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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHTRONICS

M.E (CAD)

SPRA7007 - MANUFACTURING INFORMATION SYSTEMS

UNIT- I

INTRODUCTION

The Evolution of order policies, From MRP I, MRP II, MRP III to ERP – Agile Manufacturing Information Systems, Manufacturing Database Integration.

1. INTRODUCTION

1.0 Material Requirements Planning (MRP I)

Material Requirements Planning (MRP) is software_based production planning and inventory control system used to manage manufacturing processes. MRP/ERP Systems were first introduced by George Plossl and Joseph Orlicky in the late 1960s. Oliver Wight contributed the evolution to MRP II, to include more than the factory production and material needs.

1.1 Major Objectives of the MRP

- Ensure materials and products are available for production and delivery to customers.
- Maintain the lowest possible level of inventory
- Plan manufacturing activities, delivery schedules and purchasing activities
- Ability to track material requirements
- Ability to evaluate capacity requirements
- Means of allocating production time

MRP is a tool to deal with these problems. It provides answers for several questions:

- What items are required?
- How many items are required?
- When are they required?
- Where are they required?

Figure 1.1 shows block diagram for MRP - I

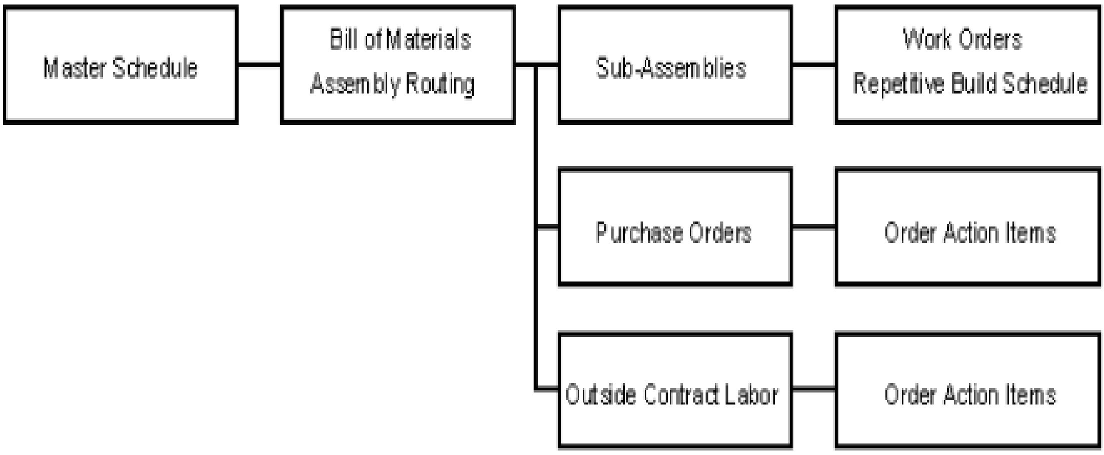


Fig 1.1 Block Diagram for MRP I

1.2 MRP Input, MRP output and MRP Processing

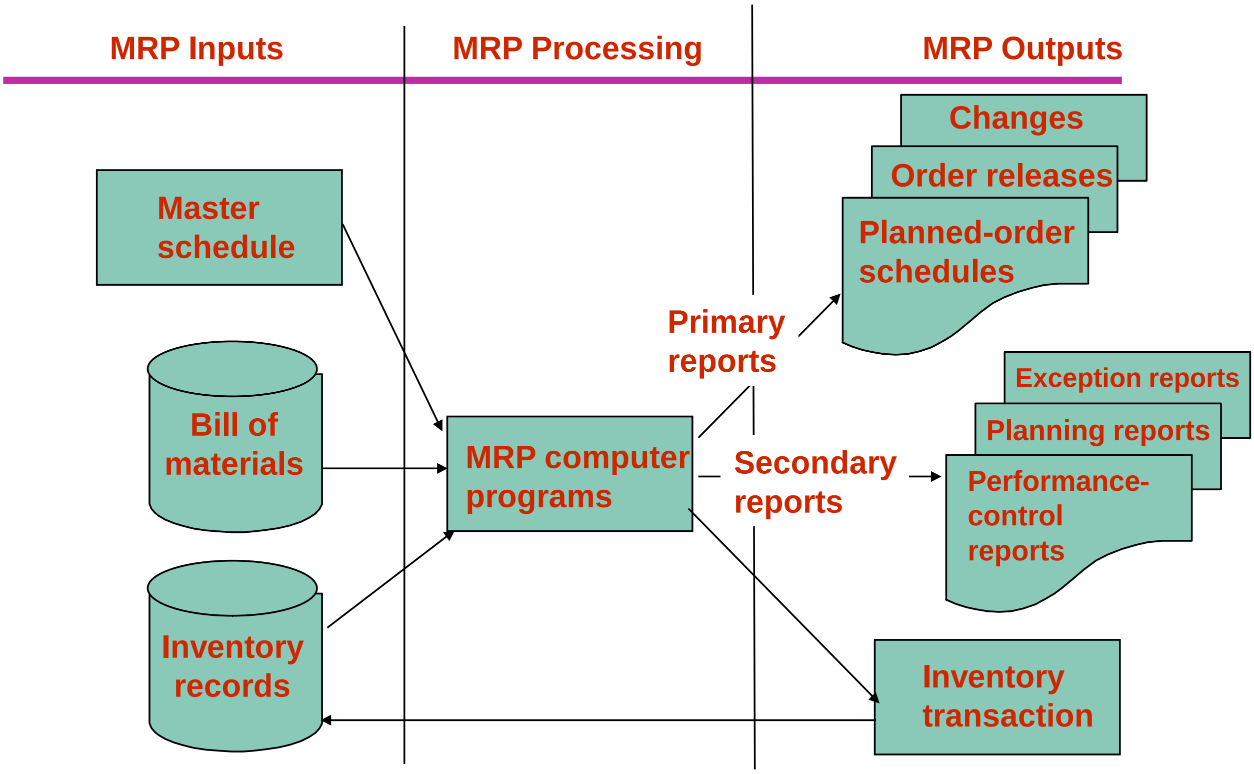


Fig 1.2 Block Diagram for MRP Input, Processing and MRP output

Figure 1.2 shows Block diagram for MRP Input, processing and MRP output. Any MRP/ERP software have three important parts. There are MRP input, MRP processing and MRP output.

1.2.1 Master Production Schedule: MPS

Time-phased plan specifying timing and quantity of production for each end item.

- MPS comes from sales and marketing
- MPS covers about 1-3 months into the future
- Must cover cumulative lead time

Cumulative lead time: The sum of the lead times that sequential phases of a process require, from ordering of parts or raw materials to completion of final assembly.

Sometimes MPS is capacity filtered; MPS is curtailed after taking the available capacity into account.

1.2.2 Bill of materials (BOM): A listing of all of the raw materials, parts, subassemblies, and assemblies needed to produce one unit of a product.

Product structure tree: Visual depiction of the requirements in a bill of materials, where all components are listed by levels. Figure 1.3 shows Product structure model for Engine.

Independent and Dependent Demand

Independent demand: Demand for final products.

Ex : Car Engine

Dependent demand: Demand for the items that are subassemblies or component parts to be used in production of finished goods.

Ex : piston, Connecting rod and shaft

Independent demand is uncertain. Dependent demand is certain.

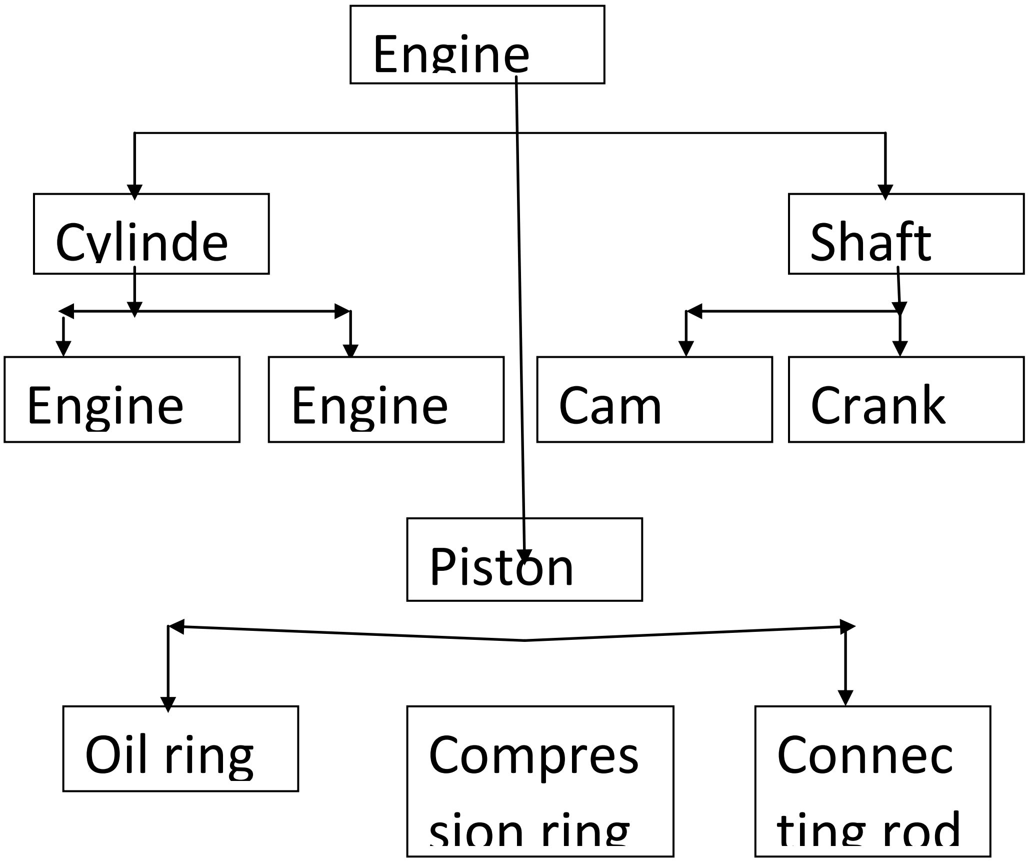


Fig 1.3 Product Structure Model for Engine

1.2.3 Inventory Levels:

Most often people do not use the term product structure tree. Instead use BOM to mean the product structure tree.

Beginning inventory on hand

Scheduled receipts

Pipeline inventory not yet received but it is in the process of coming to the inventory.

1.2.4 MRP Processing:

- Gross requirements
- Total expected demand
- Scheduled receipts

- Open orders scheduled to arrive
- Planned on hand
- Expected inventory on hand at the beginning of each time period
- Net requirements
- Actual amount needed in each time period
- Planned-order receipts
- Quantity expected to received at the beginning of the period
- Offset by lead time
- Planned-order releases
- Planned amount to order in each time period

1.2.5 MRP output:

- Planned orders - schedule indicating the amount and timing of future orders.
- Order releases - Authorization for the execution of planned orders.
- Changes - revisions of due dates or order quantities, or cancellations of orders.
- Performance-control reports, Planning reports and Expectation reports

1.2.6 Inventory Status Records

Each inventory status record contains five items of information represented as rows in a table. They are as follows:

Gross Requirements (“GR”) – total demand for the stock number in the given time period. For components and raw materials this demand is derived from all parent production plans (Master Production Schedule, if parent is a final product and/or Planned Order Releases as defined below, if parent is a component).

Scheduled Receipts (“SR”) – sometimes called "open orders". These are orders that have been placed but not yet completed/received. For a purchased item, the scheduled receipt could be in one of several stages: being processed by the supplier, being transported, or being inspected by the purchaser's receiving department. If production is making the item in-house, the order could be on the shop floor being processed, waiting for components, waiting in the queue, or waiting to be moved to the next location.

Projected on Hand ("POH") – an estimate of the amount of inventory available each week after gross requirements have been satisfied. This is calculated by taking the POH from the previous week and adding the scheduled order receipts and the planned order receipts and then subtracting the gross requirements.

Planned Order Receipts ("POR") – the quantity determined to be required for receipt at the beginning of a time period. Planning for receipt of new orders will keep the POH from dropping below safety stock.

Planned Order Releases ("PORL") - planned amount to order in each time period. This should equal the Planned Order Receipt offset by the lead-time.

Management Parameters

An MRP system provides automatic calculation for planned order releases for every item in the inventory. However, these calculations are based upon parameters that must be supplied by management for each item in the inventory. The three sets of management parameters are the following:

Safety stock ("SS")-the lowest level that estimated inventory levels, POH, should be allowed to reach. This is based on factors like reliability of supply and cost of the item.

Lead-time-the estimated time required for a released order to be received. The factors that determine lead-time depend on whether the item is purchased or produced internally. Lead-time and safety stock work together to provide reliability of supply but at the cost of higher inventory levels.

Lot sizing rules-the rules that determine how large an order, POR, should be. Lot sizing rules are discussed in the next section.

Lot Sizing Rules

A lot-sizing rule determines the size of order quantities. As described later, the decision regarding when to order is based on POH and safety stock. A lot-sizing rule is a management parameter that must be assigned to each item. The choice of lot sizing rule is important because they determine the number of setups required and the inventory holding costs for each item. Three possible lot-sizing rules are: fixed order quantity, periodic order quantity, and lot for lot.

Fixed Order Quantity ("FOQ"). The fixed order quantity rule maintains the same order quantity each time an order is issued. For purchased items the FOQ could be determined by the quantity discount level, truckload capacity, or minimum purchase quantity. Alternatively, the lot size could be determined by the economic order quantity (EOQ). Note: If an item's FOQ is insufficient, a multiple of the FOQ must be ordered.

Periodic Order Quantity ("POQ"). The periodic order quantity rule allows a different order quantity for each order issued but issues the orders at predetermined time intervals (P) such as every four weeks (P = 4). The order quantity (lot size) equals the amount of the item needed during the predetermined time period. The amount that is needed is the determined as follows:

(Total GR for the periods to be covered) + SS

-(Total SR for the periods to be covered – POH(current)

Lot for Lot ("L4L"). A special case of the POQ is the lot-for-lot (L4L) rule, under which the lot size ordered covers the gross requirements for a single period (week in our case). This value of P = 1 minimizes inventory levels but will result in the largest number of order placements. This rule ensures that the planned order is just large enough to prevent a shortage in the single week it covers.

1.2.7 MRP Calculation

The calculations in an MRP system proceed item by item by calculating GR, POH, POR and PORL in the ISR for the item. SR is part of the database and does not have to be calculated. The order in which items are processed must be based on the level structure of the BOM. This ensures that when a given item is to be processed, the processing for all its parent items has already occurred. The calculations are performed as follows:

Calculation of GR: Add the requirements for every parent item. If the item if a finished product, the requirements are found in the MPS. If the item is an intermediate item, the requirements are the PORL in the ISR for the item.

Calculation of POH and POR: POH is calculated week by week by the formula

POH = POH (from previous week) – GR + SR + POR

However, if POH as calculated fall below safety stock, an adjustment must be made by scheduling a POR for the week. The determination of POR is based on lot sizing rules discussed earlier. These rules ensure that the recalculated POH will be at least equal to safety stock. Calculation of POH continues until the next shortage occurs. This shortage signals the need for the next POR.

Calculation of PORL: PORL is determined by offsetting (moving forward) each POR by the lead-time.

EXAMPLE 1

Product Structure Trees

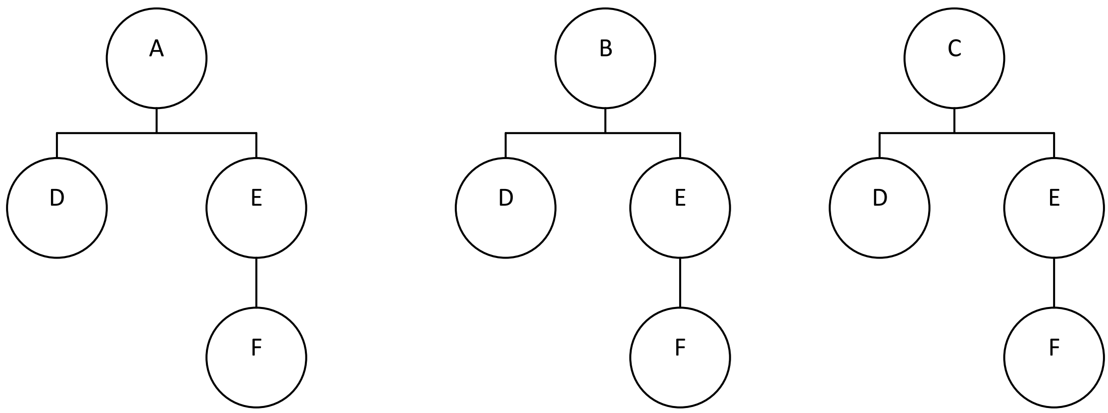


Table 1.1: Master Production Schedules

Item A	Week	1	2	3	4	5	6	7
	MPS			80			55	

Item B	Week	1	2	3	4	5	6	7
	MPS					125		

Item C	Week	1	2	3	4	5	6	7
	MPS				60		50	

Table 1.2: Inventory Status Records

Item: D		Lot Size: FOQ=150 Lead Time: 3 weeks Safety Stock: 40						
Week		1	2	3	4	5	6	7
Gross Requirements								
Scheduled Receipts		50						
Projected On Hand	150							
Planned Receipts								
Planned Order Releases								

Item: E		Lot Size: L4L Lead Time: 1 week Safety Stock: 0						
Week		1	2	3	4	5	6	7
Gross Requirements								
Scheduled Receipts			120					
Projected On Hand	0							
Planned Receipts								
Planned Order Releases								
Item: F		Lot Size: POQ=2 Lead Time: 2 weeks Safety Stock: 30						
Week		1	2	3	4	5	6	7
Gross Requirements								
Scheduled Receipts								
Projected On Hand	100							
Planned Receipts								
Planned Order Releases								

EXAMPLE 2

Product Structure Trees

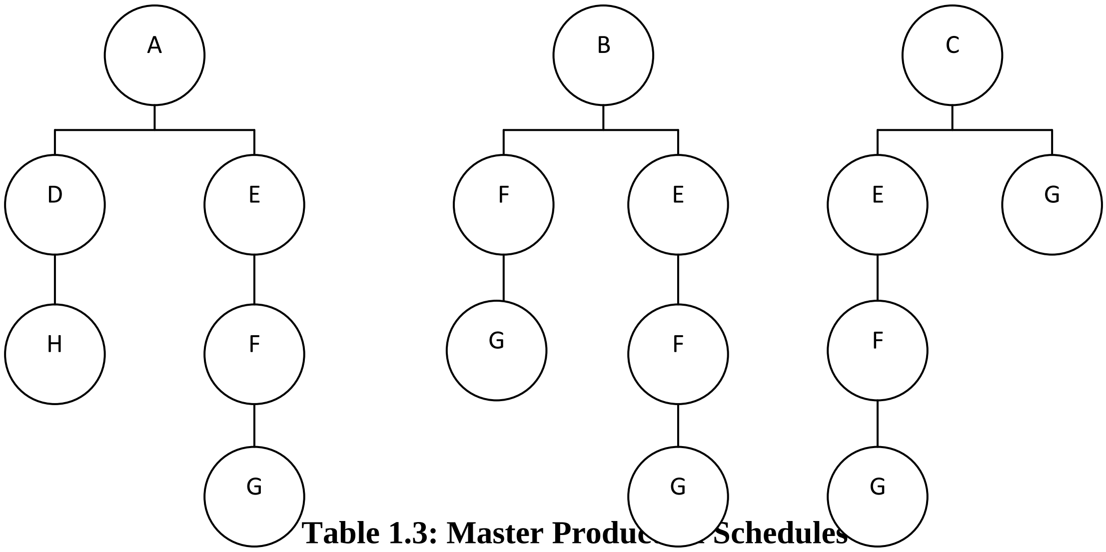


Table 1.3: Master Production Schedules

Item A	Week	1	2	3	4	5	6	7
	MPS			15		25	20	

Item B	Week	1	2	3	4	5	6	7
	MPS			40		40		

Item C	Week	1	2	3	4	5	6	7
	MPS				20	20	20	

Table 1.4: Inventory Status Records

Item: D		Lot Size: FOQ=50 Lead Time: 2 weeks Safety Stock: 10						
Week		1	2	3	4	5	6	7
Gross Requirements								
Scheduled Receipts			50					
Projected On Hand	20							
Planned Receipts								
Planned Order Releases								
Item: E		Lot Size: L4L Lead Time: 1 week Safety Stock: 5						
Week		1	2	3	4	5	6	7
Gross Requirements								
Scheduled Receipts		50	50					
Projected On Hand	25							
Planned Receipts								
Planned Order Releases								

Item: F		Lot Size: POQ=2 Lead Time: 1 week Safety Stock: 20						
Week		1	2	3	4	5	6	7
Gross Requirements								
Scheduled Receipts								
Projected On Hand	30							
Planned Receipts								
Planned Order Releases								

Item: G		Lot Size: FOQ=50 Lead Time: 2 weeks Safety Stock: 0						
Week		1	2	3	4	5	6	7
Gross Requirements								
Scheduled Receipts		250						
Projected On Hand	50							
Planned Receipts								
Planned Order Releases								

Item: H		Lot Size: FOQ=50 Lead Time: 2 weeks Safety Stock: 50						
Week		1	2	3	4	5	6	7
Gross Requirements								
Scheduled Receipts		100						
Projected On Hand	80							
Planned Receipts								
Planned Order Releases								

Table 1.5: MRP Calculation

Item: D		Lot Size: FOQ=150 Lead Time: 3 weeks Safety Stock: 40						
Week		1	2	3	4	5	6	7
Gross Requirements				160	120	125	210	
Scheduled Receipts		50						
Projected On Hand	150	200	200	40	70	95	185	185
Planned Receipts					150	150	300	
Planned Order Releases		150	150	300				
Item: E		Lot Size: L4L Lead Time: 1 week Safety Stock: 0						
Week		1	2	3	4	5	6	7
Gross Requirements				80	120	250	155	
Scheduled Receipts			120					
Projected On Hand	0		120	40	0	0	0	0
Planned Receipts					80	250	155	
Planned Order Releases				80	250	155		

Item: F		Lot Size: POQ=2 Lead Time: 2 weeks Safety Stock: 30						
Week		1	2	3	4	5	6	7
Gross Requirements				160	500	310		
Scheduled Receipts								
Projected On Hand	100	100	100	530	30	30	30	30
Planned Receipts				590		310		
Planned Order Releases		590		310				

EXAMPLE 2 SOLUTION

Item: D		Lot Size: FOQ=50 Lead Time: 2 weeks Safety Stock: 10						
Week		1	2	3	4	5	6	7
Gross Requirements				30		50	40	
Scheduled Receipts			50					
Projected On Hand	20	20	70	40	40	40	50	50
Planned Receipts						50	50	
Planned Order Releases				50	50			
Item: E		Lot Size: L4L Lead Time: 1 week Safety Stock: 5						
Week		1	2	3	4	5	6	7

Gross Requirements				150	20	190	60	
Scheduled Receipts		50	50					
Projected On Hand	25	75	125	5	5	5	5	5
Planned Receipts				30	20	190	60	
Planned Order Releases			30	20	190	60		
Item: F		Lot Size: POQ=2 Lead Time: 1 week Safety Stock: 20						
Week		1	2	3	4	5	6	7
Gross Requirements			30	100	190	140		
Scheduled Receipts								
Projected On Hand	30	30	120	20	160	20	20	20
Planned Receipts			120		330			
Planned Order Releases		120		330				
Item: G		Lot Size: FOQ=50 Lead Time: 2 weeks Safety Stock: 0						
Week		1	2	3	4	5	6	7
Gross Requirements		240		660	60	60	60	
Scheduled Receipts		250						
Projected On Hand	50	60	60	0	40	30	20	20
Planned Receipts				600	100	50	50	
Planned Order Releases		600	100	50	50			

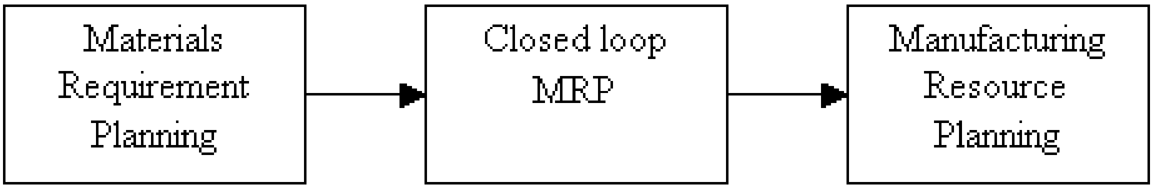
Item: H		Lot Size: FOQ=50 Lead Time: 2 weeks Safety Stock: 50						
Week		1	2	3	4	5	6	7
Gross Requirements				100	100			
Scheduled Receipts		100						
Projected On Hand	80	180	180	80	80	80	80	80
Planned Receipts					100			
Planned Order Releases			100					

The other major drawback of MRP is that takes no account of capacity in its calculations. This means it will give results that are impossible to implement due to manpower or machine or suppler capacity constraints. However this is largely dealt with by MRP II.

1.3 Manufacturing Resource Planning (MRP II)

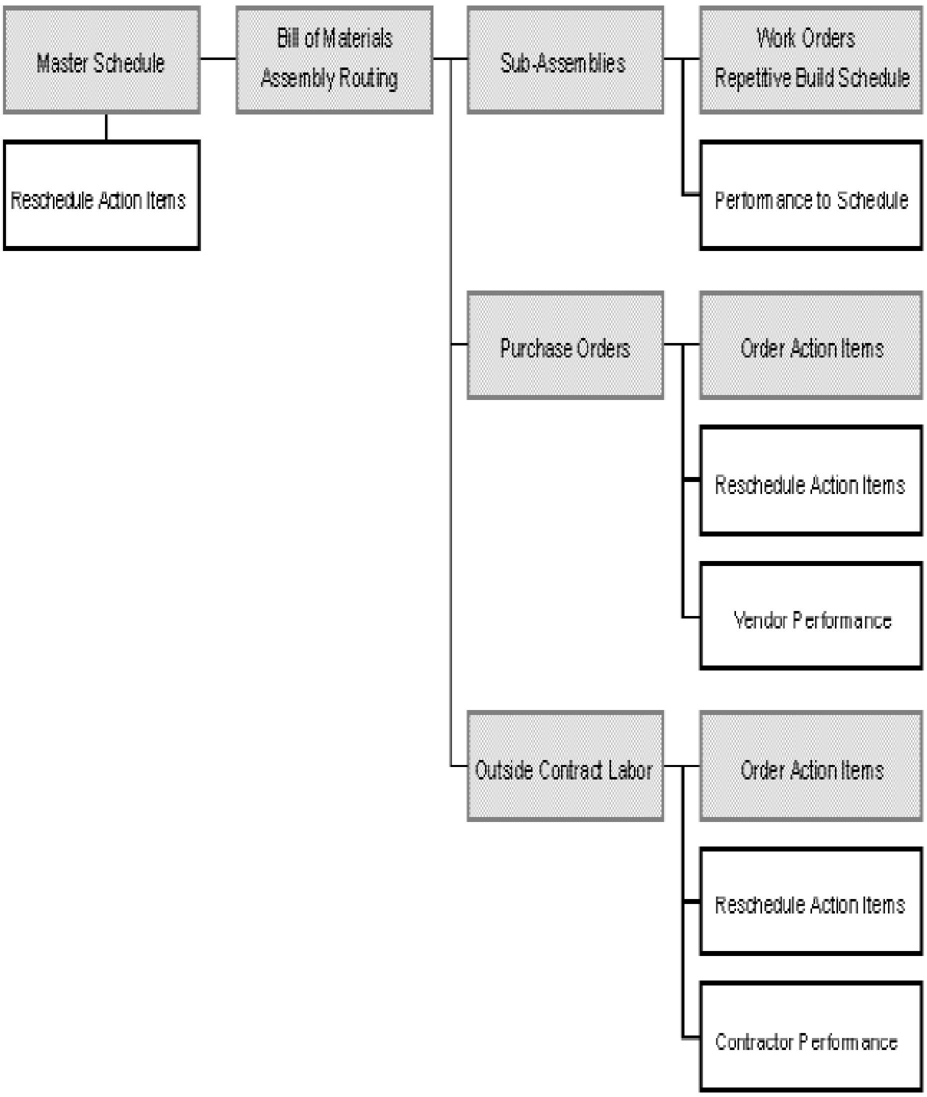
Manufacturing Resource Planning (MRP II) is defined by APICS (American Production and Inventory Control Society,) as a method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what-if" questions and extension of closed-loop MRP. Generally, MRP II refers to a system with integrated financials. An MRP II system can include finite / infinite capacity planning. But, to be considered a true MRP II system must also include financials.

In the MRP II (or MRP2) concept, fluctuations in forecast data are taken into account by including simulation of the master production schedule, thus creating a long-term control. **Closed loop material requirements planning.** Figure 1.4 shows closed loop system for MRP II and Figure 1.5 shows Block diagram for MRP II.



MRP I **MRP II**

Fig 1.4 Closed Loop System for MRP II.



1.5 Block Diagram for MRP II

Figure 1.6 shows framework of MRP II Execution diagram.

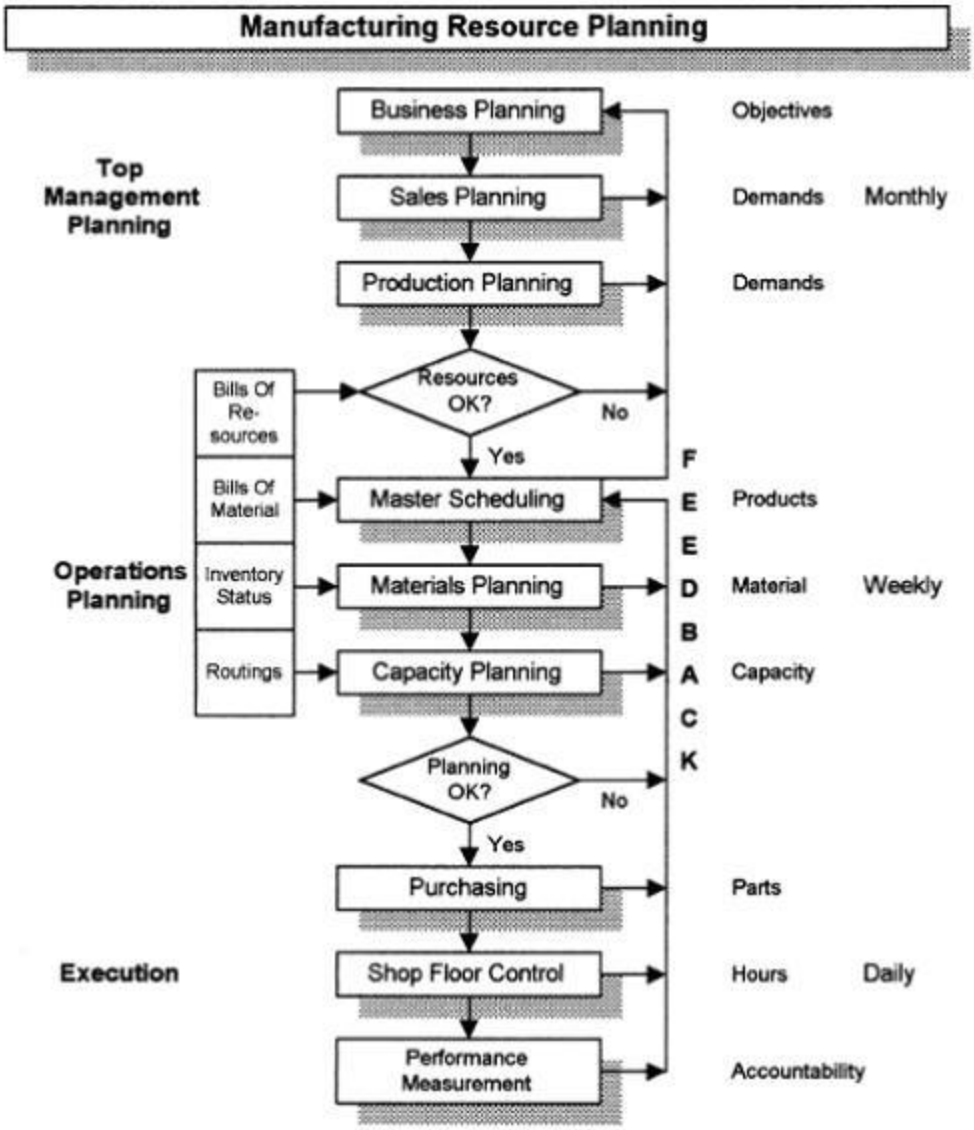


Fig 1.6 Framework of MRP II Execution Diagram

Manufacturing Resource Planning (MRP II) embeds additional procedures to address the shortcomings of MRP. In addition, MRP II attempts to be an integrated manufacturing system by bringing together other functional areas such as marketing and finance. The additional functions of MRP II include forecasting, demand management, rough-cut capacity planning (RCCP), and capacity requirement planning (CRP), scheduling dispatching rules, and input/output control. MRP II works within a hierarchy that divides planning into long-range planning, medium range planning, and short-term control.

Manufacturing resources planning (MRP II) is an extended form of closed loop MRP that also incorporates strategic planning processes, business planning, and a number of other business functions such as human resources planning, profit calculation and cash flow analysis. MRP II uses master production schedule as the basis for scheduling capacity, shipments, tool changes, some design work, and cash flow. Hence it requires several additions to the reference files. One is a bill of resources, which details key resources needed to produce one unit of product. These resources may include labour, machinery, tools, space and materials.

The MRP II system can use the bill of resources to project shortages at specific times, giving departments advance notice of required remedial action: for example, of the need to hire or train labour. MRP II can also project needs to support resources; for example, design engineering support if a customer order entails prior design work. This additional resource is added to the bill of resources. Given still more reference data, MRP II can keep track of tool wear and recommend when to replace or reshape tooling. It can also keep track of machine loads and project machine capacity shortages, which may signal a need for more machines or a subcontractor.

For financial planning, MRP II treats cash flow almost like materials. The MPS is first exploded into component parts requirements; the system then calculates the cost and payment dates of all planned order releases, effectively creating a cash flow forecast. This includes not just payments to suppliers, but also wages, power and other consumables associated with production. Cash outflows may be projected for a year or more by expense category, work centre or department, making budgeting much simpler than it would be without an MRP II system.

1.3.1 Master production schedule

The MPS is a statement of the planned production of finished products that will meet the demand on time, within the organization's capacity. The master production schedule expresses What we intend to make, How much we intend to make and When we intend to make.

The demand for end items is scheduled over a number of time periods and recorded on a master production schedule (MPS).The MPS is developed from forecasts and firm customer orders for end items, safety stock requirements, and internal orders. MRP takes the master schedule for end items and translates it into individual time-phased component requirements. Figure 1.7 - shows connecting diagram for Master Production Schedule

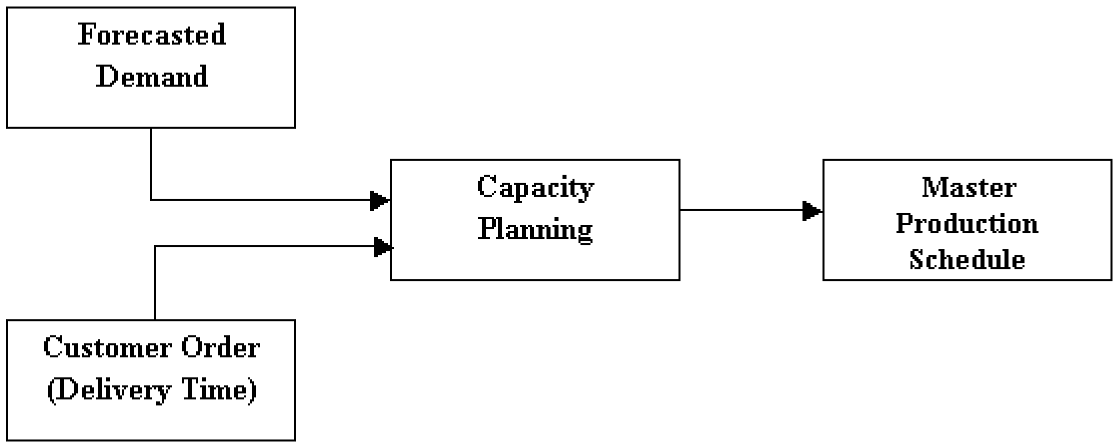


Fig 1.7 Connecting diagram for Master Production Schedule

1.3.2 Capacity Planning:

Capacity planning essentially involves the following categories.

Resource requirements planning:

Resource requirements planning refer to the planning of the overall capacities of the firm. This planning is done to validate the aggregate production plans of the firm.

1.3.3 Rough cut capacity planning (RCCP):

Rough cut capacity planning (RCCP) involves planning capacities at key / bottleneck work centers and broadly balancing workloads. It thus validates the MPS.

Material requirements planning (MRP) uses a master production schedule (MPS) of end items to determine the quantity and timing of component part production. MRP is capacity insensitive; it implicitly assumes that sufficient capacity is available to produce components at the time they're needed.

A problem commonly encountered in operating MRP systems is the existence of an overstated MPS. An overstated master production schedule is one that orders more production to be released than production can complete. An overstated MPS causes raw materials and WIP inventories to increase because more materials are purchased and released to the shop than are completed and shipped. It also causes a buildup of queues on the shop floor. Since jobs have to wait to be processed, actual lead times increase, causing ship dates to be missed. As lead times increase, forecast accuracy over the lead-time gets affected because forecasts are more accurate for shorter periods than for longer ones. Thus, overstated master production schedules lead to missed due dates and other problems. Validating the MPS with respect to capacity is an extremely important step in MRP. This validation exercise has been termed rough cut capacity planning (RCCP).

For example consider the man hour requirement for three components over a three week period as follows:

Table 1.6: master production schedules

	week 1	week 2	week 3
component A	70	70	70
component B	100	100	120
component C	80	75	80

Let us now check the total man-hours required producing this master production schedule. From the above illustrated resource requirements a rough cut analysis can be done as follows:

Table 1.7: Available Capacity

	Week 1	Week 2	Week3
Required standard hours	250	245	270
available standard hours	250	250	250
negative deviation			-20
positive deviation		+5	

1.3.4 RCCP DECISIONS

In this chapter we discuss how to determine the amount of capacity that is available. How to compare capacity available to capacity required, and the options that exist for adjusting capacity available and/or capacity required.

1.3.5 Determining Capacity Available

The plastic molding department of Al's Lamps, presented in the previous section, has three plastic molding machines. Since Al's works one eight-hour shift each day and there are 21 working days in an average month, it might seem that the capacity available to the plastic molding department is 504 hours per month (3 machines times 8 hours/day/machine times 21 days/month).

However, two additional factors must be considered. First, the plastic molding machines may not be available all the time. The machines may break down, the worker may be absent, and the mold needed or the material needed may not immediately be available. Second, there must be an adjustment between the time standard average and the actual average production rate of the department. The first adjustment factor is known as utilization. Utilization is a number between 0 and 1 that is equal to 1 minus the proportion of time typically lost due to machine, worker, tool, or material unavailability. The second adjustment factor is known as efficiency. Efficiency is formally defined to be the average of standard hours of production per clock hour actually worked. If a time standard is exactly right, efficiency is 1. If the time actually required to perform the work is less than the standard, efficiency is more than 1. If the time actually required to perform the work is more than the standard, efficiency is less than 1. As mentioned previously, time standards tend to be slightly pessimistic due to continual improvement in production methods.

Capacity available is found by multiplying time available times utilization and times time efficiency:

Capacity Available = Time Available x Utilization x Efficiency

Assume that for the plastic molding department of Al's Lamps, utilization is 0.756 and efficiency is 1.05. The time available in a month having 168 working hours (21 eight-hour days) is 504 (3 machines times 168 hours/month/ machine). Thus,

Capacity Available = 504 x 0.756 x 1.05 = 400 hours (rounded to the nearest hour).

When capacity is inadequate, four basic options are available to increase capacity: overtime, subcontracting, alternates routing, or adding personnel. If no combination of the four options can provide sufficient capacity, the MPS will have to be reduced. Options to adjust capacity required or available are discussed below

- Increase Capacity
- Additional shifts
- Overtime
- Additional resources
- Reduce Load
- Subcontract
- Reduce lot sizes if possible
- Redistribute Load
- Use alternate work centers or routings if possible
- Shift production to earlier periods that have additional capacity
- Temporarily use safety stocks and shift load to later period

If all else fails, revise MPS

1.3.6 Capacity Requirements Planning

Capacity requirements planning (CRP) is a computer-based extension of the MRP process that uses the results of MRP along with detailed production information and labor information to calculate planned workloads. It is a detailed capacity analysis that helps in validating the MRP schedule. CRP arises mainly due to batching of production work orders in the course of MRP. It is thus a computerized system that projects load from material requirements plan. Fig 1.8 shows CRP inputs and outputs.

