MONASH University

FIT2090
BUSINESS INFORMATION SYSTEMS AND PROCESSES

Lecture 8 Managing Process Flows

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MONASH UNIVERSITY

GROUP OF EIGHT AUSTRALIA

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Principles

- Businesses need to understand process flows to achieve lean operations with minimal waste
- By understanding the various types of flow, businesses can better manage their business improvement programs

Objectives

On completion of this lecture, you will be able to:

- Describe the concepts of material flow, information flow, customer flow and workflow
- Discuss how these flows are managed in a company and a supply chain

Why should we study/understand – managing process flows

- To achieve bottom line results, management and analysis of business process flows are needed
- By understanding the concepts of process flows, business analysts are able to participate and contribute to organisations’ business process improvement programs

Stocks and Flows

- Stocks
  - items on shelves
  - employees
  - financial balance in an account

... in a business process

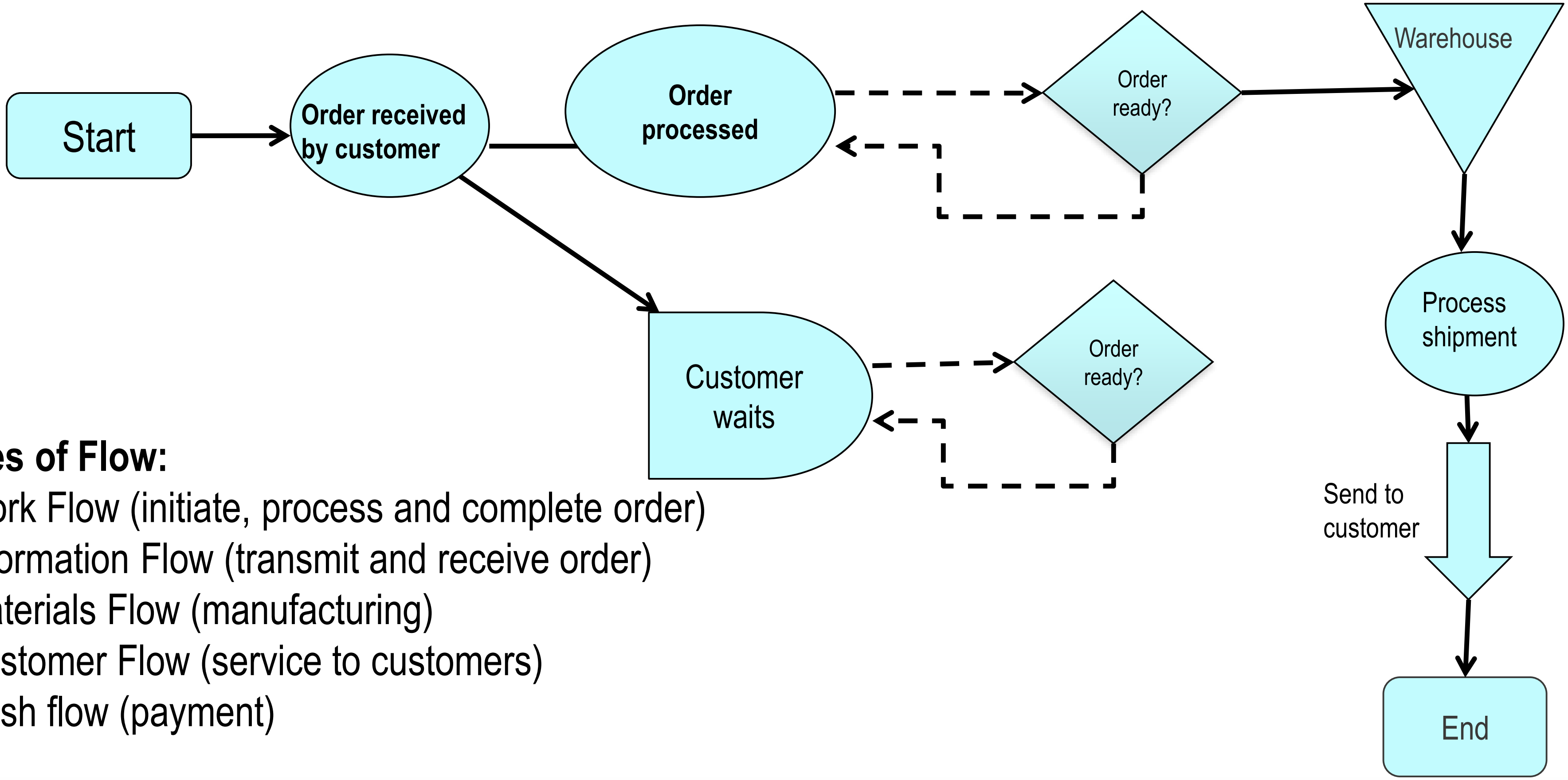
  - "work-in-progress" (number of jobs)

