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"SYSTEMS INTEGRATION THROUGH ON-LINE REPORTING STATIONS"

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"SYSTEMS INTEGRATION THROUGH ON-LINE REPORTING STATIONS FOR MANUFACTURING CELLS"

INSTITUTO TECNOLOGICO Y DE ESTUDIOS SUPERIORES
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MAESTRIA EN TECNOLOGIA Y OPERACION DE CELDAS DE MANUFACTURA

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Javier Prado Guerrero

Systems Integration Through On line Reporting Stations.

COTENTS:

Chapter 4.- Data Acquisition and Control Systems.

Chapter 5.- On Line System Design.

6.- System Implementations Issues.

7.- Conclusions.

"Systems Integration Through On Line Reporting Stations for Manufacturing Cells"

Chapter 1

Introduction.

1.1 The Evolution of Computer-Controlled Manufacturing Systems.

The revolutionary change in factory production techniques and management that is predicted to take place by the end of the twentieth century will require unprecedent involvement of computer controlled systems in the production process.

Every operation in this factory of the future, from the product design, to manufacturing, assembly, and product inspection, will be monitored and controlled by computers, and performed by robots and itelligents systems.

During the last decade computers became very powerfull. Their control capabilities have developed at a rate which surpasses many other technological advances of this century, because of this sophistication. Manufacturing now is refered as a science, this is because in order for the computer to handle information and processes efficiently, the data and statistics, as well the manufacturing process must be seen in scientific terms, logically and clearly defined. This information must be given to the computer in a very organized fashion. The big advantage of using computers is efficiency.

In order to integrate computers and microelectronics into the manufacturing process, substancial new skills are, however, required. These skills are related not only to the hardware-oriented integration of computers and machine tools but also to computer software, systems engineering, production scheduling and other organizational aspects, and include a true understanding of the manufacturing process which the system is supposed to map.

For the reason mentionated above, despite the very rapid technical advance in computers and electronics, the diffusion of computer-controlled manufacturing technology is following a more evolutionary path.

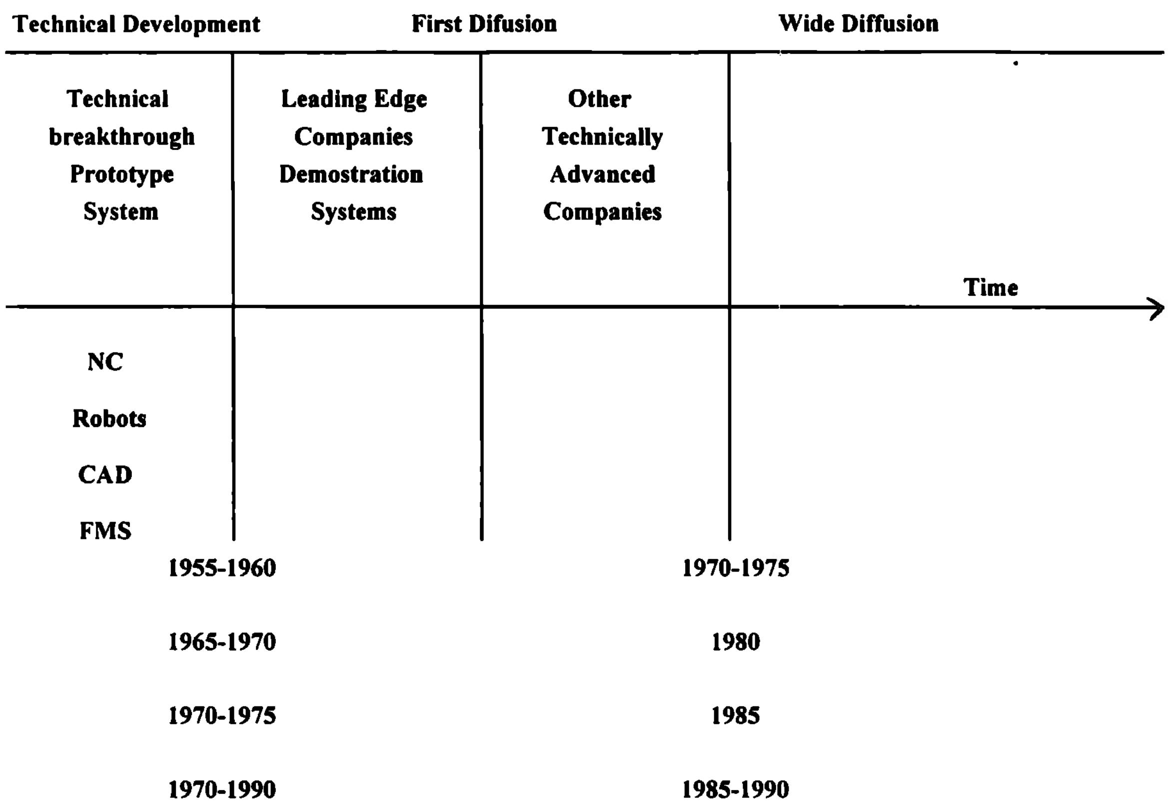


Figure 1.1 Diffusion steps for Computer Manufacturing Technology.

The development of computer-controlled manufacturing can be devided into three partly overlapping phases. The first phase, which can be labelled as Stand-Alone Machine Automation, commenced in the early 1950s with the numerically controlled machine tools (NC machines). Other technological breakthroughs which belong to this phase are:

-The NC language APT, which resulted from work in the late 1950s. In the 1960s, new versions of APT were developed, such as EXAPT;

-Computer Controlled Industrial Robots (IRB) developed in the late 1960;

-Computerized Numerical Control (CNC) developed in the early to mid 1970s;

-Computer Controlled Material Handling equipment such as carriers, cranes etc.; and

-The microcomputer from the early to mid 1970s, which was followed by an ever accelerating pace of miniaturization and price/performance improvement. The main characteristic of this phase was that more and more machines were equiped with digital control units of rapidly increasing degree of sophistication.

Now that the wide diffusion of these individually computer controlled machines has started to pick up speed the main target for the automation effort is the integration of various machines into systems. This will form the second phase, which may be called Systems Integration. it is a very complicated process which requires investment in both capital and new management and technical skills. At the same time, the great opportunities for productivity improvement lie in optimally interconnecting various processes into computer integrated manufacturing cells and the cells into integrated systems.

The phase of systems integration started in the late 1960s with direct numerical control (DNC), in wich several individual machine tools were controlled by a central computer. Two kinds of DNC have been developed : DNC-BTR (behind the tape reader) and DNC-MTC (machine-tool controller). In the latter, which was the original DNC, the central computer controls the individual machines. In the 1960s and early 1970s, this was a cost effective solution, as control units were expensive. However, there was a drawback in that if the computer failed all machines were stopped.

In the DNC-BTR system, each machine has its own control unit but receives its program instructions from the central computer, which is the program library for the machine system and supervises the individual machine operations by go and no go instructions. DNC-BTR is thus based on distributed processing and control while at the same time being centralized in the DNC-MTC.

In the early 1970s, other and more far reaching systems started to evolve, Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) systems and flexible manufacturing systems (FMS). These types of systems, are now widely diffused in industry.

The third and final phase may be termed the Computer Integrated Factory technology wich includes Computer Integrated Manufacturing (CIM) systems as major subsystems.

In the egineering industries, and especially in those subjected to strong international competition (automotive industry, computers and telecommunication, consumer electronics, household appliances etc.) systems integration is regarded as key to survival in the future.

Studies indicate that in standard manufacturing, a part spends about 5 percent of the time being machined and 95 percent waiting and moving. The breakthrough in productivity in the factory of the future will come mainly by cutting down the 95 percent waiting time substantially (Figure. 1.2).

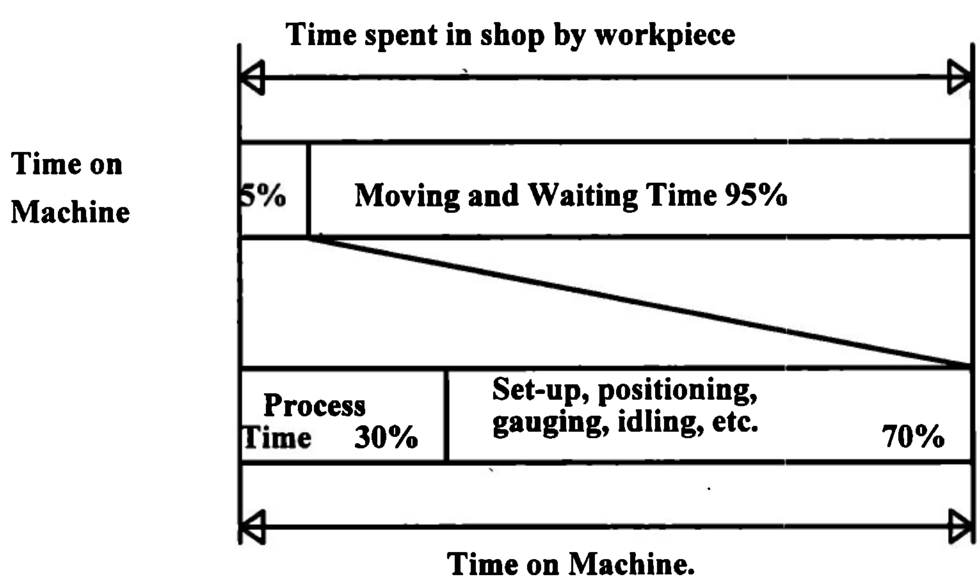


Figure 1.2 Time distribution for various operations of a workspace in conventional work shop.

This reduction will be achived by using a computer for managing an integrated manufacturing system. In managing manufacturing systems the computer functions in both off-line and on-line modes. In the Off-Line mode the computer is the main tool in resource planning, scheduling, production planning, inventory management, etc. In the On-Line mode the computer manages the production flow through the manufacturing and assembly lines.

In computer Integrated Manufacturing technology there are two important concepts: Flexibility and Integration.

An Integrated Manufacturing process is one where the material flow and the informnation flow are oranized in a well balenced system which produces the right amount of goods at the right time for actual demand. Without integration bottlenecks and sub optimization are likely to occur. A limited automation effort will often only serv to move the problems to adjacent work station. Thus, in order to realize the full potential of Computer Controlled Manufacturing technology, systems integrations is a prerequisite. In this sense, the egineering industry, which up to now has also been called an industry for discrete manufacturing, is moving towards closed continous processes similar to those of the process industry.

1.2 Systems Integration.

Integration is the incorporation of one thing into something else. When it comes to Computer Integrated Manufacturing, integration refers to information an ideas, the process of integration can be devided into three parts: Internal, external and technical integration. The concept of flexibility is two-sided, the production system should be easy to reset for the manufacture of several different products and product variants, thereby aceving, on the one hand a high degree of machine utilization and a low degree of in-process inventory and, on the other, a system with short response time to changes in consumer preferences.

A System is defined as a collection of elements working together with a common goal, a system could be the computer but also, the microprocessor that is working inside the computer can be considered as a system. Thus is important to define the level of abstraction required for the implementation, otherwise a lot of problems will arise. For this study three different systems are defined and interconnected to accomplish the task: Data Capture from floor shop

System 1.- The Barcode Reader.
System 2.- The Host Computer.
System 3.-The Work Station.
System 4.-The Data Base.

The realization of a fully Computer Integrated Manufacturing system is the long-run goal of the industrial society. The strategy being followed to get this goal is to develop a series of smaller software systems, which can, in the long run, be readily interfaced with each other to build up full systems.

The key to using the computer at an office or factory is the database. The database is a pool of information: facts, figures, quotes, prices, statistics, machine programs, mill codes, addresses, etc., that is available to everyone in the palnt or factory who requires it. This pool is up to date, and everyone in the facility uses the same figures, and the same information. Once, the paper chase of an operation creates a bottleneck to the flow of information because everyone had different source of information and different information

The system integration approach that is taken by me and also as an industry perspective is: finding problems or processes that can be improved, by using computer control and then applying avaiblable hardware and software to solve these problems.

1.3 Standarization and Interfacing.

The biggest barrier to the implementation of Computer Integrated Manufacturing is the collection of barriers that exist between the machines and systems themselves -the problem of interfacing. It would have been nice if all of the automation developments by vendors and users had followed an orderly standard so that machines would be compatible and would link together in a way that all understood, but the piecemeal development of automation breakthroughs has not supported such an orderly development. Indeed, the computer technology to integrate the entire factory system had not been discovered in the early days of numerical control, CAD/CAM, robots, and automation. Still, all of these separate machines and developments must be interconnected in a CIM system, and this is the subject of interfacing.

In a conventional manufacturing plant many of the emloyees spend most of the time communicating and interacting with other emplyees in an attempt to find out the status of machines, processes, materials, and orders that must be filled, according to the Computer Integrated Manufacturing perspective, much of this human activity is wasted, what is needed is an information processing system that ties all of these needs.

1.4 The Criteria of Flexibility.

Flexibility, achived through automation, is the aim characteristic of the new manufacturing systems, flexibility in this context is usually thought of as the ease with the system can be reseted to process a variety of parts. This is however, only one criterion of flexibility, often refered to as product flexibility. When evaluating an manufacturing system, there are several other criteria of flexibility which are of importance. These criteria, of which several are independent, are briefly discussed below:

-Machine Flexibility. The ease with which the machines in the system can be reset, with respect to tooling, fixturing, positioning, NC program etc., processing parts in a given familly of parts;

-Process Flexibility. "The ability to produce a given set of part types, each possibly using different materials, in several ways.";

-Product Flexibility. "The ability to change over to produce a new set of product(s) very economically and quickly";

-Routeing Flexibility. The ability of the system, in the case, for instance of breakdowns in some parts of it, to continue operating through alternative routeing of workpieces. It also implies that the functions of machines that have broken down can be taken over by other machines;

-Volume Flexibility. "The ability to operate a system profitably at different production volumes";

-Expansion Flexibility. "The capability of building a system, and expanding it as needed, easily and modularly";

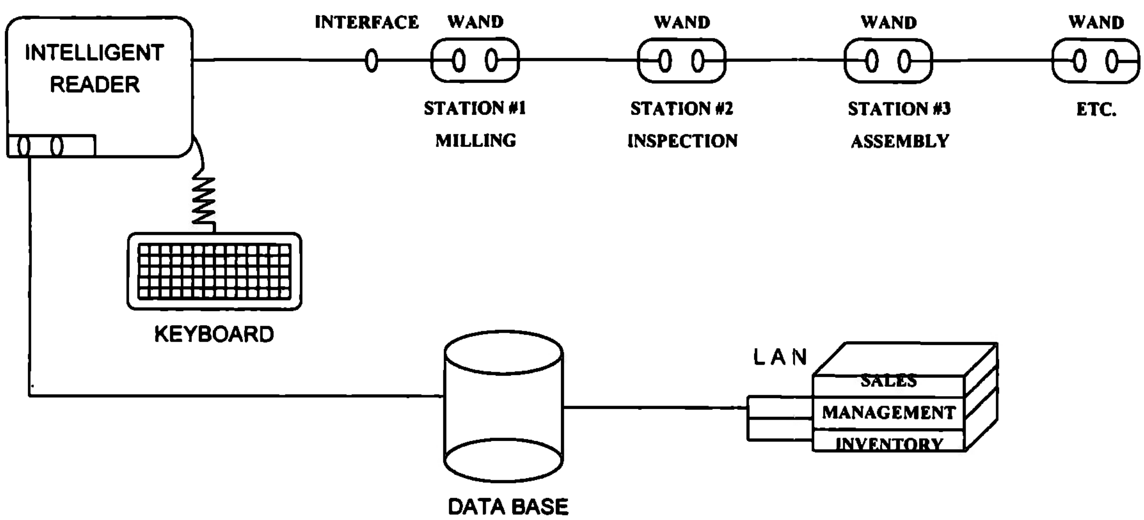
-Operation Flexibility. "The ability to intercange the ordering of several operations for each part type";

-Production Flexibility. "The universe of part types that the FMS can produce"

1.5 The Scope and Composition of the Study..

The aim of the present study is to analize and develope the different options for data collection for manufacturing data aquisition on the floor shop and also for recording transactions as they occur in different stations. When data is collected it is "uploaded" to a major system database to update files. The network can be connected to a single PC or connected to a LAN (Local Area Network) thus all the information is avaible for the rest of the organization (Production, Purchasing, Sales, Accounting) for managing pourpuses.

BARCODE READERS NETWORK
SCHEMATIC



More specifically the composition of the study deals with the following steps:

a)How to use the Systems Integration perspective for the development of system.

b)To Determine wheter there is a reasonable necessity for the information system implementation and determine Factory Information needs.

b)Select and evaluate the right hardware and software avaible for the task.

c)Define and evaluate the protocols needed for the aplication.

c)Define and evaluate the best interfacing method for this particular aplication.

e)Evaluate the technical requirements needed for the system development.

f)Define what are the trends in the future diffusion for computer controlled implementations for manufacturing.

1.6 Description of the Content of the Chapters:

-Chapter 2 "Monitoring and Control , The Needs Analysis", Describes the investigation of what the Manufacturing organization requires to significantly improve its performance, the emphasis is placed on determing what is limiting high quality productivity, the needs analysis defines the specific FIS objectives.

-Chapter 3 "Factory Information Systems" Analyzes all of the possible configurations for networking in the manufacturing shop floor, how the communications between applications can be achived, and summarizes the Standards and Interfacing problems.

-Chapter 4. "Data Aquisition and Control Systems". Summarizes the key features of each of the possible data entry technology available, and also analyzes the operator interface.

-Chapter 5 "On Line System Design" Define the task of specifically defining each component of hardware and software required to meet the application objectives, often the same need can be met with different configurations. Defines how the various pieces of harware are to be connected together.

-Chapter 6 "System Implementation Issues" A number of serious technical and enviromental issues that are related to the installation are reviewed.

CHAPTER 2

MONITORING AND CONTROL, THE NEEDS ANALYSIS.

2.1 Introduction.

It is important to know at to this point that, every technical problem in the factory, has to be first of all, an economic problem in order to define the relevance of the implementation.

We now enhance this insight by a discussion of specific techniques for determining the needs of the manufacturing plant and for optimizing the use of manufacturing resources by using the Factory Information System (FIS) and those subsystems that communicate with it. The process of determining what to monitor and control to improve resource utilization is usually called a needs analysis. This needs analysis determines what is required to improve manufacturing performance. The scope of the needs analysis should be quite broad. If conducted in this manner, it usually results in the definition of organizational changes, it usually results in the definition of organizational changes as well as functional requirements for the FIS. Once the needs are determined the FIS and associated systems can be designed to provide the functions required to meet these needs. Many of the functions involve an improvement in the way manufacturig resources are utilized.

2.2 Resource Utilization.

The approach is to examine the various resources used by manufacturing, understand how they might be used more effectively, and, finally, define what the information system can do to improve resource utilization. These resources are people, machines, and materials.

2.2.1 People Resources.

People is the most complex resource, and it is also probably used least efficiently. In contrast to inanimate machines, humans need to be motivated to function at their highest level of profiency. This means that proper incentives have to be in place. Motivational incentives have been proved to be very effective in both Westrn and Asian countries. In all cultures the primary motivation seems to come from the emloyee's identification of the relationship between his or her work and product quality and quantity. This is achived through feedback to the worker on individual performance. Such feedback can be supplied by the information system (FIS) and should be one of the system design objectives.

Other examples of social and economic incentives are piece-work, profit sharing, employee stock plans, and participation by all organizational levels in planning and decision making. The FIS system can help in the implementation of these motivational factors by measuring individual contribution fairly and without bias.

The resultis a more equitable allocation of both tangible and intangible rewards. A simple example is the accounting of piece work using weighting algorithms for quality as well as quantity. Another example is the tangible stimulus to supervision from a comparison in real time of shift performance against standard rate. The FIS can also assist with collective human decision making by clarifying the issues and by tracking the results of decisions after they are implemented to improve decision-making skills. If the FIS can monitor individual performance, it can also provide a measure of training needs. This type of feedback to employees has gained acceptance because it avoids personal discrimination when monitoring workers.

National economies are such that today manufacturing is aften located in depresed third world communities (such as México) to take advantage of low labor rates and to supply these communities with financial aid. In many cases these workers have not had the opportunity for even moderate education. In addition, these people have little experience with the technically complex products being produced and the manufacturing systems used. In this situation, the information system improves management effectiveness by providing a structured and disciplined way of stracting from the shop floor the information needed to manage a manufacturing operation populated by inexperienced workers.

Finally, production managers can utilize their time more efficiently by using the information system to get timely information for planning, decisions, and control. This accurs because data is automatically analyzed and converted to information. In addition, the information can be screened and reported.

2.2.2 Machine resources.

Machines are the second resource avaible for effective utilization. Improving machine utilization involves minimizing down-time, the time required for material transfer and processing, and the extension of the machine's useful life. This means effective equipment maintenance, production scheduling, and product flow control.

Most machines can only exercise the rather rigid instructions programmed in their controllers. These instructions are not being changed dynamically as processing proceeds. The newer control programs take the form of decision trees where limits and data from sensors ans be used to determine the path the program takes when it arrives at a logical branch. Such machines are at least more flexible than hard automation because their dynamic control programs can be changed via software to produce new parts, assemblies, or models of product. FIS systems are often used to store and download thesse control programs directly to the production equipment as model changes occur. In return, the microprocessor-based controllers are a major source of data for the FIS, saving the cost of manually collecting performance information. Historically, machines have been automated in groups as islands or cells of production to reduce labor. With the addition of mechanized product transfer between these cells, the automated factory can be connected together in two senses. First by the physical flow of product provided by these transport systems. the second is through the flow if information flow to and from production machines becomes available from the FIS.

Automation requires a high level of integrated FIS communication and more sophisticade maintenance personnel.

2.2.3 Material Resources.

Material Resources are utilized affectively by eliminating waste through better product designs and more effective control of modern manufacturing processes. This results in smaller inventory, reduced scrap, less repair, and the reclamation of process by products. The FIS contributes to all these functions by supplying better scheduling, control af factory operations, and up to date information regarding the status of materials on the production floor. This timely knowledge of the status of the factory is essential, for example, to support the just in time concept used to reduce material inventory.

2.3 Manufacturing Parameters to Monitor and Control.

The objective of monitoring a factory is to rapidly sense the nature of the many operations, detected deviations from normal, and initiate appropiate corrective action. A thorough understanding of the manufacturing process is obviously required to define what parameters to monitor and what action to take. An analysis of what is needed to control the factory is based on this understanding. It is this needs analysis that defines the control functions required of the FIS.

The needs of analysis usually results is a conclusion to which most production realists will readily agree. many manufacturing operations are not completely understood. This is because the manufacturing operations are always changing as new products are introduced and processes are refined.

The strategy used to resolve this issue of process understanding and retention is twofold: (1) gain understanding by continuosly learning more about how each process works and the relationship between processes and (2) maintain this knowledge by building it into the analysis and control programs executed by the FIS and associated process control systems.

2.3.1 Determining What to Monitor and Control.

The determination of what to monitor and control so that the minimum amount of significant data can be collected and analyzed is achived by using the iterative approach illustrated in Figure 2.1, every factory, in fact, has been applying this technique since inception. The FIS contributes by supporting the monitoring, analysis, and control functions. This makes it easier to traverse the iterative cycle more rapidly. Coupling this with the FIS's ability to retain the knowledge gained as each cycle is traversed produces a rapid learning rate. This translates to faster start up of new products and the optimum productivity for old products.

