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# ERP

## (Enterprise Resources Planning)

### Operations Management

### Dr. Mark P. Van Oyen

*Notes based in part on the work of  
Mark Spearman, Georgia Tech. & SAK Logistics  
Scott Moses, Univ. Oklahoma (formerly of i2)  
Stevenson, Chapter 14*

*Filename: ERP-lec.ppt*

# What do you know about ERP ?

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**Q1: How many of you could relate the book “*Why ERP?*” to your job?**

- **Considering ERP system**
- **Installing ERP system**
- **Homegrown system**
- **Looking for APS system (Adv. Planning & Scheduling)**

# What do you know about ERP ?

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**Q2: How many of you have an *ERP* system in place at your firm?**

**Q3: How many of you are considering an *ERP* system at your firm?**

**Q4: APS system or proprietary system?**

# Experiences with ERP ?

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**How does your firm use its ERP system?**

**How difficult was it to implement? (timetable, cost, unhappiness ☹ )**

**What has the value to your firm been?**

**Does your firm use ERP for Planning? (planning when to make products, procurement of raw materials, ...)**

# ERP is Driving Productivity!

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## MRP II Sales

- \$1.2 Billion in 1989 (almost 1/3 of software sold in US)

## ERP Sales:

- \$2.8 Billion in 1995
- \$4.2 Billion in 1996
- \$5.8 Billion in 1997 (SAP alone sold 3.2 Billion)

**1997 Monsanto: SAP/R3 installation saves \$200 million per year**

**May-2000: Grainger, (the leading MRO parts supplier to companies, aggressively blazing B2B e-commerce trails)**

**loves (at least a representative gave that perception) SAP/R3.**

**Note: Grainger does inventory and logistics as a reseller, but they do not actually make things. Also, reports from the field do not really match this projected love affair with ERP.**

# Example: Grainger

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## What is MRO?

- **Maintenance, Repair, and Operating** supplies such as lighting, janitorial supplies, motors, tools, fasteners, generators, ...

## MRO is BIG

- #1 cited e-commerce purchasing category.
- “By 2002, 90% of [purchasing professionals] will be buying over the Internet” Mark Vigorosa, *Purchasing Online*.

Their costs are 60% product and **40% process...**and they think their process costs can be reduced to 20%. (e-commerce facilitates a large part of this).

**Cost reduction is crucial:** a 5% cost decrease has the same impact on net profit after tax as a 30% increase in sales.

# Example: Grainger

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## Grainger Stat's:

- 560+ branches with total of 15,000+ employees
- 130,000 transactions per day processed
- 250,000 customer contacts per day
- > 2 million customers
- > 5 million products
- > \$1 billion in inventory
- > \$4.3 billion in sales

Grainger B2B e-commerce loves SAP/R3 for efficient global transaction execution and linkages to e-commerce.

# ERP Driving Productivity?

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**1999 Meta Group Survey of 63 companies: ROI of **negative \$1.5 million** average per ERP installation**

**SAP/R3 makes headlines in 1999:**

- **Hershey Foods Corp. misses 1999 Halloween market after installation of R/3; \$100 million + losses; problems continue after that**
- **Whirlpool Corp. delays shipments of appliances after installation of R/3 (later, *Home Depot* stores dropped their line because of a lack of proper ERP functionality)**
- **Several Fortune 500 firms “pull plug” on installation after spending \$100-250 million.**
- **Overall, about**
  - **30% of ERP installations are never used;**
  - **45% are used with partial functionality; and only about**
  - **25% are fully used.**

## ERP: True or False?

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### ERP

- **is new.**
- **is comprehensive.**
- **uses state of the art techniques to schedule production.**
- **will solve all logistical problems, provided it is installed properly.**

# In the beginning

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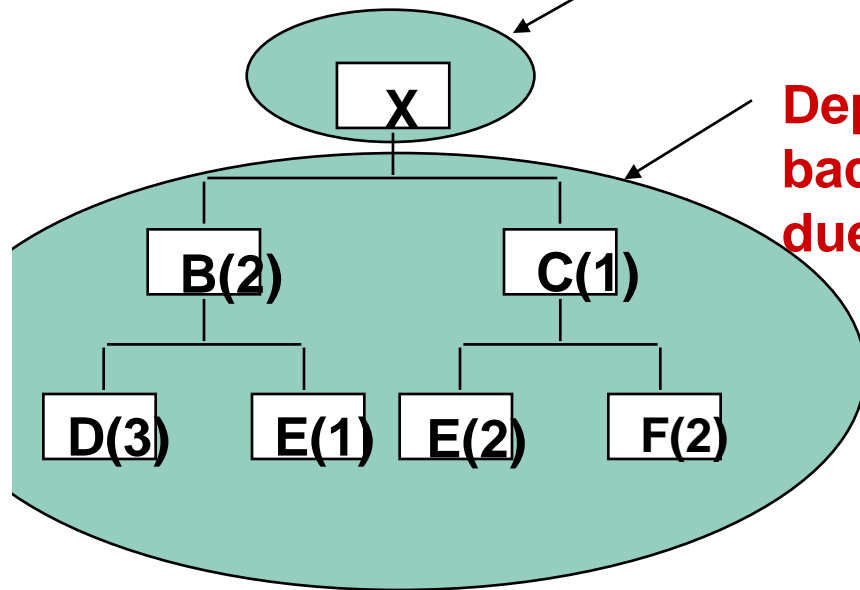
**Around 1960 ... was Joe Orlicky at IBM**

- Recognized difference between *dependent* and *independent* demand
- Independent demand should use statistical reorder points (ROP), reorder quantities (EOQ), and safety stocks (SS)
- Dependent demand is deterministic and should not be controlled statistically as in classical inventory.

**Developed MRP as a computer-based information system designed to handle ordering and scheduling of dependent-demand jobs/parts.**

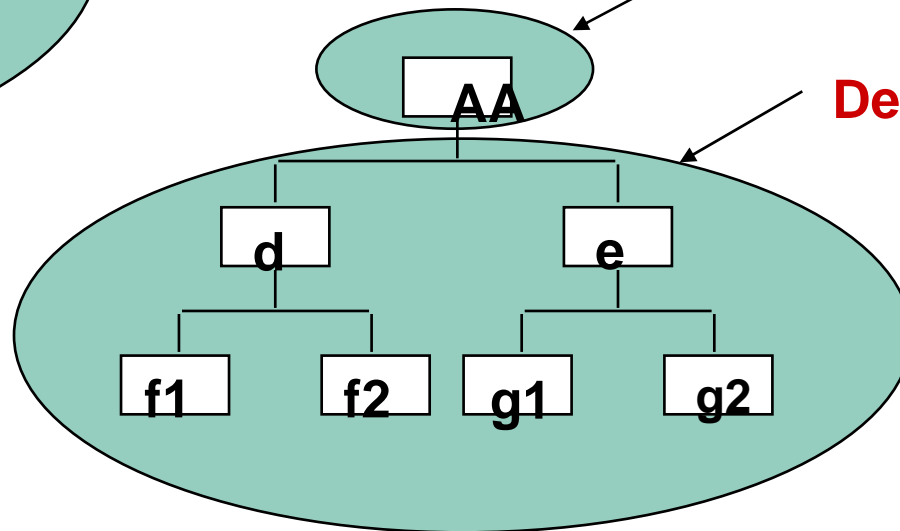
# Independent demand (Inventory). Dependent demand (MRP)

Independent Demand (forecasted, uncertain)



Dependent Demand (MRP can back-figure release times given due dates for independent demands)

Independent



Dependent

Figure 14-6 of Stevenson

# What is MRP in a Nutshell?

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**KEY IDEA: The *PUSH* approach = If the finished product is due at time T,**

- when to begin assembly?
- when to begin subassembly?
- when to begin fabrication?
- when to procure raw materials?
- Think about the process of preparing a **Thanksgiving Day dinner: an explosion of parts (foods) traced backward in time** from the start of dinner.
- Best applied to process-focused operations (associated with job shops, customized products and/or high product variety, make-to-stock production)