- Flows
  - rate of sales
  - hiring rate
  - outgoings per week
  - "throughput" (jobs per time)

Four types of flow

- Material Flow
  - Physical goods and objects
- Customer Flow and Work Flow
  - Flows involving people
- Information Flow
  - Documents, flow-charts, etc.
- Cash Flow
  - Financial transactions

Example: Process Map of a Purchase Order



Types of Flow:

1. Work Flow (initiate, process and complete order)
2. Information Flow (transmit and receive order)
3. Materials Flow (manufacturing)
4. Customer Flow (service to customers)
5. Cash flow (payment)

Waste – “D-O-W-N-T-I-M-E”

- Defects - scrap or defective product
- Overproduction - producing too soon or in greater quantities than needed
- Waiting - people /equipment that are idle, due to unbalanced workloads
- Non-utilized people - not using everyone's full range of skills and talents
- Transportation - excessive movement of materials
- Inventory - too much raw material, work-in-process, and finished goods
- Motion - unnecessary movement: walking, reaching, twisting, bending, etc.
- Extra processing - additional work or processing that is unnecessary or required due to poor designs or inadequate equipment and technology

Wastes and Flows

Waste	Addressed by	Types of Flow
Defects	Six Sigma	**Material**
Overproduction	Batch Size	**Material, Information**
Waiting	Queuing Theory	**People**
Non-utilised people	Load balancing & Cross-training	**People**
Transportation	Load-distance matrices	**Materials**
Inventory	Just-In-Time	**Material, Information**
Motion	Workstation design	**People**
Extra Processing	Business Process Reengineering	**Material, People, Information**