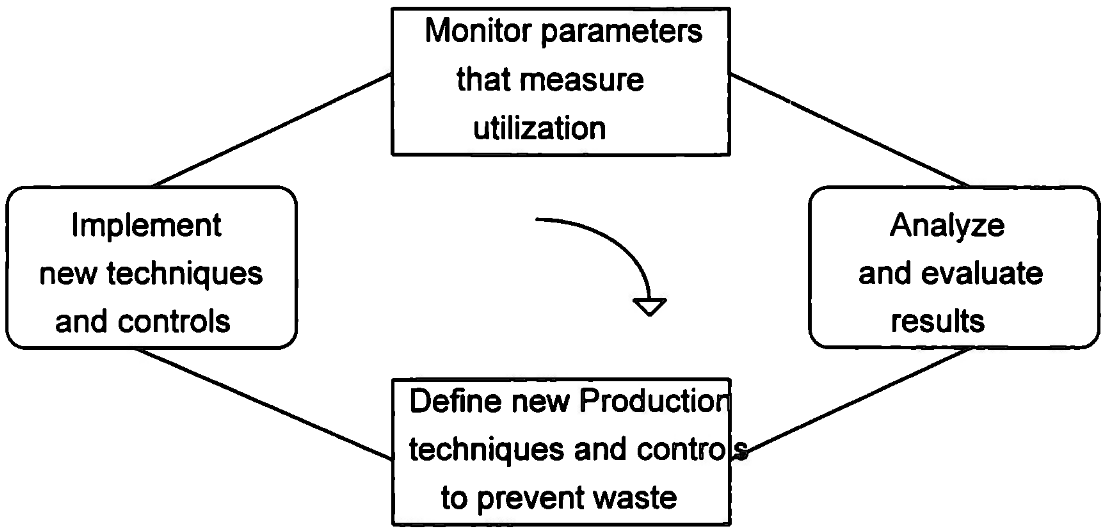


Figure 2.1

There are a number of useful techniques for systematically improving process understanding. these are (1) Cause and effect diagrams, (2) Evolutionary operation (EVOP) procedures, and (3) Pareto diagrams. These techniques, are used to determine what to monitor and control.

Cause and Effect diagrams.

The cause effect diagram was developed by Dr. Kaoru Ishikawa at the University of Tokyo in 1943 and is described in Ishikawa (1976), pp 18.28. It is a top-down diagramatic technique used to help people determine the cause(s) for a given effect. This technique defines causes that can be monitored to give effect. An example of the cause effect diagram is shown in Figure 2.2

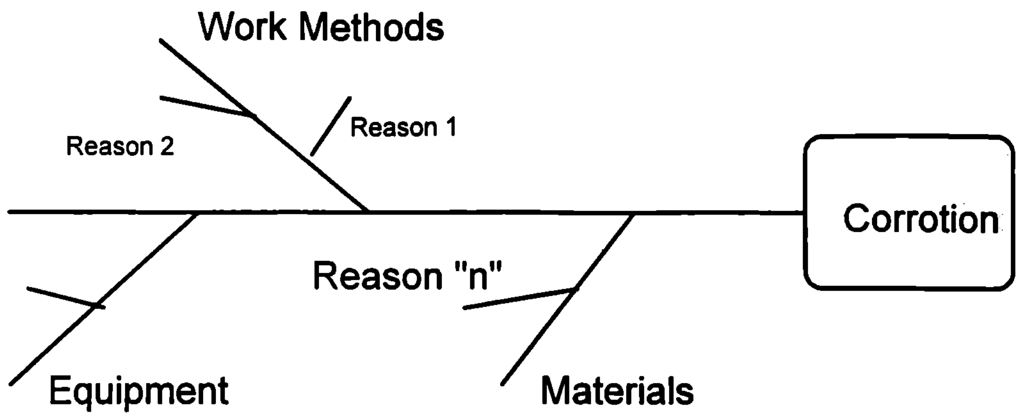


Figure 2.2 The cause and effect diagram.

These diagrams are helpful because they make people think in an organized and specific way about the reason for an effect. Finally, as the diagram is developed, measurable parameters appear at the ends of the branches. These become the parameters to monitor and controlwith an FIS system.

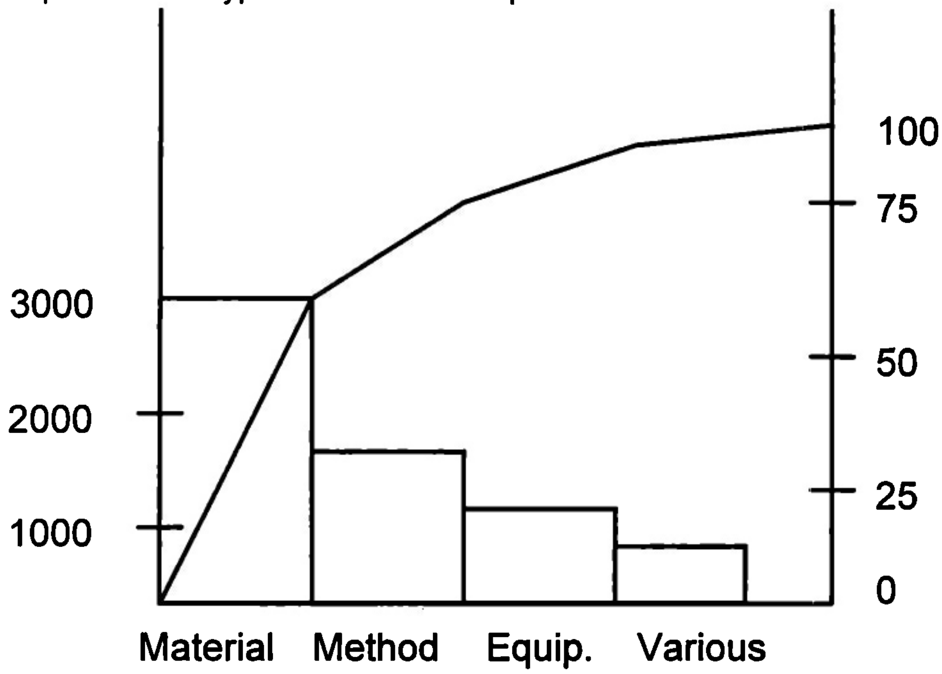
The absolute scale is helpful when comparing the impact of a change in an effect as different parameters are optimized over a long period of time. It is also very effective to show the absolute scale in monetary units.

Evolutionary Operation.

Evolutionary operation (EVOP) is a term used to describe a special class of experimental designs applicable to ongoing production processes described by Box, Hunter, and Hunter (1978). The objective of EVOP is to optimize a process by producing statically significant results from very small changes in process conditions. The changes are so small that they do not materially jeopardize the quality or quantity of goods produced. EVOP, therefore, can be a continuos effort associated with any production operation.

Pareto Diagrams

The pareto diagram is used to visually quantify the relative influence various parameters have on an effect (for example productivity). The diagram was conceived by Wilfrido Pareto, an engineer, sociologist, and economist in the late 1800s. An example of his diagram is shown in Figure 2.3 and is related, for the sake of continuity, to the parameters used in the previous cause and effect diagram shown in Figure 2.2. The diagram is plotted in descending order of impact for the types of causes that produce the corrotion effect.



2.3 The Pareto Diagram

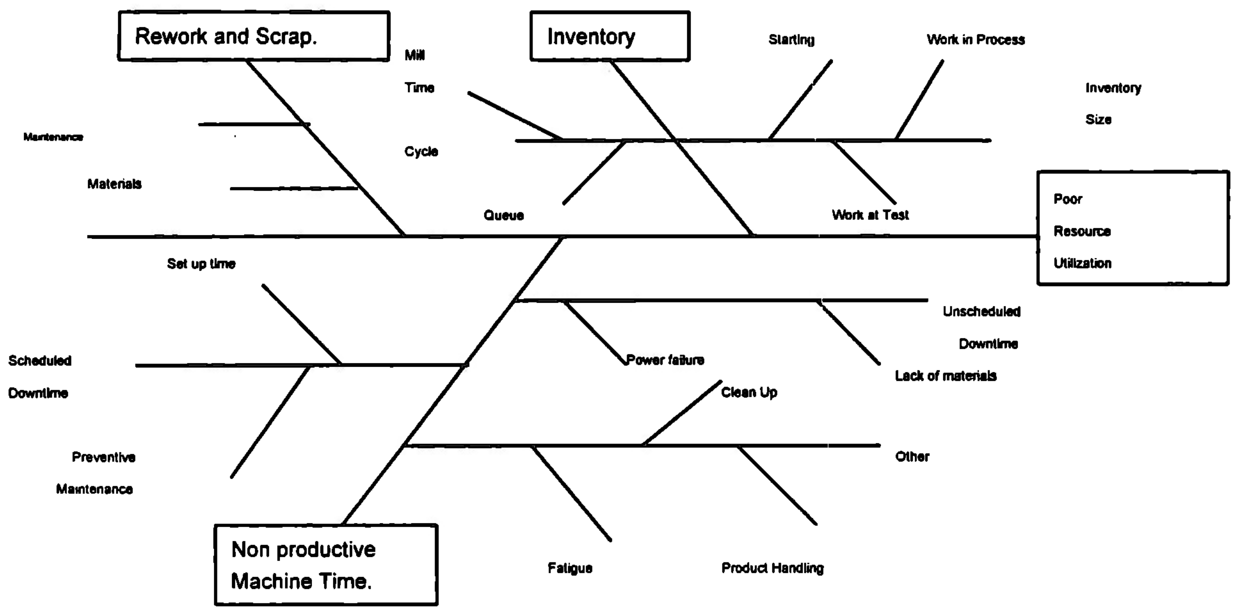
The vertical axes are usually shown in absolute units and relatively in percent of the total. In our example, it is apparent that 75% of the item corrotion can be attributed to the materials used.

One of the major problems is facing those design FIS systems is the communication of the results from the analysis of monitored data to a level of management taht has little time, wants quantitative and relative numbers, and controls the resources required to take appropiate corrective action. The Pareto diagram is very helpful because it establishes the relative impact of taking different management actions.

2.3.2 Parameters that measure resource utilization.

The cause effect diagram was discussed and it was suggested as a tool to assist in the definition and documentation of parameters to monitor. The C-E diagram shown in Figure 2.4 is now used to list the basic manufacturing parameters that are classicaly measured and to show their relationships.

In most manufacturing operations there are two basics categories of parameters that are monitored. These reflect both the history and status of (1) work in process and (2) processing equipment. The work in process is first identified as individual pieces or as lots. The current position of this identified work is then monitored and as time passes this information is converted to past movement history. The current status of the machines and people doing the processing is also monitored. Again, as time passes these data become the historical record of performance for the facility or cell.



2.4 C-E Diagram of Basic Parameters to Measure.

2.3.3 How to access Manufacturing Operation.

The problem traying to find the necessary information for the study is that the people outside of the manufacturing organization are not privy to the internal drives of the operation and do not usually have an in-depht knowledge of the product or processes.

There are some approaches that these consultants can take to make this access more effective, the time at the factory is spent obtaining five general types of information as discussed by Davis (1982). This information is used to define what will be monitored, the FIS data base structure, and the specific application programs for control and reporting. The five types of information are:

- Identification of all things and events included within the scope of the FIS system.
- Relationships between the things and events.
- Attributes of the things and events.
- validation criteria for the monitored data and for any parameters derived from the analysis of these data.
- How the data is to be analyzed and used by the FIS.

There are four approaches to gaining this information. Most FISs are designed using a combination of the following:

1.-Asking the manufacturing personnel.
2.-Derivation from existing data or system.
3.-Synthesis from the basic needs of the manufacturing.
4.-Evolution.

Asking

The most striaghforward approach is to ask. This certainly has to be exercised to obtain thet required information from the production people that are the only ones who have the required detailed knowledge of what limits performance.

Derivation from existing data.

The needs can be derived from an existing manual system or outmoded computer based system. The problem with this approach is that most old systems also collect, analyze, and report slowly compared to the real time interactive response capability of a modern FIS. Faster response allows the control of manufacturing to be much more flexible and effective. If the old transactions are simply copied by the new system, this advantages are lost.

Old systems tend to perpetuate the collection and filling of data that is no longer used. the needs analysis should identify these data and eliminate their transactions and reports.

Synthesis.

An approach that leads to fresh insight is the synthesis of the FIS applications from basic characteristics of the manufacturing operation. This is akin to starting over with the cuestion: Based on no previous knowledge or constraints how can this operation be better controlled? This requires the system designer to spend extensive time at the manufacturing site to understand its objectives and how it operates.

Evolution

The last approach is to discover the needs by first designing a small. simple FIS which is easy to modify and then to support its evolution as it is used. The disadvantage of this evolutionary method is the very slow implementation rate which extends the time required to make an impact on manufacturing performance.

2.4 Monitoring the Basic Manufacturing Parameters Efficiently.

People still run the factories, and they are the only sources of some of the information required by an FIS. The cost of labor to enter this data manually can be very significant if the input process is slow. Manual data input can be slow because the entry process is cumbersome.

Another problem with manually entered data is its inaccuracy. Humans make many errors which must be caught by validation as the data is input so that the data entry person, who is the only source for correction, can make the changes as part of the entry process.

The most cost effective and reliable method is automatic data collection directly from production and transport machines. in this section, we will reviewwhat kinds of basic data are currently input by people and machines and the types of data input equipment that is currently available for this function.

Monitoring non productive time.

Table 2.1 summarizes by reporting category the data types that are collected and the facilities used.

Reported by People.	Reported by Machines.
Scheduled down time because of:	Shift lenght
Preventive maintenance	
Excess inventory	Machine run time
Set up time.	
Un scheduled down time caused by:	Total down time from:
Corrective maintenance	Stopped time initialized by operator.
Abstenteeism	Stopped time from process failure.
Unavoidable delays	Number of faults.
Power failure	Type of fault
lack of Material.	
Other causes:	Processing rate.
Operator breaks	
Clean Up	
Product repair during manufacturing	
Product Handling	
Operator fatigue	
Using:	Using:
Video data input terminal	Direct data line to machine
Marked card sense reader	Punched paper tape (Old)
Voice input	Floppy disk
Digitizing tablet	Cassette tape
Dedicated key pad.	Magnetic tape.

Table 2.1 Monitoring Nonproductive Time.

Monitoring rework and scrap.

Table 2.2 sumarizes by reporting category some of the data types collected when monitoring rework and scrap. The devices used for data input are shown at the bottom of the table.

Reported by People	Reported by Machines
Loss of process control caused by:	Defect type producing faults
Lack of maintenance	
Operator error	Loss of sensed process control.
Faulty material	
Wrong material	portion of product reworked, scraped, or missing.
Poor design	
Using input devices cited in Table 2.1 plus:	
Barcode reader	
Magnetic card reader	
Alterable memory attached to product	
Production flow accounting system.	

Table 2.2 Monitoring Rework and Scarp.

Monitoring Production and Inventory.

Table 2.3 shows the data types collected or derived by an automated inventory and product flow control system.

Starting inventory storage time	Real process time by step
Starting inventory size	Queue size of material handlers
Work in process	Finished product storage time
Work in test	Unsellable production
Finished product inventory	Cycle or flow through time
	Production rate and quality by step.
Using the same devices cited in tables 2.1 and 2.2 plus:	
Automatic counting and weighting.	

Table 2.3 Monitoring production Inventory.

2.5 Communication Levels.

The transfer of information from the FIS to humans can be done at two levels. The simpliest is in directives for decisive action. to communicate at this level. the FIS must incorporate decision automation to produce the control directives. This is evolving as forms of statical analyses and artificial intelligence are incorporated. The advantage of decision automation is the discipline it brings to the manufacturing operation. This is particulary valuable if the operators and first level of supervision are inexperienced. Un fortunately, decision automation stymies creative though. The system will not evolve to keep up with changing products and technology if decision making is embeded in the software instead af the minds of the users. This is why a second level must exist. At this second level, factual informationis transferred but the entire decision process is left to the user.

Chapter 3

Factory Information System.

3.1 Introduction.

The computer first apperead on the factory floor in the late 1950s in the form of the first numerical control units and punched tape. The idea of operating several machine tools from a remote computer was then introduced in the mid 1960s as the first DNC application. NC and DNC where the first of many computer applications to the whole technology of manufacturing. Today computers are used for a variety of applications, many of which are manufacturing related. These include NC programing, inventory control, inspection, process planning, and tool design. And a vast array of software, interface networks, and telecomunications links now permeate the entire manufacturing area.

Three main issues account for the rapid grawth and development in computer use:

- Rapid breakthroughs in computer hardware and microprocessor technology.
- Large scale price reductions in hardware costs.
- Advanced and increasing capabilities of application software.

As the need for interfacing computers and functions together has increased, so also has the complexity due to the accelerated ploriferation and diversity of equipment, software, and local area networks (LANs). The factory computers, software, and communications lines to the variuos components and workstations are vital to the system in order to gather data and control, activate, and make decisions about rapidly changing system activities.

Communications is important whether it be between two or more poeple or between parts of a computer control system, the relations between these people and the resources they control is very complex, as in any society. The speed and accuracy with which they communicate, resolve conflicts, and make decisions directly affects the productivity and afficiency of their manufacturing operation.

To function societies have evolved languages, communication systems, transportation techniques, and rules of behaivor. Lake production operations they have defined objectives and devised ways of measuring progress toward achieving these objectives. As societies grew they made contact with other adjacent societies which had different languages, ways of communicating, transportation, and rules of behavior. In much the same way, the factory is in contact with its related organizations such as research centers, product engineering functions, marketing operations, and financial control groups, many of which are often remote from the manufacturing site.

Like isoleted societies, manufacturing plants have also evolved their own unique languages, ways of communication, and rules of behaivor which differ from product design or marketing societies. Thus when manufacturing engineers and product design engineers endeavor to move a new product into manufacturing these differences can result in misinterpretations and loss of information transfer. These differences lead to conflict between optimizing the manufacturing operation and satisfying the costumer demand.

Various computer based manufacturing systems shown in Figure 3.1 are used to improve the quality, speed, and cost effectiveness with which new products are created and produced. When connected together with the effective communications, these systems form a computer integrated manufacturing network. The realization of this network is the current goal of many manufacturing companies because it is essential for they survival in an increasingly competitive world.

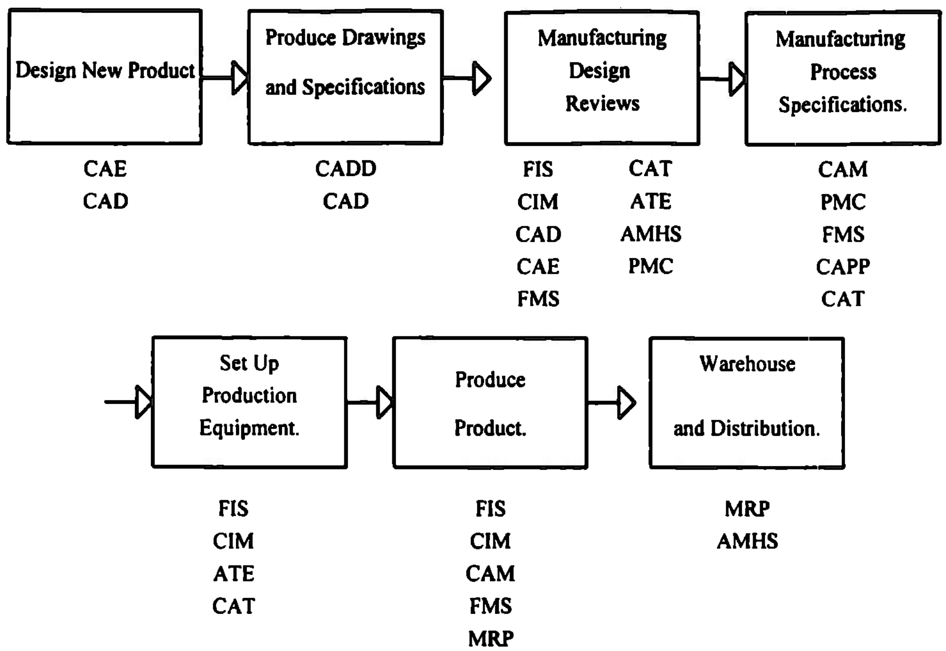


Figure 3.1

To simplify this situation they have been reduced to the five generic types listed in table 4.1 all these technologies work together to provide decision support and control for the factory.

Table 4.1 Generic Computer Based Manufacturing Systems.

1. Systems Integration.
   Factory Information System (FIS)
2. Design Support
   Computer Aided Design (CAD).
   Computer Aided Engineering (CAE).
   Computer Aided Design and Drafting (CADD)

3.Manufacturing Control.
   Computer Aided Manufacturing (CAM).
   Computer Assisted Process Planning (CAPP)
   Process Monitoring and Control (PMC)
   Flexible Manufacturing Systems (FMS)
   Automated Material Handling and Storage (AMHS)
   Distributed Monitoring and Control (DMC)
   Scheduling.

4.Testing.

Computer Aided Testing (CAT).

Automatic Test Equipment (ATE).

5.Material Acquisition.

Material Requirements Planning.

6.2 General Functions.

The computer continues to gain wide acceptance in all aspects of business and personal applications. Various types, sizes and styles along with a wide range of price and computing capability, are offered. In many cases, potential purchasers are confused by such an ever increasing array of hardware availability and options.

However, computers and computer purchases should be application dependent. That is, what the computer is being purchased to do, depending on how broadly or narrowly defined, should be the driving force behind the actual purchase. In a manufacturing organization, for example, many activities surround computer usage, such as payroll, accounting, engineering, manufacturing engineering, and shop data collection. These activities involve not only the day to day transactions but also management information for analysis and decision making.

Typically, in a manufacturing operation the computer is used to store, process, retrive, manage, and control data relating to the following functions:

1. Sales records and forecast data.
2. Accounting, payroll, and cost control information.
3. Design engineering data consisting of drafting, analysis, revision history, and bills of material.
4. *Shop Floor control.
5. Tool inventory and design information.
6. Work in process inventory and scheduling control.
7. Capacity planning and process planing.
8. NC progarmming.
9. Shipping and receiving data.
10. Quality control information.

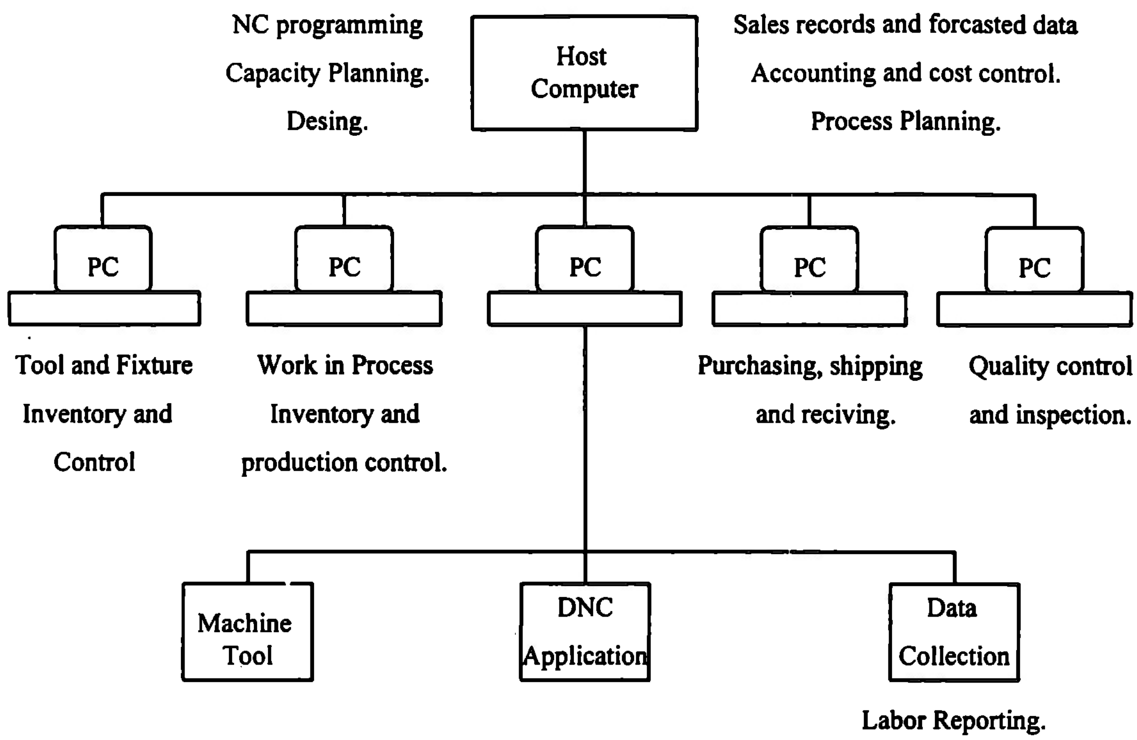
All these data groups , although listed as independent pieces of information and designed for convinience of the user, must be able to interface through one form to another and exchange files and records.