## Rough Example of MRP Planning Horizon

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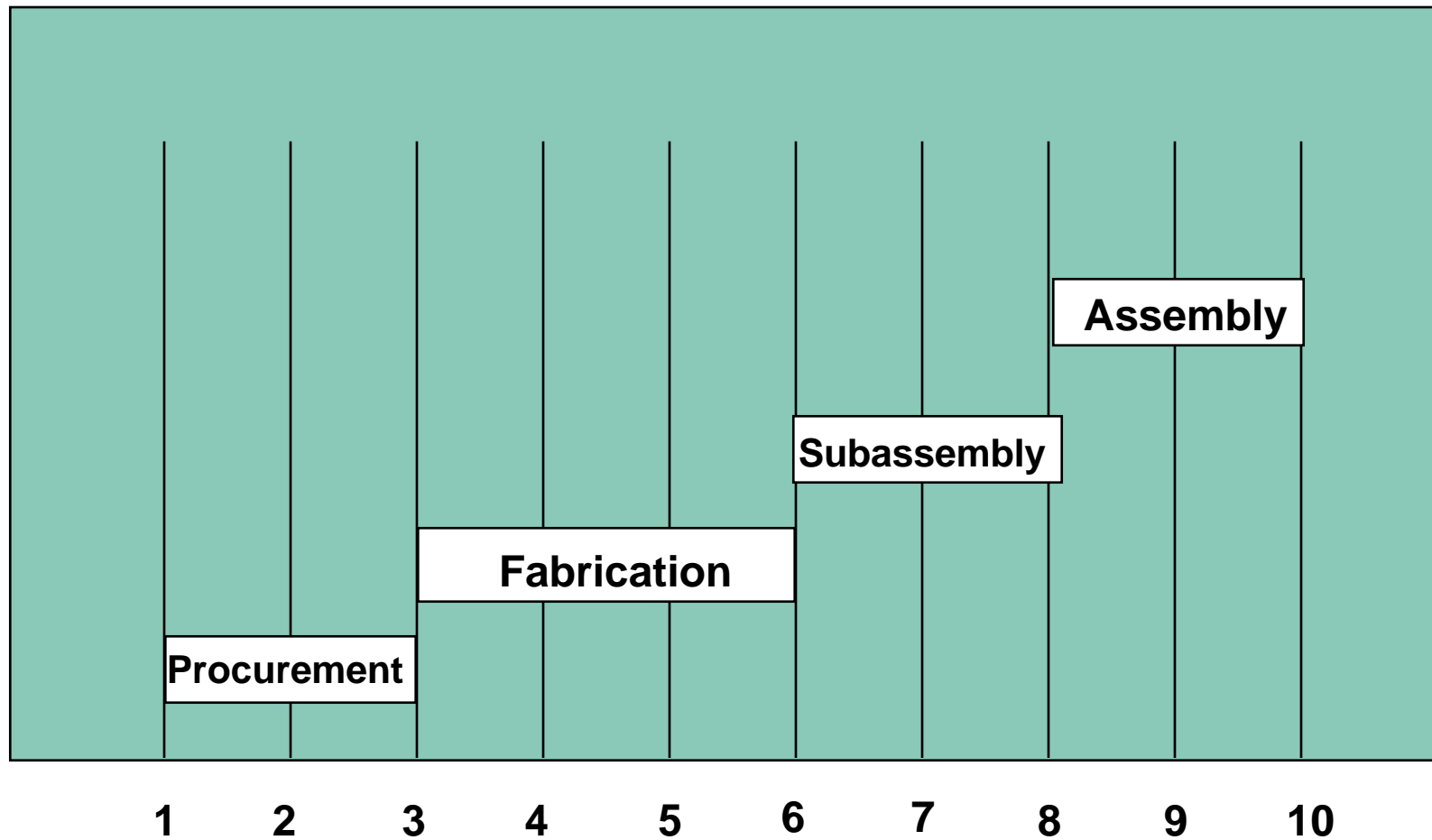


Figure 14-4 of Stevenson

# MRP Assembly Time Chart – More Detail

Backwards explosion of components to establish release times

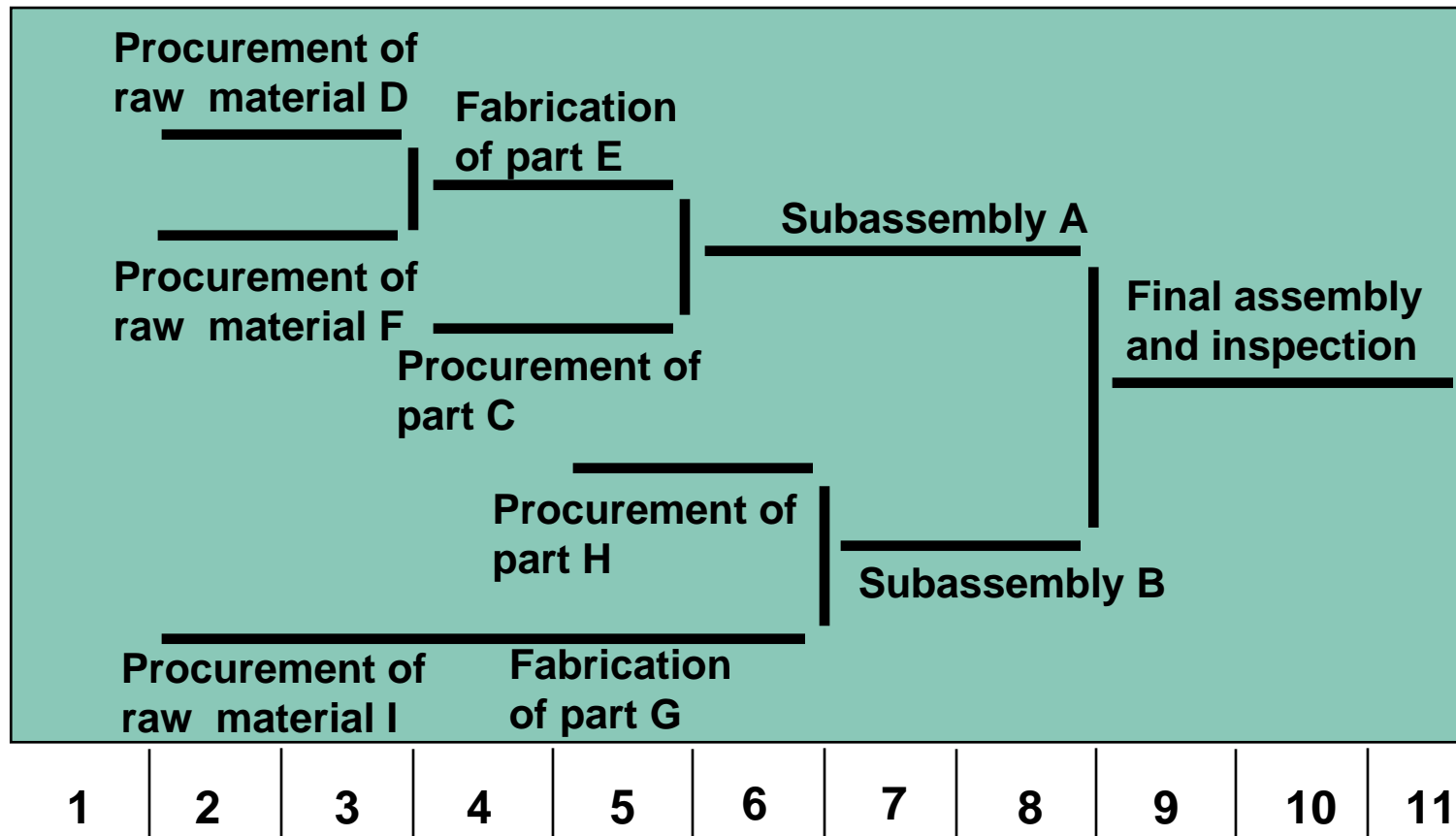
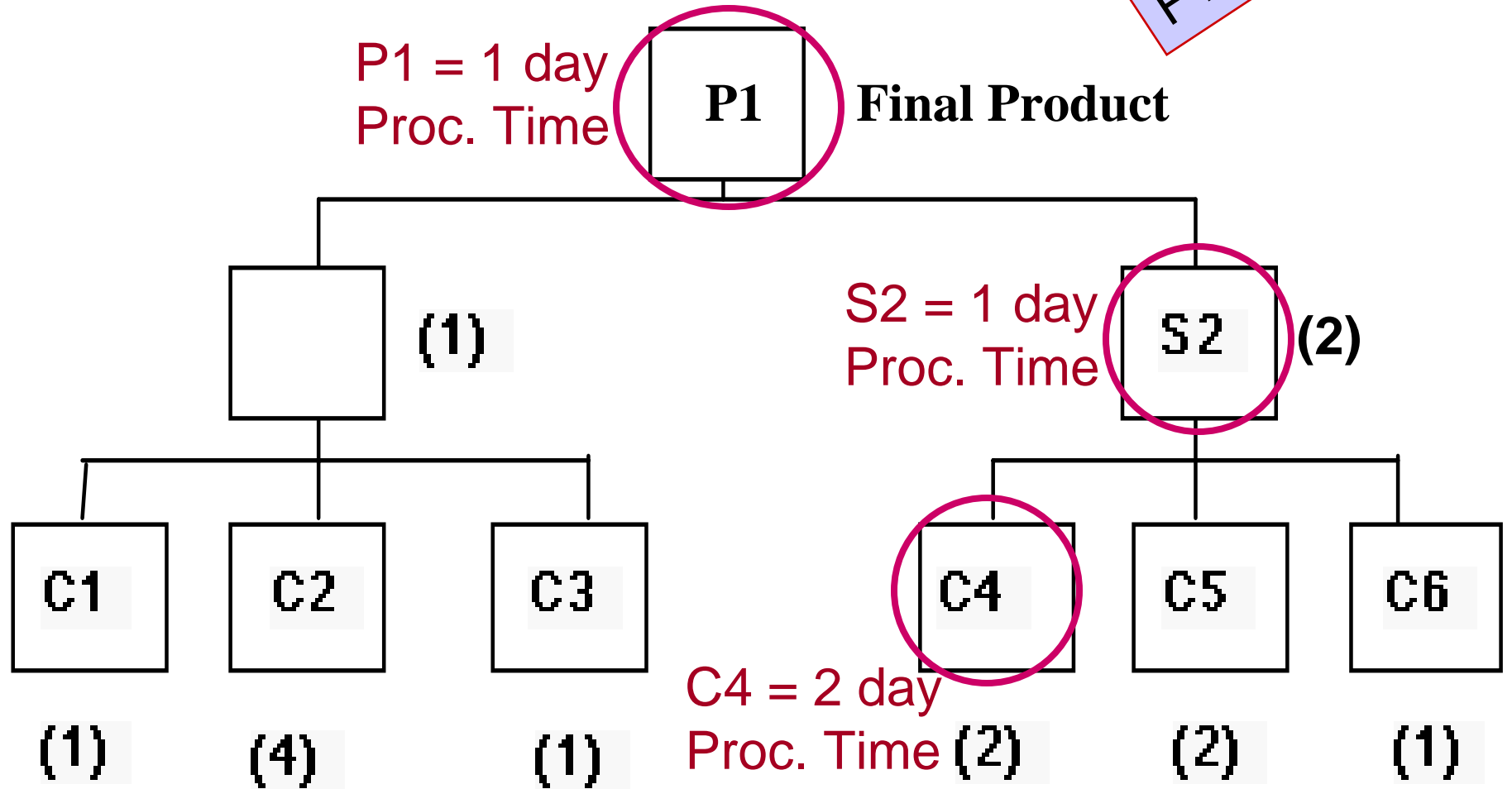