CRP Inputs & Outputs

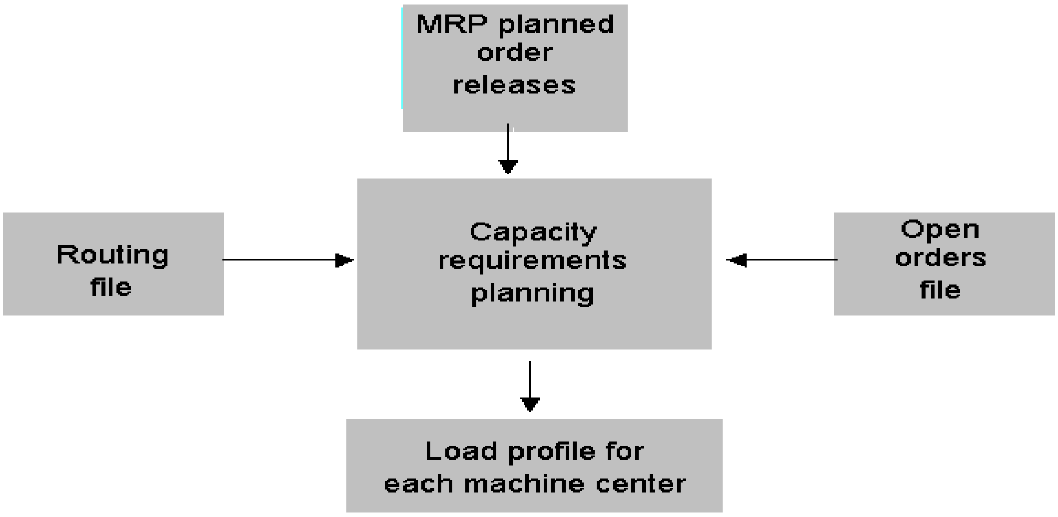


Fig 1.8 Diagram for CRP inputs and outputs

Key Inputs

Schedule of open orders and planned order releases (from MRP) are key inputs in the system.

A typical example would be as follows:

Table 1.8: Schedule of open orders and planned order releases

Release date	Due date	Planned orders	Number of batches of 20
05.12.12	03.01.13	40	2
04.01.13	08.02.13	80	4

1.4 Manufacturing Resource Planning (MRP III)

The 'M.R.P. III' process begins with an Accurate Demand Forecast, for it is this Demand Forecast that drives the remainder of the business. Using the best possible demand forecast, a Master Schedule is developed. Ideally the total number of master scheduled items will be minimized, so that the M.R.P. system can appropriately generate build schedules for components and 'accessories' automatically, and will be derived directly from the Demand Forecast with little or no changes.

From the Master Schedule, the 'M.R.P. III' system derives the individual component and assembly requirements, and recommends new purchase orders, just like a 'standard M.R.P.'

system, and also generates recommended purchase order reschedules, and automatically reschedules non-master scheduled assemblies based on the availability of components/resources and material requirements, just like an 'M.R.P. II' system. **The M.R.P. III system also monitors and reports vendor performance and 'performance to plan'** by the assembly line, similar to an 'M.R.P. II' system. However, to minimize the total amount of 'detail information', the 'M.R.P. III' system concentrates on only reporting those items that fall outside of the allowed tolerances, thus minimizing the number of reported items.

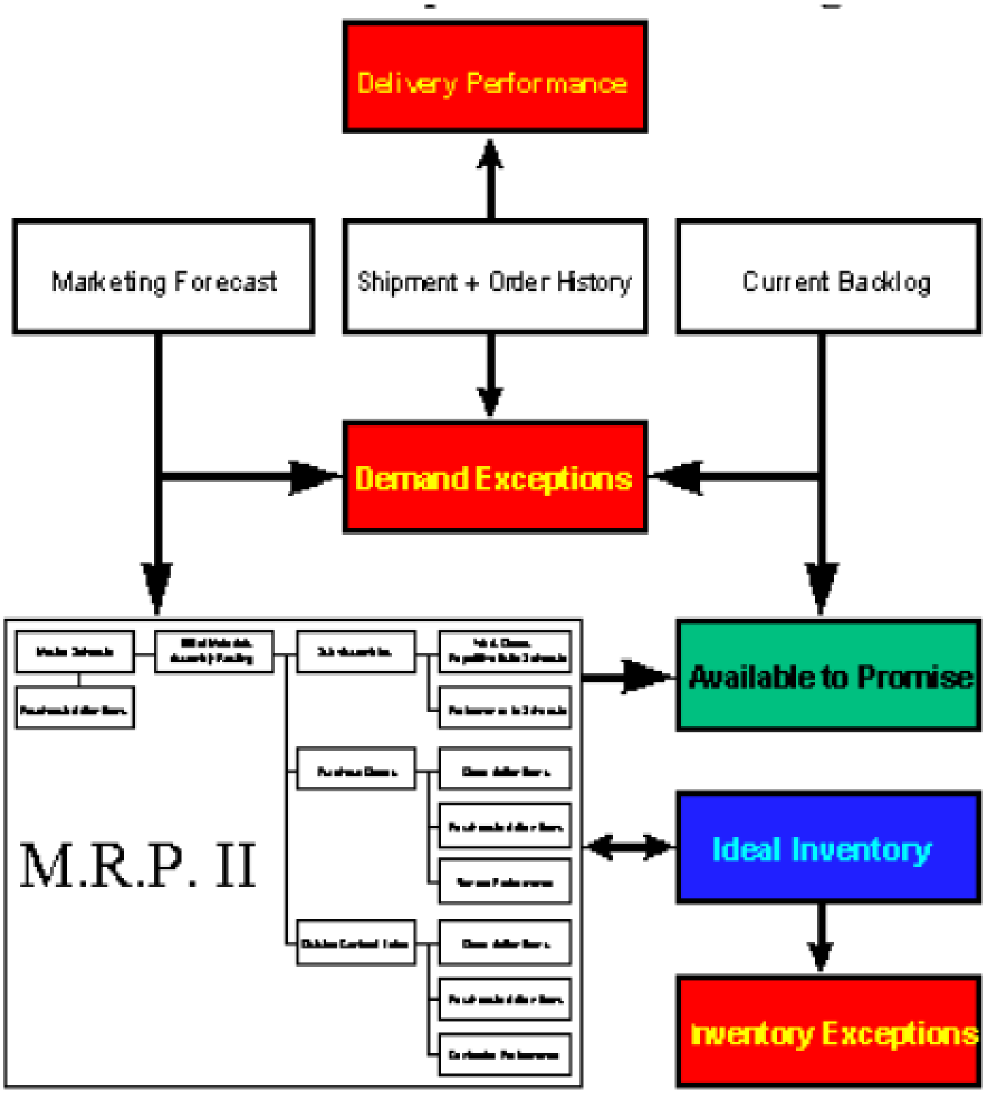


Fig 1.9 Integration Diagram for MRP II and MRP III

When the M.R.P. system has been fully integrated with the Order Management system, it becomes possible to calculate 'Available to Promise' inventory, based on a combination of existing order backlog, the current inventory, and the projected availability of a product over time as it is built from the current production schedule. In this way, if a customer orders a product within lead time, and delivery is already promised to another customer, order management personnel can use this information to negotiate a realistic delivery schedule with the customer. Also, delivery re-schedules would become easier to manage, since order management personnel can view the current ‘available to promise’ inventory, and use this information to determine when partial or full shipments could be re-scheduled. In all likelihood, there will be available inventory to ship ahead of schedule, should the customer need to perform a ‘crash buy’. An ‘M.R.P. III’ system must therefore include the ability to view the ‘available to promise’ inventory, based on current inventory, current backlog, and the current production plan.

Finally, the ‘M.R.P. III’ system bases its operating parameters on the principles of Bandwidth Management, dynamically adjusting parameters such as lead times and ‘ideal inventory’ according to the historic data (when needed), and measuring performance to a set of statistically derived ‘control bands’, rather than fixed parameters. The ‘M.R.P. III’ system then generates exception reports for those items that fall outside of the control bands, and automatically maintains as much of the manufacturing planning process as possible, with little or no human intervention.

A process such as ‘M.R.P. III’ would help to eliminate certain kinds of errors that currently plague manufacturing businesses on a nearly universal level. By far, the greatest single factor in ruining a perfectly good manufacturing plan is the tendency for the Demand Forecast to change on a regular basis, typically inside planning lead time. Or, the Demand Forecast may be completely useless for manufacturing purposes, forcing the person responsible for the master schedule to literally generate his own forecast in an attempt to predict what the demand actually will be. Often times, a combination of both of these conditions exists, where the marketing forecast is so inaccurate as to make it useless, forcing the master scheduler to perform this task of generating a forecast. And, without some kind of forecast, there is no master schedule. And, without a master schedule, there is no ‘M.R.P.’. Any ‘M.R.P.’ system without a demand forecast analysis capability is thus severely limited in its ability to help reduce overall inventory and simultaneously meet the requirements of the production plan. After all, **“Garbage In, Garbage Out.”**

Still, with all of the potential for automating the manufacturing planning process, people still need to use their skills and judgement within critical points in the planning process. Using ‘exception planning’ will minimize the amount of items that people need to look at. This ‘exception planning’ process is derived directly from Bandwidth Management, so that only those items that need attention will be addressed. It is still the planner’s responsibility to implement purchase order re-scheduling or ‘crash buy’ programs, outside contracting, and so forth, and (potentially) any manufacturing schedules oriented around a process or piece of equipment that is considered a ‘critical path’ in the manufacturing process. The ‘M.R.P. III’ system must therefore supply as much useful information to the planner as possible, to help him make informed decisions, yet also limit this information to only those items that may actually require his attention. Figure 1.9 shows integration diagram for MRP II and MRP III.

1.5 MRP Updates

Regenerative MRP

Do the planning from scratch

Time between regenerations is long

Ok for stable environments

Net Change MRP

Update the plan according to changes

1.6 Enterprises Resources Planning (ERP)

An ERP system differs from the typical MRP II system in technical requirements such as graphical user interface; relational database; use of fourth-generation language; and computer-assisted software engineering tools in development, client/server architecture, and open system portability.

Enterprise Resource Planning (ERP) system is Enterprise wide information system,

Single master database and Origins in manufacturing Computer Integrated Manufacturing (CIM) and Materials Requirement Planning (MRP). It Ties with back office functions Accounting, marketing, manufacturing, Quality, plant maintenance etc.,

A more general feature of MRP2 is its extension to purchasing, to marketing and to finance (integration of all the function of the company), ERP has been the next step.

Enterprise resource planning (ERP) systems are extensions of MRP systems that run on a single database in a client server environment. ERP systems support marketing and finance departments in addition to the production department. Significant coordination advantages arise when all functions draw and add to the same data. SAP is currently the leading provider of ERP systems. Many companies such as i2 Technologies and Manugistics have developed bolt-ons programs that run on top of ERP systems. These companies address specific problems that are not solved by ERP. For example, a better forecasting system or a finite-capacity scheduler can be added to SAP. Lately SAP has developed many of the capabilities that were formerly available only through bolts –ons.

1.6.1 Enterprises Resources Planning (ERP) Packages:

1.SAP 2.JD Edwards

3.Mfg/Pro 4.BPCS

5.Marshal 6.Oracle Financials

1.6.2 Evaluation form MRP to ERP

Table 1.9: Evaluation form MRP to ERP

Sl.no	**Concept**	**Mainly Focused on**
1	MRP - I	Open loop system Not manual planning and all the numerical are computerized (On hand, net requirement and cross requirement) Bill of Material and inventory record But MRP – I output is not good for current environment
2	MRP - II	Closed loop system Demand forecasting and demand management Rough cut capacity planning Capacity requirement planning

		Master Production schedule
3	MRP - III	Accurate demand forecasting Standard MRP - II Included vendor performance report Report generation by using control band
4	ERP	Ties with back office function HR, Material Management, Marketing, production, Quality, plant maintenance and finance etc.,

1.7 Evaluation of Order Policy

1.7.1 Order Information terms and condition for model Purchase order

Kindly ref Annexure – I

1.7.2 Order Policy Analysis

Rules as to when an inventory replenishment order is to be issued, such as when the stock falls to a certain level or to zero. Order policies set the frequency for deliveries to a company. This has a major influence on the amount of inventory a company carries and on the number of transactions (and corresponding overhead) a company must support.

1.7.3 Traditional Solution:

The majority of companies base their ordering policies on a part's ABC classification. The ABC classification is a way of stratifying parts into their relative value. Typically companies will designate as "A" parts, the relatively few parts that make up the top 80% of the forecasted spend, "B" parts will make up the next 15% of the forecasted spend, and the vast number of parts that make up the last 5% of the forecasted spend will be designated as "C" parts. In terms of ordering policy, companies determine the weeks of supply they want buyers to purchase for

each category - for example:

A = 2 weeks of supply

B = 6 weeks of supply

C = 13 weeks of supply

This methodology has survived since the early part of the 20th century because it is easy to implement and easy to understand. In traditional order evaluation only quantity is considered.

In the first studies performed by Dickson (1966), 23 separated criteria are presented to decide what is relevant to Order evaluation. These factors are listed below

- Pure costs (included discount and transportation costs) that are determined by every supplier
- Ability is that every supplier reaches qualitative property
- Services given after selling
- Predict the time of delivery
- Geographic location of each supplier
- Financial position of each supplier
- Manufacturing facilities and capacity that every supplier has
- Time experience that every supplier has
- Technical capacity (note of simplification for research and improvement) that each supplier has
- Management and organization of each supplier
- Future purchases that company may buy supplier
- Information system (information under processing) with supplier
- Operational control (including reporting, quality control and inventory control systems) from supplier
- Relevant situation to each industry (including leader and credit) for every supplier

- Experience in relation with relevant people to each supplier
- Relevant Organizational behavior to each supplier
- Amount of supplier's business corporation interest with purchaser company
- Policies to guarantee and interlocutors for each supplier
- Ability of each supplier for reaching product packing requirements Bottom of Form
- Effects related to contract with the supplier in relation to other contracts
- Availability of education assistance for product from supplier
- Accepting process and instructions to the purchaser company
- Performance history relevant to the supplier.

But in most of the modern order evaluation **quantity, quality and on time delivery** are considered. The major consideration also includes quantity with units, tax and mandatory spares For Ex in Fan purchasing, bearing is the most important spares Hence it is mandatory to provide two spare bearings without extra charge. Another important scope of work, along with equipment supply, civil, electrical and manual labour are also included modern order evaluation

Quality is the mantra for any business. For eg purchasing hydrogen generation plant, H2 with 99.999999 % purity is most important factor. If purity islesser than , it will lead corrosion to the power plant turbine.

On time delivery is another important factor in the world. In india, delhi metro project was the first project to delivered on time, which saved people money and benefited to the society. Another Ex 1 x 600 MW mettur thermal power project is not completed on time. hence the private contractor should pay Rs 160 cr/month as penalty.

Warranty/Guarantee It comes after delivery but it also considered in evaluation time. Warranty ensures repair of damaged parts whereas guarantee ensures replacement of damaged parts for particular period. Eg In leading mixer grinder brands five years warranty on motor is given.

1.8 Role of Production Organization

Production organization, or the organization of production, is at the heart of businesses involving the manufacturing process of goods. According to the American economist pioneer Richard Ely in his book, **"Elementary Principles of Economics**," the concept of production organization is applicable in modern economics in a number of ways. As the term suggests, production organization is simply the manner in which you organize the process of production of goods or services in your business. It is through production organization that you are able to effectively coordinate the factors of production, which include raw materials, labor and capital. Consequently, you will derive significant benefits from the organization of the production process.
Figure 1.10 shows Contingency view of organization.

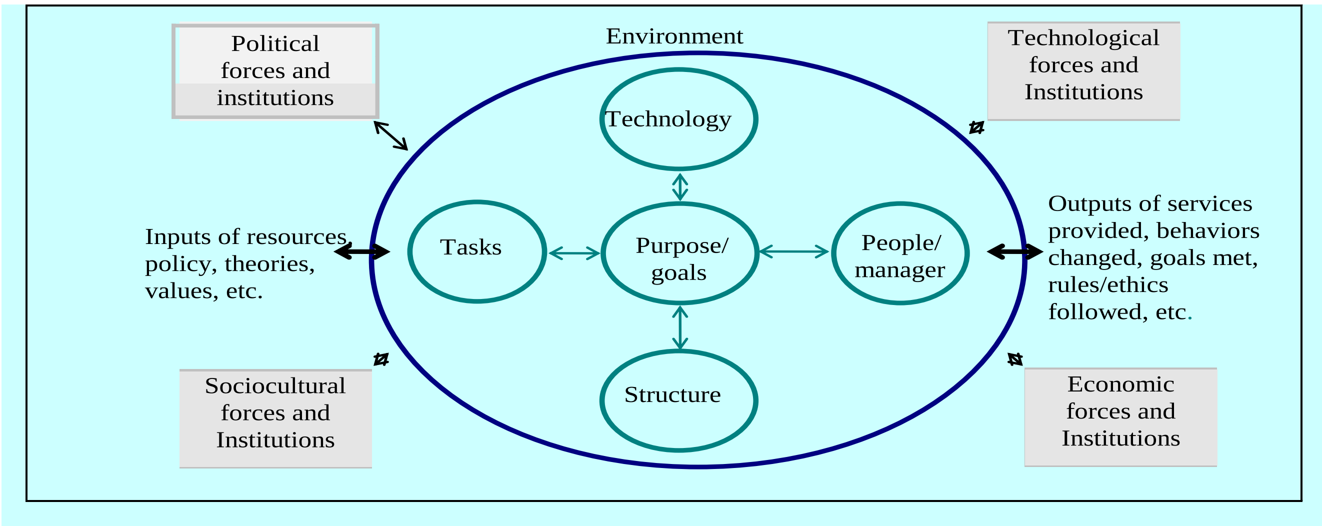


Fig 1.10 Contingency View of Organization

Purpose (i.e., goals of the organization)

- Mission based in profits
- Multiple goals, not conflicting
- High accountability for product

People (e.g., professional, motivation, etc.)

- Most skilled at top
- Complex motivation

- ☐ Identity to organization
- ☐ Salaries can be high

Tasks (e.g., nonrepetitive, nonprescribed,)

- ☐ Involve things
- ☐ Repetitive
- ☐ Programmable
- ☐ Easy to measure units of production
- ☐ Easy to measure outcome & impacts

Technology (e.g., procedures & tools)

- ☐ High use of hard technology (machines)
- ☐ High use of soft technology (protocols)

Structure, e.g., hierarchy, network, etc.

- ☐ High use of hard technology (machines)
- ☐ High use of soft technology (protocols)
- ☐ Single management hierarchy
- ☐ Driven by profit

Environment (i.e., political, ecc, tech, sociocult)

- ☐ Customer funded
- ☐ Influenced by market forces
- ☐ One customer with well defined needs
- ☐ Customers always voluntary
- ☐ Customers have few rights
- ☐ Advertising is key, Lobbying is good

1.8.1 Production Organization Structure

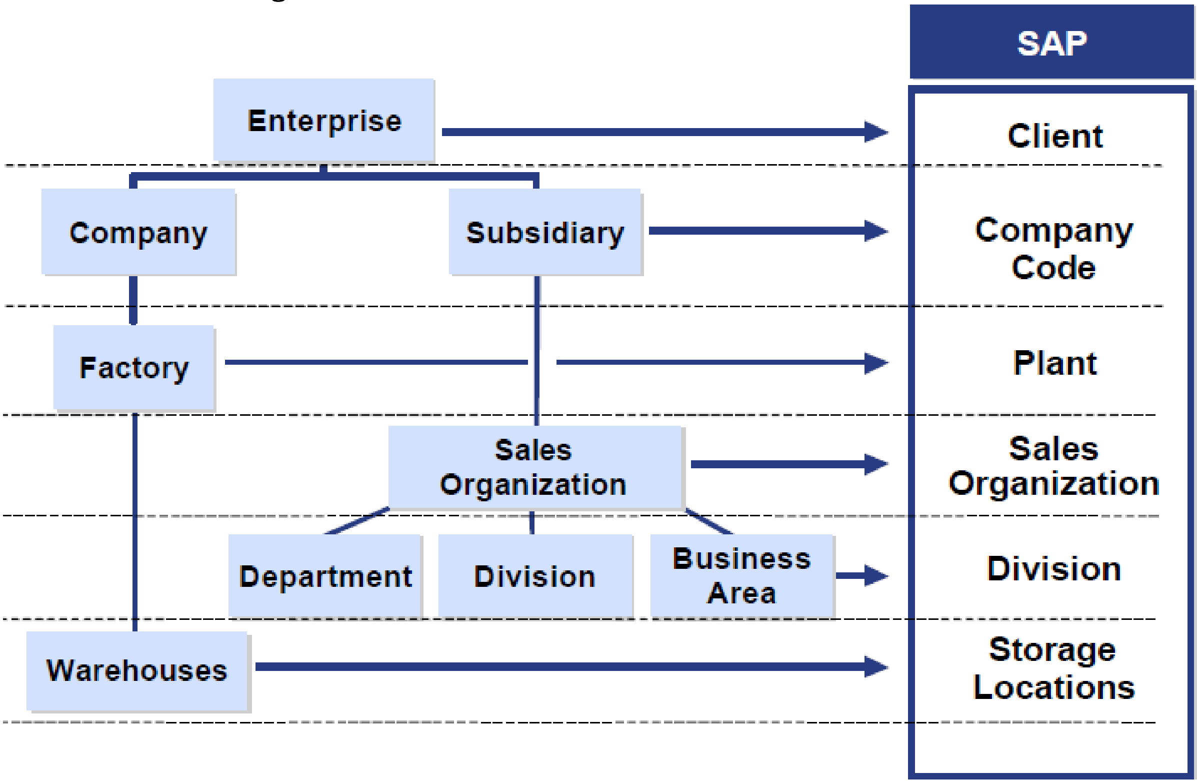


Fig 1.11 Production Organization Structure

The company code is the smallest organizational unit for which you can have an independent Accounting department within external Accounting. A company code represents an independent accounting unit, for example, a company within a corporate group (client).

A plant is an organizational logistics unit that structures the enterprise from the perspective of production, procurement, plant maintenance, and materials planning. A plant is a manufacturing facility or branch within a company.

The storage location is an organizational unit that allows the differentiation of material stocks within a plant. Inventory Management on a quantity basis is carried

out at storage location level in the plant. Physical inventory is carried out at storage location level. Figure 1.11 shows Production Organization Structure diagram.

1.8.2 Factors involved of Production/Operation Control:

Organization of Enterprises means to plan a business, to start it and run it. It means to bring the factors i.e. land, labour and capital together to undertake a business or production process. Organization implies not only running the business but also shouldering the loss, if any. The man who undertakes all this work is called as organizer

Importance of Organization: Now a day, organization is very important as Production process has become too much complicated. A small happening within the country or abroad influences the business. The organization if done properly the production process will not hamper. Hence proper planning and execution of business is necessary. In view of this, the job of organizer becomes very important. Therefore whole time devotion of organizer is required for successful business. The other factors land is possessed by land owner, capital is possessed by capitalist and labourer is only ready to offer. They lay scattered hence these three needs to be combined and It is the job of organizer. Thus, there would be no organization if the above characteristics will absent.

Function of Organizer

1) **Initiation:** Taking the review of situation and availability of resources organizer initiates a business or production. Here planning of business is undertaken.
2) **Organization:** Organizer now combines the land, labour and capital resources and starts the business or production.
3) **Direction and supervision:** During the course of production proper direction and timely supervision is required. Thus, organize executes the business in a proper way.
4) **Control:** Organizer is keeping watch on changing situation. Because of changes in situation in respect of marketing, Govt. decision, etc. will hamper the business. Therefore control is also important.
5) **Risk taking:** Risk means uncertainty. It may be physical or market risk. The business cannot be always in profit. Sometimes losses are required to accept. Risk taking therefore becomes an important function of an organizer.
6) **Innovation:** A successful organizer is always innovative. He can introduce new method or commodity in the production process or in business.

1.9 Agile manufacturing-concept and philosophy

Agile manufacturing can he defined as (1) an enterprise level manufacturing strategy of introducing new products into rapidly changing markets and (2) an organizational ability to thrive in a competitive environment characterized by continuous and sometimes unforeseen change.

The agile manufacturing enterprise can be defined along four dimensions:

1. value-based pricing strategies that enrich customers;

2. co-operation that enhances competitiveness;
3. organizational mastery of change and uncertainty; and
4. Investments that leverage the impact of people and information.

Agility has four underlying principles:

1. delivering value to the customers
2. being ready for change
3. valuing human knowledge and skills
4. Forming virtual partnerships.

1.9.1 Need for Agile manufacturing in the manufacturing industry

1. Enrich the customer
2. Have a flexible that allows rapid reconfiguration of resources
3. Cooperate internally and with other companies in order to enhance competitiveness
4. Nurture an entrepreneurial culture that leverages the impact of people and information
5. Agile teams are multifunctional in order to combine the knowledge and skills necessary to enrich the customer
6. Agile teams are co-operative both within and between companies, to enable the intra- and extra-firm cooperation needed to enhance competitiveness
7. Agile teams are virtual, which allow the company to combine resources (people and information) as needed in order to pursue entrepreneurial goals

The 1991 study identified four principles of agility" Manufacturing companies that are agile competitors tend to exhibit these principles or characteristics. The four principles are:

Organize to Master Change " An agile company is organized in a way that allows it to thrive on change and uncertainty'? In a company that is agile, the human and physical resources can be rapidly reconfigured to adapt to changing environment and market opportunities.

Leverage the Impact of People and Information - In an agile company, knowledge is valued, innovation is rewarded, and authority is distributed to the appropriate level of the organization. Management provides the resources that personnel need. The organization is entrepreneurial in spirit. There is a "climate of mutual responsibility for joint successes"

Cooperate to Enhance Competitiveness - "Cooperation internally and with other companies is an agile competitor's operational strategy of first choice."? The objective is to bring products 10 markets as rapidly as possible. The required resources and competencies (Ire found and melts wherever they exist. This may involve partnering with other companies, possibly even competing companies to form virtual enterprises

Enrich the Customer" - An agile company is perceived by its customers as enriching them in a significant way not only itself."' The products of an agile company are perceived as solutions to customers' problems. Pricing of the product can be based on he value of the solution to the customer rather than on manufacturing cost

Market Forces and Agility

A number of market forces can be identified that are driving the evolution of agility and agile manufacturing in business. These forces include:

Intensifying competition Signs of intensifying competition include (I) global competition, (2) decreasing cost of information, (3) growth in communication technologies.(4'! pressure to reduce time to market, (5) shorter product lives. and (6) increasing pressures on costs and profits

Fragmentation of mass markets Mass production was justified by the existence of very large markets for mass produced products. The signs of the trend toward fragmented markets include: (1) emergence of niche markets, for example, different sneakers for different sports and non sports applications; (2) high rate of model changes; declining barriers to market entry from global competition; and (4) shrinking windows of market opportunity. Producers must develop new product styles in shorter development periods.

Cooperative business relationships there are mare cooperation occurring among corporations in the United States. The cooperation takes many forms including' increasing inter enterprise cooperation, (2) increased outsourcing, (3) global sourcing. (4) Improved labor management relationships. and (5) the formation of virtual enterprises among companies. One might view the increased rate of corporate mergers that are occurring at time of writing as an extension of these cooperative relationships.

Changing customer expectations Market demands are changing. Customers are becoming more sophisticated and individualistic in their purchases. Rapid delivery of the product. support throughout the product life. and high quality are attributes expected by the customer of the product and of the company that manufactured the product. Quality is no longer the basis of competition that it was in the 1970s and 19S0s.Today·~products me likely to have an increased information content. Increasing societal pressures Modern companies are expected to be responsive tell social issues, including workforce training and education, legal pressures, environmental impact issues Gender issues, and civil rights issues.

Modern firms are dealing with these market forces by becoming agile. Agility is a strategy for profiting from rapidly changing and continually fragmenting global markets for customized products and services. Becoming agile is certainly not the only objective of the firm. There are important other objectives, such as making a profit and surviving into the future. However. Becoming more agile is entirely compatible with these other objectives. Indeed, becoming agile represents a working strategy for company survival and future profitability. How does a company become more agile? Two important approaches are: (1) to reo organize the company's production systems to make them more agile and (2) to manage relationships differently and value the knowledge that exists in the organization. Let us examine each of these approaches in a company's operations as it seeks to become an agile manufacturing firm.

1.9.2 Reorganizing the Production System for Agility

Companies seeking to be agile must organize their production operations differently than the traditional organization. Let us discuss the changes in three basic areas: (1) product design. (2) Marketing, and (3) production operations.

Product Design Reorganizing production for agility includes issues related to product design. As we have noted previously, decisions made in product design determine approximately 70'1(,of the manufacturing cost of a product. For a company to be more agile, the design engineering department must develop products that can be characterized as follows'

Customizable, Products can be customized for individual niche markets. In some cases, the product must be custornizable for individual customers.

Upgradeable It should be possible for customers who purchased the base model to subsequently buy additional options to upgrade the product.

Reconfigurable Through modest changes in design, the product can be altered to provide it with unique features. A new model can be developed from the previous model without drastic and time consuming redesign effort.

Design modularity. The product should be designed so that it consists of several modules (e.g ... subassemblies) that can he readily assembled to create the finished item. In this way. if a module needs to be redesigned, the entire product does not require redesign. The other modules can remain the same

Frequent model changes within stable market families. Even for products that succeed in the marketplace. The company should nevertheless introduce new versions of the product to remain competitive.

Marketing A company's design and marketing objectives must be closely linked The best efforts of design may be lost if the marketing plan is flawed. Being an agile marketing company suggests the following objectives. Several of which arc related directly to the preceding product design attributes

• Aggressive and proactive product marketing. The sales and marketing functions of the firm should make change happen in the marketplace. The company should bc the change agent that introduces the new models and products

• Cannibalize successful products. The company should introduce new models to replace and obsolete its most successful current models.

• Frequent new product introductions. The company should maintain a high rate of new product introductions.

• Life cycle product support. The company must provide support for the product throughout its life cycle

• Pricing by 'customer value. The price of the product should be established according to its value to the customer rather than according to its own cost.

• Effective niche market competitor. Many companies have become successful by competing effectively in niche markets. Using the same basic product platform, the product has been reconfigured to provide offerings for different markets. The sneaker industry is a good example here

Production Operations A substantial impact on the agility of the production system can be achieved by reorganizing factory operations and the procedure, and systems that support these operations. Objectives in production operations and procedures that are consistent with an agility strategy are the following:

Be a cost effective, low volume producer. This is accomplished using flexible production systems and low setup times.

Be able to produce to customer order. Producing to customer order reduces inventories of unsold finished goods

Master mass customization, the agile company is capable of economically producing a unique product for an individual customer. Use reconfigurable and reusable processes, tooling, and resources. Examples include computer numerical control machine tools, parametric part programming, robots that arc reprogrammed for different jobs, programmable logic controllers, mixed model

production lines, and modular fixtures (fixtures designed with a group technology approach, which typically possess a common base assembly to which are attached components that accommodate the different sizes or styles of work units).

Bring customers closer to the production process. Provide systems that enable customers to specify or even design their own unique products. As an example, it has become every common in the perusal computer market for customers to be able to order exactly the PC configuration (monitor size, hard drive, and other options) and software that they want.

Integrate business procedures with production. The production system should include sales. marketing, order entry, accounts receivable, and other business functions These functions are included in a computer integrated production planning and control system based on manufacturing resource planning (MRP II,

Treat production as a system that extends from suppliers through to customers. The company's own factory is a component in a larger production system that includes suppliers that deliver raw materials and parts to the factory. It also includes the suppliers' suppliers.

1.9.3 Managing Relationships for Agility

Cooperation should be the business strategy of first choice (third principle of agility). The general policies and practices that promote cooperation in relationships and, in general, promote agility in an organization include the following:

- management philosophy that promotes motivation and support among employees
- trust based relationships
- empowered workforce
- shared responsibility for success or failure
- pervasive entrepreneurial spirit

Internal Relationships Internal relationships arc those that exist within the firm. Between coworkers and between supervisors and subordinates. Relationships inside the firm must be managed to promote agility. Some of the important objectives include (1) make the work organization adaptive. (2) provide cross functional training, (3) encourage rapid partnership formation and (4) provide effective electronic communications capability

External relationships External relationships are those that exist between the company and external suppliers. Customers, and partners, it is desirable to form and cultivate external relationships for the following reasons: (1) to establish interactive. Proactive relationships with customers; (2) to provide rapid identification and certification of suppliers: (3) to install effective electronic communications

SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHTRONICS

M.E (CAD)

SPRA7007 - MANUFACTURING INFORMATION SYSTEMS

UNIT - II

DATABASE

Data modelling for a database, records and files, abstraction and data integration. Three level architecture for DBMS, Components of DBMS, Advantages and disadvantages of DBMS. Terminologies – Entities and attributes – Data models, schema and subschema - Data Independence – ER Diagram – UML notation for describing the enterprise–wide data objects Trends in database, Team center Introduction.

2. DATABASE

2.1Introduction:

In computerized information system data is the basic resource of the organization. So, proper organization and management for data is required fro organization to run smoothly. Database management system deals the knowledge of how data stored and managed on a computerized information system. In any organization, it requires accurate and reliable data for better decision making, ensuring privacy of data and controlling data efficiently.

The examples include deposit and/or withdrawal from a bank,hotel,airline or railway reservation, purchase items from supermarkets in all cases, a database is accessed.

2.2 What is data:

Data is the known facts or figures that have implicit meaning. It can also be defined as it is the representation of facts ,concepts or instruction in a formal manner, which is suitable for understanding and processing. Data can be represented in alphabets(A-Z, a-z),in digits(0-9) and using special characters(+,-.#,$, etc)

2.2.1 Information:

Information is the processed data on which decisions and actions are based. Information can be defined as the organized and classified data to provide meaningful values.

Eg: “The age of Ravi is 25”

2.2.2 File:

File is a collection of related data stored in secondary memory.

2.2.3 File Oriented approach:

The traditional file oriented approach to information processing has for each application a separate master file and its own set of personal file. In file oriented approach the program dependent on the files and files become dependent on the files and files become dependents upon the programs

2.2.4 Disadvantages of file oriented approach:

Data redundancy and inconsistency:

The same information may be written in several files. This redundancy leads to higher storage and access cost. It may lead data inconsistency that is the various copies of the same data may longer agree for example a changed customer address may be reflected in single file but not else where in the system.

Difficulty in accessing data :

The conventional file processing system do not allow data to retrieved in a convenient and efficient manner according to user choice.

Data isolation :

Because data are scattered in various file and files may be in different formats with new application programs to retrieve the appropriate data is difficult.

Integrity Problems:

Developers enforce data validation in the system by adding appropriate code in the various application program. How ever when new constraints are added, it is difficult to change the programs to enforce them.

Atomicity:

It is difficult to ensure atomicity in a file processing system when transaction failure occurs due to power failure, networking problems etc.

(atomicity: either all operations of the transaction are reflected properly in the database or non are)

Concurrent access:

In the file processing system it is not possible to access a same file for transaction at same time

Security problems:

There is no security provided in file processing system to secure the data from unauthorized user access.

2.3 Database:

A database is organized collection of related data of an organization stored in formatted way which is shared by multiple users.

The main feature of data in a database is:

- It must be well organized
- it is related
- It is accessible in a logical order without any difficulty
- It is stored only once

For example:

consider the roll no, name, address of a student stored in a student file. It is collection of related data with an implicit meaning.

Data in the database may be persistent, integrated and shared.

Persistent:

If data is removed from database due to some explicit request from user to remove.

Integrated:

A database can be a collection of data from different files and when any redundancy among those files is removed from database is said to be integrated data.

Sharing Data:

The data stored in the database can be shared by multiple users simultaneously with out affecting the correctness of data.

2.3.1 Why Database:

In order to overcome the limitation of a file system, a new approach was required. Hence a database approach emerged. A database is a persistent collection of logically related data. The initial attempts were to provide a centralized collection of data. A database has a self describing nature. It contains not only the data sharing and integration of data of an organization in a single database.

A small database can be handled manually but for a large database and having multiple users it is difficult to maintain it, In that case a computerized database is useful. The advantages of database system over traditional, paper based methods of record keeping are:

compactness:

No need for large amount of paper files

speed:

The machine can retrieve and modify the data more faster way then human being

Less drudgery:

Much of the maintenance of files by hand is eliminated

Accuracy:

Accurate, up-to-date information is fetched as per requirement of the user at any time.

2.4 Database Management System (DBMS):

A database management system consists of collection of related data and refers to a set of programs for defining, creation, maintenance and manipulation of a database.

2.4.1 Function of DBMS:

1. Defining database schema: it must give facility for defining the database structure also specifies access rights to authorized users.
2. Manipulation of the database: The dbms must have functions like insertion of record into database updation of data, deletion of data, retrieval of data
3. Sharing of database: The DBMS must share data items for multiple users by maintaining consistency of data.
4. Protection of database: It must protect the database against unauthorized users.
5. Database recovery: If for any reason the system fails DBMS must facilitate data base recovery.

2.4.2 Advantages of DBMS:

Reduction of redundancies:

Centralized control of data by the DBA avoids unnecessary duplication of data and effectively reduces the total amount of data storage required avoiding duplication in the elimination of the inconsistencies that tend to be present in redundant data files.

Sharing of data:

A database allows the sharing of data under its control by any number of application programs or users.

Data Integrity:

Data integrity means that the data contained in the database is both accurate and consistent. Therefore data values being entered for storage could be checked to ensure that they fall with in a specified range and are of the correct format.

Data Security:

The DBA who has the ultimate responsibility for the data in the dbms can ensure that proper access procedures are followed including proper authentication schemas for access to the DBS and additional check before permitting access to sensitive data.

Conflict resolution:

DBA resolve the conflict on requirements of various user and applications. The DBA chooses the best file structure and access method to get optional performance for the application.

Data Independence:

Data independence is usually considered from two points of views; physically data independence and logical data independence.

Physical data Independence allows changes in the physical storage devices or organization of the files to be made without requiring changes in the conceptual view or any of the external views and hence in the application programs using the data base.

Logical data independence indicates that the conceptual schema can be changed without affecting the existing external schema or any application program.

Disadvantage of DBMS:

- DBMS software and hardware (networking installation) cost is high
- The processing overhead by the dbms for implementation of security, integrity and sharing of the data.
- centralized database control
- Setup of the database system requires more knowledge, money, skills, and time.
- The complexity of the database may result in poor performance.