In some cases this information is captured on several different computers in many different data bases and in varying formats. In other cases, the various information resides on one central computer and in one data base. This is the centralized decentralized argument of computers and computers and computer control. Each has advantages and disadvantages.

The first large mainframe computers to control manufacturing operations were expensive and every attempt was made to fully utilize their centralized computing power. It quickly became apparent that, as installation size and complexity, reliability and responsivness decreased. In the case of a major computer failure, if the entire system breakes down all plant communications would be lost. However, having large central computers provides more consolidated control of computer changes and expenses, while reducing duplication of new application programming effort within the overall organization.

Decentralized computers give users more control of their own destiny for improved responsivness and may be connected to other computers or to a central main frame computer for data distribution. Duplication of programming effort may existas users provide for their own needs. Additionally, centralized control of expenses and computation changes is difficult to obtain due to local or departamental control of the decentralized computers.

With the rapid increase in microprocessor technology, large scale price reductions, and increased capabilities of application software, personal computers are more and more making their way in the manufacturing floor (Figure 3.2). These personal computers are in many cases networked together for on line real time communication and may be tied to a host computer for central data base control of common and shared information. Applications could range from manufacturing monitoring and control to assure that schedules are met and activities are coordinated, to processing of NC part programs and DNC download of tape data files to machine tool controllers. Other applications for this type of networked architecture include shop floor labor reporting, material dispatching, and production, tooling and inventory control.



igure 3.2 Typical Manufacturing Computer Architecture and Computer Applications

In smaller shops, powerful personal computers handle a multitude of these tasks due to the increased capability and affordability of modern computers. The computer has gained and continues to gain rapid use in manufacturing as well as other business and personal enviroments. The application and required response time will dictate the type, size, architecture, and ultimately the cost of the systems.

3.2 Communication Networks for Factories.

Communication networks are the information highways of an automated manufacturing system. Selection of either the network or the computer, in many cases, may determine the other. Some networks are closer to being standarized and supported by computer vendors than others. The choice of a communication system largerly determines the capability and productivity of the factory as a whole.

Networks are generally based on the elements that need to be linked together in a given area. Consequently, the acronym LAN (Local Area Network) is used in many cases to designite the network or data transfer line. Local area networks (LANs) fit between the computer connection and long-haul networks such as the telephone system, or a series of closely connected systems or buildings.

Network topology is the road map of the entire network. Although the word topology is basically a misuse of the word topography, it is the geometric layout of the data links and computers that require linkage. Network topology can have many forms, but the two most common are point to point and multidrop.

Point to point topology is a circuit connecting two points or computer nodes without passing through an intermediate point. As seen in figure 3.3, its primary use is for very simple networks or subnetworks.

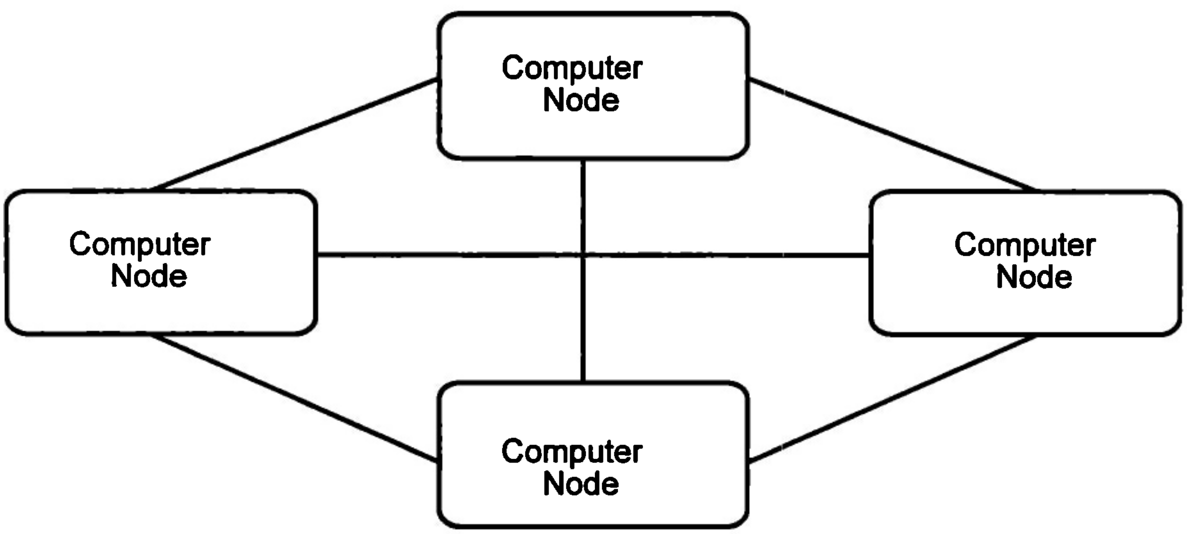


Figure 3.3 Point to point circuit connecting two points without passing through an intermediate point.

A multidrop network (Figure 3.4) is a single line that is shared by two or more computers nodes. Multidrop networks reduce overall line costs but increase the complexity of data transfer in the network, as well as the cost of line connection. The method of data control and priorities in either a point to point or multidrop application is the control topology.

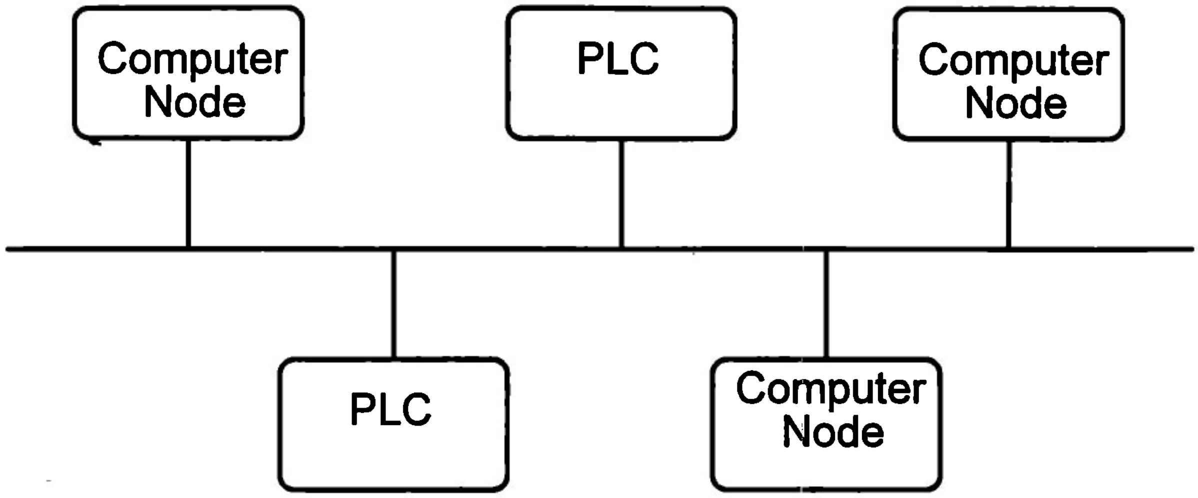


Figure 3.4 A multidrop network shares a line with two or more points.

Networks are generally classified in three types:

Star or Radial.
Ring or loop.
Bus.

Control of a star or radial network (Figure 3.5) remains at the node where two points are joined. The main controlling node may also be called the master or net master node. The connecting point would be called the slave. This is a simple master-slave relationship.

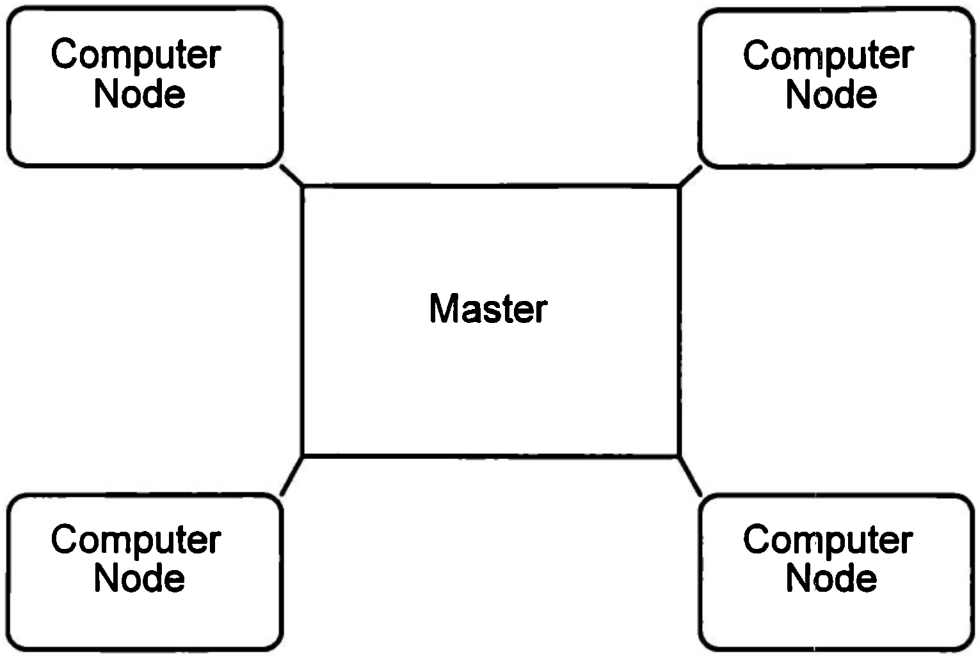
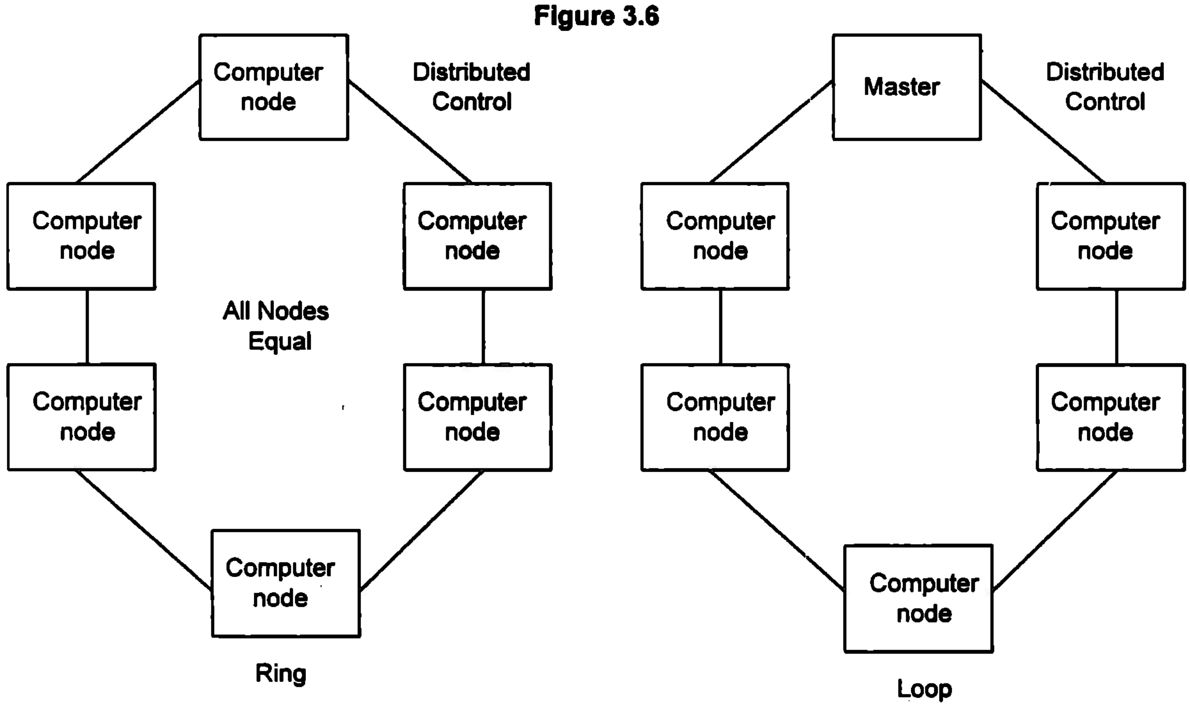


Figure 3.5 Star or Radial network controlled by the net master in a master slave relationship.

Ring or loop networks may be classified in two types depending on control type, as seen in Figure 3.6 , centralizing control in one node of the network creates what is generally referred to as a loop network. Subnodes in the network can only communicate with other subnodes when permitted by the controlling master node.

Figure 3.6



Ring networks use distributed control. In this case, each node can communicate with every other node without direction from a controlling master node. This method is more complex than loop arrangement, but in either case (ring or loop) data may be passed from node to node around the ring. Each node must have an active repeater to transmit the data to the next node.

One of the most commonly used forms of control topology is the bus network, as seen in Figure 3.7. a bus network is significantly different from the other arrangements in that data may be sent to all nodes at the same time, as opposed to passing data from node to node around a ring.

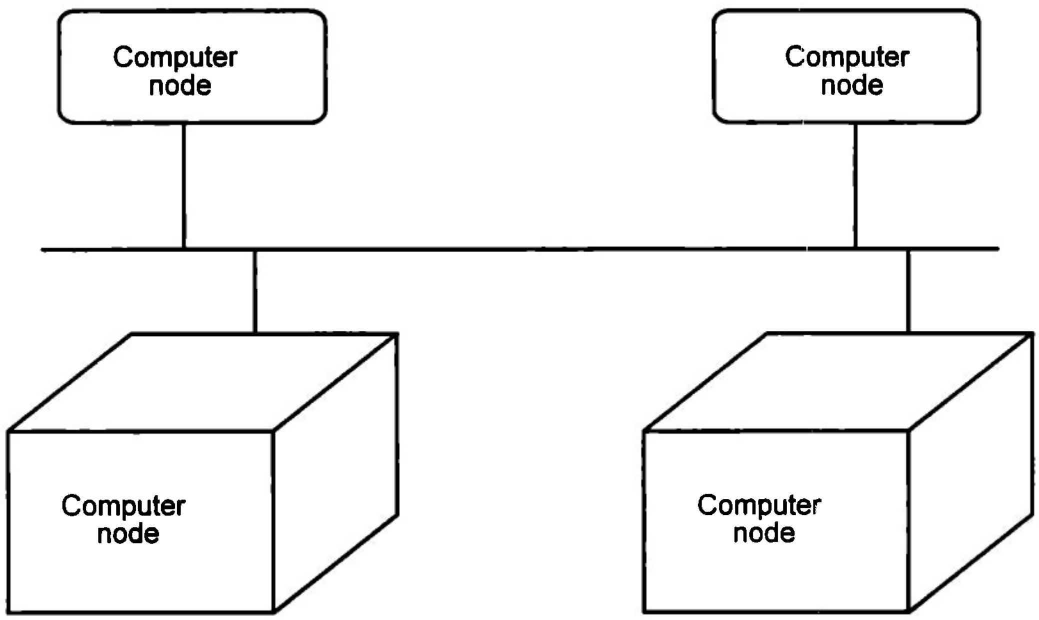


Figure 3.7 In a bus network, data can be sent to all nodes at the same time.

3.2.1 A Continually Growing Market.

The investment in computer based production control in the 1970s formed only a marginal proportion of the overall information technology market. However, the size of the sector has shown unending growth since then and in 1988 represented $68 billion worldwide.

A breakdown of these figures (source BIPE, 1988) shows that the share of the world market taken up by computer based production and inventory control (PIC), and thus by the "upper" levels of the management information system (MIS) amounted to $8.3 billion. This compares with $7.7 billion invested in the ancillary devices, the programmable logic controllers, the local area networks and the controllers that form the "lower" levels.

Production control is clearly one of the main concerns of industrialists: 95% of them wish to posses a computer based PIC facility by the begining of the next decade (source MORI, 1984).

The complete integration of data processing systems into the production process, and more generally the CIM concept, like all avant grade technology, suffers from a lack of credibility because of its youth as well as from a natural resistance to change.

However, the major brake on the integration of all functions of the firm through computerization has long been the poor performance and the lack of standards in the sphere of industrial local area networks (ILANs). This technology, in currently on the way to becomingh the leading sector in computarized production if the current growth and the future prospects of the market are to be belived (Figure 3.8)

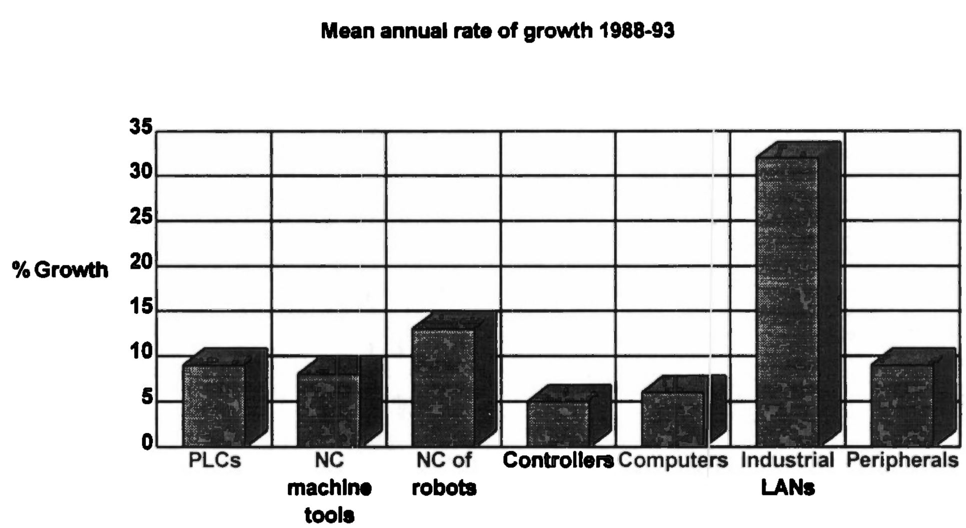


Figure 3.8 Growth in the information technology market.

Moreover, the development of the market has modified the aims of industrial automation methods. Ten years ago, the profitability of computerized production applications was sought exclusively through the improvement of direct productivity (shorter manufacturing lead times) together with the reduction of immobile material (optimization of stock and of partes in process of manufacture). Today, the quality and variety of what is supplied have become the dominant factors.

3.2.2The OSI Model.

There are currently very many incompatible manufacturer specific protocol architectures for general computer communications, for example: DECNET, SNA, TCP/IP and SINEC. When participants supported by two different architectures wish to comunicate, expensive network interfaces are required which lead to a decreased communications performance and mapping losses. Manufacturer independent, internationally standarized communication systems are needed to overcome these disadvantages in the future.

The International Standards Organization (ISO) has developed a model to describe data communications. The base reference model is a general model for digital communications between two or more participants, it provides the framework for the elaboration of standards for open communication systems. The key concept in this model is describing communications in terms of autonomous layers. Figure 3.9 depicts the model called the open systems interconnection (OSI) model, which has seven layers. The physical layer, for example, describes the cable, connectors, signal levels, and basic signaling. Specifications for this layer can be developed without reference to the concept of the messages being transmitted.

The reference model is based on the following four principles:

- The communication function are devided into layers.
- The services to be provided by each layer are specifed.
- Layer N+ 1 which is immediately above layer N uses the services of the latter to implement its functions.
- The communications between the layer N and the participating terminals is specified by the ISO protocols.

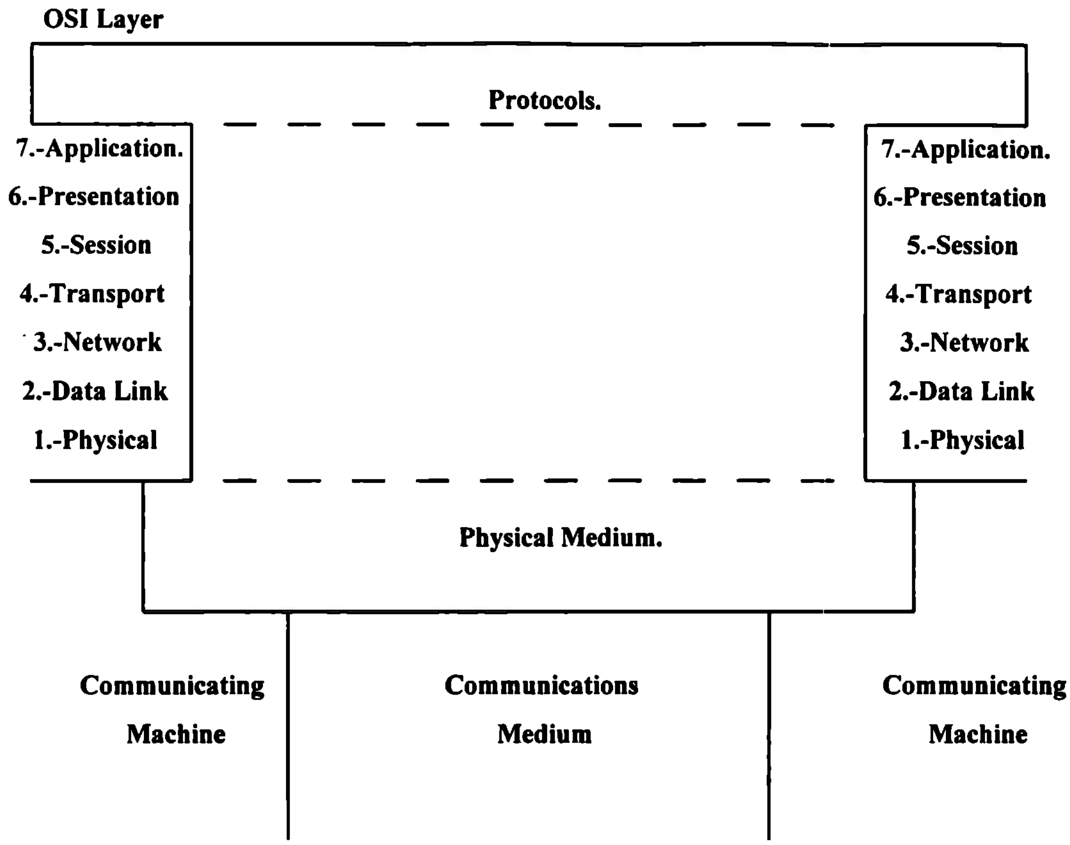


Figure 3.9 the OSI Model for Open Systems Interconections.

The designers at each end of the communication link can address the network control aspects of the communications without worrying about the physical media being used i.e. coaxial cable, twisted pairs, radio waves, etc. It is this concept of dividing the description of the communication process into layers that has facilited the rapid development of standards for those layers . The OSI model is a powerful tool for understanding communications and for describing compatible systems. Two systems on a communication channel are not compatible unless they are compatible on all levels of the OSI model. A device that has an RS-232C interface does not make it compatible with other RS-232C device unless all of the layers of protocol have been addresed. The RS-232C specification only addresses the phisical layer.

A brief description of the individual layers of the OSI reference model is given below.

Layer 1:Physical Layer.

Layer 1 defines the functional, electrical and mechanical characteristics of the transmission medium necessary for transparent physical transmission.

- Parallel/serial conversion, multiplexing (frequency, time division),
- Physical interfacing to the transmission medium (fiber-optics, coaxial cables and so on),
- Synchronization at the bit level,
- Definition of valid signals and connecting lines.

Layer 2: Data link layer.

This layer provides for access to the transmission medium and securetransmission of individual data blocks. This involves:

- Activation/Deactivation of access to the transmission medium.
- Monitoring of the data-block sequence,
- Dataflow control,
- Error detection and, if necessary, error correction.

Layer 3:Network Layer.

The main task of the network layer is to switch the data to be transmitted between the end systems by selecting the best path. By end systems, we mean the sender and the recipent of a message; under certain circumstances, these may be physically interconnected via a transit system. The control of the passage (switching and transmission) of the information packets through the network involves the following functions:

- Packet assembly, disassembly,
- Control of the exchange of packets between data terminals and the network,
- Establishment and release of virtual connections between data terminals.
- Transport of the data packets between two data terminals.
- Routing within the network.

