Resource Planning

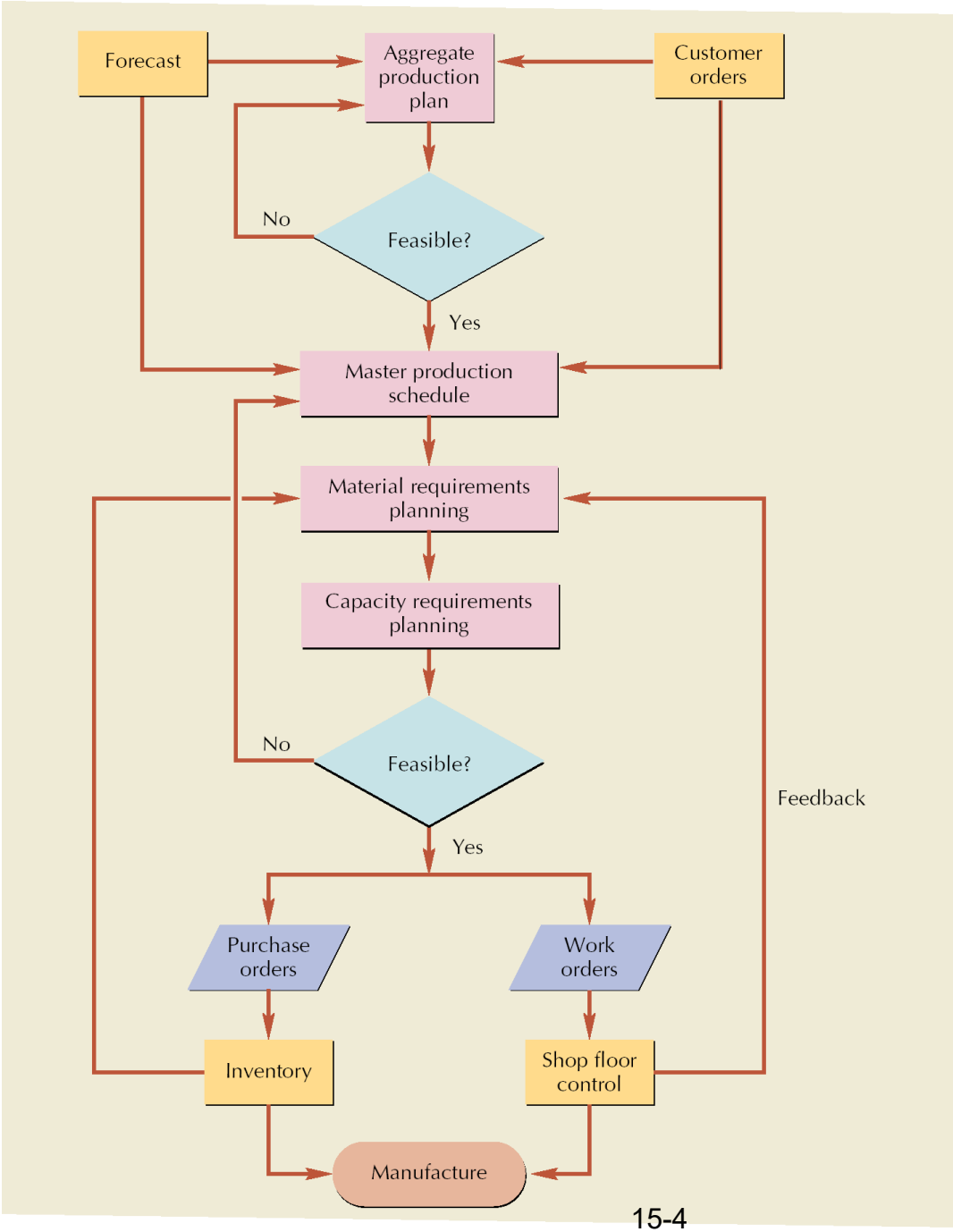
Lecture Outline

- **Material Requirements Planning (MRP)**
- Capacity Requirements Planning (CRP)
- Enterprise Resource Planning (ERP)
- Customer Relationship Management (CRM)
- Supply Chain Management (SCM)
- Product Lifecycle Management (PLM)

Learning Objectives

- Discuss the differences between independent and dependent demand systems
- Describe the inputs and outputs to an MRP system, and execute the MRP process
- Determine resource capacity and load percent, and perform load leveling on capacitated resources
- Explain the hierarchical planning process for resources as a closed loop system, and discuss the assumptions on which this process is based
- Describe basic ERP systems and the scope of their implementations, including the connection to SCM, CRM and PLM
- Discuss the issues, advantages and drawbacks of the enterprise IT software systems that run today's global businesses

Resource Planning for Manufacturing



MRP

- **Material requirements planning (MRP):**
  - A computer-based information system that translates master schedule requirements for end items into time-phased requirements for subassemblies, components, and raw materials.
  - The MRP is designed to answer three questions:
    1. What is needed?
    2. How much is needed?
    3. When is it needed?

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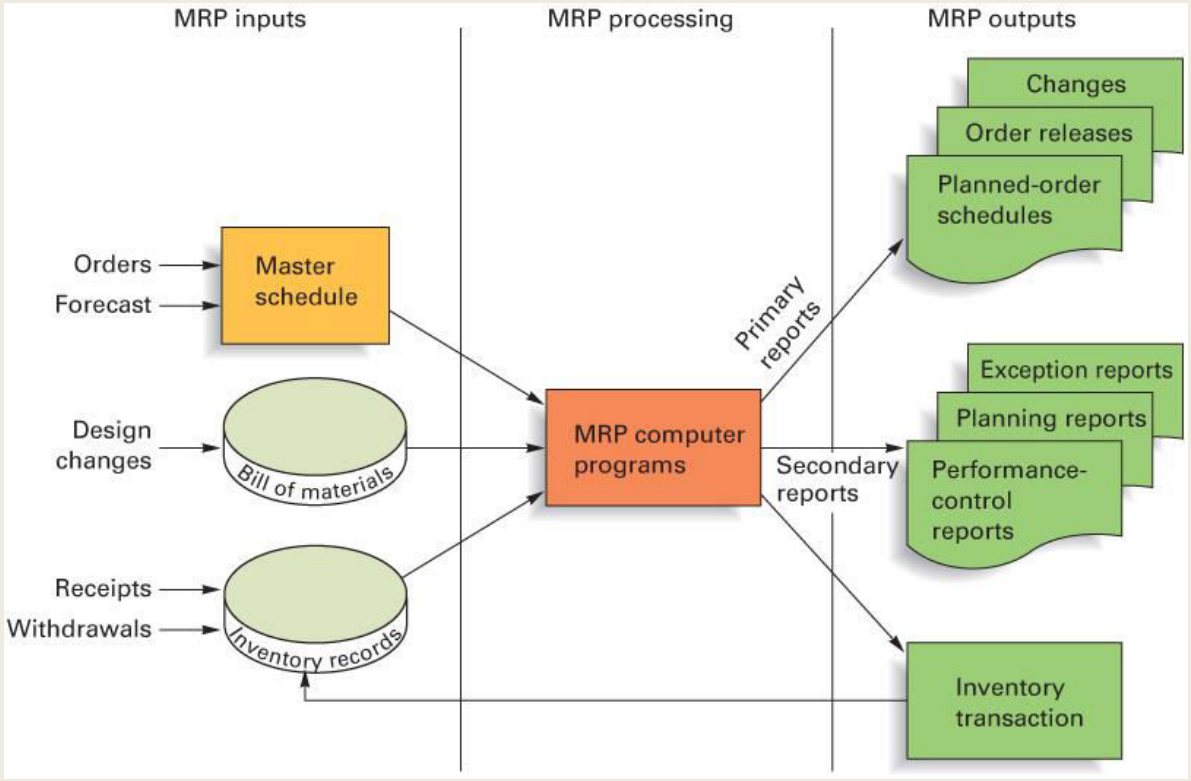
Overview of MRP



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MRP Inputs: Master Schedule

- **Master schedule:**
  - One of three primary inputs in MRP; states which end items are to be produced, when these are needed, and in what quantities.
  - Managers like to plan far enough into the future so they have reasonable estimates of upcoming demands
  - The master schedule should cover a period that is at least equivalent to the 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 the final assembly.

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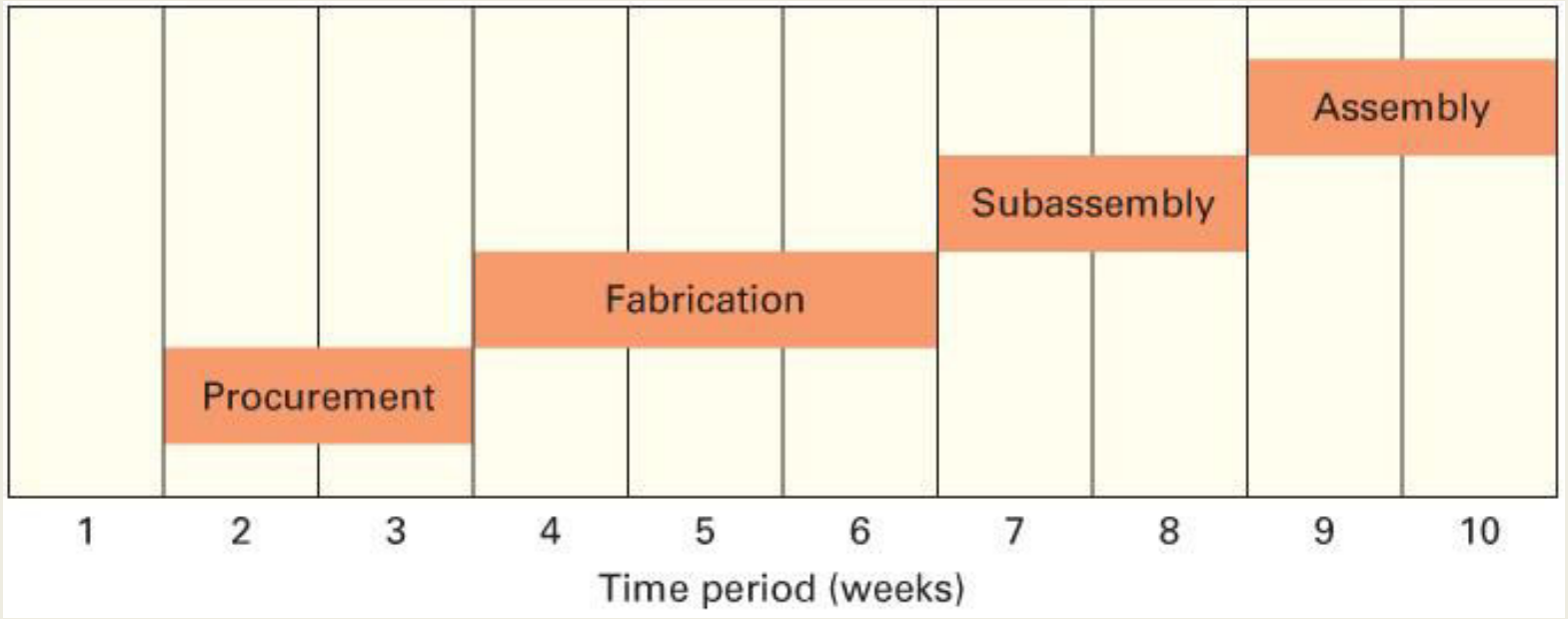
Cumulative Lead Time



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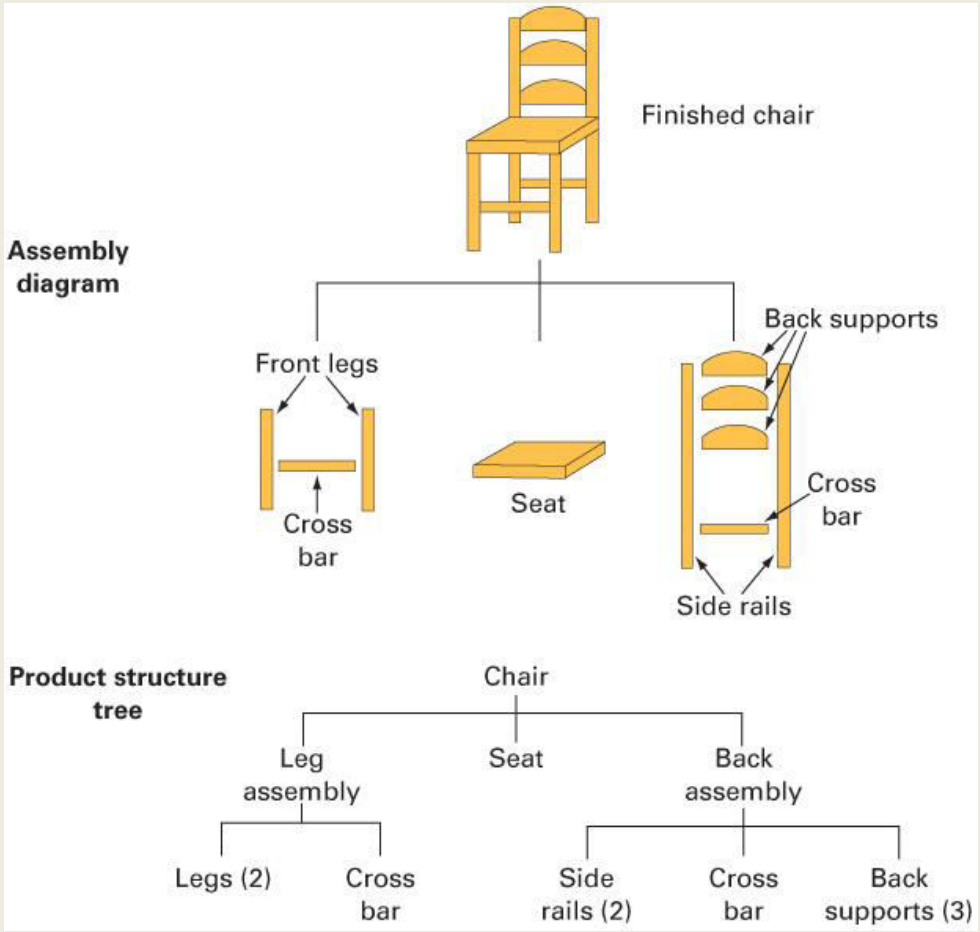
MRP Inputs: Bill of Materials