Material Flows

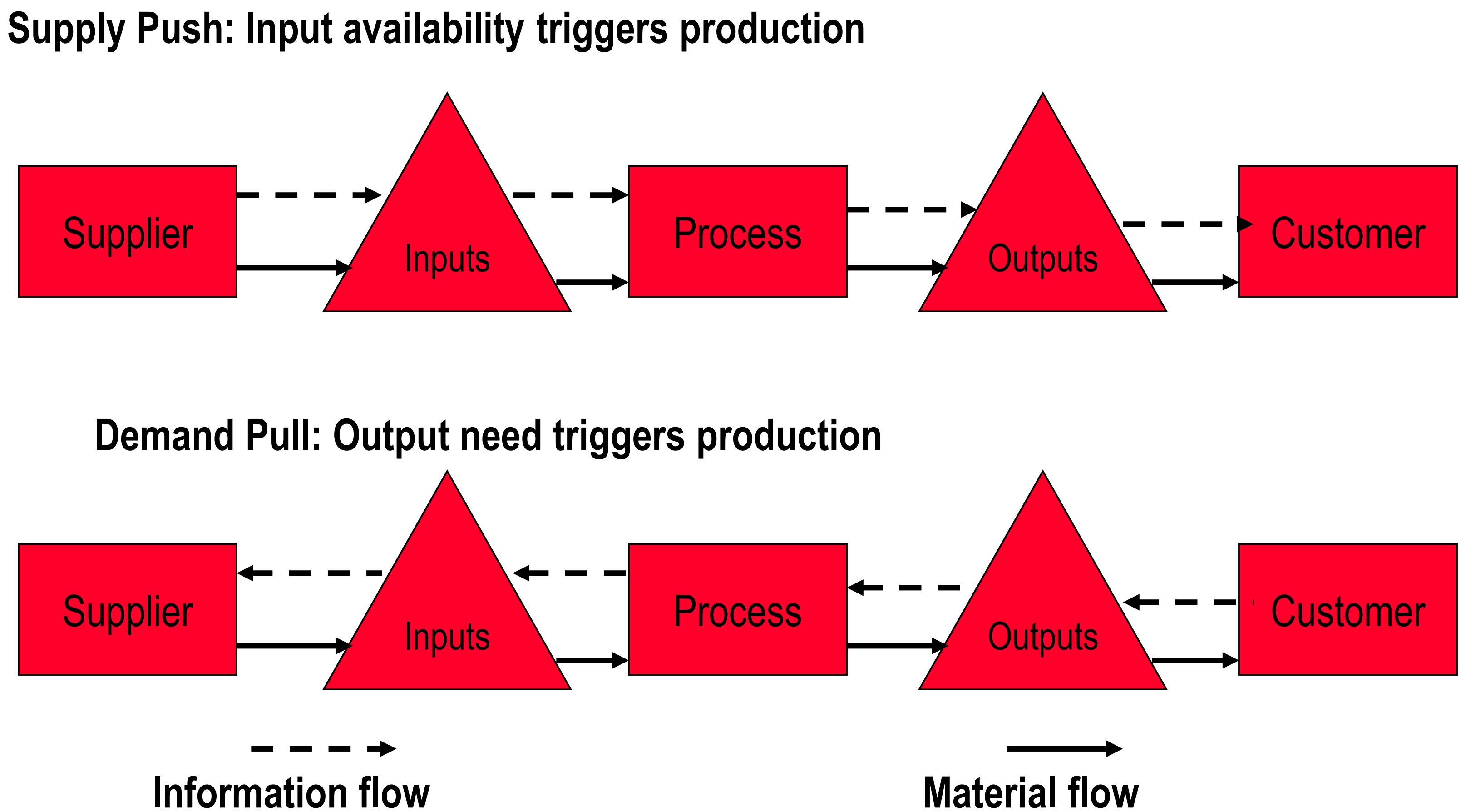
- Just-In-Time
- Process Flow Diagrams
- Load-Distance Analysis
- Flow Charts
- Discrete/Continuous; Convergent/Divergent
- Work-In-Progress
- Batch Sizes

Material Flows: Just-In-Time

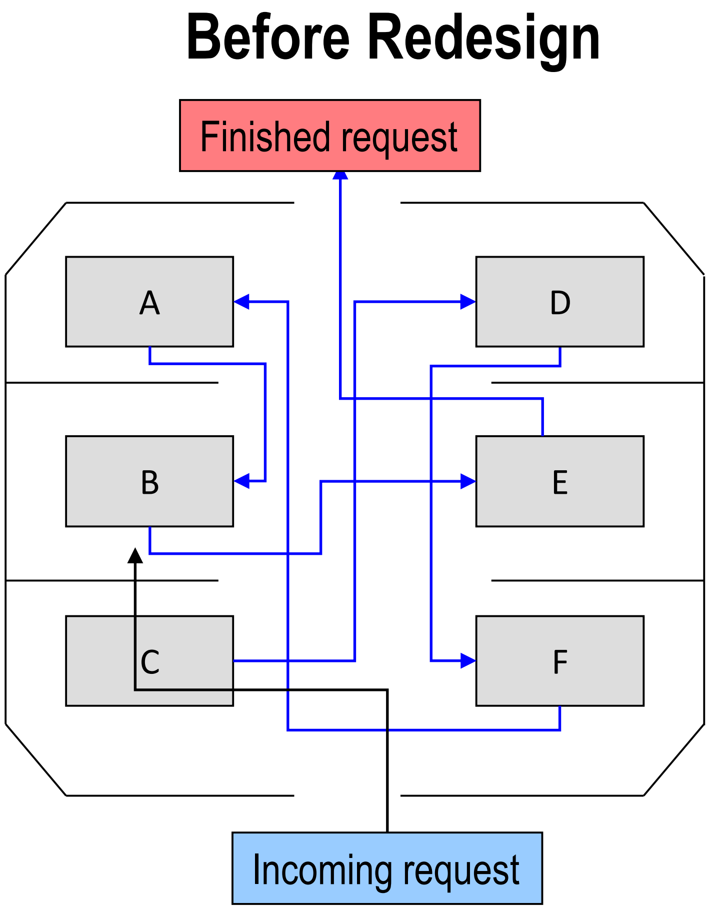
- Exactly what is needed (not wrong or defective)
- Exactly how much is needed (no more no less)
- Exactly when it is needed (not before or after)
- Exactly where it is needed

