# King Saud University

# College of Engineering

# IE – 462: "Industrial Information Systems"

# Spring – 2021 (2$^{nd}$ Sem. 1442 H)

## Introduction (Chapter 1)

*part 2 – Introduction to Industrial Information Systems (IIS)*

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# Lesson Overview

Part 2:

- MRP / MRP II

- ERP

- MES

- ERP/MES/Control

- Information flow within the IS

- Network Architecture

- Functions of an Information System

# Why IS in Industry?

- Industrial firm:
  - Set of activities, or processes, that interact with each other (creating and exchanging information)

- Example:
  - When *quality control* gives final approval to use material

  - This is *information* passed on to *production* before production personnel can *process* the material

# Material Requirements Planning as IIS

- Material Requirements Planning (MRP):
  - Represents a typical example of IIS for inventory/production management

  - Input to the MRP is the **Master Production Schedule** (MPS) through *sales order* or *warehouse stock replenishment request*

  - MPS contains *how much* and *when* (i.e. gross requirements) for finished product units (see e.g. below):

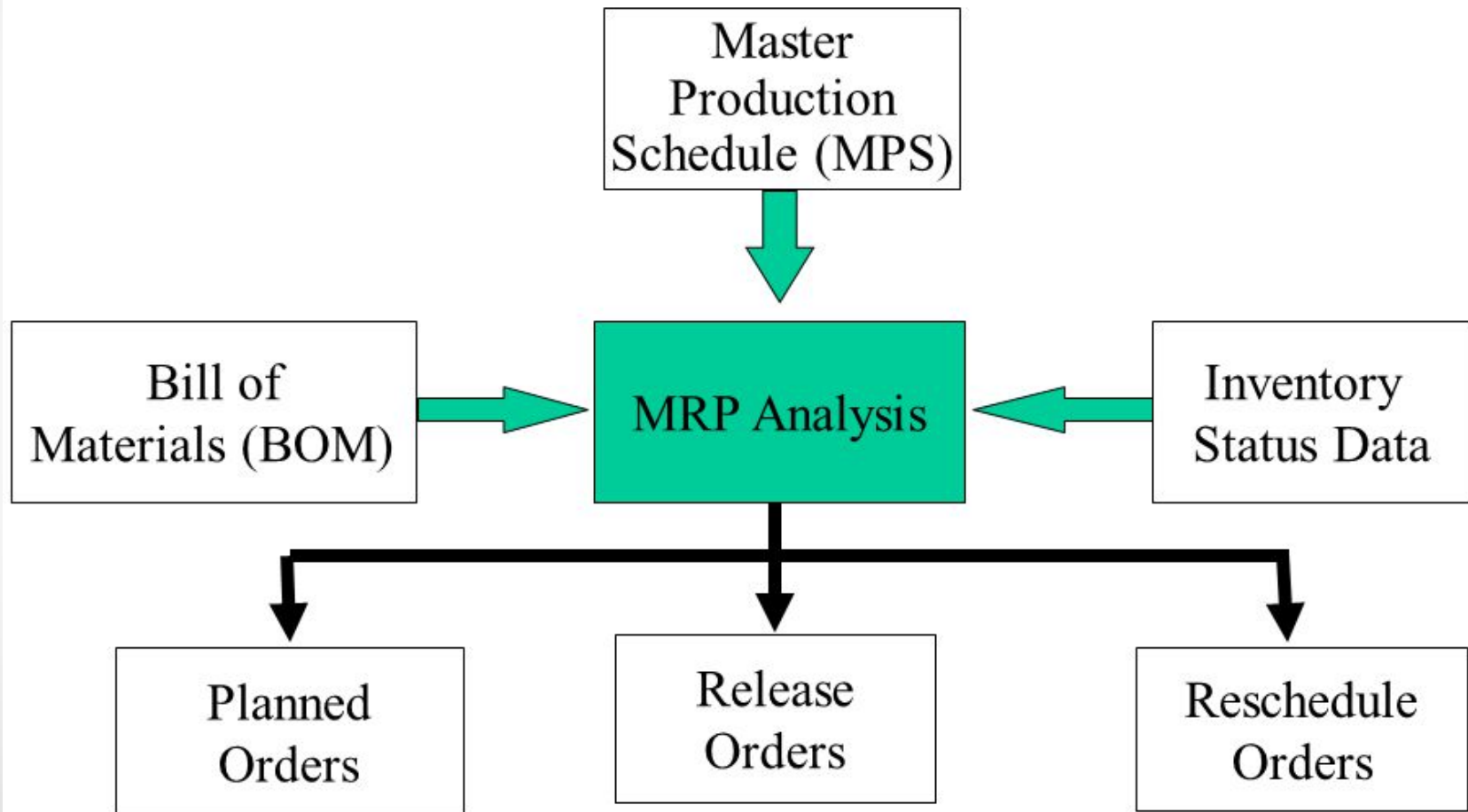| Production Plan for Week 2, December 09 | 12/7 | 12/8 | 12/9 | 12/10 | 12/11 |
|---|---|---|---|---|---|
| Demand Management | | | | | |
| Monthly Demand for Product A | 4000 | 4000 | 4000 | 4000 | 4000 |
| Working Days in Month | 23 | 23 | 23 | 23 | 23 |
| MPS Daily Demand for Product A | 174 | 174 | 174 | 174 | 174 |

# Material Requirements Planning as IIS (cont.)

- Demands for subassemblies and components:
  - determined through **Bill of Materials** (BOM) explosion

