The Structure and Application of Task-Centered Multimedia Manufacturing Information System

Track: Information Technology and Management

Bin Wu

School of Industrial and Manufacturing Science, Cranfield University, Cranfield, Bedford MK43 0AL, UK

E-Mail: B.Wu@cranfield.ac.uk

Abstract

This paper discusses the structure of a task-centered, multi-media (TCMM) manufacturing information system which aims to provide a working environment to help the user collect, select and present manufacturing data according to the specific needs of managers/operators. With a task-centered user interface and an integrated computer-based training (CBT) module, such a system can be used at various levels within the organization both as a computer-aided training tool, and as an interactive system to help carry out on-line operations. A number of cases of industrial TCMM application are also presented.

Introduction

With a task-centered user interface, on-line referencing, digital manuals and an integrated computer-based training (CBT) module, a task-centered, multi-media (TCMM) manufacturing information system aims to provide a user-friendly information environment. It can be used at various levels within a manufacturing organization as: a reference library to provide information about product data and operational procedures; a task-centered, interactive system to help carry out on-line operations; and a computer-aided training tool to train the company's managers/operators. The platform used for system development involves the web technology and the HTML language. These provide facilities for the system's electronic format and its distribution, and allow a TCMM to combine the capabilities of formerly separate entities such as animation, graphics, video, text, etc., to support the structure of an open system, linking documents of various types in a task-centered way.

This paper starts by proposing the generic structure for a TCMM system. It identifies the critical requirements related to a task-centered approach, and outlines the required system functionality and contents. The paper then reports a number of cases of industrial application and discusses how the collaborating companies have benefited from the the implemented systems.

Task-centered approach

The concept of a task-centered approach within the context of this paper is partially the result a previous research project funded by the UK Engineering and Physical Science Research Council (EPSRC GR/J 84656). Although the main concern of this project was with computer-aided manufacturing systems design, its task-centered approach for information grouping and presentation provided valuable insight for the proposed TCMM

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structure (Wu, 1997; Wu and Ellis, 1997). In general, the development of future information systems should strongly emphasize the thorough understanding of the task in hand, making sure that the managers/operators are provided with the essential information where and when needed. For example, in order to carry out a manufacturing task efficiently and effectively, the operators need to have access to a range of relevant information, such as component drawings, assembly drawings, detailed written instructions of the operational sequences, etc. Ideally, this information should be provided to the operator in a focused and accessible way, relevant to the job at hand. A task-centered approach is a useful concept because it conforms to the way that humans do their work every day. It concentrates on the management and organization of data/tools in a way that the user can understand. Specifically, it aims to develop a generic, structured method for the design, implementation and maintenance of a TCMM manufacturing information environment which will enable the user to collect, select and present manufacturing data according to the specific needs of a particular company. Reflecting these requirements, the following concepts and techniques have been explored:

1) ***Task-centered approach.*** Task-centered is the concept of providing all the information relating to a particular task “on-line” to the point where the task is to be executed, allowing the user to navigate through the system as required and access the relevant information in a focused way. Necessary elements such as task description, instructions, processes, drawings, tools and data should be assembled and integrated into a single working page, and presented to him/her as a single entity, here known as a "task document" (*see Figure 1*). The efficiency can be further enhanced by providing photographs/video of, for instance, complex setups and any special fixturing configurations (Leung et al, 1995).

2) ***On-demand training.*** This provides comprehensive "know-how" on the processes involved, and addresses the need for timely provision of training about specific tasks due to, for example, new product introduction.

3) ***Electronics documentation.*** This solves some of the problems associated with paper-based documents. One of the possible approaches is a web-based document management system delivered through the company Intranet. An obvious advantage of this is the reduction of effort and cost in updating and maintaining the content of the system. Once the electronic workbook is up and running through the Intranet, many sites connected to the network can access the most relevant and up-to-date information. Similarly, this can be achieved through a CD-ROM based approach.