- **Bill of Materials (BOM)**
  - A listing of all of the assemblies, subassemblies, parts, and raw materials needed to produce one unit of a product
  - **Product structure tree**
    - A visual depiction of the requirements in a bill of materials, where all components are listed by levels

Assembly Diagram and Product Structure Tree



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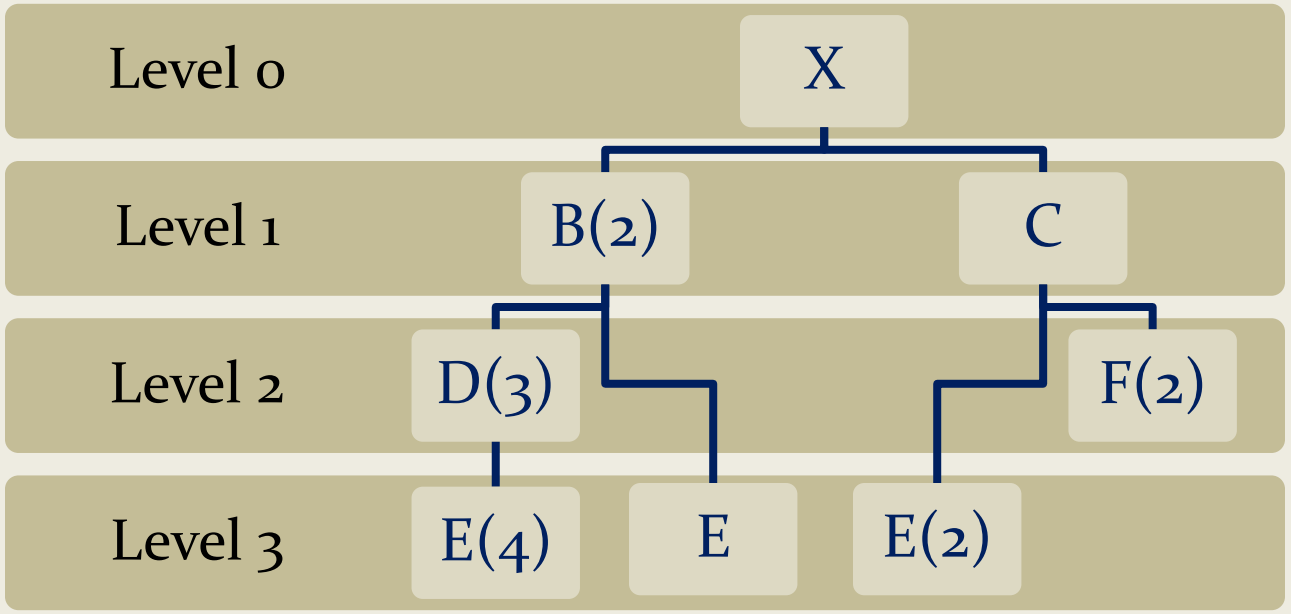
Low-Level Coding

- **Low-level coding**
  - Restructuring the bill of materials so that multiple occurrences of a component all coincide with the lowest level at which the component occurs



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MRP Inputs: Inventory Records

- **Inventory records**
  - Includes information on the status of each item by time period, called *time buckets*
    - Information about
      - Gross requirements
      - Scheduled receipts
      - Expected amount on hand
    - Other details for each item such as
      - Supplier
      - Lead time
      - Lot size policy
      - Changes due to stock receipts and withdrawals
      - Canceled orders and similar events

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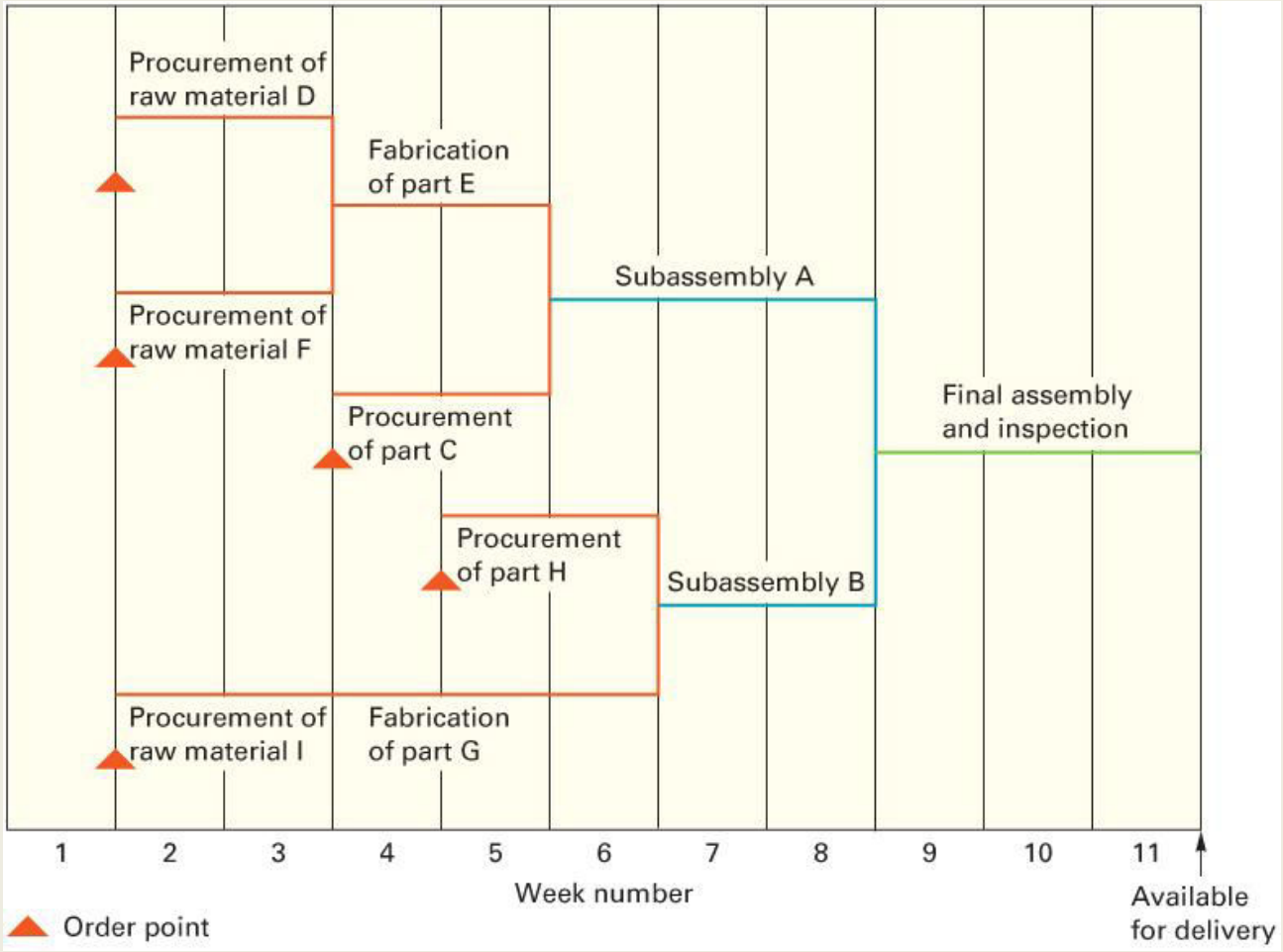
Assembly Time Chart



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MRP Outputs: Primary

- **Primary Outputs**
  - **Planned orders**
    - A schedule indicating the amount and timing of future orders
  - **Order releases**
    - Authorizing the execution of planned orders
  - **Changes**
    - Revisions of the dates or quantities, or the cancellation of orders

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MRP Outputs: Secondary

- **Secondary Outputs**
  - **Performance-control reports**
    - Evaluation of system operation, including deviations from plans and cost information
      - e.g., missed deliveries and stockouts
  - **Planning reports**
    - Data useful for assessing future material requirements
      - e.g., purchase commitments
  - **Exception reports**
    - Data on any major discrepancies encountered
      - E.g., late and overdue orders, excessive scrap rates, requirements for nonexistent parts

MRP Processing

- MRP processing takes the end item requirements specified by the master schedule and "explodes" them into *time-phased* requirements for assemblies, parts, and raw materials offset by lead times

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MRP Record

Week Number	1	2	3	4	5	6
Gross Requirements						
Scheduled Receipts						
Projected on hand						
Net requirements						
Planned-order-receipt						
Planned-order release						

Gross requirements

- Total expected demand

Scheduled receipts

- Open orders scheduled to arrive

Projected Available

- Expected inventory on hand at the beginning of each time period

MRP Record

Week Number	1	2	3	4	5	6
Gross Requirements						
Scheduled Receipts						
Projected on hand						
Net requirements						
Planned-order-receipt						
Planned-order release						

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

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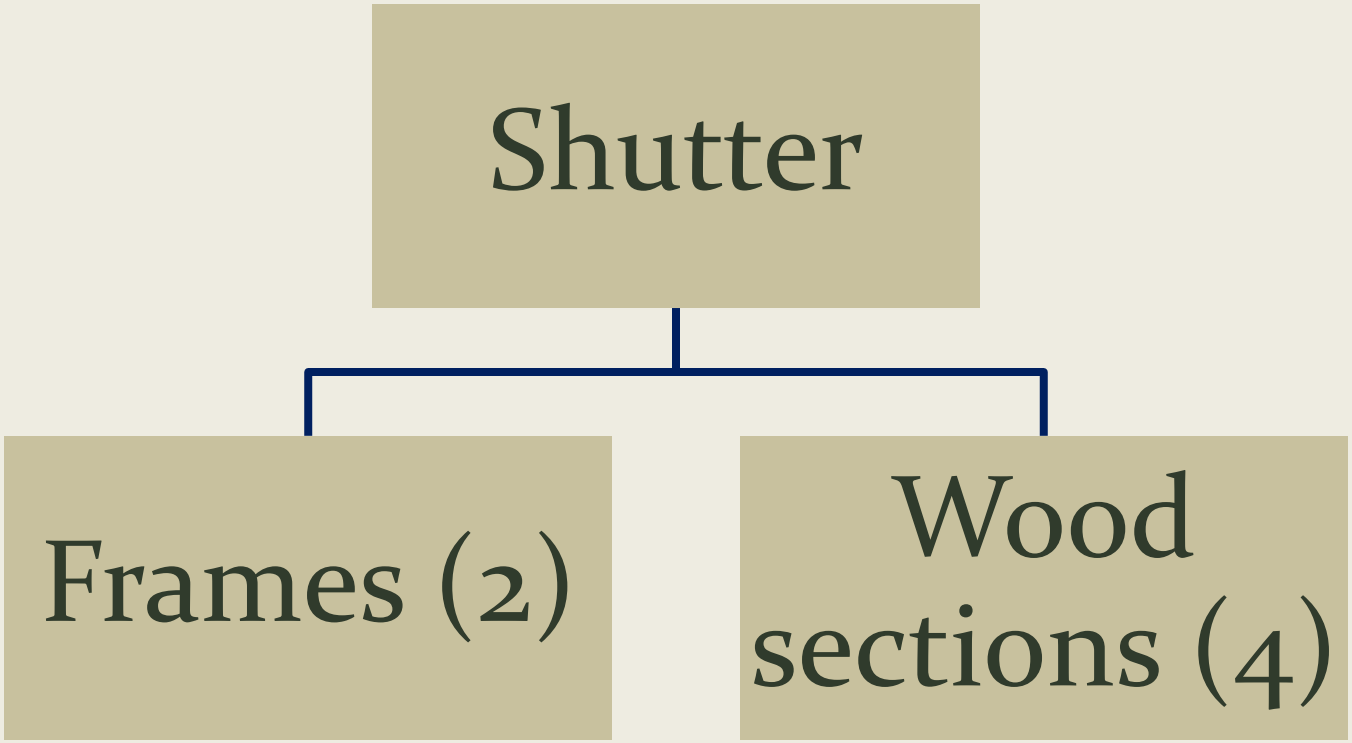
MRP: Development

- The MRP is based on the product structure tree diagram
- Requirements are determined level by level, beginning with the end item and working down the tree
  - The timing and quantity of each "parent" becomes the basis for determining the timing and quantity of the "children" items directly below it.
  - The "children" items then become the "parent" items for the next level, and so on