2.5 Three level architecture of DBMS :

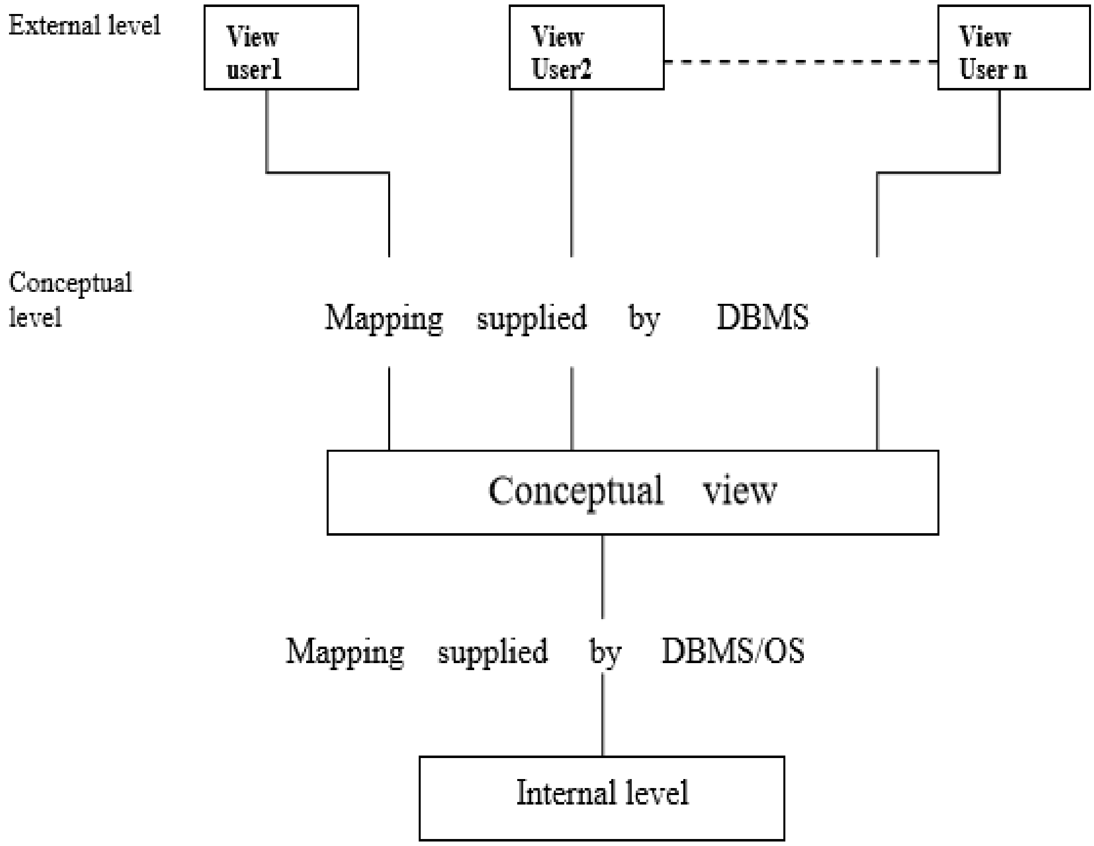


Fig.2.1. Three level architecture of DBMS

A database management system that provides three level of data is said to follow threelevel architecture .

1. **External level**
2. **Conceptual level**
3. **Internal level**

2.5.1 External level :

The external level is at the highest level of database abstraction . At this level, there will be many views define for different users requirement. A view will describe only a subset of the database. Any number of user views may exist for a given global or subschema.

for example , each student has different view of the time table. the view of a student of Btech (CSE) is different from the view of the student of Btech(ECE).Thus this level of abstraction is concerned with different categories of users.

Each external view is described by means of a schema called schema or schema.

2.5.2 Conceptual level :

At this level of database abstraction all the database entities and the relationships among them are included . One conceptual view represents the entire database . This conceptual view is defined by the conceptual schema.

The conceptual schema hides the details of physical storage structures and concentrate on describing entities , data types, relationships, user operations and constraints.

It describes all the records and relationships included in the conceptual view . There is only one conceptual schema per database . It includes feature that specify the checks to relation data consistency and integrity.

2.5.3 Internal level :

It is the lowest level of abstraction closest to the physical storage method used . It indicates how the data will be stored and describes the data structures and access methods to be used by the database . The internal view is expressed by internal schema.

The following aspects are considered at this level:

- Storage allocation e.g: B-tree,hashing
- access paths eg. specification of primary and secondary keys,indexes etc
- Miscellaneous eg. Data compression and encryption techniques,optimization of the internal structures.

Database users :

Naive users :

Users who need not be aware of the presence of the database system or any other system supporting their usage are considered naïve users . A user of an automatic teller machine falls on this category.

Online users :

These are users who may communicate with the database directly via an online terminal or indirectly via a user interface and application program. These users are aware of the database system and also know the data manipulation language system.

2.6 Database Terminologies

2.6.1 Entity

It is one Object in the real world. An entity type represents a group of data objects which share the same properties and are capable of having independent existence in a specified application.

2.6.2 Attributes

It describes each entity. Attributes are used to model the properties of an entity type. Normally attributes are enclosed in brackets.

Example – entity type tool

– tool (Tool Slno, Tool name, Tool material, Tool material grade)

2.6.3 Entity instance (i.e., entity occurrence): a specific data object within an entity type. It is created by assigning specific values to attributes.

• Example – an instance of tool

tool (Tool Slno, Tool name, Tool material, Tool material grade)

tool (001SSS09, single point cutting tool, stainless steel, SS-316)

2.6.4 Entity set

Group of similar entities (share same attributes)

2.6.5 Attribute domain

It describes one aspect of an entity type; usually [and best when] single valued and indivisible (atomic). Values that can be used for the attribute

Graphical Representation in Entity and Attribute

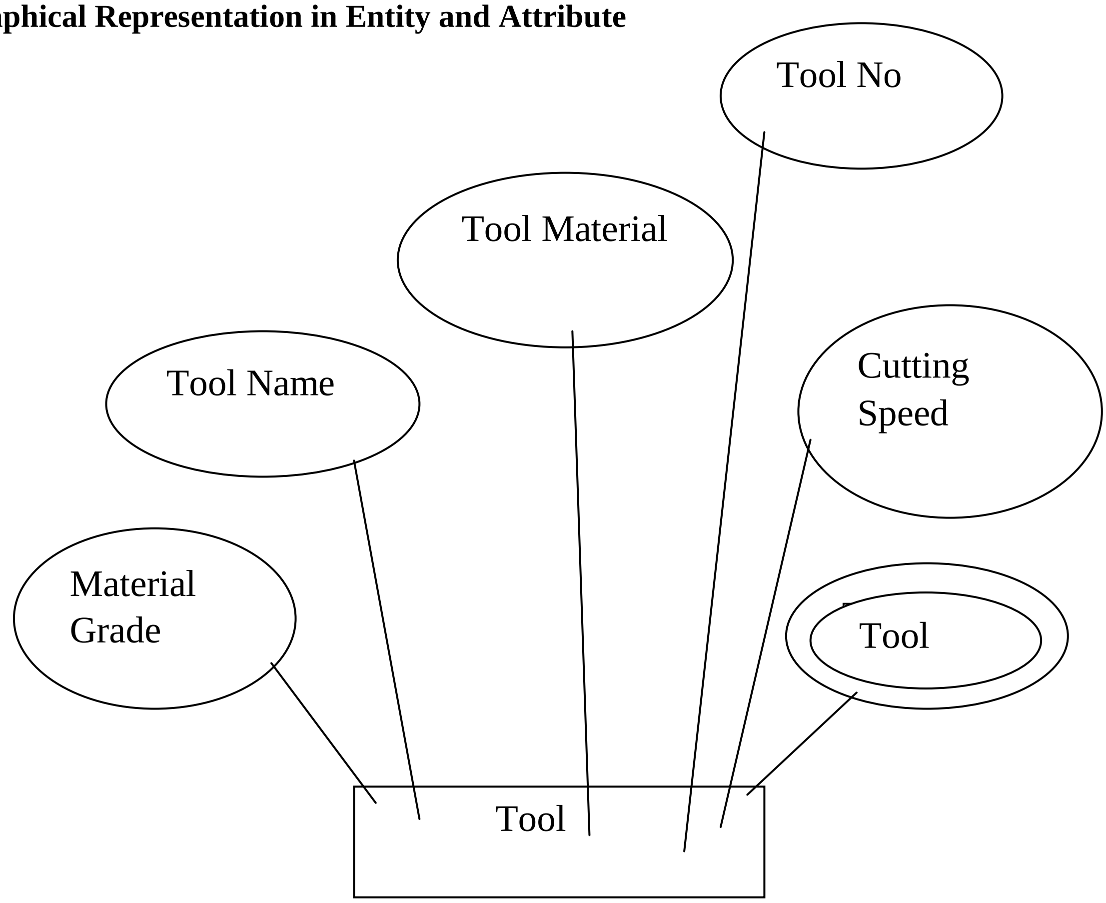


Fig 2.2 Entity and Attributes Diagram

Rectangle -- Entity

Ellipses -- Attribute (underlined attributes are [part of] the primary key)

Double ellipses-- multi-valued attribute, it is derived attribute, e.g. tool life is derivable from cutting speed.

Relationship – diamond

Link – line. Figure 2.1 shows Graphical Representation of Entity and Attribute.

2.7 Weak Entities

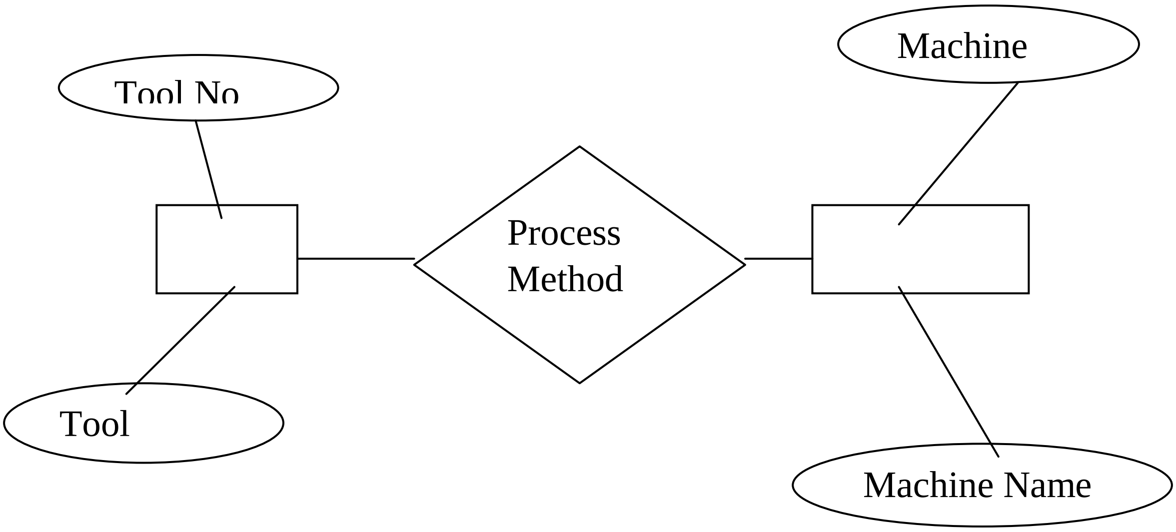


Fig 2.3 Weak Entity Diagram

In the above Fig 2.2, Tool is a weak entity.

It Cannot be uniquely identified using only the Tool No and it need to know which process enrolled in. A weak entity can only be identified using the attributes of another entity. It must be in a one to one relation with the relationship used to uniquely identify it. It also called as external identifier.

2.8 Key

Key is a minimal set of attributes within an entity type that can uniquely identify each instance/occurrence of that type.

2.8.1 Primary key

The candidate key chosen to be used for identifying entities and accessing records. Unless otherwise noted "key" means "primary key". The candidate key that is selected to uniquely identify each instance of an entity type. It always choose the one consisting of fewest number of attributes

- Example of primary key: the tool no

2.8.2 Secondary key: attribute or set of attributes commonly used for accessing records, but not necessarily unique

• Example of primary key: the tool material (different tool no with same material)

2.8.3 Composite key: a candidate key that consists of two or more attributes.

• Example of composite key:

– (Tool No, Tool Name, Tool material, Tool material grade)

2.8.4 Candidate key: a superkey such that no proper subset of its attributes is also a superkey (minimal superkey – has no unnecessary attributes). A candidate key is not used for primary key.

2.8.5 Foreign key: term used in relational databases (but not in the E-R model) for an attribute that is the primary key of another table and is used to establish a relationship with that table where it appears as an attribute also. So a foreign key value occurs in the table and again in the other table. This conflicts with the idea that a value is stored only once; the idea that a fact is stored once is not undermined.

2.8.6 Properties of key & Types of Key:

– **Uniqueness**

– **Non-redundancy**: none of the attributes within the key may be removed without destroying the uniqueness property.

2.9 Relationships

It represents meaningful relationships associations between/among entities. It connects two or more entities into an association/relationship

2.9.1 Degree of relationship

The number of roles in the relationship

Binary – links two entity sets; set of ordered pairs (most common).Figure 2.3 shows binary relationship diagram

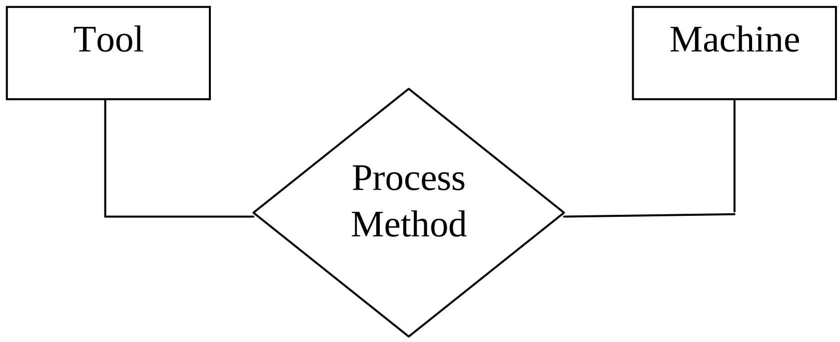


Fig 2.4 Binary Relationship Diagram

Ternary (Rare case only) – links three entity sets; ordered triples (rare). If a relationship exists among the three entities, all three must be present. Figure 2.4 shows ternary relationship diagram

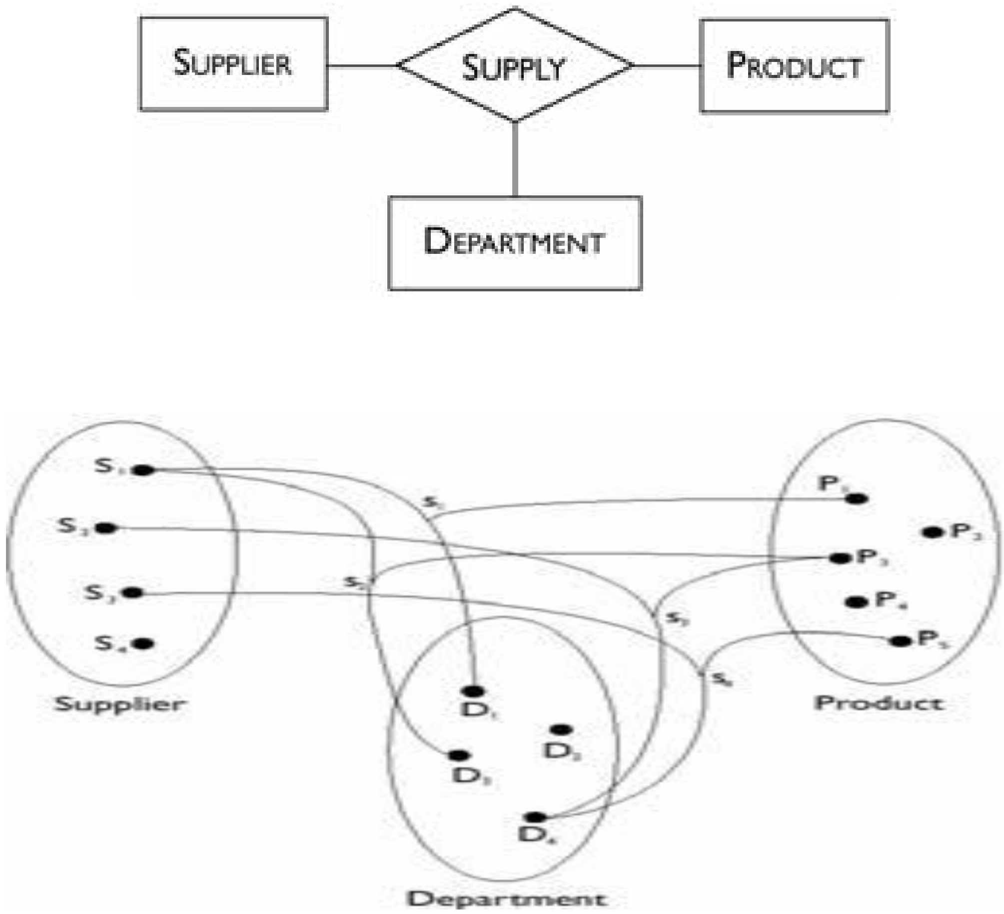


Fig 2.5 Ternary Relationship Diagram

N-ary (Rare case only) **–** links n entity sets; ordered n-tuples (very rare). If a relationship exists among the entities, then all must be present. It Cannot represesnt subsets.

2.9.2 Cardinality of Relationships

Cardinality is the number of entity instances to which another entity set can map under the relationship. This does not reflect a requirement that an entity has to participate in a relationship. **Participation** is another concept. Cardinality of a relationship (sometimes called **functionality**): determines the maximum number of possible relationship occurrences for an entity participating in a given relationship type. It describes how many instances of an entity type are associated with an instance of another entity type.

Possible cardinalities of a binary relationship:

– One-to-one (1:1)

– One-to-many (1:M)

– Many-to-many (M:M)

One-to-one: X-Y is 1:1 when each entity in X is associated with at most one entity in Y, and each entity in Y is associated with at most one entity in X.

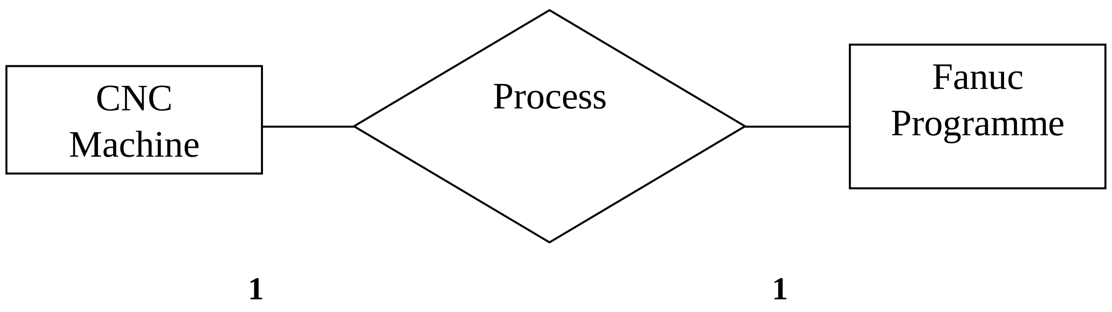


Fig 2.6 One to One relation

One-to-many: X-Y is 1: M when each entity in X can be associated with many entities in Y, but each entity in Y is associated with at most one entity in X.

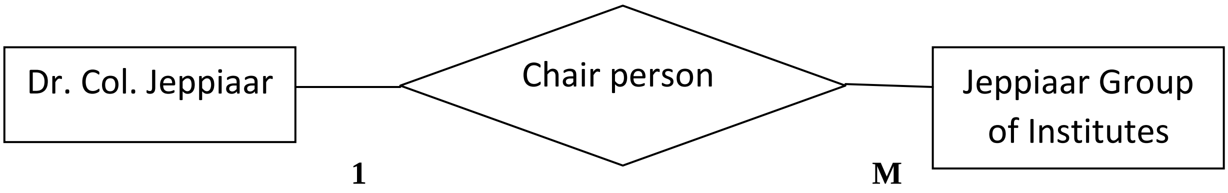


Fig 2.7 One to Multi relation

Many-to-many: X:Y is M:M if each entity in X can be associated with many entities in Y, and each entity in Y is associated with many entities in X ("many" =>one or more and sometimes zero)

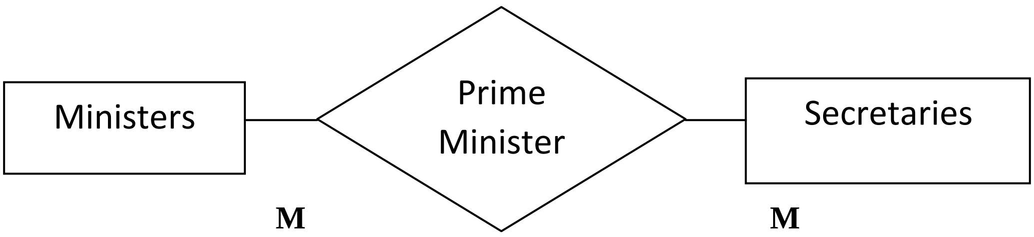


Fig 2.8 Multi to Multi relation

Figure 2.4, 2.5 and 2.6 shows possible cardinalities of a binary relationship

2.9.3 Relationships - Participation

Participation constraint (sometimes called membership class) of a relationship: determines whether all or only some entity instances will participate in the relationship.

• Mandatory participation: all entity instances will participate

• Optional participation: only some entity instances will participate

Relationship Participation Constraints

Total participation

- Every member of entity set must participate in the relationship
- Represented by double line from entity rectangle to relationship diamond

- E.g., A Class entity cannot exist unless related to a Faculty member entity in this example
- In a relational model we will use the references clause.

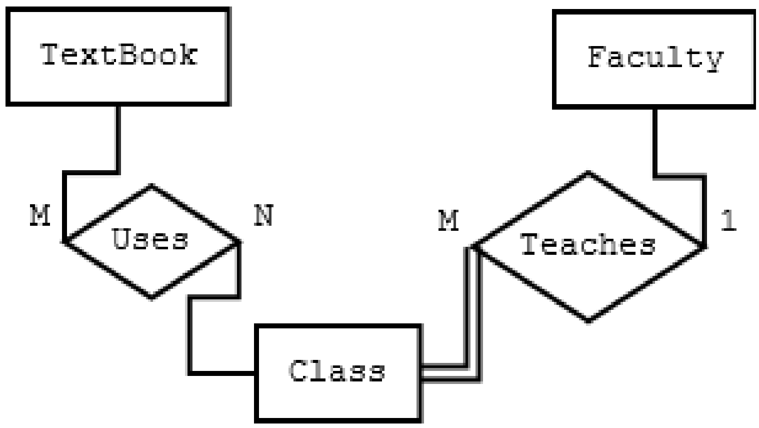


Fig 2.9 Total and Partial Participation Relation

Partial participation

- Not every entity instance must participate
- Represented by single line from entity rectangle to relationship diamond

E.g., A Textbook entity can exist without being related to a Class or vice versa. Fig 2.7 shows total and partial participation relation

Key constraint

- If every entity participates in exactly one relationship, both a total participation and a key constraint hold
- E.g., if a class is taught by only one faculty member.

2.10 Entity-Relationship (ER) Diagram

E-R Model is not SQL based. It's not limited to any particular DBMS. It is a conceptual and semantic model – captures meanings rather than an actual implementation. The goal of good database design is to generate a formal specification of the database schema.

2.10.1 Methodology:

1. Use E-R model to get a high-level graphical view of essential components of enterprise and how they are related.
2. Then convert E-R diagram to SQL DDL, or whatever database model you are using

2.10.2 The E-R Model:

The enterprise is viewed as set of

- Entities
- Relationships among entities

2.10.3 Symbols used in E-R Diagram

- Entity – rectangle
- Attribute – oval
- Relationship – diamond
- Link - line

2.10.4 ER Diagram Example

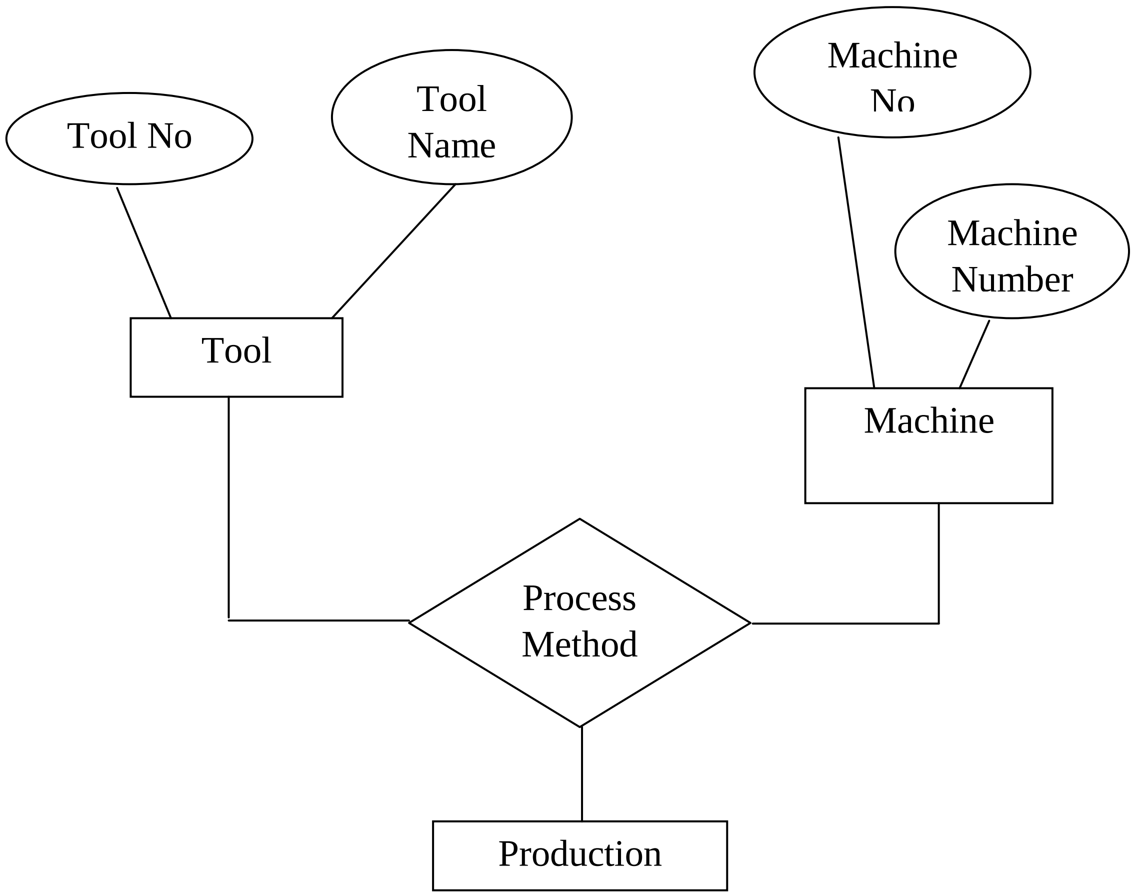


Fig 2.10 ER Diagram Example 1

2.10.5 ER Diagram Example

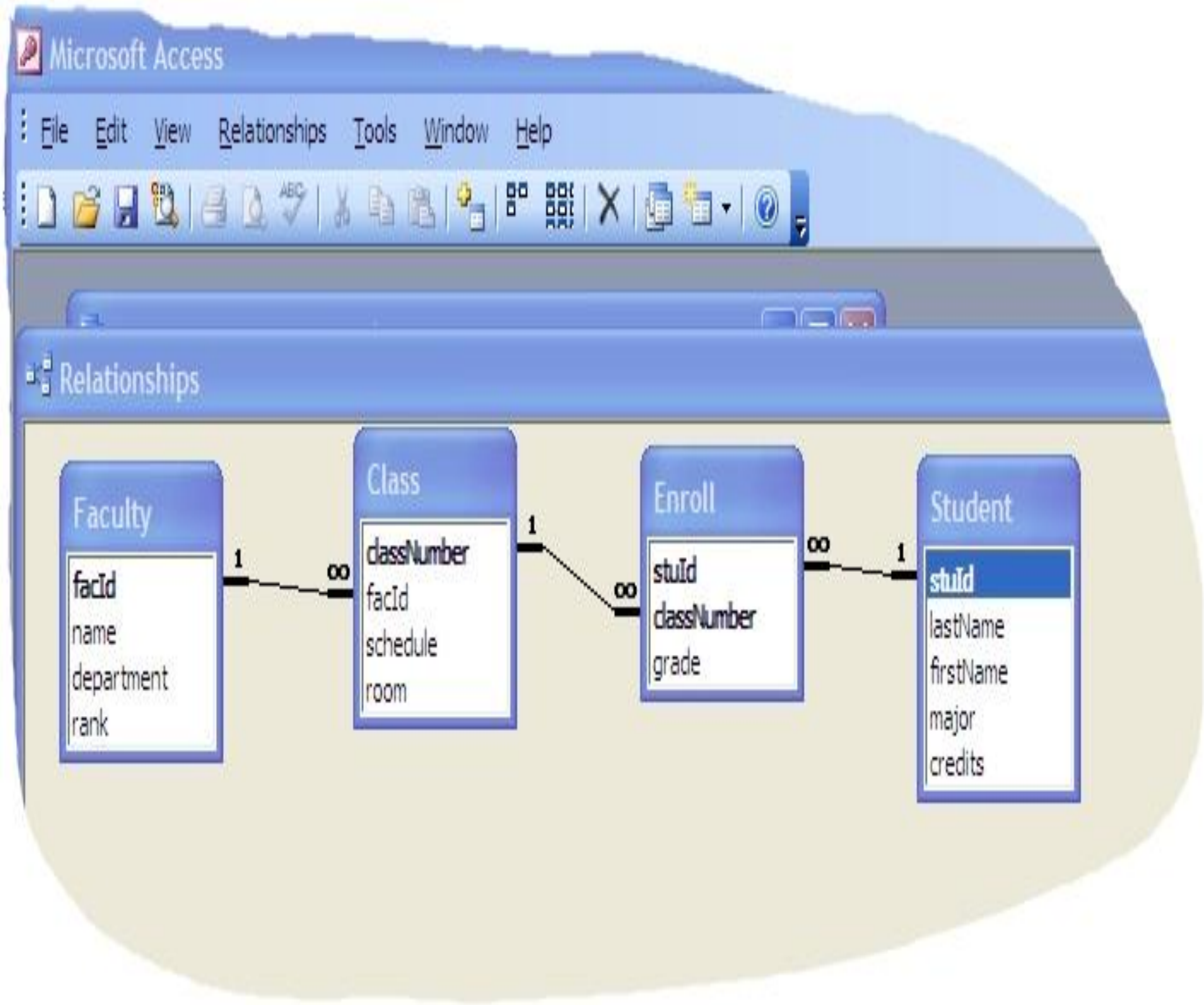


Fig 2.11 ER Diagram Example 2

Figure 2.8 and 2.9 shows ER diagram example1 and example 2.

2.10.6 Entity Relationship (ER) Diagram for a Customer Ordering Database

A Customer places their Order (Book) on the web. The Customer has an address, and provides a form of payment. The Order includes the quantities of each Product that they want to have delivered. In order to plan deliveries and allocate delivery system must determine the volume of orders being delivered, so in addition to the name, cost price and sale price of each Product, they also need to know the cubic volume required for a single item of that Product. Figure 2.10 shows ER diagram for customer ordering database.

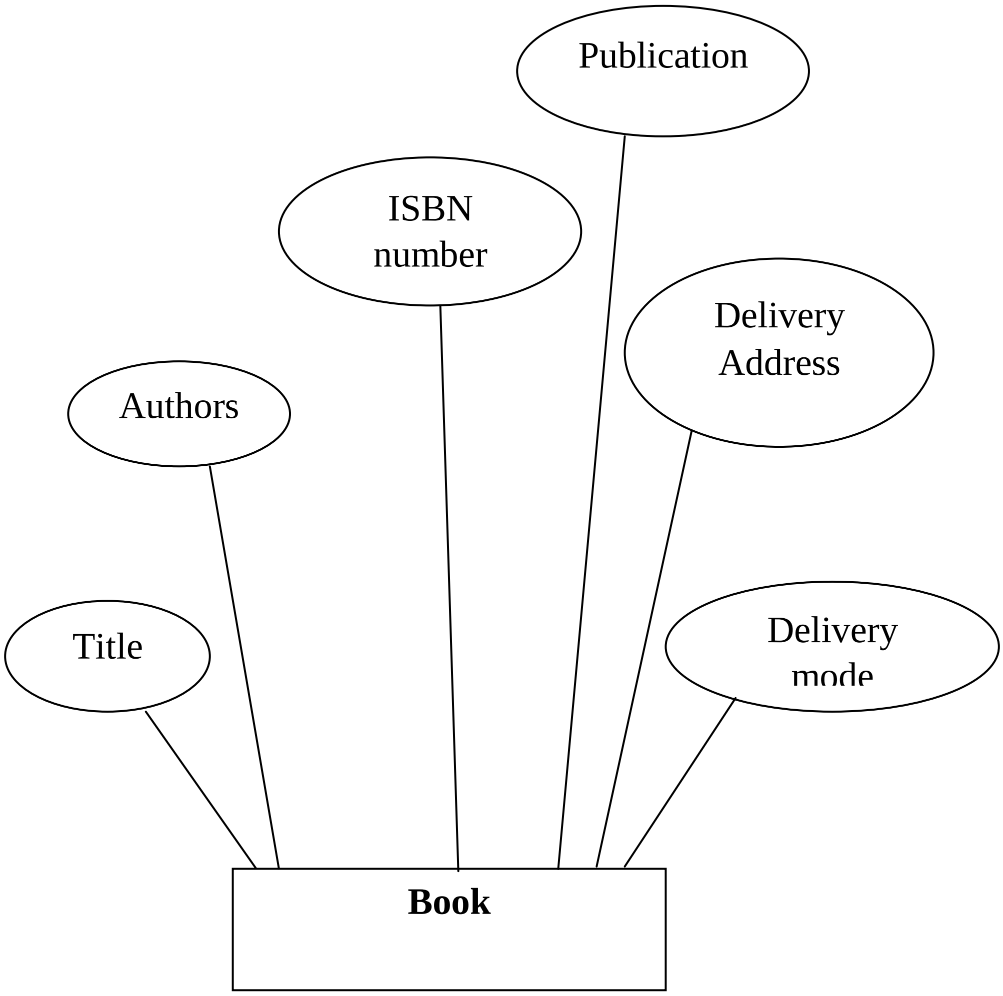


Fig 2.12 ER Diagram for customer ordering database

2.11 Analysing DB Applications using ER Model and ER Diagrams

The company needs to develop a manufacturing process database to record the following information:

- Basic machine data, including their performance
- Information about tools and application
- Module elements of a course
- Work piece enrolment to machine
- For each department, information about the

Manpower that is responsible for the operation. Fig 2.11 ER Diagram for manufacturing database

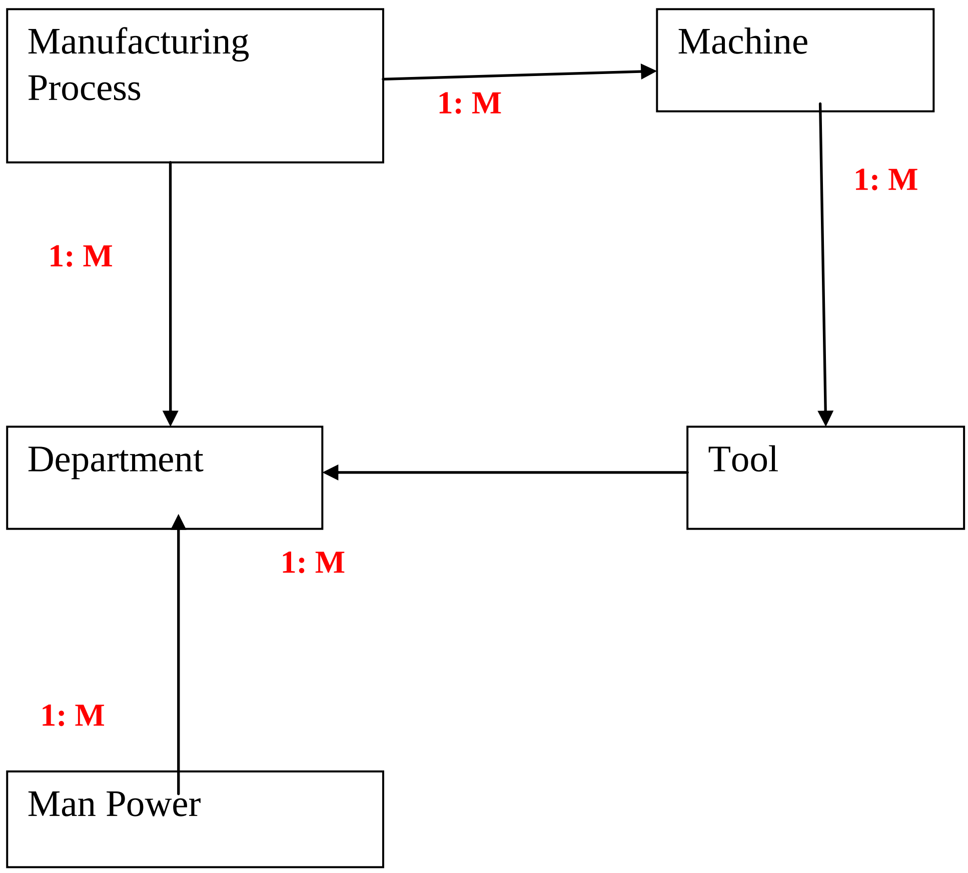


Fig 2.13 ER Diagram for manufacturing database

Entities and attributes

• Tool (Tool no, Tool name, Tool material, material grade)

• Machine (machine no, machine name, machine location, machine production incharge, machine maintenance incharge)

• Manufacturing process (machining, grinding, boring, press work, cutting, broaching, surface finishing, drilling)

• Department (Design, purchase, production, maintenance, project, quality control, marketing, sales)

• Man power (StaffID, StaffName, Designation workplace)

2.11.1 Relationships

Enrolled For:

• Many-to-one between process and machines

• Mandatory for both entities

Comprise:

• Many-to-many between tools and machines

• Mandatory for both entities

Attend:

• Many-to-many between machine and process

• Mandatory for both entities

• Has an attribute Mark to record performance

Module_Leader:

• One-to-many between manpower and department

• Mandatory for manpower and department

2.12 Relational Data Model

• All information about entities and their attributes as well as relationships is represented in the relational data model as tables (called relations).

• It contains nothing but tables.

• The rows of the tables may be considered as records and the columns as fields.

• Each row corresponds to an entity occurrence or a relationship occurrence and Each column refers to an attribute.

• The model is called relational and not tabular, because tables are a lower level of abstractions than the mathematical concept of relation.

• In the relational model, it is assumed that no ordering of rows and columns is defined.

Table 2.1: Data Model for Tool

Tool no	Tool name	Tool material	material grade
KKS001	Drill bit	Stainless steel	SS -312
KKS002	Single point cutting tool	Stainless steel	SS -316

Table 2.2: Data Model for Machine

Machine no	Machine name	Machine location	Machine incharge
MCS001	Drilling machine	Workshop - I	Dev
MCS001	Lathe	Auto workshop	Rajan

• Tool (Tool no, Tool name, Tool material, material grade)

• Machine (machine no, machine name, machine location, machine production incharge, machine maintenance incharge)

• Manufacturing process (machining, grinding, boring, press work, cutting, broaching, surface finishing, drilling)

• Department (Design, purchase, production, maintenance, project, quality control, marketing, sales)

• Man power (StaffID, StaffName, Designation workplace)

2.12.1 Properties of relations:

_Each relation contains only one record type.

_Each relation has a fixed number of columns that are explicitly named. Each attribute name within a relation is unique.

_No two rows in a relation are the same.

_Each item or element in the relation is atomic, that is, in each row, every attribute has only one value that cannot be decomposed and therefore no repeating groups are allowed.

_Rows and columns have no orderings associated with them.

2.12.2 Mapping ER Model to Relational Model

Transformation of entity types

_ Each entity type in the ER model is transformed into a relation, in which the attributes of the entity type become attributes of the relation.

_ The primary key of the entity type will become the primary key of the relation.

Transformation of binary relationships

_ The transformation of a relationship depends upon the functionality of the relationship and upon the membership classes of participating entity types.

2.12.3 Mandatory membership class (i.e. total participation in the relationship)

Guidelines:

• **For two entity types E1 and E2:**

If **E2 is a mandatory member of a many-to-one (or M: 1)** relationship with E1, then the relation for E2 will include the primary key of E1 as a foreign key to represent the relationship. (E2 is on the many side.)

• For a **1:1 relationship:** If the membership class for E1 and E2 are both mandatory, a foreign key can be used in either relation to represent the relationship.

• For a **many-to-one relationship:** If the membership class of E2, which is on the many-side of the relationship, is optional (i.e. partial), then the above guideline is not applicable.

2.12.4 Optional membership classes (i.e. partial participation in the relationship)

Guidelines:

• If entity type E2 is an optional member of the **many-to-one relationship** with entity type E1 (i.e. E2 is on the many-side of the relationship), then the relationship is usually represented by a new relation containing the primary keys of E1 and E2, together with any attributes of the relationship. The key of the entity type on the many-side (i.e. E2) will become the key of the new relation.

• If both entity types in a **1:1 relationship** have the optional membership, a new relation is created which contains the primary keys of both entity types, together with any attributes of the relationship. The primary key of either entity type
will be the key of the new relation.

• A **M:M (many-to-many)** relationship is always represented by a new relation
which consists of the primary keys of both participating entity types together with any attributes of the relationship.

