video and sound (under development). This information is displayed in pop-up and overlapping windows to maximize the display area because it is possible to stack display windows on top of each other. These windows can be iconized or resized so that side-by-side comparison is possible. The windows have vertical and horizontal scroll bars to pan through different areas of a picture so that it is possible to view a picture which is larger than the display window size. The numbers of windows can be displayed at one time is limited by the memory of the computer. Normally 10-15 pieces of information can be displayed simultaneously. In addition to viewing capability, these windows allow adding additional information as well. Viewers can add comments (text) to the picture, mark regions, and save the changes. This creates an environment to document any ideas and problems which might occur during the evaluation of the as-built project information.

MULTROL vs. Existing Approaches to Project Control & Documentation

MULTROL provides richer and more efficient information storage and retrieval than existing approaches to project control and documentation. Multimedia information in MULTROL combines text, picture, sound and video, and gives users immediate access to project information in a matter of seconds. Because the information is stored digitally, the storage space for documents can be greatly reduced. On average, 300,000 pages of information can be replaced by a single CD-ROM. In addition, digital information can be transmitted through network or telephone lines. Home offices or experts can access site information immediately and directly.

MULTROL SCHEMATIC DESIGN

MULTROL is designed with two major components: (1) information collection/storage module and (2) information retrieval module. The information collection module consists of a graphical user interface to store text, picture, video, and sound associated with an activity. This module also interacts with project scheduling information. The information retrieval module provides the mechanism to retrieve information with diverse formats and user-definable queries. Figure 3 shows the schematic design of MULTROL.

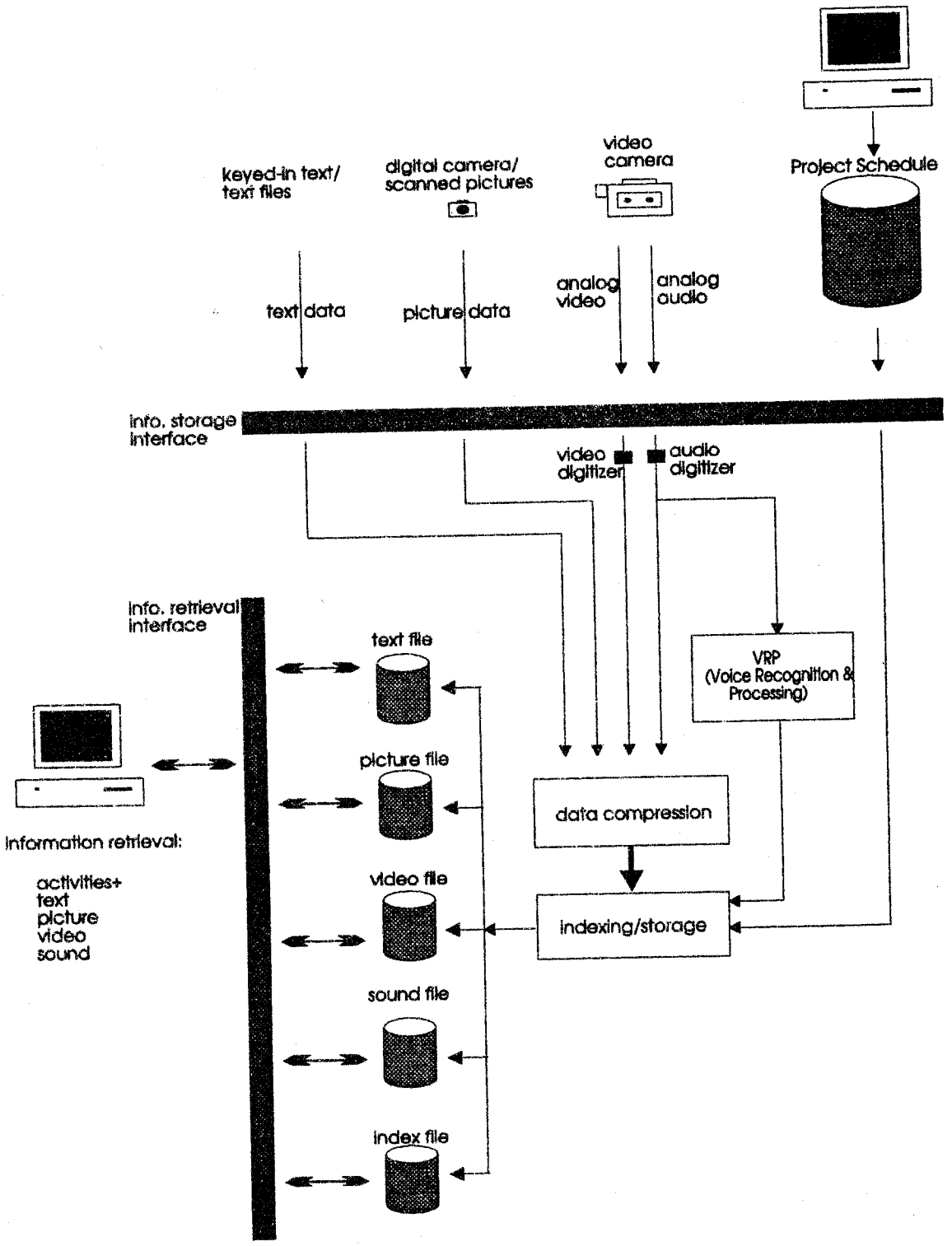

Figure 3. MULTROL Schematic Design

Information Collection Module

The information collection/storage module is a collection of hardware and software that work together to allow user to store different formats of information related to a project. This module interfaces and reads the project schedule information from a scheduling program and allows the user to attach as-built information in the format of text, picture, video, and sound. Text information can be typed in directly using a built-in editor or imported from files created by other word processors. Digital images (pictures from digital cameras) can be stored directly. Other photos, forms, drawings can be scanned and imported into MULTROL. The video and sound data from a video camera are stored as analog format. They have to be converted to digital format and indexed before they can be stored by the computers.