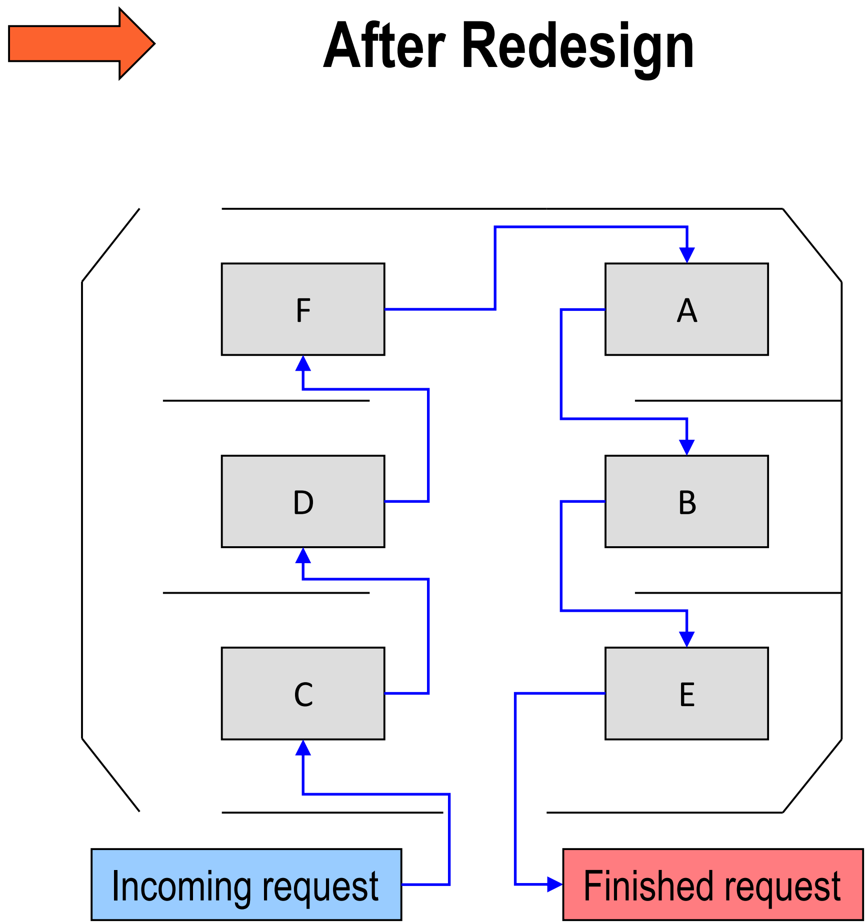
=> Just-In-Time (JIT) paradigm

Material Flows: Just-In-Time



Material Flows: Process Flow





Material Flows: Process Flow

- Analysis geared towards reducing excessive and unnecessary transportation and movements of items/jobs
  - Long distances
  - Crisscrossing paths
  - Repeated movements between the same activities
  - Other illogical flows
- Can be used as a basis for computing Load Distance (LD) scores
  - Useful for quantitatively comparing alternative designs/layouts with regards to flow rates and distances

Material Flows: Load-Distance Analysis

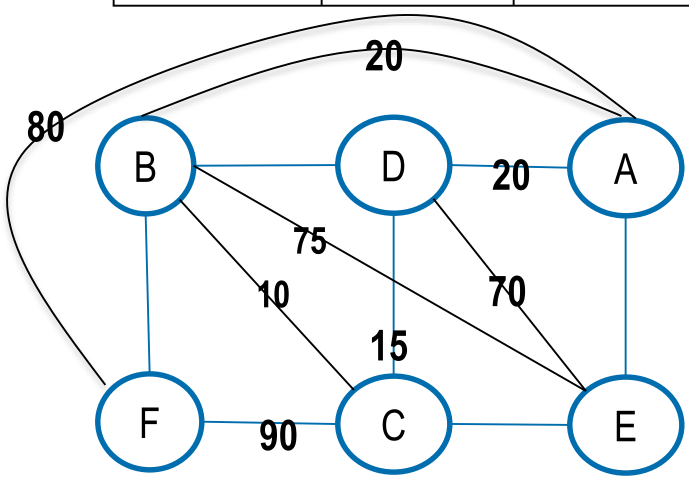
- LD(i,j) = LD score between work stations i and j