Layer 4: Transport Layer.

the task of the transport layer is to give the user a reliable logical transport connection. the layer 4 services provided to the user enable him to communicate with the target end system in a network independent fashion, without having to be concerned with the detailed physical characteristics of the transmission medium in question. Thus, this layer represents the dividing line between the transport orinted and the application oriented parts of the OSI reference model. The mostimportant functions of the transport layer include:

- Establishment and release of transport connections,
- Multiplexing of layer 3 transport connections and virtual connections,
- Dialog control.
- Re -establishment of interrupted transport connections.

Layer 6:Presentation Layer.

The main task of this layer is to convert the system internal data presentation into a uniform network presentation, which can be negotied between the communication partners.

Layer 7:Application Layer:

Layer 7 is the most important layer of the OSI reference model from the user's point of view. The definition of uniform protocols for the application layer is made extremely complicated by the large variety of posssible applications.

The powerful as this model is, it is limited by the assumption of completely autonomous layers. Any layer is strongly influenced by the adjacent layers, and care must be taken in defining the interface between layers. Also, overall parameters like throughput require consideration af many of not all af the layers.

3.2.3 Communications Between Applications.

The first data processing structures encountered in manufacturing indutry were star networks around a host computer. Today there is a wide range of equipment in the typical manufacturing plant: robots, programmable logic controllers (PLCs), various terminals, microcomputers, each with their own intelligence and store of local data. Providing a means of communication between these diverse systems is thus a major factor in improving the integration of functions. One of the main aims of modern manufacturing is to support and coordinate exchanges of information between applications.

A standard way of representing a company divides its functions into five levels (Figure 3.10). Within each level, horizontal communications is provided through a local network. Vertical communication between two adjacent levels is provided by a gateway system between two local networks (e.g. the company LAN and the factory LAN are coupled in the functional sense by the production control system).

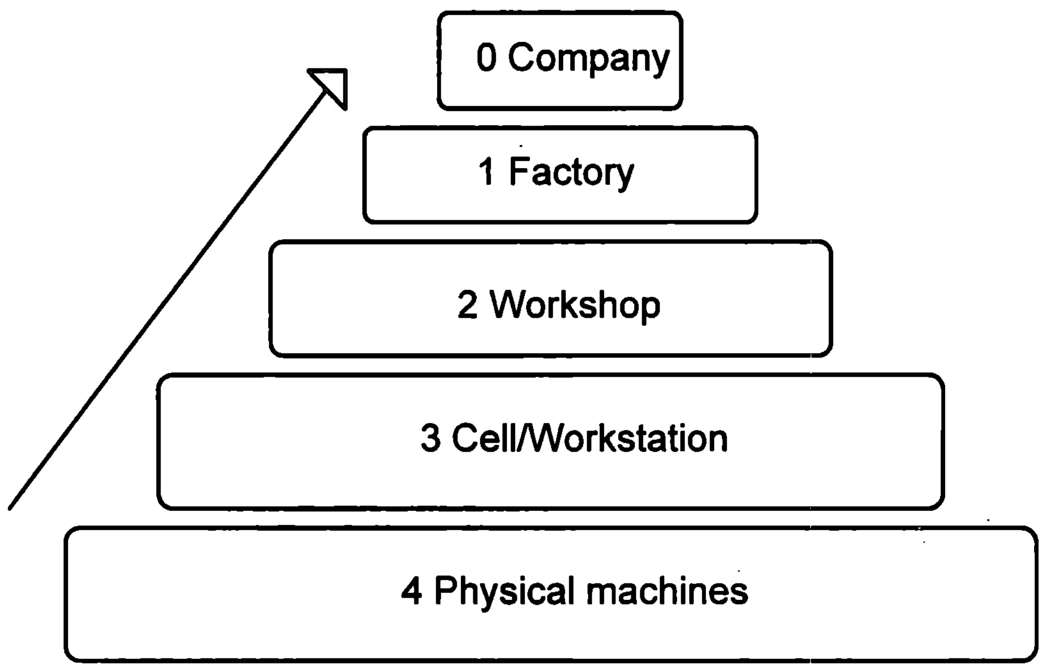


Figure 3.10 The hierarchical structure of a company

We thus arrive at a distributed structure for the company's information system (Figure 3.11). Each application or information system which communicates within the system will most often have its own store of local data. Integrating the data at the company level requires a knowledge of the possible ways in which the various elements can communicate with each other and it also means complying with a new distribution procedure.

Implementing this procedure involves the widest possible study of the set of applications to be integrated so that each item of information is stored only once in the most appropiate system.

The LAN world, particularly that of industrial LANs, has long suffered from being restricted to a very closed set of proprietary networks. Faced with the large number of international standards (ISO and CCITT) capable of being adapted for these networks, users decided to make themselves mutually comprhensible through two groups. MAP (Manufacturing Automation Protocol) and TOP (Technical and Office Protocol)

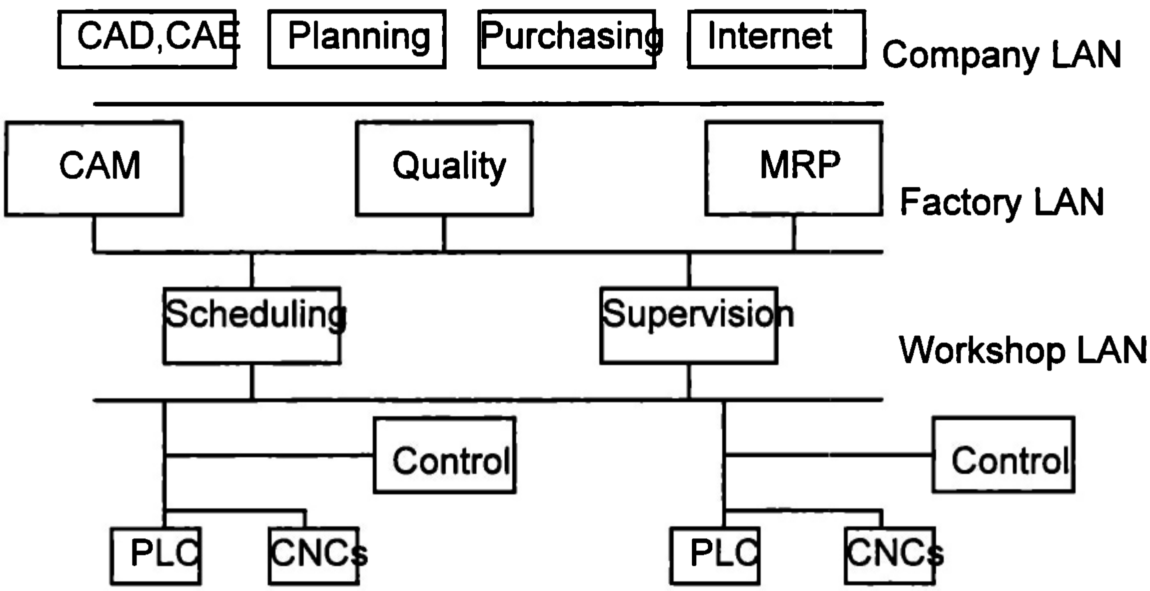


Figure 3.11 The structure of a managementinformation system.

3.3 Standards and Interfacing Problems.

Because of the different device technologies and demands used in the modern manufacturing enviroment there are always lots of problems related with interfacing. In addition, office communications networks impose different requirements than factory communications networks. In the office area, communications is primarly used for inter-computer file access and transfer. In such a communication system there are also high data-protection requirements. In computer integrated manufacturing, communication is largerly used to control programmable manufacturing equipment, here the time requirements are high, and error free data transmission is a necessity.

In the 1970s, the board range of communication devices used and the numerous manufacture and system specific implementations (mostly incompatible) led to the cooperation of various international standarization bodies with the goal of a systematic analysis of the requirements for open communications systems and suggestions for standarization.

Some of this efforts are reviewed below:

1. The European ESPIRIT program, especially the projects involving CIM (the CIM-OSA model, the CNMA project and the MAP 3.0 standard).
2.International's CAM-I
3. Data transfer standards in CAD graphics (IGES, VDA, SET, STEP).
4.The EDI data interchange standard (EDIFACT)

The ESPIRIT Project.

The European Strategic Programme for Research and Development in the Information Technology (ESPIRIT), was set up in 1984 on the initiative of the European Commision. The project has Three main objectives:

1.Making avaible to European data processing industries the basic technology for ensuring that they remain competitive in the 1990s.

2.Promoting industrial cooperation in Europe in the field of information technology.

3. Opening the way to setting up standards.

CIM-OSA (Open Systems Architecture)

The aim of the CIM-OSA project, known as AMICE (European CIM Arquitecture) in the ESPIRIT programme, is to define a standard for the open architecture of CIM systems through a set of concepts and rules facilitating the setting up of a computer-integrated manufacturing enviroment.

CIM-OSA consist of a list of models with complementary references enabling the requirements of a company as regards organization, data processing and human and material resources to be synthesized. The design of the CIM system to be installed is deduced directly from the model formed in this way.

The infrastructure of the system will be based on ISO-OSI standards (International Standards Organization and Open Systems Interconnection)which define the standard for communication between information systems.

CNMA and the MAP 3.0 standard.

The inability of disparate equipment to communicate with each other in the 1980s led General Motors and Boeing to describe and develop the Manufacturing Automation Protocol (MAP) and Technical and Office Protocol (TOP) programs respectively. These standards are based on the reference model for OSI defined by the international standards Organization. The MAP 3.0 version was introduced *during* the Enterprise Networking Event in 1988 at Baltimore USA.

Chapter 4.

Data acquisition and Control systems.

4.1 Definition of Data Acquisition and Control.

Data acquisition and control may take a variety of forms. At the simpliest level, data acquisition can be accomplished by a person, using paper and pencil, recording readings from a volt meter, ohmeter, or other any instrumet. For some situations this form of data acquisition may be adequate. Many applications, especially situations where the number of data points being recorded is relatively low and the frequency of the readings is slow enough for humans to record the data, this "low-tech" method of recording data is very appropiate. Those of us interested in technology, and applying technology, and applying technology to accomplish the tasks, need to be sensitive to the suggestion that we tend to complicate life and often use technology solely for the sake of using technology.

However, data recording applications that require large numbers of data readings or situations where very frequent readings are necessary, must rely on instruments or computers to acquire and record the data. These situations may require the use of more complicated systems to record large amounts of data, or to record data ocurring at fast rates.

Control of electrical devices can also occur at various levels of sophistication. At the "low-tech" level, a simple electrical switch can control a motor, conveyor belt, or other electrical/mechanical device. Often this approach to technology is adequate and frequently preferred over more complicated methods of control, particulary where the cost of sophisticated control system is not justified. Again, we do not want to use "high tech" where high tech is not justified.

Other control applications may require a more sophisticated approach industrial equipment including robots, integrated process control systems, and conveyor belts may need the processing power and flexible programming ability of a personal computer to provide the control needed in complicated systems.

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4.2 Data Entry Techniques.

Computers have become an integral part of almost all business operations. They are actevily used for planning, controlling, producing, and analyzing most aspects of modern life. The ever decreasing cost and size of computers has allowed them to penetrate a wide variety of businesses, institutions, agencies, and even homes.

A piece of computer harware by itself is not exceptionally useful. In order to be productive, a computer must be equipped with software suitable to the particular application. The effectiveness of the computer hardware/software system is a function of the input data that is provided to it. In order to maximize the benefit from a computer, timely (ideally, real-time) and accurate data is required. There are many data collection techniques that can be used with computer and also can be devided into two major categories.

4.2.1 Manual Methods

The traditional method of entering data into a computer system has involved manually keying in information (using a keyboard) that has been gathered an sheets of paper. Studies show that the error rate with this technique is approximatly 1 error for every 300 characters entered. Obviously, every data transaction requires that a human operator be involved.

Manual keying does not provide real-time data entry since the data being entered usually reflects events that occurred in the past. Because data is often gathered first on paper sheets and then transcribed via keyboard, several opportunities for making data errors exist.

4.2.2 Automatic Methods.

To avoid the disadvantages of manual entry methods, several automatic data entry technologies have been developed. In this usage refers to the fact taht a single entry event can result in the capture of a stream of data (from a single character to dozen of characters). In this definition of automatic data capture, a human operator may or may not be part of the actual entry event. Some of this methods are reviwed above.

A.-Optical Character Recognition.

Traditional optical character recognition (OCR) uses a highly stylized printed font. The two most common fonts are OCR-A and OCR-B Figure 4.1 illustrates an example of text printed in the OCR-A font.

Figure 4.1 Optical Character Recognition (OCR)

OCR fonts can be printed by several different techniques and are readable by humans as well as machines.

When used to read pages of OCR-printed text, an automatic page scanner can quickly capture all the data, while exhibiting an error rate of 1 character out of approximately every 10,000 scanned.

When traditional OCR is used to label products or documents, a hand operated scanner is employed. Some operator skill is required, and the first read rate can easily be less than 50 percent. If good quality labels are used, careful operators who have recived suitable training can achive a first read rate of 80 percent or more.

Unlike bar code, OCR is two dimensional technology. An OCR scanner examines both vertical and horizontal features of the printed characteres during the decoding process, therefore requiring control of print quality in both axes.

Recent developments in font independent scanning equipment have been made possible by advances in recognition algorithms and the decreasing cost of computing, but this technology has not yet had much impact on automatic identification applications. The primary market for this technology has shifted: font independent OCR is now primarily used as an entry technique for word processing and desktop publishing systems. many retail stores installed OCR equipment, but its use declined in the 80s because of:

- Low first read rate with semi-skilled operators.
- Lack of an automatic omnidirectional OCR scanner for checkout counters.
- High substitution error rate compared to bar code.
- Heavy in roads made by bar code technology.

B.-Magnetic Ink.

Magnetic ink character recognition (MICR) is the technology commonly employed in the making of U:S: bank checks (see Figure 4.2)

⑆125000037⑆ 0875506308⑈

Figure 4.2 Magnetic Ink Character Recognition

A highly stylized font is printed with an ink that has magnetic properties. Although the information could be read optically, MICR characters are decoded with fully automatic magnetic scanners. As in all magnetic technology, the reading equipment makes contact with the character to be read.

This technology is well entrenched in the banking industry, having been used for many years. At the time MICR was introduced for bank chacks, this was the only technology available for automatic entry of the account data. Because of the special ink and complex reading equipment, MICR is not used or situable for general purpose applications outside of banking.

C.-Magnetic Stripe.

Electromagnetic data is recorded on tape sections, generally attached to plastic films such as credit cards, ID cards, payments services and miscellaneous items such as cards for highway tolls and transportation in some countries, this way is possible to encode a great deal of information onto a magnetic stripe similar to standard audio cassette tape but tailored to a rigid base film. Information is

stored as a series of regions with differing magnetization, Data can be changed an a magnetic strip, adding flexibility to an information system.
Magnetic stripes have not been widely adopted for general tracking because of:

- The unavailability of nonconatct scanning equipment
- Enviromental considerations.
- The inability of conventional printing methods to encode magnetic information.
- Higher labeling costs compared to those of optial technologies that use images printed onto paper substrates.

D.-Voice Data Entry.

This technology is well suited for certain manned applications like bagagge sortation, where operators need both hands free. Voice recognition, however, does not fit our definition of automatic identification: part numbers willhave to be spoken character by character and the operator is an integral part of the data capture process and is the main cause af al errors.

E.-Machine Vision.

Machine vision systems are used in many manufacturing companies to sort, to inspect, or to measure products automatically. They consist of a high resolution television camera interfaced to a computer via signal processing circuitry. Considerable software complexity is involved in most machine vision systems. This equipment is usually custom tailored for each application. A vision system can perform automatic identification via bar code or OCR symbols, but its primarily function is inspection and sortation.

F.-Radio Frequency and Infrared.

Automatic identification systems using radio frequency (RF) can read data from tags that are not even optically vivible to the system. A radio signal is transmitted toward the tag, and it responds with a radio signal that is modulated with information stored in the tag. One of the initial applications involved the tracking of livestock, but many applications in transportation and manufacturing have subsequently developed.

Tags can be reprogramed with data, or they can allow the data to be changed in response to comands modulated onto the interrogating radio signal. Most programmable tags require an internal battery; nonprogrammable tags usually derive their operating power from the interrogating beam.

The tags are fabricated either from conventional integrated circuit technology ar as surface a surface acoustic wave (SAW) device. The SAW technology makes a very simple and potentially low cost device, but capacity is low and the data must be programmed into the tag during fabrication.

G.-Smart Card Identification

Smart cards and optical cards are credit card sized auto ID active systems containing miniature solid state electronic devices. such as microchips able to store digital data in their memory system. They can be programmable or not. Most current applications for smart cards involve financial or medical data, and the card is normally carried by an individual.

H.-Bar Codes and Barcode Readers.

No doubt this is the best known and most widely adopted identification system especially for automatic processing of mass consuption items and is one of the best options for data collection in the shop flooras well as the use of terminals for data aquisition. Further information is shown in the next section.

4.3 Introduction to Bar Code.

Bar code is a technology that has recived much publicity in the past few years. Widley implemented in the retail marketplace, it is rapidly gaining increasing visibility in a board range of diverse applications.

Fig 4.3 A Simple Bar Code Symbol.

Bar code can be thought of as a printed version of the Morse code, with narrow bars representing dots, a wide bars representing dashes. To read the information contained in a bar code symbol, a scanning device such as light pen is moved across the symbol from one side to the other. As the scanning device is moved across the symbol, the width pattern of the bars and spaces is analyzed by the reading equipment and the original data is recovered. Some scanning devices do not require the operator to provide the scanning motion: an electronic scanning systems or moving optical element allow the symbol's bars and spaces to be sequentially examined automatically.scanning sucess rate to most 100 percent.

The most visible application is in the supermarket industry, where it has been used since the early 1970s. Bar code is now the de facto automatic identification technology is a wide range of industries.

Fig 4.4 Scanning Procedure.

Bar code is an automatic identification technology. It allows real-time data to be collected accurately and rapidly. But bar code by itself does not solve problems. The combination of bar code with appropiate computer hardware and application software creates the potencial for improving performance, productivity, and, ultimately, profitability.

Bar code symbols can be printed at low cost with a wide variety of printing techniques, and the overall symbol can be uniformly scaled up or down to suit particular requirements. Bar code is a single dimensional technology only the widths of the bars and spaces contain information. The height of these elements can be considered as a measure of the bar code symbol's data redundancy. Bar code systems can offer very high data security; the substitution error rate often can be better than 1 error in 1 million characters. The first read rate is usually better then 80 percent, and many automatic scanners increase the percived

4.3.1 History.

Retail applications drove the early technological development of bar coding. but industrial applications soon followed.

Wallance Flint, son of a Massachusetts grocery wholesaler, wrote his 1932 master's thesis at harvard on a system used flow racks and pounched cards to automatically dispense products to costumers. The propousal was economically unfeasible, but this was the first time that the benefits of an automated checkout had been completly documented. Forty years later. Flint was the vise president of the National Association of Food Chains, and he actevily supported the standarization effort that led to the Universal Product Code and its associated symbology.

In the late 1940s, Joe Woodland and Berny Silver were investigating technical approaches that would allow prices of grocery items to automatically be read at the checkout stand. several approaches were pursued, and their developments culminated in the filing of U.S. Patent 2,612,994 in 1949.

The Woodland and Silver patent describes a circular printed pattern that resembles a miniature archery target. This format is often refered to as a Bull's-eye code. The concentric rings of the target are, however, symply bars and spaces curved into a circular form. Conceptually, bull's eye format for barcoding and bar codes are the same. Technology and retail economics were still not ready for bar code, but twenty years later Joe Woodland, then an IBM engineer , was part of the team that develop the precursor to the UPC bar code symbol.

In the late 1950s and early 1960s, several inventors proposed the constroction of stylized human-readable characters that would look like bar code to the automatic scanner but appear like numarals or letters to a person.

Unfortunately, such arrangements are more difficult for machines to read than true bar code and less pleasant for humans to read than traditional type fonts.

Serious efforts toward developing a standard for automating the supermarket point-of-sale began in 1968. RCA developed a bull's eye symbol and scanner taht operated in a Kroger store in Cincinati for an 18-month period begining in 1972. This test store provided much valuable data for cost benefit analysis and system refinement

4.4 Decision of Data Entry Technology.

It is important at to this point to decide wich one of all the posibilities avaible for data entry is adequate for the task, so it is important to review all the characteristics of all the data entry techniques.

Table 4.1 sumarizes the key features of each of the described data entry techniques. The statistics in this table reflect the assumption that a human operator was going to capture the data on a label attached to a carton. The data entry times include allowances for an operator to pick up the scanning device, oriented it, and move it to the label.

Bar code and human readable text are often printed together, so little additional costs is associated with the inclusion of a bar code symbol. A single beam scanned through a symbol can extract all of the information. This inherent simplicity has led to the availability of effective yet low cost handheld scanners and high performance fixed scanners that can read bar code symbols from a distance of several feet on objects moving hundreds of feet per minute.

Because of these advantages, bar code has become the dominant automated identification technology.

Finally compared to the other automatic identification techniques outlined in table 4.1, Bar code stands out as an attractive technology as well as Manual

Keying though a Terminal because the cost. Bar Code It is inexpensively printed by a variety of techniques and offers high data security. A wide variety of reading equipment is available to suit all imaginable applications.

Table 4.1

Comparison of Data Entry Techniques

	Time to Enter.	Error Rate.	Size of Label.	Cost of Label.	Cost of Reading Equipment	Advantag-es.	Disadvan-tages.
Manual Keying.	10 sec.	High.	.4"x 2.2"	Low.	Low.	Low initial equipment costs.	Requires human operator error rate.
OCR	4 sec.	Medium.	.5" x 2.5"	Low.	Medium.	Can be read by humans.	Poor error rate, inflexibility
MICR	Normally. Machine Scanned.	Medium	.5" x 2.5"	Medium.	High.	Can be read by humans	Expensive. Inflexibility of reading equipment
Magnetic Strip.	4 sec.	Low.	.4" x 1"	Medium.	Medium.	large amounts of data can be encoded,	Affected by magnetic fields.
Voice Recogniti-on.	20 sec.	High.	.4" x 2.2"	Low.	High.	"Hands Off" operation.	Requires human operator
Machine Vision.	Normally Machine Scanned.	Depends on Marking.	Variable.	Variable.	Very High.	Can be part of inspection system.	Expensive. Not suited for general applications.
Radio Frequency	2 sec.	Low.	1" x 1.5" x .2"	High.	High.	Label does not need to be visible	Expensive labeling.

Bar Code.	4 sec.	Low.	.6" x 2.5"	Low.	Low.	Flexibility of printing and reading equipment.	

4.5 Operator Interface.

Unless a fixed mount input device is used, an operator is associated with each bar code reading system. the particular application often requires that prompts or error messages be sent to the operator, this can take several forms:

1.-Programmable beeps:

The attached computer is able to cause the reading system to sound a series of controllable beeps. The number and tone of the beeps are usually programmable.

2.-Status lights:

The reading system can be controlled to selectively illuminate status lights that are located on the decoder; these lights have special significance in a given application and are labeled accordingly.

3.-Displays:

The decoder can include a display that is visible to the operator. This display may present numeric or alphanumeric messages to the operator in one or several lines, using LCD, LED, VF, CRT, Plasma or other technologies.

Some applications require the use of a keyboard to enter exception data. This keyboard may consist of purely numeric keys, dedicated function keys, a full alphanumeric keyboard, or a combination. The error rate with keyboard use is expected to be higher than when scanning bar code symbols.

4.6 Applications.

Barcode can be effectively used in a wide variety of applications. This section provides a brief overview of the applicability of bar code to several different industries and applications such as: Library Applications, Inventory control, Work in process tracking, MRP and MRP II applications, Receiving applications, Shipping, Electronic data interchange, and Retail applications. We will focus only on those applications related with manufacturing.

Inventory Control.

The use of bar code can significantly reduce the effort required to do a physical inventory, while simultaneously increasing the accuracy level.

Portable readers are used to scan inventory items and/or boxes that have been marked with a bar code part numbers. If appropiate, bar coded shelf identification labels are also scanned as part of the transaction sequence.