- Demand for raw materials:
  - determined from subassemblies and components demands
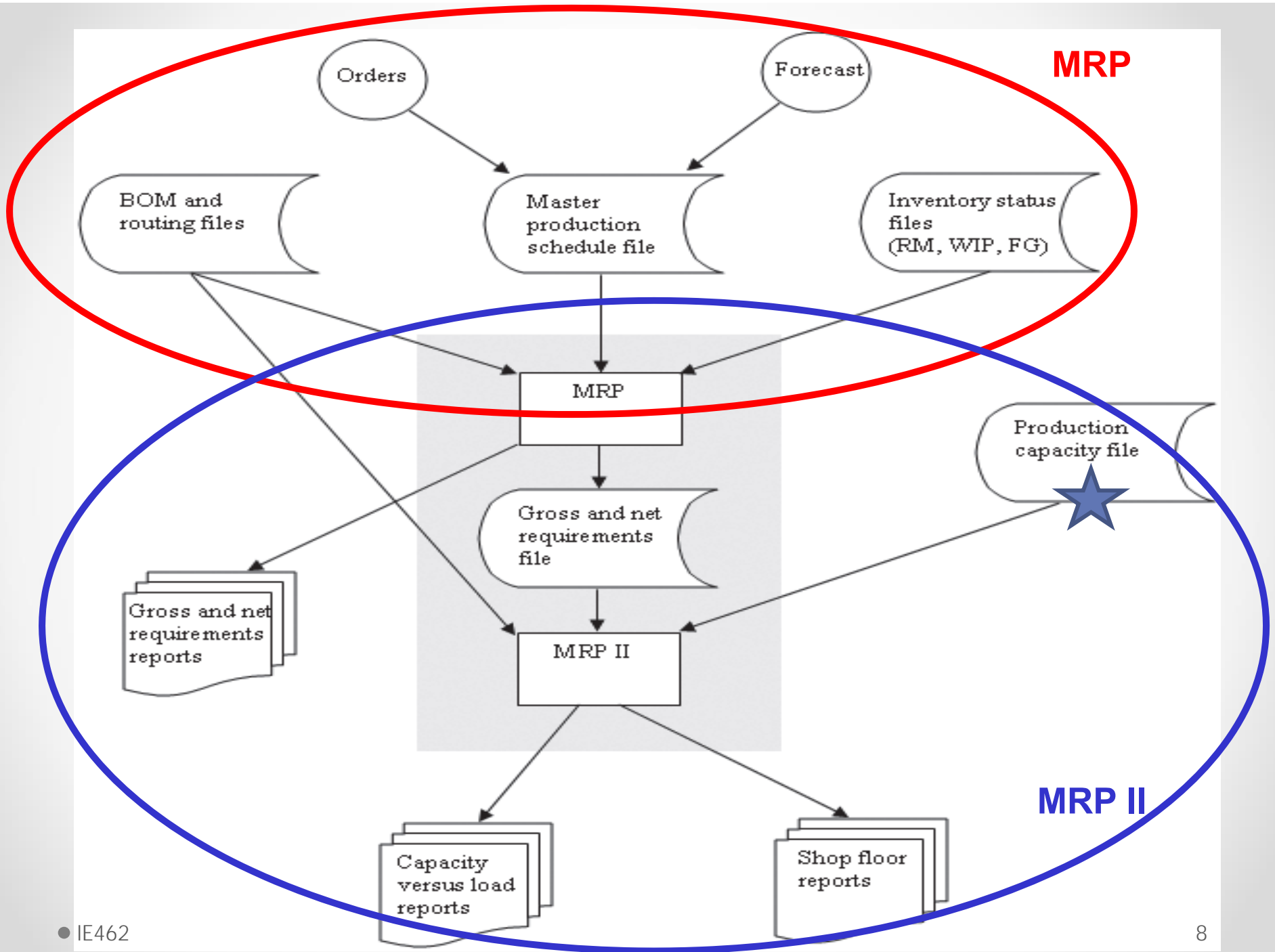  - and fulfilled either from *stock* or through *purchase requisitions*
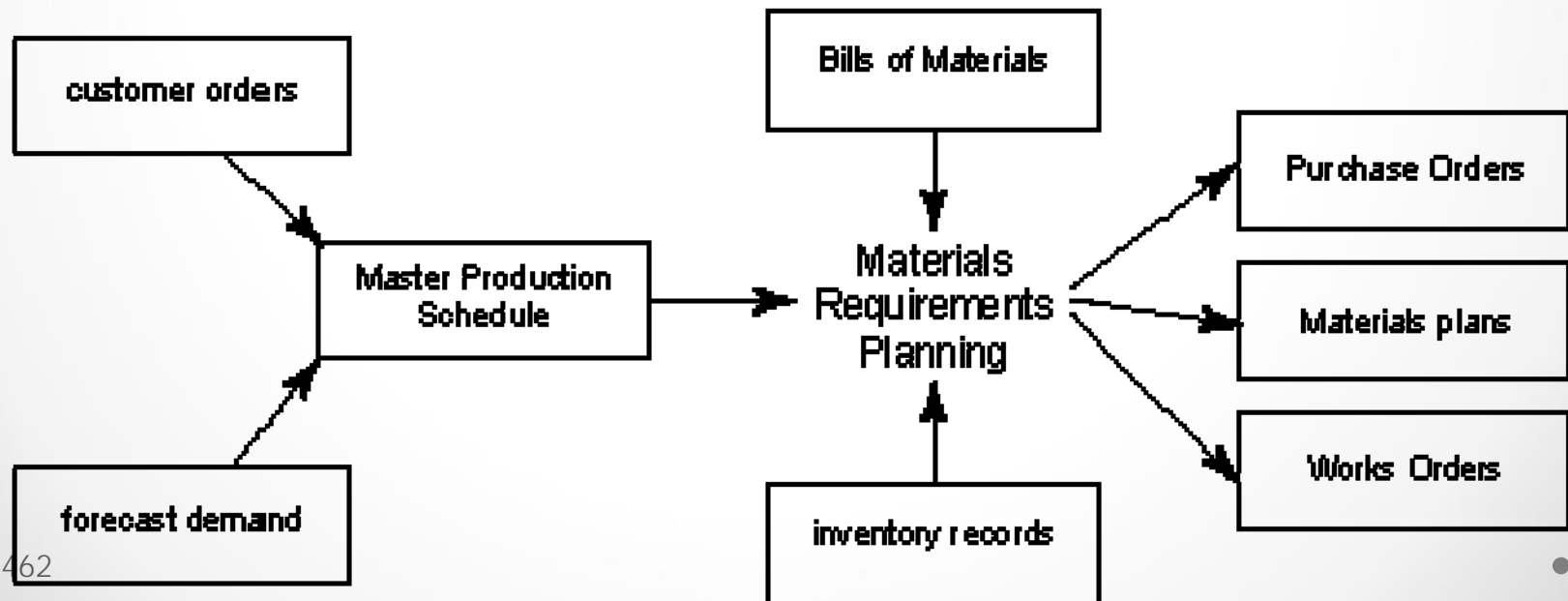
# Material Requirements Planning as IIS (cont.)