• The combination of the prime attributes will form the primary key of the new relation.

• Membership classes don't matter.

2.12.5 Transformation of involuted (i.e., recursive) relationships

• This is similar to those for transforming binary relationships.

• The name of the primary key needs to be changed to reflect the role each entity instance plays in the relationship.

2.13 Mapping ER Model to Relational Model

2.13.1 Manufacturing process database

Relations:

• Tool (Tool no, Tool name, Tool material, material grade)

• Machine (machine no, machine name, machine location, machine production incharge, machine maintenance incharge)

• Manufacturing process (machining, grinding, boring, press work, cutting, broaching, surface finishing, drilling)

• Department (Design, purchase, production, maintenance, project, quality control, marketing, sales)

• Man power (StaffID, StaffName, Designation workplace)

2.14 Recursive Relationships

An entity can have relationships with itself. If the relationship is not symmetric,

It need to indicate the two roles that the entity plays in the relationship. Fig 2.12 shows Recursive relationship diagram.

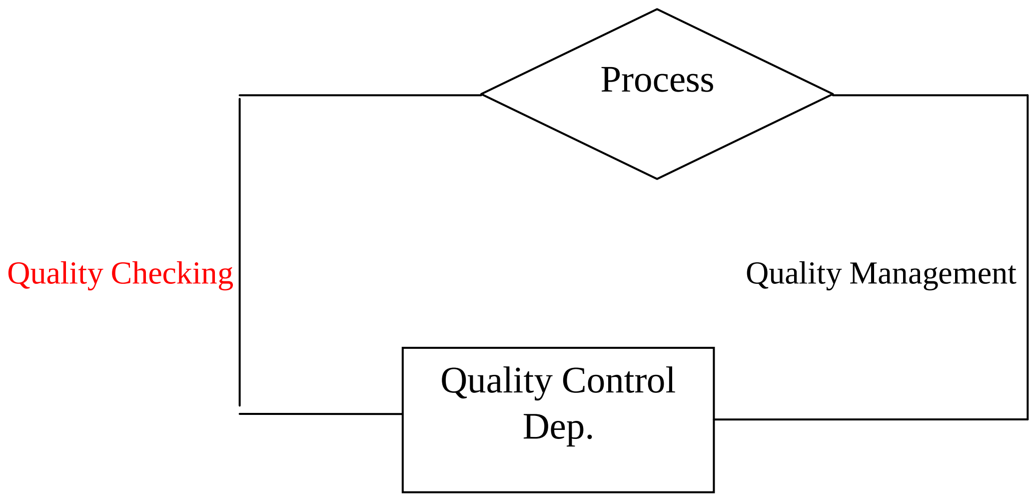


Fig 2.14 Recursive Relationship Diagram

2.15 Data Independence

Data independence is the type of data transparency that matters for a centralized DBMS. It refers to the immunity of user applications to make changes in the definition and organization of data. Physical data independence deals with hiding the details of the storage structure from user applications. The application should not be involved with these issues, since there is no difference in the operation carried out against the data. The data independence and operation independence together gives the feature of data abstraction. There are two levels of data independence.

2.15.1 First Level

The logical structure of the data is known as the schema definition. In general, if a user application operates on a subset of the attributes of a relation, it should not be affected later when new attributes are added to the same relation. Logical data independence indicates that the conceptual schema can be changed without affecting the existing schemas.

2.15.2 Second Level

The physical structure of the data is referred to as "physical data description". Physical data independence deals with hiding the details of the storage structure from user applications. The application should not be involved with these issues since, conceptually, there is no difference in the operations carried out against the data. There are two types of data independence:

2.15.3 Logical data independence: The ability to change the logical (conceptual) schema without changing the External schema (User View) is called logical data independence. For example, the addition or removal of new entities, attributes, or relationships to the conceptual schema should be possible without having to change existing external schemas or having to rewrite existing application programs.

2.15.4 Physical data independence: The ability to change the physical schema without changing the logical schema is called physical data independence. For example, a change to the internal schema, such as using different file organization or storage structures, storage devices, or indexing strategy, should be possible without having to change the conceptual or external schemas.

2.15.5 View level data independence: always independent no effect, because there doesn't exist any other level above view level.

2.15.6 Data Independence Types

Data independence has two types. They are:

1. Physical Independence
2. Logical Independence.

Data independence can be explained as follows: Each higher level of the data architecture is immune to changes of the next lower level of the architecture.

2.15.7 Physical Independence: The logical scheme stays unchanged even though the storage space or type of some data is changed for reasons of optimisation or reorganisation. In this external schema does not change. In this internal schema changes may be required due to some physical schema were reorganized here. Physical data independence is present in most databases and file environment in which hardware storage of encoding, exact location of data on disk,merging of records, so on this are hidden from user.

2.15.8 Logical Independence: The external scheme may stay unchanged for most changes of the logical scheme. This is especially desirable as the application software does not need to be modified or newly translated.

2.16 Generalizations

It Shows “is-a” relationships between entities Inheritance:

– Every instance of a child entity is also an instance of the parent entity

– Every property of the parent entity (attribute, identifier, relationship or other generalization) is also a property of a child entity

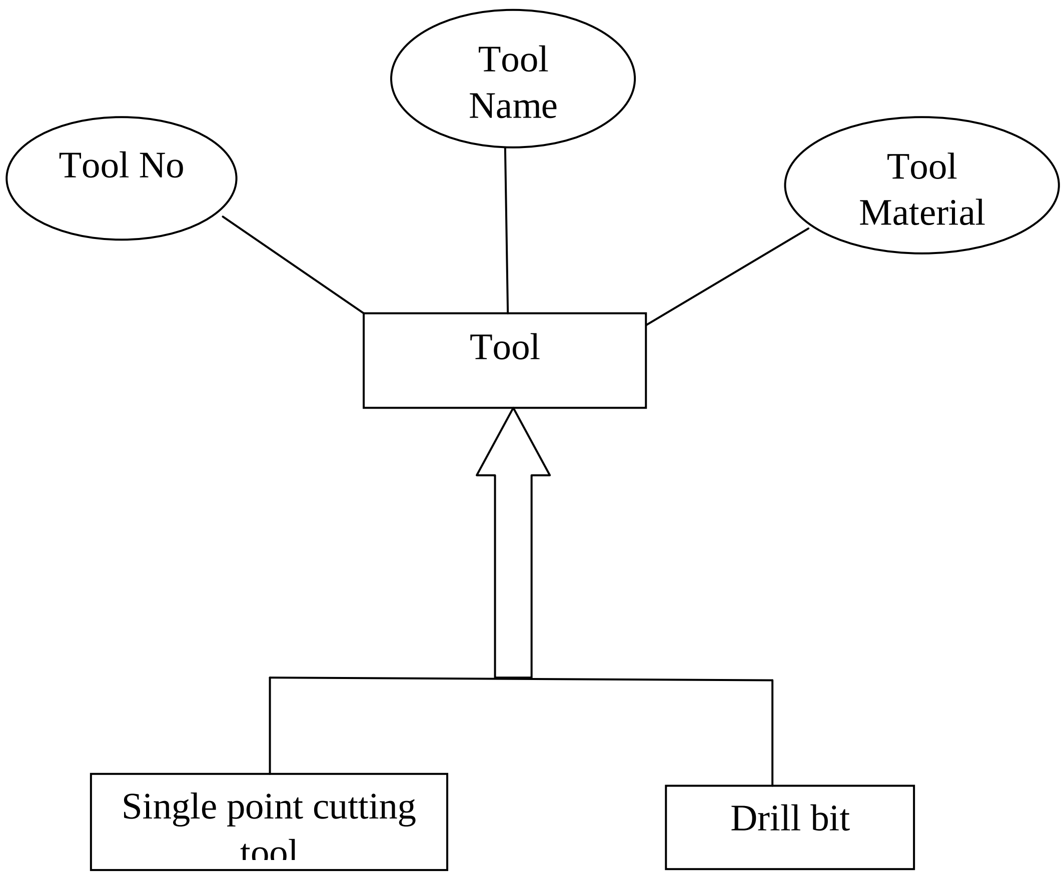


Fig 2.15 Entities Generalization

Fig 2.13 shows Entities generalization and it shows every instance of the parent entity is an instance of one of its children.

2.17 Recent trend in Database

Currently there are some main technologies used for data management (relational database, Object Oriented, and XML). Cloud Computing/Big Data Expos are future/current trend research for database because it simplified data performance, analysis, and testing capabilities.

First Generation DBMS: Network and Hierarchical

Required complex programs for even simple queries.

Minimal data independence.

No widely accepted theoretical foundation.

Second Generation DBMS: Relational DBMS (Current)

Helped to overcome these problems.

Third Generation DBMS: (Future)

OODBMS (Object oriented Data base Management System) and ORDBMS (Object relational database System).

Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet). The Cloud is where all previous technologies come together in easy to manage manner

–"Smart" RDBMS

– Storage technologies

– NoSQL

– MapReduce

NoSQL simplifies programming model and relaxes constraints

Different design points from classical RDBMS:

– Relational model encourages joins: may be expensive and unpredictable at scale

– Drop or relax atomicity, consistency, isolation, durability

– Limited support for schemas

• Individual design choices lead to very different products

• Ideal for some workloads and some hardware configurations

NewSQL ACID-compliant databases

• Highly scalable

• How: data partitioning ☐ simplified code paths (e.g. no locks)

• But data partitioning is difficult, suffer under skews

MapReduce Widely used for: Extract, Transform, Load In situ big data processing

MapReduce community Implementing indexes, views, query optimization

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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHTRONICS

M.E (CAD)

SPRA7007 - MANUFACTURING INFORMATION SYSTEMS

UNIT - III

DESIGNING DATABASE

Hierarchical model – Network approach- Relational Database concepts, principles, keys,– functional dependency – Normalization types – relational operations- Query Languages-Case studies.

3. DESIGNING DATABASE

3.0 Designing Data base

3.1 Database Terminologies

3.1.1 Data

A necessity for almost any enterprise to carry out its business. Consists of raw facts, and when organized may be transformed into information

3.1.2 Database

A collection of data organized to meet users' needs

3.1.3 Database management system (DBMS)

A group of programs that manipulate the database and provide an interface between the database and the user of the database or other application programs

A collection of programs that enables you to store, modify, and extract information from a database. There are many different types of DBMSs, ranging from small systems that run on personal computers to huge systems that run on mainframes. The following are examples of database applications:

- computerized library systems
- automated teller machines
- flight reservation systems
- computerized parts inventory systems

Figure 3.1 shows Graphical Representation of Entity and Attribute.

3.1.4 Data terminology Definition

Table 3.1: Data terminology Definition

Sl. no	**Terminologies**	**meaning**
1	Database	A collection of integrated and related files
2	File	A collection of related record
3	Record	A collection of related fields
4	Field	A group of characters
5	Character	Basic building block of information, represented by a byte

Database	Tool file, Machine file and Manpower filr
File	Tool file
Record	Tool no, Tool name, Tool material and material grade
Field	Enter last name as Raja Mohamed
Character	1000100 for Letter 'F' in ASCII (bytes)

Fig 3.1 Data Terminology Definition

3.1.5 Services of DBMS

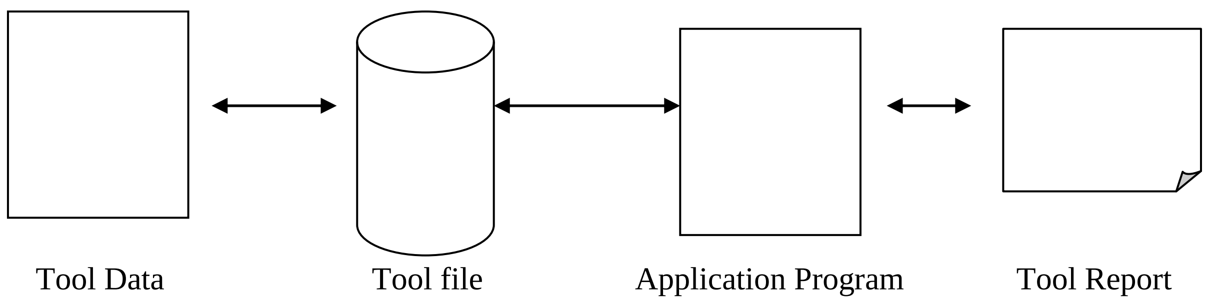
Table 3.2: Services of DBMS

Sl. no	Terminologies	meaning
1	Data Definition	Defines the structure of data and its storage
2	Data Maintenance	Verifies whether each record has fields containing all information as defned using data defination
3	Data Manipulation	Allows data in the database to be inserted updated, deleted and sorted
4	Data Display	Provides way to view to data
5	Data integrity	Check the accuracy of data

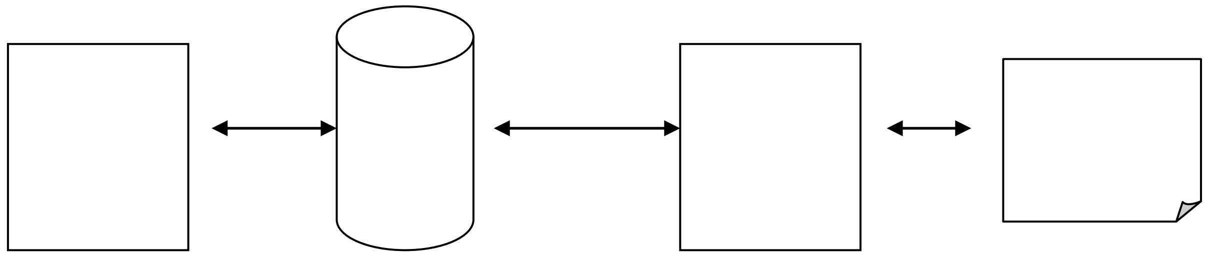
DBMS is a set of programs to access the interrelated data. The interrelated data is called database. Database system support single user and multi user environment. DBMS permits only one person to access the database. RDBS allows many users for simultaneous access to the database.

3.2 Traditional database management System

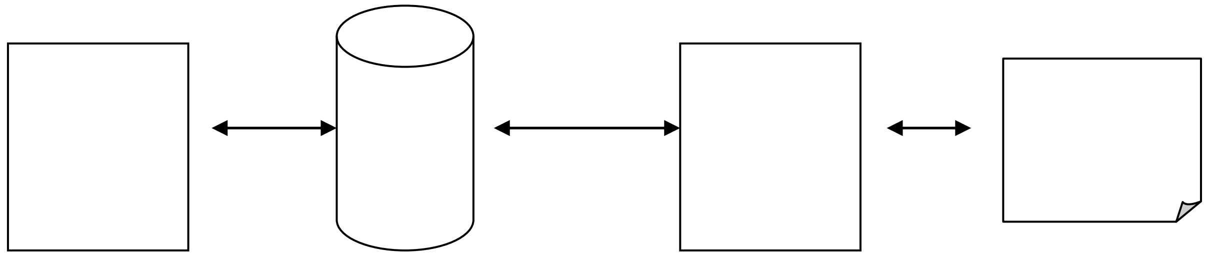
Separate files are created and stored for each application program. Figure 3.2 shows traditional database management system.



(Tool Control)



(Machine Control)



(Manpower Control)

Fig 3.2 Traditional Database System

3.2.1 Disadvantages of traditional database

Data redundancy

Duplication of data in separate files

Lack of data integrity

The degree to which the data in any one file is accurate

Program-data dependence

A situation in which program and data organized for one application are incompatible with programs and data organized different for another application

3.3 Modern database System

A pool of related data is shared by multiple application programs

Rather than having separate data files, each application uses a collection of data that is either joined or related in the database. Figure 3.3 shows traditional database system.

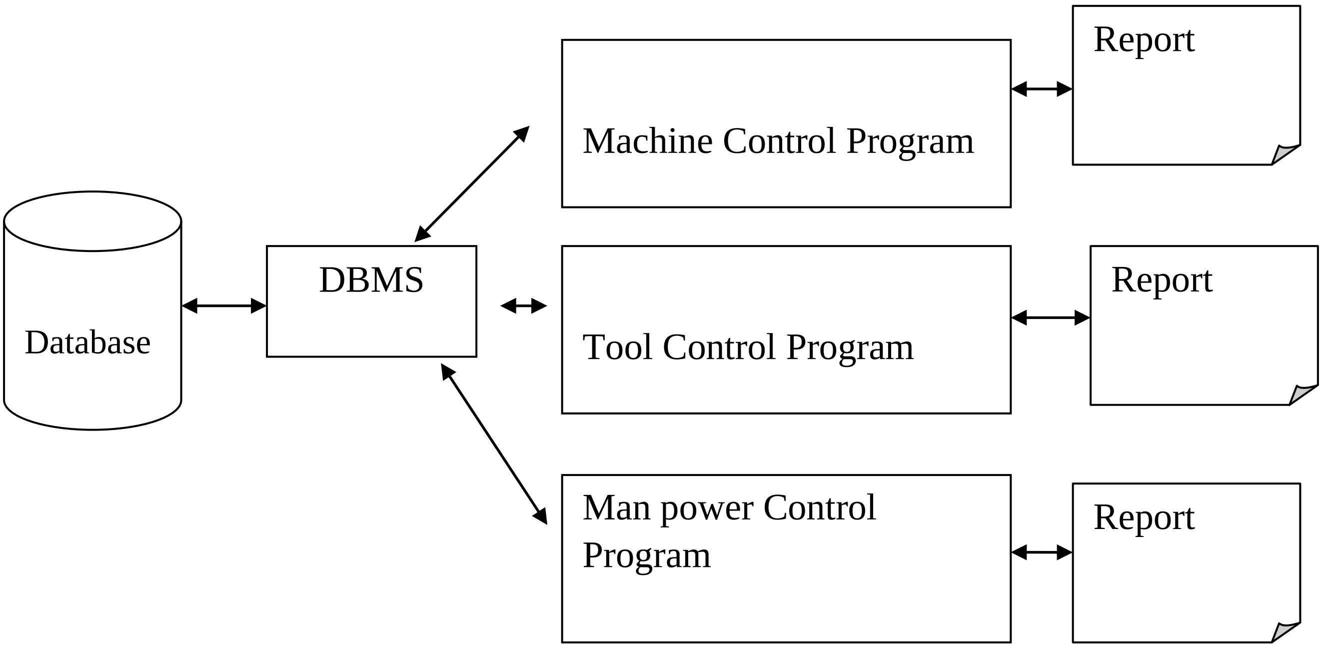


Fig 3.3 Modern Database Management System

3.3.1 Modern database approach advantages

- Improved strategic use of corporate data
- Reduced data redundancy
- Improved data integrity
- Easier modification and updating
- Data and program independence
- Better access to data and information
- Standardization of data access
- A framework for program development
- Better overall protection of the data
- Shared data and information resources

3.3.2 Modern database approach dis advantages

- Relatively high cost of purchasing and operating a DBMS in a mainframe operating environment
- Increased cost of specialized staff
- Increased vulnerability

3.4 Data modelling and database models

Planned data redundancy

A way of organizing data in which the logical database design is altered so that certain data entities are combined. Summary totals are carried in the data records rather than calculated from elemental data. Some data attributes are repeated in more than one data entity to improve database performance

3.4.1 Data model

A map or diagram of entities and their relationships

3.4.2 Enterprise data modeling

Data modeling done at the level of the entire organization. Figure 3.4 shows enterprise data modelling.

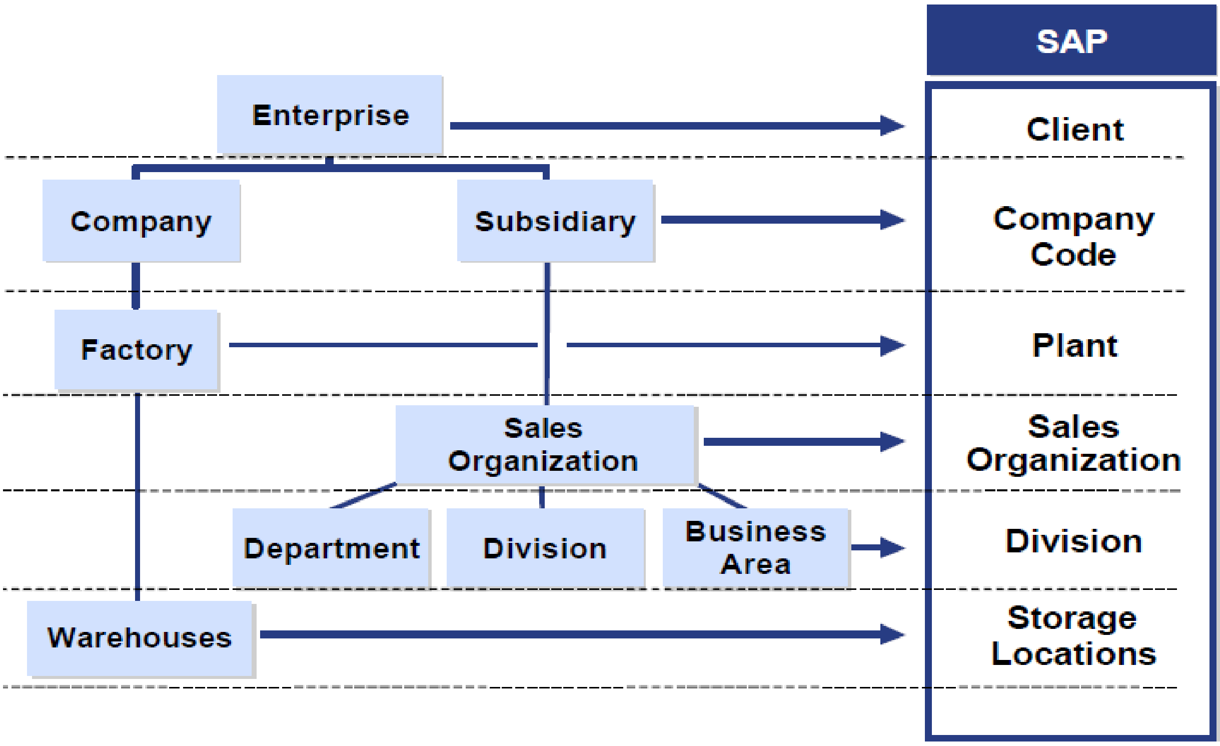


Fig 3.4 Enterprise Data Modelling

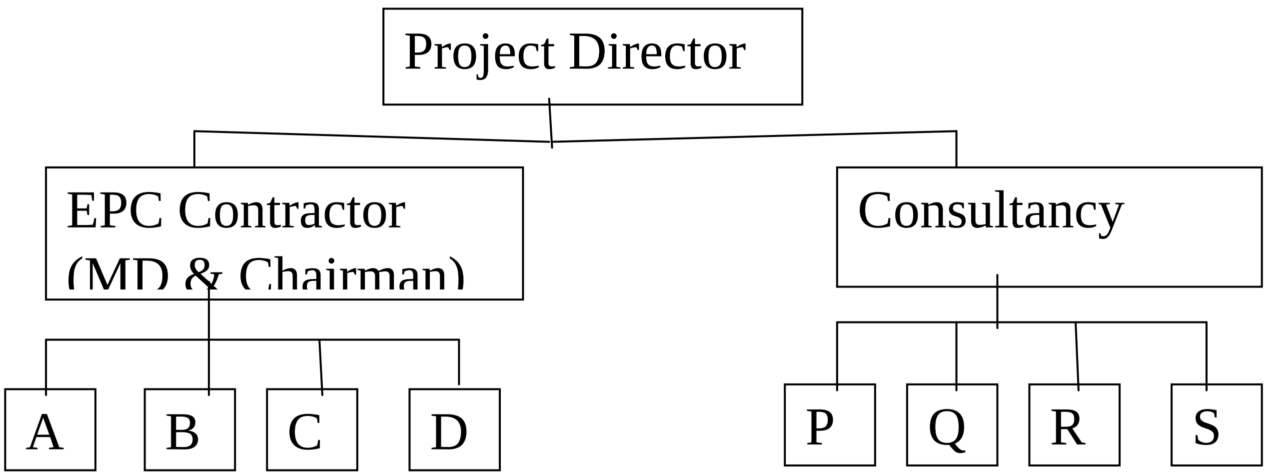
3.5 Entity-relationship (ER) diagrams

A data model that uses basic graphical symbols to show the organization of and relationships between data.

3.5.1 Hierarchical Database Model

Data is represented by a tree structure type of organization. The hierarchiel tree specifies what record types are followed to be included in the database and permissible relation between record types. Any record other than the root of the tree must be connected with the superior record (the parent). Thus to insert record, the user must select the parent record first. When record is deleted all the descendants of the records are also deleted. data model in which data are organized in a top-down, or inverted tree structure Figure 3.5 shows hierarchical data base model.These connections are called the structure of the data, and a diagram of them looks like an upside down tree. The file at the top is called the parents or owner file, while the files at the bottom are called the child or member file. In hierarchical system, the connection between files do not depend on the data in the file

1 x 600 MW Mettur Power project



A – Design Team Head

B – Purchase Team Head

C – Site Project Team Head

D – Quality Team Head

P – Mechanical work Head

Q – Civil work Head

R – Electrical work Head

S – Site work monitoring Head

Fig 3.5 Hierarchical Database Model

3.5.2 Network data model

An expansion of the hierarchical database model with an owner-member relationship in which a member may have many owners. Figure 3.6 shows network data base model. A segment can have multiple parent segments are grouped as levels but logical associations can exist between segments belonging to any level. A network data base is like a hierarchical data base with one modification – you can relate any record types or files with any other record type or files; that are the data structure is many to many instead of one to many. A hierarchical data base is a degenerate case of a network structure. Again, you must do the relation data base, but a program will run faster if you define the data structure in advance. The network model was created for the three main purposes. This purpose includes representing a complex data relationship more effectively, improving data base performance and imposing a database standard.

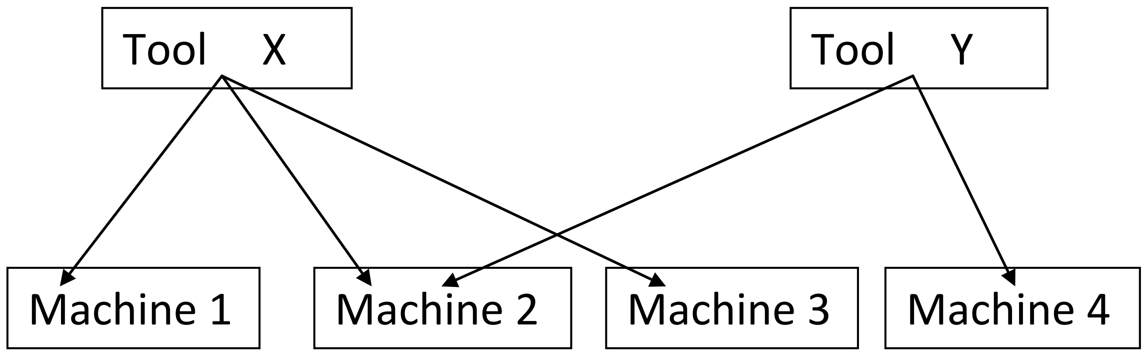


Fig 3.6 Network Data Model

3.5.3 Relational data model

All data elements are placed in two-dimensional tables, called relations, that are the logical equivalent of files

Table 3.3: Relational data model for Tool information

Tool no	Tool name	Tool material	material grade
KKS001	Drill bit	Stainless steel	SS -312
KKS002	Single point cutting tool	Stainless steel	SS -316

Table 3.4: Relational data model for Machine information

Machine no	Machine name	Machine location	Machine incharge
MCS001	Drilling machine	Workshop - I	Dev
MCS002	Lathe	Auto workshop	Rajan

3.5.4 Linking Data Tables to Answer an Inquiry

From the above table

Inquiry 1

Who is in-charge for MCS001?

Ans 1

Dev

Inquiry 2

What is the tool name for KKS002?

Ans 1

Single point cutting tool

3.5.5 Relational Database Terminology

Selecting

Data manipulation that eliminates rows according to certain criteria

Projecting

Data manipulation that eliminates columns in a table

Joining

Data manipulation that combines two or more tables

Linked

Relating tables in a relational database together

3.5.6 Data Base Design Criteria

Generally speaking, the steps in a design data process involves

- Collecting information, which includes defining fields, assigning and resolving fields, defining usage and so forth
- Formulating the requirements including performance
- Forming records and files
- Analyzing structure with respect to the need
- Forming an overall structure for the database includes the specification of access paths and the placement of files in storage if needed.

3.6 Schema

A description of the entire database. Pronounced skee-ma, the structure of a database system, described in a formal language supported by the database management system (DBMS). In a relational database, the schema defines the tables, the fields in each table, and the relationships between fields and tables.

Schemas are generally stored in a data dictionary. Although a schema is defined in text database language, the term is often used to refer to a graphical depiction of the database structure. Figure 3.7 shows Schema and sub schema structure.

3.7 Subschema

A file that contains a description of a subset of the database and identifies which users can perform modifications on the data items in that subset.

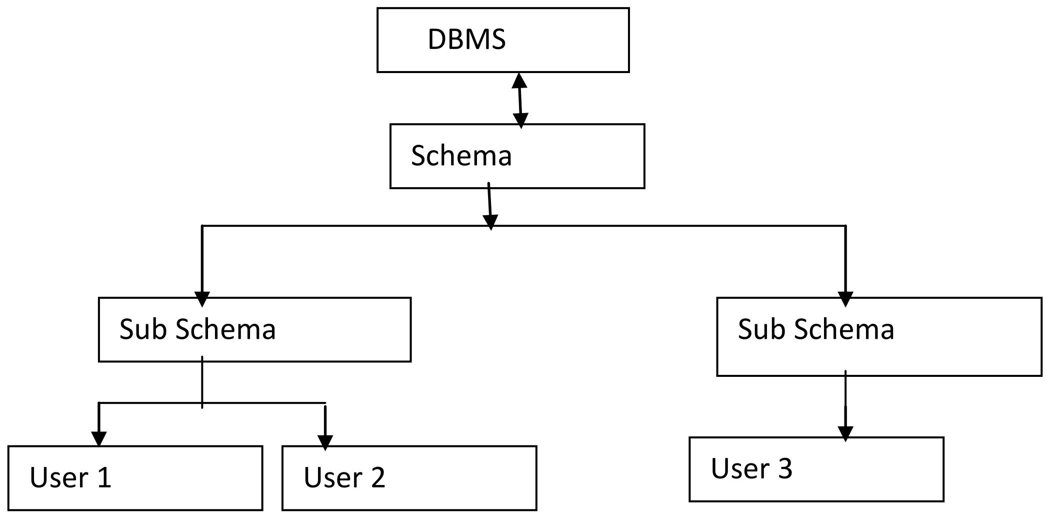


Fig 3.7 Schema and Sub Schema Structure

3.8 Data Definition Language

A collection of instructions and commands used to define and describe data and data relationships in a specific database

SCHEMA DESCRIPTION

SCHEMA NAME IS **Plastic mould design**

AUTHOR Sasi

DATE 14.02.11

FILE DESCRIPTION

FILE NAME IS “Plastic mould Design”

ASSIGN siva

AREA DESCRIPTION

AREA IS 40 cm sq2

Specification DESCRIPTION

LENGTH IS 2 cm

BREATH IS 20 cm

HEIGHT IS 1 cm

In Auto cad

Commends: Circle

Enter center point/select center point:

Enter radius/ select radius:

3.9 Data Dictionary

A detailed description of all data used in the database

Hydrogen Generation Plant Layout and Equipment Drawing

PREPARED BY: S SATHISH

DATE: 24 FEB 2013

APPROVED BY: DR PRAKASH **DATE:** 26 FEB 2013

VERSION: 2

PAGE: 1 OF 1

DATA ELEMENT NAME: PARTNO

DESCRIPTION: KKS EQUIPMENTS

VALUE RANGE: 100 TO 5000

DATA TYPE: NUMERIC

POSITIONS: 4 POSITIONS OR COLUMNS

3.9.1 Data Dictionary Features

- Provide a standard definition of terms and data elements
- Assist programmers in designing and writing programs
- Simplify database modification
- Reduce data redundancy
- Increase data reliability
- Faster program development
- Easier modification of data and information

3.10 Data on Storage Devices

3.10.1 Logical access path (LAP)

Application requires information from the DBMS

3.10.2 Physical access path (PAP)

DBMS accesses a storage device to retrieve data. . Figure 3.7 shows Schema and sub schema structure. Figure 3.8 shows LAP and PAP integration with DBMS.

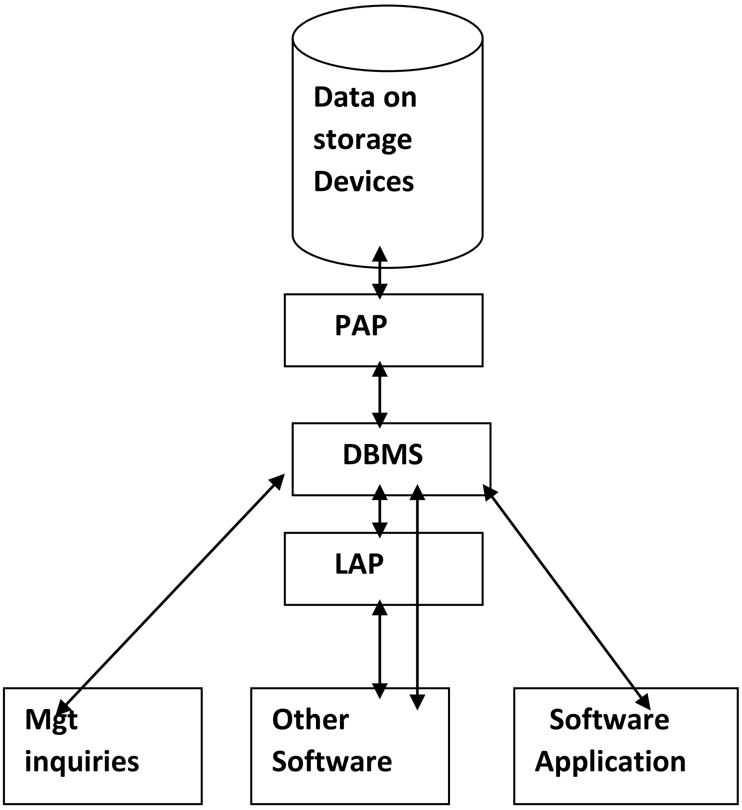


Fig 3.8 LAP and PAP integration with DBMS

3.11 Manipulating Data

3.11.1 Concurrency control

A method of dealing with a situation in which two or more people need to access the same record in a database at the same time

3.11.2 Data manipulation language (DML)

The commands that are used to manipulate the data in a database

Structured query language (SQL) is **a** standardized data manipulation language

3.12 Structured Query Language (SQL)

"Invented" at IBM's Almaden Research Centre (San Jose, CA) in the 1970sAbbreviation of structured query language, and pronounced either see-kwell or as separate letters. SQL is a standardized query language for requesting information from a database. The original version called SEQUEL (structured English query language) was designed at IBM research center in 1974 and 1975. SQL was first introduced as a commercial database system in 1979 by Oracle Corporation. Historically, SQL has been the favorite query language for database management systems running on minicomputers and mainframes.

Increasingly, however, SQL is being supported by PC database systems because it supports distributed databases (databases that are spread out over several computer systems). This enables several users on a local-area network to access the same database simultaneously. Although there are different dialects of SQL, it is nevertheless the closest thing to a standard query language that currently exists. In 1986, ANSI approved a rudimentary version of SQL as the official standard, but most versions of SQL since then have included many extensions to the ANSI standard. In 1991, ANSI updated the standard. The new standard is known as SAG SQL.

3.13 Popular Database Management Systems for End Users

- Microsoft Access 98
- Lotus Approach 98
- Inprise (formerly Borland) dBASE

3.14 DBMS Selection Criteria

The following factors should be considered at the DBMS selection criteria

- Database size
- Number of concurrent users
- Performance
- Integration
- Features
- The vendor
- Cost

3.15 Distributed database

A database in which the actual data may be spread across several smaller databases connected via telecommunications devices. Figure 3.9 shows LAP and PAP integration with DBMS.

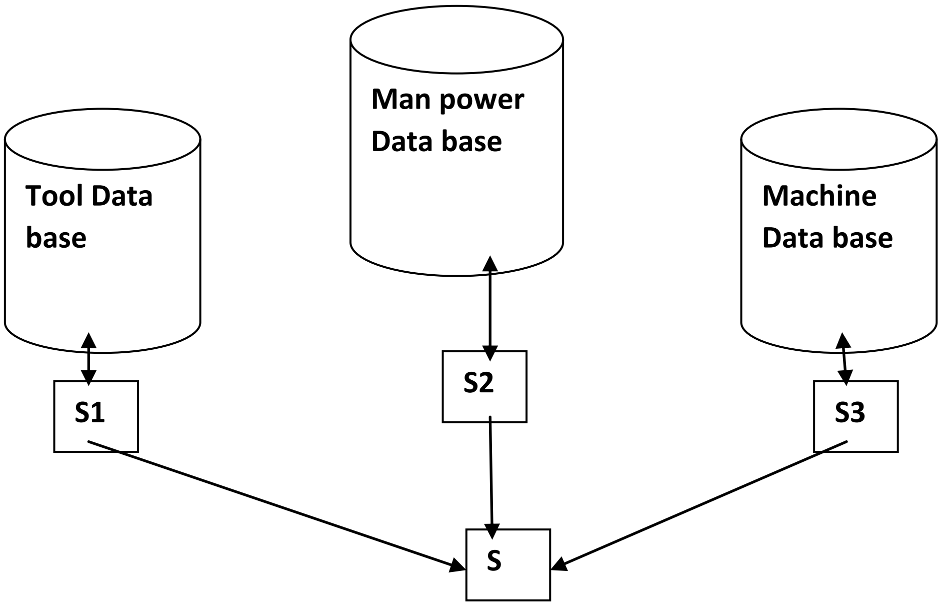


Fig 3.9 LAP and PAP integration with DBMS

S1 **-** Tool Data base connectivity system
S2 - manpower Data base connectivity system
S3 - machine Data base connectivity system
S – Tool manpower and machine Data base connectivity system

3.16 Data Mart

A subset of a data warehouse for small and medium-size businesses or departments within larger companies

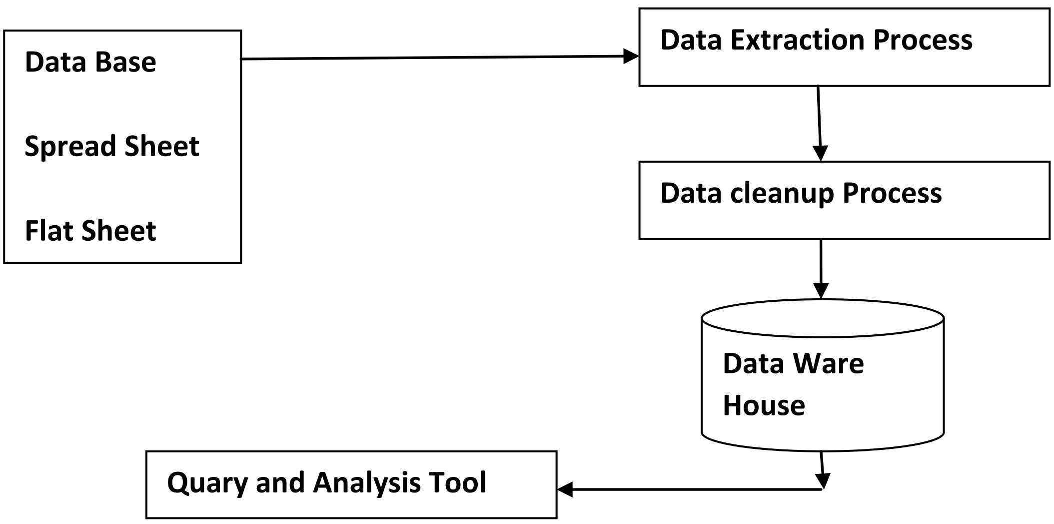


Fig 3.10 Data Mart Model

3.17 Data warehouse

A relational database management system designed specifically to support management decision making. Large companies have branches in many places and each generate a large volume of data. Further, large organizations have a complex internal organization structure and therefore different data may be present in different location or different operational system. For instance, manufacturing data may be stored in different database system. Corporate decision makers require access to information from all such sources and need to access to past data as well. For instance information about how purchase patterns have changed in past year could be of great importance. Data warehouse provide a solution to these problem. A data ware house is a achieve of information gathered from multiple sources, stored under a unified scheme at a single site. Once gathered, the data are stored for a long time, permitting access to historical data. Thus data ware house provide the user a single consolidated to data, making decision support queries easier to write. More ever, by accessing information for decision support from a data warehouse, the decision maker ensures that online transaction processing systems are not affected by the decision support workload. Figure 3.11 a. shows data warehouse model.