LO 12.3

Example MRP



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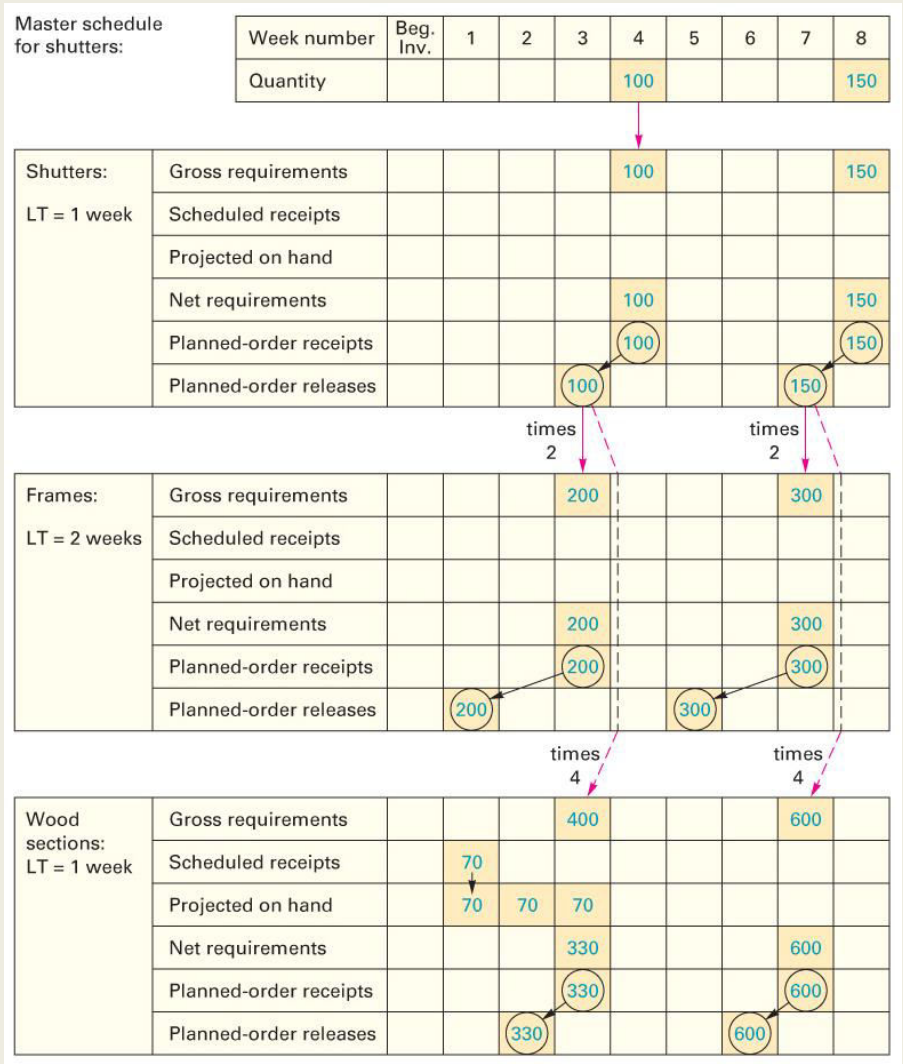
Example MRP



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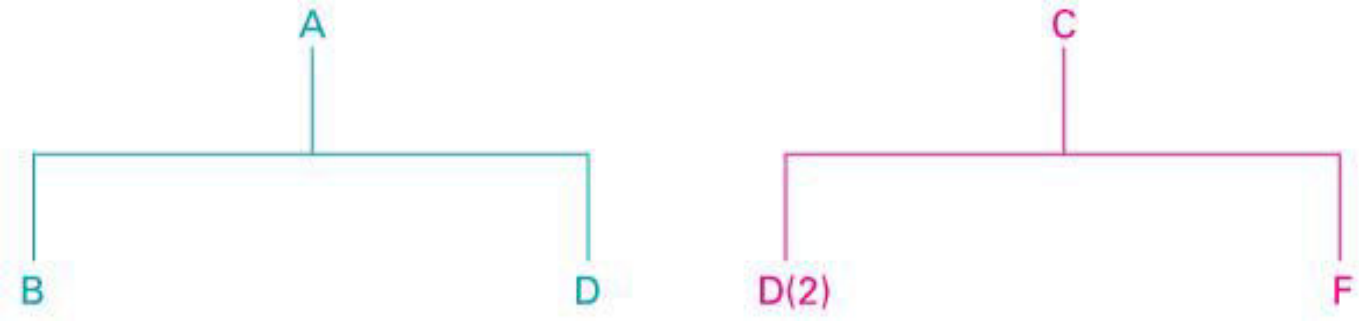
Using the MRP

- **Pegging**
  - The process of identifying the parent items that have generated a given set of material requirements for an item



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Updating the System

- **An MRP is not a static document**
  - As time passes
    - Some orders get completed
    - Other orders are nearing completion
    - New orders will have been entered
    - Existing orders will have been altered
      - Quantity changes
      - Delays
      - Missed deliveries

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Updating the System

- **Two basic systems**
  - Regenerative system
    - Approach that updates MRP records periodically
      - Essentially a batch system that compiles all changes that occur within the time interval and periodically updates the system
      - A revised production plan is developed in the same way the original plan was developed
  - Net-change system
    - Approach that updates MRP records continuously
      - The production plan is modified to reflect changes as they occur
      - Only the changes are exploded through the system

Other MRP Considerations: Safety Stock

- **Safety Stock**
  - Theoretically, MRP systems should not require safety stock
  - Variability may necessitate the strategic use of safety stock
    - A bottleneck process or one with varying scrap rates may cause shortages in downstream operations
    - Shortages may occur if orders are late or fabrication or assembly times are longer than expected
    - When lead times are variable, the concept of *safety time* is often used
      - **Safety time**
        - Scheduling orders for arrival or completions sufficiently ahead of their need so that the probability of shortage is eliminated or significantly reduced

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Other MRP Considerations: Lot Sizing Rules

- **Lot-for-Lot (L4L) ordering**
  - The order or run size is set equal to the demand for that period
  - Minimizes investment in inventory
  - It results in variable order quantities
  - A new setup is required for each run
- **Economic Order Quantity (EOQ)**
  - Can lead to minimum costs if usage of item is fairly uniform
    - This may be the case for some lower-level items that are common to different 'parents'
    - Less appropriate for 'lumpy demand' items because inventory remnants often result
- **Fixed Period Ordering**
  - Provides coverage for some predetermined number of periods

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MRP Benefits

- **Enables managers to easily**
  - determine the quantities of each component for a given order size
  - To know when to release orders for each component
  - To be alerted when items need attention
- **Additional benefits**
  - Low levels of in-process inventories
  - The ability to track material requirements
  - The ability to evaluate capacity requirements
  - A means of allocating production time
  - The ability to easily determine inventory usage via ***backflushing***
    - Exploding an end item's BOM to determine the quantities of the components that were used to make the item

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MRP Requirements

- **To implement an effective MRP system requires:**
  - A computer and the necessary software to handle computations and maintain records
  - Accurate and up-to-date
    - Master schedules
    - Bills of materials
    - Inventory records
  - Integrity of data files

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MRP Difficulties

- **Consequence of Inaccurate Data**
  - Missing parts
  - Ordering incorrect numbers of items
  - Inability to stay on schedule
- **Other problems**
  - Assumptions of constant lead times
  - Products being produced differently from the BOM
  - Failure to alter a BOM when customizing a product
  - Inaccurate forecasts

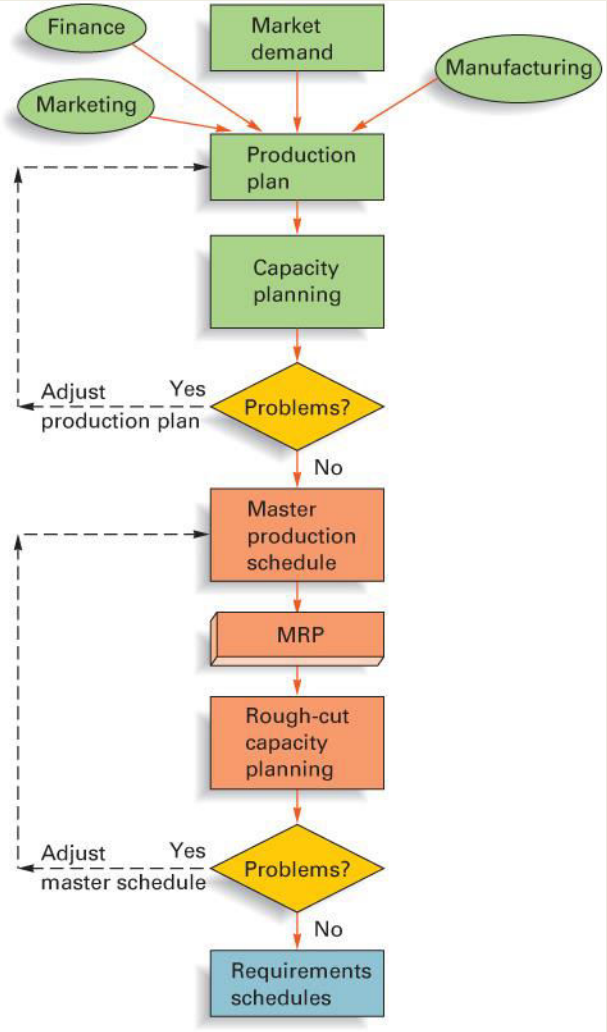
LO 12.5

MRP II

- **Manufacturing resources planning (MRP II)**
  - Expanded approach to production resource planning, involving other areas of the firm in the planning process and enabling capacity requirements planning
    - Most MRP II systems have the capability of performing simulation to answer a variety of "what if" questions so they can gain a better appreciation of available options and their consequences

LO 12.6

MRP II: Overview



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Closed Loop MRP

- When MRP II systems began to include feedback loops, they were referred to as closed loop MRP
- Closed Loop MRP
  - Systems evaluate a proposed material plan relative to available capacity
  - If a proposed plan is not feasible, it must be revised
    - This evaluation is referred to as capacity requirements planning

LO 12.6

Capacity Requirements Planning

- **Capacity requirements planning (CRP)**
  - The process of determining short-range capacity requirements.
  - Inputs to capacity requirement planning
    - Planned-order releases for the MRP
    - Current shop loading
    - Routing information
    - Job time
  - Key outputs
    - Load reports for each work center

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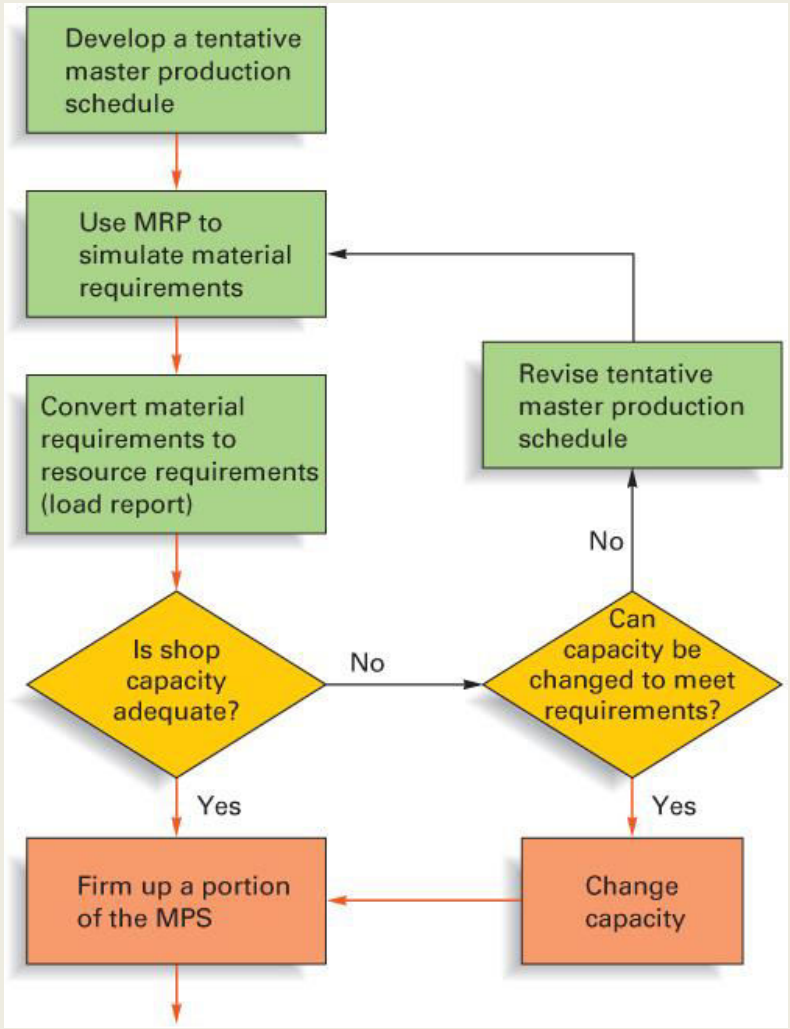
Using MRP to Assist in CRP



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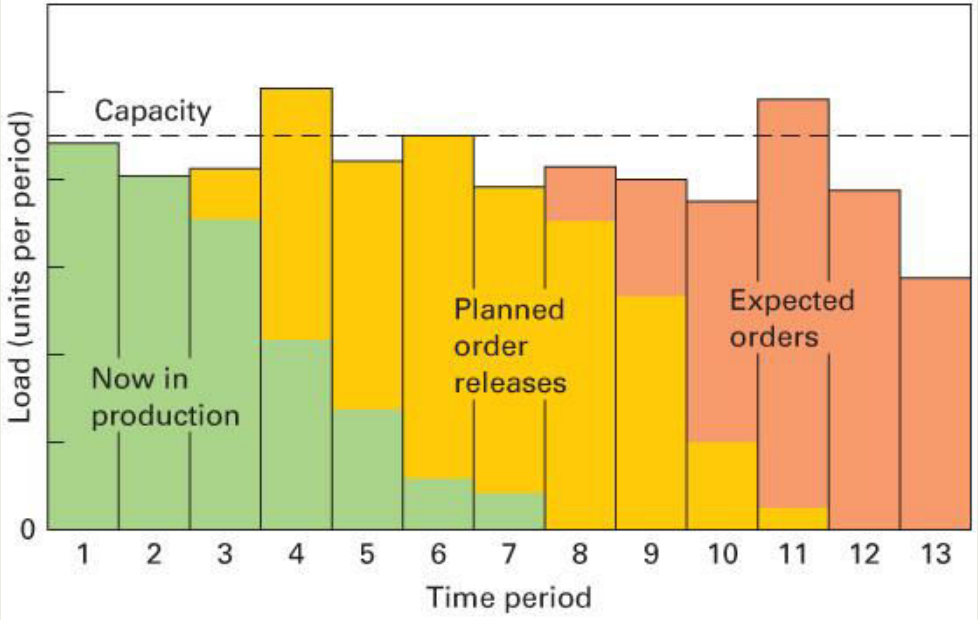
Load Reports

- **Load reports**
  - Department or work center reports that compare known and expected future capacity requirements with projected capacity availability.