The generic TCMM structure and system development

The generic overall structure and functionality of TCMM is as shown in *Figure* 1, with:

A digitized reference library to provide information such as products data and operational procedures (Module a). This module uses a Web-based database of reference manuals to provide a means of supplying company personnel with comprehensive tools for looking up procedures and product information. A client-server model can be implemented to allow a centralized reference management system, enabling the development of an open environment. In this case, HTML is

normally chosen as a front-end application as it is the standard for web applications. It can support simple multimedia objects and has the added benefits that both authoring and viewing tools are widely used and well known. Furthermore, the approach is cost-effective, easy to install and highly flexible. It allows for change without major systems development efforts, and the skill requirements are relatively low (Ginige et al, 1995; Koshy et al, 1996). The HTML front-end can be connected to a database back-end if required.

A task-centered, interactive system to help carry out on-line operations (Module b). Here the system should support the current operations in a task-centered way. This module requires formal specification of a generic task-document frame and implementation of a selection of task documents for various levels of an organization. In addition to presenting data in such a user-focused manner, a more sophisticated web-based documentation system is needed to allow the user to send a feedback to the server, hence enabling two-way communication. Linking to other IT applications, can be established using the ActiveX technology or Dynamic Link Library.

A computer-aided training tool to train the company's managers/operators (Module c). Here the system runs in 'offline' mode while the user progresses through a training sequence. This allows a first time operator to learn about how to carry out a new task/operation from start to finish with either minimal or no external training. Typically this part of the system should provide *structured lessons* that guide a trainee completely through the process of concern, o*perational simulation* with a virtual environment for the trainee to explore and experiment through simulation, and *learning assessment.*

TCMM application

According to the generic TCMM structure and system development approach previously outlined, a number of TCMM systems have been developed and work have been carried out in all of the main areas of concern. This section provides an example of these. The collaborating company involved in this case is part of a global provider of integrated communications solutions. The organisation is dedicated to the research, development and manufacture of GSM (Global System for Mobile Communications) equipment, the digital standard adopted world-wide for mobile telephone technology. The manufacturing processes involve the production and assembly of mainly base transceiver stations. These are used as part of the infrastructure to support the providers of GSM services. World-wide demand for the equipment is such that the manufacturing process is continuous 24 hours a day, seven days a week. The environment in the assembly area of the base transceiver stations is highly automated but the human factor is important in testing the final products. The testing remains labor intensive, and depends on the operators' experience. With many varieties of configurations, the traditional approach makes it difficult to guarantee the standards and quality of the operations. The company had been trying to consolidate its manufacturing processes by maximizing the use of its resources in personnel, hardware, software and information technology. In particular, the organization was developing a generic platform to enhance the efficiency of its production test facilities. Its objective was to provide an infrastructure for

communication, sharing and recycling resources, reducing test development cycle time, minimizing manual operations, and improving the faultfinding processes. Within this environment, all the engineers will share their experience in various aspects of systems engineering and will develop test systems concurrently. The system also aims to provide series of tools and functions to be used throughout the factory for the testing of multiple products. The situation has provided an ideal test-bed for the research and development work of TCMM, with the possibilities of testing all of the project objectives as outlined previously. As part of the company's overall initiative, a fully functional TCMM system has been developed, providing a working environment to train the company's new operators, as well as its joint venture partners in different parts of the world. Utilising the TCMM concept, the two main objectives identified are to develop a system that:

Supplies the testing area personnel with a comprehensive tool for looking up technical information about products, testing equipment and procedures. This should be of use to first time operators, as well as skilled technical personnel.

Provides a tool that would teach a first time operator to test a product from start to finish with either minimal or no external training. The system should also provide an assessment tool for the qualification of the trainees, and for recording the performance of skilled personnel.

The overall system structure is as shown in *Figure 2*, with the following modules.

Reference Module. The reference module serves as the knowledge repository of the system. It contains all the technical information relevant to the testing procedures, the base stations, and the technology used. The reference module can be readily accessed within the system whenever the users require more in depth technical information about a subject. The information contained in the reference module is organised into four related parts. Each of these parts is then subdivided into smaller sections in order to make the retrieval of information easier and quicker. All these parts are linked, either directly or indirectly, to help in cross-referencing. Organising the information in this way also facilitates the maintenance/updating of the data.