## Definition of MRP

```
                    ┌─────────────────┐
                    │     Master      │
                    │   Production    │
                    │ Schedule (MPS)  │
                    └─────────────────┘
                             │
                             ▼
┌──────────────┐    ┌─────────────────┐    ┌──────────────┐
│   Bill of    │───▶│                 │◀───│  Inventory   │
│  Materials   │    │  MRP Analysis   │    │ Status Data  │
│    (BOM)     │    │                 │    │              │
└──────────────┘    └─────────────────┘    └──────────────┘
                             │
          ┌──────────────────┼──────────────────┐
          ▼                  ▼                  ▼
   ┌──────────────┐   ┌──────────────┐   ┌──────────────┐
   │   Planned    │   │   Release    │   │  Reschedule  │
   │   Orders     │   │   Orders     │   │   Orders     │
   └──────────────┘   └──────────────┘   └──────────────┘
```

# Material Requirements Planning as IIS (cont.)

- **MRP II:**
  - This is an extension of MRP

  - Includes additional **capacity planning** (aka: resources planning: workers, machines, etc.) required to meet the manufacturing activities

  - MRP II answers the question of whether or not a *sufficient* week-by-week plant *capacity* exists to meet the planned production schedule ([see next slide](#))

**MRP**

**MRP II**

# Enterprise Resource Planning (ERP)

- The standard MRP system has been expanded to include much more functionality within a concept known as **enterprise resource planning (ERP)**

- In addition to the traditional MRP, ERP has added support for some of the following functions:
  - Quality management
  - Sales and distribution
  - Human resource management
  - Project management

# Enterprise Resource Planning (ERP) – cont.

- More recently, ERP was extended *beyond the factory* and the firm to include functions that link the company to its *customers and suppliers*, such as:
  - o Logistics supply chain management

  - o Inter-company communications

  - o Electronic commerce
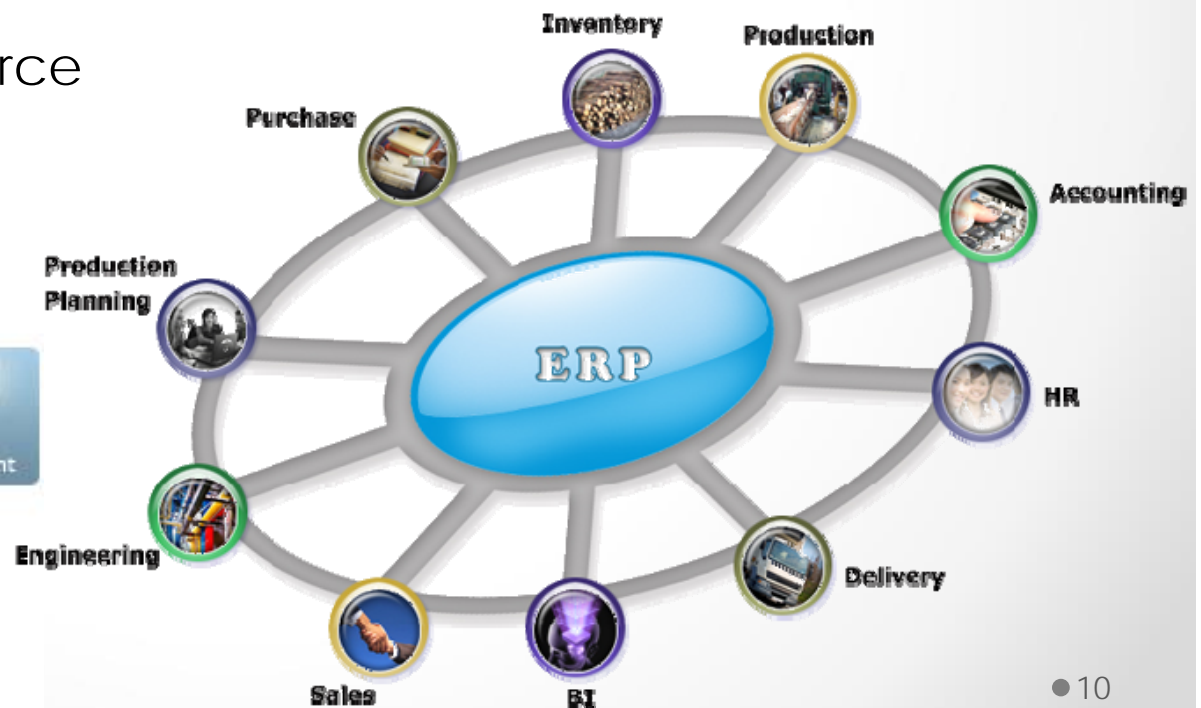
# Manufacturing Execution System

- MRP / MRP II / ERP:
  - o Generally considered as "planning" systems

  - o They're not very well integrated into *execution* of production

- Absence of available software solutions for production execution in the shop floor has led to development of the **manufacturing *execution* system (MES)**