Objects that sre too small to mark individually are precounted and kept in labeled bags containing two bar code symbols: the part number and the quantity. Symbols encoding quantity information use flag characters or others schemes to avoid being misinterpreted as part numbers.

During the actual inventory taking process, a simple application program in the portable reader prompts the operator through the sequence and checks for the entry of duplicate part numbers. The operator is asked first to enter the part number and then to enter the quantity. Quantity data is entered either by scanning the quantity symbol on a sealed package or by counting the items and entering the data via keyboard or barboard. Field checks in the portable's application program ensure that valid data is being entered.

During the physical inventory process, the portable's application program is building a data file in its memory, containing a list of part numbers and quantities. Optionally, the file may also include location and/or time information.

When the inventory operation is complete, or at other regular intervals, the contents of the portabel reader are uploaded to the host computer system via either modem or direct connection. If a radio-linked device is being used, the uploading can occur while the operator is performing the invetory operation.

The process is somewhat different for a cycle count. At the start of the operation, a data file is downloaded from the host computer into the portable reader. This file lists the part numbers to be checked as well as the current estimate of the inventory level. The file may also have location data, and may have been processed so that the operator takes an orderly route through the stockroom or warehouse.

When the cycle count file has been downloaded, the portable reader's display prompts the operator as to which part number or location to check. The operator is the asked to scan the symbol on the object to be counted. The application program confirms that the object has the correct part number and then prompt the operator to enter the quantity counted. If the quantity counted does not match the quantity expected (based on the downloaded file), the application program makes an entry into the exception file. The operator is then prompeted to move to the next item to check.

When the operator has completed the list of items, the portable terminal is connected to the host computer so that the inventory level file can be uploaded.

Work in Process Tracking.

A manufacturing company's inventory has three components: raw material, work in process(WIP), and finished goods. Of these, WIP is the hardesttype of inventory for many companies to control. WIP includes components and assemblies that are currently being worked on as well as semifinished products and assemblies that are waiting between work centers.

It is natural to want to have high WIP buffers between manufacturing operations in order to minimize the possibility of shortages. The disadvantages of this approach are:

1.-More capital is tied up in WIP, thereby incurring excessive interest costs.

2.-Higher occupancy costs (rent,insurance, heat, light, taxes, etc.).

3.-Larger quantity of product to rework if problems are found.

4.-Poor visibility of quantity problems.

5.-Poor responsiveness to changes in the production schedule.

6.-Greater exposure to obsolete inventory costs.

The annual cost of WIP inventory can be about 30 to 35 percent, providing ample incentive for reducing the WIP levels. Taken to the extreme. WIP can be reduced all the way to just in time (JIT) levels with a single unit batch size.

As WIP and batch sizes are reduced, accurately tracking the flow of materials, assemblies, and products becomes increasingly important. Bar code has been used successfully to track WIP in a variety of industries.

A bar code WIP tracking system can have many forms. In its simpliest configuration, a computer (microcompute, or mainframe) is connected to a series of on line readers and at least one printer. Each work center has a reader that an operator uses to log products or assemblies as they pass through. Assuming that the products themselves are not individually bar code serialized (although in many cases they are), a paper work order follows the actual product flow.

The work order has a bar-coded work order number and lists all of the operations that are to be performed. Each operation description has a bar code next to it that uniquely identifies the operation number.

As an operator completes an operation, the bar code reader is used to enter the serial number or work order number, the operation code, the employee ID, and the quantity completed. Any necessary exceptions to the normal routing can also be indicated through the scanning of appropiate preprinted labels.

The data collection network timestamps each transaction and updates a database. The collected data can be used as feedback to a material requirements planning (MRP) system and can also provide reports on:

- Work order status.
- WIP levels.
- Bottlenecks.
- Productivity.
- Yeild.

MRP and MRP II Applications.

MRP II stands for "Manufacturing Resource Planning" which is rapidly overtaking traditional material requirements planning (MRP) as an effective computer based tool in manufacturing operations. MRP II has the ability to significantly decreaseproduction costs and increase quality.

MRP II is more than just a software program; it is a way of conducting business. It has been traditional to grade the effectiveness and commitment to MRP II on a three level scale: Class A, Class B, and Class C. For MRP II to be truly efective, a company must reach and maintain a class A rating. Class A has associated with it a number of procedural and accuracy requirements. Bar code can effectively be used to achieve the following Class A minimum accuracy requirements:

Inventory accuracy	95%
Bill of materials accuracy	98%
Routing accuracy	95%

An ongoing program of cycle counting using bar code is a cost-effective way of achieving the Class A inventory accuracy goal. Bar code can contribute to the attainment of the other accuracy goals as well. MRP II software is available from many vendors and can be run on a variety of computers.

With accurate data files in place, the main driving function of an operating MRP II system is the master production schedule which determines what products will be built in which time period. The master production schedule is arrived at

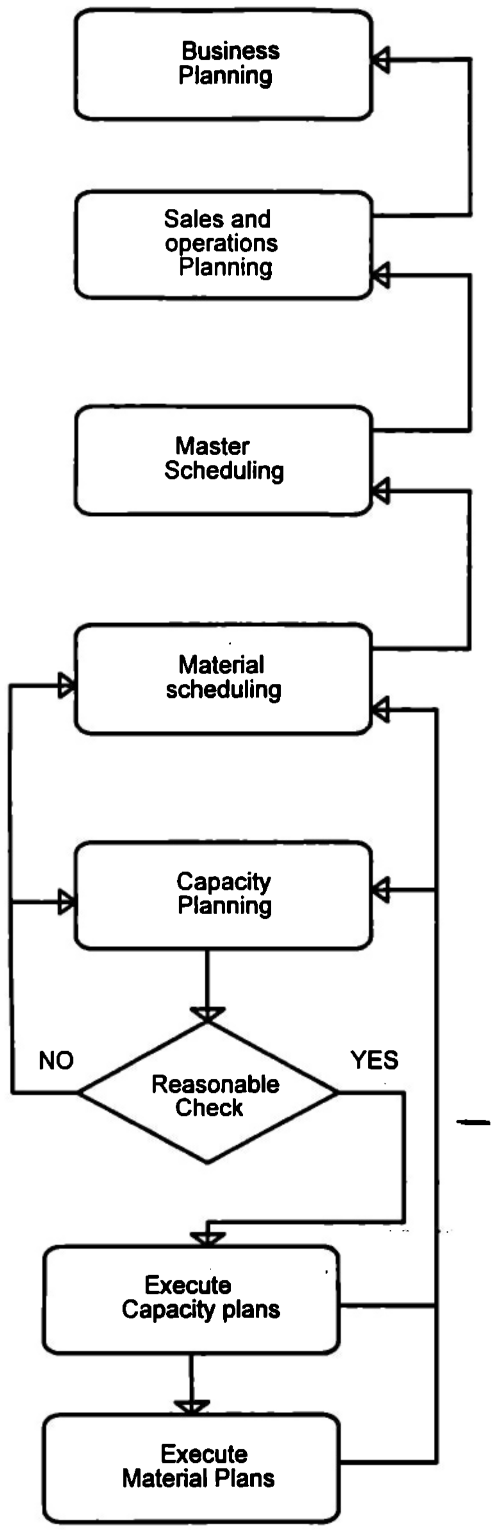


Figure 4.5 The iterative MRP II Process

The MRP II system needs to be made aware of any failuresto follow the actual plan on the factory floor (due to yields, scrap, shortages, etc.). When discrepancies occur, the production schedule may need to be modified to reflect the consequences of the deviation. early and accurate vivibility of problems can be provoded by a bar code WIP (work in process traking system). Like all computer based systems, MRP II relies on accurate and timely data. Bar code is ideally suited to fill this information need.

CHAPTER 5

ON LINE READER SYSTEM DESIGN.

5.1 Introduction.

We have seen in the last chapters all the different Information Systems as well as the different data entry techniques, and we found that one of the most outstanding data aqusition systems is the bar code reader and also the traditional way, the terminal.

The systems design is often used to cover all the phases leading up to actual implementation of a bar code system. Actually, systems designs is only one of the four distinct phases in any bar code development project. The four phases in a bar code application are definition, systems analysis, system design, and implementation.

5.2 Definition Phase.

During the definition phase, the flows of material and information are examined and modeled. Grid flow, data flow, and/or work flow diagrams are useful tools in modeling the proposed system. The actual users of the propoused system must take an active role in this phase.

When monitoring the system, planners must take care not to overemphasize data input rather than data output.

The flow of information can be categorized as follows:

- Action information:
  Usually real time in nature, this data is used to cause some action.
- Archival information.
  This data is not acted on immediately but is stored for traceability requirements.
- Report Information:

This data may not be acted on immediately but is used in a report that is used for decision making; examples would be inventory levels, labor hours, or cost summaries.

5.3 Analysis and Design Phases.

The charts and flow diagrams developed during the definition phase are an important input to the analysis and design phases. Structured modeling techniques and network simulation models (examining material and information flow relationships) can be effective tools during these phases.

Three types of system architecture can be used: a stand alone system; a fully integrated, on line system; and a hybrid system. A stand alone system uses a separate, dedicated computing resource to manage the data collection activity. Data is transferred between the factory data collection computer and the corporate processor in a batch mode at regular intervals. In a fully integrated, on line system, the bar code periphericals, be they printers or readers, are connected directly to the existing corporate data processing system. A hybrid system provides computing capabilities at the bar code reader but is still basically a fully integrated, on line system.

5.4 Local intelligence.

Independent of other selection criteria, bar code reading systems can be divided into two categories: nonintelligent readers and intelligent readers. In a non intelligent reader, data from the decoding process is passed in an unaltered format to either the host computer (on line or wireless portable) or is stored (portable reader). In the case of an on line reader, the host computer's application program is a part of every transaction. Figure 5.1 shows a block diagram of a nonintelligent reader.

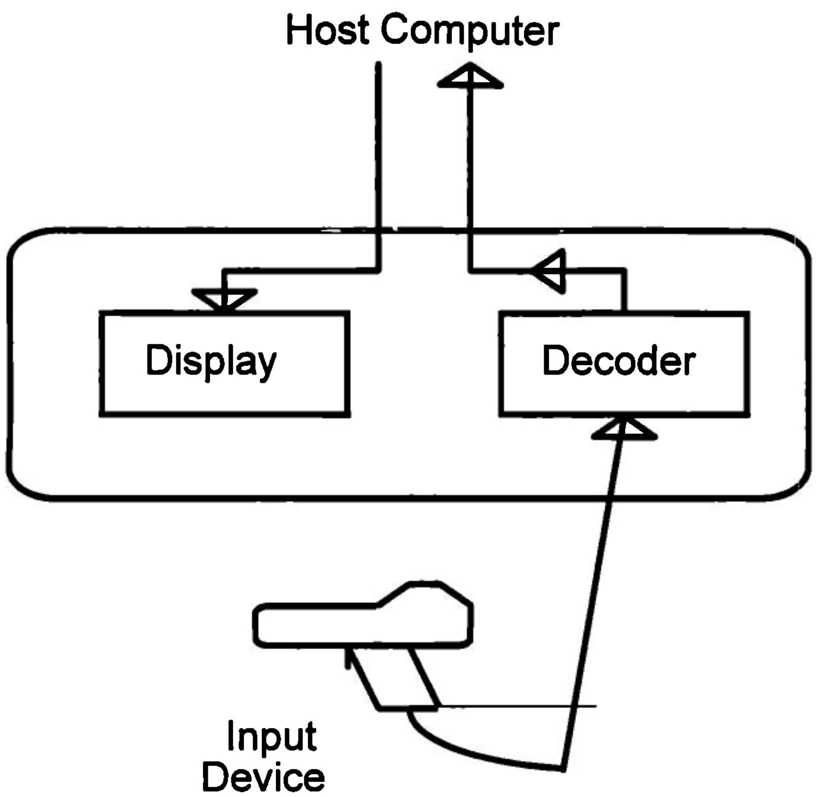


Figure 5.1 Nonintelligent Reader Concept.

An intelligent reader is illustrated in figure 5.2. Data from the decoding process interacts with an application program that is resident in the reader. This application program can perform local data editing on validation and can reformat the data. Prompts and error messages are generated locally, off-loading the host computer, and providing extremely short response time to the operator.

The local application program is typically retained in nonvolatile memory and can be loaded into the reader via several different methods:

- Download from a host computer.
- Transfer from another reader.
- Enter via a locally attached CRT.
- Enter via a connected or integral keyboard.
- Enter via scanning a series of bar code symbols.
- Plug in a pre-programed chip or cartridge.

The intelligent reader provides distributed intelligence to a data collection system, allowing for improved system response and off-loading the host computer. An intelligent reader can be operated in a store and forward mode, allowing data capture to continue at the reader level, even if the host computer is inoperative or unavailable. When the computer is back on line, it can retrive the transactional data that was stored in the intelligent reader's memory.

All communications to and from the host computer is handled by the application program, there is no direct connection between the data interface port and the reader's decoder, display, or keyboard (if present).

The actual application program is written in a high level programming language. This high level language is converted to machine code by an interpreter or compiler. Some equipment manufacturers require that this conversion be performed on a separate software development system; others allow this process to ocurr in the reader itself.

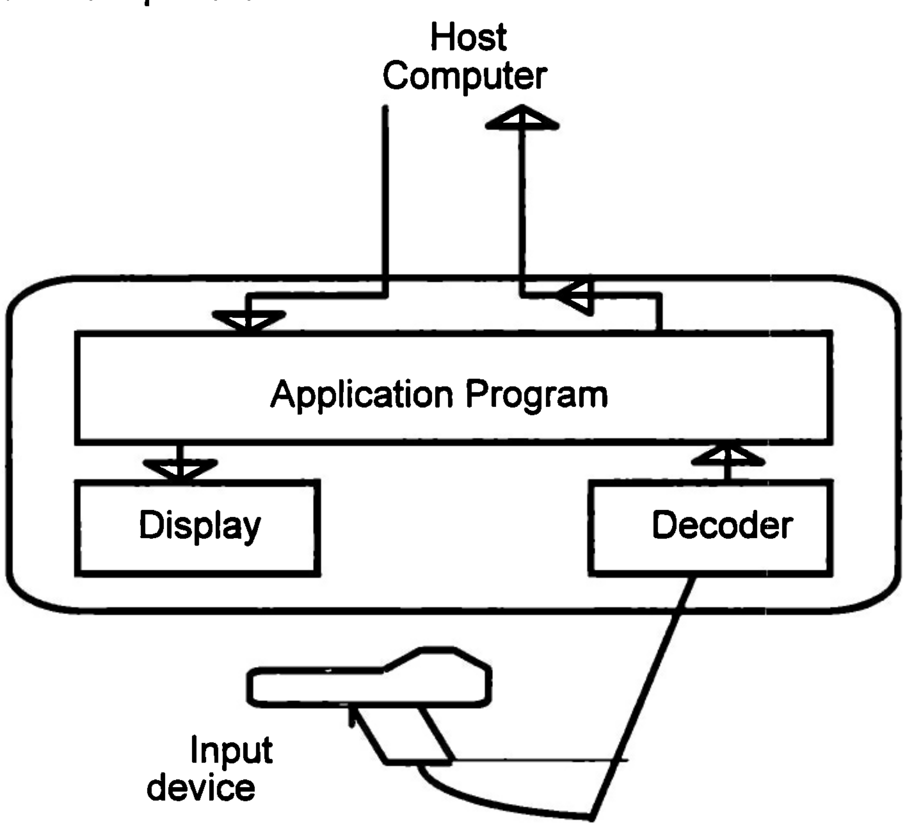


Figure 5.2 Intelligent Reader Concept.

5.5 Connecting Readers:

Almost all applications involving bar code readers require that they be interfaced to a computer system. A variety of techniques and equipment are available to perform this function.

5.5.1Keyboard Wedges.

The term "wedge" is used to describe a class of bar code readers designed to be connected in series with the keyboard of a personal computer or CRT terminal that is equipped with a detachable keyboard. The keyboard can still be used normally, but data resulting from the scanning of a bar code sysmbol will be treated by the PC or terminal as though it originated from the keyboard. Figure 5.3 illustrates the physical arrangement.

A keyboard wedge allows bar code reading capability to be rapidly added to an existing computer without requiring special programming. Wedges are sometimes equipped with auxiliary ports for transporting data from a portable terminal.

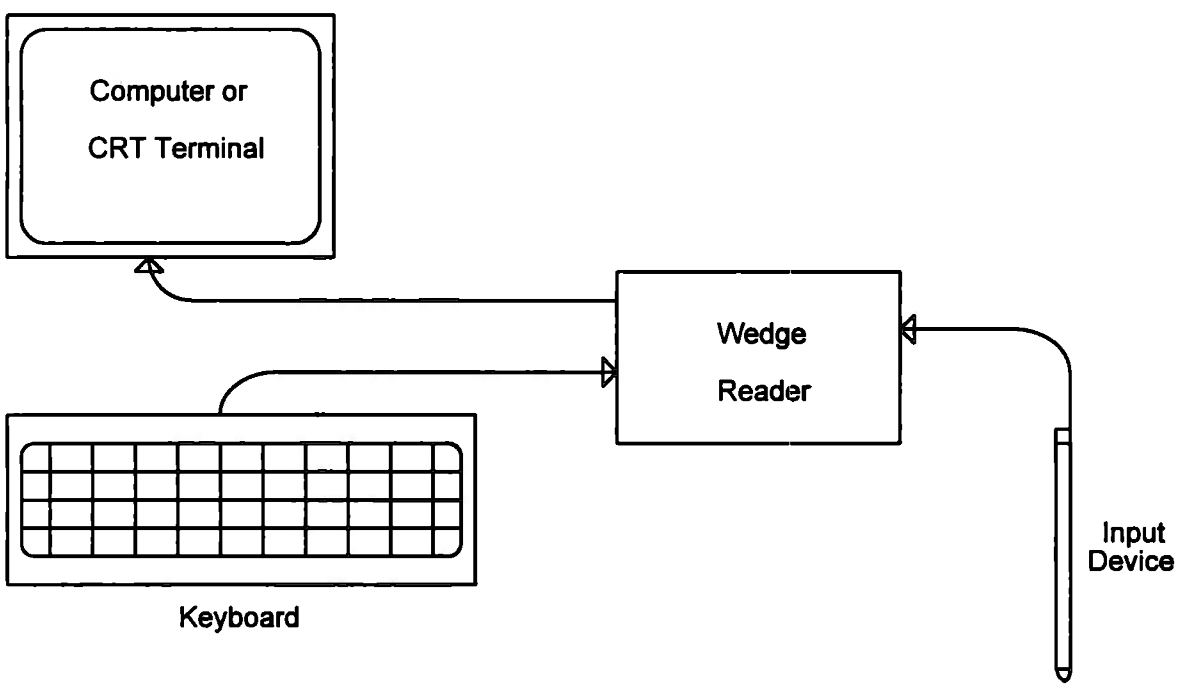


Figure 5.3 Keyboard Wedge Concept.

5.5.2 ASCII Wedges

Most non-IBM computers transfer data to and from attached terminals by means of asynchronous transmission of ASCII characters. Many bar code readers are provided with dual data connectors, allowing them to be connected in series with the terminal as shown in Figure 5.4. The actual data communication may employ RS-232, RS-422, or current loop levels.

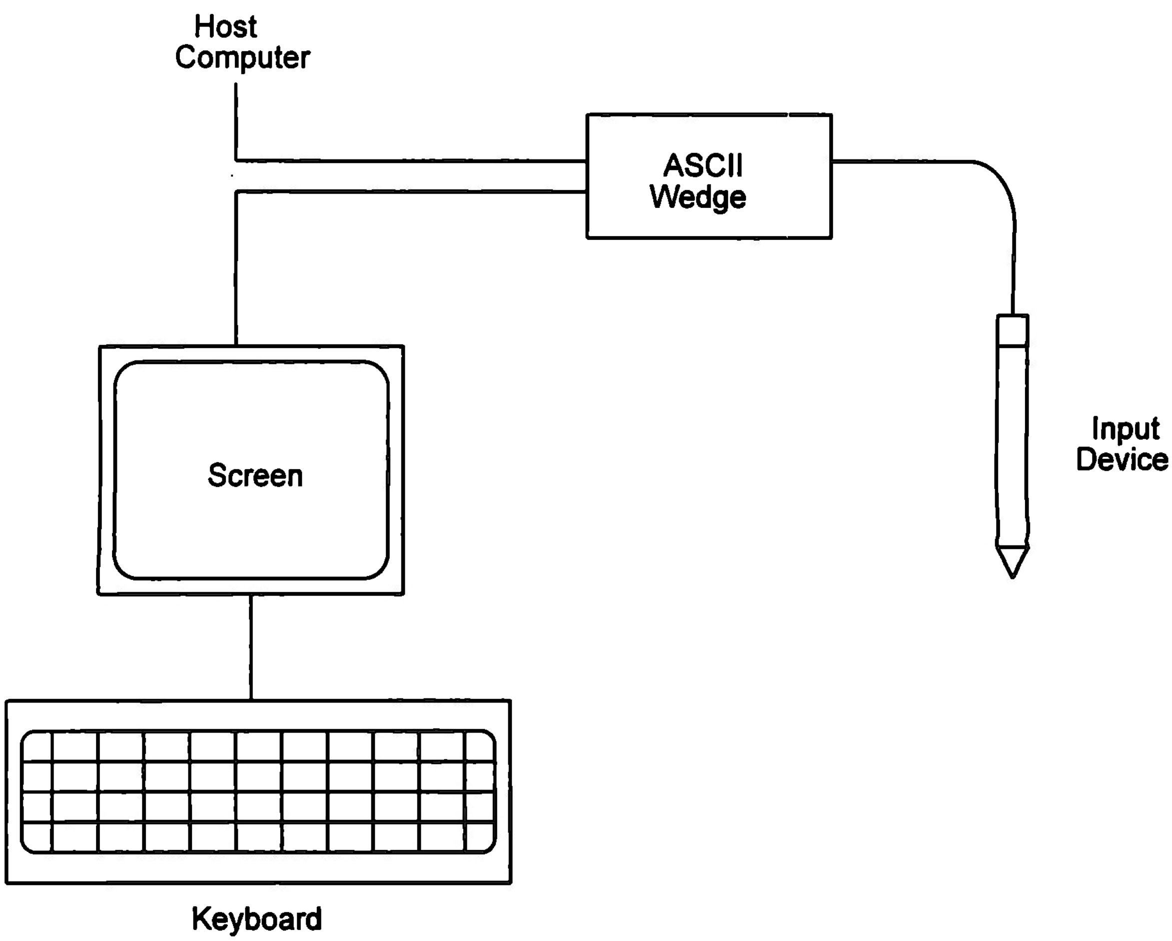


Figure 5.4 ASCII Wedge Concept.

Data from the host computer passes through the reader to the terminal's display. Data from terminal's keyboard passes through the reader to the host computer. Data from the bar code reader is transmitted to the host computer as though it originated at the keyboard. No special software is required to interface the bar code readert.

5.5.3 Direct Connection.

Bar code reading equipment is often interfaced to a host computer without being associated with a PC or terminal. A keyboard and/or display may be provided. The simpliest interface is a direct, point to point connection, as shown in figure 5.6.

The direct point to point interface usually uses asynchronous ASCII data, and RS-232, RS422, or current looplevels. Larger computers use terminal controllers to interface top attached periphericals.

