DEVELOPMENT OF A LAN SYSTEM FOR TEXTILE COMPUTER INTEGRATED MANUFACTURING

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Abstract: Today's textile industrial complex is characterized by a multitude of conflicting demands: increased product flexibility, higher product quality and decreasing delivery times. To operate successfully in such a demanding and highly competitive global market, textile industry must deploy the state-of-the-art *manufacturing* and *information management* techniques. This paper outlines the construction of a LAN (Local Area Network) computer system, which is the base of a *knowledge-based* monitoring and management system, for a textile factory having the departments of weaving and dyeing. In the development of the network, hardware choices and programming methodologies; ISO 9000 standards, work in process tracking with barcode and the design of a future intelligent process management system that will effectively utilize the distributed databases in the enterprise are taken into consideration. The network software has a scaleable, 32-bit high-performance *Client/Server* structure running under Windows NT and Windows 95.

Key Words: Knowledge based monitoring system, Computer integrated manufacturing.

Tekstilde Bilgisayar Destekli Üretim İçin Yerel Ağ Sisteminin Geliştirilmesi

Özet: Günümüzün tekstil sanayii, artan ürün çeşitliliği, yüksek ürün kalitesi ve azalan teslim süreleri gibi birçok birbiri ile çatışan istekler ile karşı karşıya gelmektedir. Oldukça rekabete açık küresel pazarda, bu şekildeki istekleri yerine getirerek çalışabilmek için, tekstil sektörü üretim ve bilgi yönetim tekniklerini kullanmak zorundadır. Bu makale, dokuma ve boyama bölümlerine sahip bir tekstil işletmesi için, bilgi temelli görüntüleme ve yönetim sistemi esasına dayanan yerel ağ yapısını tanımlamaktadır. Böyle bir ağ yapısının geliştirilmesinde, donanım seçimi ve programlama metodolojiler, ISO 9000 standartları, barkod ile proses takibi ve işletmede bulunan veritabanlarının kullanımını etkileyecek proses yönetim sistemlerinin tasarımı dikkate alınmaktadır. Ağ yazılımı, Windows NT ve Windows 95 altında çalışan, scalable 32-bit yüksek performanslı kullanıcı/server yapısına sahiptir.

Anahtar Kelimeler: Bilgi temelli görüntü sistemi, bilgisayar destekli üretim.

1. INTRODUCTION

Many plants in industry use monitoring systems to control and to manage their production. The latest developments are in the area of applications of *Knowledge-Based Expert System* (KBES) to monitoring systems. These two technological trends are being used in many industrial fields, but there are few applications in the textile industry (Adolphe and Drean 1995, Arakawa and Ono 1995, Jayaraman 1995). Process monitoring, management and planning in a textile factory are complex activities and the expertise for these processes is invaluable. Since human experts are scare, this area of enterprise activities is a potential domain for the application of KBES technology.

Traditionally, optimization tools such as linear programming have been used in the production planning and scheduling functions of the manufacturing enterprise. However, such purely algorithmic approaches for optimization, do not account for some realities of the manufacturing shop floor operations. Constraints are not always linear, and the schedules are frequently modified to accommodate changing product demands and availability of resources (operators, materials and machines). The individual's experience and expertise greatly influence both the way the function is carried out and the resulting schedule. While the task itself is fairly well-defined, there is generally a shortage of experienced planners,

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thus making this task one of many suitable candidates for the development of a KBES. For example, in weaving and dyeing processes, the expert's opinion that the fabric has been woven and dyed to the right shade is the outcome of a complex knowledge processing task that cannot be often be encoded in black or white. In the inspection of produced cloth rolls, the reasons for fabric defects are not so clear in many cases. We can apply the principles of fuzzy logic and expert systems to many processes in weaving, dyeing and quality control in the textile mill.

This paper outlines one part of a large project under development, and is a joint work of the Electronics and Textile Engineering Departments with a textile factory in Bursa. The first target of the project is the design and construction of a LAN computer system for the textile factory having the departments of weaving and dyeing. The network has a flexible structure which can be configured according to the scale and need of the similar textile factories. In the development of the network, hardware choices and programming methodologies; ISO 9000 standards, work in process tracking with barcode and the design of a future *intelligent process management system* that will effectively utilize the distributed databases in the mill are also taken into consideration. This paper discusses the *automated production* (*Computer Integrated Manufacturing—CIM*) activities in textile weaving and dyeing processes. However, CIM involves not only the production activities but also marketing, sales, engineering, materials, finance, and personal.