- MES *manages resources* (materials, machines, and personnel, etc) on a *daily* or *hourly basis*
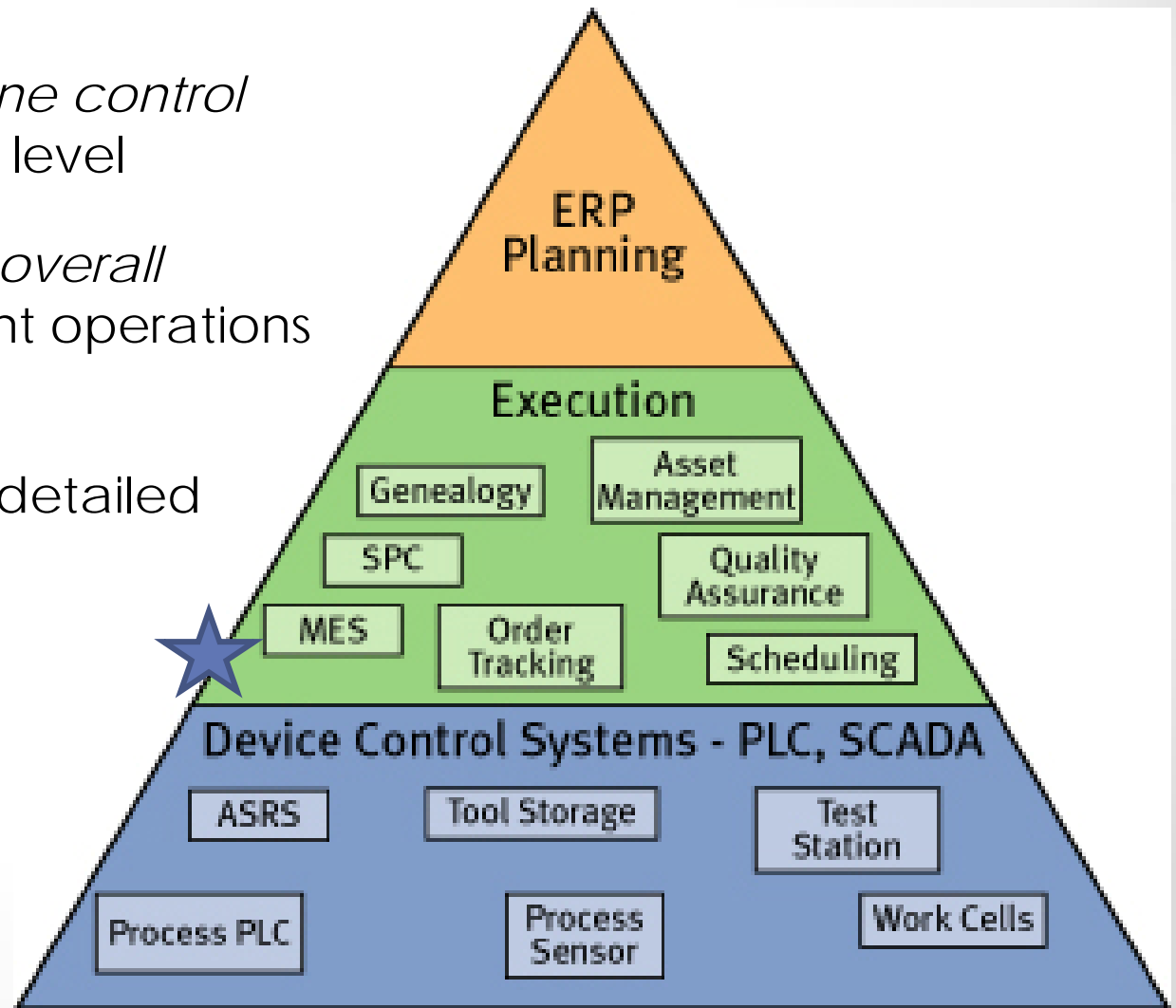
# Manufacturing Execution System (*cont.*)

# MES Functions

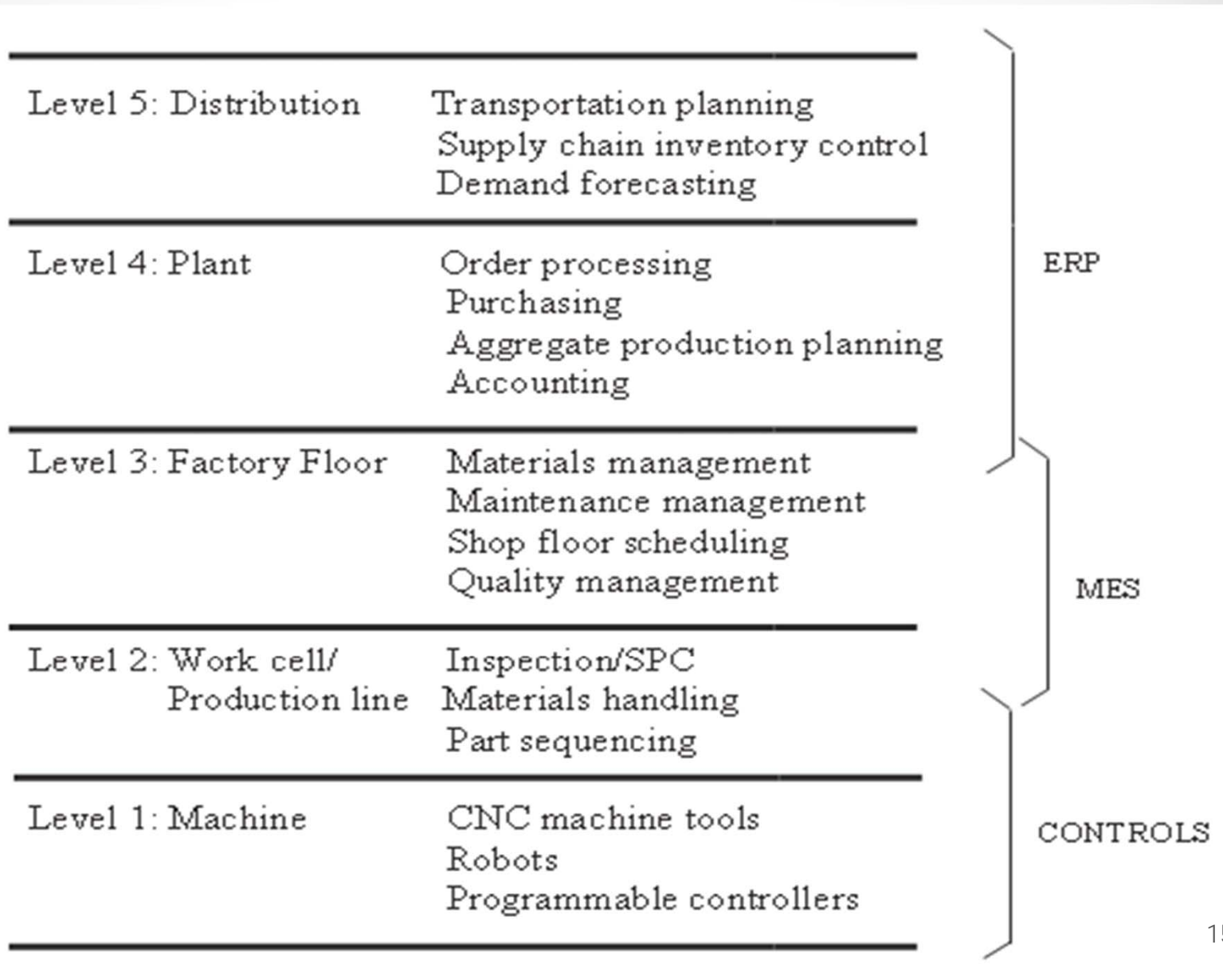Typical MES functions include the following:

- Dispatching and monitoring production:
  - controlling the release of work orders to the shop floor
  - tracking work-in-process inventory

- Detailed scheduling

- Data collection:
  - from factory floor operation
  - provides a history of factory events

- Quality data analysis:
  - real-time analysis of manufacturing
  - notification of out-of-tolerance values
  - sometimes recommending corrective action

# ERP/MES/Control: I.S. Hierarchy in Plant

- A hierarchy of decisions must be made in manufacturing:
  - o from the *machine control* (unit operation) level

  - o up through the *overall planning* of plant operations (i.e. ERP)

  - o this hierarchy is detailed in the [next slide](#)



Pyramid diagram:
- ERP Planning (top, orange)
- Execution (middle, green): Genealogy, Asset Management, SPC, Quality Assurance, MES, Order Tracking, Scheduling
- Device Control Systems - PLC, SCADA (bottom, blue): ASRS, Tool Storage, Test Station, Process PLC, Process Sensor, Work Cells

# ERP/MES/Control: I.S. Hierarchy in Plant (cont)

| Level | | Functions | System |
|---|---|---|---|
| Level 5: Distribution | | Transportation planning<br>Supply chain inventory control<br>Demand forecasting | ERP |
| Level 4: Plant | | Order processing<br>Purchasing<br>Aggregate production planning<br>Accounting | |
| Level 3: Factory Floor | | Materials management<br>Maintenance management<br>Shop floor scheduling<br>Quality management | MES |
| Level 2: Work cell/<br>Production line | | Inspection/SPC<br>Materials handling<br>Part sequencing | |
| Level 1: Machine | | CNC machine tools<br>Robots<br>Programmable controllers | CONTROLS |

# ERP/MES/Control: I.S. Hierarchy in Plant (cont)

- Production line or work cell level (level 2):
  o Control the interactions between a group of related machines or processes

  o This level of decision making is concerned with the release and delivery of materials at the correct time

  o Considered part of the *MES* level, but there is some overlap with the *controls* level

- Examples of decisions at this level include:
  o Routing of material among machines

  o Decision to extract out-of-specification components while they are being processed

# The Nature and Role of I.I.S.

- Industrial system is modeled as a *hierarchy of decisions:*
  - where the **upper levels** of the hierarchy place *constraints* and …
  - control *decisions* on each succeeding *lower level*



- Domain of an IIS:
  - *complete* integration of all levels of decision processes
  - supported by *computer information systems*
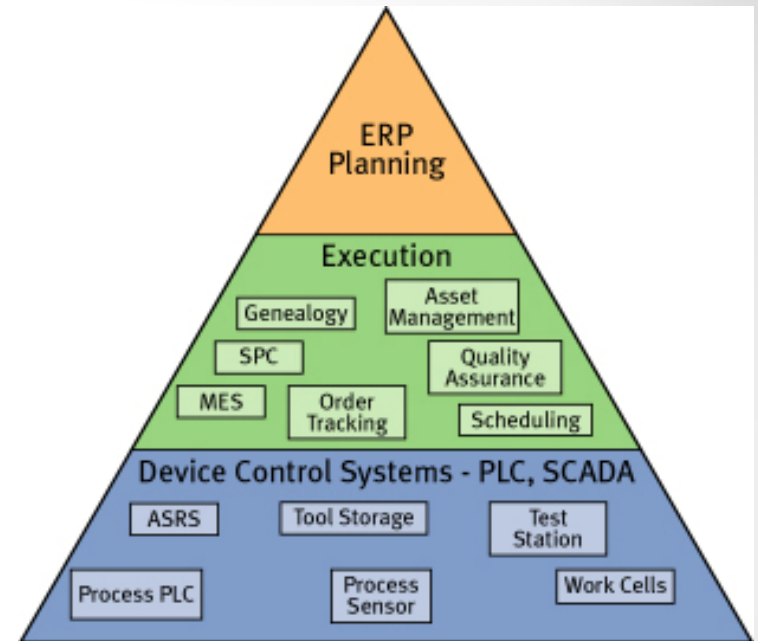
# Information Flow within the I.S.

- ERP, MES, & Control are standard software solutions
  - ERP provides the MES level with an *overall plan* of what is to be produced during the current planning horizon

  - The MES level is then responsible for *detailed production* operations on the factory floor