3.17.1 On-line analytic processing (OLAP)

- Access to multidimensional databases providing managerially useful display techniques
- It is used to describe the analysis of complex data from the datawarehouse
- Now used to store and deliver data warehouse information
- It Provides top-down, query-driven analysis

3.17.2 On-line Transaction processing (OLTP)

- This includes insertions, updates and deletions while also support information query requirements.

3.17.3 Open database connectivity (ODBC)

A set of standards that ensures software written to comply with these standards can be used with any ODBC-compliant database

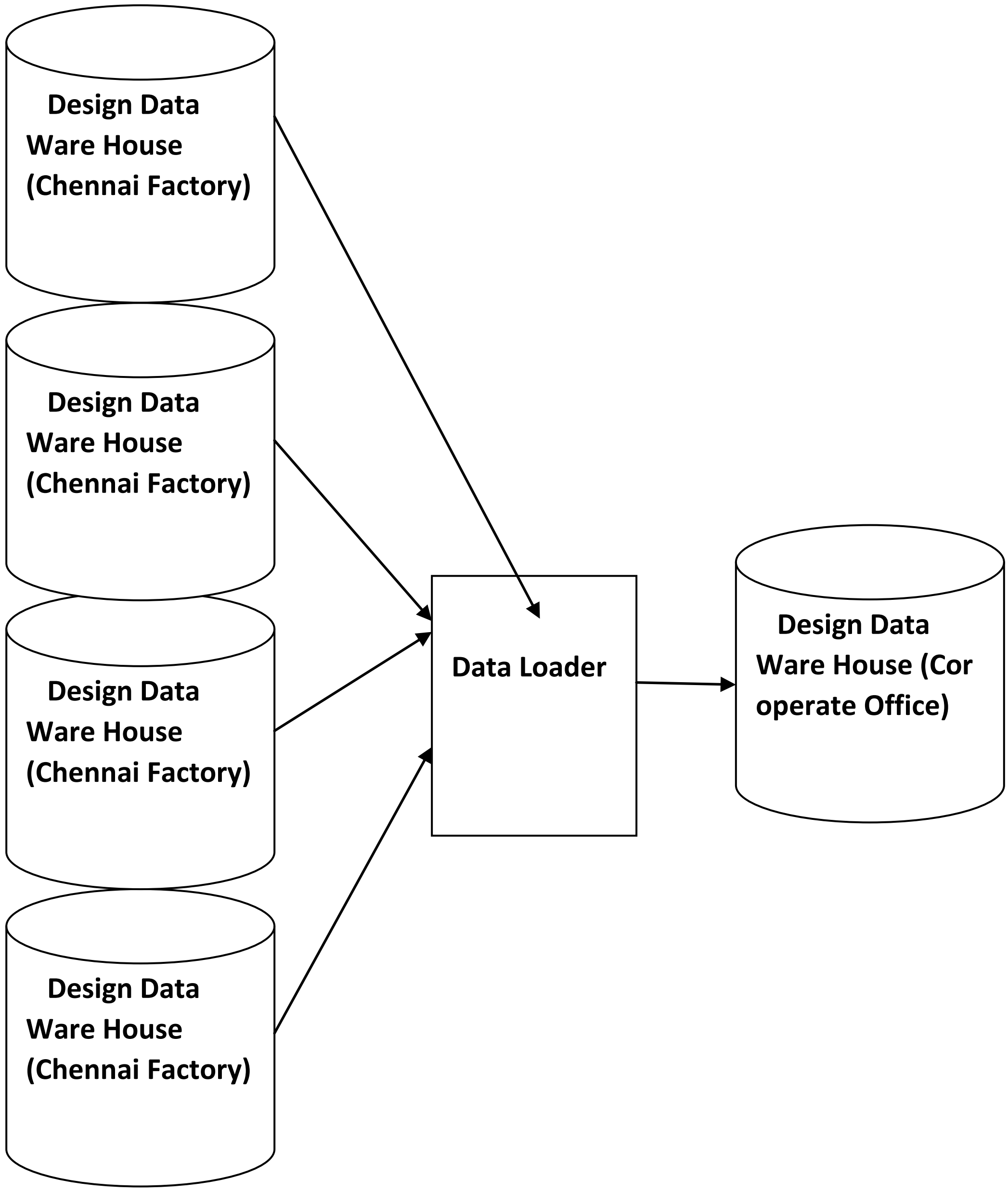


Fig 3.11 a Data Ware House Model

3.17.4 Object-relational database management system (ORDBMS)

A DBMS capable of manipulating audio, video, and graphical data.

Hypertext

- Users can search and manipulate alphanumeric data in an unstructured way

Hypermedia

- Allows businesses to search and manipulate multimedia forms of data

Spatial data technology

- Use of an object-relational database to store and access data according to the location it describes and to permit spatial queries and analysis

3.18 Characteristics of Data warehouse

- Multi dimensional conceptual view
- Generic dimensionality
- Unlimited dimensions and aggregation levels
- Dynamic spares matrix handling
- Client – server architecture
- Multi user support
- Accessibility
- Transparency
- Intuitive data manipulation
- Consistent reporting performance
- Flexible reporting

3.18.1 Difference between Data warehouse and Data Mining

Table 3.5: Difference between Data warehouse and Data Mining

Data Warehouse	Data Mining
Gathering information from under a unified schema at single site.	Analyzing larger database to useful patterns

3.19 Consider factor for Designing a Customer Data Warehouse

- Sharply define your goals and objectives before you build the warehouse
- Choose the software that best fits your goals
- Determine who/what should be in the database
- Develop a plan
- Measure results

3.20 Data mining

The automated discovery of patterns and relationships in a data warehouse. It Provides bottom-up, discovery-driven analysis.Data mining refers to the process of semi automatically analyzing large database to find useful patterns. Data mining differs from machine learning and statistics in that it deals with large volumes of data stored in the disk.Where the data mining deals with knowledge discovered in databases. Knowledge discovered from a database can be represented by a set of rules.

Example people who have joining date on or before june 2012, they will not eligible for summer vacation.

3.20.1 Data mining applications

- Market segmentation
- Customer queries
- Fraud detection
- Direct marketing
- Market basket analysis
- Trend analysis

Prediction: Data mining can show how certain attributes within the data will behave in future.

Classification: Data mining can partition the data so that different classes or categories can be identified based on combinations of parameters.

Optimization: To optimize the use of limited resoures such as time, space, money and material and to maximize output variables such as profit under a given set of constraints.

3.20.2 Type of knowledge discovered during data mining

The term knowledge is very broadly interpreted as involving some degree of intelligence. Data mining addresses inductive knowledge which discovers new rules and patterns from the supplied data.

Association Rules: These rules correlate the presence of a set of items with another range of values for another set of variables.

Classification: The goal is to work from an existing set of events or transactions to create a hierarchy of classes.

Sequential Patterns: A sequence of action or events is sought. Detection of sequential pattern is equivalent to detecting associating among events with certain temporal relationships.

Pattern within Time Secures: Similarities can be detected within position of a data which is sequence of data taken at regular interval

Cluster: A given population of events or items can be partitioned into set of similar elements.

3.21 Normalization Transparencies

Normalization is a technique for producing a set of suitable relations that support the data requirements of an enterprise.

3.21.1 Characteristics of a suitable set of relations include:

- the minimal number of attributes necessary to support the data requirements of the enterprise;
- attributes with a close logical relationship are found in the same relation;
- minimal redundancy with each attribute represented only once with the important exception of attributes that form all or part of foreign keys.

3.21.2 The benefits of using a database that has a suitable set of relations is that the database will be:

- easier for the user to access and maintain the data;
- take up minimal storage space on the computer**.**

3.21.3 How Normalization Supports Database Design

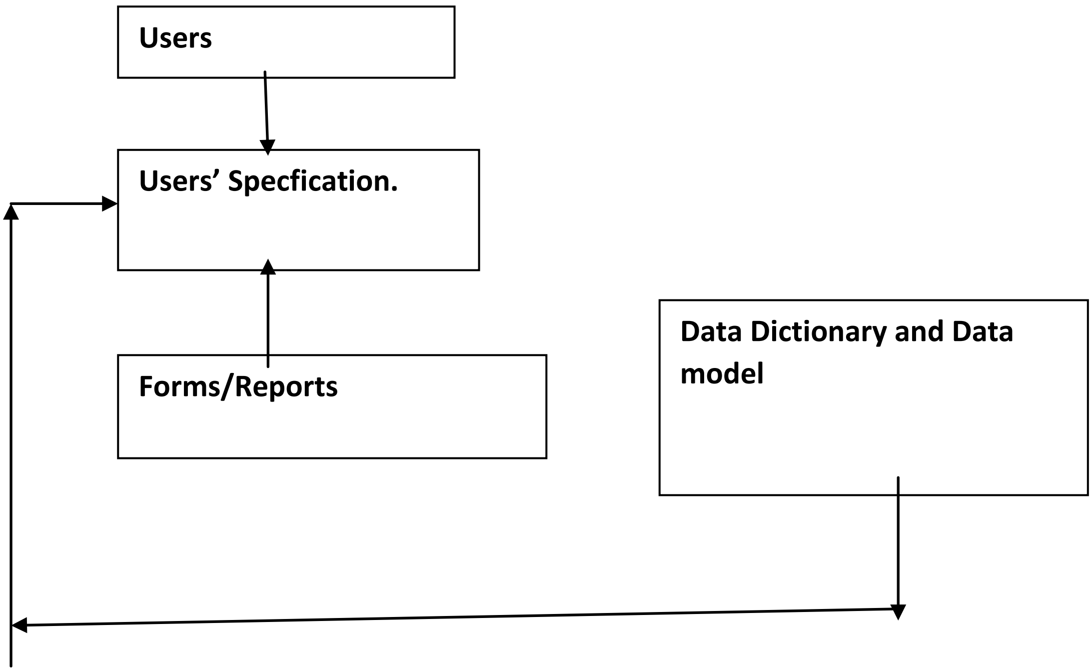


Fig 3.11 b Data Source Generation

Normalization is carried out in practice so that the resulting designs are of high quality and meet the desirable properties. The process of decomposing unsatisfactory "bad" relations by breaking up their attributes into smaller relations.

The practical utility of these normal forms becomes questionable when the constraints on which they are based are hard to understand or to detect. The database designers need not normalize to the highest possible normal form (usually up to 3NF, BCNF or 4NF). Figure 11 b shows data source generation, it explains that how can generate data. Fig 3.11 c shows two approaches for normalization supports database design.

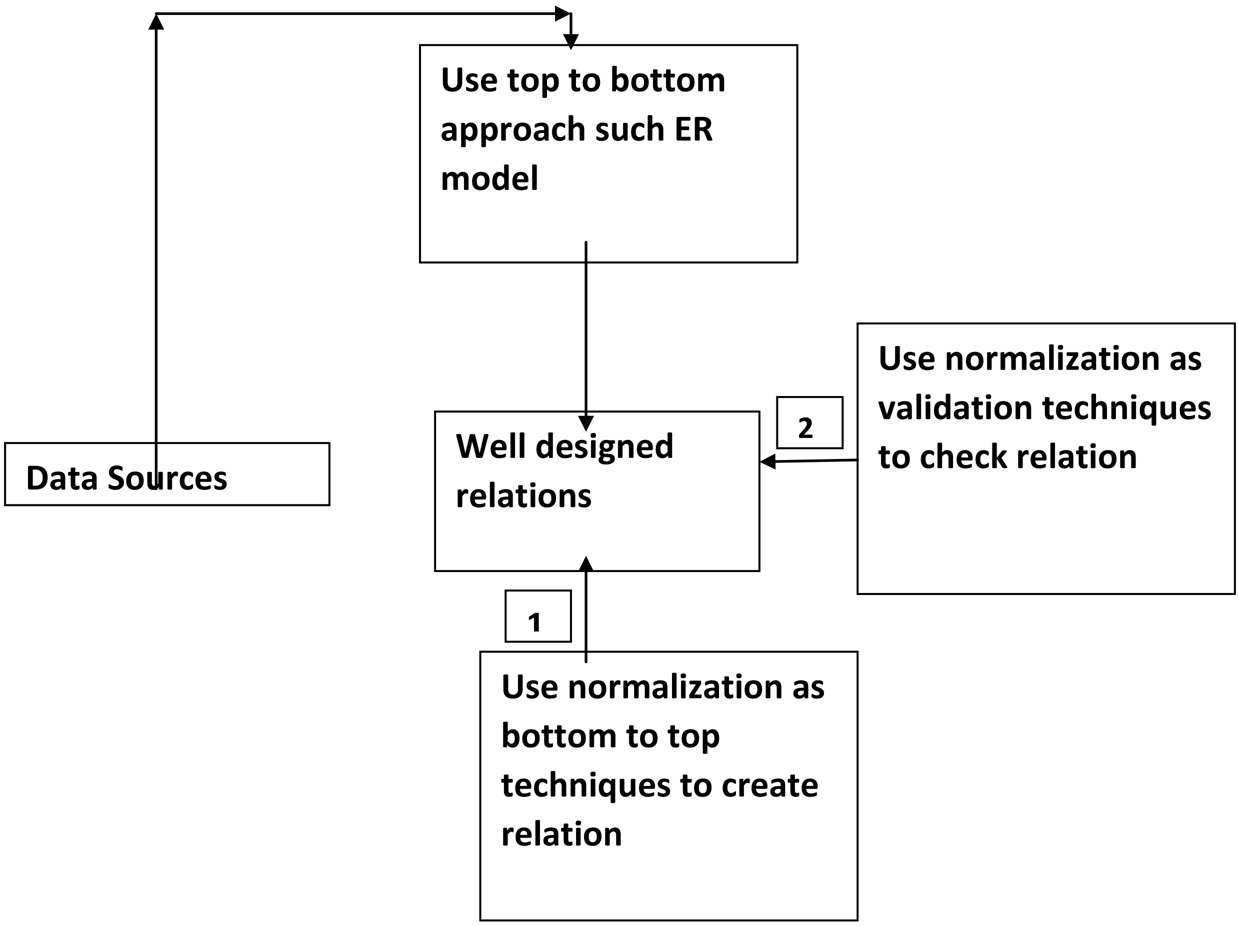


Fig 3.11 c Two Approach for Normalization Supports Database Design

Normal form:

Condition using keys and FDs of a relation to certify whether a relation schema is in a particular normal form

3.21.4 Data Redundancy and Update Anomalies

Major aim of relational database design is to group attributes into relations to minimize data redundancy.

3.21.5 Potential benefits for implemented database include:

Updates to the data stored in the database are achieved with a minimal number of operations thus reducing the opportunities for data inconsistencies.

Reduction in the file storage space required by the base relations thus minimizing costs.

Table 3.6: Tool

Department	Tool no	Tool name	Tool material	material grade
MP001	KKS001	Drill bit	Stainless steel	SS -312
MP001	KKS002	Single point cutting tool	Stainless steel	SS -316
MP001				
MP001				

Table 3.7: Machine

Department	Machine no	Machine name	Machine location	Machine incharge
MP001	MCS001	Drilling machine	Workshop - I	Dev
MP001	MCS002	Lathe	Workshop - I	Rajan
MP001				
MP001				

Problems associated with data redundancy are illustrated by comparing the machine no and machine location and the tool no and tool material. Machine location relation has redundant data; the details of a location are repeated for every member of tool no. In contrast, the department information appears only once for each department in the department relation and only the department number (department No) is repeated in the machine relation, to represent where each member of machine is located.

Relations that contain redundant information may potentially suffer from update anomalies.

Types of update anomalies include

- Insertion
- Deletion
- Modification

3.22 Functional Dependencies

It is a Important concept associated with normalization.

Functional dependency describes relationship between attributes.

For example, if A and B are attributes of relation R, B is functionally dependent on A (denoted $A \rightarrow B$), if each value of A in R is associated with exactly one value of B in R. It is used to specify formal measures of the "goodness" of relational designs

and keys are used to define normal forms for relations and it constraints that are derived from the meaning and interrelationships of the data attributes

3.22.1 Characteristics of Functional Dependencies

Property of the meaning or semantics of the attributes in a relation.

Diagrammatic representation.

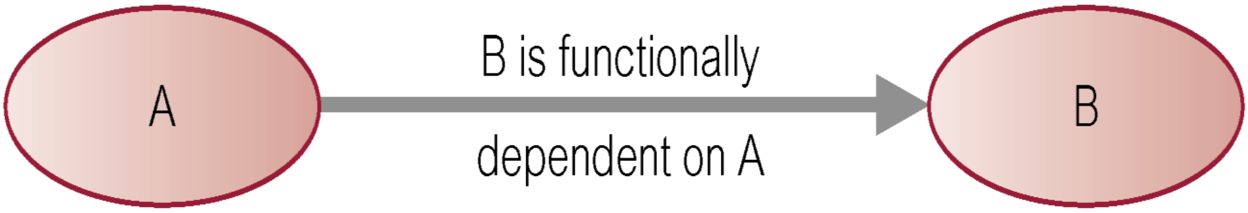


Fig 3.12 (a) Functional Dependency General Diagram

The determinant of a functional dependency refers to the attribute or group of attributes on the left-hand side of the arrow.

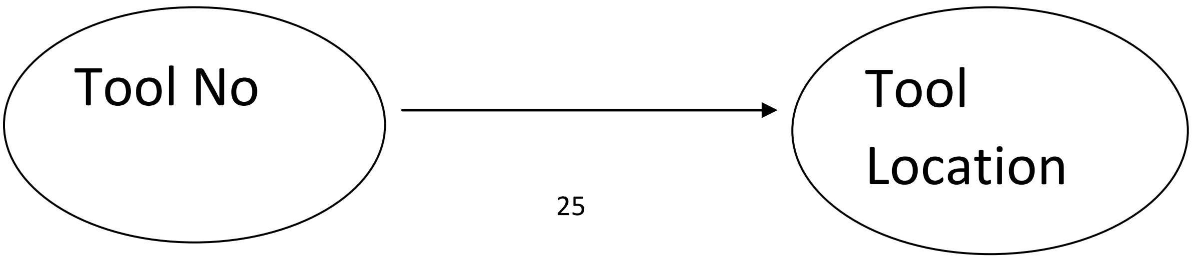


Fig 3.12 (b) Functional Dependency for Tool no & Tool Location

Tool no functionally determines tool location

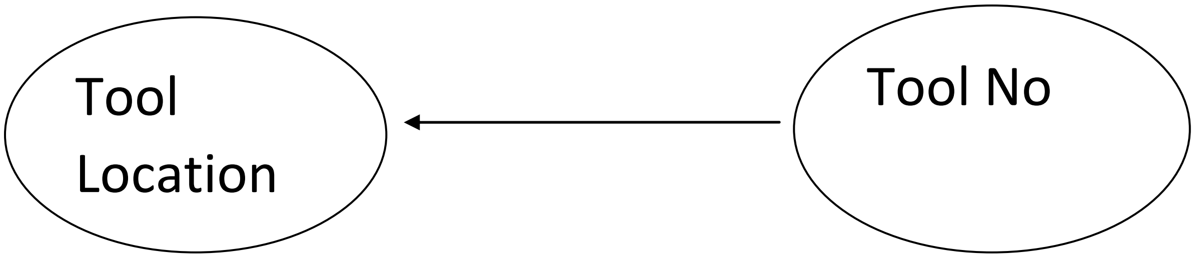


Fig 3.12 (c) Functional Dependency for Tool location & Tool no

Tool location not functionally determines tool no

Example Functional Dependency that holds for all Time, Figure 3.12 (a), (b) and (c)

Represents general and tool no and tool location functional dependency diagram. Consider the values shown in tool No and tool Name attributes of the tool relation

It is based on sample data, the following functional dependencies appear to hold.

tool No → tool Name

tool Name → tool No

Determinants should have the minimal number of attributes necessary to maintain the functional dependency with the attribute(s) on the right hand-side. This requirement is called full functional dependency. Full functional dependency indicates that if A and B are attributes of a relation, B is fully functionally dependent on A, if B is functionally dependent on A, but not on any proper subset of A.

3.22.2 Main characteristics of functional dependencies used in normalization:

There is a one-to-one relationship between the attribute(s) on the left-hand side (determinant) and those on the right-hand side of a functional dependency. It Holds for all time. The determinant has the minimal number of attributes necessary to maintain the dependency with the attribute(s) on the right hand-side.

3.22.3 Transitive Dependencies

Important to recognize a transitive dependency because its existence in a relation can potentially cause update anomalies.

Transitive dependency describes a condition where A, B, and C are attributes of a relation such that if A → B and B → C, then C is transitively dependent on A via B (provided that A is not functionally dependent on B or C).

Example Transitive Dependency

Tool No → tool Name, tool material, tool material grade, Department No

Tool name → tool material

Tool material → tool material grade

3.22.4 The Process of Normalization

Formal technique for analyzing a relation based on its primary key and the functional dependencies between the attributes of that relation. Often executed as a series of steps. Each step corresponds to a specific normal form, which has known properties.

3.22.5 Identifying Functional Dependencies

Identifying all functional dependencies between a set of attributes is relatively simple if the meaning of each attribute and the relationships between the attributes are well understood. This information should be provided by the enterprise in the form of discussions with users and/or documentation such as the users' requirements specification.

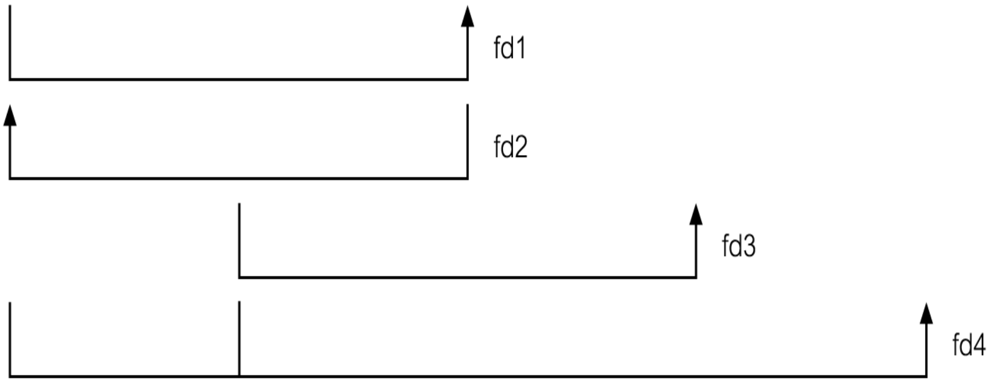
Example - Using sample data to identify functional dependencies

Consider the data for attributes denoted A, B, C, D, and E in the Sample relation

Important to establish that sample data values shown in relation are representative of all possible values that can be held by attributes A, B, C, D, and E. Assume true despite the relatively small amount of data shown in this relation.

Sample Relation

A	B	C	D	E
a	b	z	w	q
e	b	r	w	p
a	d	z	w	t
e	d	r	w	q
a	f	z	s	t
e	f	r	s	t



Example - Using sample data to identify functional dependencies.

Function dependencies between attributes A to E in the Sample relation.

$A \rightarrow C$	(fd1)
$C \rightarrow A$	(fd2)
$B \rightarrow D$	(fd3)
$A, B \rightarrow E$	(fd4)

3.22.6 Identifying the Primary Key for a Relation using Functional Dependencies

Main purpose of identifying a set of functional dependencies for a relation is to specify the set of integrity constraints that must hold on a relation. An important integrity constraint to consider first is the identification of candidate keys, one of which is selected to be the primary key for the relation.

Example - Identify Primary Key for StaffBranch Relation

To identify all candidate key(s), identify the attribute (or group of attributes) that uniquely identifies each tuple in this relation.Sample relation has four functional dependencies. The determinants in the Sample relation are A, B, C, and (A, B). However, the only determinant that functionally determines all the other attributes of the relation is (A, B). (A, B) is identified as the primary key for this relation.

As normalization proceeds, the relations become progressively more restricted (stronger) in format and also less vulnerable to update anomalies. Figure 3.13 shows normal form updation.

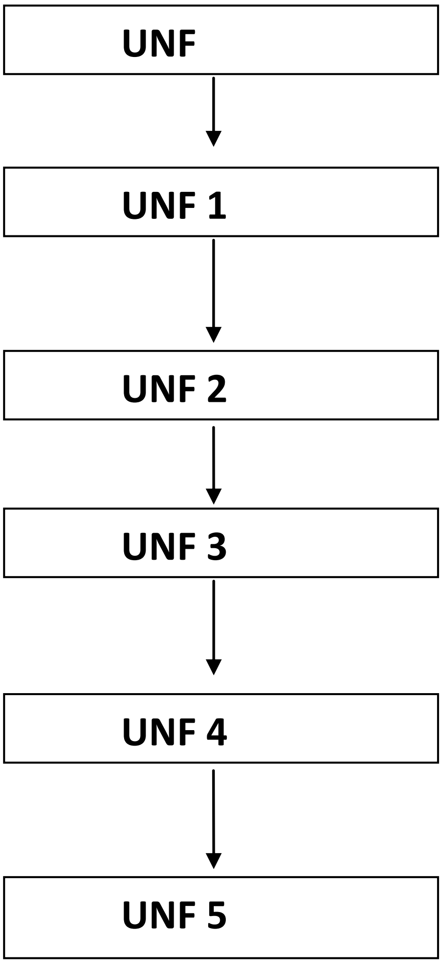


Fig 3.13 Normal Form updation

3.22.7 Unnormalized Form (UNF)

A table that contains one or more repeating groups.It creates an unnormalized table

It Transforms the data from the information source (e.g. form) into table format with columns and rows.

3.22.8 UNF to 1NF

Nominate an attribute or group of attributes to act as the key for the unnormalized table. It Identifies the repeating group(s) in the unnormalized table which repeats for the key attribute(s).

3.22.9 Second Normal Form (2NF)

A relation that is in first normal form and every non-primary-key attribute is fully functionally dependent on any candidate key. It is based on the concept of full functional dependency.

Full functional dependency indicates that if

- A and B are attributes of a relation,
- B is fully dependent on A if B is functionally dependent on A but not on any proper subset of A.

3.22.10 1NF to 2NF

It Identifies the primary key for the 1NF relation and the functional dependencies in the relation. If partial dependencies exist on the primary key remove them by placing then in a new relation along with a copy of their determinant.

3.23.11 Third Normal Form (3NF)

A relation that is in first and second normal form and in which no non-primary-key attribute is transitively dependent on any candidate key. It is based on the concept of transitive dependency. Transitive Dependency is a condition where A, B and C are attributes of a relation such that if $A \rightarrow B$ and $B \rightarrow C$, then C is transitively dependent on A through B. (Provided that A is not functionally dependent on B or C).

3.24.12 2NF, 3NF, BCNF

based on keys and FDs of a relation schema

3.25.13 4NF

It based on keys, multi-valued dependencies : MVDs; 5NF based on keys, join dependencies. In Additional properties may be needed to ensure a good relational design (lossless join, dependency preservation

3.25.14 Denormalization:

The process of storing the join of higher normal form relations as a base relation—which is in a lower normal form

3.23 Query Languages

Query languages are computer languages used to make queries into databases and information systems.

Broadly, query languages can be classified according to whether they are database query languages or information retrieval query languages. The difference is that a database query language attempts to give factual answers to factual questions, while an information retrieval query language attempts to find documents containing information that is relevant to an area of inquiry.

Examples include the following :

SQL is a well known query language and Data Manipulation Language for relational databases. PL/SQL is the abbreviation for proceeded language structured query language. It is an extension of SQL and bridges the gap between the application program and the database system. It combines the flexibility of SQL with the power of a third generation language.PL/SQL extends SQL by adding control structures found in other proceeded language. The procedure constructs and database access are present in PL/SQL.PL/SQL can be used in the oracle relation database in the Oracle server and in the client side application development tools. PL/SQL is a completely portable, high performance transaction processing languages.

3.23.1 Architecture of PL/SQL

Oracle Server

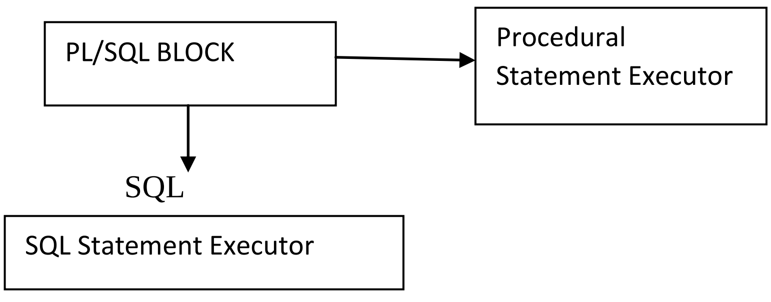


Fig 3.13 Architecture of PL/SQL

PL/SQL blocks are executed by PL/SQL engine. The PL/SQL engine executes the procedural statements and sends the SQL statements to the SQL statements executor in the oracle server. The PL/SQL engine can either in the oracle tools or oracle server. Figure 3.13 shows Architecture of PL/SQL engine.

3.23.2 Structure of PL/SQL

The Oracle block consists three parts

- Declaration part
- Execution part
- Exception error handling part

```
Declare
Declaration 1;
Declaration 2;
Begin
Executable statement 1;
Executable statement 2;
Exception
Exception handlers
End;
```

Declation part in which all the PL/SQL variables constraints and expression are declared.Unless the objects are declared in this part, error message will be displayed in this part,error message will be displayed during execution. This part is optional.

PL/SQL program codes are placed in execution part section. All the PL/SQL variables and constants we use in this part must be declared in the declare section. The execution part begins with keyword begin and ends with the keyword End followed by semicolon.

Exception part is essential for good programming. If error occurs in the execution part then the program terminates abruptly. Exception part is placed within the execution part lastly beginning with keyword Exception.

3.24 Other Important Languages

.QL is a proprietary object-oriented query language for querying relational databases; successor of Datalog;

Contextual Query Language (CQL) a formal language for representing queries to information retrieval systems such as web indexes or bibliographic catalogues.

CQLF (CODASYL Query Language, Flat) is a query language for CODASYL-type databases;

Concept-Oriented Query Language (COQL) is used in the concept-oriented model (COM). It is based on a novel data modeling construct, concept, and uses such operations as projection and de-projection for multi-dimensional analysis, analytical operations and inference;

D is a query language for truly relational database management systems (TRDBMS);

DMX is a query language for Data Mining models;

Datalog is a query language for deductive databases;

Gellish English is a language that can be used for queries in Gellish English Databases, for dialogues (requests and responses) as well as for information modeling and knowledge modeling

HTSQL is a query language that translates HTTP queries to SQL;

ISBL is a query language for PRTV, one of the earliest relational database management systems;

LINQ query-expressions is a way to query various data sources from .NET languages

LDAP is an application protocol for querying and modifying directory services running over TCP/IP;

MQL is a cheminformatics query language for a substructure search allowing beside nominal properties also numerical properties;

MDX is a query language for OLAP databases;

OQL is Object Query Language;

OCL (Object Constraint Language). Despite its name, OCL is also an object query language and an OMG standard;

OPath, intended for use in querying WinFS Stores;

OttoQL, intended for querying tables, XML, and databases;

Poliqarp Query Language is a special query language designed to analyze annotated text. Used in the Poliqarp search engine;

QUEL is a relational database access language, similar in most ways to SQL;

RDQL is a RDF query language;

SMARTS is the cheminformatics standard for a substructure search;

SPARQL is a query language for RDF graphs;

SQL is a well known query language and Data Manipulation Language for relational databases;

SuprTool is a proprietary query language for SuprTool, a database access program used for accessing data in Image/SQL (formerly TurboIMAGE) and Oracle databases;

TMQL Topic Map Query Language is a query language for Topic Maps;

UnQL (Unstructured Query Language) is a functional superset of SQL, developed by the authors of SQLite and CouchDB;

XQuery is a query language for XML data sources;

XPath is a declarative language for navigating XML documents;

XSPARQL is an integrated query language combining XQuery with SPARQL to query both XML and RDF data sources at once;

YQL is an **SQL**-like query language created by Yahoo!

SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHTRONICS

M.E (CAD)

SPRA7007 - MANUFACTURING INFORMATION SYSTEMS

UNIT- IV

MANUFACTURING CONSIDERATION

The product and its structure, inventory and process flow – Shop floor control Data structure and procedure – various models – the order scheduling module, Input/output analysis module, and stock status database – the complete IOM database – Case studies

4. MANUFACTURING CONSIDERATION

4.1 Product and its Structure

Product structure is a hierarchical decomposition of a product, typically known as the bill of materials (BOM). The product structure provides a hierarchical classification of the items which form a product. With the product structure, the understanding of the components which compose a product as well as their attributes can be represented. The product structure shows the material, component parts subassemblies and other items in a hierarchical structure that represents the grouping of items on an assembly drawing or the grouping of items that come together at a stage in the manufacturing process.

4.1.1 Bill of Materials

A bill of material is a formally structured list for an object (semi-finished or finished product) which lists all the component parts of the object with the name, reference number, quantity, and unit of measure of each component. A bill of material can only refer to a quantity greater than or equal to one of the object. It is a product data structure, which captures the end products, its assemblies, their quantities and relationships.

There are usually two kinds of bills of materials needed for a product: engineering and manufacturing BOM. The engineering BOM normally lists items according to their relationships with parent product as represented on assembly drawings. But this may not be sufficient to show the grouping of parts at each stage of the production process nor include data needed to support manufacturing or procurement. These requirements may force the arrangement of the product structure to be different in order to assure manufacturability. Thus, engineering and manufacturing will usually have different valid views for the same product.

Manufacturing Requirements Planning (MRP) systems typically rely on a Bill of Materials (BOM) and the product structure for their information. In theory, the BOM can and should be produced automatically by the CAD system but in practice there is usually human intervention or even re-entry. The main reasons are:

The difficulty of tracking changes to the BOM (product structure) and effectivity dates and transferring this data back to the design system. Many changes, such as different suppliers for fasteners, do not affect the design form, fit and function and are therefore only made and stored in the manufacturing systems.

The need in manufacturing to view the product structure differently. It is often necessary to batch similar components from different products together for mass production or efficient purchasing.

4.2 Product Data Management (PDM)

Technology enables changes to be tracked and implemented through the design and engineering change process and then passed over to the MRP system when approved. Therefore PDM systems use BOM to represent configuration management of the product.

A Bill of Materials is a product data structure which captures the end-products, its assemblies, their quantities and relationships. The structure of a part's list determines the accessibility of the part's information by various departments in a company. It also helps to determine the level of burden put on the computational device in searching for product information. In many companies the BOM is structured for the convenience of individual departments. This, however, engenders problems in other departments.

In Figure 4.1, a product named Product 1 is shown graphically with the summarized products structure and the number of all items that are needed to make the parent products are enclosed in brackets.

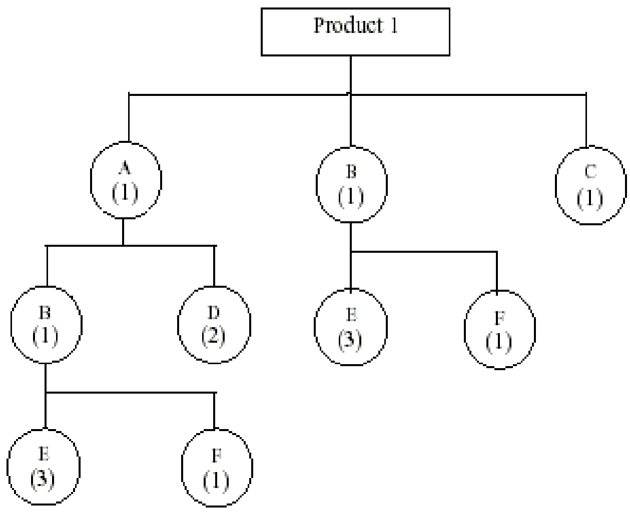


Fig 4.1 Data terminology Definition

Figure 4.2 contains a bill of materials for Product 1 in which the total usage of each item is collected into a single list for the product. This kind of list is convenient for the master production schedule but results in duplication assemblies. This implies that each product bill that uses assembly must be changed whenever there is a change in assembly. Furthermore, since lead times of intermediate assemblies cannot be determined, parts are ordered too early the first time they are encountered in the product structure.

Part	Qty
A	1
B	2
C	1
D	2
E	6
F	2

Figure 4.2 Summarized Bill of materials (BOM)

Other arrangements used in arranging the bill of materials is by indenting the product data as shown in Figure 4.3. One disadvantage of this method is that all components of an assembly are repeated each time the assembly is used, resulting in massive duplication of data.

Product 1			Qty
A			1
	B		1
		E	3
		F	1
	D		2
B			1
	E		3
	F		1
C			1

Figure 4.3 Indented bill of materials

One solution to the duplication problem is by holding each assembly only once in ‘single level’ bill of materials as shown in Figure 4.4. In this approach it identifies only the components used by one level and a required subassembly. This means that engineering changes can be made in only one place.

Level 1

Part/Product 1	Qty	Pointer to level
A	1	A
B	2	B
C	1	

Level 2

Part/A	Qty	Pointer to
B	1	B
D	2	

Level 3

Part/B	Qty	Pointer to
E	3	
F	1	

Figure 4.4 Single-level bill of materials

'Where used' lists give an easy overview of the products where a given material is contained. This happens by displaying of all BOM’s, which contain this component.

The table below shows the typical information which can be found in a bill of materials:

- Header (Product or Higher-Level Assembly)
- Product/Assembly Item Number
- Product/Assembly Name
- Product/Assembly Description
- Unit of Measure
- Revision Level
- Each Component/Item
- Item Number
- Item Name
- Item Description
- Revision Level
- Unit of Measure
- Quantity per item (each higher level assembly)
- Effectivity (date in and date out or serial number in and serial number out)

These concepts are divided into two main aspects. First the product breakdown is discussed which involves all the physical aspects of a product. Second, different views at the product structure are indicated.

4.3 Product Structure

Product structure views are made upon several activity domains within the company. Due to the fact not everyone in the company has to have a detailed overview of the product several components with their attributes can beextracted.

When the MASTER STRUCTURE is made out of several items of the product assembly, multiple views can be made upon this MASTER STRUCTURE. Thus this MASTER STRUCTURE contains every item in detail, which is important to the ASSEMBLY of the product.

Product views are classified into five types. One is service view and others are design view, manufacturing view, purchasing view and sales view. From the view we can derived master structure. From the master structure we can define product definition.

4.3.1 **Product breakdown**

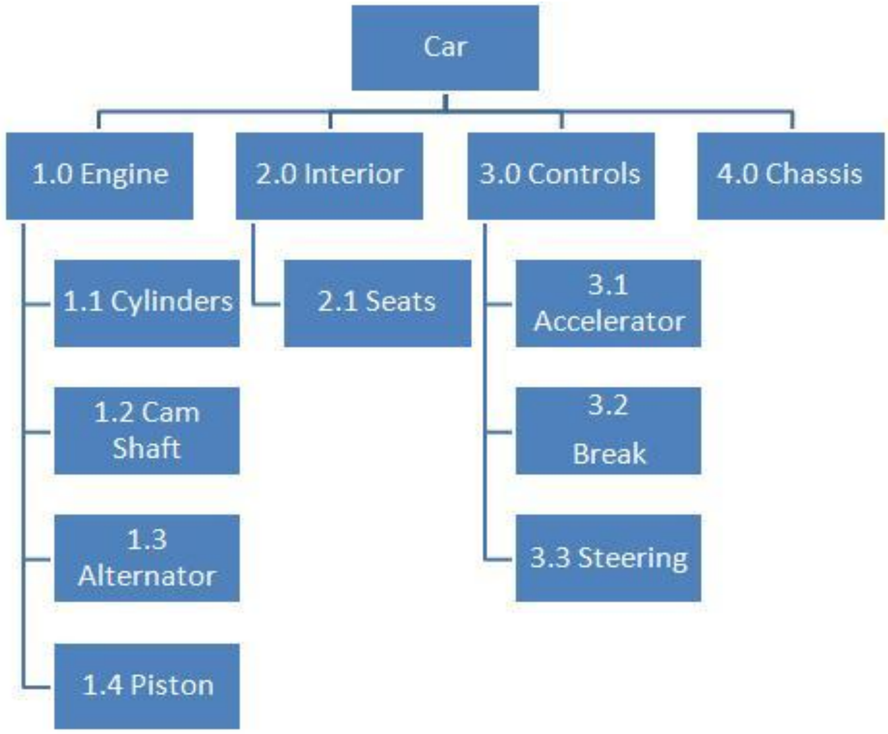


Figure 4.5 Product Breakdown Structure

Figure 4.5 illustrates the concepts that are important to the structure of a product. This is a meta-data model, which can be used for modelling the instances in a specific case of product structuring. The core of the product structure is illustrated by the product components (ITEMS) and their RELATIONSHIPS. Thus, this involves the linking between ITEMS related to the product. The ASSEMBLY can exist of

SUBASSEMBLIES and PARTS, whereas SUBASSEMBLIES can also consist of other SUBASSEMBLIES or PARTS. Thus this is typically hierarchically ordered. These concepts are generalized into the concept of ITEM. This classification is overlapping, because a SUBASSEMBLY could be a PART in another ASSEMBLY configuration. Due to differentiation and variation of items several concepts must be indicated into the product breakdown structure. Three concepts are involved in this differentiation, namely ALTERNATIVES, VARIANTS and REVISIONS. An ALTERNATIVE of an ITEM is considered as a substitute for that particular item, whereas a VARIANT is another option of an item which the consumer can choose. When an error occurs at a part or subassembly, it needs to be revised. This revision indicates the change in the history of the ITEM.