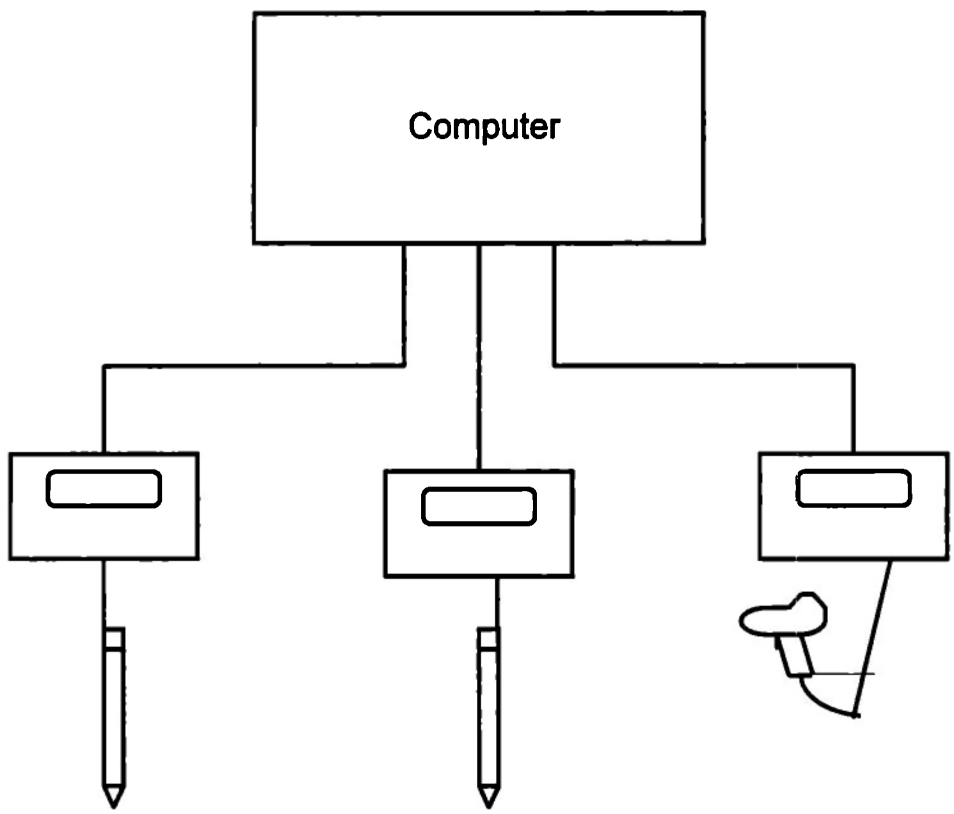
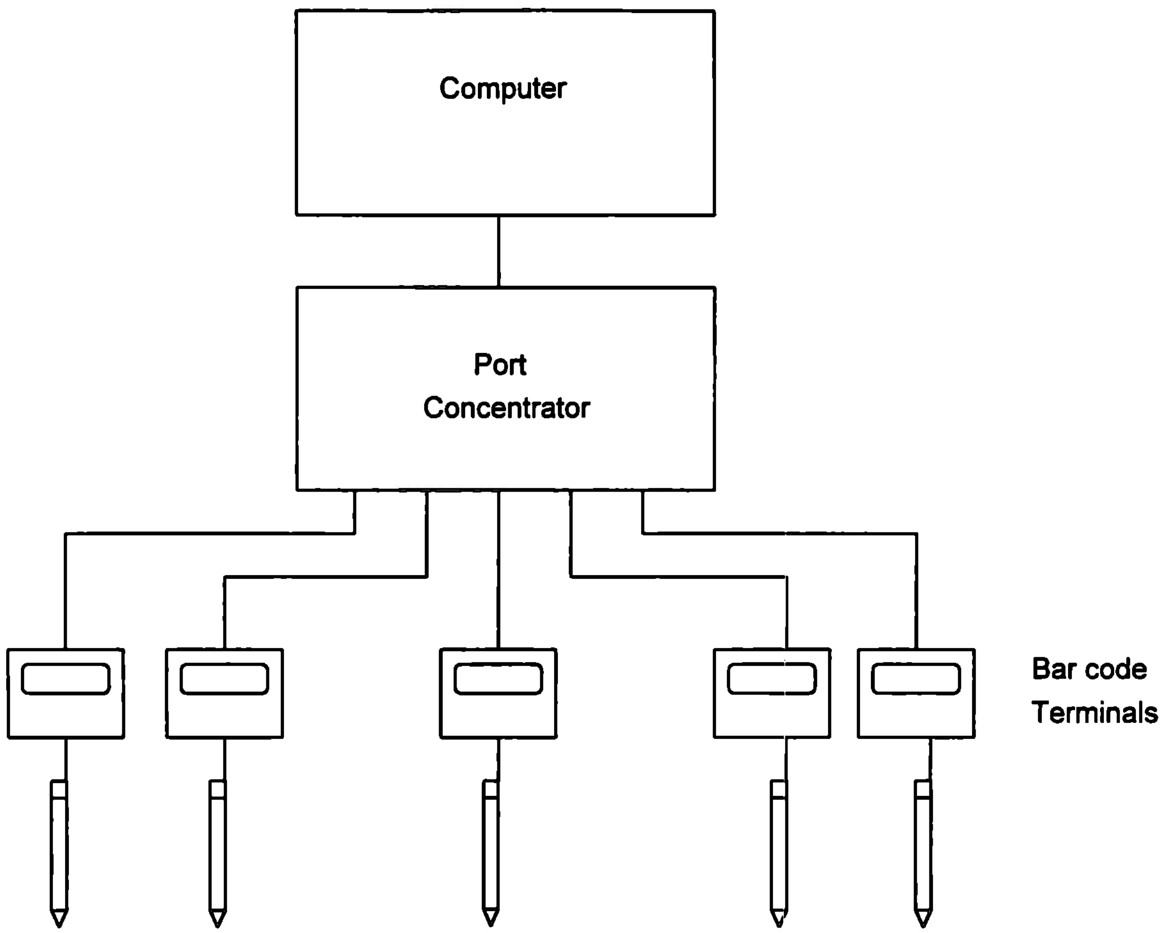


Figure 5.5 Point to point Concept.

If insufficient ports are available to support the reuired number of readers, a port concentrator can be used. A port concentrator communicates to the host via a single link but handles traffic to a quantity of bar code equipment via a series of point to point or multidrop lines, as shown in figure 5.7.



5.6 Data Acquisition Using a Serial Interface

One type of commercial device available for connection through a serial interface is a data acquisition and control device. Such a device permits analog signal convertion under control of the IBM PC. A primary advantage of this approach is that no boards need to be inserted inside the PC. All connections are external through the standard asynchronous communication adapter. This permits further separation between the PC and the site of data acquisition than is normally permitted with a bus-connected data acquisition system. A primary disadvantage is that the speed of such an approach is limited by the necessity to transfer all data through a serial link, as opposed to a dedicated bus system, which can transfer sampled data in parallel to the PC. This may limit its usefulness in some applications.

Figure 5.4 shows how several of these acquisition devices can be connected along an RS-232 cable. In this example, the PC controls which of them is selected at a given time by sending out its unique address to activate it. Only one of the devices can interact with the PC at once because of the shared serial interface. The device closet to the PC receives the message and relays it to the next device through a serial interface. In a typical application, the PC selects a device and issues commands to do such operations as set the sampling rate, set the number of samples to convert , and start convertion. Once the device has accomplished this task, the PC commanmds it to transfer the sampled data back. The PC can then manipulate, store, and display the captured data.

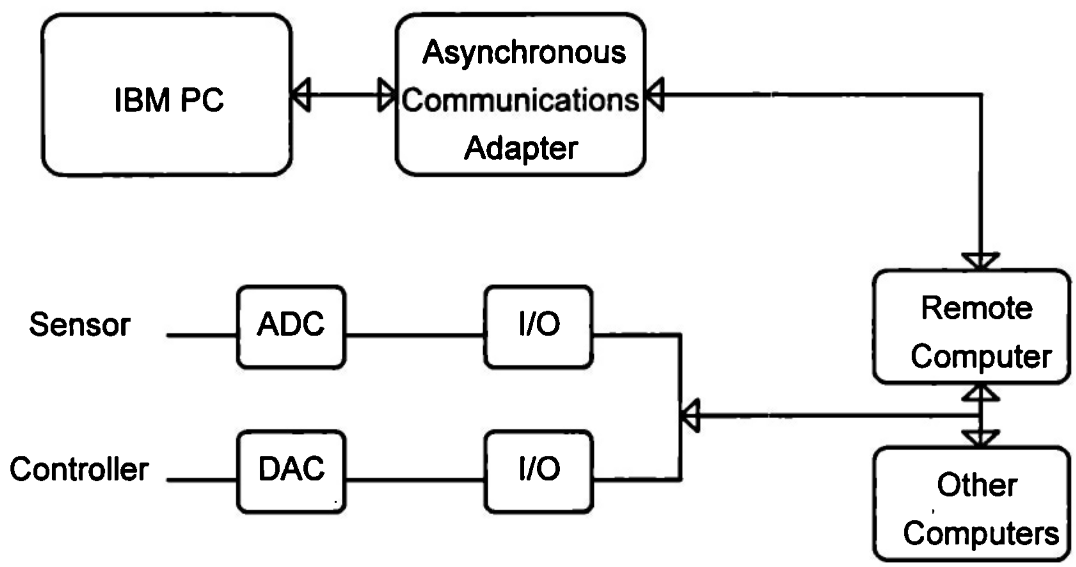


Figure 5.7 Computer control of remote-sensing devices connected through a serial interface.

5.6 Characteristics of the Implemented System.

the system uses intelligent barcode readers, located on the shop floor, to collect manufacturing data, the readers are programmed so they can lead the user through the sequence of steps needed for proper data collection, as the data in entered, the barcode reader program checks to make sure it is correct (format and Character only), and then prompts the user for the next entry.

Advantages of barcode data collection include:

- Barcode data is not subject to keyboard error by person entering data,
- Intelligent reader prompts user for needed information.
- Data input is standarized for all users.
- Multiple barcode readers can be connected to a single PC for a board coverage data collection device.
- Data collection is independent of PC operation, so PC can be used for other applications while manufacturing continues.

Disadvantages of a barcode data collection network include:

- Updating databases is done in batch mode and data may note be current,
- Data is not compared to previous transactions or plans so the data entered may not be what is needed.
- errors are not detected until after the data is uploaded to the system. Then someone must try to figure out what the person was trying to do and must manually correct the information. Manual data correction increases both the processing time and costs need to get accurate data.
- Labor and work center tracking only, does not support material transactions.

Many kinds of software is available in the market that are designed to incorporate barcode readers for use in capturing data. The data is captured by simply passing the wand of the reader over the selected codes on the process plan, a barcode sheet, an ID badge, or other barcode list. The codes identify:

- The activity,
- Who is doing the task,
- Records the time,
- Number of part made,
- and if there are any rejects to be recorder.

There are essentially two barcode data collection systems, a barcode network or barcode readers connected directly to a PC as we seen early.

A barcode reader uses a laser light to "read" a pattern of printed bars. The bar code contains specific information needed by the system. .PAMS for instance uses Code 39 barcodes (see Apendix B), and it is also the software available for the implementation.

5.6.1 A Barcode Network Implementation.

In the simplest system a single barcode reader can be connected to a single PC and all data collected from that station. When data is collected it is "uploaded" to the system databases to update files. In most application this is not a practical solution since there is usually a need to collect data from a number of different locations, sometimes quite a distance apart. In addtion, the PC may be needed for another applications and having a single PC severely limits flexibility.

This limitation can be overcomed by connecting a number of barcode readers to a centralized data collection device, capture the data from the various readers and store it untill is needed, then upload the data to any Manufacturing Management system like PAMS or Fourth Shift.. These data collection (barcode) networks come in a variety of configurations but fall into two categories, port concentrator or multi-drop configurations. The port concentrator is basically a parallel device with each barcode reader conected to a "port" on the controlling device. The multi-drop systems connects multiple barcode readers to a single cable. These then uses "intelligents" barcode readers (such as the Intermec 9512) for data collection. An intelligent bar code reader (as we seen in section 5.4) contains a display that can be programmed to promt the user for the needed information. When data is entered the reader time stamps the transaction and then compares it to "programmed" limit to determine if the expected data is what is entered.

As the data is collected, it is stored by the data collection device (port concentrator or multi-drop contoller) until is required.. Then it is necessary to upload the collected data to the Factory Information System (FIS), updating the tracker database to include all of the latest transactions. Barcode data collection system reduce the data entry errors related to job numbers, times, quantities, etc.

This type of data collection works in batch mode, and since it is not real time, is prone to transactions errors (opetator does a start instead of an end, enters the wrong job or work center number, etc.) These errors must then be corrected to maintain the data integrity. A more practical solution would be to have a real-time system that could verify the information as it was entered. Another disadvantages is that barcodes networks, because is there programmmability limitations, cannot handle material or non-standard transactions.

5.6.2 Programs Development.

For this particular applications two different programs had been developed with the software,one for the case of a Multi-Drop Configuration, and the other for Direct Connect configuration (see Apendix A). Both programs have been written in IRL (Interactive Reader language), this language allows you to develop custom programs for the reader Intremec 9512. This language expands upon the BASIC programming language to provide with the flexibility of a high-level language.

IRL programming capability is built into the reader, so you do not need a separate development system.

IRL programs can be entered easily by scanning bar-coded program statements with a wand or scanner or by entering the commands from a CRT terminal or keyboard.

Programs can be stored in the reader´s memory (two 32K x 8 RAMs) or stored in the host´s memory and downloaded to the reader, Also, a program in one reader can be copied into another reader.

5.6.3 Using Direct Connect Option.

The barcode can be readed form either direcction, right-to-left, or left to right. The wand should just touch to surface of the paper, it uses light to read the label so you don´t need to press down.

The following paragraph describes the prompts and operations involved in recording data using a programmable barcode reader such as the Intermec 9512. Normally the data is collected by the reader and stored by multi-drop contoller or port concentrator.(See Appendix B for the Interface Cable needed)

To start, the reader must be ready (the "**OPERATION TYPE**" prompt on the screen). The operator must enter one of the standard operation types (**START**, **STOP**, place a job on **HOLD**, etc.) to start the reader sequence. On the sequence is started the displays and responses required are as follows:

ENTER OPERATION TYPE: Wand the operation type from one of the codes on the Standard Barcode sheets.

ENTER A JOB NUMBER: Wand a job number code on Process Plan the readers "beeps" when the number is read correctly and the next prompt is displayed. (If the wrong item is scanned the reader "beeps" rapidly several times and the prompt remains until the correct information is entered).

ENTER SEQUENCE NUMBER: Wand the sequence number from the Process Plan.

ENTER THE EMPLOYEE NUMBER: Wand ID number from your badge.

ENTER NUMBER OF REJECTS: Enter the number of rejects (or 0) then wand the enter code from the standards Barcode sheet. This is a special barcode operation that lets your record up to 9999 rejects.

ALL DATA CORRECT: Wand enter Y or N from the barcode sheet. If you wandd N (No) the data just entered is descarded. So if you make a mistake you can reenter the information.

That completes the operation. The system automatically starts (or stops) a timer and records the time that the operation was completed. This information is saved by the system and is used to determine the real cost of building the part of operation being tracked.

5.6.4 Barcode Symbol Formats

This section describes the barcode readers and the format for barcode data used by PAMS. While this topic deals primarily whith the Intermec Barcode readers.that we use during the implementation, other barcode readers (e.g. Aedex, Recognition, or Symbol Technologies) can be used by the systems as long as they conform to the general requirements outlined here. As long as this formats guidelines are followed, the end-user is free to modify the barcode programs, operator input, etc.

5.6.5 Standard Barcodes

PAMS uses code 39 (3 of 9) barcodes for data collection. Any barcodes needed for data collection can be printed on the Process Plan or special barcodes can be printed as needed using the Print Barcode option of the System Utilities.

Standard Barcodes- used with all system where barcode reader networks are used for data collection.

5.6.6 Barcode Reader Options.

There are two types of barcode readers supported by PAMS: RS-232 type readers (communicate to the host device through an RS-232 port), and wedge readers (inserted in-line between the PC an the keyboard).

The RS-232 style reader used with a controller/port concentrator as part of a barcode data collection network. The wedge type reader is used on network as part of an On -Line Reporting Station (OLRS).

The communications parameters must be 1200 baud, no parity, 8 data bits 1 stop bit. The reader must be attached to the COM1 port, further information about these parameters come in the next chapter.

5.7 Data Collection for PAMS.

Platinum Advanced Manufacturing System (referred as PAMS) is a manufacturing software system, initially designed to run on a PC or local area network (LAN), PAMS was the software selected for the implementation because strongly supports the requirements and is used in the industry.

PAMS combines all the parts of the manufacturing process into one fast and aesy to use package. It has modules to do specific tasks such as process planning, estimating, scheduling jobs through the shop, tracking the job, preparing reports, and collecting time and attendance information. With the complete system, actual (real) data is captured and compared to the plan. PAMS has the ability to perform a specific task easily, and integrates all of the information into a single interactive package, sharing the information with the rest of the system.

Tracking is the PAMS way of keeping track of the activities and materials that are part of making a product. Tracking consists of recording the work center time, applied labor (for one or more employees), any indirect costs, and all material that is used. The tracker uses existing data (work center setup files, process plans, employee files, and inventory information) as a basis for determining the progress of jobs and the cost it takes to make an item.

Sections on the Tracking module of PAMS:

-Tracker	The shop floor data collection module. Collected data is shared with other modules.
-Shop Reports	Provides specific reports and graphing routines for a quick retrival and analysis of information.
-Cross reference	Gives you the ability to cross reference tracking numbers with part numbers or job numbers for tracking of manufacturing data for future use.
-Quality Tracking	Permits the collection and reporting of reject and failure information related to the manufacturing process
-Component	Lets you create lists of assemblies and parts for units as they Linking are manuafctured.

-Production A status report to quickly identiry the location/status of each job Status Report in the manufacturing queue. The report includes the job number and the last sequence or opearation performed

Accurate data collection is the key to tracking jobs and related costs. The tracking module records the collected data for use by the system. Once an order has been entered, and manufacturing order created, the job is planned, scheduled, and loaded to the shop floor (to be released for manufacturing). once manufacturing order is created, the quantities, due dates, and other key information are completed. The process plan for the item then is used to define the manufacturing process. The process plan includes the step-by-step sequence of events, the estimated time to complete each operation, and can include such things as formulas, standard text, and material requirement. The plan now can be used to estimate the costs for making a particular part. Once the job is released to manufacturing the system lets you track the progress and costs.

As the job moves through manufacturing the Tracker records all related information including :

Work center time used.
Emplyee labor (actual person working on the job)
Material used,
Direct purchase and sub-contract costs.
and, etc.

When tracking jobs, dates and times are automatically appended by the system. These are then used to compute the actual work time charged to the job.

Chapter 6

SYSTEM IMPLEMENTATION ISSUES.

6.1 Introduction.

During the system implementation there is a lot of considerations that require attention from the systems integrator, some of these topics cause the 90% of all the installation problems and tears. Most of the special implementation issues are reviewed below.

6.2 Data Communications.

The key part of any automatic identification system is the data communications subsystem, which links the reading or data capture equipment with the data processing resource.

A data communications system can be as simple as a cable between a reader and the serial port of a dedicated personnal computer, or it can involve large numbers of local and remote devices communicating with a large mainframe computer through the use of communication controllers, local area networks, and processors. No matter what the extent of the data communications system, five issues must be addressed:

1.-Accuracy: Accuracy of the acquired data must not be compromised by the data communications system.

2.-Speed. How fast is data transferred between the bar code peripherals and the computing resource and vice versa.

3.-Compatibility. Ensuring that the bar code products and the computing resource can interchange compatible and understandable data.

4.-Flexibility. The ability to reconfigure the system as operational needs change.

5.-Growth. The ease of expanding the current system and integrating it with new systems.

The majority of existing systems use point to point communication, whereby two devices communicate with each other over a single channel. These systems are radially connected. Each remote device has an independent channel back to the system controller. The simpliest point to point channel is hand carried data, often in the form of a floppy disk. The scheme is applicable to systems that are loosely connected and only pass files periodically, such as in shop floor data collection where batch files are output at the end of each shift. the bandwidth of this system is substantial. It takes five minutes (300 seconds) to hand carry a disk between systems, and if a 3 1/2" disk has approximately 1.4 megabytes on it, the data rate of this is over 37,000 bits per second. This is faster than a 19,200 baud communications channel.

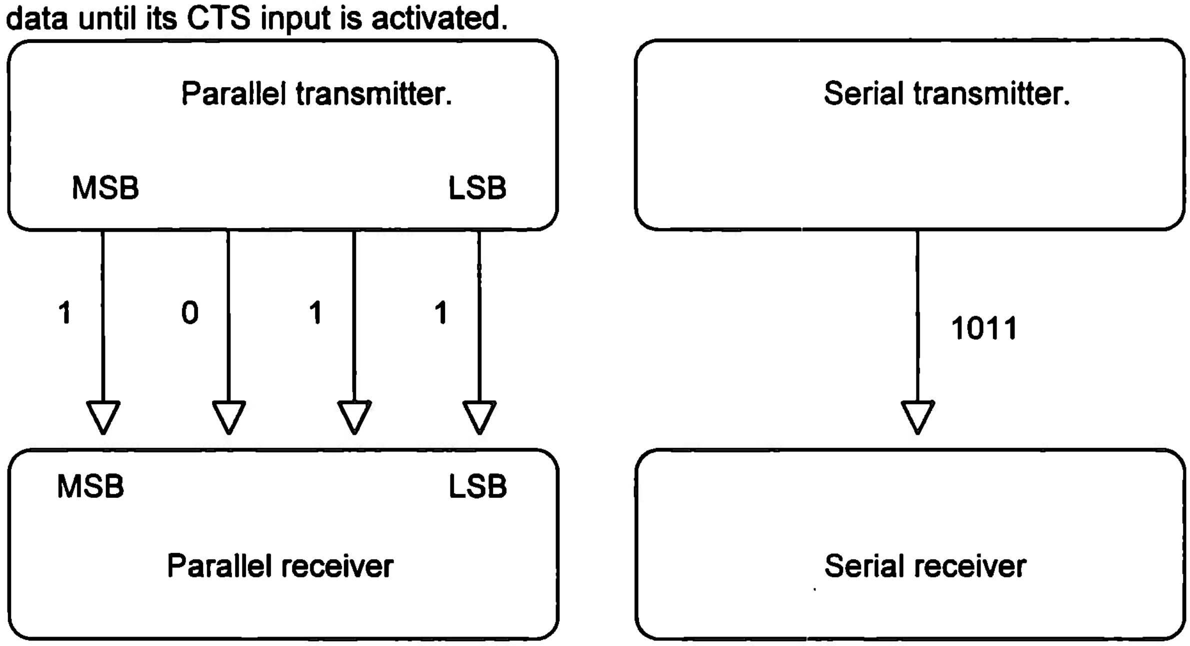
6.2.1 Serial RS-232C Interfacing.

One reason for using a serial rather than parallel interface is for transmitting data to a relatively distant peripheral. For transmission, the serial interface requires only one data wire, as oppossed to the eight wires normally used for data in a parallel configuration. A single-wire transmission has two advantages. one is that the cost of cable and any required line drives and receivers is significantly less than for a multiwire link. Especially for large distances, this may very well make the serial interface more economical than its alternative. Moreover, serial transmission enables data equipment to use commercial communication facilities such as regular telephone or data lines.

Figure 6.1 illustrates simple parallel and serial communication alternatives. It compares transmission of an 4-bit character (1011) using each technique. In a parallel interface a certain wire is dedicated to a certain bit (e.g. MSB most significant bit, and LSB less significant bit) and that is how we keep track of the word transmitted. In a serial interface, all the bits are transmitted over a single wire. We keep track of each individual bit by knowing its position and duration in the serial bit steam. The LSB is transmitted first by convention. Note that for proper operation, we usually need handshaking between the transmitter and receiver. This is the case unless the communication speed is so slow that there is no danger of transmitting the data faster than the receiver can accept it. The number of handshaking lines is independent of the type (serial or parallel) of transmission. A serial link requires more time to transmit a character than parallel link. An n-bit character transmitted serially takes at least n times longer than its parallel transmission. However, data exchange rates far greater than necessary for most sensor and controller applications are achievable using either technique. Mechanical devices such as printers are frequently controlled using serial transmission without any speed loss, since their response time is still much lower than typical serial baud rates.

To establish successful communication, devices typically provide signals to inform each other if they have any data available to transmit or they are ready to accept data. If a device sendes a character to another device that is busy doing some other task, the signal will be lost. Handshaking is the process of using signals to establish conditional communication.

To inform the receiver that data are available, the transmitter activates a request to send (RTS) signal. This signal either interrupts the receiver or the receiver senses it by a polling process. Upon detecting this signal the receiver signal that it is ready to accept characters. The transmitter does not transmit any data until its CTS input is activated.