  - The MES level tells the machine controllers how to produce a particular part by **controller programs**
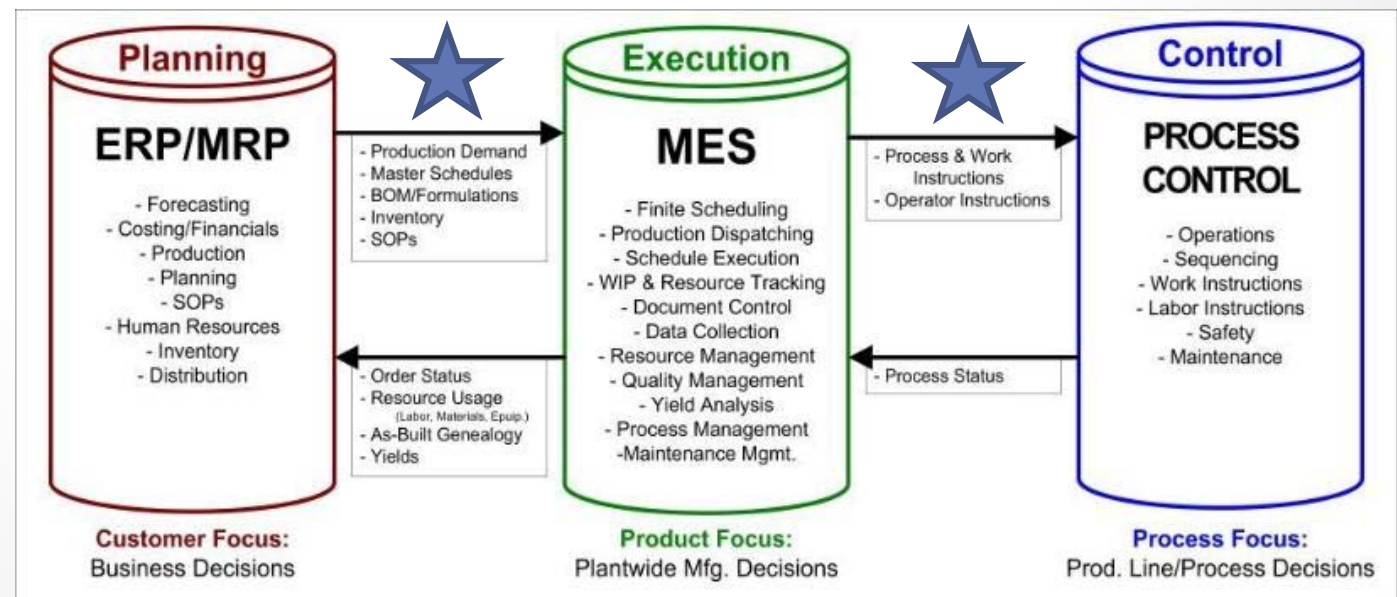
# Information Flow within the I.S. (cont.)

- ERP, MES, & Control software solutions (cont.):
  - o As production is executed, actual *results* concerning what was produced are *fed back* to the planning level