4.4 Data Modelling Process

The process of constructing the product model consists of six main activities, which can be decomposed in several sub-activities. The next table describes these activities and the sub-activities within them provided with a description about this activity.

Table 1: The activities within product structure modelling for Example

This example discusses the product structure modeling within car manufacturing. This will be discussed through the main activities which are identified within the process of product structure modeling.

4.4.1 Define product components

First, all components are identified and indicated. In the area of car manufacturing, the product components are as follows. A car (ASSEMBLY) consists of several SUBASSEMBLIES such as the body and the engine of the car. The engine for example is assembled in several parts such as screws and small pipes.

4.4.2 Define product assortment

In case of car manufacturing instances of these concepts can be made. For example an engine has several alternatives. For example a car manufacturer (ref fig 4.6)

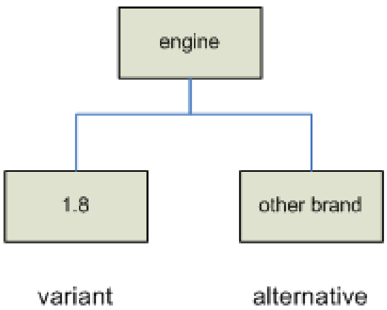


Figure 4.6 Product Assortment Diagram

engine made in America or Japan. Within these different engines, variants exist. Initially an engine can be made as a 1.6 engine, but a variant, such as a 1.8 engine, can be made of this engine. Thus the 1.6 engine is used as base concept for the new 1.8 engine.

4.4.3 Product structuring

An example (ref fig 4.7) of a correlation between items within car manufacturing can be indicated as follows. The engine is connected to the body with several screws. Thus, these two items must be linked by the concept of a relationship.

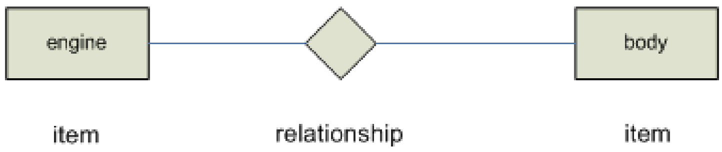


Figure 4.7 Binary Product Structure

4.4.4 Create master structure

After structuring the product with all the listed items and relationship between them this must be combined into one MASTER STRUCTURE which contains all of the details of the product. In case of the car (ref fig 4.8), all items from engine to screw must documented in one MASTER STRUCTURE.

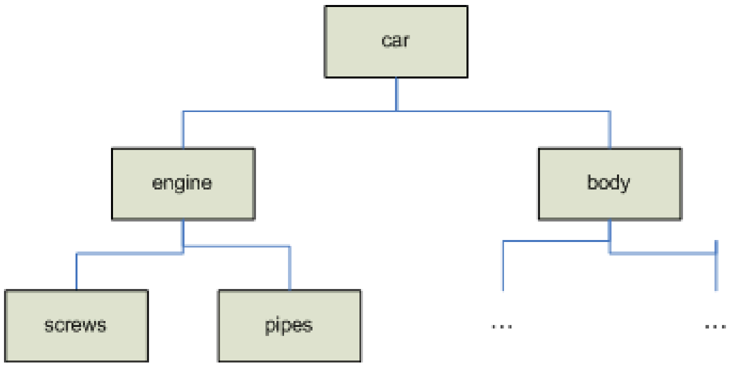


Figure 4.8 Master Structure

4.4.5 Documenting

When the MASTER STRUCTURE of the car is created one must link this structure with documents which contains the product definition of this specific car. Primarily, this consists of an extensive description of the car which is linked to the MASTER STRUCTURE of this product.

4.4.6 Define product structure views

In case of the car manufacturer multiple views can be made out of the car assembly. For example a structure from a sales point of view will need more detail about the functions and characteristics of the car rather than detailed information about the body. Thus a sales manager needs information about the color of the car or the type of gear (automatic of manual). From a purchasing view more information is needed about the mixing of the paint instead of the general color, which is only needed for the customer. Purchasing department also needs more information about the suppliers of the used components within the manufacturing of the car, so they can easily overview where which component is used and from which supplier is comes from car. Figure 4.9 shows sales and purchasing view car.

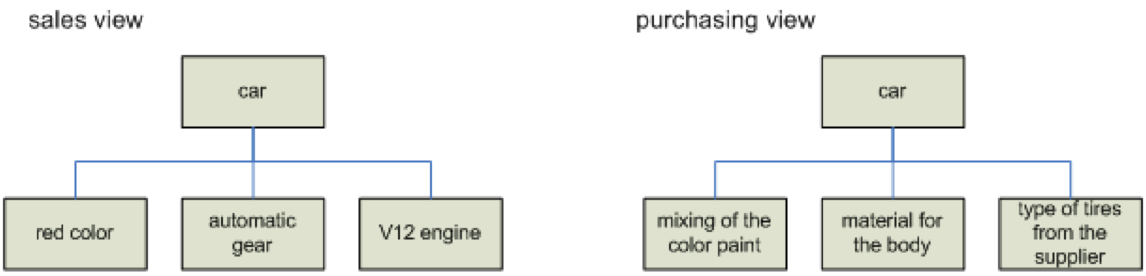


Figure 4.9 Sales and Purchasing view

4.5 Process-data model

When combining the activities with the concepts of the product structure model it will result in a process-data diagram. This diagram displays the steps which are needed to be taken within the process of product structure modelling together with the deliverables, at the right side, which are outcomes of these activities. Figure
4.10 shows process data model, it represent all the activities.

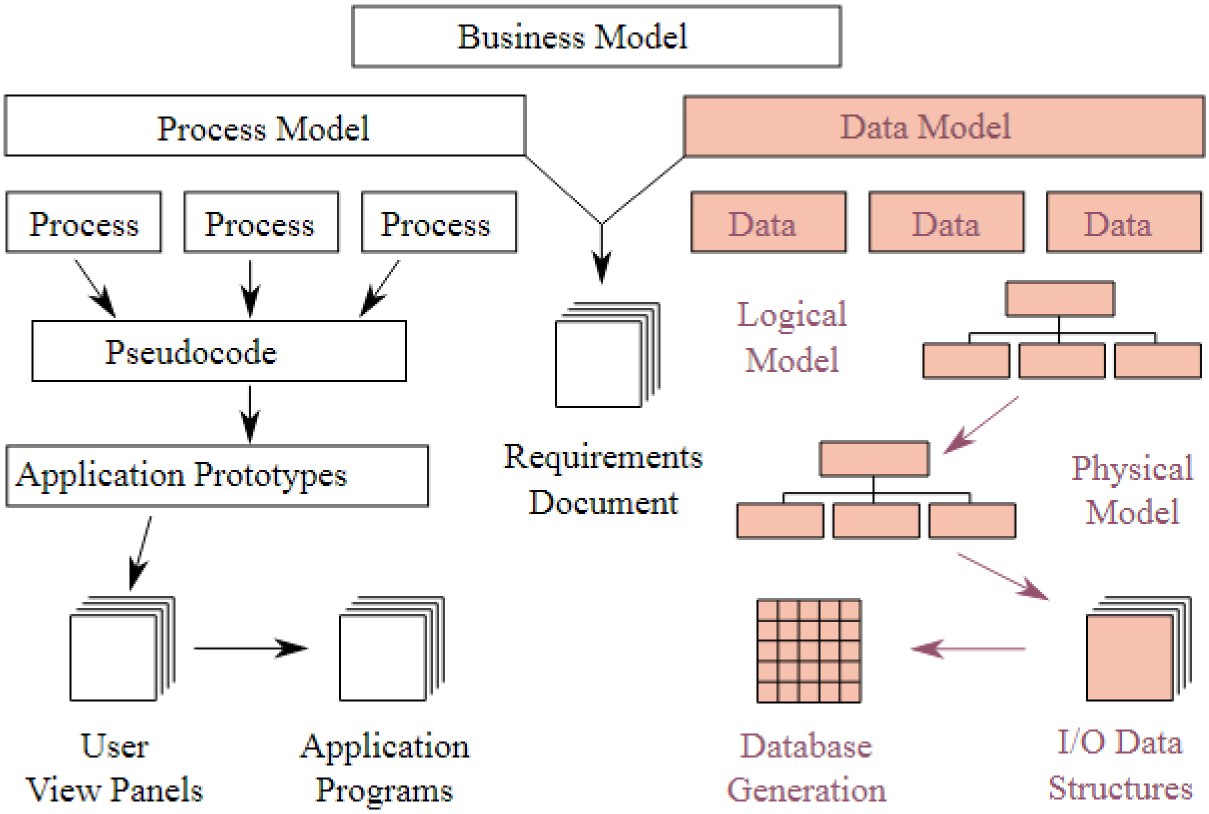


Figure 4.10 Process Data Model

A data model

is an abstract model that organizes elements of data and standardizes how they relate to one another and to the properties of real-world entities. For instance, a data model may specify that the data element representing a car be composed of a number of other elements which, in turn, represent the color and size of the car and define its owner.

The term **data model** can refer to two distinct but closely related concepts. Sometimes it refers to an abstract formalization of the objects and relationships found in a particular application domain: for example the customers, products, and orders found in a manufacturing organization. At other times it refers to the set of concepts used in defining such formalizations: for example concepts such as entities, attributes, relations, or tables. So the "data model" of a banking application may be defined using the entity-relationship "data model". This article uses the term in both senses

A data model explicitly determines the structure of data. Data models are typically specified by a data specialist, data librarian, or a digital humanities scholar in a data modeling notation. These notations are often represented in graphical form.

A data model can sometimes be referred to as a data structure, especially in the context of programming languages. Data models are often complemented by function models, especially in the context of enterprise models

The role of data models

The main aim of data models is to support the development of information systems by providing the definition and format of data. According to West and Fowler (1999) "if this is done consistently across systems then compatibility of data can be achieved. If the same data structures are used to store and access data then different applications can share data. The results of this are indicated above. However, systems and interfaces often cost more than they should, to build, operate, and maintain. They may also constrain the business rather than support it. A major cause is that the quality of the data models implemented in systems and interfaces is poor".

- "Business rules, specific to how things are done in a particular place, are often fixed in the structure of a data model. This means that small changes in the way business is conducted lead to large changes in computer systems and interfaces".
- "Entity types are often not identified, or incorrectly identified. This can lead to replication of data, data structure, and functionality, together with the attendant costs of that duplication in development and maintenance".
- "Data models for different systems are arbitrarily different. The result of this is that complex interfaces are required between systems that share data. These interfaces can account for between 25-70% of the cost of current systems".
- "Data cannot be shared electronically with customers and suppliers, because the structure and meaning of data has not been standardized. For example, engineering design data and drawings for process plant are still sometimes exchanged on paper".

The reason for these problems is a lack of standards that will ensure that data models will both meet business needs and be consistent.

A data model explicitly determines the structure of data. Typical applications of data models include database models, design of information systems, and enabling exchange of data. Usually data models are specified in a data modeling language

Database model

A database model is a specification describing how a database is structured and used.

Several such models have been suggested. Common models include:

Flat model

This may not strictly qualify as a data model. The flat (or table) model consists of a single, two-dimensional array of data elements, where all members of a given column are assumed to be similar values, and all members of a row are assumed to be related to one another.

Hierarchical model

The hierarchical model is similar to the network model except that links in the hierarchical model form a tree structure, while the network model allows arbitrary graph.

Network model

This model organizes data using two fundamental constructs, called records and sets. Records contain fields, and sets define one-to-many relationships between records: one owner, many members. The network data model is an abstraction of the design concept used in the implementation of databases.

Relational model

is a database model based on first-order predicate logic. Its core idea is to describe a database as a collection of predicates over a finite set of predicate variables, describing constraints on the possible values and combinations of values. The power of the relational data model lies in its mathematical foundations and a simple user-level paradigm.

Object-relational model

Similar to a relational database model, but objects, classes and inheritance are directly supported in database schemas and in the query language.

Object-role modeling

A method of data modeling that has been defined as "attribute free", and "fact based". The result is a verifiably correct system, from which other common artifacts, such as ERD, UML, and semantic models may be derived. Associations between data objects are described during the database design procedure, such that normalization is an inevitable result of the process.

Star schema

The simplest style of data warehouse schema. The star schema consists of a few "fact tables" (possibly only one, justifying the name) referencing any number of "dimension tables". The star schema is considered an important special case of the snowflake schema.

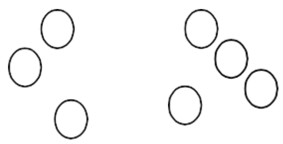
4.6 Data Structure and Procedure

A data structure is a scheme for organizing data in the memory of a computer.

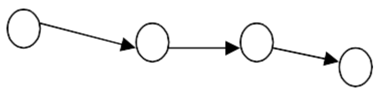
A data structure is data type whose values (i) can be decomposed into a set of component elements each of which is either simple (atomic) or another data structure (ii) include a structure involving the component parts.

There are four possible data type structure included

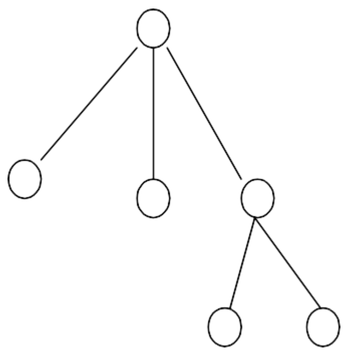
Set data Structure

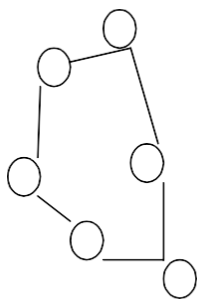


Linear data Structure



Tree data Structure





Graph data Structure

Note : the above data structure ○ meant by node, holds an item of data

Some of the more commonly used data structures include lists, arrays, stacks, queues, heaps, trees, and graphs.

Binary Tree

The way in which the data is organized affects the performance of a program for different tasks. Computer programmers decide the data structures to be use based on the nature of the data and the processes that need to be performed on that data. A binary tree is another commonly used data structure. It is organized like an upside down tree. Each spot on the tree, called a node, holds an item of data along with a left pointer and a right pointer. Figure 4.11 shows process data model.

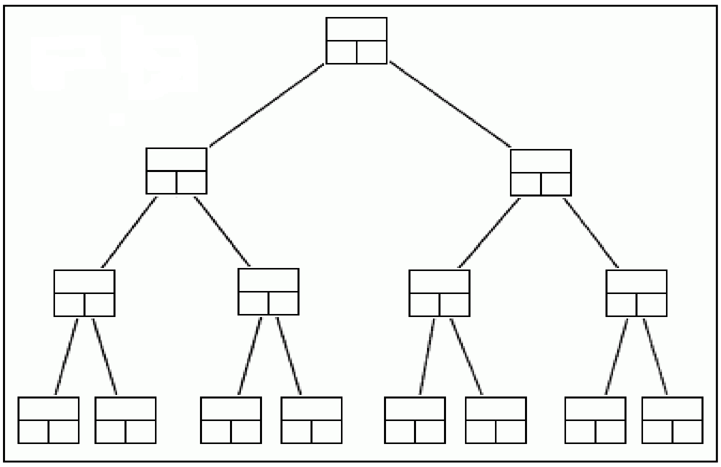


Figure 4.11 Process Data Model

Queue

A queue is an example of commonly used simple data structure. A queue has beginning and end, called the front and back of the queue. Data enters the queue at one end and leaves at the other. Because of this, data exits the queue in the same order in which it enters the queue, like people in a checkout line at a supermarket (Ref 4.12).

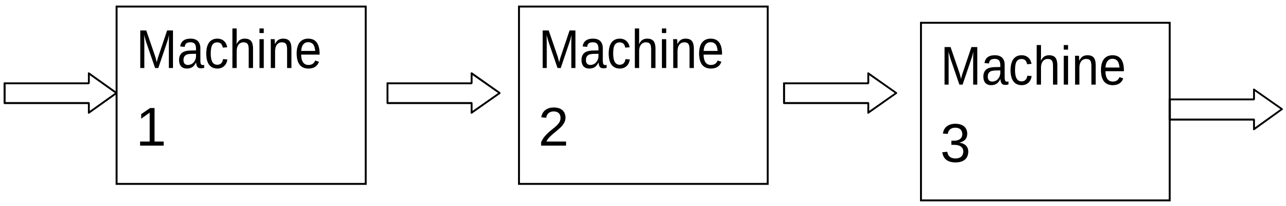


Figure 4.12 Queue Data Model

Data Structures in Alice

Alice has two built-in data structures that can be used to organize data, or to create other data structures:

- Lists
- Arrays

List and Arrays

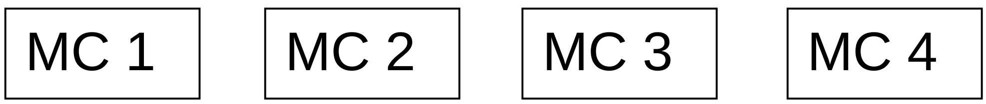
A list is an ordered set of data. It is often used to store objects that are to be processed sequentially. A list can be used to create a queue.

An array is an indexed set of variables, such as machine 1, machine 2, machine 3, machine 4. It is like a set of boxes that hold things. A list is a set of items. An array is a set of variables that store an item.

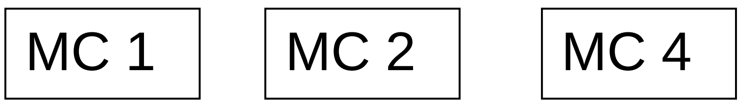
You can see the difference between arrays and lists when you delete items.

List

Before Deletion



After Deletion of MC 3



Array

Before Deletion

MC 1	MC 2	MC 3	MC 4

After Deletion of MC 3

MC 1	MC 2		MC 4

In a list, the missing spot is filled in when something is deleted. In an array, an empty variable is left behind when something is deleted.

4.7 Shop Floor Control

Shop Floor Control (SFC) is the process by which decisions directly affecting the flow of material through the factory are made. The input to the SFC system is the collection of production plan(e.g. result of process planning, MRP, capacity planning). A typical SFC system consist three phases, order release, order scheduling and order progress. In CIM, this phases are augmented by the computer.

Major Sub-functions of SFC

- Maintain WIP quantity information
- Provide quantity by location by shop order for WIP inventory and accounting purposes
- Measure of efficiency, utilization, and productivity of the work force and machines
- Provide actual output data for capacity control purposes

(Source: APICS Dictionary). Figure 4.13 shows Shop floor Control – Information System

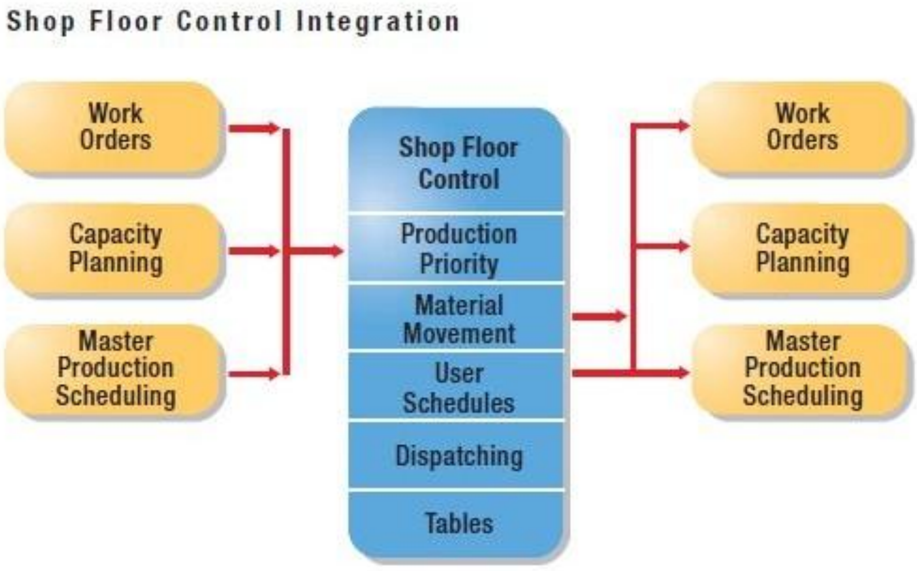


Figure 4.13 Shop floor Control – Information System

4.7.1 Shop Floor Control System Three Phases

4.7.2 Order release:

The order release phase of SFC provides the documentation needed to process a production order through the factory. It consists of

- Route sheet
- Material requisitions
- Job cards
- Move ticket
- Parts list

For automated methods, these documents are necessary. The order release is driven by authorization to produce engineering manufacturing data base.

Order Release The order release in shop floor control provides the documentation needed to process a production order. The documents in the shop floor order may consists of the following documents (i) Route Sheet (ii) Material requisition to draw necessary materials from the stores (iii) Job cards or other means to report direct labour time given to the order. (iv) Instructions to material handling personnel to transport parts between the work centres in the factory (v) Parts list for assembly, in the case of assembly operations. In a typical factory which works on manual processing of data these documents move with the production order and are used to track the progress through the shop. In a CIM factory, more automated methods are used to track the progress of the production orders. The order release is connected with two inputs. Authorization proceeds through the various planning functions

(MRP, capacity planning). These provide timing and scheduling information. The engineering and manufacturing database provides the product structure and process planning information needed to prepare the various documents that accompany the order through the shop.

4.7.3 Order scheduling:

The order scheduling module assigns the production orders to the various work centers in plants. It executes the dispatching function in production planning and control it. It is used to solve two problems control: machine loading
and job sequencing. Allocating the orders to the work centers is termed as machineloading or shop loading job sequencing involves determining the order in which the jobs will be processed through a given work centre .to determine the sequence priorities has to befixed some of the priority rules are:

- Earliest due to data (higher priority)
- Shortest processing time(higher priority)
- Least slack time(higher priority)
- Critical ratio(higher priority for lower critical ratio)

The three phases and their connections to other functions in the production management system are illustrated in fig 4.14.
This module assigns the production orders to various work centres, machine tools, welding stations, moulding machines etc., in the plant. It follows directly from the order release module. Order scheduling executes the dispatch function in production planning and control. The order scheduling module prepares a dispatch list that indicates which production order should be accomplished at the various work centres. It provides the information on the relative priorities of the various jobs by showing the due dates for each job. By following the dispatch list in making work assignments and allocating resources to different jobs the master schedule can be best achieved. The order schedule module addresses to two important activities in shop floor production control. (i) Machine loading (ii) Job sequencing. 70 Allocating the orders to the work centres is termed as machine loading or shop loading, which refers to the loading of all machines in the plant. In most cases each work centre will have a queue of orders waiting to be processed. This queue problem can be solved by job sequencing. This involves determining the order in which the jobs will be processed through a given work centre. To determine this sequence, priorities are given to jobs in the queue and the jobs are processed according to the priorities. Several queuing models are available in

operations management to solve this problem. This control of priorities is an important input to the order scheduling module. Rules to establish the priorities are: (i) Earliest due date: These are given high priority (ii) Shortest processing time: Shorter processing time orders are given high priority. (iii) Least slack time: Orders with least slack time are given high priority. Fluctuations in market demand, equipment breakdown, cancellation of the order by customer and defective raw material or delay in the receipt of materials affect the priority. The priority control plan reviews the relative priorities of the orders and adjusts the dispatch list accordingly.

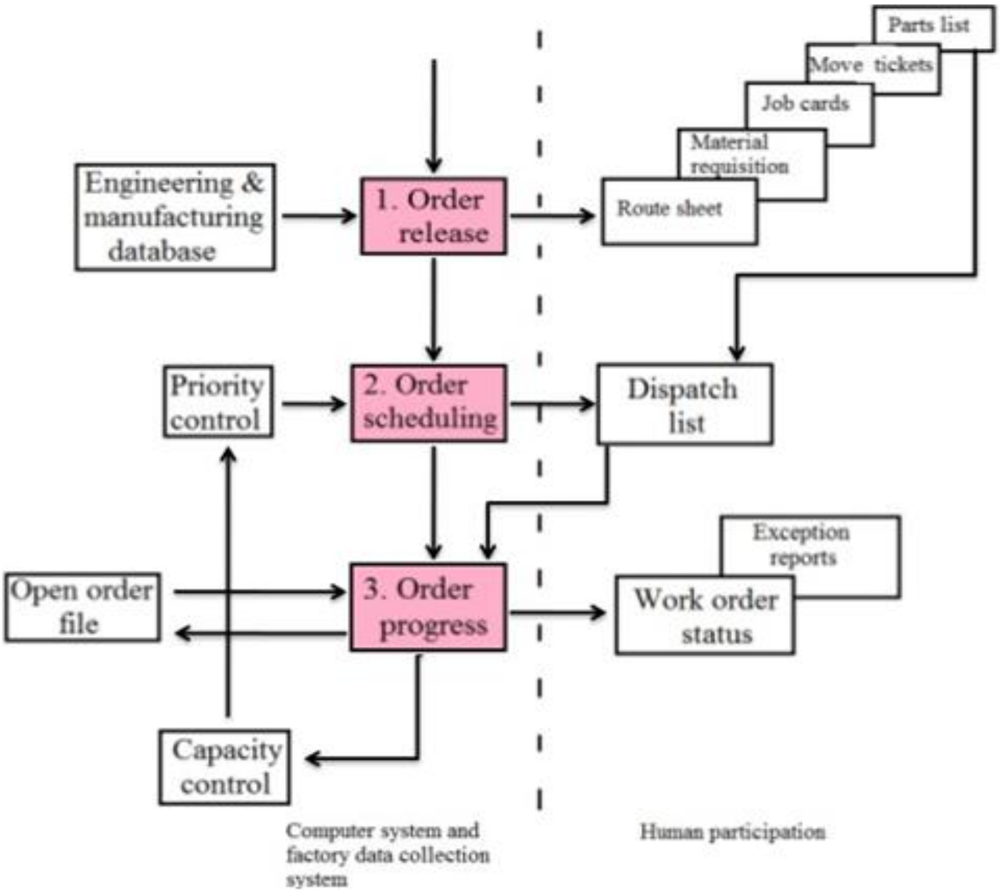


Figure 4.14 Shop floor Control – Three Phases

Slack time is defined as the difference between the time remaing until due data and the process time remaining. Critical ratio is defined as the ratio of the time remaining until due data divided by the process time remaining

4.7.4 Order Progress:

The order progress module monitors the status of the various orders in the plant , work-in-progress, etc. Its function is to provide information that is useful in managing the factory based on data collected from the factory.

The various information reports are:

- Work order status reports
- Progress reports
- Exception reports

Order Progress The order progress module in the shop floor control system monitors the status of the various orders in the plant work-in-process and other characteristics that indicate the progress and performance of production. The function of the order progress module is to provide the information that is useful in managing the factory based on the data collected from the factory. The order progress report includes:

(i) Work order status reports: These reports indicate the status of the production orders. Typical information in the report includes the current work centre where each order is located, processing hours remaining before completion of each order, whether the job is on-time or behind schedule, and priority level.

(ii) Progress report: A progress report records the performance of the shop during the period of master schedule and reports the number of operations completed and not completed during the time period.

(iii) Exception reports: These reports bring out the deviations from the production schedule (ex. overdue jobs). The above reports are useful to production management in making the decisions about allocation of resources, authorization of the overtime hours, and other capacity issues, and in identifying areas of problems in the plant that adversely affect the implementation of the master production schedule.

4.8 Shop Floor Data Collection

There are several of data collection techniques to gather data from the shop floor. Some of the data are keyed by the employees and the rest are recorded automatically. Later the data is compiled on a fully automated system that requires no human intervention. These methods are collectively called as shop floor data collection systems. These data collection systems consist of various paper documents, terminals and automated devices located through the plant in a plant. The shop floor data collection system serves as an input to the order progress module in shop floor.

Examples of the data collection in shop floor are:

(i) To supply data to the order progress module in the shop floor control system.

(ii) To provide up to date information to the production supervisors and production control personnel.

(iii) To enable the management to monitor implementation of master schedule. To carry out this, the factory data collection system inputs the data to the computer system in the plant.

4.8.1 Types of Data Collection Systems

The shop floor data collection systems can be classified into two groups.
(i) On-line data collection systems
(ii) Off-line data collection systems

4.8.2 On-Line Data Collection Systems

In an on-line system, the data are directly entered to the computer and are available to the order progress module. The advantage lies in the fact that the data file representing the status of the shop is always at the current state. As and when the changes in the order progress module are reported they can be fed to computer and in turn to the status file. In this way the production personnel are provided with most up-to-data information.

4.8.3 Off-Line (Batch) Data Collection Systems

In this the data are collected temporarily in a storage device or a stand-alone computer system to be entered and processed by plant computer in a batch mode. In this mode there is delay in the entry and processing of the data. The delay may vary depending upon the situation. So this system cannot provide real time information of shop floor status. The advantage of this system is that it is easier to install and implement.

4.8.4 Data Input Techniques

As stated earlier, the data collection techniques include manual procedures and computer terminals located on the shop floor. The manual data collection methods require the production workers to fill out paper forms indicating order progress data. These forms are compiled using a combination of clerical and computerized methods. The manual data collection methods rely on the co-operation and clerical accuracy of the employees to record a data property on a proper document. Errors may creep in this type of method. The common forms of errors that can be checked and rectified are wrong dates, incorrect order numbers and incorrect operation numbers. These can be detected and corrected. There are, however, other errors which are difficult to identify. Another problem is that there may be a delay in submitting the order progress for compiling. The reason is that there will be always a time lapse between when occurrence of events and recording of events. These problems necessitate the location of the data collection equipment in the factory itself. The various input techniques include manual input by push-button pads or keyboards. Error checking routines can be incorporated to detect the syntax errors in the input. The data entry methods also include more automated technologies, such as bar code reader, magnetic card readers etc. 73 An important type of equipment used in shop floor data entry is keyboard based systems. There are various types of such systems.

They are discussed in the following sections.

4.8.5 Centralized Terminal

A single terminal is located centrally in the shop floor. This requires the employees to go to the terminal and input the data. So employee’s time will be wasted and in a big shop, this becomes inconvenient.

4.8.6 Satellite Terminals

These are multiple data collection centres located throughout the shop floor. In this arrangement a balance is to be struck between the minimization of the investment cost and maximization of the convenience of the employees in the plant.

4.8.7 Work Centre Terminals

The most convenient arrangements to the employees are to have a data collection terminal at each work centre. This reduces the time to go to the central terminal. This can be applied when the amount of data to be collected is very large.

4.8.8 Automatic Data Collection System

The recent trend in industry towards use of more automation necessitates putting in human participation is unavoidable in many cases. The advantages of the automatic data collection methods are:

(i) The accuracy of data collected increases

(ii) The time required by the workers to make the data entry can be reduced. The basic elements in data collection systems are: (i) Machine readable media (ii) Terminal configuration

(iii) Software for data collection. 74 Machine Readable Media Typical machine readable media include: (i) Bar Code Technology (ii) Optical Character Recognition (OCR) (iii) Magnetic Ink Character (iv) Voice Recognition (VR) (v) Magnetic Strip Technology (vi) Smart Cards Bar Code Technology

Bar code technology

is primarily an automatic identification technique. The data is simply reduced to a printed form, which consists of a symbol made of successive line segments. A bar code reader is used to illuminate the bar code symbol and examine successive segments of the symbol. The detected area may be a highly reflected area (space) or a non-reflective (bar). As the reader moves reader over the bar code symbol, due to reflectivity and no reflectivity, alternate transitions from light to dark and dark to light occur. These are detected and the time it will take will be converted to digital representations of ones and zeros of the bar code messages. Most commonly used bar codes are: (i) Universal Product Code (UPC) (ii) Interleaved 2 of 5 (ITF) (iii) Code 39 There are two types of bar code readers. They are classified as: (i) Fixed Beam Reader (ii) Moving Beam Reader

Fixed Beam Reader

Bar code readers are either fixture mounted or hand held. The simplest form of bar code reader is a light pen. The tip of the light pen is moved in contact with the symbol and moves the tip from leading zone through trailing zone in a smooth sweeping motion. The fixed beam light pen nearly or actually touches the symbol. In fixture mounted 75 reader the beam reader is fixed and the symbol moves. The reader is mounted on a conveyor or a transport system, observing a symbol while it passes through a reader beam. The fixed beam reader reads the symbol only once. In hand-held fixed beam reader the symbol can be rescanned easily. In the fixture mounted bar code reader some mechanism which moves the symbol towards the symbol is necessary i.e., an intervention by operator is needed. In fixed beam reader the contact with the symbol may erase the symbol and so it is less readable in subsequent attempts to read the symbol. Contact scanning of the symbol requires a smooth surface. So it is not suitable to read all the surfaces on which the symbols are printed. Light pens interpret a narrow section of the symbol printed on a surface. This may cause the distortion of the image. Fixed beam reader takes more time to read the symbol. Speed of fixed beam readers is a function of conveyor speed and height of the bar code symbol. Faster scanners are required for shorter symbols and slower scanners are required for larger symbols.

Moving Beam Reader

These minimize limitations of the fixed beam reader i.e., intervention problem and contact with the symbol. Moving beam reader, as the name indicates, scans the symbol by a line of light emitted from the reader. This is actually a spot which moves at faster rates appearing as a straight line. A moving beam reader takes less time to scan the symbol depending on the type of equipment. The light emitted from the moving beam reader can be drawn through the symbol in both the configurations i.e., hand held and conveyor configurations. Multiple viewing of the symbol provides quick and correct information to convert the image to computer data.

4.8.9 Elements of Bar Code Readers

The hardware of a bar code reader consists of a detector and a light source.

(i) All fixed, moving beam readers will have a single detector which samples very small areas of the symbol. The detector used is linear charge coupled device. These employ a line of detectors which takes a snap shot of the symbol and projects the image on photo sensitive device. Then the detector is amplified to know whether it has observed a space or a bar. This is applied for a bar code of maximum length of 5 cm or less. This cannot be used for larger bar codes. A matrix charge coupled device has a matrix of detectors (64 pixels long and 64 pixels high). These can be used either hand held or moving configurations or eliminates the problems associated with the voids, spots and edge roughness of the code. These can be used to detect long narrow bars as well as wide bars.

(ii) The light source employed in a bar code reader to illuminate the symbol may be a red light or infrared light. Red light is obtained from Helium-Neon lamp transmitting at 633 nanometres. The problem associated with this is that red and white colors appear to be same for the detector. Infrared light source operates at 900 nm and is invisible to the human eye but can be detected by the photo detector. Limitations of this type are the ink used to print bar code should have high carbon content. A light source which operates at 800 nm or nearly infra red range will be able to read dye and colour based inks having high carbon content. The cost of bar code system depends on the manufacturing facility. If the same manufacturing organization is printing and reading the symbol, the cost may be less. Optical Character Recognition

The optical character recognition (OCR)

employs special fonts which can be read by man and machine. This is more reliable than key entry but less reliable compared to bar code technology. OCR fonts or characters are 'read' by software template techniques or feature extraction or combination of both. So each character is to be unique compared to other characters in the set. When a number of pages of data are to be input to a computer system, optical page readers are very useful. Optical page readers are similar to the office copiers. In OCR, entire page is to be scanned before next page is presented to the reader. The characters in a page are identified by the reader by the specific font styles and sizes. In OCR, the reading device is to be passed over the OCR character a number of times. Here, the reader must be precisely positioned over the string which is to be read. The poses a problem when long strings of information are to be read. OCR is very sensitive to the motion of the operator's hand during reading. OCR cannot read the symbols on 77 the moving objects. To read the information on the moving objects a strobe light is to be synchronized with object. OCR techniques identify the horizontal and vertical strokes, curves and endings peculiar to each character. The absence of vertical redundancy and repeating character pattern causes OCR to be prone to errors. These are caused by poor print quality and those introduced through scanning process.

Magnetic Ink Character Recognition

Magnetic Ink Character Recognition (MICR) uses stylized OCR fonts. The fonts are printed with a magnetic ink to permit readability after being overprinted or even smudged. MICR is used to read smaller documents of size 7 to 20 cm. Like OCR, these also require precise orientation and registration.

Voice Recognition

Speech is the most natural way of communication. This eliminates the need of the user to understand a computer system. Voice technology is intelligently packaged and applied in several applications. Moreover the training can be minimized and the key board entry can be eliminated and hand and eye co-ordination is no longer needed. Voice recognition (VR) is of two types: (i) Speaker dependent (ii) Speaker independent Most voice recognition systems are speaker independent systems. VR systems recognize the user's vocabulary and store a computer image of each utterance and compare later the input words to the computer stored words. If the input matches the stored pattern, recognition is achieved. This provides larger vocabulary and accurate recognition. Commercial VR systems are having around a few hundred words in active vocabulary and skilful programming can develop application dependent vocabularies. Real application of VR systems rests on the fact that user need not be trained to use the system. Speaker independent system uses recognition template from memories of the previously recorded images. The templates represent speech patterns of both male and female speakers. These are now available with limited vocabularies.

Smart Cards

Smart cards are made of plastic. They are of the size of a credit card and are embedded with one or more microchips. These have an 8-bit or higher level microprocessors and will have a storage capacity of about 8 kB. Recent cards can carry up to 256 kB with the contacts removed and integrated with keypads. Personal identification numbers (PIN) prevent unauthorized use of smart cards.

Data Acquisition Systems (DAS)

The trend in shop floor data collection is towards the more use of the automated systems. Some of the bar code reading methods and other automatic identification methods discussed earlier can be operated in a fully automated mode. Computer process monitoring system involves a computer which is directly connected with the manufacturing process for the purpose of collecting the data on the process and the equipment. The hardware components of the computer process monitoring system used to input the data from the process are sensors and transducers, analog-to-digital converters, limit switches and photo detectors, pulse generators etc. A data acquisition system is a computer system used to collect the data from a process or piece of equipment. These perform an analysis of data or transmit the data to another computer for processing and analysis. A microprocessor is used as the controller/processor in a DAS. Other controllers use minicomputers or single board computers. The function of the controller/processor is to synchronize the data sampling and storage and tabulate data for presentation and statistical and other analysis. Components of DAS include analog transducers, Analog-to-digital converters, digital transducers, and digital input interfaces. Separate data acquisition modules are often attached with FMS elements to enable operation to send status information to the control computer.

4.8 Input and Output model Analysis in Manufacturing

A Typical Production System

Aim of Production System: To produce goods and services required for human consumption in the right quantity with the right quality at the right time in the most economical way

Classification of Production System:

- on the basis of Size – small, medium & large
- Input – Man, m/c, material, money, management, information, energy
- Output – Goods and services.

Production is defined as step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user.

A system is defined as a collection of elements which are interdependent and independent to achieve objective.

- A system consists of many sub-systems.

- A car is a system. Take out carburetor (sub-system) & the system as car cease to exist.

- A heap of sand is not a system. Take out a particle of sand and heap of sand is still there.