A video board and a sound board, add-on boards for PCs, are used to convert the analog input of sound and video from the video camera into digital files. The sound signal is further processed by a Voice Recognition & Processing (VRP) system to assist the building of the relationship database between the activities and the compressed video and sound files. VRP (under development) processes analog sound and video signals into digital format and, at the same time, builds the database indexes automatically. Basically, inspectors can have a small video camera mounted on his/her hard-hat. Wherever the inspector goes, he/she can control the on/off switch of the camera and at the same time narrate site conditions and the observed problems. The VRP can be trained to recognize certain commands so that when these commands are detected during processing, VRP automatically chunks a piece of analog signal and stored it into proper files. The VRP relies on certain reserved words for commands. These words will be picked up by the voice recognition system and translate into computer commands. As an example, ACTV-ACTV (repeated to distinguish from spoken ACTV) can be defined as a reserved word to signify the start and end of a piece of information. For example, to document video and sound related to an activity, C112203, the inspector can say "ACTV-ACTV C112203" at the beginning and the end to signify the beginning and the end marks for storing information. The alpha-numerics, C112203, are processed and used as an index to establish the relationship database. Any video and sound signals in between are stored and compressed into files that are indexed in the relationship database.

Information Retrieval Module

The information retrieval module consists of a graphical user-interface for displaying activity information and several functional listboxes. The interface responds to mouse operations and translates the menu selection and selection of items on the listboxes into commands. When an activity is selected, its associated information of text, picture, video, and sound is retrieved and displayed in listboxes. If information associated with an activity is requested by the user, this item will call the corresponding display server to display itself, be it text, picture, video, or sound. MULTROL, taking advantage of its

object-oriented design, can communicate through DDE (dynamic data exchange) and OLE (object linking and imbedding) to call outside programs to display information. This strategy keeps the design simple and the development effort to the minimum. The text information is displayed in a built-in editor. Picture information is displayed through Paint Brush, a free software that comes with Microsoft Windows™. Video and sound are displayed through a sound board and Microsoft Video for Windows™.

MULTROL SYSTEM IMPLEMENTATION

MULTROL is developed by using object-oriented programming. All entities in MULTROL including the graphical user interface, database, activities, and pieces of information are all modeled as objects (software entities that mimic the behavior of real world entities). The main advantage of object-oriented design is that each module is loosely coupled. There is very little dependence between modules. Each module responds to a specific set of messages (commands) that will trigger certain functions defined by the module. The message can be the same; however, the object may respond differently, a paradigm called polymorphism. Polymorphism reduces the complexity in system design because a protocol can be defined to simplify the implementation. For example, the same message "show" can be sent to a text object, picture object, video object, or sound object to display the information. How to display is defined within the object itself. Object-oriented programming languages also provide inheritance capability, permitting objects to inherit functions and attributes from the ancestor. This inheritance characteristic makes code highly re-usable and enables use of many functions from the existing code libraries.

Using object-oriented programming allows maximum flexibility for changes and modification during the design and development phases. Because of the access to DDE and OLE mentioned previously, the system can be developed with minimum amount of effort in terms of time and cost. The language chosen to develop the prototype is Symantec-Whitewater Actor, an object-oriented programming language for Windows.

FUTURE DEVELOPMENT

The current version of MULTROL focuses on collecting multimedia information for evaluating project progress; therefore, the indexing and retrieval mechanism is based on project activity breakdown. There are, however, other types of as-built information, such as weather records, material deliveries, and delays, which are not tied directly to project activity breakdown. Plans have been made to expand MULTROL to allow the storage and retrieval of as-built information through multiple and user-definable indexing and retrieval mechanisms to support different needs of construction management.

CONCLUSION

Accurate and complete as-built project information provides benefits to designers, contractors, and owners. Designers can obtain valuable feedback for their design.

Contractors can benefit from well-documented past experience. Owners can document and trace actual construction progress. In disputes, arbitration, or claims, this information could keep all parties honest and potentially avoid misunderstanding and finger-pointing.

With the advancements in multimedia technology and computer hardware and software, multimedia information system can be developed to assist collecting and retrieving as-built project information more effectively. Multimedia information preserves original information formats of sound, images, and videos which eliminates the needs to rely on human processing to text. Stored information can be quickly retrieved and played back directly on the computer in its original format, eliminating losses due to processing or errors.

It is the hope of the authors to provide the construction industry with a more efficient means of documenting and retrieving as-built project information to promote better project control and management, and eventually to facilitate the collection of construction experience and knowledge.

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