Figure 14-9 of Stevenson

# Detailed MRP EXAMPLE

FYI ONLY!



# MRP EXAMPLE

FYI ONLY!

**P1**  
1 day

Product P1	0	1	2	3	4	5	6
Gross Reqmts							400
On Hand							
Scheduled Receipts							
Net Reqmts							400
Order Releases						400	

**S2**  
1 day

Assembly S2	0	1	2	3	4	5	6
Gross Reqmts						800	
On Hand	10	10	10	10	10	110	
Scheduled Receipts					100		
Net Reqmts						690	
Order Releases					690		

**C4**  
2 days

Component C4	0	1	2	3	4	5	6
Gross Reqmts					1380		
On Hand	50	50	50	50	50		
Scheduled Receipts					400		
Net Reqmts					930		
Order Releases			930				

# Material Requirements Planning (MRP) Logic

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**Starting with independent demand and working down the bill of material, do following**

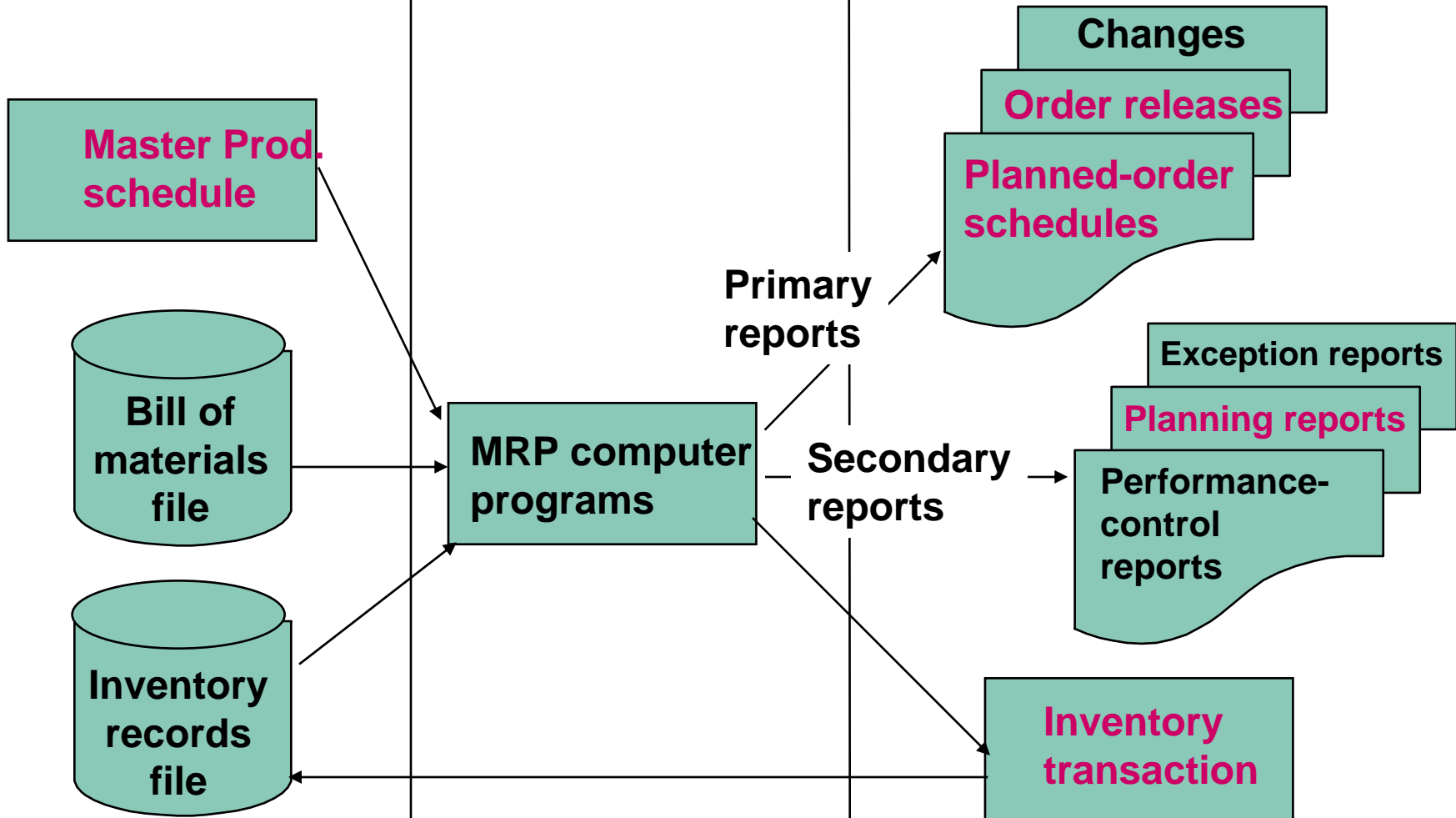
- 1. “Net” demand against existing orders and inventory**
- 2. “Lot-size” (determine batch size, possibly by EOQ) the netted demand for efficiency in presence of setups and inventory carrying costs**
- 3. “Time-phase” lot-sized, netted demand to determine “planned order release” times**
- 4. Planned order release times become demand for next level in Bill-of-Mat’l (BOM)**

# MRP

## MRP Inputs

## MRP Processing

## MRP Outputs



# APICS and the MRP Crusade

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*MRP Crusade* launched in 1971

In 1971, 150 companies were using MRP

By 1975 there were over 700

By 1981 there were over 8,000

**APICS**

[www.apics.org](http://www.apics.org)

**Old Name: American Production Inventory Control Society.**

**New: The Association for Operations Management - Advancing  
Productivity, Innovation, and Competitive Success**

**In 1970s and 1980s, APICS was recognized for its contribution  
to promote MRP in the U.S.**

## But there were problems ...

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***An MRP system is capacity-insensitive, and properly so, as its function is to determine what materials and components will be needed and when, in order to execute a given master production schedule. There can be only one correct answer to that, and it cannot therefore vary depending on what capacity does or does not exist.***

**—Joseph Orlicky**

***The problems were ... by design. They assumed INFINITE Capacity plants! And a lack of a better way, which we still struggle with today.***