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Enterprise Resource Planning

- **Enterprise resource planning (ERP)**
  - ERP was the next step in an evolution that began with MRP and evolved into MRPII
  - ERP, like MRP II, typically has an MRP core
  - ERP provides a system to capture and make data available in real time to decision makers and other users throughout an organization.
  - ERP systems are composed of a collection of integrated modules

LO 12.8

Overview of ERP Software Modules

Module	Brief Description
Accounting/Finance	A central component of most ERP systems. It provides a range of financial reports, including general ledger, accounts payable, accounts receivable, payroll, income statements, ad balance sheets
Marketing	Supports lead generation, target marketing, direct mail, and sales
Human Resources	Maintains a complete data base of employee information such as date of hire, salary, contact information, performance evaluations, and other pertinent information
Purchasing	Facilitates vendor selection, price negotiation, making purchasing decisions, and bill payment
Production Planning	Integrates information on forecasts, orders, production capacity, on-hand inventory quantities, bills of material, work in process, schedules, and production lead times
Inventory Management	Identifies inventory requirements, inventory availability, replenishment rules, and inventory tracking
Distribution	Contains information on third-party shippers, shipping and delivery schedules, delivery tracking
Sales	Information on orders, invoices, order tracking, and shipping
Supply Chain Management	Facilitates supplier and customer management, supply chain visibility, and event management

LO 12.8

ERP Project Organization

- ***The 'big bang'***
  - Companies cast off all of their legacy systems at once and implement a single ERP system across the entire company
  - The most ambitious and difficult implementation approach
- ***Franchising strategy***
  - Independent ERP systems are installed in each business unit of the enterprise while linking common processes across the enterprise
  - Suits large or diverse companies that do not share many common processes across business units
- ***Slam Dunk***
  - ERP dictates the process design where the focus is on a few key processes
  - More appropriate for smaller companies expecting to grow into ERP

ERP Considerations

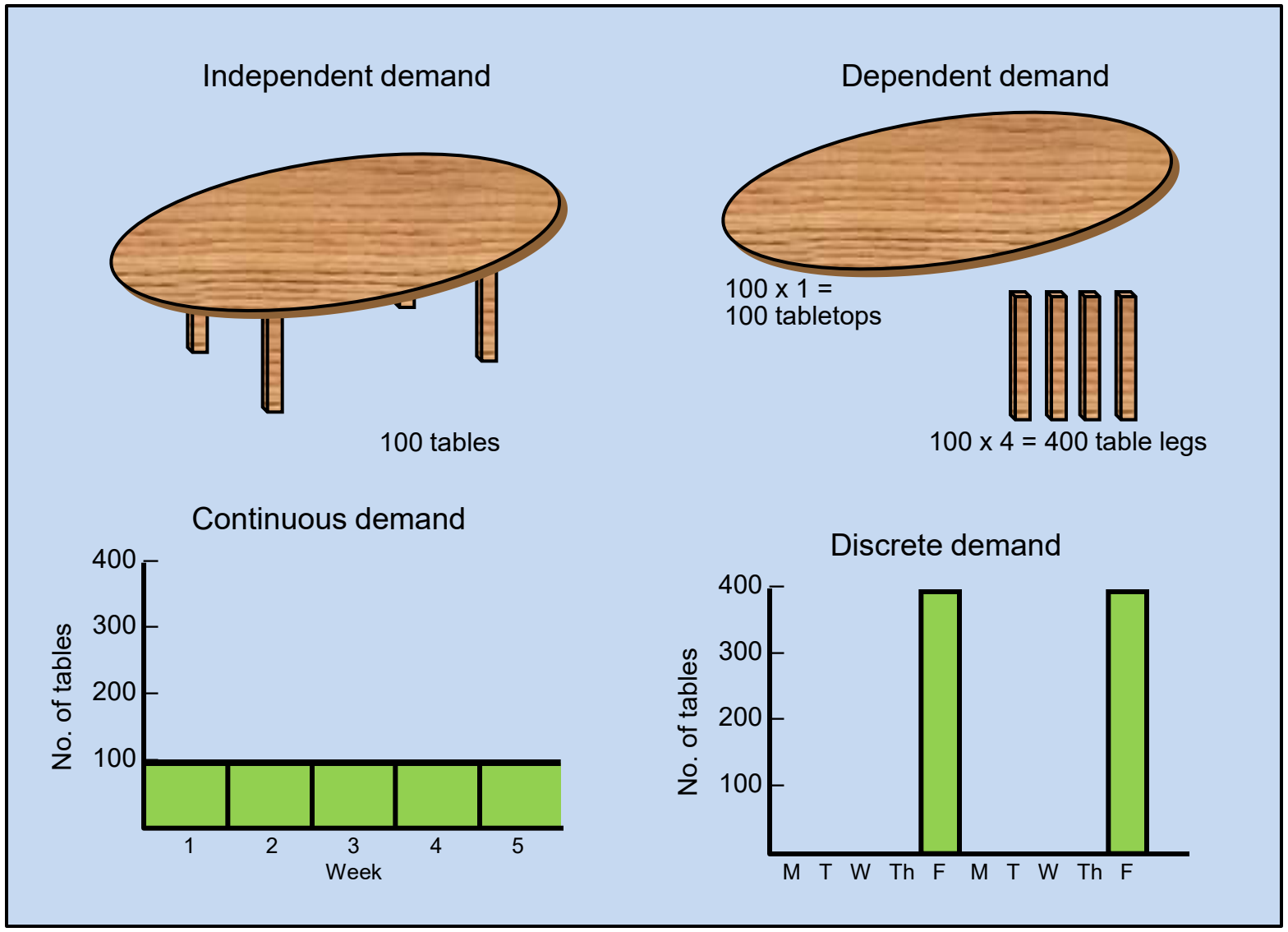
- How can ERP improve a company's business performance?
- How long will an ERP implementation project take?
- How will ERP affect current business processes?
- What is the ERP total cost of ownership?
- What are the hidden costs of ERP ownership?

LO 12.8

Material Requirements Planning (MRP)

- Computerized inventory control and production planning system
- When to use MRP?
  - Dependent demand items
  - Discrete demand items
  - Complex products
  - Job shop production
  - Assemble-to-order environments

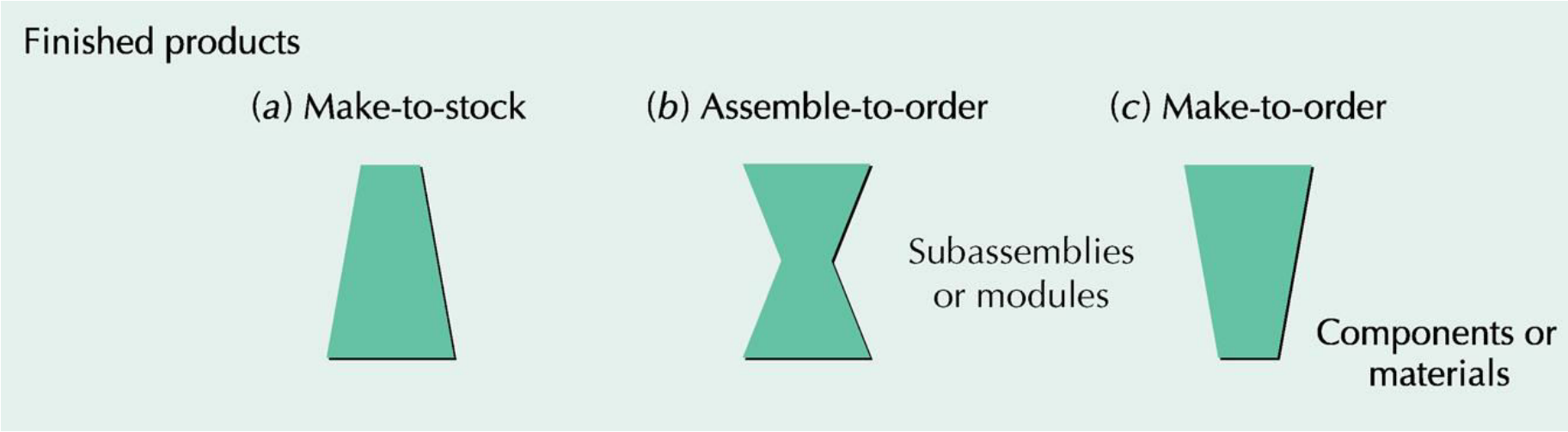
Demand Characteristics



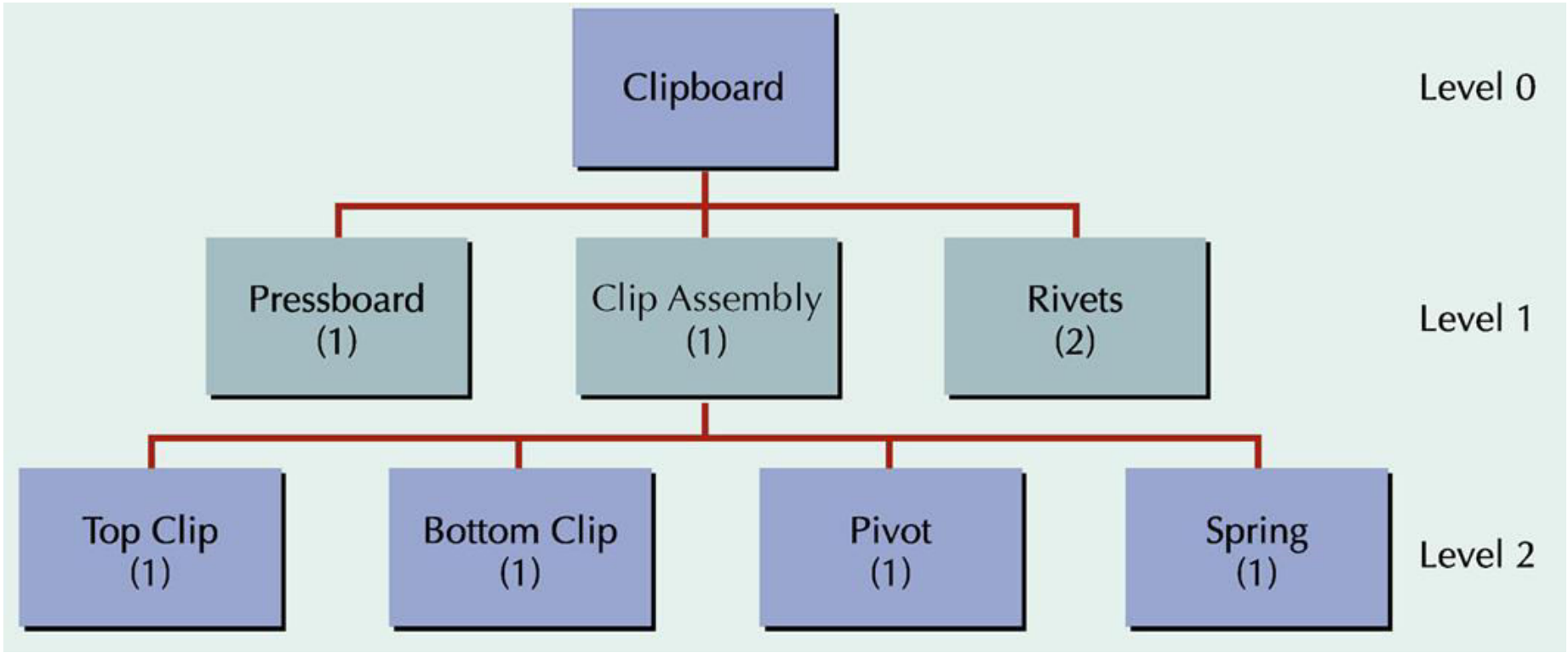
Master Production Schedule

	PERIOD				
MPS ITEM	*1*	*2*	*3*	*4*	*5*
Pencil Case	125	125	125	125	125
Clipboard	85	95	120	100	100
Lapboard	75	120	47	20	17
Lapdesk	0	50	0	50	0