(a) (b)

Figure 6.1 Transmission of bit pattern1011. (a)Parallel (b)Serial.

Handshaking signals have different names in different systems. Additional handshaking signals are present in more advanced systems. Note that two way communication requires all the handshaking signals mentioned above, whereas only two handshaking signals (one input and one output) are necessary for a one way transmission such as acquiring data from a sensor where the computer is only receiving data and the sensor is only transmitting data (Figure 5.2). The DTE (Data Terminal Equipment) is typically a terminal or computer. The DCE (Data Communications Equipment) is typically a modem (modulator/demulator) or an output device such as a printer.

There are cases where rapid response to a handshaking line is necessary, for example, a sensor is likely to have correct data available shortly after being activated. The computer addresses the device, activates it, waits a short period, then reads the data made available by the device.

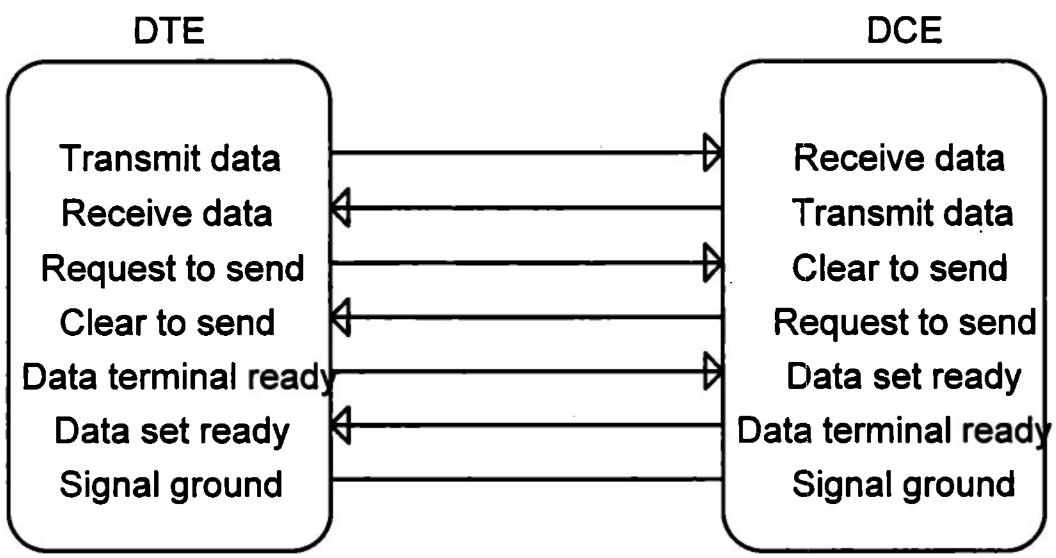


Figure 6.2 Handshaking example.

6.2.2 Asynchronous Techniques.

In serial communications the bits are transmitted as a stream. Asynchronous serial communication permits transmission of one character at a time. Synchronous communication provides for sending messages composed of many characters or bits in one continuos bit stream.

The duration of a bit is determined by the communication speed. This differs according to the characteristics of the sending or receiving device. The IBM PC can send and receive at standard data rates between 50 and 9600 baud.

Figure 6.3 shows how a character is transmitted asynchronously. The interface sends only one bit at a time and is usually programed to send data in one byte (e. g.one character) groups. The transmitter is not synchronized with the receiver - the receiver has no knowledge of when a new byte is about to enter the receiver. This is accomplished by sending an extra bit called the start bit just before the data bits of one byte. The transmitter continuously transmits the voltage level corresponding to logic 1 (sometimes called the mark) in its idle state. A 1-to-0 transition signals the receiver that the bit stream of a character is about to be sent. This first = bit (sometimes called space) is called start bit.

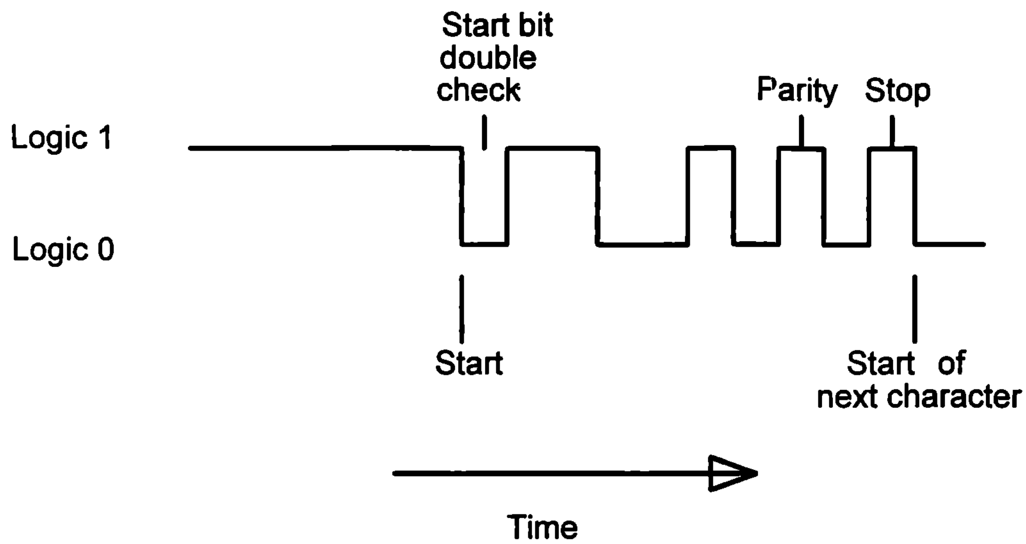


Figure 6.3 Asynchronous transmission format for a 7-bit character, even parity, and one stop bit. Character being transmitted is a binary 1010011 and ASCII representation of the letter S.

After seeing the transition from 1 to 0, the receiver then samples the line half a bit to ensure that the detected logic 0 was a valid 0, not a noise transient. At that time, if the line is still at logical "0", the receiver assumes a valid start bit and samples the line at 1-bit interval. It forms a charcter according to previously programmed character specifications such as the character lenght, and the type of parity. On the other hand, if the start bit is judged to be invalid, the receiver ignores the detected zero and returns to the idle state looking for a valid start bit (0). The probability of detecting a false start bit or of ignaoring a valid start bit is very small since it is very unlikely that noise burts will occur at exactly the sampling points.

In asynchronous communication a character ends with transmission of one or two stop bits (logic 1), usually one bit for all speeds greater than 110 baud. The transmitter sends a sequence of 1´s when there are no characteres ready to transmit.

In 6.3 shows an example of the transmission of the letter S. The asynchronous adapter normally sends a sequence of 1 bits (called a mark signal) until it is ready to send a byte. It then signals that a byte follows by sending a 0 (the special start bit) for one bit time.

The clock plays a crucial role in serial communication. In the asynchronous technique, the only clock constraint is that the clock frequencies of both transmitter and receiver must be equal within a close tolerance. The clock frequency is an integer multiple of the transmitter bit rate (16 times the bit rate is the most popular).

A special integrated circuit that implements the serial communication functions that are summarized in this section is the UART (Universal Asynchronous Receiver /Transmitter). The asynchronous communication adapter of the IBM PC uses the National Semiconductor 8250 UART.

A UART can detect three different types of errors: (1) parity, (2) overrun, and (3) framing.

1.-Parity Error.

The parity bit is the most-significant bit (MSB) in a character. The user can elect to use even parity, odd parity, or ignore parity. If even parity is chosen, the parity bit bit, generated on the transmitting side, is set or reset so that the total number of set bits (i. e. logic 1) in the character (including the parity bit) is an even number. Similary, odd parity results is an odd number of 1 bits in each character. For example, in transmitting the 7-bit ASCII character 0100110, the eight bit, the MSB, is set for odd parity and reset for even parity. On the receiver side, an incorrect parity bit sets the parity error flag in the status register of the UART.

2.-Overrun Error.

The UART decodes the character received on its serial data input pin by stripping off the start bit and stop bit(s) and then transfers the character into its receive buffer. Once an entire character is decoded, the UART places it in the data-bus buffer. where it can be accessed by the microprocessor. The UART sets its receiver-ready flag to indicate that a character is available. This flag can be polled with software. Alternatively, an output pin that reflects the flag´s status can be connected directly to an interrupt pin in the microprocessor's interrupt-handling hardware.

3.-Framing Error.

The framing error flag in the UART's status register is set when the receiver is expecting a 1[stop bit] at the end of a character but reads a 0 instead. Framing error occurs as a result of false bits due to noise burst. It also results from reading a bit stream at the wrong baud rate.

6.3 Transmission Line Considerations.

this is only a brief background given here just to introduce the problems that the designer has to keeep in mind in order to construct a satisfactory communication link.

As the lenght of line interconnecting the transmitter and the receiver and the transmission frequency (i. e. baud rate) increases, it becomes more nad more necessary to consider the transmission line characteristics. For very long lines or even relatively short lines at high baud rates, the interconnecting cable cannot simply be thought of as a conductor with negligible resistance. The transmission line is then modeled as shown in Figure 6.4 R, L, C, and G are, respectively, the resistance, inductance, capacitance, and the conductance per unit lenght. Gis simply a measure of leakage loss between the two conductors.

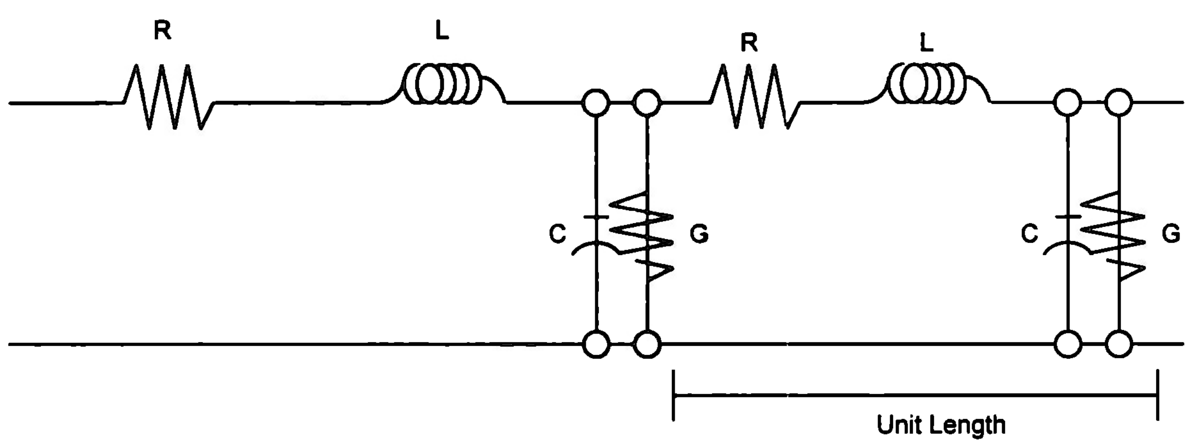


Figure 6.4 Transmission Line model.

We can summarize the problems encountered in a communication system that are directly related to the transmmision line as follows:

1.-Reflections occur if the load is not matched to the line. therefore, if the propagation delay is long with respect to one bit interval, the bit may be latched before the steady state is reached and detected incorrectly. Also, the reflection from one bit can cause errors in detection of the following bits. The simpliest solution to this problem is to terminate the line in its characteristic impedance to eliminate reflections.

2.-Signal attenuation may be severe for very long lines. this may cause an error in logic-level detection. signal repeaters can overcome this problem.

3.-Increasing the frequency of transmmision will increase the signal distortion and crosstalk and consequently the error rate. The line characteristics and the transmission technique (Logic 1 and 0 conventions) limit the transmission speed.

4.-The capacitance of the transmission line and the rise time of the voltage signal require a current drive capability of the source given by.

$$i = C_t \, dv/dt$$

Where C_t is the total capacitance of the line (Ct = C X Length). This current drive capability is crucial only when the rise time is much longer than the line propagation delay. Therefore, the current drive capability of the line driver puts a limit on the length of the line and may also influence the rise time.

5.-Difference in the ground level voltages of the sending and receiving ends can cause erroneous logic detection at the receiving end. this problem can be solved by connecting the ground wire only at one common ground point (see Figure 6.5)

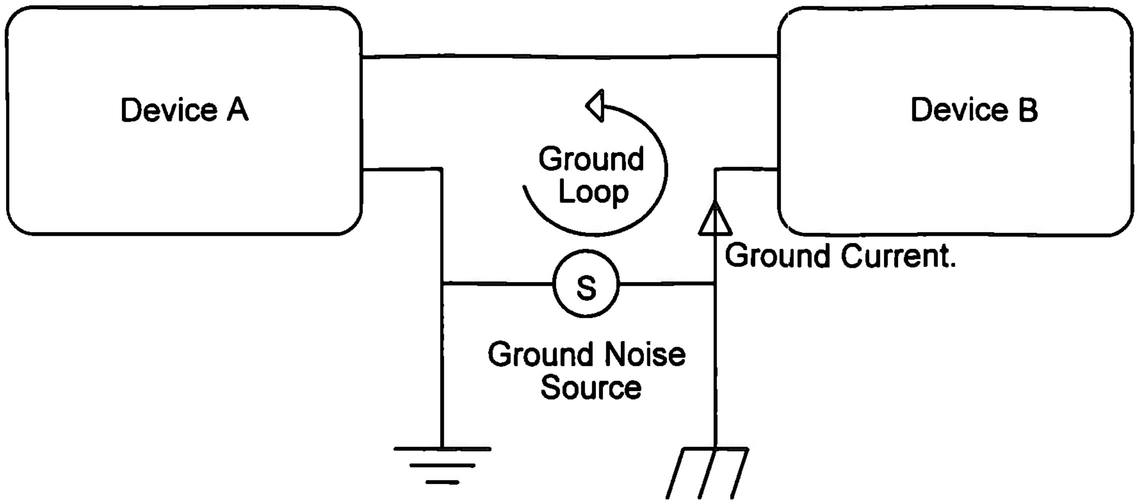


Figure 6.5 Ground Loops. localized differences in ground voltages can cause noise currents to flow throgh data cables.

If a shielded cable is used, there are advantages to grounding the shield at both ends. The ground currents in the shield generate magnetic flux around the cable; tjis flux induces equal voltages in the signal leads. This inducted voltage minimizes the voltage seen by the line isolation.

6.4 Voltage and Mechanical Definitions of RS-232.

The RS-232 standard was initally developed to inteface a terminal or data equipment (DTE) to a modem or data communication euipment (DCE). It is now used to interface almost any device imaginable to the IBM PC, including another PC. The asynchronous communication adapter of the IBM PC implements the standard EIA RS-232 DTE interface. For devices other than modems, such as printers, manufacturers make up their own unique definitions of some of the control lines of the interface.

This is why use of this interface can sometimes become complicated.

Figure 6.6 shows a 25-pin D connector which is used for the male plug (DB25P) or female socket (DB25S) on devices that use the RS-232 interface standard, such as the asynchronous communication adapter of the IBM PC. Not all the pins on the RS-232 connector are defined by the EIA. In addition the data signals, numerous handshaking and control signals are assigned to different pins. The rear of the D-connector is the side on which solder or wire-wrap connections are made. The pin numbers are usually stamped on the backl of the connector (see table 6.1)

Pin number	Direction	Function.
1	-	Frame Ground
2	Out	Transmitted data
3	In	Received data
4	Out	Request to Send
5	In	Clear to Send
6	In	Data Set Ready
7	-	Signal Ground
8	In	Received line signal detector
9	Out	+ Transmit current loop data
11	Out	- transmit current loop data
18	In	+Recive current loop data
20	Out	Data terminal ready
22	In	Ring indicator
24	-	No connection
25	In	- Receive current loop return

Table 6.1 Pinout of the Db25 connector of the asynchronous communication adapter on the IBM PC.

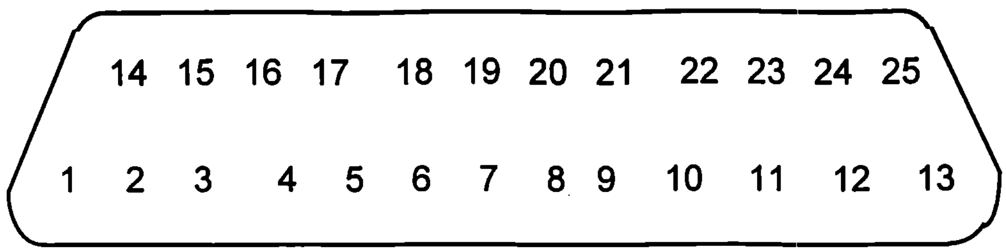


Figure 6.6 The Pins assignaments on RS-232

Figure 6.7 shows, in the RS-232 standard, an electrical level between +5 and +15 V represents a "HI" or logic =. A level between -5 and -15 V is a "LO" or logic 1. A logic 1 is the true state of asignal and 0 the false state regardless of voltage level. The levels assume a properly loaded dirver cicuit. The unloaded levels can vary between +/- 25V. the receiver accepts ranges of +3 to +25 V and -3 to -25 V. the large voltage ranges with the undefined region between +/- 3V is to minimize electrical noise problems in long cable runs. This permits reliable operation with a separation between the terminal and modem of 15 m.

All the handshaking signals are active 0 (positive voltage).

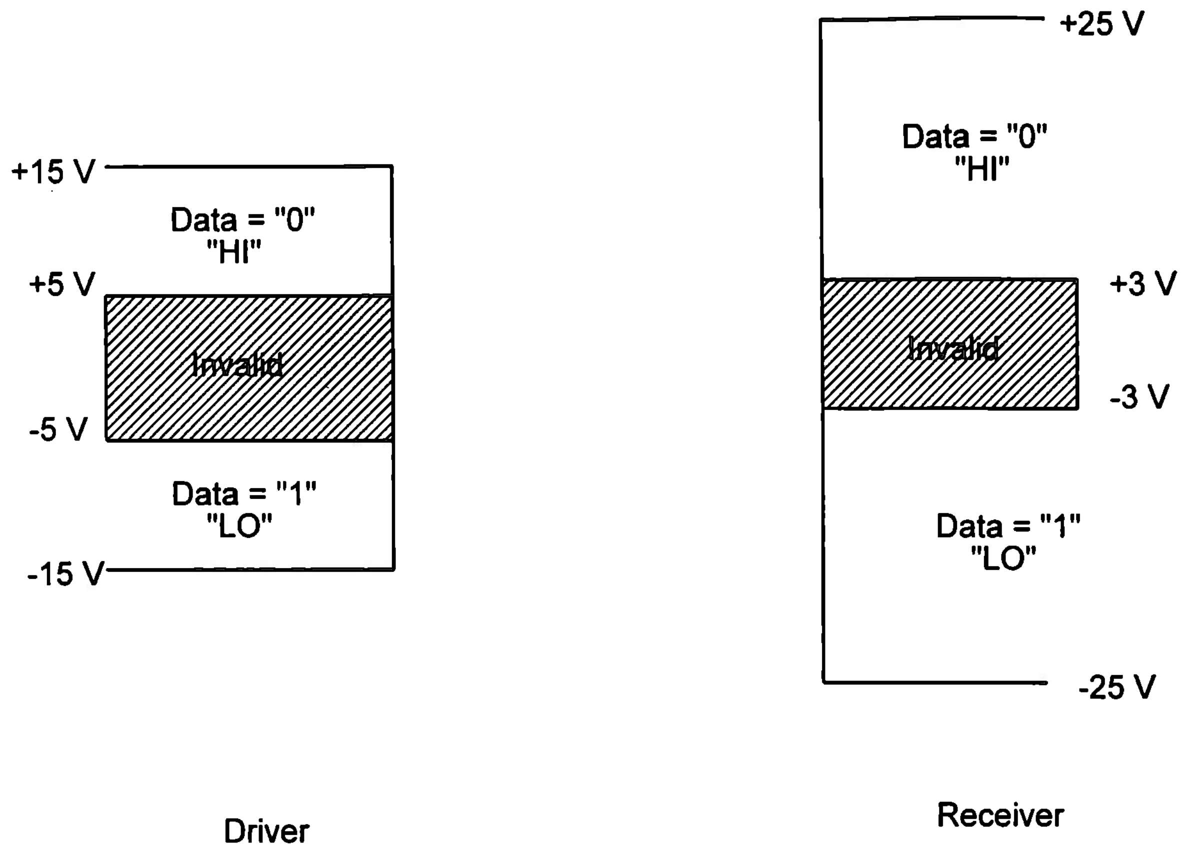


Figure 6.7 EIA RS-232 signal levels.

The PC has the capability to control two optional asynchronous communication adapters. They have the logical device names COM1 and COM2. Each assigned its own system bus interrupt pin. Before using one of these adapters, it must be initialized. On start up PC DOS directs output to the parallel printer adapter by default using the logical device name LPT1:.

To initialize an asynchronous adapter, the MODE program can be used this program is supplied with DOS.

MODE COM1:1200,N,8,1,P

This sets the COM1 device for communications at 1200 baud, no parity, eight data bits, one stop bit, and serial printer operation.

In addition to establishing this software initialization of the adapter, the systems integrator must be sure that all the handshaking lines necessary for operation are connected properly. The critical handshaking connections on the adapter´s connections are:

pin 5 CTS (Clear to Send)
pin 6 DSR (Data set ready)
pin 8 CD (Carrier data).

6.4.1 Cabling requirements

RS-232, RS-422, or 4-wire RS-485 Multidrop interface can be used depending upon the distance between the reader and the system configuration.

RS-232 is designed for short distances and is generally not used for long data lines, However, RS-232 can be used succesfully over longer distances if there is a "clean" electrical enviroment in the floor shop. Because RS-232 connects the two signal grounds of the units together, any ground noise is coupled directly to the units, see the table for further information

If the Distance is:	The preferred interface is:
50 feet max.	RS-232C
2000 feet max.	RS-485 Multi Drop.
4000 feet max.	RS-422

6.5 Intermec 9512 Characteristics.

The reader used for the application was an Intermec 9512, which has some characteristics that are reviewed below.

Host Protocols.

The reader supports five protocols which gives you great flexibility when choosing the host data link protocol. The five protocols are: Point-to-Point, Polling Mode D, Multi-drop, User-Defined Multi-Drop.

Point-to-Point Protocol.

Point-to-Point is the only full duplex, asynchronous protocol for readers. This is not a solicited protocol since the POLL character is disabled. Whenever data is avaible to transmit, the data will be transmited inmeditely. The only means of controlling the flow of data is to enable X-ON/X-OFF or to use the hardware signal CTS (Clear to Send) from the host.

Point-to-Point, and similar protocols which disable the solicitation and handshake sequences, will accept and then transmit all data to the host when the RX EOM character has been recived or when the time out delay limit is reached even though the RX EOM character has not been recived.

Polling Mode D Protocol.

Polling Mode D protocol is used in a Ponit-to-Point enviroment and supports only one polled device on the line. It is a half duplex, solicited, asynchronous protocol. In Polling Mode D, the Terminal Port Mode allows either Transparent Mode or Buffered Mode and defaults to buffered.

Multi-drop Protocol.

Multi-Drop protocol is a multi-point, half duplex, solicited, asynchronous protocol. It is synonymous with polling Mode E and is designed to work in a RS-422/RS-485 enviroment with up to 32 devices on a single multi-drop transission line.

User-Defined and User-Defined Multi-Drop Protocols.

User-Defined protocol allow the operator to define the protocol. By defining specific protocol parameters, the operator can duplicate any protocol.

Host Port Protocol.

Some protocols are very roboust and secure while other not. A secure data link protocol allows recovery for transmission line errors (parity and farming errors) and uses affirmative and negative responses to verify sucessful and unsuccessful communication events. If the transmiting device recives a negative acknoledgement , re-transmission of the data occurs. The maximum re-try count is three for all asynchronous protocols.

However, Point-to-Point Protocol allows massages to be recived and transmitted simultaneusly. IBM SDCL (Synchronous data link control) is a good example of a full duplex protocol. A full duplex protocol can only be achived when there are separate, dedicate channels for reciving and transmitting data. Furthermore, before implementing a true full duplex protocol, the end devices must have the necessary harware (interrupt structure) to support reciving and transmitting data simultaneosly.