# MRP Planning

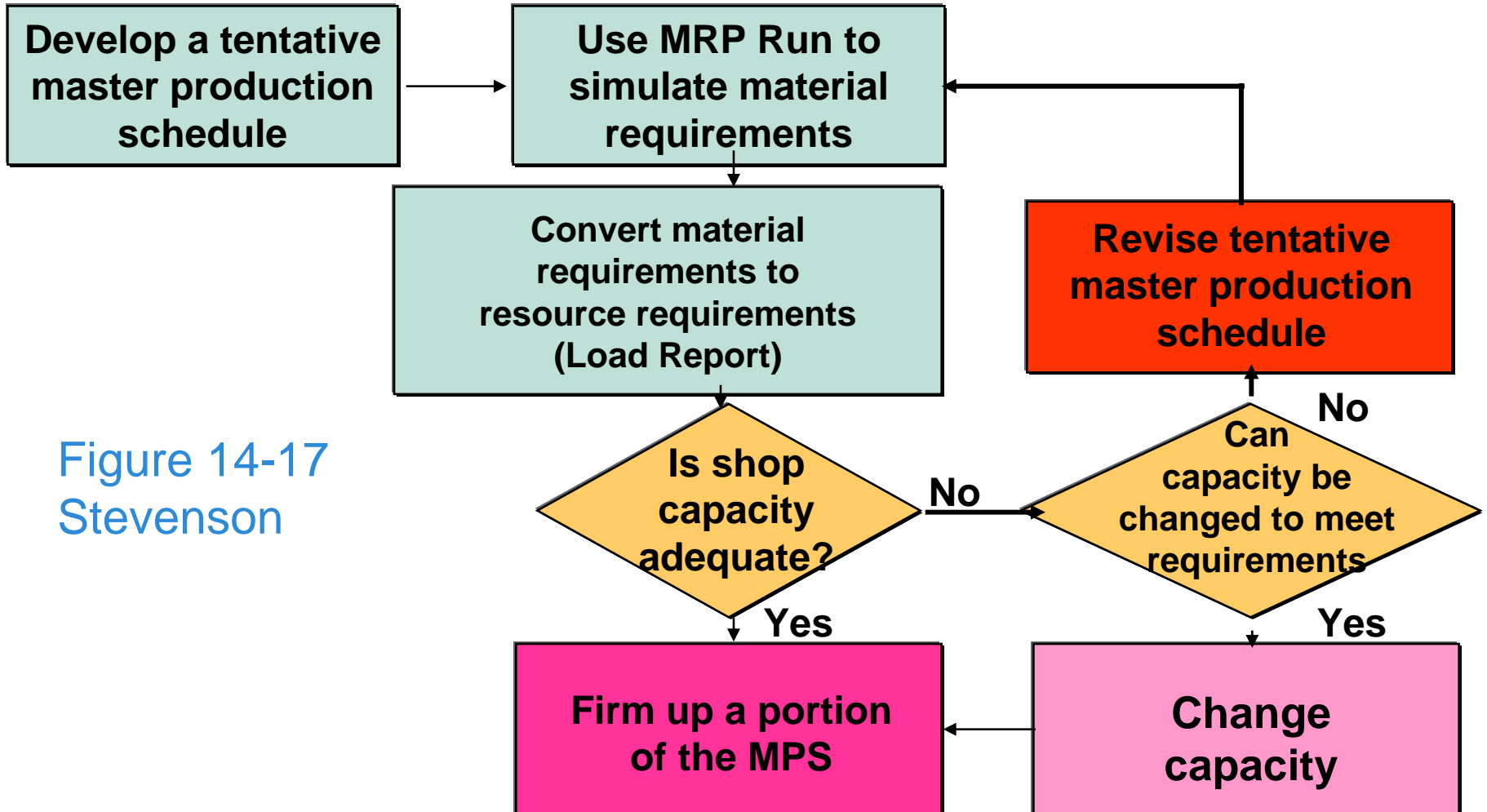


Figure 14-17  
Stevenson

Done!

# MRP II

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**MRP II** expanded MRP with and emphasis placed on **integration**

- Financial planning
- Marketing
- Engineering
- Purchasing
- Manufacturing

# **Manufacturing Resources Planning—MRP II**

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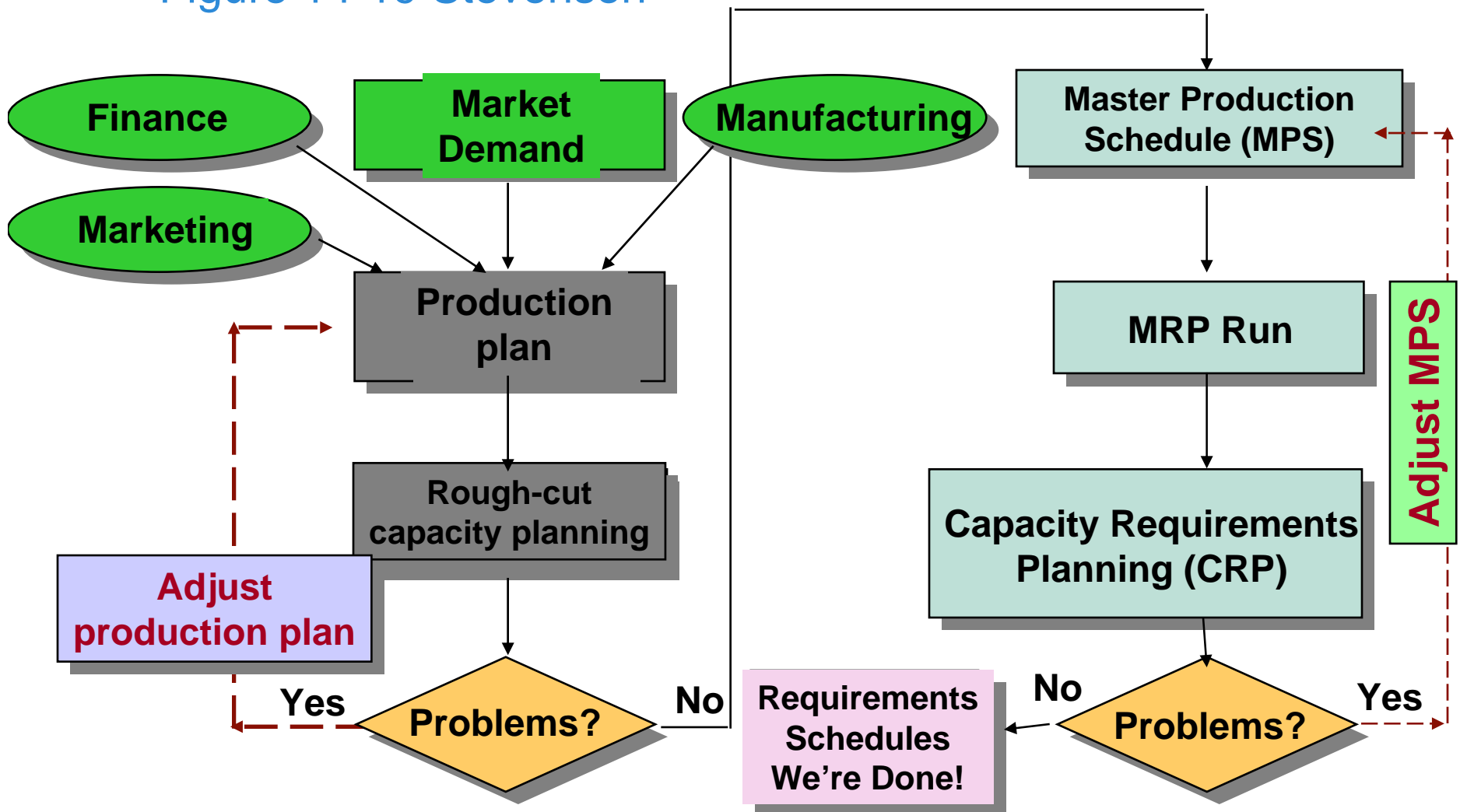
**Several modules added to MRP to check capacity**

- **Rough-cut Capacity Planning (RCCP)**
  - before MRP run
- **Capacity Requirements Planning (CRP)**
  - after MRP run
- **Note that RCCP and CRP both assume fixed lead times!**
- **Input/Output Control**