Generalized Model of Production System:

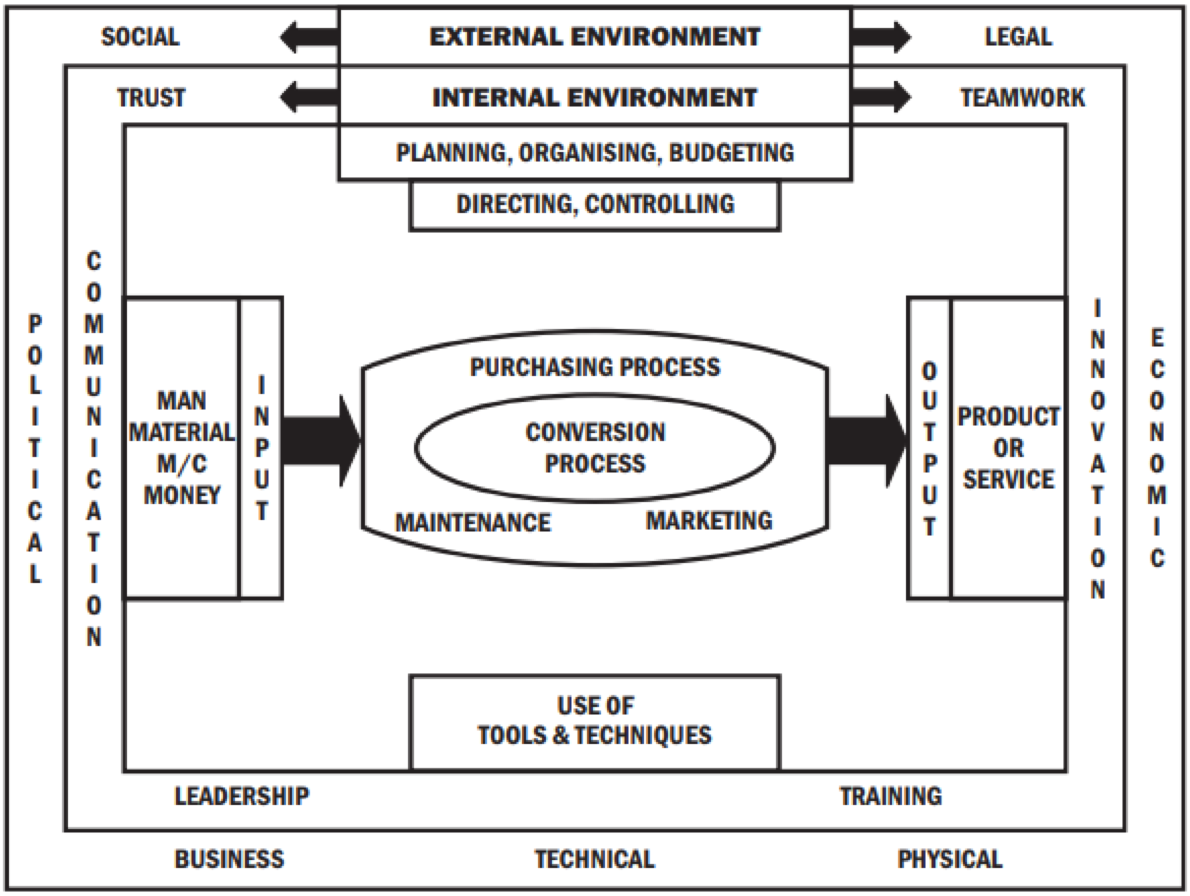


Fig. 4.15 Generalized Model of a Production System

Manufacturing systems use raw materials and auxiliaries such as water and air, and transform them into finished products. The transformation process requires inputs of energy. Solid and liquid wastes and gaseous pollution are often produced as byproducts of the manufacturing process. Figure 4.15 shows the basic inputs and outputs of a manufacturing system. Therefore, production systems and production activities can have both positive and negative impacts on the natural environment, natural resources, economy, and the surrounding communities. The negative effect may imply that soil is contaminated, and natural resources, water sources, energy sources, and pristine land mass depleted at such a rate that manufacturing activities cannot be sustained in the long-term without exceeding the natural limits. With this new awareness to minimize the impact of economic activities on the environment and natural resources, the term "sustainable manufacturing" has been coined.

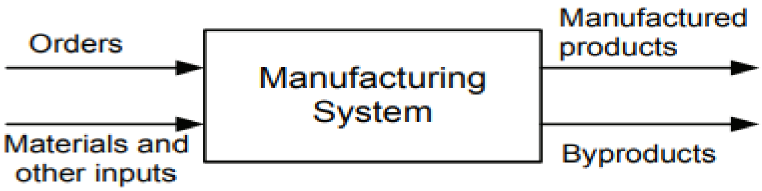


Fig. 4.16 Basic inputs and outputs of a manufacturing system

Manufacturing system model, in which the real manufacturing process is described with all the main characteristics which have a significant role in it, is based on the real manufacturing system layout and logical interdependence between the different elements of the manufacturing system. Data module is based on the data about the resources in the manufacturing system and the data about the schedule plan (manufacturing processes course). The model of the manufacturing system, presented in Fig.4.15, is based on the characteristics of a typical small company's representative with unique quantity production and is composed of three sub models, which are mutually interconnected and intertwined:

- product sub model,
- process sub model
- resources sub model.

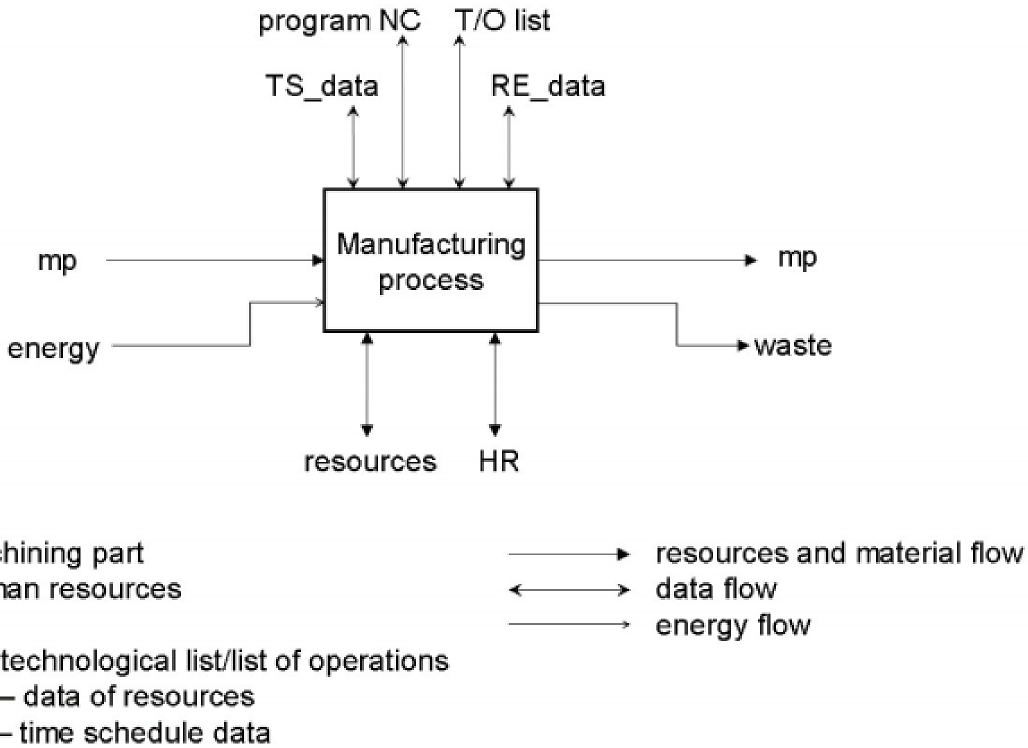


Fig. 4.17 Inputs and outputs of manufacturing process

The product sub model represents all cases of products in an observed time period and includes all variants of processes that can be carried out in the observed time period and are defined in detail. The resources sub model comprises all data about the resources in the production process and the data about the production process structure (factory structure) such as the manufacturing system layout and logical dependences between all the elements of the manufacturing system. The manufacturing process model from Fig. 4.16 incorporates all basic suppositions for the single manufacturing process execution. The manufacturing process can be started under the condition that all manufacturing factors like program NC, time schedule data, technological/operational list, data about all resources, energy, physical resources, human resources and the machining part, described in Table 1, are presented at the location where the manufacturing process will be carried out. Considering the previously mentioned sub models, the manufacturing process execution for the individual machining part is defined through a combination of the product sub model and the production process (factory) sub model. Manufacturing process execution actually consists of the sequence of operations which are defined in the technological plan of the production process. The operations' execution sequence for an individual workpiece with its input and output elements, especially resources, is presented by a logical scheme of manufacturing process execution, shown in Fig. 4.17.

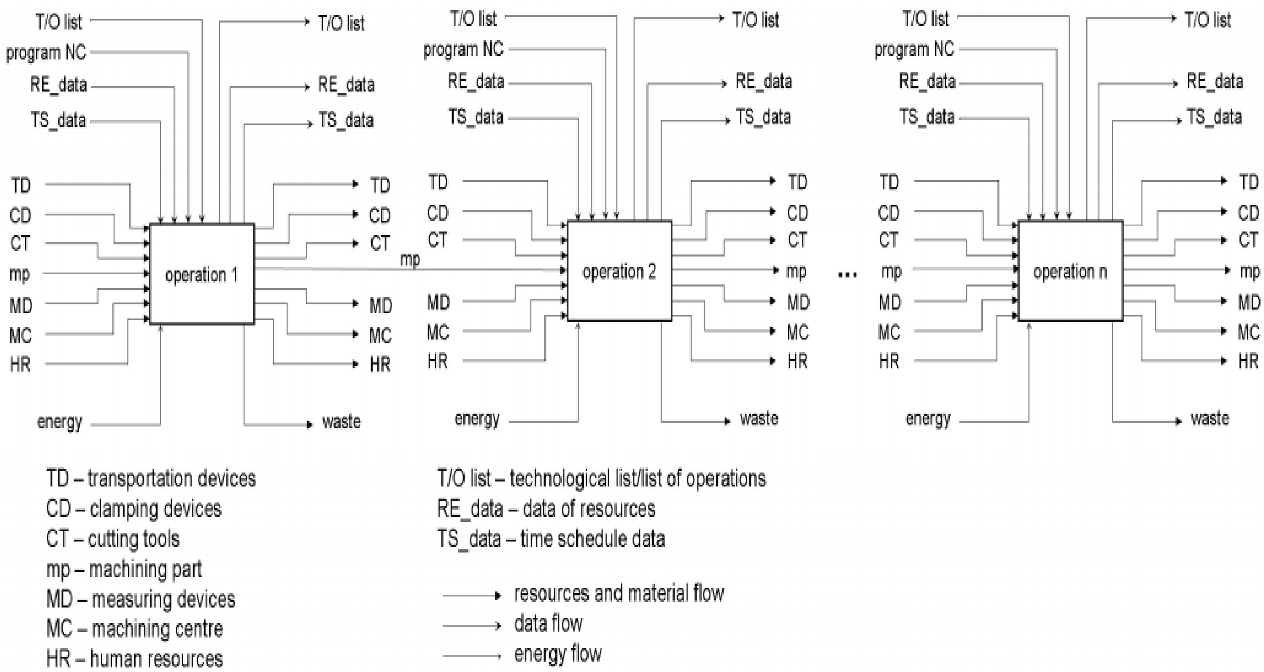


Fig. 4.18 Sequence of operations for individual machining part inside manufacturing process

Categories of Production Systems:

1. Make to Stock e.g. TV, Motors, Nuts & Bolts, Bearings etc.

2. Make to Order e.g. Custom Tailored Clothing, Special Purpose M/c etc.

3. Assemble to Order e.g. Computer System

Table 4.1: Comparisons

Particulars	Make to Stock	Make to Order	Assemble to Order
Product Range	Low	High	Medium / High
Production Volume	High	Low	Medium
Lead Time	Low	High	Medium
Customer Producer Interface	Limited / Distant	High at sales & design level	High at sales level
Handling of Fluctuations in demand	Safety stock of product units	Planning of excess capacity & raw material stock	Planning of standard modules & parts
Basis of plannning	End item forecasts	Back logs and marketing intelligence report	Back logs and trend analysis
Inventory level	High inventory level & associated inventory carrying costs	Low inventory level & associated inventory carrying costs	Major modules / parts held in inventory
Product Category & costs	Standardised products with loser price / unit	Special products (high variety) & high cost / unit	Modular parts / Sub-assembly Medium / high price / unit

4.8 Input and Output Modules for Stock Order

4.8.1 Master Creation:

The following master we must required for stock order input and output modules

- Material Master (included Material Code, Material Description, plant, storage location)
- Vendor Master (included vendor Code, Vendor Address, tax code, payment terms, vendor PAN number)
- Invoice Verification:

Once material came in to the factory along with invoice bill, To Compare Purchase order and invoice To check the material description, PO qty, Received Qty To Check tax are captured or not (VAT,CST,SEN VAT)

- Good Receipt:

Once material is came in the factory along with invoice bill, To Compare Purchase order and invoice To check the material description, PO qty, Received Qty To Check tax are captured or not (VAT,CST,SEN VAT)

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DEPARTMENT OF MECHTRONICS

M.E (CAD)

SPRA7007 - MANUFACTURING INFORMATION SYSTEMS

UNIT – V

INFORMATION SYSTEM FOR MANUFACTURING

Parts oriented production information system – concepts and structure – Computerized production scheduling, online production control systems, Computer based production m a n agreement system, computerized manufacturing information system -RFID-Telecommunication– case study.

5. INFORMATION SYSTEM FOR MANUFACTURING

5.1 Parts Oriented Production System

Thinking of production system in terms of allocation target, the system is called Parts Oriented Production System. In this system, standard parts and units are produced in advance, and these items are provided to the orders from customers. In this case, a wide variety of orders can be handled by combining these items with each other. The standard items which are produced in advance are called slack parts or intermediate stock goods, which are handled as policy inventory items. The parts, as shown in the figure, are produced according to the anticipation based on the demand forecast, and the productions from slack parts to products are performed according to actual job order. In other words, the Parts Oriented Production System is a complex production system where make-to-stock (before slack parts) and make- to-order (after slack parts) are coexisting. In this production system, the diversification of products and quicker delivery can be handled by setting the position of the slack parts, and the reduction of inventory is also possible by using the product allocation scheme. It is also important in this system to standardize the slack parts, keep the number of items to be controlled as few as possible, improve the accuracy of demand forecast in the slack parts. MRP is mainly used in the material planning of "make to stock" at the lower level than slack parts. Figure 5.1 shows make to order and make to order stock.

5.1.1 Parts Oriented Production Information System

"Parts-Oriented" is the concept which differs from "modularization and standardization of parts". Its focus is put on parts assembly and drastic restructuring of the whole construction process. One of the goals for this development is "The life of a building is extended twice longer, and construction cost and period are reduced to half." The main reason such extreme goal value was set up is that it could not be attained by mere development of any construction system on the extended line of the existing technology.

The parts- oriented production information systems (POPIS) is designed for the purpose of - producing diversified products, decreasing the manufacturing lead time, reducing the product inventory, and increasing the service level.

Structure of Parts Oriented Production Information Systems

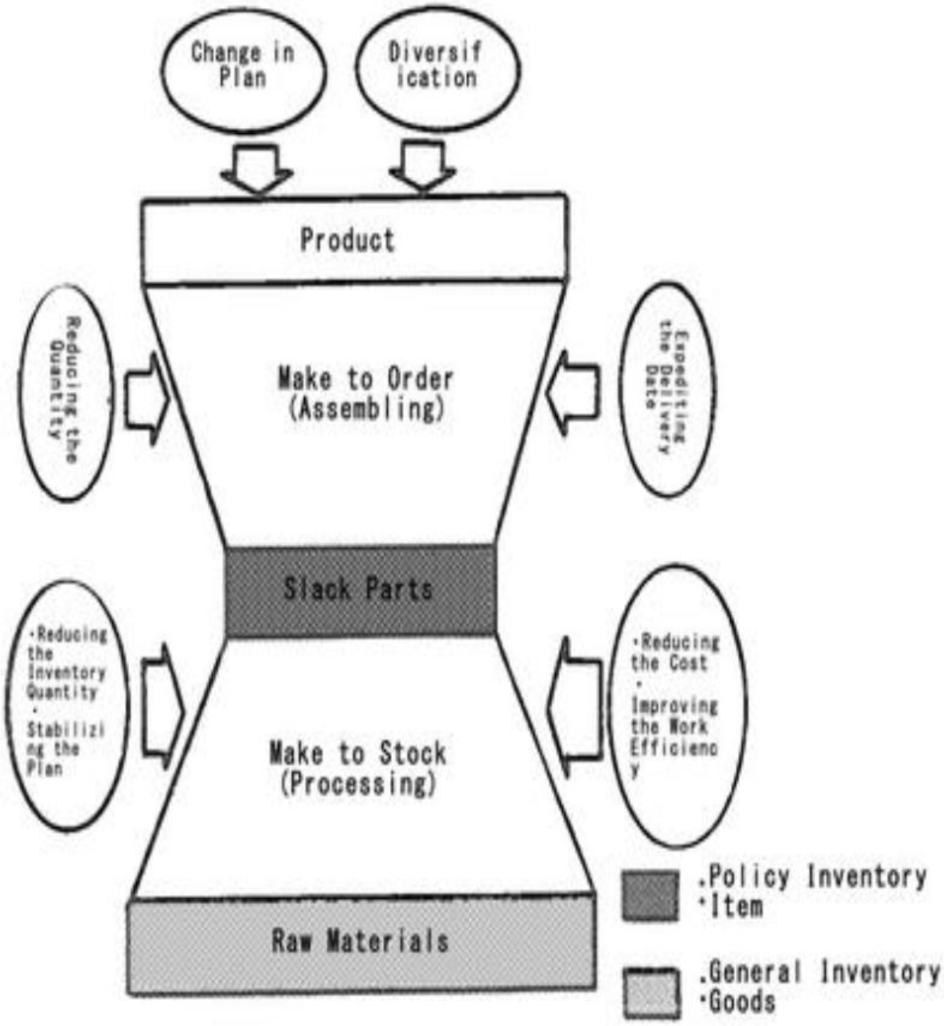

Fig 5.1 Make to order and Make to stock

The parts- oriented production information system (POPIS) is made up of three basic modules:

- The demand forecasting and production planning subsystem
- The parts production subsystem

- The products assembly subsystem

Module 1 Demand forecasting and production planning subsystem is concerned with forecasting demands and sales and planning, parts production and products assembly. It consists of the following functions:

Demand forecasting Receipt of orders Determining safety stock Parts production planning Products assembly planning

Module 2 Parts production subsystem establishes a production schedule required parts. It consists of:

Parts production scheduling

Parts production and inventory control

Module 3 Products assembly subsystem establishes the assembly schedule for required products. This consists of:

Products assembly scheduling Products assembly and shipment

Advantages of Parts Oriented Production Information Systems

The parts- oriented production information system provides the following general advantages:

- Variation in the amounts ordered and deviation between the primary and secondary information do not greatly affect parts production
- Manufacturing lead times are reduced or eliminated
- Parts- oriented production and information systems (POPIS) are very feasible and effective in the present day ever changing dynamic environmental situation of the manufacturing system.

5.2 Computerized Production Scheduling System

A computerized production scheduling system is described as the system that was developed to replace a manual system for scheduling production in a subsystem consisting of one hundred seventy people and considerable amount of expensive production equipment. This computerized system uses a deterministic simulator for scheduling production and requires large data bases.

5.2.1. Computerized Production Scheduling System Description

A computerized production scheduling system was designed and developed to schedule production for the production subsystem described above having the following capabilities:

- To produce a production schedule for a specified future time horizon given a set of available production resources and production requirements.
- To determine the impact on a production schedule for the changed available production resources in the plant.
- To determine the impact of changes in the production requirements on the scheduled completion dates of a current schedule and on the utilization of available resources.
- To enable the production supervisor to evaluate and select the “best” production schedule and assignment of resources by running the computerized production scheduling system for a various levels of available production requirements, including the use of over time.

5.2.1 Computerized Production Scheduling System Modules

This computerized production scheduling system consists of three modules (computer programs) that are designed to execute in series as one batch computer. The modules are a pre processor, a scheduling model, and a report generator. For each computer run the input required consists of general information, production resources information, and job (production requirements) information, and the system’s output consists of two resource utilization and three production scheduling reports. A diagram of this system is given in Fig.5.2.

The production schedule obtained from each computer run of this system depends upon the three sets of information input into the system .The general information input includes the time horizon of the desired production scheduled and the time intervals the time horizon is divided into specifying the available production resources. The production resources information input consists of the amounts of available production resources for each time interval in the time horizon. The job information input consists of information on the status of jobs in production (Job Categories I and III) and on future jobs(job categories II and IV), i.e., jobs that have not yet started production. Specifically, the information input on each future job (block) consists of its earliest possible starting date, production route or production routes allowed, job category, type of job, whether its task times are small, medium, or large (if it is a standard job, otherwise the estimated times to perform each task), and the number of map sheets in each block and for each job (block or map sheet) in production its status in addition to the appropriate information required for the future jobs.

The purpose of pre processor is to create in each computer run a production resources data base and job data base. The production resource data base is created from the input data with its size determined by the number of time intervals in the time horizon. Approximately 20% of its data entries are entered when the data base is created and remainder are entered as the production schedule is developed by the scheduling model. The job data basis is created from the input data and the task time data base contained in the pre processor. The task time data base contains three levels (small, medium and large) of estimated times in man hours to perform each task of all standard jobs. The size of the job data base usually large as each map sheet scheduled can have up to fifty five data entries.

A typical production schedule for the next two years will have 600 to 1000 map sheets resulting in the job data base having up to fifty-five thousand entries. Approximately half of job data entries are entered when the data base is created and the remainder are entered as the production schedule is developed by the scheduling model.

The scheduling model is a deterministic simulator of the production subsystem in Fig. 5.3 and its decision rules. This simulator is run over the time job and production resource data bases. As the simulator moves through time, the information required to create the production schedule (e.g., job) are stored in the job data base and the information reports (e.g., utilization of the production resources and number of jobs processed by each resource during each time interval) are stored in the production resource data base. After the scheduling model has run, the report using the stored data in the production resource data base. After the scheduling model has run, the report generator generates the five output reports using the data stored in the job and production resources data bases.

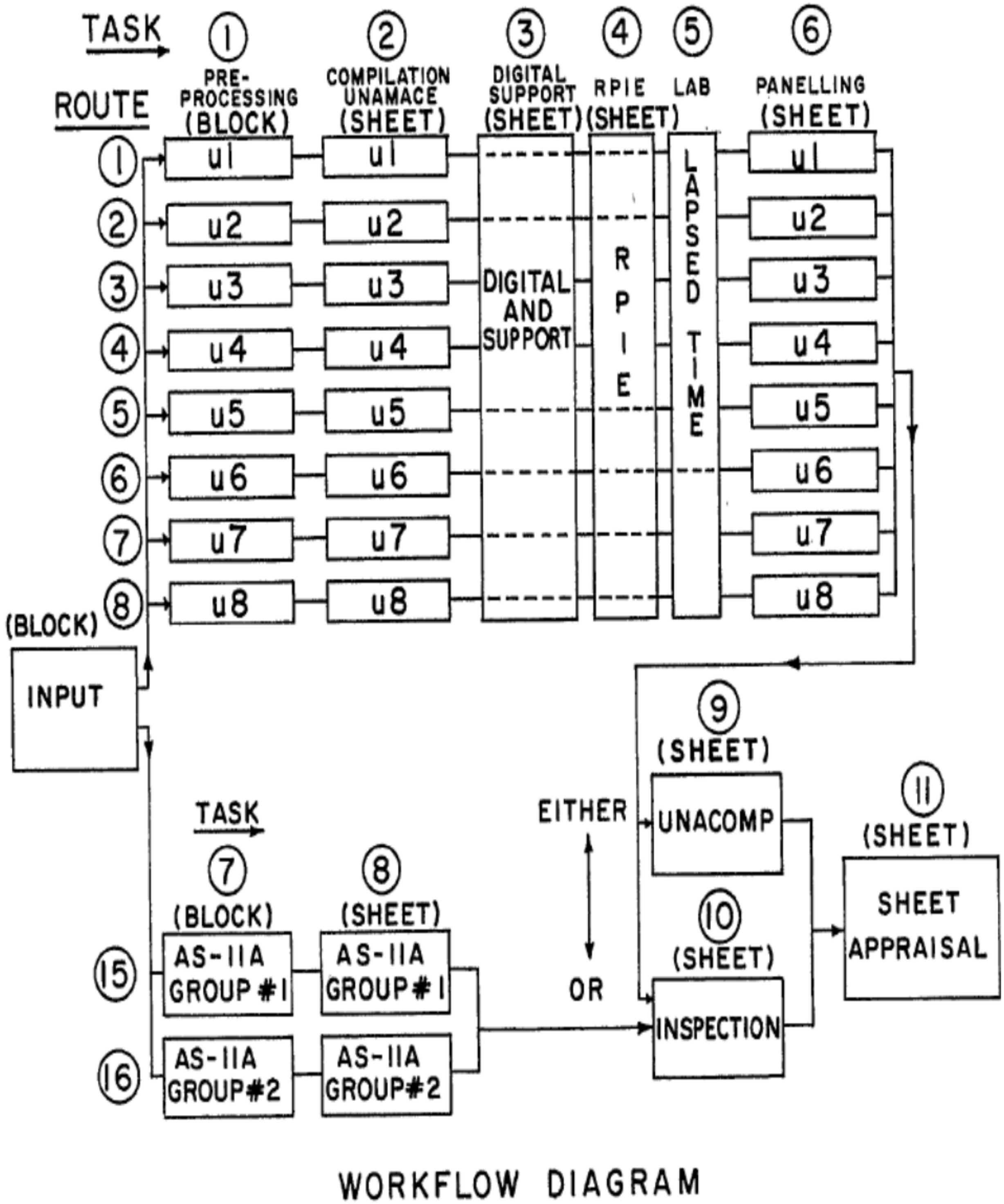

Fig 5.2 Work Flow Diagram

The resource utilization output reports are consists of a detail report and a summary report. The detail report contains the utilization of each resource for each time interval and information on jobs using each resource in each time interval such as the number of jobs processed, average job waiting time, and the number of jobs waiting at the end of the time interval. The summary report summarizes the detailed report.

The production scheduling reports consist of one detailed scheduling report and two scheduled job detailed, scheduling report and two scheduled job completion reports. The detail report contains the route scheduled and the scheduled starting and finishing times of each task for each job. The scheduled job completion reports are (1) a report of all scheduled job (map sheets) completions ordered by the scheduled completion data and the status of the jobs still in production at the end

of the time horizon, and (2) a report using a format currently in use containing the jobs (map sheets) scheduled to be completed over the next twenty four months ordered by block.

The computer language chosen for this computerized production scheduling system was FORTRAN. The reasons this language was selected were (1) the computer center limited all day and evening users of the computer to a small amount of main (core) programming, (2) the personnel knew FORTRAN, (3) three large data bases were required, (4) available simulation languages either could not handle this problem or could not handle it under the constraint imposed by the computer center, and (5) the desirability to have efficient program execution. The data bases were stored in secondary storage and the data bases were moved in sets periodically between main and secondary storage using a special fast Input\Output system available on this computer system. The data sets had to be designed with respect to what was needed and being generated by the scheduling model during its execution.

This computerized production scheduling system was verified and validated (Sargent 1979, 1981, Shannon 1975), by the production scheduler and one of the operations researches working together as a team. The methodology used was

- To initially test portions of the computerized system using a small number of job,
- To gradually increase the number and variety of job and production resources available until the total system was being tested

- To compare the results of an actual quarterly scheduling report(QSO) developed using the manual system with one produce from the computerized system.

(A QSR is a production schedule for the next two years prepared quarterly, i.e. every three months , given a set of available production resources, a set of job requirements, and status of job in production.) Initially, the two QRS's did not agree but the differences were traced to a different set of inputs being used. When identical inputs were used, the QSO's agreed and the computer system were considered verified and validate.

This new scheduling system was further evaluated during its first application. As the end of six weeks, seventy five percent (75%) of the jobs were found to be on target. The causes for the twenty five percent (25%) that were not on schedule were found to be unforeseen production delays or the production rates used were incorrect. Overall, the users were satisfied with the results time was reasonable for producing a production schedule for the next twenty four months which typically consists of thousands jobs. The most time consuming aspects of using this new production scheduling system is determined by the status of jobs in production to input into the computerized system.

Computerized production scheduling system containing a deterministic simulator and large data bases for scheduling production of a large production system was developed. The computer execution time was reasonable for producing a production schedule for the next twenty four months which typically consists of thousands jobs. The most time consuming aspects of using this new production scheduling system is determining the status of jobs in production to input into the computerized system.

5.2.2 Production Scheduling Software

Dispatch Lists

Production Scheduling is the process of generating "to-do" lists or dispatch lists for the shop floor. As part of a larger planning and scheduling process, production scheduling is essential for the proper functioning of a manufacturing enterprise.

Typically, staff generate dispatch lists for key production resources, be they machine, tooling, or labor. The lists consist of operations sorted in start date order. Sometimes, schedules show start and finish times, calculated based on estimated set up and run times for operations and the available time of the resource. The goal of the process is for the shop floor to operate in the most efficient manner possible, while still satisfying the timing of customer requirements.

The production scheduling process can over-emphasize efficiency at the expense of customer satisfaction, or customer satisfaction at the expense of efficiency.

Therefore, the best production schedules are generated not by shop floor staff, who are measured on efficiency, or customer service staff, who are measured by on-time delivery, but by a third group within operations that receives input from both the shop floor and from customer service.

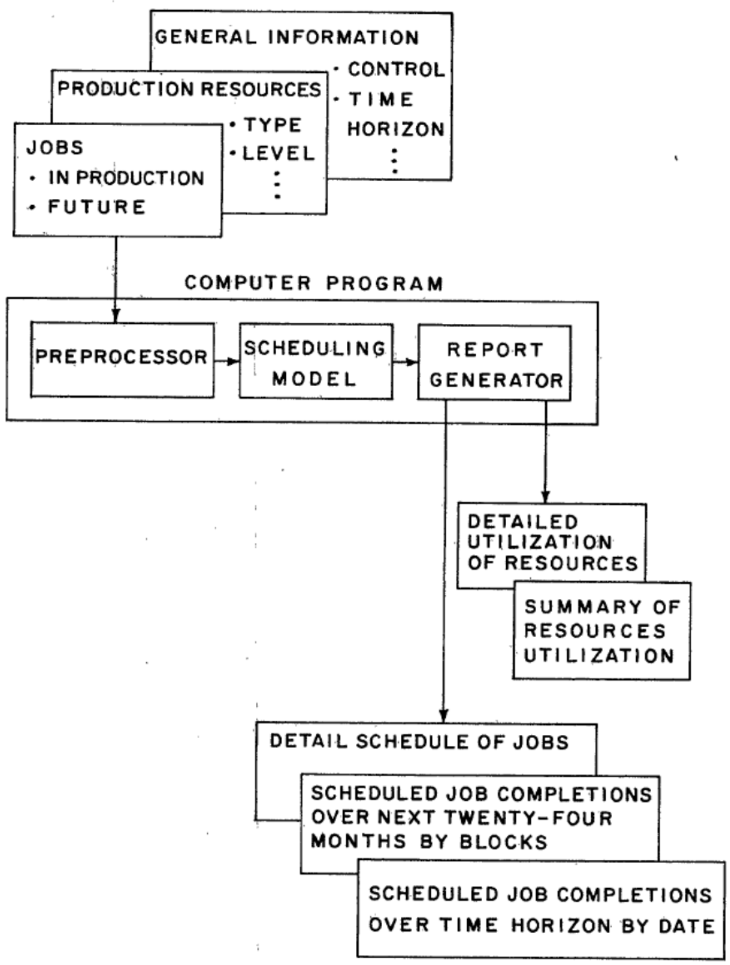

Fig 5.3 Computerized Production Scheduling System

5.2.3 Computerized Scheduling

Production scheduling can be a time consuming, tedious task. As work is completed, new orders are introduced, and other changes (e.g. machine breakdowns) occur, the schedule needs to be modified and / or regenerated. Prior to the computer age, staff scheduled by hand using pad and paper or with magnetic wall boards. With the advent of computers, practitioners at one point believed that MRP systems would eliminate the need for production scheduling. Operations staff soon realized that the Master Production Scheduling and Capacity Planning paradigms did little help to schedule the shop floor, and that these systems in no way eliminated the need to do so.

Production scheduling continued to be performed manually until the advent of readily available personal computers. PCs allowed schedulers to make use of software such as spreadsheets (i.e. Excel) to essentially automate manual scheduling . While spreadsheets sped up scheduling, they did little to change the fundamental approach.

Improved Modelling = Improved Scheduling

By their very nature, spreadsheet approaches are limited in their modelling capability. Without robust modelling capability, scheduling software loses its ability to accurately predict when the operations will finish. Modern, commercially available Finite Capacity Scheduling software and Advanced Planning and Scheduling software give users the ability to create detailed models of capacity. When capacity is accurately modelled, schedules that accurately predict operation start and finish times over any time can be easily generated. Just as importantly, the capacity models can be used as a what-if tool to aid in the decision making process.

5.3 Online production Control system

Online production control is dependent on manufacturing/service strategy and influenced by production organization, manufacturing technology and information management. The chapter analyses the fundamentals of an online production control system: control objectives, criteria for identifying potential problems in the forthcoming production period, in particular bottlenecks, and decision-making procedures. It proposes a framework for developing the decision support environment above a simulation software system in the creation of an online production control system.

Example: online production control system of a machine shop, based on PCM model simulation software and TURBO-PROLOG

Production/service on line control creates a well-defined set of procedures for coordinating people, materials, and machinery.

- Planning
- Routing
- Scheduling
- Dispatching
- Follow-up

Dispatching

Manager instructs each department on what work to do and the time allowed for its completion.

Follow-Up

Employees and their supervisors spot problems in the production process and determine needed changes.

Sequencing and Scheduling

develop a plan to guide the release of work into the system and coordination with needed resources (e.g., machines, staffing, materials).

Methods:

Sequencing:

- Gives order of releases but not times.

Scheduling:

- Gives detailed release times.

5.3.1 Case Study 1: online fees payment process for satyabama university

Step 1

University web site : www.satyabamauniversity.ac.in

Step 2

Click Tution fees, Special fees, Training fees, Book fees

Step 3

Give student information (Enter roll no, reg no and Date of Birth)

Step 4

Give mode of payment (Credit card, Debit card)

Step 5

Give name, sec number ()

Step 6

Get printed challen

Step 7

Verification purpose, you can see payment history

5.3.2 Case Study 2: Advantech's Multi-station Woodworking CNC Solution

Introduction

With the improvement of living standards and the awakening of the new generation's consciousness of individuality, custom furniture and full house customization is now the mainstream trend. Meeting customers' needs for custom furniture has become an important breakthrough point in the transformation of many traditional furniture manufacturers. Custom furniture for the whole house poses new challenges to production efficiency and styles. How to make custom furniture faster and more flexibly based on customer orders is a problem that equipment suppliers need to solve urgently.

Industry Status

At present, most of the new smart custom furniture manufacturers use order splitting software to send the orders to the woodworking processing equipment through the database, and then execute the processing program through the CAM software's path optimization feature and the CNC controller to realize custom processing. As the type and quantity of orders increase, higher requirements are placed on the processing rate and flexibility of the woodworking CNC. The traditional CNC system cannot meet these requirements, mainly in the following aspects:

- The traditional CNC system architecture is relatively closed; it's hard to expand and customize optimization, making it difficult to substantially increase efficiency;
- Traditional control systems have few interfaces and insufficient scalability, making it difficult to integrate upstream and downstream equipment to form production lines. It has low compatibility with the latest mechanical structures in the market;
- The G/M code is rigid, so it cannot quickly adapt to the specifications of the new processing application;
- Informatization is difficult; it is hard to connect the database and MES system, and difficult to informatize the production line;

Project Background

Client is a system integration company that integrates R&D, manufacturing, and sales. A long-term CNC wood milling machine customer proposed new demands to our client, hoping to further upgrade and optimize the original CNC milling machine's efficiency and ordering method, and at the same time, increase its compatibility with more higher-level software and MES systems to realize online dispatch and production.

Customer Needs

Enhance processing rate and control costs: Processing rate is the core indicator of equipment. Since the original controller is a traditional CNC system, the number of axes and programs are relatively fixed. To meet the new efficiency requirements, the customer must purchase three sets of CNC systems. As the costs increase, the communication and debugging costs between the CNC systems increase as well. Easy to connect other equipment: Woodworking equipment, originally stand-alone machinery, is now connected. This CNC wood milling machine requires an interface to connect to the PLC controller of the upstream double-end saw. The traditional CNC system cannot connect to the upstream PLC due to insufficient interfaces. High code compatibility: The G-code/M-code format of the original CNC system is rigid. If the new software introduces newly defined M-code, R&D support from the manufacturer is needed, which is difficult and takes a long time. Connect the database and MES to realize informatization: The dispatch and flexible processing of panel furniture requires the customer's equipment to be connected to the database and MES. The original system information interface is difficult to expand and integrate IT and OT.

Advantech's Solution

In response to the above customer requirements, Advantech jointly developed a WISE-5580 multi-station woodworking CNC solution with customer, which increased the processing rate from 2 minutes to 20 seconds, realized multi-station expansion, and connected the MES.

Solution Overview

Advantech's edge control solution, high-performance Intel processing core, using a sub-core and sub-system structure, a set of solutions integrates the Windows7 open information environment and CODESYS real-time automation kernel to achieve multi-axis motion control, CNC processing, and database and human-machine interface features. The embedded CNC function allows customers to define M-code flexibly, supports the EtherCAT bus, breaks the bottleneck of the traditional controller's axis control, and works with Shihlin Electric's SDP EtherCAT series servo motor drivers to easily realize multi-station simultaneous processing, greatly improving equipment processing rate. Modular interface expansion allows equipment to connect upstream and downstream equipment. Advantech's CODESYS database module allows equipment to quickly connect to an MES to achieve online dispatch.

Project Implementation

- AMAX-5580: PC-based edge controller, which can expand the plug-in I/O module and servo driver through the EtherCAT bus;

- AMAX-5000 I/O modules: Based on the EtherCAT I/O module, 1.2 cm slim design, realizes up to 100μs real-time communication control and can be flexibly configured according to different models;
- Advantech CODESYS PLC control software: Supports multi-axis motion control, CNC G/M code, and ODBC database protocol, can realize multi-axis open CNC control systems, connect IT and OT, and realize flexible processing through the database and MES.