2. ELEMENTS OF AN AUTOMATED TEXTILE MANUFACTURING SYSTEM

The elements of an automated textile manufacturing systems can be the following: Sensors, actuators, industrial robots, computerized textile machines, Programmable Logic Controllers (PLCs), material transport systems, barcode readers/writers, microprocessors based controllers, personal computers (clients) and mainframe computers (servers). A textile manufacturing communication network is intended to interconnect the preceding elements. Since the subject of automated manufacturing for textile production is too broad, we concentrate on production planning and control whose main attributes are monitoring and control.

3. TEXTILE PRODUCTION LINE PROBLEMS

As compared with general production lines such as TV or car assembly lines, the textile production factories has some peculiarities. Some of these are as follows:

- There are many causes of forcing weaving machines to stop working. Since the time necessary for restarting the stopped machine depends on the causes, it is difficult to precisely predict the time on which the product on the machine will be finished.
- The quality of the product is approximately proportional to the number of times the weaving machine stopped. In other words, the machine halt affects not only the productivity but also the quality of the products.
- There are many machines without capability of communication with external devices. Therefore the automatic monitoring of these machines under a LAN are not possible.
- The installation of a LAN system is not taken into account in many factories.

Taking these into consideration in the project; the overall principles of developing a LAN system for a textile management system is given, and the development of the future expert systems based on the statistical data provided by this LAN system is considered.

4. A MONITORING AND CONTROL SYSTEM FOR A TEXTILE FACTORY

Several hierarchical monitoring and control models for CIM have been suggested in the literature (O'Grady 1986, Juan 1990). The *Automated Manufacturing Research Facility* (*AMRF*) model of National Bureau of Standards (NBS) is used in the design and development of the monitoring and control system for the textile mill. The AMRF model has the following levels:

1. *Facility (factory) level*: This is the highest level in the hierarchy, and it includes process planning, production management (including long-term schedules), manufacturing engineering, and information management, with links to financial and other administrative functions.
2. *Shop level*: It manages the coordination of resources and jobs on the shop floor. (Task management and resource allocation).
3. *Cell level*: Production cell control systems for scheduling and controlling the jobs. (Batch management, scheduling, dispatching).
4. *Workstation level*: Set up, equipment tasking, take down.
5. *Equipment level*: The lowest level of the planning and control hierarchcy, the controller for individual resources such as machine tools, robots, or material handling systems and associated sensors and actuators. (Machining, handling, monitoring).

Some functions are generic enough so that they can be performed at different hierarchical levels. The functions performed at each level are of the following types:

- resource monitoring,
- planning information update,
- requirements generation,
- scheduling of part production,
- resource planning (e.g., tool allocation),
- event generation,
- status monitoring,
- event prediction, and
- performance evaluation.

For many textile mills having weaving and dyeing departments, the textile processes can be described by a block diagram given in Figure 1.

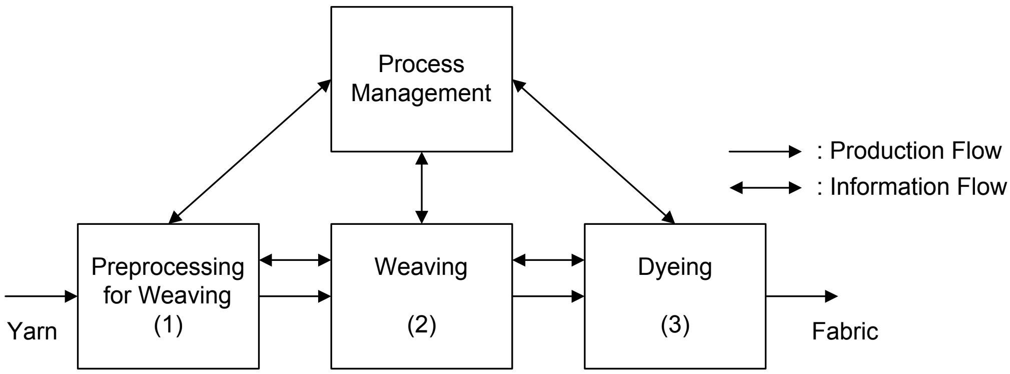

Figure 1.
Departments in the production of textile fabrics.