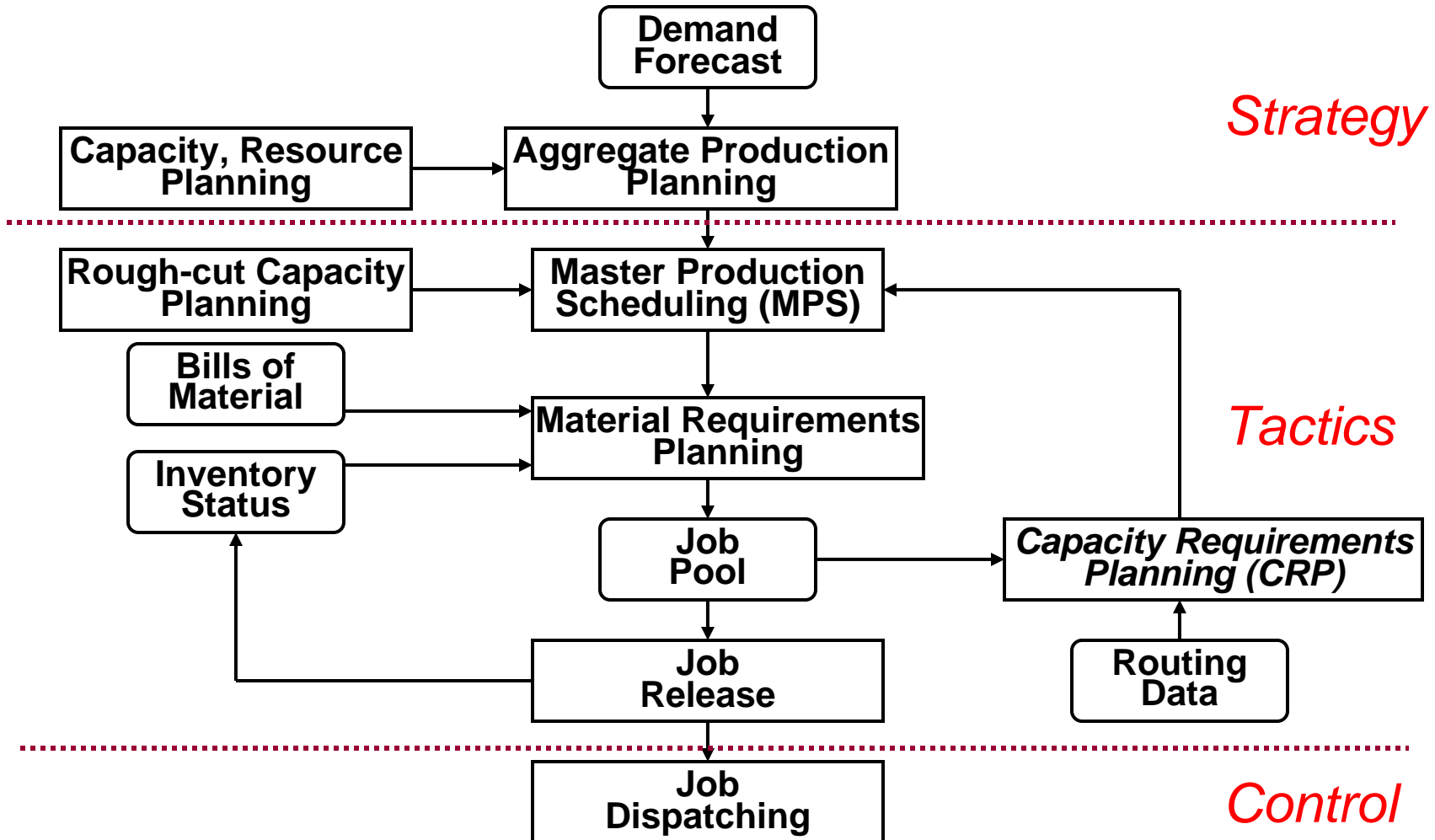
**Procedure was to iterate by changing the Master Production Schedule (see next slide for details)**

# MRP II

Figure 14-19 Stevenson



# MRP II (ERP) Planning Hierarchy



# MRP II Catches On But Does It Work?

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**In 1984, 16 companies sold \$400 million in software  
By 1989 \$1.2 billion was sold in the U.S. alone.**

**Booz, Allen & Hamilton Survey (1980) of 1100  
showed less than 10% recouped their investment  
in 2 years.**

**APICS funded survey in 1982 showed less than 10%  
regarded themselves as Class “A” users**

**“\$100 billion mistake”**

**“90 % of MRP users are unhappy”**

**“MRP perpetuates such plant inefficiencies as high  
inventories”**

# The JIT and TQM Revolutions

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**MRP perpetuates large inventories and long lead times**

**JIT promotes lower inventories using standardized production and by eliminating waste**

**Message: You do not need a computer to run your shop floor ... it can and should be run with *kanbans***

# More Incarnations

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I am sure you have all heard of these...

**Closed-loop MRP**

**MRP III**

**RRP**

**MRP 8**

**JRP**

**BRP** (were they really serious!?)

**These never quite stuck.**

## ***CITED* Reasons for Failure (Excuses)**

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**Inaccurate data**

**Lack of top management commitment**

**Unrealistic master production  
schedules**

**Lack of education of those who use the  
system**

**Why don't many people talk about  
MRP II's flawed production  
models? That's still ahead of us.**

# Then Came ERP

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**ERP is a common information system to link accounting, sales, manufacturing, materials management, etc. ERP automates basic business processes and provides a common real-time view of *selected* company resources and commitments using database(s).**

**Example: Salesman sells Doo-Hickey, boots up his notebook PC, enters the order, which alerts purchasing/procurement to order parts. Manufacturing receives the info (both in aggregate forecast as well as detailed bill of material), and use it to generate a workable Master Production Schedule (MPS).**

# Who is ERP?

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**SAP:** SAP AG is the leader in ERP: 31% of market. SAP's R/3 software package is a favorite among big users.

**Oracle:** The leading provider of relational database management systems, 14% of the market. Modular approach to ERP, offering separate applications, such as Oracle Financials and Oracle Manufacturing, that use common computing tools. The complete package is also available as Oracle Applications.

**PeopleSoft:** Provider of human resources software, PeopleSoft Inc., now has 7% of ERP market. Offers Enterprise Solutions for financials, materials management, distribution, and manufacturing.

**J.D. Edwards:** Total ERP solution in *World* and *One World* (client-server based) or a process-based solution with modules for finance, manufacturing, and logistics/distribution.

**Baan:** ERP solutions as individual applications: manufacturing, finance, and distribution/transportation, or complete as Baan IV.

**Note:** This data as of July 1998.

**Current condition (as of September 2005):** PeopleSoft bought J.D. Edwards and later Oracle bought PeopleSoft.

# Enterprise Resources Planning—ERP

Materials Management and Production Planning were just two modules in a “suite” of offerings

SAP/R3 became a “standard”



# **The Dirty Little Secret of ERP**

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**Is that within ERP we find our long-lost friend, MRP II, used for**

- Materials Management &**
- Production Planning.**

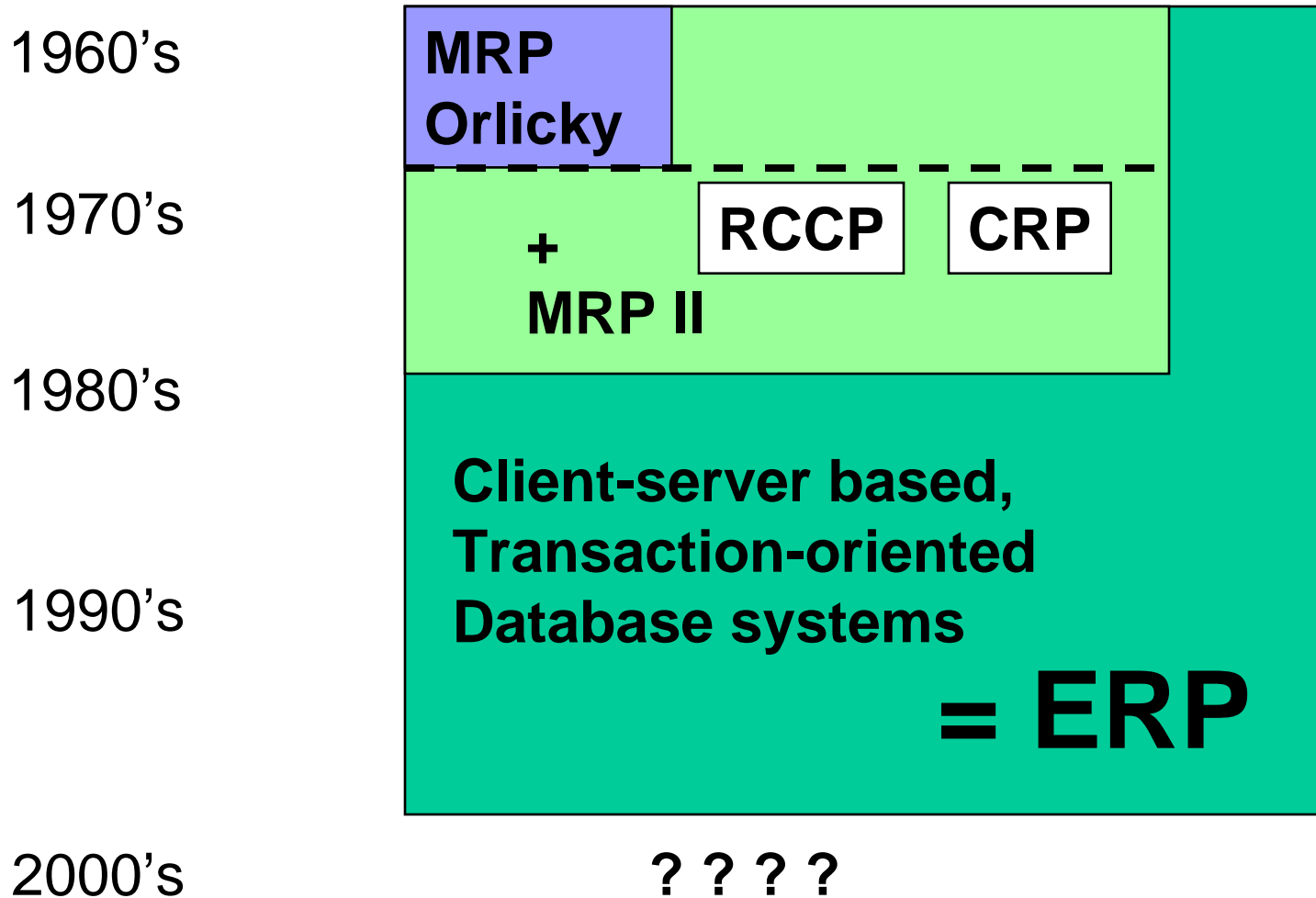
**It gets worse...the “new” ERP software has the**