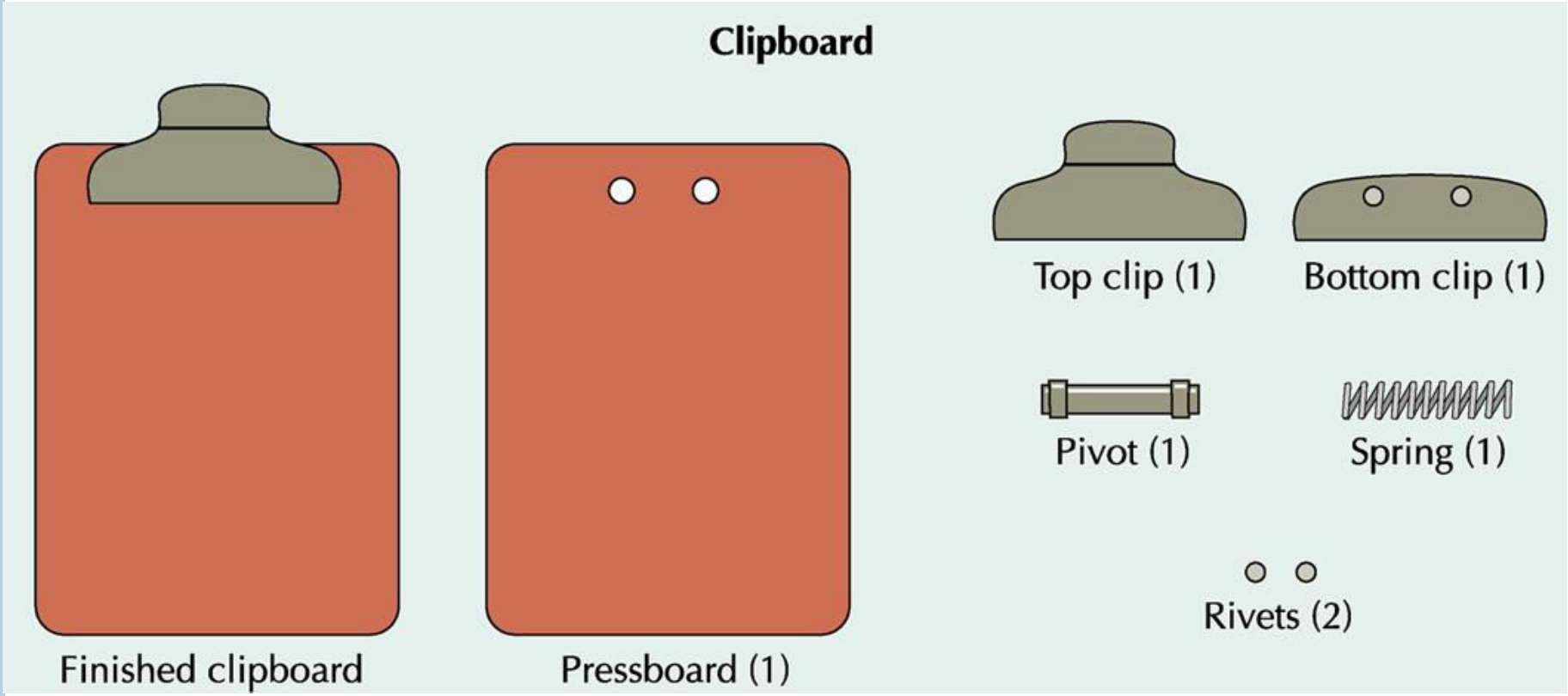
Product Structures



Product Structure Tree



Product Structure



Multilevel Indented BOM

LEVEL	ITEM	UNIT OF MEASURE	QUANTITY
0 - - - -	Clipboard	ea	1
- 1 - - -	Clip Assembly	ea	1
- - 2 - -	Top Clip	ea	1
- - 2 - -	Bottom Clip	ea	1
- - 2 - -	Pivot	ea	1
- - 2 - -	Spring	ea	1
- 1 - - -	Rivet	ea	2
- 1 - - -	Press Board	ea	1

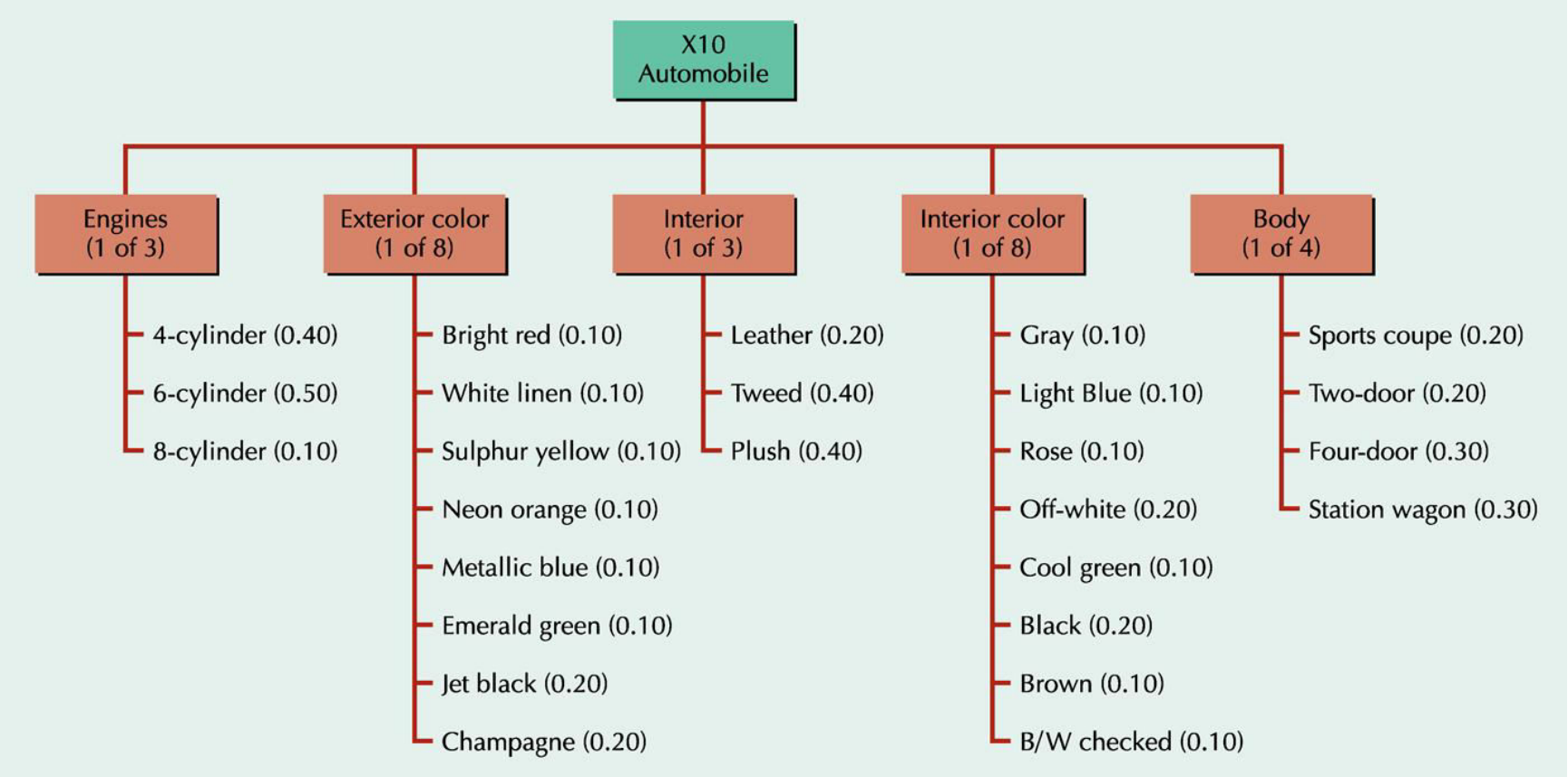
Specialized BOMs

- Phantom bills
  - Transient subassemblies
  - Never stocked
  - Immediately consumed in next stage
- K-bills (kit numbers)
  - Group small, loose parts under pseudo-item number
  - Reduces paperwork, processing time, and file space

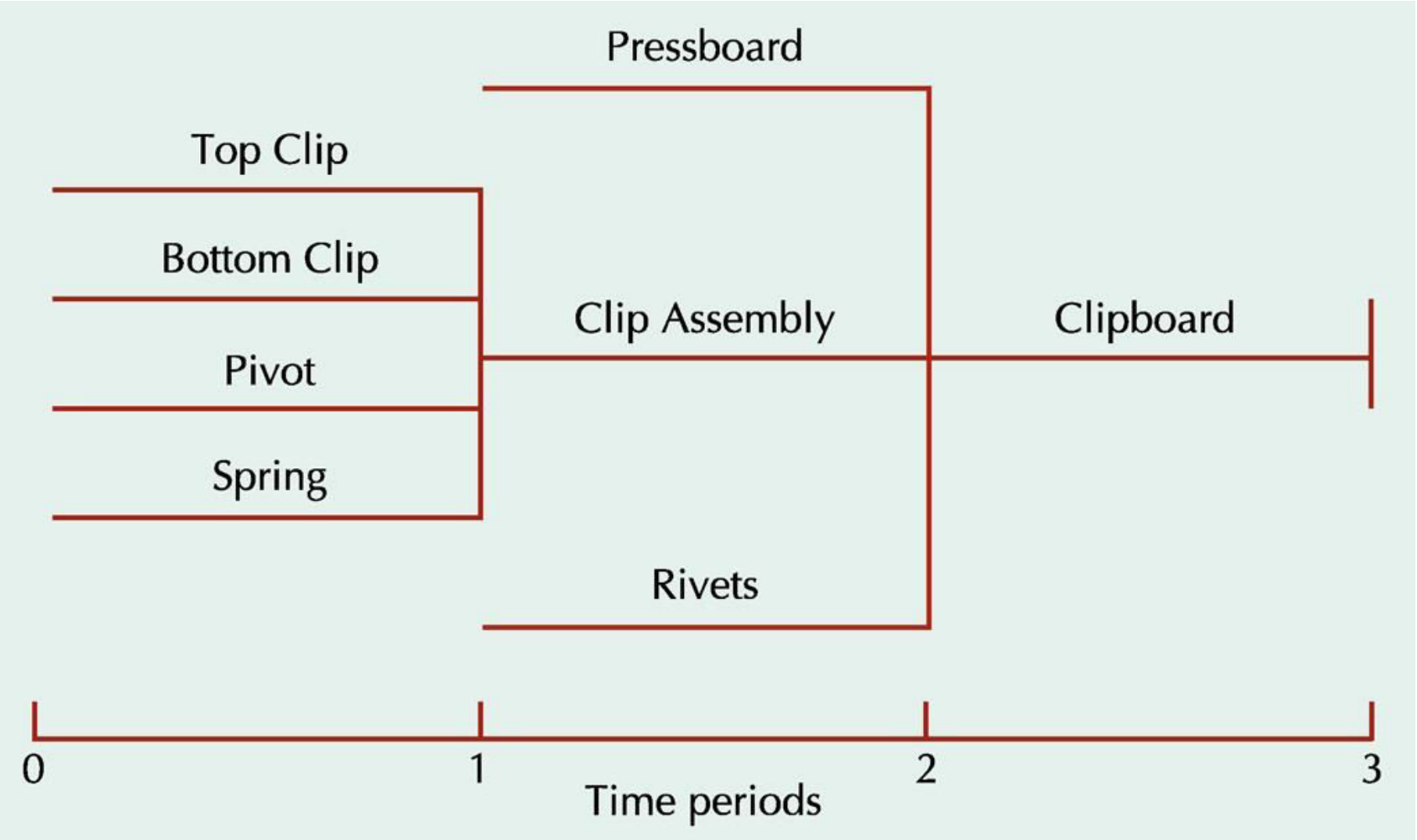
Specialized BOMs

- Modular bills
  - Plan production of products with many optional features
  - Product assembled from major subassemblies and customer options
  - Modular bill kept for each major subassembly
  - Simplifies forecasting and planning
  - X10 automobile example
    - 3 x 8 x 3 x 8 x 4 = 2,304 configurations
    - 3 + 8 + 3 + 8 + 4 = 26 modular bills

Modular BOMs



Time-phased Bills



Time-phased Bills

- Forward scheduling
  - start at today‘s date and schedule forward to determine the earliest date the job can be finished. If each item takes one period to complete, the clipboards can be finished in three periods
- Backward scheduling
  - start at the due date and schedule backwards to determine when to begin work. If an order for clipboards is due by period three, we should start production now

Item Master File

DESCRIPTION		INVENTORY POLICY	
Item	Pressboard	Lead time	1
Item no.	7341	Annual demand	5000
Item type	Purch	Holding cost	1
Product/sales class	Comp	Ordering/setup cost	50
Value class	B	Safety stock	0
Buyer/planner	RSR	Reorder point	39
Vendor/drawing	07142	EOQ	316
Phantom code	N	Minimum order qty	100
Unit price/cost	1.25	Maximum order qty	500
Pegging	Y	Multiple order qty	1
LLC	1	Policy code	3

Item Master File

PHYSICAL INVENTORY		USAGE/SALES	
On hand	150	YTD usage/sales	1100
Location	W142	MTD usage/sales	75
On order	100	YTD receipts	1200
Allocated	75	MTD receipts	0
Cycle	3	Last receipt	8/25
Last count	9/5	Last issue	10/5
Difference	-2		
		CODES	
		Cost acct.	00754
		Routing	00326
		Engr	07142

MRP Processes

- Exploding the bill of material
- Netting out the inventory
- Netting
  - the process of subtracting on-hand quantities and scheduled receipts from gross requirements to produce net requirements
- Lot sizing
  - determining the quantities in which items are usually made or purchased
- Time-phasing requirements