5. TEXTILE PRODUCTION CELLS AND TERMINALS

The detailed process flow and the LAN network to monitor and control textile processes are shown in Figure 2. Textile fabrics manufacturing operations are broken down into cells (such as warp and sizing processes, weaving on machines, different storage and inspection points), with each cell responsible for a specific job. Cells are interconnected by a manual transport system for material and finished products. Each cell may have several workstations (subcells or subjobs) and each workstation may have different equipment. The computers running under three separate servers are located to monitor production points (cells), and to collect data from each department. These servers are connected to the main server in the Process Management department. The computers collect data mainly in semi-automatic ways by the operators. Each PC in Figure 2 represents one or more than one computer terminals.

The input of the factory is yarn and the final product is finished textile fabrics. The Process Management where all the factory management activities take place is performed in a central office located away from three textile processes (Preprocessing, Weaving and Dyeing). These three processes are generally performed in separate buildings, and also they have not to be in the same factory. The target factory has all these three processes in separate buildings physically close to each other.

5.1. Preprocessing for Weaving

The yarn quality control is the first operation in the production line. The quality and yarn storage information is updated by the yarn storage terminal PC1. The warp and optional sizing operations are the next processes. In the warp process, the stop and start of the warp machine operation is performed manually, and the time duration (machine stop) is measured by an electronic way. When the warp and sizing operations are completed, the database is updated by the operator using the terminals PC2 and PC3.