Training module. The training module provides a new trainee with introductory information about four different subjects: overview of GSM and its component parts, product information, equipment information (cable connections required between different instruments in order to set up tests), and test information (test procedures that an operator must follow in order to test a product). The subjects are presented in sequential chapters. This format is considered the most appropriate for training purposes since the trainee is required to cover all the material included in the desired sequence. At the end of each chapter, the trainee has the option to carry out a self-assessment. This facility provides him/her with feedback on the progress made.

Simulation module. The simulation module here is a sub-set tool of the training module. It provides a virtual environment of the testing area, and a suite of tools that allows a trainee to learn and try out a complete cycle of the testing process. The system is interactive with the trainee throughout the simulation run. It provides step-by-step instructions, a list of options for each action to be carried out, and possible tools and/or devices. Icons symbolising the tools, devices and plugs needed during

the testing process are available in the right column, and can be clicked if the trainee requires a particular piece during the exercise. The system then monitors the actions undertaken by the trainee, and—depending on whether the required one has been chosen—either continues the operation or offers instructions and help. At any time during the simulation cycle, the trainee will have access to all of the product information and operational documentation by simply clicking the reference button. This on-line facility is useful for finding answers to questions that the trainee may have on hand. In addition, video clips are available to provide further guidance as requried. The simulation process is developed mainly using Dynamic HTML, which allows the development of a virtual environment for the interactive actions that can be performed on the cabinet.

Assessment module. This complete the logical cycle of training that is adopted within the TCMM environment (lessons/simulated operation/qualification). The qualification module developed follows a straightforward procedure. After the corroboration of the identity of the employee, a set of questions is selected randomly from a database. The trainee's choice of answers is assessed and results recorded for both self-assessment and employee qualification. A final report can to be generated at the end of the offline training session.

The management of the company has carried out a detailed survey to evaluate the effectiveness of the system. Feedback from these has been very positive. It was pointed out that, compared with the existing approaches that leave the users almost entirely on their own to identify relevant data/information to support the manager/operators' current work, the TCMM working environment equips the user with a structured, user-friendly way to make use of company information/operational manual/data. Out of a choice ranging from "poor" to "very good" regarding the system's overall performance, more than 80% of the group considered the system as "very good" or "good". The system will be both supplementary to the company's exiting system and compatible with its new information environment, currently under construction. When developed in line with the current systems, utilizing the same application, user interface, development procedures and methods, TCMM will help achieve a more flexible and user-friendly system across all platforms. In this regard, the use of the HTML environment allows an easy on-line implementation from any part of the factory over its Intranet. Also, a CD-ROM version has also been developed for the system to be used on a stand-alone basis. This can be easily dispatched to the organisation's joint venture partners in other parts of the world.

Conclusion

This paper has outlined the generic structure of a task-centered, multimedia information environment, aiming to provide a generic method for a manufacturing organization to analyze and utilize its information in a user-oriented way. Although multimedia was mainly used initially for entertainment purposes, a large number of applications have been introduced in the industrial sector, with the main applications being computer-based training, on-line referencing and digital manuals. They have the potential to enhance the traditional manufacturing systems. However, the initial design of such systems must be very carefully considered, because the way in which they are structured and organized

will have a profound effect on the way in which information can be delivered and utilized to support the company's strategic aims. The concept of the TCMM approach provides a logical implementation foundation, providing a general mechanism for MIS task/tool/data integration, so that the operator is given direct, structured and ready access to relevant information and tools. Its practical applications up to date have illustrated clearly its value both as a self-contained information system, and as a supplementary system to the existing databases and other information applications. Furthermore, its structure as a "knowledge repository" should lend itself to grow and adapt, as the company's product ranges and manufacturing processes progress through time. The collaborating organizations have all benefited directly from the work, and knowledge gained through this is expected to be of significance to an area in which many manufacturing organizations are seeking help.