MRP Matrix

Item	LLC	Period				
Lot size	LT	1	2	3	4	5
Gross Requirement		*Derived from MPS or planned order releases of the parent*				
Scheduled Receipts		*On order and scheduled to be received*				
Projected on Hand	Beg. Inv	*Anticipated quantity on hand at the end of the period*				
Net Requirements		*Gross requirements net of inventory and scheduled receipts*				
Planned Order Receipts		*When orders need to be received*				
Planned Order Releases		*When orders need to be placed to be received on time*				

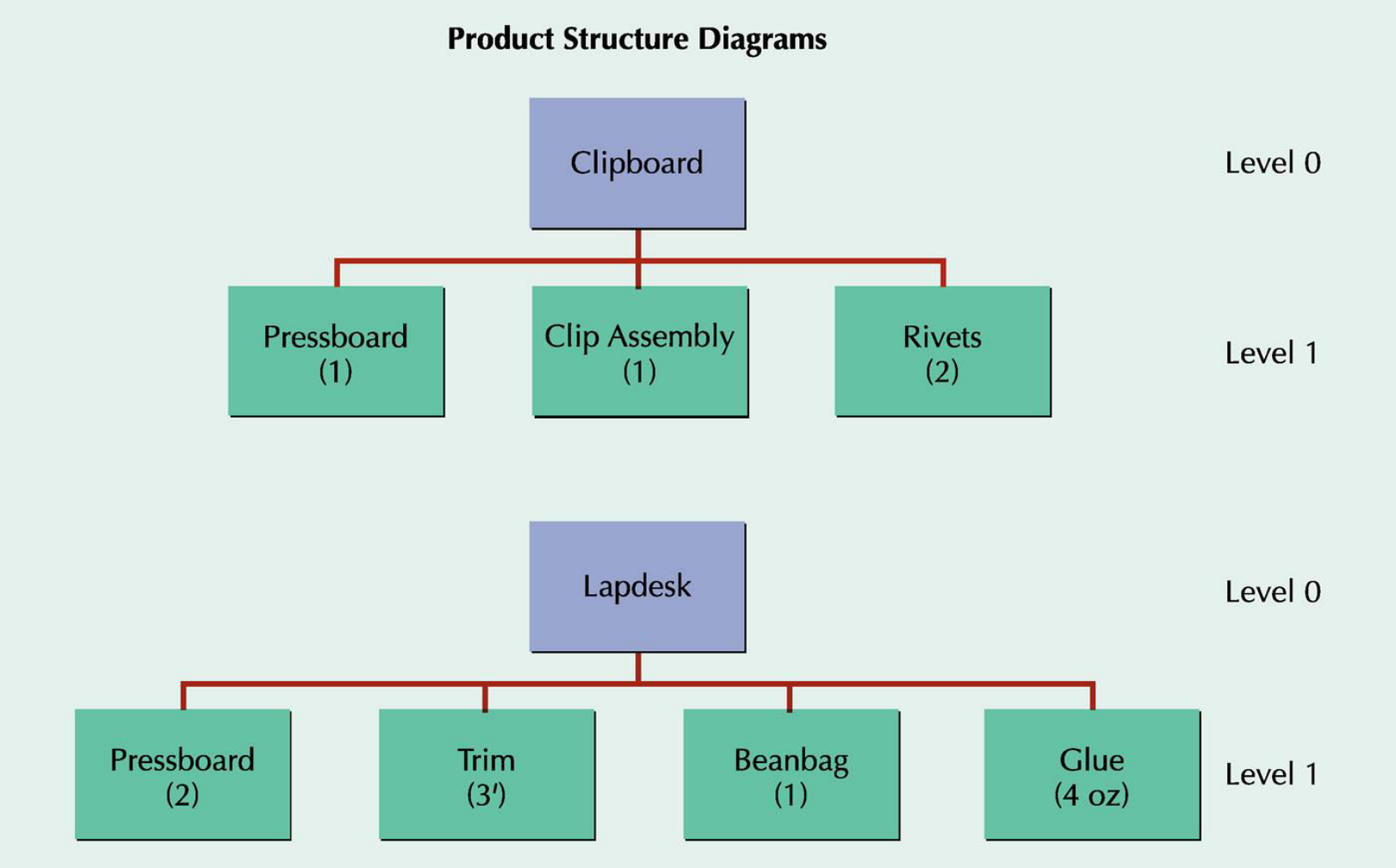
MRP Example

Clipboard	85	95	120	100	100
Lapdesk	0	60	0	60	0

Item Master File

	CLIPBOARD	LAPDESK	PRESSBOARD
On hand	25	20	150
On order (sch receipt)	175 (Period 1)	0	0
LLC	0	0	1
Lot size	L4L	Mult 50	Min 100
Lead time	1	1	1

MRP Example



MRP - 1

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25					
Net Requirements						
Planned Order Receipts						
Planned Order Releases						

MRP - 2

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25	115				
Net Requirements		0				
Planned Order Receipts						
Planned Order Releases						

(25 + 175) = 200 units available
(200 - 85) = 115 on hand at the end of Period 1

MRP - 3

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25	115	20			
Net Requirements		0	0			
Planned Order Receipts						
Planned Order Releases						

115 units available
(115 - 85) = 20 on hand at the end of Period 2

MRP - 4

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25	115	20	0		
Net Requirements		0	0	100		
Planned Order Receipts				100		
Planned Order Releases			100			

20 units available
(20 - 120) = -100 — 100 additional Clipboards are required
Order must be placed in Period 2 to be received in Period 3

MRP - 5

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		85	95	120	100	100
Scheduled Receipts		175				
Projected on Hand	25	115	20	0	0	0
Net Requirements		0	0	100	100	100
Planned Order Receipts				100	100	100
Planned Order Releases			100	100	100	

Following the same logic Gross Requirements in Periods 4 and 5 develop Net Requirements, Planned Order Receipts, and Planned Order Releases

MRP - 6

ITEM: LAPDESK	LLC: 0	PERIOD				
LOT SIZE: MULT 50	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		0	60	0	60	0
Scheduled Receipts						
Projected on Hand	20					
Net Requirements						
Planned Order Receipts						
Planned Order Releases						

MRP - 7

ITEM: LAPDESK	LLC: 0	PERIOD				
LOT SIZE: MULT 50	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		0	60	0	60	0
Scheduled Receipts						
Projected on Hand	20	20	10	10	0	0
Net Requirements		0	40		50	
Planned Order Receipts			50		50	
Planned Order Releases		50		50		

Following the same logic, the Lapdesk MRP matrix is completed as shown

MRP - 8

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases			100	100	100	

ITEM: LAPDESK	LLC: 0	PERIOD				
LOT SIZE: MULT 50	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases		50		50		

ITEM: PRESSBOARD	LLC: 0	PERIOD				
LOT SIZE: MIN 100	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements						
Scheduled Receipts						
Projected on Hand	150					
Net Requirements						
Planned Order Receipts						
Planned Order Releases						

MRP – 9

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases			100	100	100	

ITEM: LAPDESK	LLC: 0			PERIOD		
LOT SIZE: MULT 50	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases		50		50		

ITEM: PRESSBOARD	LLC: 0			PERIOD		
LOT SIZE: MIN 100	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		100	100	200	100	0
Scheduled Receipts						
Projected on Hand	150					
Net Requirements						
Planned Order Receipts						
Planned Order Releases						

MRP – 10

ITEM: CLIPBOARD	LLC: 0	PERIOD				
LOT SIZE: L4L	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases			100	100	100	

ITEM: LAPDESK	LLC: 0	*x1*		PERIOD	*x1*	*x1*
LOT SIZE: MULT 50	LT: 1	*1*	*2*	*3*	*4*	*5*
Planned Order Releases		50		50		

ITEM: PRESSBOARD	LLC: 0	*x2*	*x2*	PERIOD		
LOT SIZE: MIN 100	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		100	100	200	100	0
Scheduled Receipts						
Projected on Hand	150	50	50	0	0	
Net Requirements			50	150	100	
Planned Order Receipts			100	150	100	
Planned Order Releases		100	150	100		

MRP - 11

Planned Order Report	PERIOD				
ITEM	*1*	*2*	*3*	*4*	*5*
Clipboard		100	100	100	
Lapdesk	50		50		
Pressboard	100	150	100		

Lot Sizing in MRP Systems

- Lot-for-lot ordering policy
- Fixed-size lot ordering policy
  - Minimum order quantities
  - Maximum order quantities
  - Multiple order quantities
  - Economic order quantity
  - Periodic order quantity

Advanced Lot Sizing Rules: L4L

Period	1	2	3	4	5
Gross Requirements	30	50	20	10	40

$C_o = \$60$

$C_c = \$1$

$\bar{d} = (30 + 50 + 20 + 10 + 40)/5 = 30$

Item: Rod	**LLC: 0**	**Period**				
Lot size: L4L	**LT: 1**	*1*	*2*	*3*	*4*	*5*
Gross Requirements		30	50	20	10	40
Scheduled Receipts						
Projected on hand	30	0	0	0	0	0
Net Requirements			50	20	10	40
Planned Order Receipts			50	20	10	40
Planned Order Releases		50	20	10	40	

Total cost of L4L = (4 X \$60) + (0 X \$1) = \$240

Advanced Lot Sizing Rules: EOQ

$$EOQ = \sqrt{\frac{2(30)(60}{1}} = 60$$ minimum order quantity

Item: Rod	LLC: 0	Period				
Lot size: EOQ 60	**LT: 1**	*1*	*2*	*3*	*4*	*5*
Gross Requirements		30	50	20	10	40
Scheduled Receipts						
Projected on hand	30	0	10	50	40	0
Net Requirements			50	10		
Planned Order Receipts			60	60		
Planned Order Releases		60	60			

Total cost of EOQ = (2 X $60) + [(10 + 50 + 40) X $1)] = $220

Advanced Lot Sizing Rules: POQ

$POQ = Q / \bar{d} = 60 / 30 = 2$ periods worth of requirements

Item: Rod	LLC: 0	Period				
Lot size: POQ 2	LT: 1	*1*	*2*	*3*	*4*	*5*
Gross Requirements		30	50	20	10	40
Scheduled Receipts						
Projected on hand	30	0	20	0	40	0
Net Requirements			50		10	
Planned Order Receipts			70		50	
Planned Order Releases		70		50		

Total cost of POQ = (2 X $60) + [(20 + 40) X $1] = $180

Planned Order Report

Item	#2740	Date	9 - 25 - 05
On hand	100	Lead time	2 weeks
On order	200	Lot size	200
Allocated	50	Safety stock	50

DATE	ORDER NO.	GROSS REQS.	SCHEDULED RECEIPTS	PROJECTED ON HAND	ACTION
				50	
9-26	AL 4416	25		25	
9-30	AL 4174	25		0	
10-01	GR 6470	50		- 50	
10-08	SR 7542		200	150	Expedite SR 10-01
10-10	CO 4471	75		75	
10-15	GR 6471	50		25	
10-23	GR 6471	25		0	
10-27	GR 6473	50		- 50	Release PO 10-13

Key: AL = allocated, CO = customer order, PO = purchase order, WO = work order, SR = scheduled receipt, GR = gross requirement

MRP Action Report

Current date 9-25-08

ITEM	DATE	ORDER NO.	QTY.	ACTION		
#2740	10-08	7542	200	Expedite	SR	10-01
#3616	10-09			Move forward	PO	10-07
#2412	10-10			Move forward	PO	10-05
#3427	10-15			Move backward	PO	10-25
#2516	10-20	7648	100	De-expedite	SR	10-30
#2740	10-27		200	Release	PO	10-13
#3666	10-31		50	Release	WO	10-24