**Same functions as in MRP II**

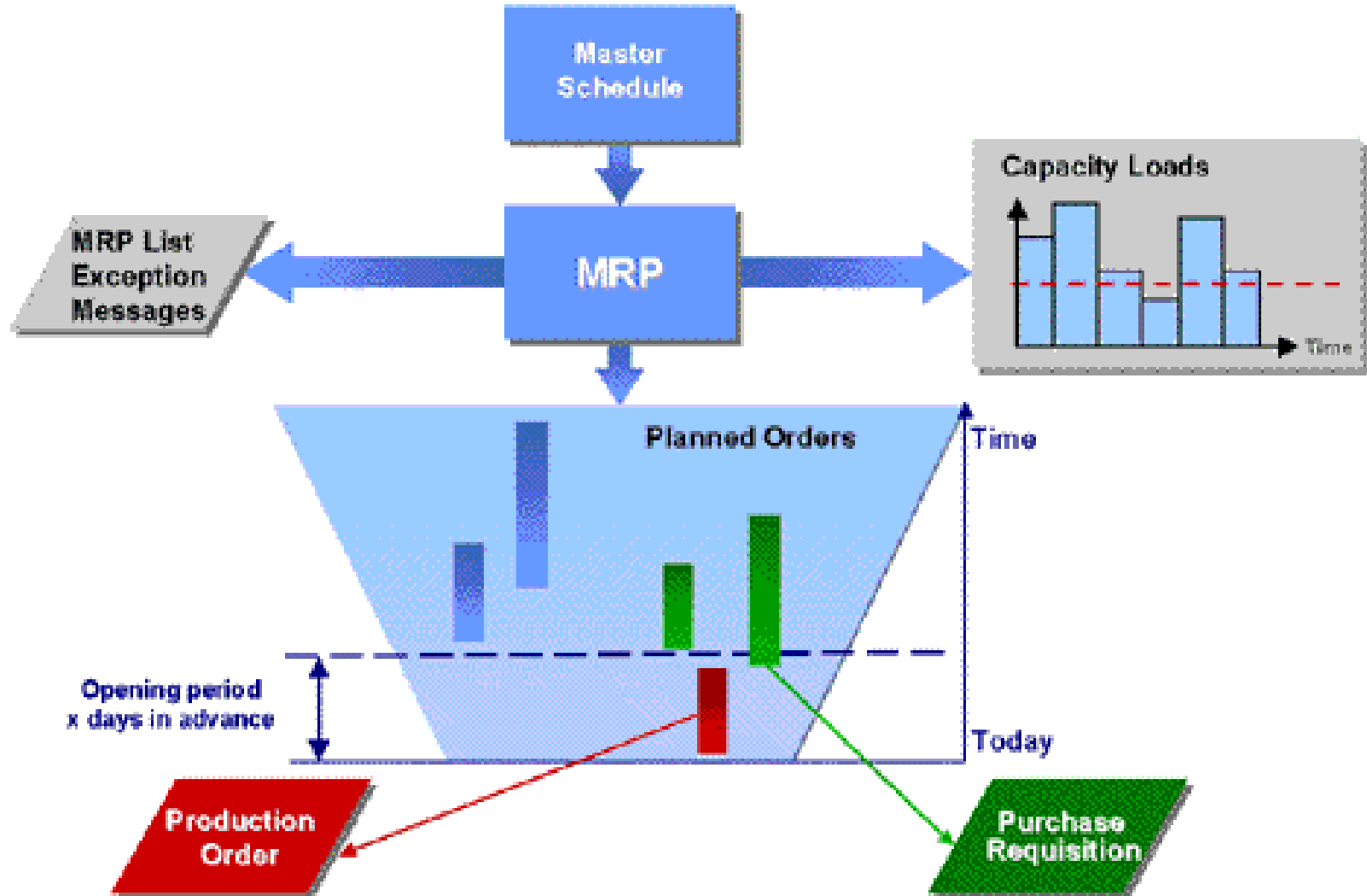
**Used in same way as in MRP II**

# ERP's PUSH "planning"

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# Within Materials Management *Is 1960's MRP!*



## Have the problems with MRP been remedied? (Recall the list of Excuses)

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- **Inaccurate data**

*Manufacturing Execution Systems now collect the data automatically*

- **Lack of top management commitment**

*\$100 million is a lot of commitment*

- **Unrealistic master production schedules (MPS's)**

*MPS is a major component in ERP*

- **Lack of education of system users**

*MRP education has become a multi-million dollar industry in itself*

# ERP is really ERPXT

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Enterprise Resources Planning is  
Enterprise Resources Transactions execution

ERP Transaction processing is ...

- Collect and store data about a business transaction
- Automation of one or more business (sub)processes
- May include the automation of decision-making functions (e.g., search for lowest cost available flight to Orlando)
- Closely linked to accounting functions
- A part of every critical business process and process flow
- **+ ERP is potential enabler of e-commerce!**

# Transaction example

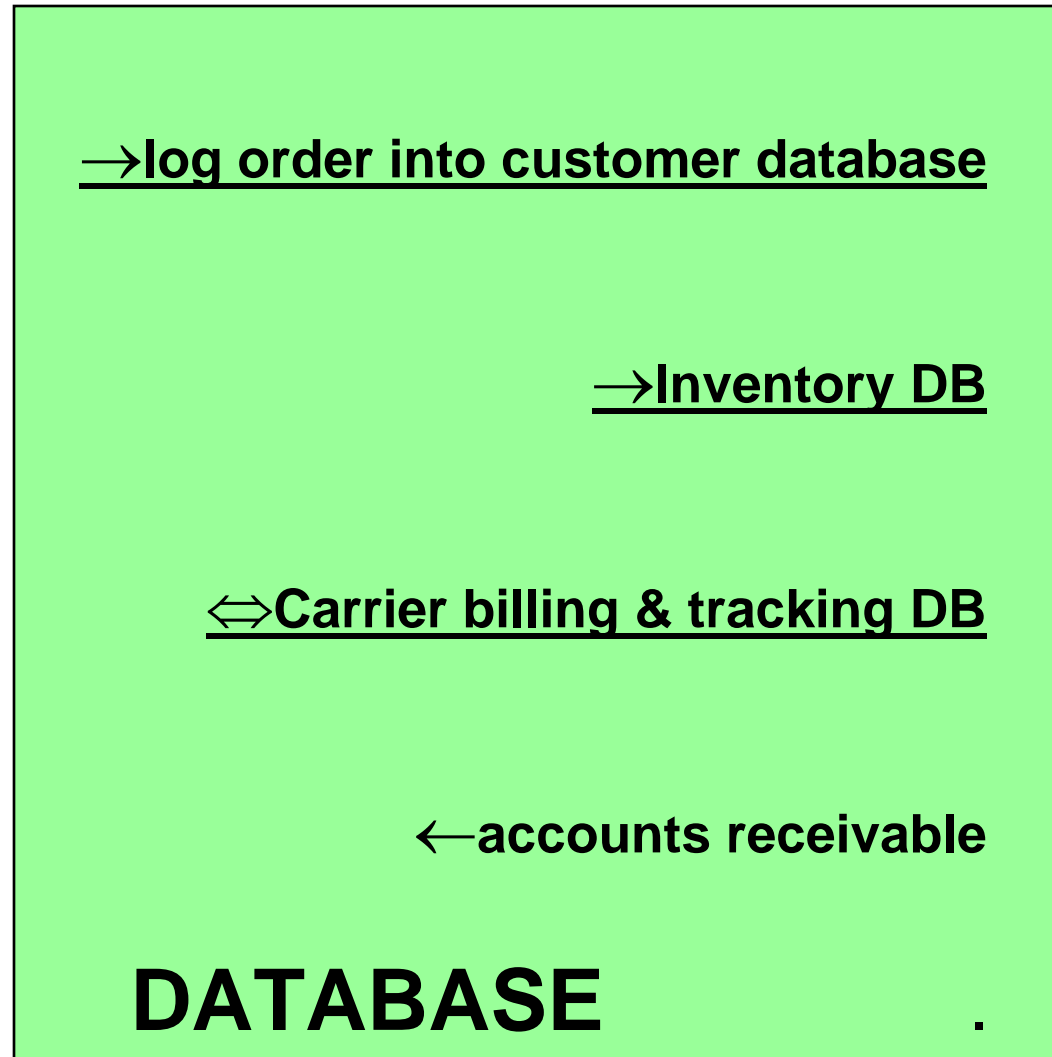
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1. Take customer order and log it into database (e.g. calling inbound call center)
2. **If Make-to-Stock (MTS) system:** Allocate inventory (If no stock on hand (stockout), then must place backorder and possibly order from supplier)  
**If Make-to-Order (MTO) system:** Fabricate order from raw materials or semi-finished goods.
3. Coordinate all parts in the order; pack them; ship to customer
4. Bill the customer (accounts receivable)