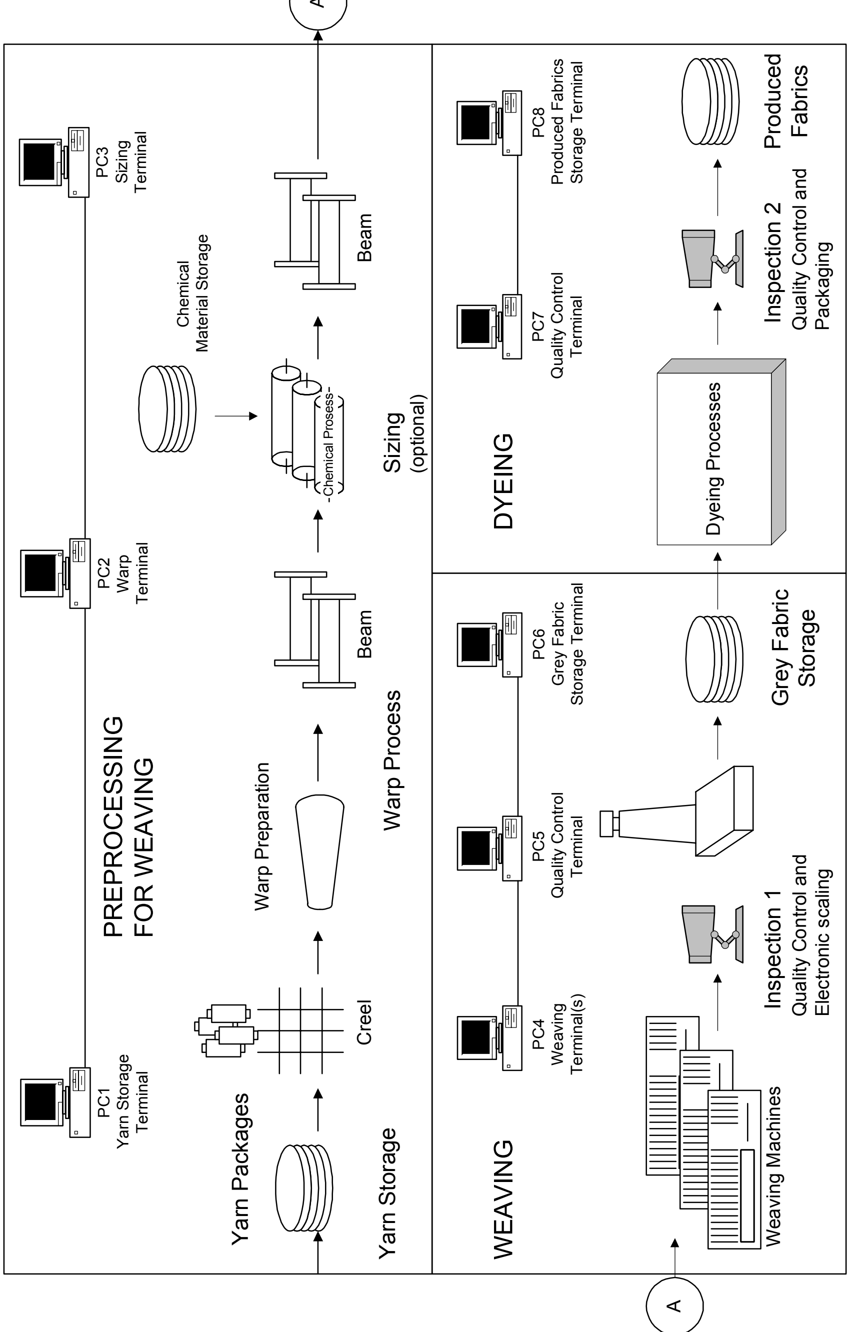

Figure 2.
Simplified work flow and the LAN Monitoring System for Weaving and Dyeing Processes.

5.2. Weaving

After the preprocessing for weaving operation is completed, the weaving process starts. As a general procedure, the following operation is repeated in the weaving department: When a maximum cloth-length is produced by a weaving machine, the operator stops the machine, cuts the cloth off, and sends it to the inspection process. To measure the cloth-length, generally a semi-electronic counter or a mechanical counter, which basically measures the rotational angle of the friction roller, is used.

In Figure 2, PC4 represents one or more than one computers. If the working weaving machine in the plant has the capability of communicating with a computer, each machine or a group of machines can be monitored and controlled by a computer. In this case, data are collected truly in an automatic way. Otherwise, after each cloth roll is produced, the necessary information is entered by an operator manually. Therefore, PC4 terminal or terminals are responsible for setting or modifying the settings of the operations by means of a nodal computer in an individual or grouped way, transferring all the settings parameters to the machine, storing the gray fabric quality characteristics and transferring these data to a higher level in the network hierarchy. PC5 represents the quality control terminal for the first inspection, and PC6 represents the gray fabric storage terminal.

5.3. Dyeing

The dying processes are the last operations in the production. In figure 2, only the quality control terminal PC7 for the second inspection, and the produced fabrics storage terminal PC8 are shown. Actually there are more terminals and operations in the dyeing department.

6. A CLIENT/SERVER DISTRIBUTED COORDINATION MODEL FOR TEXTILE CIM

The textile LAN monitoring system described in this paper is a distributed ethernet network. Critical design issues for distributed systems include (Adler, 1995):

- locating programs and data resources distributed across the network,
- establishing and maintaining interprogram communication on the network,
- coordinating the execution of distributed applications,
- synchronizing replicated programs or data to maintain a consistent state,
- detecting and recovering from failures in an orderly, predictable manner, and
- securing resources by limiting remote access to authorized users.

Coordination models represents one way to handle these diverse design issues coherently and uniformly. The client/server architecture, one coordination model widely used in distributed systems is used for the textile mill. The client/server coordination model offers simplicity in closely matching the flow of data with the control flow. The model also promotes modular, flexible, and extensible system designs. Any data resource or computing operation can be organized, integrated, and accessed as a service. Services include operating system functions (such as naming and authentication), shared information resources (such as networked file systems and printers), and applications (such as database engines, electronic mail, and dedicated graphic or numeric compute engines). Programs can act as either clients or servers, depending on the context.

The distributed databases of the textile fabrics production processes described above are shown in Figure 3. These databases are linked closely to each other and are updated on real-time by the production cells with information such as working rates of weaving machines, the cost of each process, and the results of quality inspections.

The main server in the Process Management department collects different kinds of data from all three departments through the network. The databases accessed by the main server are distributed databases or remote databases with some duplication of data, instead of centralized databases. The main server will have data mainly for the product management, quality control, machine control and textile management operations.