  - o The MES level monitors *real-time actual results*, and data summaries are logged for storage in factory databases

  - o Steps are summarized in schematic shown on <u>next slide</u>
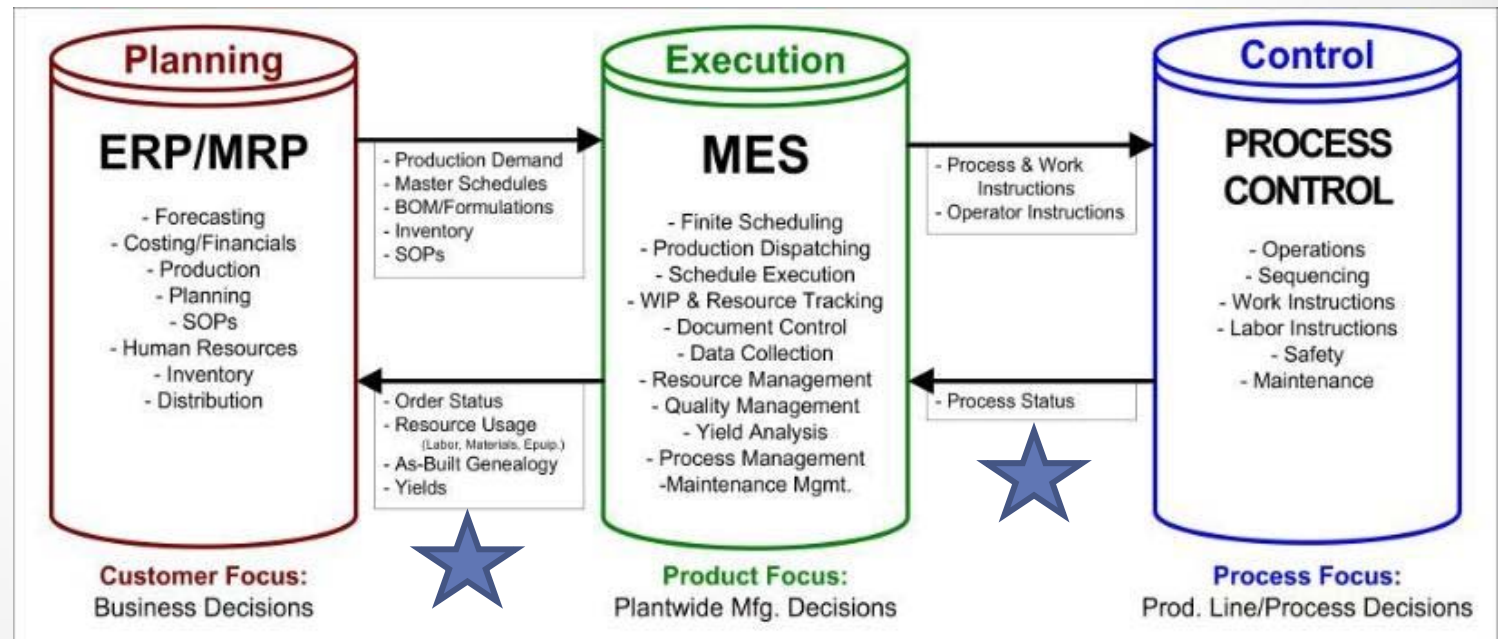
# Coordinating Layer Interaction in the IIS
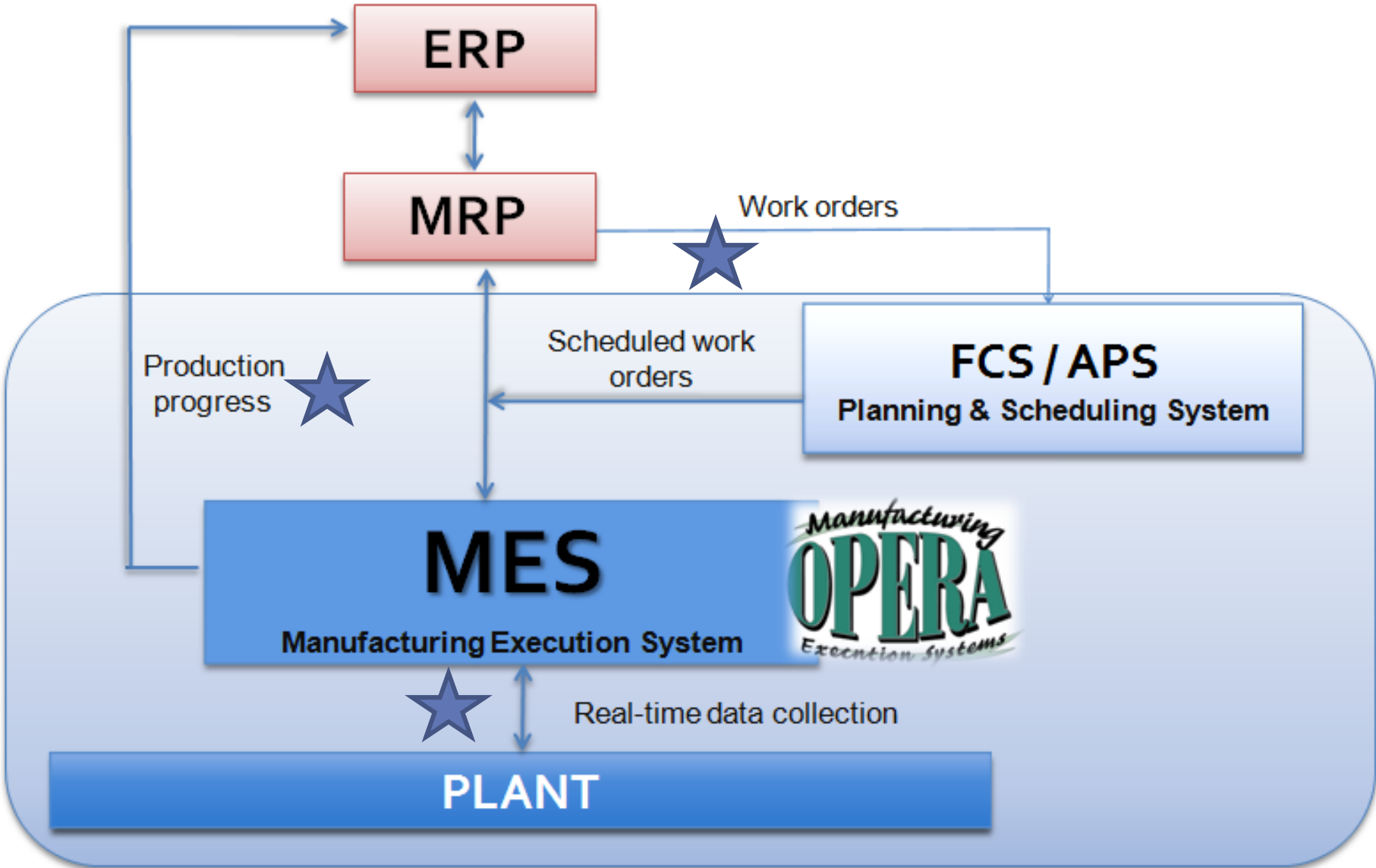
# Network Architecture