# Trans. Facilitated by Database

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1. Take order
2. Allocate inventory or Fabricate order
3. Pack & Ship
4. Bill the customer



# Value of Transaction Processing

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- 1. Speeds up the execution of tasks, particularly communication and/or passing work from one station to another. Reduces cycle time (CT); increases throughput (TH); reduces Work in Process (WIP) if done well.**
- 2. Products with more parts, more complexity, and a more complex supply chain can be effectively produced.**
- 3. Reduce COST (potential for better managed inventory, lower costs of communication, better coordination, information sharing)**
- 4. Improve coordination with suppliers (efficient communication of detailed data, vendor-managed inventory)**
- 5. Eliminate boring, distasteful jobs while increasing accuracy**
- 6. Potential for customers to customize their account, perform their own data entry, and possibly track their order, or get account information (e.g. Salomon Smith Barney)**

# ERP Systems: Some Facts

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“A complete system could take several years and several hundred million dollars to deploy.” [The Economist]

“The average time to implement R/3 is approximately five person-months per concurrent user.” [GartnerGroup]

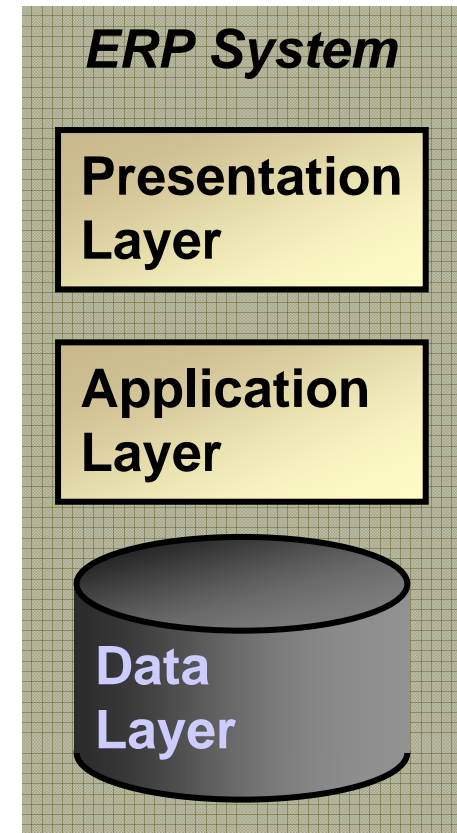
“It's not unusual for the big, complex deals to be \$50,000 to \$75,000 per concurrent user,” [GartnerGroup]

"The data is in there, but there's this excruciatingly painful effort to make sure that what you pull out is what you need." [Colgate-Palmolive]

**The data is often not even in the database!**

Big Bang implementation approach is very risky (Hershey, Whirlpool, FoxMeyer, etc. suffered greatly)

## 3-Tiers



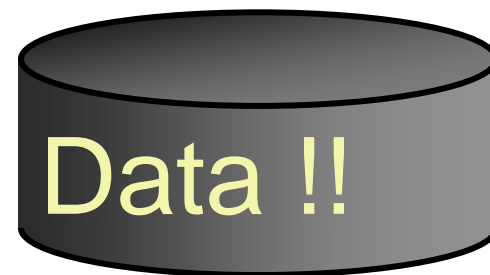
## Business Justification for Current Generation ERP Systems

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“The United States has a tremendous data processing industry that caters to the **managerial conviction that better information means better management.**”

“Machine processing of business data is usually justified on the basis of machine-processing costs relative to costs in the previously existing system.”

**Jay Forrester, 1961**  
**Industrial Dynamics**



# Current Generation ERP Systems: Myths

Myth	Reality	Implication
<p><b>ERP systems have all the data.</b></p> <p>ERP systems make it easier for you to get data for an optimization model</p>	<p>Other systems exist (MES, Legacy)</p> <p>No system collects data on "everything"- just for functions performed by the system.</p>	<p>Application integration needed (Databases, Data warehouses, Excel spreadsheets, etc.)</p> <p>Technology needed to improve data quality</p>
<p><b>Single (centralized) database</b></p>	<p>Multiple database instances (therefore, separate transaction systems).</p> <p>Partial adoption across enterprise / supply chain.</p>	<p>Distributed databases</p> <p>Information latency and uncertainty</p>
<p><b>Single-vendor integrated solution can provide all necessary functionality.</b></p>	<p>800-lb. Industry Gorillas that are really good at one thing.</p>	<p>Best of breed</p> <p>Application integration (Semantic translation)</p>

# Current Generation ERP Systems: Myths

Myth [OR/MS Today, 06-99]	Reality	Implication
<p>“When a sales rep. enters an order into ERP system, the data are immediately available on plant floor”</p>	<p>Why would you want this?</p>	<p>Research on tactical planning</p>
<p>“ERP allows the sales rep’s to easily, quickly and simultaneously consider inventory-on-hand, raw material availability, work-in-progress and production capacity across the enterprise” to make a delivery time commitment.</p>	<p><b>Only finished goods inventory (possibly only at a single location) is easily checked.</b></p>	<p>Research on real-time ordering promising</p> <p>Intelligent e-Business potential</p>
<p><b>ERP “easily adaptable” and “can be easily changed or expanded without disrupting the course of business.”</b></p>	<p><b>Fit org. &amp; bus. processes <u>to</u> software. “Poured liquid concrete into your org.”[Hammer]</b></p>	<p>Object oriented design.</p> <p>Componentization.</p> <p>Use standards (Web).</p>

# ERP's "7 Habits for Success"

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1. **Look at your business's competitive needs.** Do not focus on the glitzy software. Use cross-functional teams and executive-level input to identify, examine, and rethink existing business processes.
2. **Plan ahead:** Establish business goals, Map out a strategy for getting there, Reengineer existing business processes and/or develop new business processes to support the strategy. Think long-term (5 yrs). Mar. 2000 *Man. Rev.* "...20-30 % of companies using ERP have seen an ROI."
3. **Prove you need ERP.** Spell out how an ERP system will support overall business strategy and how it will work with your new business processes. If you can't make a case for ERP, you probably don't need it. It is a mistake to think of ERP as "... an IT change, when fundamentally it is a business change" Oswald Mata, Deloitte Consulting.
4. **Choose partners wisely.** Select the ERP provider that's right for your business needs. Consultants must understand your business as well as ERP technology.

# ERP's 7 Habits for Success

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5. **Pick the best man/woman for the job.** ERP implementation is tricky. Consultants can help, but stock implementation teams with your company's smartest workers. A good rule: If an operation can't run without a particular person, you want them on the implementation team.
6. **Start off slow.** A good ERP implementation can help a company run smoother. A bad one can shut a company down. (Hershey's lost 100 million dollars in only 6 months after going live with a full-scale implementation). Install ERP on a rolling basis, starting with small but highly visible business units first. Lessons learned can make the rest of implementation run smoother. Early successes will help get buy-in from both the executive suite and the plant floor.
7. **Change everything.** ERP will open your eyes to information and processes you never thought possible. Be flexible enough to change the way you operate over and over again.