Data link protocol becomes full duplex when both the solicitation sequence (Poll and Select) and AFF/NEG handshakes are disabled. These protocols do not support re-transmission of data messages. The reader transmits data when commanded by the operator to do so, but the reader recives data from the host at any time.

Half duplex protocols are designed to work on a single channel which is used for both transmitting and reciving. Half duplex protocols can be executed over a full duplex medium, but the protocol requires that only one device at the time transmit data over the shared or dedicated channel.

Full Duplex Devices vs. Half Duplex Devices.

The DLE Character and X-ON/X-OFF Flow Control.

The DLE (data link escape) character must precede any transmited transparent parameter of the enabled protocol that is to be treated as data.
The DLE must also precede the EOR character (or characters) and the EOF character if these presentation parameters are defined and the characteres are sent as data during file transmission.

Received data is also checked for a DLE. If X-ON/X-OFF flow control is enabled and the X-ON or the X-OFF character is preceded by a DLE, the X-ON or X-OFF character will be interpreted as data only.

Terminal Modes.

If a reader is connected to a CRT terminal, the reader can be set for one of five types of terminal operation:

- Buffered
- Transparent
- Block
- Nonbuffered, Full Duplex.
- Nonbuffered, Half Duplex.

Buffered Terminal Operation.

In Buffered terminal operation, the reader emulates the data buffering capability of a smart terminal for batch transmission to the host.

Transparent Terminal Operation.

Transparent terminal operation is the same as for buffered mode with the exception that no screen formatting is performed and diagnostic messages are not displayed. limited commands from the terminal are allowed. Is also used for batch transmissions to the host with the host formating the terminal screen. The reader will transmit the data to the host when a transmit command or a regular label is scanned or [enter] is entered from the terminal keyboard.

Nonbuffered Full Duplex Operation.

In Nonbuffered, Full Duplex operation, all terminal port input is sent out the modem port as the input is recived. It is assumed that the host echo all recived data. Scanned input is sent to the host and is displayed on the terminal when the host echoes this data. All terminal commands are disabled. the reader doesn't buffer, format, or display the data. For example, when you enter data from the terminal keyboard or scan a label, the reader transmits that data to the host. Then the host displays the data it recived on the terminal screen.

Nonbuffered Half Duplex Operation

In Nonbuffered, Half Duplex Operation, the host formats the terminal screen. The reader transmits scanned data to the host and terminal screen simultaneously. The reader will not buffer or format data from the terminal or scanner but will display and update the current data buffer on the terminal screen.

For example, when you enter data from the terminal keyboard or scan a label, that data is displayed on the terminal screen at the same time it is transmited to the host.

The host must also be set for Half Duplex operation and therefore will not echo the terminal or scanner data. The reader will send host messages directly to the terminal without formating; the host formats the terminal screen. The reader will not accept terminal commands.

Block Terminal Operation

Block terminal operation is generally used with "smart" terminals that can buffer data. The reader does not buffer, format, or display data from the terminal but sends this data directly out the Modem Port to the host.

6.6 String Formats (How the Reader Transmmits Data to the Host)

General Barcode String Formats
Every barcode string has the general format:
<introduction string>, <data>*
where the <introduction-string> is one of two formats:
&CURRENT/DEFAULTPRODUCTSGROUPUSED
%XXXX PRODUCT GROUP USED
where xxxx is a 1 to 4-character product group.

The following are examples of each form:
&,IT,00001011,123-123-123* %PCBA,IT.00001011,123-123-123,R*

Note: 1) data items are separated by commans
2) the string end with a *
4) do not use commas in the imput data.

Chapter 7

Conclusions and Recomendations.

7.1 Introduction.

This study has illustrated both the importance of information and the potential benefits that companies can realize from technology. At the same time, it has been pointed out that the sucess of an Information System depends primarily not on technical perfection but rather on the care devoted to the planning and preparation of its implementation

In conclusion, there are a number of conditions that should be considered to ensure the sucess of an Information System implementation. In this context implement means the entire process from conception of the need for an Information System to the users consistent use of the installed system.

To be considered sucessful, a system has to be designed, built, and installed within agreed to time and budget constraints and the system must perform according to user expectations, it is also necessary to ensure the involvement of all groups of personnel within the company. This involvement should commence already at the planning stage. Involvement, however, requires knowledge.

The decision to invest in Factory Information Systems should be an integral part of a broader decision to adopt new organizational and managerial principles for the whole company. The implementation of a Factory Information System with a view to solving production problems in a particular process section, without prior analysis of how this will afect adjacent process sections, is most likely to result in suboptimization.

In undertaking an investment appraisal of FIS, experience shows that it is difficult to measure and quantify many of the potential benefits.

7.2 Introduction to the Shop Floor.

Because shop personnel are specially sensitive to changes, due to the situation that manufacturing errors are more apparent than other organizational errors (accounting, marketing, sales, etc), and they think that maybe the system will affect their salary. It is important for acceptance to introduce this system with a full explanation of what the system is, how it works and the benefits derive from its use.

As an implementation starategy, both systems, the old data manual collection, and the new one are going to be runned together for a while.

There is also a very important issue to analyze, the labor implications. In México, there is a minimum wage per day, instead of the hourly payment in the industralized countries such as U.S., Canada, Japan etc thus if the salary is going to be calculated based on the data captured, the hourly payment system is very much appropiated, and accurate, Thus in the future there will be more implementations of systems like this in the industralized world , because of the salary and work performance calculation is more appropiated to their systems.

7.3 Trends.

Bar code has been a successful application for retail applications, Inventory and the next step is for the controllers to process for a local area for example, shop floor data collection in a work center. This distributes the processing, and the next level of sophistication is to distribute the data base also. This requires either sophisticated networking of the data base or multiple copies of files. Multiple copies run the risk of diverging from each other as transactions are processed, resulting in confusion if not error.

The trend is toward cell controllers where a controller manages all the functions in an area. Here a controller manages the data collection as well as the movement of material, etc. These controllers are interconnected by a network such as MAP. These systems have shared databases and standarization at high levels. Such systems are in the future, but demostrational systems are already operational.

Apendix A
Program for Direct Connection IRL

```
D$0="" : limpia el registro 0
D$1="" : registro 1
D$2="" : registro 2
D$3="" : registro 3
D#1=0  : define registro numerico  (0)
C#2=$0 : initializa
D#3=1  : initializa reg. 3 como  (1)
I$1"&,"
P"                "
P"Regsitre la Operacion  "
A2
G$0="Subir".UPLD
D$2=$1+$0
D$1=$2
D$3=$0
G$0="RE".OPRE : rechazo
G$0="CI".OPCI : checar entrada
G$0="CO".OPCI : checar salida
G$0="LL".OPLL : unir
G$0="LU".OPLL : desunir
G$0="IT".OPIT : iniciar rastreo
G$0="TR".OPTR: referencia de rastreo
G$0="VN".OPVN
: si no es ninguno de los anteriores, debe ser BB,BE,HB,HE, or
BC
S.TRACK  :
S.PROSEQ :
S.EMP    :
T        : adiciona tiempo y hora
D$2=$1+$0
D$1=$2
I$1","
G$3="HB".GETQTY
G$3="BE".GETQTY
I$1"0,0*"
G.GETOK
: ========
.GETQTY
D$0=""
P"introduzca la Cantidad "
N
D$2=$1+$0
```

```
D$1=$2
I$1","
D$0=""
P"Scanee el numero de rechazos "
N
D$2=$1+$0
D$1=$2
C#1=$0
I$1"*"
: ========
.GETOK
D$0=""
S.SEND
G.OPER
: ========
D$1="&,"+$3
I$1","
S.EMP
T
D$2=$1+$0
D$1=$2+"*"
D$0=""
S.SEND
G.OPER
: ========
S.TRACK :
:I$1=","
D$0=""
P"Scaner numero de parte"
A
S.APPEND
D$2="R*"
D$3=$1+$2
D$1=$3
S.SEND
G.OPER
: ========
S.TRACK :
.TRAGAIN :
P"Scanne la Referencia o DONE"
A1,4 :
S$0="DONE"
D$2=$1+$0
D$1=$2
D$0=""
```

```
: ========
P"Referencia o -  Scanee # o DONE:"
A
S$0="DONE".DNEREF
D$2=$1+$0
D$1=$2+","
D$0=""
D#2=#2+#3 : incrementar contador
G#2=9.DNEREF :
G.TRAGAIN
: ========
.DNEREF :
G#2=0.OPER :
I$1"*"
D$0=""
S.SEND
G.OPER
: ========
D$0=""       :
I$1","       :
:P"Introduzca  Pariente    S/N o DONE"
P"Scan Parent S/N or DONE"
A            : get PARSN
S$0="DONE".OPER :
D$3=$1+$0    :
I$3","       :
: ========
.SPAGAIN     :
D$0=""       :
D$1=$3       :
P"Scanee Subparte S/o DONE"
A            :
S$0="DONE".OPER : if DONE,
S.APPEND     :
D#2=#2+#3    :
T            :
D$2=$1+$0
D$1=$2
S$3>"&,LU,".REASON
D$2=$1+"*"
D$1=$2
S.SEND :
G.SPAGAIN
: ========
.REASON
```

```
I$1","
D$0=""      :
P"Scanee la razon para desligar "
A
S.APPEND    :
D$2=$1+"*"
D$1=$2
S.SEND :
G.SPAGAIN
: ========
S.TRACK  :
S.PROSEQ :
T      :
D$2=$1+$0
D$1=$2
D$0=""
I$1","
P"Scanne el codigo de Rechazo o  DONE"
A4
S$0="DONE".OPER :
D$2=$1+$0
D$1=$2
I$1","
D$0=""
D#2=#2+#3 :
G.GETRSUB :
Q
: ========
.FAGAIN :
G.GETRSUB :
S$0="DONE".DONEREJ
Q
: ========
.GETRSUB
P"Scanee el subcodigo de Falla o DONE"
A4
G$0="DONE".DONEREJ
D$2=$1+$0
D$1=$2
I$1","
D$0=""
D#2=#2+#3 :
G#2=15.DONEREJ :
G.FAGAIN
Q
```

```
: ========
.DONEREJ :
I$1"*"
D$0=""
S.SEND
G.OPER
: ========
.TRACK :
I$1","
D$0=""
P"Scannee numero de trabajo "
A8
S.APPEND
Q
: ========
OSEQ : subrutina para obtener la sequencia
P"Scanee la sequencia del Proceso"
A7
S.APPEND
Q
: ========
.EMP :
D$0=""
P"Scanee la Idendificacion "
A5
D$2=$1+$0
D$1=$2
I$1","
D$0=""
Q
: ========
.GET : get string
I$1","
D$0=""
A
S.APPEND
Q
: ========
.SEND : subrutina para enviar los datos
P"todos los      datos correctos?"
D$0=""
A1
G$0="Y".GO
Q$0="N"
B0000
```

```
G.SEND
: ========

R$1 : subir los datos
Q
: ========
.APPEND : append $0 to $1
D$2=$1+$0
D$1=$2
I$1","
D$0=""
Q
: ========
.UPLD  : ******** Subiendo Datos **********
D$0=""
P"Listo para Subir Datos?"
A1
G$0="Y".DOUP
G.OPER
: ========
.DOUP
P"                Subiendo..."
XMP,0;3000  :
G#1=0.CLEAR
C$0=#0
D$1=" Error!   Status: "+$0
P$1
D$0=""
P"Intentar de Nuevo?"
A1
G$0="Y".UPLD
G.OPER
: ========
.CLEAR
P"Transmission Completa."
W2
G.OPER
: ========
P"V3.0  Copyright 1989 Metatron"
W3
P"Coneccion directa a Intermec 9154"
W3
G.OPER
E
```

```
:FILE: BARPC.IRL         Multi-Drop 9512 Barcode Reader IRL
D$0="" : limpiar el registro  0
D$1="" : limpiar el registro  1
D$2="" : limpiar el registro  2
D$3="" : limpiar el registro  3
D#1=0  : define el registro numerico. 1 a cero (0)
C#2=$0 :  (initializa) el registro numerico. 2 a cero (0)
D#3=1  : (initializa) el registro numerico. 3 a uno (1)
I$1"&,"
P"                "
P"Operacion de Scanner  "
A2
G$0="UP".UPLD
D$2=$1+$0
D$1=$2
D$3=$0
G$0="RE".OPRE : modo de rechazo
G$0="CI".OPCI : clock-in (entrar)
G$0="CO".OPCI : clock-out(salir)
G$0="LL".OPLL : link
G$0="LU".OPLL : unlink
G$0="IT".OPIT : iniciar track
G$0="TR".OPTR: referencia de track
G$0="VN".OPVN
: si no es nunguno de los anteriores, debe ser BB,BE,HB,HE, o
BC
S.TRACK  : obtener referencia del track #
S.PROSEQ : obtener el proceso/sequencia #
S.EMP    : obtener  identificacion
T        : sumar  fecha/hora
D$2=$1+$0
D$1=$2
I$1","
G$3="HB".OTENER CANTIDAD
G$3="BE".OBTENER CANTIDAD
I$1"0,0*"
G.OK
: ========
.OBTENER CANTIDAD
D$0=""
P"Scaneo de la Cantidad Correcto "
N
D$2=$1+$0
D$1=$2
I$1","
```

```
D$0=""
P"Scanear el numero     de Rechazos "
N
D$2=$1+$0
D$1=$2
C#1=$0
I$1"*"
: ========
.GETOK
D$0=""
S.SEND
G.OPER
: ========
D$1="&,"+$3
I$1","
S.EMP
T
D$2=$1+$0
D$1=$2+"*"
D$0=""
S.SEND
G.OPER
: ========
S.TRACK : obtener el numero del tracking
:I$1=","
D$0=""
P"Scanear numero      de Parte"
A
S.APPEND
D$2="R*"
D$3=$1+$2
D$1=$3
S.SEND
G.OPER
: ========
S.TRACK : obtener el numero del  tracking
.TRAGAIN :routina de referencia del tracking
P"Scane el codigo de Referencia o DONE"
A1,4 :
S$0="DONE (HECHO)".DNEREF
D$2=$1+$0
D$1=$2
D$0=""
: ========
P"Referencia a scanear-  # or DONE(HECHO):"
```

```
A
S$0="DONE(HECHO)".DNEREF
D$2=$1+$0
D$1=$2+","
D$0=""
D#2=#2+#3 : incrementar  el contador en una unidad(1)
G#2=9.DNEREF : si el contador es 2 es = 9, envia los datos
G.TRAGAIN
: ========
.DNEREF :
G#2=0.OPER : isi el contador 2 es cero comienza
I$1"*"
D$0=""
S.SEND
G.OPER
: ========
D$0=""      : limpia el registro 0
I$1","      : ahora contiene '&,L(?),'
:P"Introduzca Pariente    S/N or DONE"
P"Scanee  Pariente  S/N or DONE"
A           : get PARSN
S$0="DONE(HECHO)".OPER :
D$3=$1+$0   : set string 3 to '&,L(?),PARSN'
I$3","      : set string 3 to '&,L(?),PARSN,'
: ========
.SPAGAIN    :
D$0=""      : limpia el registro de entrada
D$1=$3      : fija el registro 1 como  '&,L(?),PARSN,'
P"Scanee  Sub-parta  S/No DONE"
A           : get subpart
S$0="DONE(HECHO)".OPER : if DONE,
S.APPEND    :
D#2=#2+#3   :
T           :
D$2=$1+$0
D$1=$2
S$3>"&,LU,".REASON
D$2=$1+"*"
D$1=$2
S.SEND : enviar este registro hacia arriba
G.SPAGAIN
: ========
.REASON
I$1","
D$0=""      :
```

```
P"Scanne la razon para desconectarse"
A
S.APPEND   :
D$2=$1+"*"
D$1=$2
S.SEND :
G.SPAGAIN
: ========
S.TRACK  :
S.PROSEQ :
T      : addicionar fecha/hora
D$2=$1+$0
D$1=$2
D$0=""
I$1","
P"Scanee el codigo de recahzo o  DONE(HECHO)"
A4
S$0="DONE(HECHO)".OPER : no rechazos
D$2=$1+$0
D$1=$2
I$1","
D$0=""
D#2=#2+#3 :
G.GETRSUB :
Q
: ========
.FAGAIN :
G.GETRSUB :
S$0="DONE".DONEREJ
Q
: ========
.GETRSUB
P"Scane Sub codigo de Falla o DONE(HECHO)"
A4
G$0="DONE".DONEREJ
D$2=$1+$0
D$1=$2
I$1","
D$0=""
D#2=#2+#3 :
G#2=15.DONEREJ :
G.FAGAIN
Q
: ========
.DONEREJ :
```

```
I$1"*"
D$0=""
S.SEND
G.OPER
: ========
.TRACK :
I$1","
D$0=""
P"Scanee el numero de Tracking   "
A8
S.APPEND
Q
: ========
OSEQ :
P"Scanee la secuancia      del Proceso"
A7
S.APPEND
Q
: ========
.EMP : subrutina para obtener la identificacion del empleado
D$0=""
P"Scanee la identificacion      del Empleado"
A5
D$2=$1+$0
D$1=$2
I$1","
D$0=""
Q
: ========
.GET :
I$1","
D$0=""
A
S.APPEND
Q
: ========
.SEND : subrutine para mandar datos
P"Todos los datos      Estan Bien?"
D$0=""
A1
G$0="S.GO
Q$0="N"
B0000
G.SEND
: ========
```

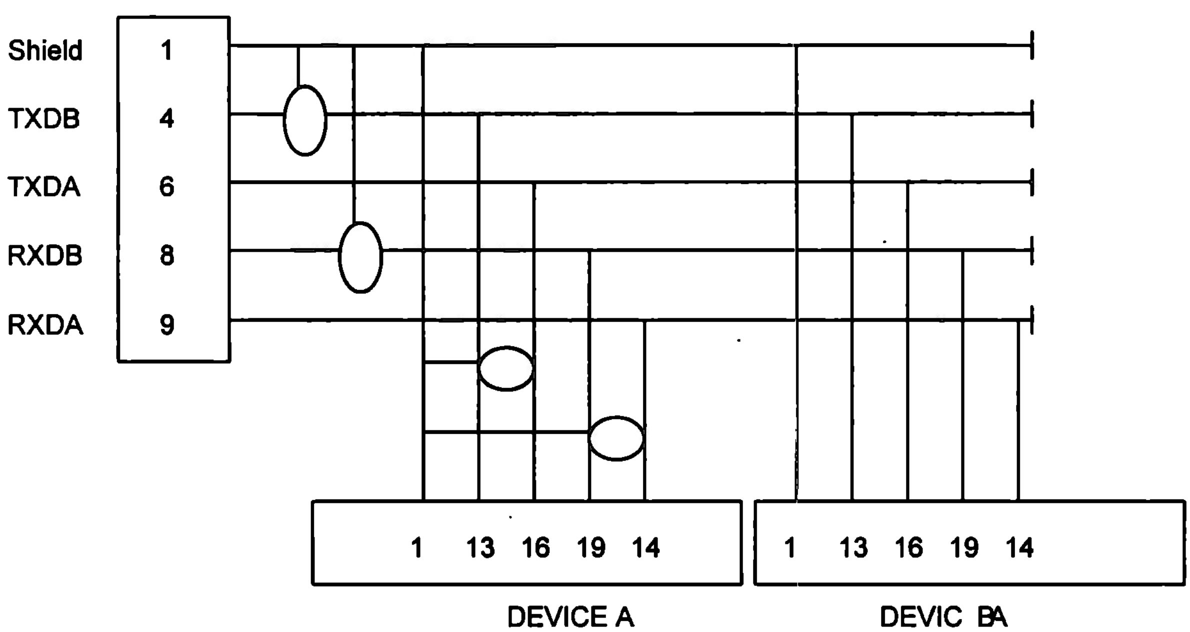
```
XMP,$1 : Q
: ========
.APPEND :
D$2=$1+$0
D$1=$2
I$1","
D$0=""
Q
: ========
.UPLD  : ******** Subiendo los Datos***********
D$0=""
P"Listo para Subir datos      "
A1
G$0="Y".DOUP
G.OPER
: ========
.DOUP
P"                Subiendo ....."
XMP,0;3000  :
G#1=0.CLEAR
C$0=#0
D$1=" Error!   Status: "+$0
P$1
D$0=""
P"Intentar de Nuevo?"
A1
G$0="Y".UPLD
G.OPER
: ========
.CLEAR
P"Transferencia Completa"
W2
G.OPER
: ========
W3
P"Multi-Drop para   Intermec 9154"
W3
G.OPER
E
```

APENDIX B

CROSS CONNECTIONS FOR DIRECT CONNECT AND MULTIDROP CONFIGURATIONS.

Category	Function	Pin	Pin	Function
Ground	PG	1	1	PG
Ground	SG	7	7	SG
Data	TD	2	2	TD
Data	RD	3	3	RD
Control	RTS	4	4	RTS
Control	CTS	5	5	CTS
Control	DCD/RLSD	8	8	
Control	DSR	6	6	DSR
Control	DTR	20	20	DTR

SERIAL INTERFACE FOR DIRECT CONNECTION



MULTIDROP CONNECTION.

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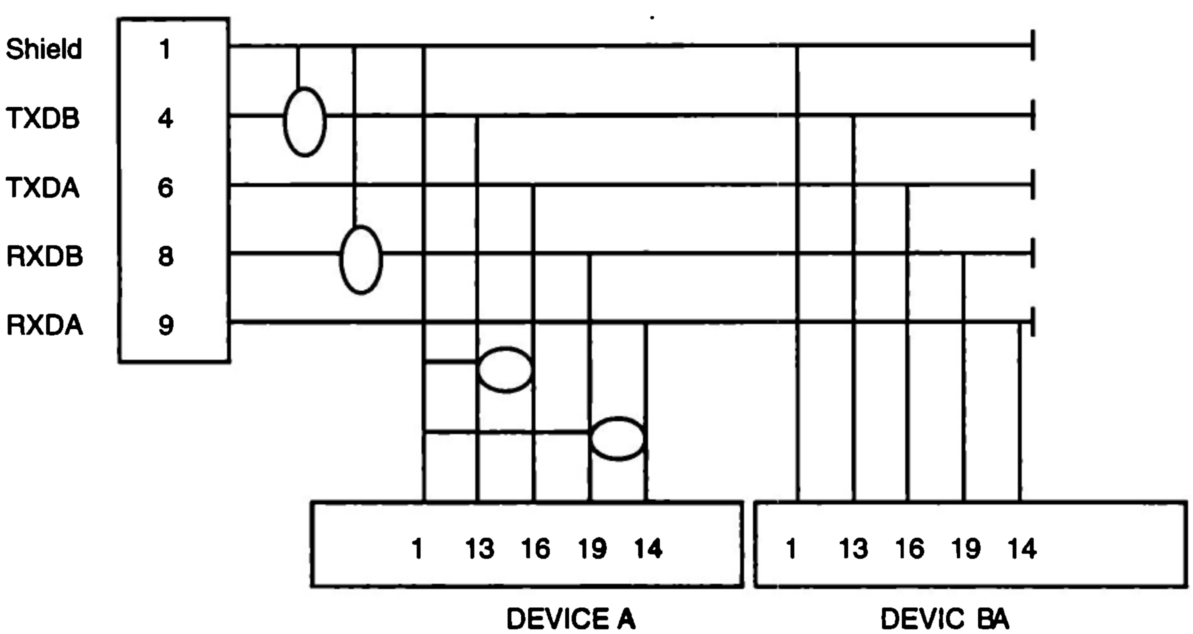
APENDIX B

CROSS CONNECTIONS FOR DIRECT CONNECT AND MULTIDROP CONFIGURATIONS.

Category	Function	Pin	Pin	Function
Ground	PG	1	1	PG
Ground	SG	7	7	SG
Data	TD	2	2	TD
Data	RD	3	3	RD
Control	RTS	4	4	RTS
Control	CTS	5	5	CTS
Control	DCD/RLSD	8	8	
Control	DSR	6	6	DSR
Control	DTR	20	20	DTR

SERIAL INTERFACE FOR DIRECT CONNECTION.



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