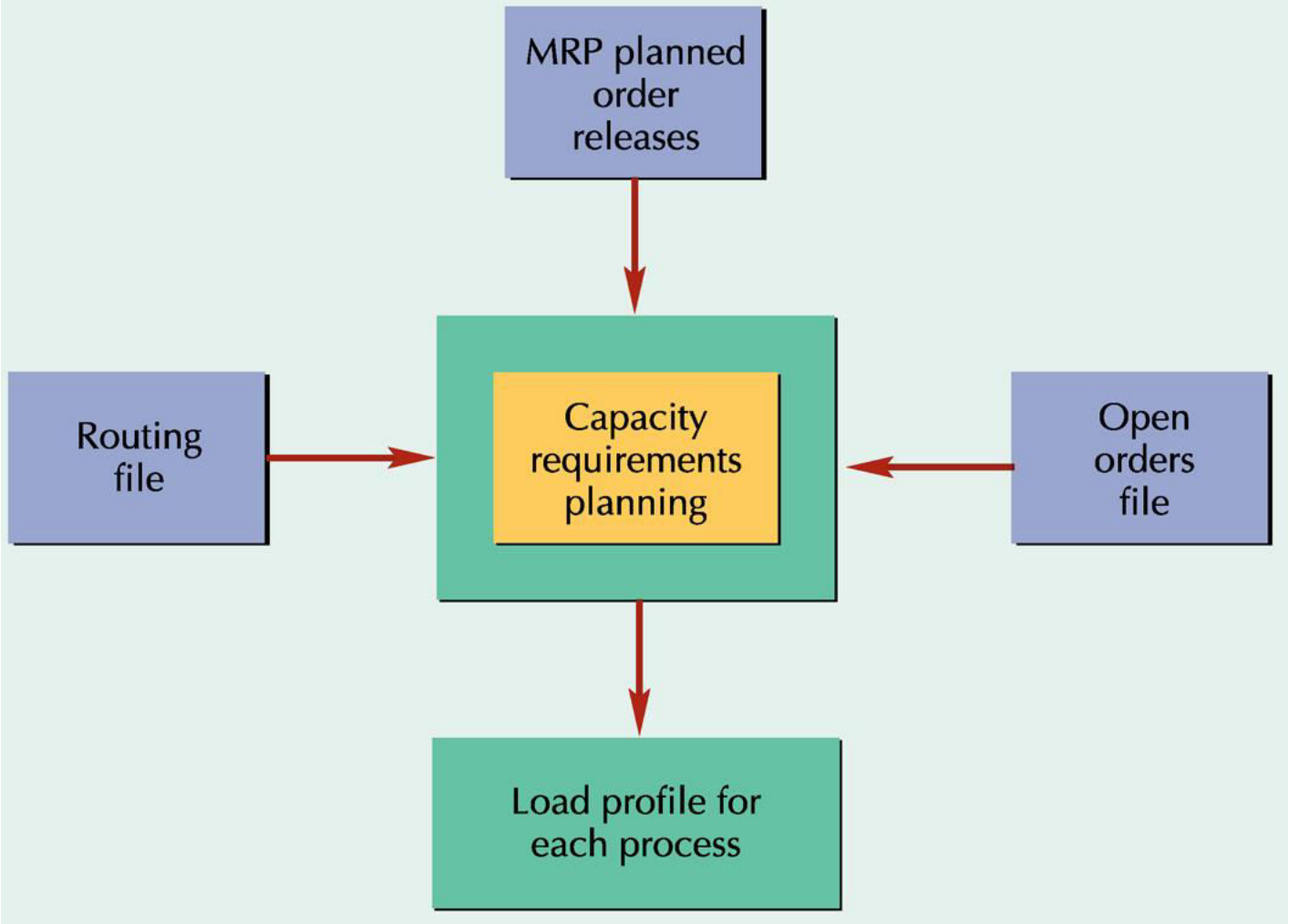
Lecture Outline

- Material Requirements Planning (MRP)
- **Capacity Requirements Planning (CRP)**
- Enterprise Resource Planning (ERP)
- Customer Relationship Management (CRM)
- Supply Chain Management (SCM)
- Product Lifecycle Management (PLM)

Capacity Requirements Planning (CRP)

- Creates a load profile
- Identifies under-loads and over-loads
- Inputs
  - Planned order releases
  - Routing file
  - Open orders file

CRP



Calculating Capacity

- Maximum capability to produce
- Rated Capacity
  - Theoretical output that could be attained if a process were operating at full speed without interruption, exceptions, or downtime
- Effective Capacity
  - Takes into account the efficiency with which a particular product or customer can be processed and the utilization of the scheduled hours or work

Effective Daily Capacity = (no. of machines or workers) x (hours per shift) x (no. of shifts) x (utilization) x (efficiency)

Calculating Capacity

- Utilization
  - Percent of available time spent working
- Efficiency
  - How well a machine or worker performs compared to a standard output level
- Load
  - Standard hours of work assigned to a facility
- Load Percent
  - Ratio of load to capacity

$$\text{Load Percent} = \frac{\text{load}}{\text{capacity}} \times 100\%$$

Load Profiles

- Graphical comparison of load versus capacity
- Leveling underloaded conditions:
  - Acquire more work
  - Pull work ahead that is scheduled for later time periods
  - Reduce normal capacity
- Load leveling
  - Process of balancing underloads and overloads

Reducing Over-load Conditions

- Eliminate unnecessary requirements
- Reroute jobs to alternative machines, workers, or work centers
- Split lots between two or more machines
- Increase normal capacity
- Subcontract
- Increase efficiency of the operation
- Push work back to later time periods
- Revise master schedule

Copy Courier

- Two high-speed copiers that can be operated by one operator.
- 2 shifts per day
- 8 hours/shift , 5 days/week.
- No breaks during the day
- 30 minutes for lunch or dinner
- Machine service time = 30 minutes at the beginning of each shift
- Machine efficiency = 90%.
- Capacity
  - 2 copiers * 2 shifts * 8 hrs/day * 7/8 utilization * .90 efficiency = 1512 minutes/day

Copy Courier

Job	No. of Copies	Setup Time (min)	Run Time (min/unit)
10	500	5.2	0.08
20	1000	10.6	0.10
30	5000	3.4	0.12
40	4500	11.2	0.14
50	2000	15.3	0.10

Load Calculations

Job	Setup + Run x No. Copies	Job Time
10	5.2 + (500 X 0.08)	= 45.20
20	10.6 + (1000 X 0.10)	= 110.60
30	3.4 + (5000 X 0.12)	= 603.40
40	11.2 + (4500 X 0.14)	= 641.20
50	15.3 + (2000 X 0.10)	= 215.30
		1,615.70 min

Loading

Capacity

2 copiers * 2 shifts * 8 hrs/day * 7/8 utilization * .90 efficiency
= 1512 minutes/day

Load percent = 1615.70/1512 = 1.068 X 100% = 106.8%

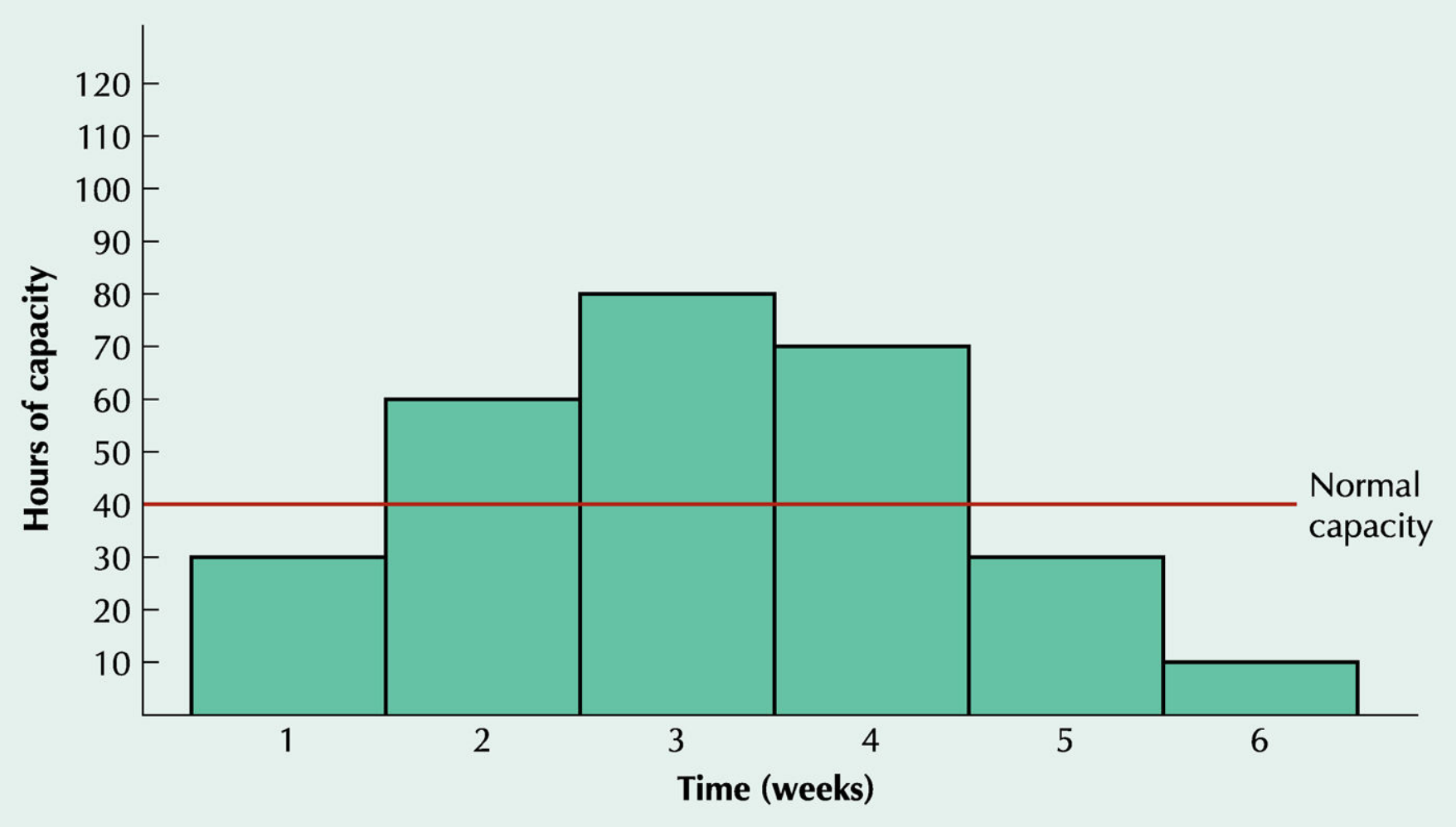
Overloaded by 6.8%.

Extends working day by approximately 36 minutes

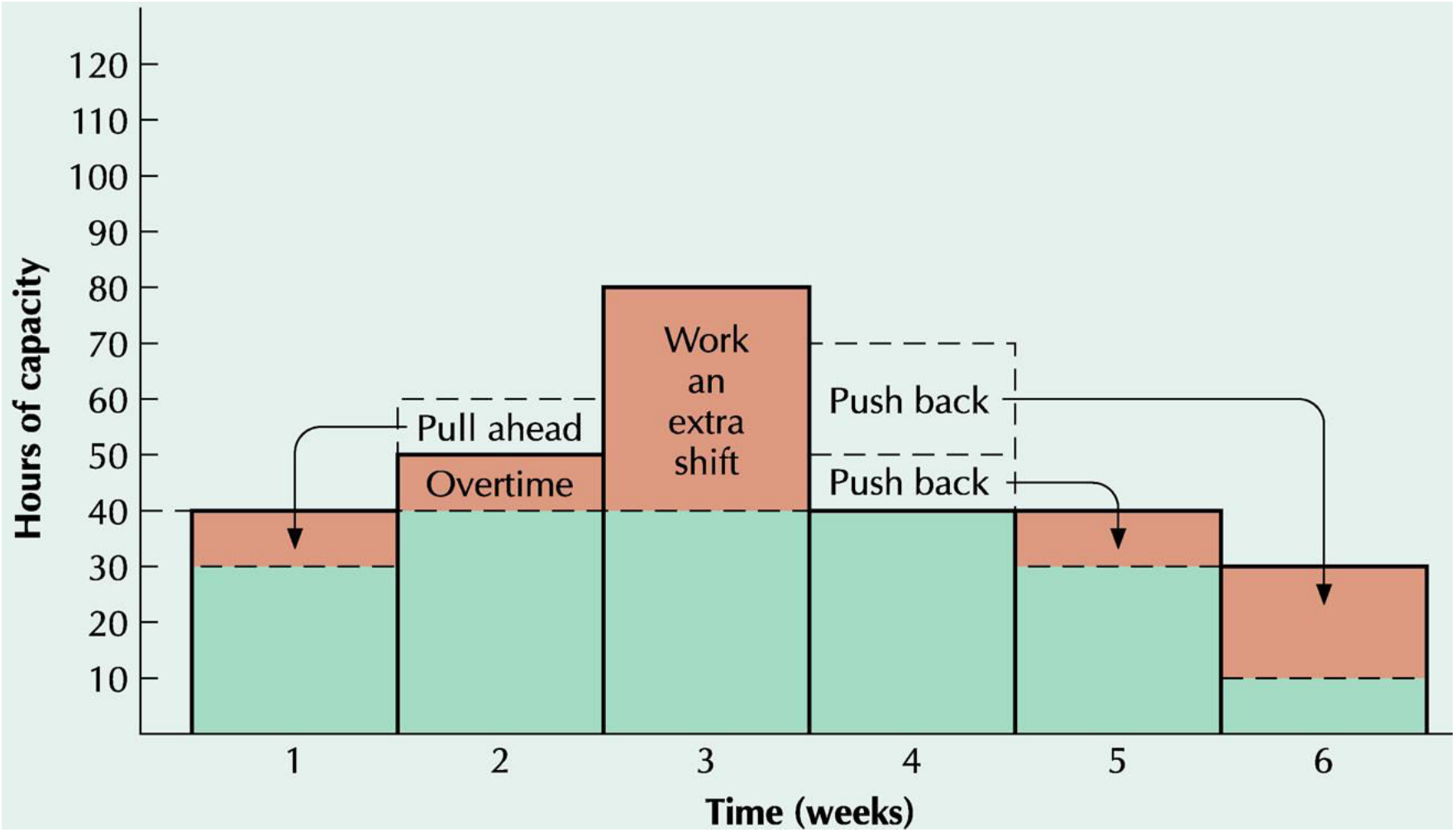
Load percent = 99%.

Increase efficiency to 97%.

Initial Load Profile



Adjusted Load Profile



Relaxing MRP Assumptions

- Material is not always the most constraining resource
- Lead times can vary
- Not every transaction needs to be recorded
- Shop floor may require a more sophisticated scheduling system
- Scheduling in advance may not be appropriate for on-demand production.