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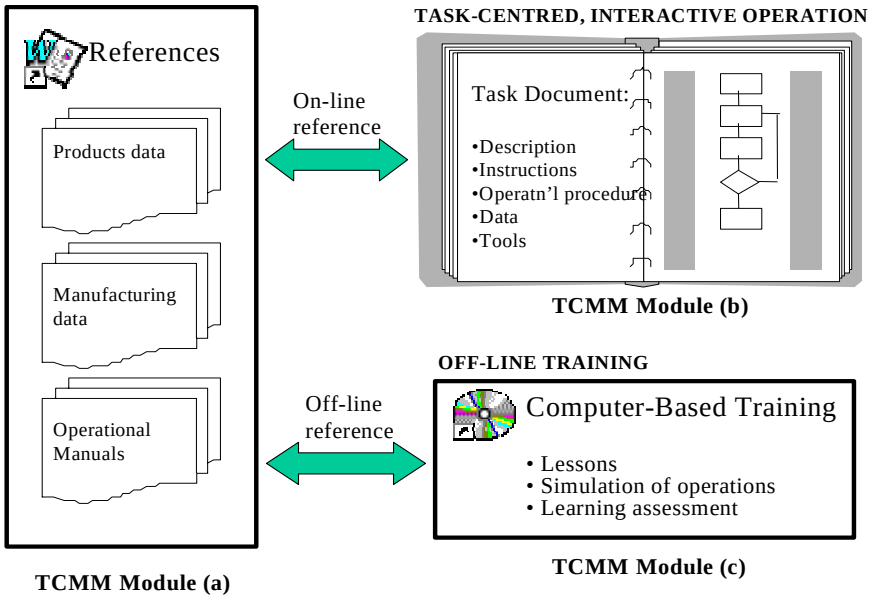

Figure 1 General structure of a TCMM system

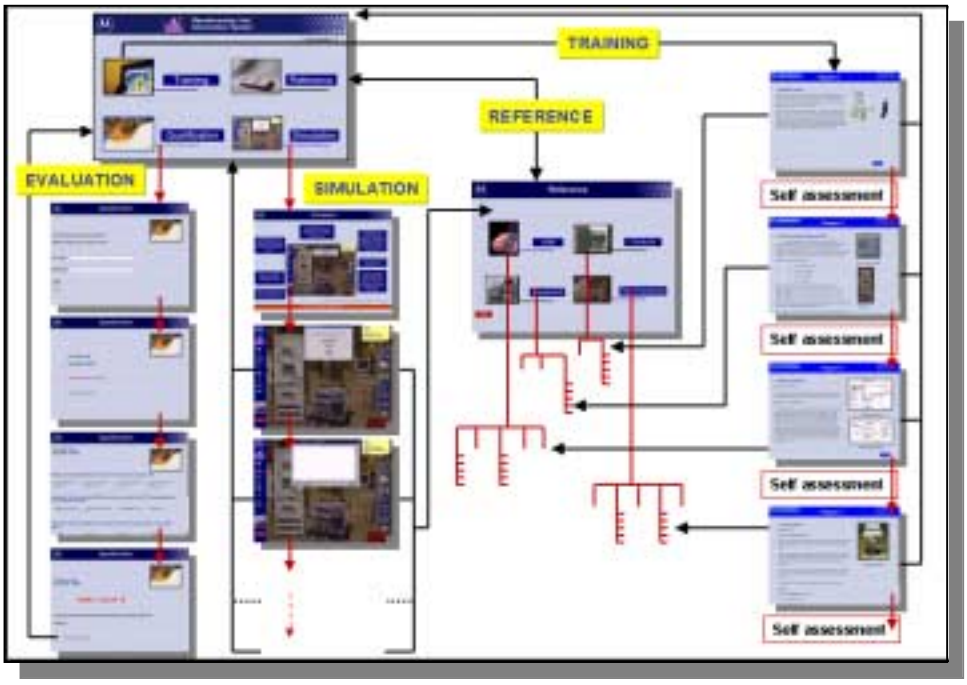

Figure 2 TCMM implementation