Source: July 16, 1998 Purchasing Magazine <http://www.manufacturing.net/magazine/purchasing/archives/1998/pur0716.98/071erp.htm>

# Advanced Planning & Scheduling (APS)

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**ERP Systems lack intelligence for planning and control**

**APS seeks to fill the gap:**

**APS packages "bolt-on" to an ERP system. They are the next-generation of material requirements planning (MRP) technology. MRP and its successor, MRP II (Manufacturing Resource Planning), promised to bring better control and order to the manufacturing floor. However, both systems operated under the assumption that companies have infinite manufacturing capacity (resources & labor).**

**Most MRP II users still need “safety lead time” and/or “safety stock” in an attempt to buffer against the “stupidity” of the software.**

**APS tends to focus on:**

- scheduling & control**
- supply chain management**
- logistics**
- facility location, forecasting, etc.**

# Who is APS?

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**BDM International Inc.--Supply Chain Div. 703-848-5000 [www.bdm.com](http://www.bdm.com)**

**i2 Technologies Inc. 800-800-3288 [www.i2.com](http://www.i2.com)**

**ILOG 800-367-4564 [www.ilog.com](http://www.ilog.com)**

**Industri-Matematik Inc. 914-631-2700 [www.imi.se](http://www.imi.se)**

**Logility 800-762-5207 [www.logility.com](http://www.logility.com)**

**Manugistics 301-984-5000 [www.manugistics.com](http://www.manugistics.com)**

**Red Pepper/PeopleSoft 888-773-8277 [www.peoplesoft.com](http://www.peoplesoft.com)**

**ThinkSystems/i2 973-299-4500**

**ThruPut Technologies 408-920-9711 [www.thru-put.com](http://www.thru-put.com)**

**and many, many more!**

## What Is Underlying Model of MRP?

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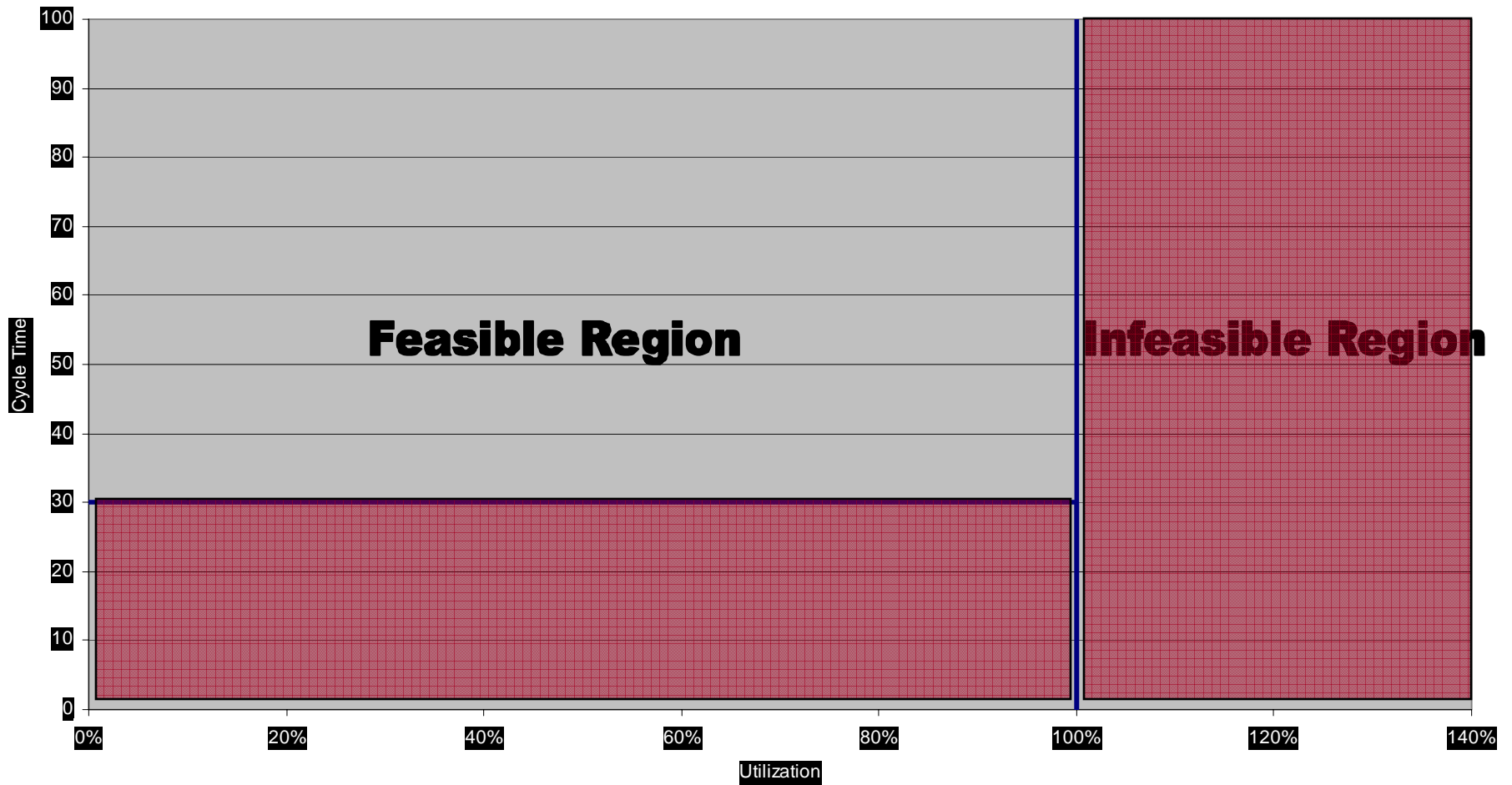
*Procurement lead time parameter* may be a function of  
the part  
supplier  
component Price  
order quantity

It is not a function of  
the facility (resources, capacity, layout)  
the WIP already in the system  
unpredicted events such as breakdowns

*This is equivalent to assumption of **infinite** capacity!*

# Basic Model of MRP

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# What's Wrong at the Heart of MRP?

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**MRP and MRP II use FIXED lead times that depend ONLY on the part type, not on the conditions of the factory floor.**

Example of typical MRP data structures offered:

- Part Type
- Supplier
- Component Price
- Procurement lead time parameter
- Order quantity

Cannot capture status of shop floor! Plant capacity is assumed infinite! People keep looking for clever tricks to “make ERP work”

TIP: Part Type, Supplier Identity, & Component Price can be factored into a formula to try to accurately estimate the best (fixed) lead time (but it's not well-known how to do this effectively!). (Dr. Mike Hegedus of IBM did Ph.D. thesis on this).

# Consequently

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“fat” production schedules with long lead times and large inventory levels.

Lead times tend to be pessimistic, because

- **Customers can scream (so don't promise optimistically)**
- Inventory cannot even make a peep

Long lead times lead to:

- More inventory (\$)
- More scrap (\$, time, waste)
- More forecasting (ouch!)
- Less responsiveness to customers (time)

**Fact: SAP R/3 has many, many production and inventory methods (like EOQ) built in; however, none of them are designed to minimize flow time!**

## Advanced Planning and Optimization Systems (APS)

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**Perform finite capacity scheduling of MRP output**

**Some optimize (in the strong sense of the term), but many just simulate alternatives**

**Most are “black-box” without documented performance (“how we do it is our business – not yours!”)**

**Many are “too little, too late”**

**... but we can expect to see (soon) a NEXT generation of ERP systems that learns from the APS vendors, or at least integrates with them more successfully**

# The Challenge for Real O.M. Solutions

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1. **Replace the “fixed lead time” assumption of MRP II with a more sophisticated method based on nearly real-time information about inventories and the shop floor congestion.** [requires improved O.M. methods and algorithms, or merely implementing what is already known!]
2. **Proven methods to identify what data can really be stored, retrieved, and presented usefully as an aid in decision-making** [requires more flexibility in databases and data structures of application software]
3. **Making all of this happen on the Web** [tap standards, pervasive off-the-shelf technology, and a common base of labor pool knowledge - in contrast to extensive package-specific user training.]

# **Next Generation Business Systems**

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## **Flexible**

- Reconfigurable

## **Connected**

- Scalable to a large number of casual users

## **Optimizing**

- Meaning optimization in the broad sense, including heuristic methods and interactive decision support

## **Collaborative**

- Based on defined Authority Domains