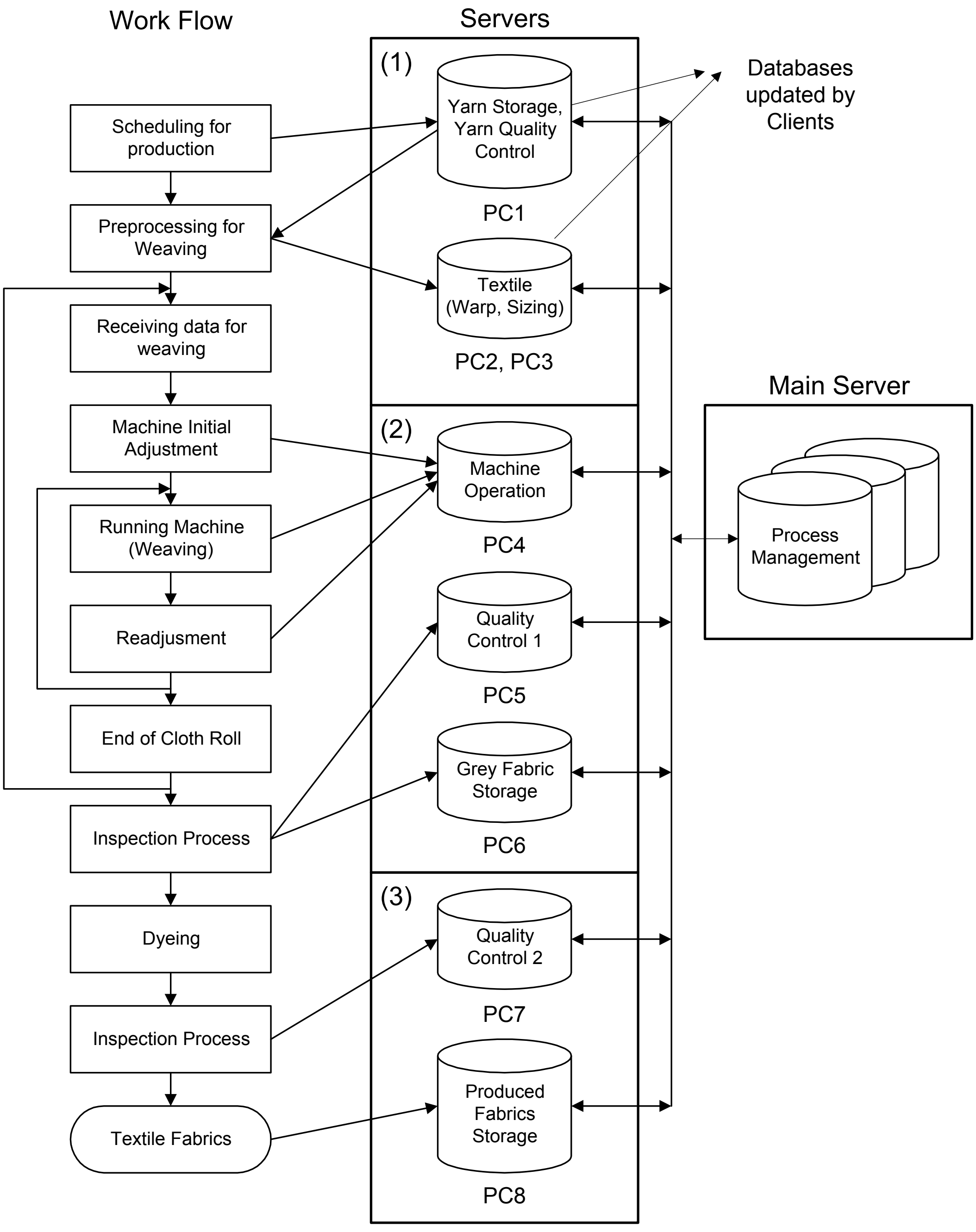

Figure 3.
The work flow and related databases of the textile fabrics production processes.

7. TEXTILE INFORMATION MANAGEMENT AND EXPERT SYSTEMS

The computer scientist has resorted to conventional data processing for a long time; however limitations of this approach have forced the scientist to explore other techniques, specially the application of KBES to solve the problem. The software developed for this system can carry out analysis in relation to the different kinds of data so that it can help the expert in his/her own analysis. It can perform prediction of the time needed to finish products, schedule new products, the reasons of fabric defects, the analysis of causes that weaving machines are forced to stop, and so on. It can output various kinds of reports as the results. Different expert systems can be developed for this LAN-based monitoring system using the distributed databases as shown in Figure 3 in the mill. One example of an expert application for this system is presented in (Babaev, Gümüşkaya, Ulcay 1997).

8. CONCLUSION

The network software has a scaleable, 32-bit high-performance client/server architecture running under Windows NT and Windows 95. The software will support the InterBase, Oracle, Sybase, Informix and MS SQL Servers depending on the needs. Currently the programs have been developing using the Delphi 2.0 Client/Server Suite, and they have been using the InterBase databases (Delphi 2.0, 1996).

The outlined LAN system has a flexible structure which can be configured according to the scale and need of the factories. It supports the high degree of automation, integration and flexibility which are major characteristics for automated manufacturing systems.

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