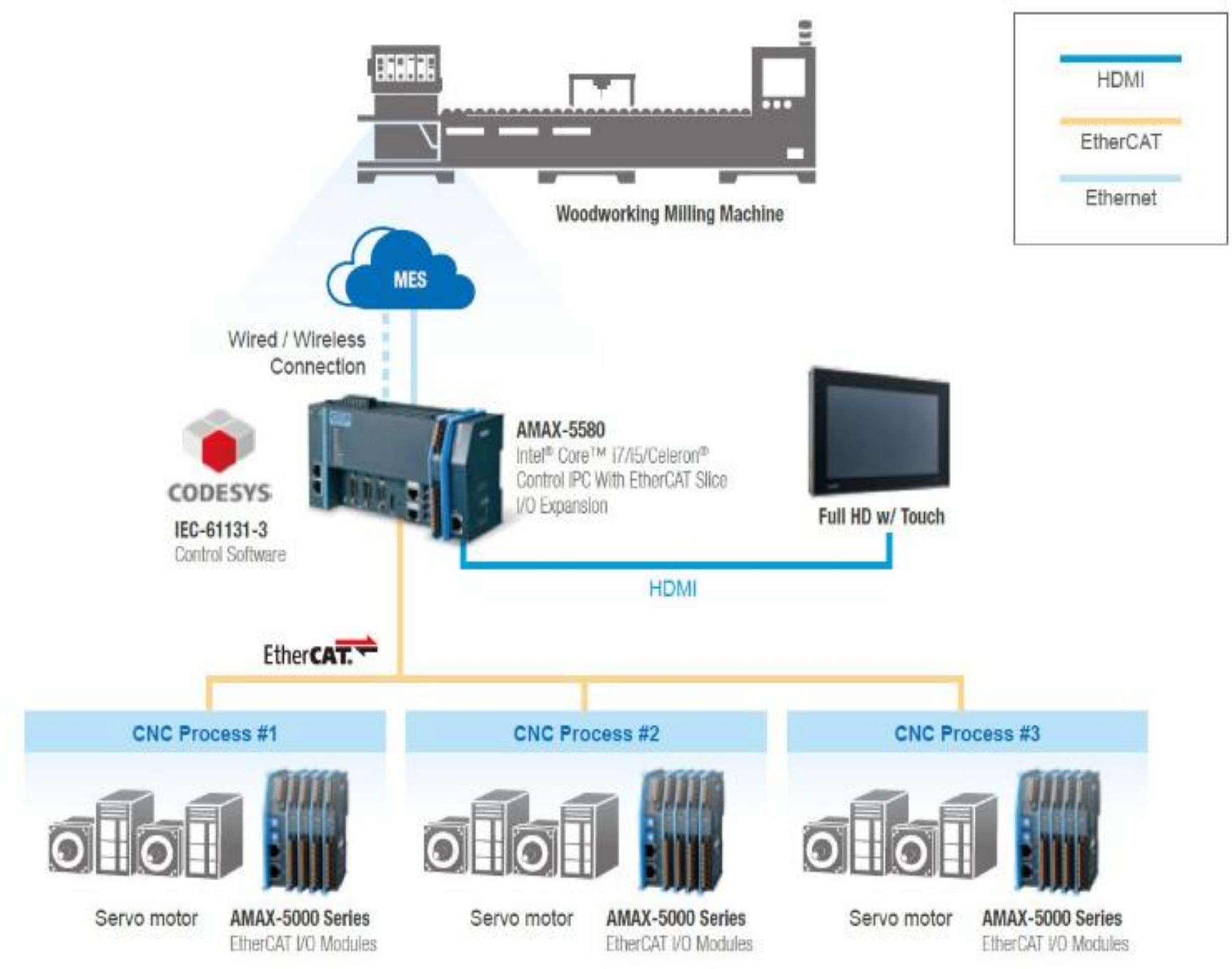

Fig 5.4 Advantech's Multi-station Woodworking CNC Solution

Advantages

- **Integrate IT and OT to achieve flexible manufacturing:** Because of Windows and the database communication feature, the customer's CAM software and MES can be integrated to realize order-based production and flexible manufacturing.
- **The number of axes is no longer a bottleneck, greatly improving the processing rate:** Based on the EtherCAT bus technology, it can quickly expand the servo axis to support up to 128 axes. It can increase the original processing station to three-stations for simultaneous processing. No human intervention is required to load and unload, which greatly improves the processing rate.
- **Rich communication interface that connects the upstream and downstream stations:** Advantech's edge controller supports RS232/422/485, Modbus, EtherCAT, EtherNet/IP, ProfiNET, and CANopen interfaces, which allows customers to easily connect the PLC of the upstream double-end saw and combine upstream and downstream stations to form a production line.
- **Open CNC system:** The support for standard G-code and custom M-code can be used to explain to customers that they may use various high-level CAM software to meet the requirements of more orders.

Project Outcomes

After the customer's CNC woodworking production line used Advantech's comprehensive solution, production efficiency was greatly improved. By optimizing the single-station to three-station processing, the original 2-minute process was reduced to 20 seconds. The MES and database communication interface integrates informatization and automation technologies to realize flexible processing and order-based manufacturing. The flexible expansion interface realizes the integration of upstream and downstream control equipment as well as woodworking and processing production lines.

5.4 Computer Aided Production Management system (CAPM)

Information systems are responsible for

- Transaction processing - maintaining, updating and making available specifications, instructions and production records

- Management information - for exercising judgements about the use of resources and customer priorities
- Automated decision making - producing production decisions using algorithms

CAPM Systems Modules

- Planning
- Control
- Performance measurement

Planning Modules

- Master Production Scheduling (MPS) - high level production plan in terms of quantity, timing and priority of planned production
- Materials Requirements Planning (mrp) / Manufacturing Resources Planning (MRP)
- Capacity Planning

Control Modules

- Inventory control - keeping raw material, work in process (WIP) and finished goods stocks at desired levels
- Shop floor control (Production Activity Control) - transforming planning decisions into control commands for the production process
- Vendor measurement - measuring vendors' performance to contract, covering delivery, quality and price

Performance measurement

- Chain Efficiency and effectiveness
- Payment process
- Penalty and Liquid damage control
- Man power appraisal
- Quality management measurement
- Supply chain Score card System

- Balance card System
- Six sigma performance measurement
- System Evaluation
- Quality Function Deployment

A module diagram of CAPM is given in Fig. 5.5.

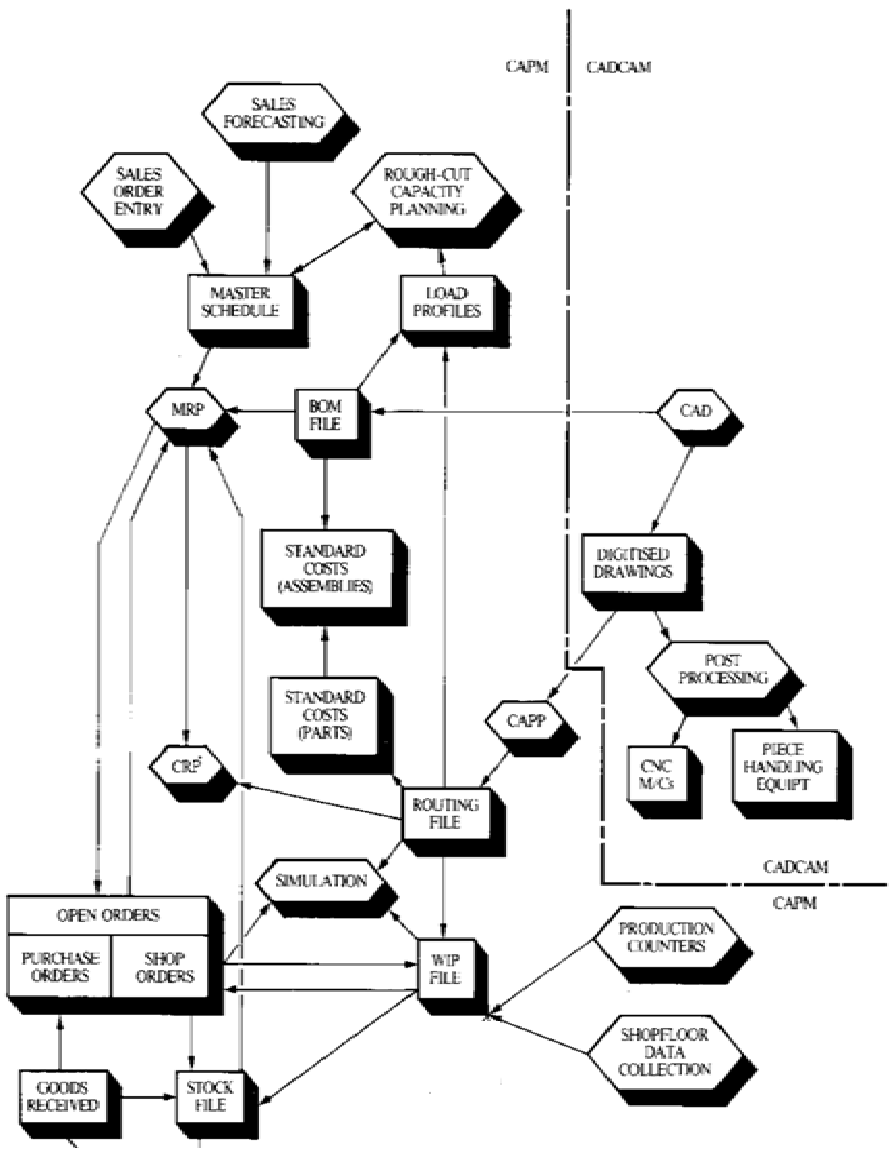

Fig 5.5 CAPM Systems Modules

5.4.1 Computer Aided Production Planning (CAPP)

With the advances both in computer software and hardware, certain manufacturing decisions presently are taken with the help of computer in efficient manner. With a suitable computerized production planning and control system, top management is generally able to get timely information of shop floor outputs.

Some of the common manufacturing subsystem that completes a PPC system includes:

- Product structure processor,
- Material requirement
- Product costing system,
- Inventory management system ,
- Master production scheduling system
- Capacity planning system
- Shop floor control and monitoring system,etc.

A Computer assisted production planning and control system must consists of central shop floor data handling system which processes the actual shop floor data. The secondary programmer covers the function of costing, maintenance, production planning, and covers different module of production system. A brief description of various computerized subsystem are given below.

Product Structure Process

This sub system includes data of an end product and its subsequent breakdowns, known as bill of materials. A program reads the bill of material files and interacts with the main production planning system as per the logic created in the system.

Any changes of this module can also schedule timing of planned order releases and generates specifications of components or assembly can be incorporated in this model through an updating program.

Any change of specification of component or assembly can be incorporated in this model through an updating programme.

Material requirement system

This sub systems performs periodical calculation for entire material plan. Updation of data can be incorporated from the inventory status file.This module also schedules timing of planned order releases and generates reports of inventory status, receipt of purchased items, lead time details, etc.

Product costing system

This subsystem generates report of product costing and indicates the breakup of costs of raw materials processing, labour, etc. When the cost of the product component changes, the subsystem prepares a cost comparison or cost variance report.

Inventory management system

Inventory management system produces the following documents:

1) Demand forecast for end items.
2) Net requirements from suppliers.
3) Report of inventory stock finished products.
4) Reorder point calculation sheet of each component.
5) Report of make or buy decision, etc.

These documents are sent to various departments so that appropriate action can be taken by the concerned departments.

Master production scheduling system

The master production schedule system assists the main system to maintain:

1) Accurate master production schedule data input,
2) proper treatment of backlog in production, and
3) Proper shop floor feedback.

A program written to validate the data can also be included in the system for preliminary check.backlog of production data, sales forecast, direct customers order and distribution centre orders form the input for the system.

Capacity planning system

In a computerised PPC system, short-term operational sequence planning is carried out as a first step in capacity planning system.

The aim of this module is to highlight the utilization versus capacity evaluation for each work centre.The time period requirements for specific machine centres are computed by programmes and comparison is made with the time availability of each machine centres.

Shop Floor Control and Monitoring System

Computerised shop floor control system ensures that the information gap between planning and shop floor functions is minimum.The rescheduling can be computed with the help of the shop floor control module and overall productivity of the shop floor can be improved.

This subsystem also prepares the following reports which are useful in the shop for:

1) Attendance,
2) Shop floor documentation,
3) Job assignment,
4) Quality control and manufacturing activities report, and
5) Materials handling report.

5.5 Radio-Frequency Identification (RFID)

Radio Frequency Identification (RFID), is a technology that is similar in theory to barcode identification. It is a wireless non-contact use of radio frequency electromagnetic fields to transfer data, for the purpose of automatically identifying and tracking tags attached to objects.

The tags contain electronically stored information. Some tags are powered and read at short ranges by magnetic fields. Others are powered by a local power source such as a battery, or in some cases they don't have a battery but collect energy from the interrogating EM field, and then act as a passive transponder to emit microwaves or UHF radio waves.

RFID tags are used in several different industries. They can be attached to an automobile during production and can be used to track its progress through the assembly line. Additional RFID applications include, pharmaceuticals which can be tracked through warehouses, during deliveries and when they have reached their destination. Livestock and pets may have tags injected, allowing positive identification of the animal. RFID tags can also be used to save lives when they are used on offshore oil and gas platforms. The tags are worn by personnel as a safety measure, allowing them to be located 24 hours a day and to be quickly found in emergencies.

The RFID chip's information is stored electronically in a non-volatile memory. The tag includes a small RF transmitter and receiver. An RFID reader transmits an encoded radio signal to interrogate the tag. The tag receives the message and responds with its identification information, which may only be a unique serial number or it may even be product related information such as a stock number, lot or batch number, production date, or other product specific information.

RFID systems can be classified by the type of tag and reader they require. A Passive Reader Active Tag (PRAT) system has a passive reader which only receives radio signals from active tags. The reception range of a PRAT system reader can be adjusted from 1-2,000 feet, allowing flexibility in applications such as asset protection and supervision.

An Active Reader Passive Tag (ARPT) system has an active reader, which transmits interrogator signals and also receives authentication replies from passive tags. An Active Reader Active Tag (ARAT) system uses active tags that is initiated with an interrogator signal from an active reader. A variation of this system could also use a Battery Assisted Passive (BAP) tag which acts like a passive tag but has a small battery to power the tag's return reporting signal.

Readers that are fixed in place can be setup to create a specific interrogation zone which can be tightly controlled. This allows a highly targeted reading area for when the tags go in and out of the interrogation zone.

RFID is an acronym for "radio-frequency identification" and refers to a technology whereby digital data encoded in RFID tags or smart labels (defined below) are captured by a reader via radio waves. RFID is similar to barcoding in that data from a tag or label are captured by a device that stores the data in a database. RFID, however, has several advantages over systems that use barcode asset tracking software. The most notable is that RFID tag data can be read outside the line-of-sight, whereas barcodes must be aligned with an optical scanner. If you are considering implementing an RFID solution, take the next step and contact the RFID experts at AB&R® (American Barcode and RFID).

5.5.1 How does RFID work?

RFID belongs to a group of technologies referred to as Automatic Identification and Data Capture (AIDC). AIDC methods automatically identify objects, collect data about them, and enter those data directly into computer systems with little or no human intervention. RFID methods utilize radio waves to accomplish this. At a simple level, RFID systems consist of three components: an RFID tag or smart label, an RFID reader, and an antenna. RFID tags contain an integrated circuit and an antenna, which are used to transmit data to the RFID reader (also called an interrogator). The reader then converts the radio waves to a more usable form of data. Information collected from the tags is then transferred through a communications interface to a host computer system, where the data can be stored in a database and analyzed at a later time.

5.5.2 RFID Tags and Smart Labels

As stated above, an RFID tag consists of an integrated circuit and an antenna. The tag is also composed of a protective material that holds the pieces together and shields them from various environmental conditions. The protective material depends on the application. For example, employee ID badges containing RFID tags are typically made from durable plastic, and the tag is embedded between the layers of plastic. RFID tags come in a variety of shapes and sizes and are either passive or active. Passive tags are the most widely used, as they are smaller and less expensive to implement. Passive tags must be "powered up" by the RFID reader before they can transmit data. Unlike passive tags, active RFID tags have an onboard power supply (e.g., a battery), thereby enabling them to transmit data at all times. For a more detailed discussion, refer to this article: Passive RFID Tags vs. Active RFID Tags.

Smart labels differ from RFID tags in that they incorporate both RFID and barcode technologies. They're made of an adhesive label embedded with an RFID tag inlay, and they may also feature a barcode and/or other printed information. Smart labels can be encoded and printed on-demand using desktop label printers, whereas programming RFID tags are more time consuming and requires more advanced equipment.

5.5.3 RFID Applications

RFID Technology Is Employed In Many Industries To Perform Such Tasks As:

1. Inventory management
2. Asset tracking
3. Personnel tracking
4. Controlling access to restricted areas
5. ID Badging
6. Supply chain management
7. Counterfeit prevention (e.g. in the pharmaceutical industry)

5.5.4 RFID Applications

Although RFID technology has been in use since World War II, the demand for RFID equipment is increasing rapidly, in part due to mandates issued by the U.S. Department of Defense (DoD) and Wal-Mart requiring their suppliers to enable products to be traceable by RFID.

Whether or not RFID compliance is required, applications that currently use barcode technology are good candidates for upgrading to a system that uses RFID or some combination of the two. RFID offers many advantages over the barcode, particularly the fact that an RFID tag can hold much more data about an item than a barcode can. In addition, RFID tags are not susceptible to the damages that may be incurred by barcode labels, like ripping and smearing.

From the read distance to the types of tags available, RFID has come a long way since World War II and there is a bright future ahead. Review the evolution of RFID.

For more information about how RFID works and how to integrate this technology into your business processes, read our RFID Basics.

5.5.5 RFID Case studies

Case Study

subject matter for RFID implementation in its Manufacturing Supply Chain Process. Time and Cost for each step of Manufacturing Process was reviewed and financial model was established to convince entrepreneur to adopt RFID and its associated Information Technology as tools for maximizing business output.

One main stream export oriented Knit Garment Manufacturer and Exporter, Posh Apparel Ltd. Bangladesh was studied to capture manufacturing business process and scope of implementing RIFD and its associated IT solutions.

While studding following hypothesis were considered:

Hypothesis 1: IT with captured information through RFID will increase transparency between parties involved. Apparel Manufacturers will be the center of these beneficiary parties. **Hypothesis 2:** RFID implementation will reduce work load for management team, increase purchase order from buyer by ensuring clear view of Supply Chain and Manufacturing pipe line. Assumptions: All labour and physical process of manufacturing processes are optimized, no further enhancement is necessary to adopt RFID and IT Solutions.

Definitions of Related Terms

Return on Investment (ROI):

Calculating return on investment (ROI) is one of the most challenging and intriguing issues facing the information technology (IT) sector. Several factors are driving this increased interest in ROI. ROI computation takes the sum of returns over a three-year period, which often drastically overstates ROI. In the research RIO is used to project feasibility of RFID implementation

RFID & Its Evolution

RFID is considered as “a key to automating everything”. RFID technology is classified as a wireless automatic identification and data capture (AIDC) technology. Basically RFID system composed of three layers: a tag containing a chip, a reader, its antennas and a computer. RFID tag can be attached to or embedded in a physical object and communicates through radio frequencies with the reader’s antennas. The reader sends the location and identification of the object to a computer equipped with a middleware program, in which business rules are configured.

Establishing Scope of Work:

Innovation of RFID has opened scope for optimizing several business processes and derives financial benefit out of it. In the perspective of Supply Chain, RFID ensure elimination of manual inventory counting, warehouse miss-picking, and order numbering mistakes by providing precise data on product location, product characteristics and product levels. From an information systems perspective, RFID can be viewed as another technology for capturing source data. RFID technology has been considered as “the next revolution in supply chain”. since it allows the tracking of each object or product in real time in the supply chain. Supply chain with RFID technology can be considered as global network of integrated hubs of suppliers and clients that create, track and deliver RFID tagged finished products manufactured from raw materials and semi-finished parts to multiple destinations from multiple supply sources. C. Work-in-progress (WIP) Monitoring in Manufacturing System with RFID Tracking work-in-progress with RFID gives real time visibility into processes and operation. Which ensures time saving, quality improvement, commitment to concerned supply chain partners and other beneficiary. RFID in will ensure right inputs at each stage of manufacturing work in progress; it will confirm right input, in right time and at right place. Central MIS system facilitated by latest communication infrastructure provide decision making tools to all relevant parties to ensure manufacturing WIP more coordinated.

RFID and Manufacturing Supply Chain Model of Knit Apparel

Among different types of Apparel, Knit Apparel manufacturing process involve different sequential sub processes. Knit garments manufacturing involves multiple inter-party process. To successfully complete and export a consignment suppler and manufacturer has to ensure coordinated effort between each part of the manufacturing supply chain process. Quality, quantity and time have to be ensures among all parts of the manufacturing supply chain process

Manufacturing Supply Chain Tracking

Every step of Knit Apparel Manufacturing process has its own activity and every process is interdependent. To make successful completion of export order, progress at each step has to be tracked. Currently real-time information on work-in progress tracking is almost unavailable. But keying work-in progress data from traditional system has human involvement, may have wrong information. Which eventually result as failure to delivering goods on time.

Scope of RFID and Associated Technologies

Considering higher cost of RFID tag, it would not be feasible to cover each individual item of apparel manufacturing work in progress. The research may use RFID tag for each larger unit of output at every work in progresses. RFID tags might be reused; it will start its journey from RAW materials input into the manufacturer's store and end at delivery of master pack to shipping agent for export. Again the same RFID can be reused starting from RAW material store. RFID tags will be reused at every steps of manufacturing supply chain process. Like goods from knitting section will be tagged on 100 lbs bundle and captured by RFID antenna while exiting through the store of Knitting section. When the knitted fabric received at dyeing section it will pass through the RFID antenna of dyeing store, RFID tags will be detached from the fabric. After necessary process by dyeing section same tags will be attached with larger measurable unit of dyed fabric and pass through the RFID antenna while delivering to next manufacturing process section. The back-end system will use this data to track how many pieces are completed, as well as how many pieces of each garment order have reached each step in the manufacturing process. This kind of real-time information sharing is not possible with the paper-ticket tracking system.

Application Software for RFID Adaptation

Four level application architecture is required for utilization of RFID information. To cover all parties involved in Knit Apparel Manufacturing Supply Chain process, the research recommend to utilize web service as middle tier between Work in progress executing parties and all other relevant parties.

1) Application Level 1:

The research suggested tools to assign and reassign tag and map with respective work in progress item at its appropriate quantity. Every large measurable unit of raw material will be assigned with RFID tag and Tags will be reused.

2) Application Level 2:

At this stage application is used to capture Work-in-progress data. After receiving raw materials for work in progress at any specific stage goods will be entered at store through RFID Reader antenna. It will update stock of Raw material for said stage. RFID tags will then be removed for the goods. After necessary conversion at this stage same tags will be assigned to finished goods of this stage

3) Application Level 3:

Using application interface of Level 3, management team of the main manufacturer and exporter may monitor and track work in progress for total ordered quantity. Main advantage of RFID implementation will be derived by this application. Looking at the application window Main manufacturer can take decision which part of the work-in-progress is not aligned with targeted progress and can take corrective measures before it's too late.

4) Application Level 4:

At this level application will be prepare to facilitate monitoring by Buyer/Importer and Exporter and can help to take reorder decision. Application window of level 4 will show L/C wise overall status. Viewing application interface of Level 4 buyer can arrange his location of the work in progress will have this server to store captured RFID data, generate at each work in progress stage. The third level of server works a gateway between all application servers to transport data between data generation point to data viewers. A web service server will be deployed at this level. Data generated by RFID tag assign/ reassign server and RFID tag capture server will be passed to web service server. Fourth level of servers is core application servers maintained at Buyer, exporter and raw materials suppliers premises. Three main application servers namely Buyer's Application Server, Manufacturer's Application Server and RAW material Supplier's Application Server can exist. At this stage pull data from Web Service Server to update its' database with work-in-progress tracking information. Application Level 3 and 4 mentioned at previous section server at this stage. Data flow at this stage help buyer and exporter to track work in progress for each L/C.

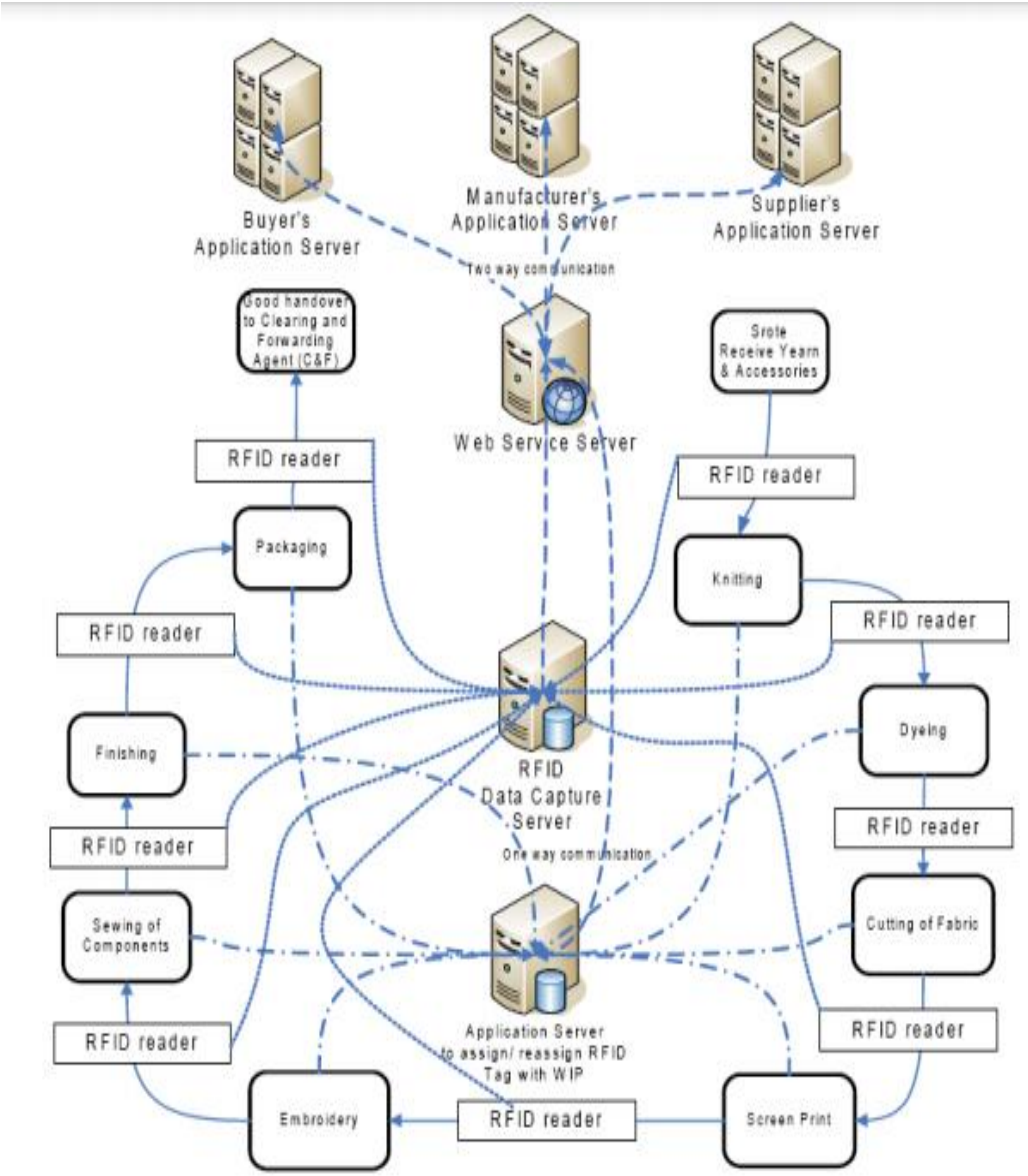

Fig.5.6 Data Flow architecture and server

Network Infrastructure for RFID Implementation

It will be mixed architecture for network infrastructure. Level 1 of Figure 1, i.e. application server for assign/ reassign RFID Tag will be under LAN of factory/ office network. This application server will be connected with Level 2 of Figure 1, i.e. RFID data capture server with local area network. Server of level 2 will have Internet connectivity to ensure data transmission to web service server at level 3. Internet connectivity with bandwidth around 16 KB would serve for data transmission with web service server, though actual bandwidth depends on volume of data generated and transmitted at Level 1 and 2. Level 3 Web service server will require high speed Internet connectivity to facilitate data push pull by local application of level 1, 2 and 4. Level 4 servers will fetch data from web service through Internet. Bandwidth requirement for this level is similar to level 3's needs. Bandwidth requirement may change based of data generation and transmission volume at level 1 and 2 as well.

Manpower for RFID Implementation

Manpower for manual counting and capturing work-inprogress can be utilized for adaptation RFID. They can be utilized to physically attached RFID tag with output of specific work in progress. For RFID tag assign/reassign activity, data entry operator can be assigned. RFID data capture will be done automatically no extra manpower is required to capture RFID data. While passing goods with RFID tag through RFID antenna and reader data will be automatically read and entered into RFID data capture server. Web server operates automatically, RFID assigning server and capture servers will update web service server programmatically. Application Server at Buyer, manufacturer and supplier end will also be updated with work in progress data programmatically. To run application for viewing status these parties usually already should have very good manpower.

Costs and Benefits Analysis of RFID Implementation

The IT project's costs of integration, support, training, and maintenance are much higher than the actual purchase price of needed hardware and software. For this reason, the costs should be calculated with a total cost of ownership (TCO) analysis. Costs Factor: To have idea of financial involvement for RFID implementation, the research may consider following basic components cost as mentioned bellow:

1. Passive RFID tags: passive 915-MHz Electronic Product Code (EPC) Gen 1 and 2 - $0.20 to $0.45 each

2. EPC-compliant antennas — $250 to $600 each

3. EPC-compliant readers — $500 to $2,500 each Cost for RFID implementation for Knit Apparel Manufacturing Supply Chain depends on number of factory and warehouse, number of subcontractor involved etc.

5.6 Information Systems

Information system has been defined in terms of two perspectives: one relating to its function; the other relating to its structure. From a functional perspective; an information system is a technologically implemented medium for the purpose of recording, storing, and disseminating linguistic expressions as well as for the supporting of inference making. From a structural perspective; an information system consists of a collection of people, processes, data, models, technology and partly formalized language, forming a cohesive structure which serves some organizational purpose or function. The functional definition has its merits in focusing on what actual users - from a conceptual point of view- do with the information system while using it. They communicate with experts to solve a particular problem. The structural definition makes clear that IS are socio-technical systems, i.e., systems consisting of humans, behaviour rules, and conceptual and technical artefacts.

An information system can be defined technically as a set of interrelated components that collect (or retrieve), process, store, and distribute information to support decision making and control in an organization. In addition to supporting decision making, coordination, and control, information systems may also help managers and workers analyze problems, visualize complex subjects, and create new products.

Three activities in an information system produce the information that organizations need to make decisions, control operations, analyze problems, and create new products or services. These activities are input, processing, and output. Input captures or collects raw data from within the organization or from its external environment. Processing converts this raw input into a more meaningful form. Output transfers the processed information to the people who will use it or to the activities for which it will be used. Information systems also require feedback, which is output that is returned to appropriate members of the organization to help them evaluate or correct the input stage.

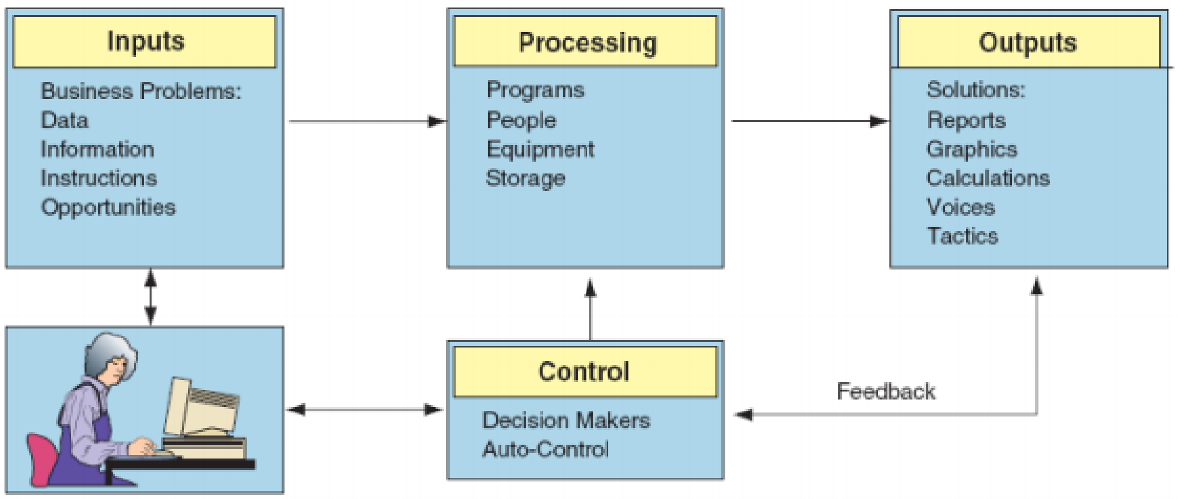

Fig 5.7: Functions of an information system

5.7 Computer-Based Information System

A computer-based information system (CBIS) is an information system that uses computer technology to perform some or all of its intended tasks. Such a system can include as little as a personal computer and software. Or it may include several thousand computers of various sizes with hundreds of printers, plotters, and other devices, as well as communication networks (wire-line and wireless) and databases. In most cases an information system also includes people. The basic components of information systems are listed below. Note that not every system includes all these components.

Components of Information Systems

1. Resources of people: (end users and IS specialists, system analyst, programmers, data administrators etc.).

2. Hardware: (Physical computer equipments and associate device, machines and media).

3. Software: (programs and procedures).

4. Data: (data and knowledge bases), and

5. Networks: (communications media and network support).

5.7.1 People Resources

• End users: (also called users or clients) are people who use an information system or the information it produces. They can be accountants, salespersons, engineers, clerks, customers, or managers. Most of us are information system end users.

• IS Specialists: people who actually develop and operate information systems. They include systems analysts, programmers, testers, computer operators, and other managerial, technical, and clerical IS personnel. Briefly, systems analysts design information systems based on the information requirements of end uses, programmers prepare computer programs based on the specifications of systems analysts, and computer operators operate large computer systems.

5.7.2 Hardware Resources

• Machines: as computers and other equipment along with all data media, objects on which data is recorded and saved.

• Computer systems: consist of variety of interconnected peripheral devices. Examples are microcomputer systems, midrange computer systems, and large computer systems.

5.7.3 Software Resources

Software Resources includes all sets of information processing instructions. This generic concept of software includes not only the programs, which direct and control computers but also the sets of information processing (procedures). Software Resources includes:

• System software, such as an operating system

• Application software, which are programs that direct processing for a particular use of computers by end users.

• Procedures, which are operating instructions for the people, who will use an information system. Examples are instructions for filling out a paper form or using a particular software package.

5.7.4 Data Resources

Data resources include data (which is raw material of information systems) and database. Data can take many forms, including traditional alphanumeric data, composed of numbers and alphabetical and other characters that describe business transactions and other events and entities. Text data, consisting of sentences and paragraphs used in written communications; image data, such as graphic shapes and figures; and audio data, the human voice and other sounds, are also important forms of data.

Data resources must meet the following criteria:

- Comprehensiveness: means that all the data about the subject are actually present in the database.
- Non-redundancy: means that each individual piece of data exists only once in the database.
- Appropriate structure: means that the data are stored in such a way as to minimize the cost of expected processing and storage.

The data resources of IS are typically organized into:

- Processed and organized data-Databases.
- Knowledge in a variety of forms such as facts, rules, and case examples about successful business practices.

5.7.5 Network Resources

Telecommunications networks like the Internet, intranets, and extranets have become essential to the successful operations of all types of organizations and their computer-based information systems. Telecommunications networks consist of computers, communications processors, and other devices interconnected by communications media and controlled by communications software. The concept of Network Resources emphasizes that communications networks are a fundamental resource component of all information systems. Network resources include:

• Communications media: such as twisted pair wire, coaxial cable, fiber-optic cable, microwave systems, and communication satellite systems.

• Network support: This generic category includes all of the people, hardware, software, and data resources that directly support the operation and use of a communications network. Examples include communications control software such as network operating systems and Internet packages.

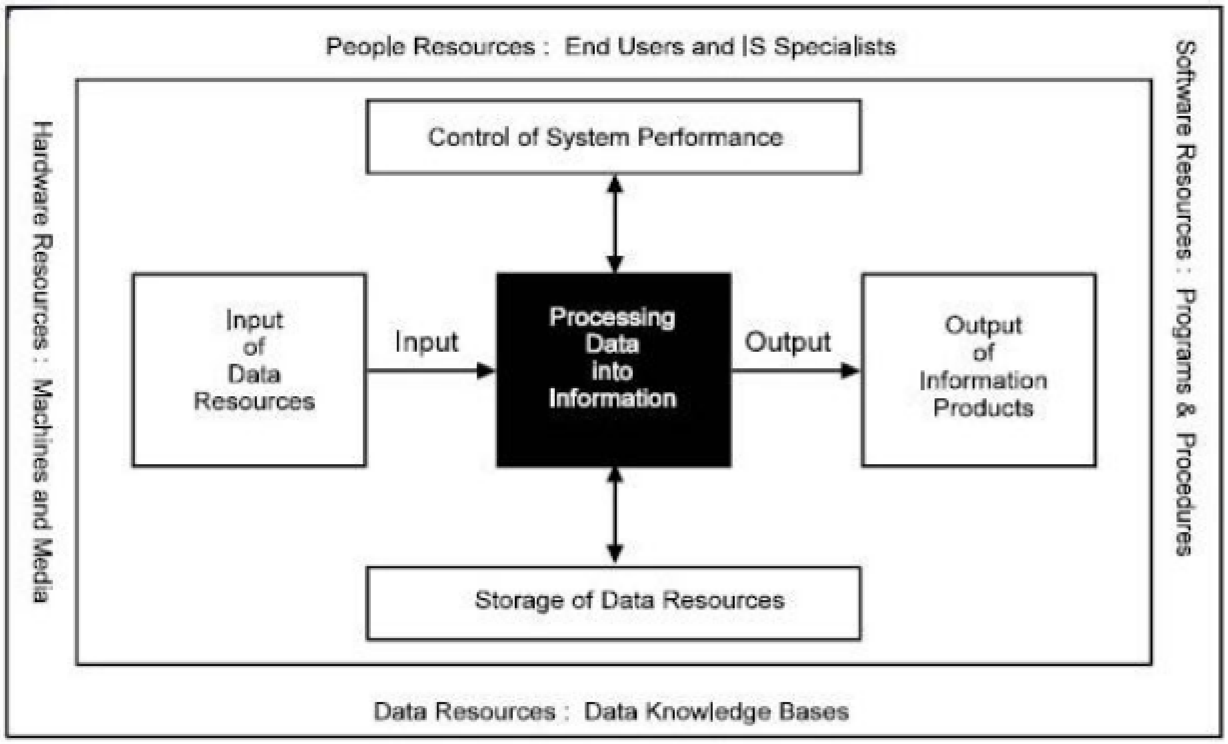

Fig 5.8: Components of Information System

5.7.6 Difference between Computers and Information Systems

Computers provide effective and efficient ways of processing data, and they are a necessary part of an information system. An IS, however, involves much more than just computers. The successful application of an IS requires an understanding of the business and its environment that is supported by the IS. For example, to build an IS that supports transactions executed on the New York Stock Exchange, it is necessary to understand the procedures related to buying and selling stocks, bonds, options, and so on, including irregular demands made on the system, as well as all related government regulations. In learning about information systems, it is therefore not sufficient just to learn about computers. Computers are only one part of a complex system that must be designed, operated, and maintained. A public transportation system in a city provides an analogy. Buses are a necessary ingredient of the system, but more is needed.

Designing the bus routes, bus stops, different schedules, and so on requires considerable understanding of customer demand, traffic patterns, city regulations, safety requirements, and the like. Computers, like buses, are only one component in a complex system.

5.7.7 Information Technology and Information Systems

Information technology broadly defined as the collection of computer systems used by an organization. Information technology, in its narrow definition, refers to the technological side of an information system. It includes the hardware, software, databases, networks, and other electronic devices. It can be viewed as a subsystem of an information system. Sometimes, though, the term information technology is also used interchangeably with information system. The term IT in its broadest sense used to describe an organization's collection of information systems, their users, and the management that oversees them.

A major role of IT is being a facilitator of organizational activities and processes. That role will become more important as time passes. Therefore, it is necessary that every manager and professional staff member learn about IT not only in his or her specialized field, but also in the entire organization and in inter-organizational settings as well. Obviously, you will be more effective in your chosen career if you understand how successful information systems are built, used, and managed. You also will be more effective if you know how to recognize and avoid unsuccessful systems and failures. Also, in many ways, having a comfort level with information technology will enable you, off the job and in your private life, to take advantage of new IT products and systems as they are developed. (Wouldn't you rather be the one explaining to friends how some new product works, than the one asking about it?) Finally, you should learn about IT because being knowledgeable about information technology can also increase employment opportunities. Even though computerization eliminates some jobs, it also creates many more. The demand for traditional information technology staff—such as programmers, systems analysts, and designers—is substantial. In addition, many excellent opportunities are appearing in emerging areas such as the Internet and e-commerce, m-commerce, network security, object-oriented programming, telecommunications, multimedia design, and document management. According to a study by the U.S. Bureau of Labor Statistics, each of the top seven fastest-growing occupations projected through 2010 fall within an IT- or computer related field. These top seven occupations are:

1. Computer software applications engineers
2. Computer support specialists
3. Computer software systems engineers
4. Network and computer systems administrators
5. Network systems and data communications analysts
6. Desktop publishers
7. Database administrators

To exploit the high-paying opportunities in IT, a college degree in any of the following fields, or combination of them, is advisable: computer science, computer information systems (CIS), management information systems (MIS), electronic commerce, and e-business. Within the last few years, many universities have started e-commerce or e-business degrees. Many schools offer graduate degrees with specialization in information technology.