- Enterprise integration
  - Involves the *integration* of functional areas through *information sharing*

  - To realize efficient information sharing, it is desirable to *network* the levels of the hierarchy of the manufacturing enterprise

- Network architecture
  - Description of how various *layers* of the decision hierarchy will *communicate* with one another (see next slide)

  - Network architecture is typically implemented with the use of **local area networks** (LAN)

# Typical Network Architecture for Modern Industrial Company
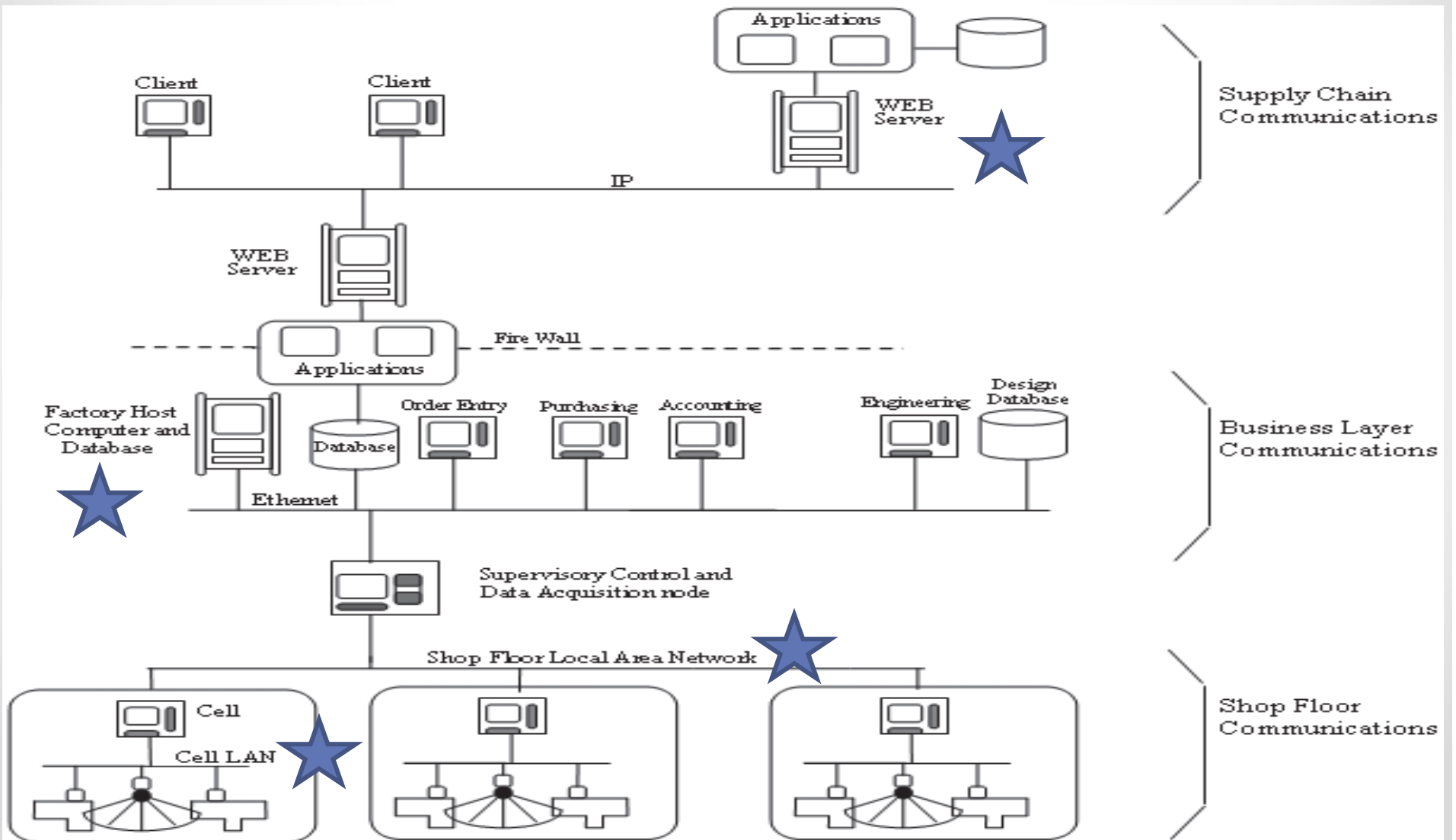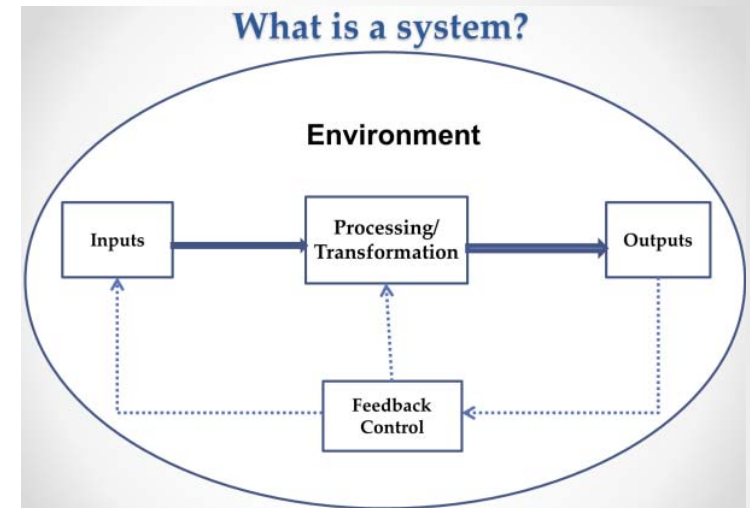
# Functions of an Information System

- Data collection:
  - o captures data about events affecting the system and its environment

  - o loads data into input devices

  - o collected data are classified and indexed in order to make retrieval of desired information easy



What is a system?

- Data storage:
  - o storing past data and information into database for future retrieval

- Information retrieval:
  - o database management system (DBMS) extracts necessary processed data as information needed for decision making
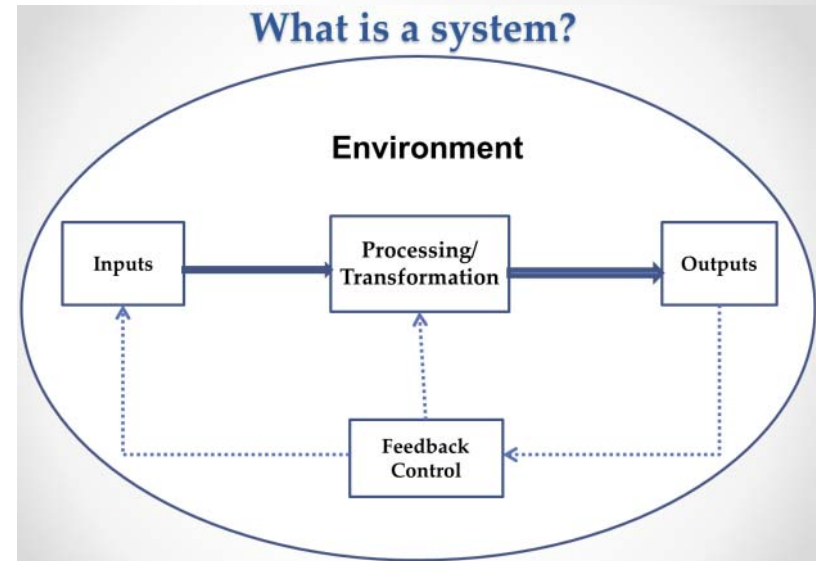
# Functions of an Information System (*cont.*)

- ## Data processing:
  - o computation or summarization

  - o includes all transformation process on input data into information

- ## Data / information transmission:
  - o communication of coded information between geographically separated points

- ## Data display:
  - o presentation of output information in a form suitable for human perception

  - o achieved by means of printed form, or temporary display (e.g. on CRT display)

**What is a system?**

Environment

Inputs → Processing/ Transformation → Outputs

Feedback Control

# Videos to Watch (1. ERP)

- **ERP Basics - 1**
  https://youtu.be/6qys-562kp4 (*Arcus Universe*)

- **ERP Basics - 2** (longer video)
  https://youtu.be/PVRgIXLWDHs (*Jonar Systems*)

- **ERP Cloud**
  https://youtu.be/c9HfNg4a_Og (*Oracle*)

- **ERP – Short Case Study**
  https://youtu.be/C7Bp07T5img (*Oracle*)

# Videos to Watch (2. MES)

- **MES Basics** (Smart Manufacturing 4.0)
  https://youtu.be/lLyBV5qgAB0 (*Wipro*)

- **MES - Short Case Study 1**
  https://youtu.be/cKo1foTkE-k (*Crossroads RMC*)

- **MES - Short Case Study 2**
  https://youtu.be/tkq56lE0Nb0 (*GE Digital*)

# Sources

- Design of Industrial Information Systems. Thomas Boucher, and Ali Yalcin. Academic Press. First Ed. 2006. Chapter 1.