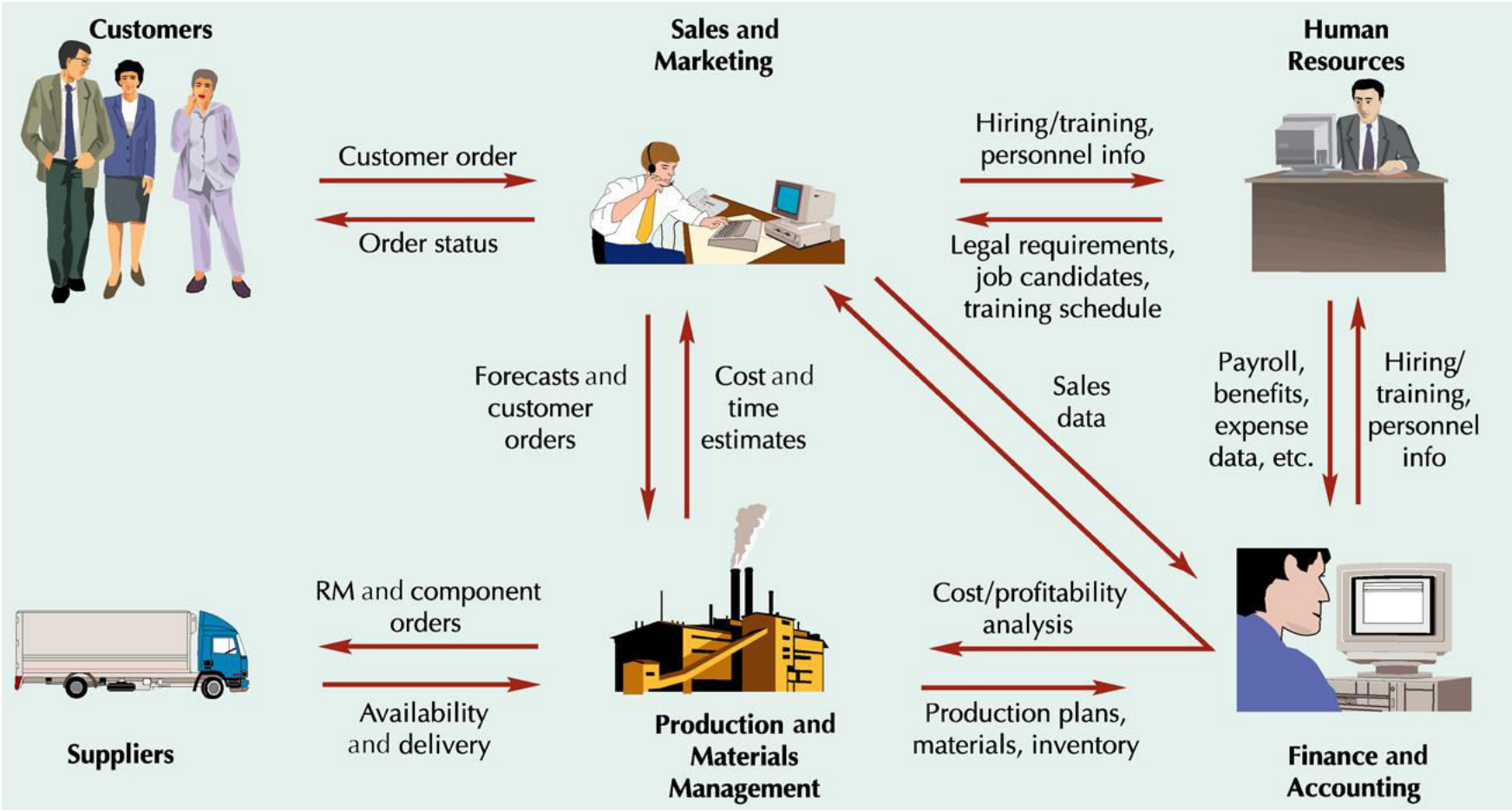
Lecture Outline

- Material Requirements Planning (MRP)
- Capacity Requirements Planning (CRP)
- **Enterprise Resource Planning (ERP)**
- Customer Relationship Management (CRM)
- Supply Chain Management (SCM)
- Product Lifecycle Management (PLM)

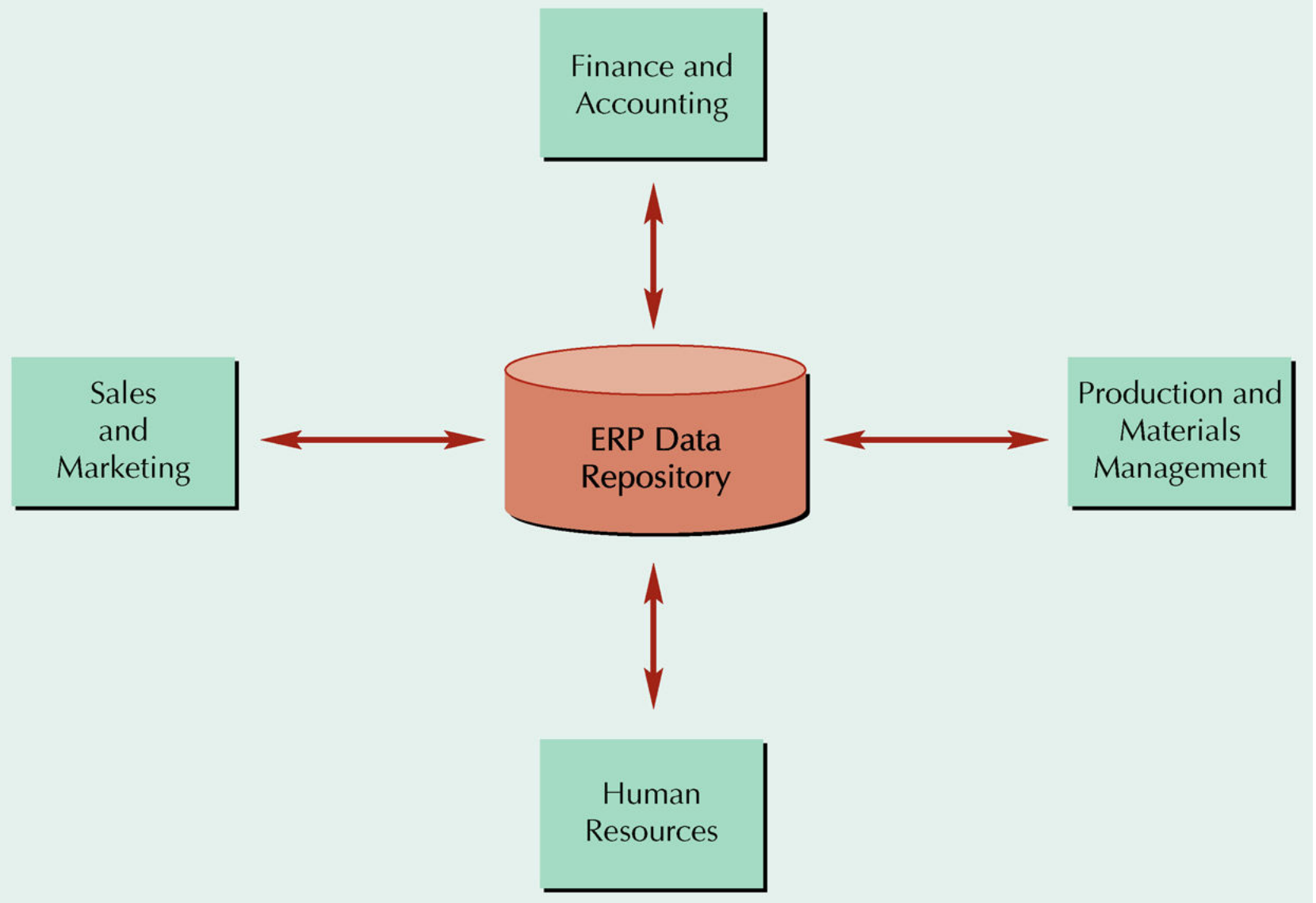
Enterprise Resource Planning (ERP)

- Software that organizes and manages a company's business processes by
  - sharing information across functional areas
  - integrating business processes
  - facilitating customer interaction
  - providing benefit to global companies

Organizational Data Flows



ERP's Central Database



Selected Enterprise Software Vendors

Vendor	Specially
1. SAP	Large enterprise discrete manufacturing ERP, SCM
2. Oracle Corp.	Large enterprise discrete manufacturing and services
3. Oracle's PeopleSoft	Human resources and employee relationship management
4. Oracle's Siebel Systems	Customer relationship management (CRM)
5. i2 Technologies	Supply chain management (SCM)
5. PTC, EDS, Dassault Systems	Product lifecycle management (PLM)
7. Siemens Energy & Automation	Manufacturing execution systems (MES)
8. SCT	Process industry; education; energy
9. QAD	Multinational midmarket manufacturing
10. Microsoft Dynamics	Small to midmarket ERP, CRM

ERP Implementation

- Analyze business processes
- Choose modules to implement
  - Which processes have the biggest impact on customer relations?
  - Which process would benefit the most from integration?
  - Which processes should be standardized?
- Align level of sophistication
- Finalize delivery and access
- Link with external partners

Lecture Outline

- **Material Requirements Planning (MRP)**
- Capacity Requirements Planning (CRP)
- Enterprise Resource Planning (ERP)
- **Customer Relationship Management (CRM)**
- **Supply Chain Management (SCM)**
- **Product Lifecycle Management (PLM)**

Customer Relationship Management (CRM)

- Software that
  - Plans and executes business processes
  - Involves customer interaction
  - Changes focus from managing products to managing customers
  - Analyzes point-of-sale data for patterns used to predict future behavior

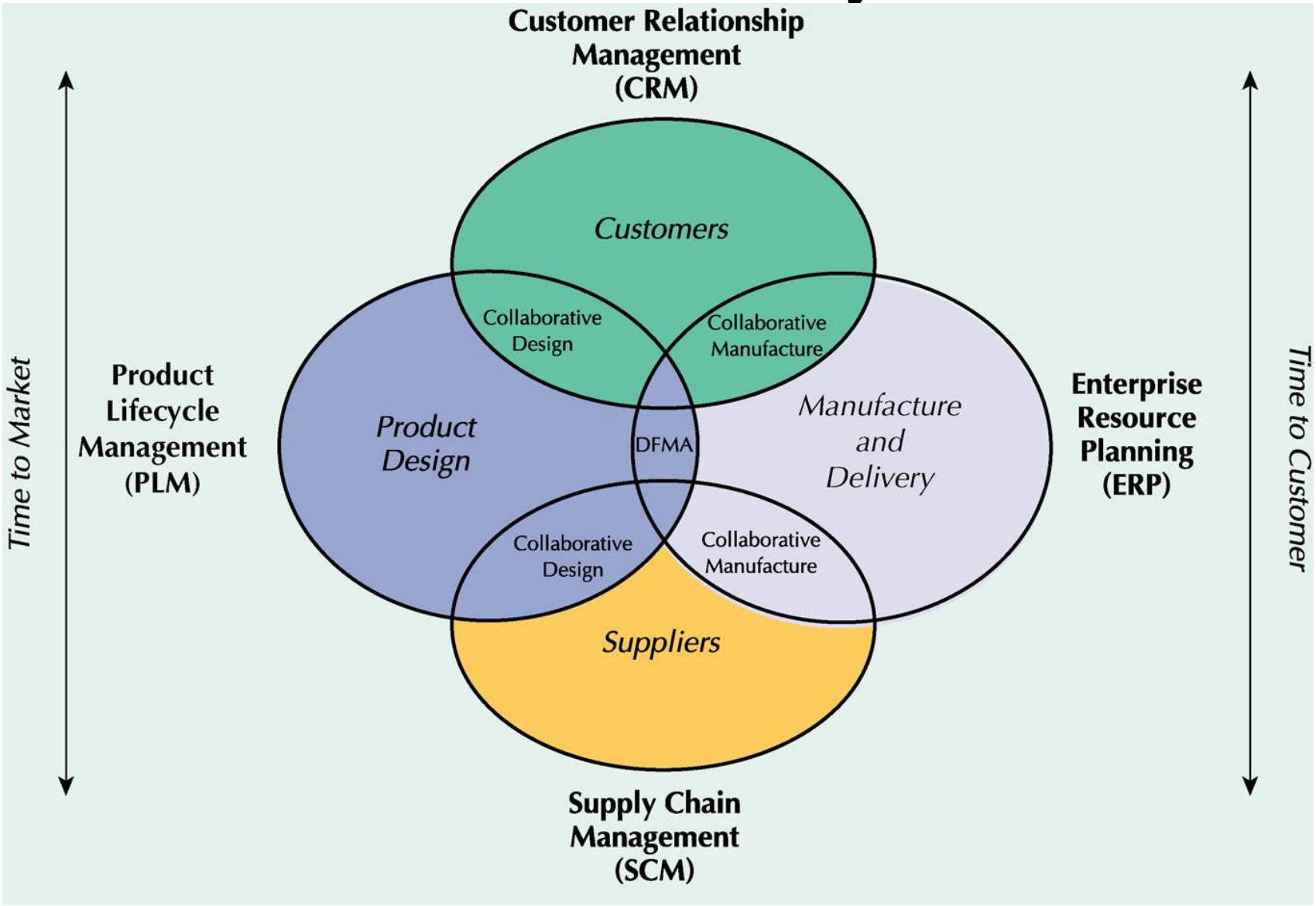
Supply Chain Management

- Software that plans and executes business processes related to supply chains
- Includes
  - Supply chain planning
  - Supply chain execution
  - Supplier relationship management
- Distinctions between ERP and SCM are becoming increasingly blurred

Product Lifecycle Management (PLM)

- Software that
  - Incorporates new product design and development and product life cycle management
  - Integrates customers and suppliers in the design process though the entire product life cycle

ERP and Software Systems



Connectivity

- Application programming interfaces (APIs)
  - give other programs well-defined ways of speaking to them
- Enterprise Application Integration (EAI) solutions
- EDI is being replaced by XML, business language of Internet
- Service-oriented architecture (SOA)
  - collection of “services” that communicate with each other within software or between software