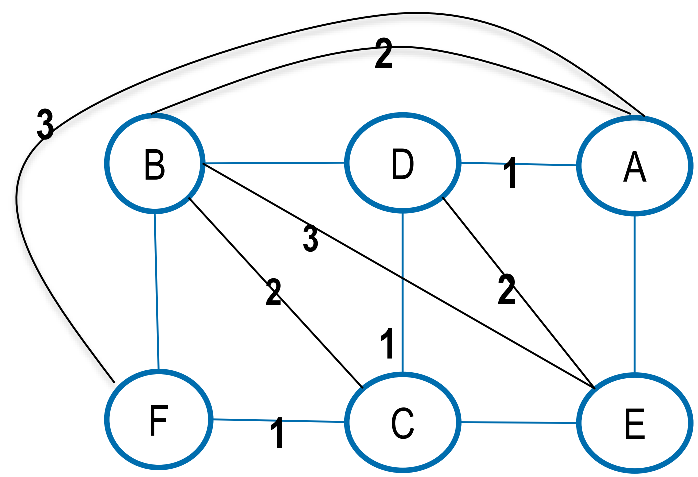
LD(i,j) = Load(i,j)*Distance(i,j)

- The LD score measures the attraction between two work stations (activities)
  – The larger the traffic volume the higher the score and the higher the incentive to keep the work stations together
- The goal is to find a design that minimizes the total LD score (the sum of individual scores between work stations)
- The Load Matrix summarizes the load (flow rate = # of jobs) that needs to be shipped between each pair of work stations

A Sample Load Matrix

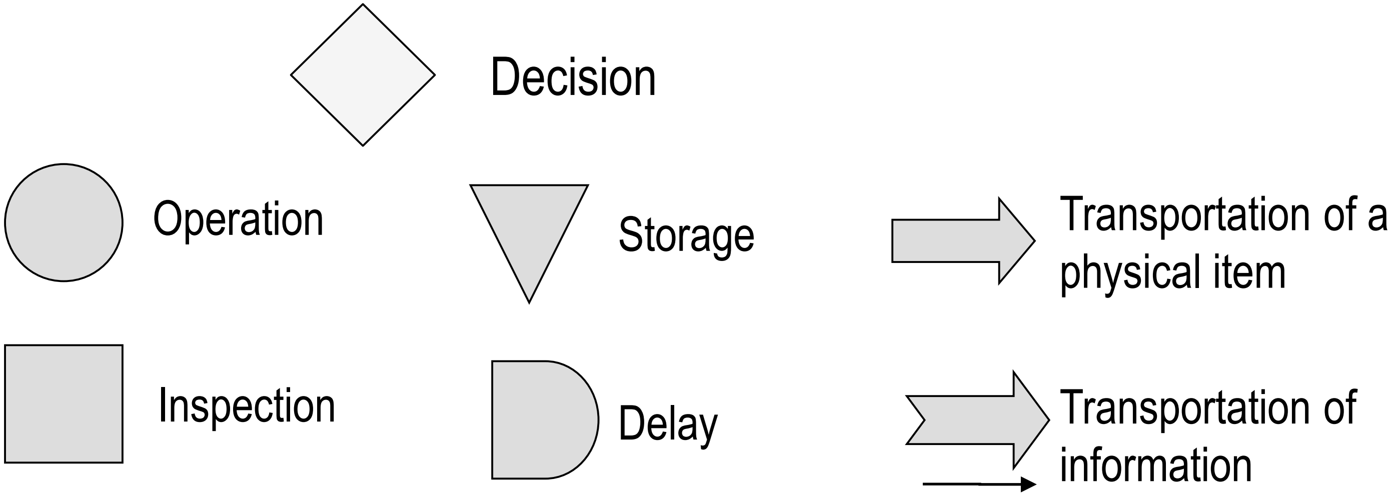
	A	B	C	D	E	F
A		20		20		80
B			10		75	
C				15		90
D					70	



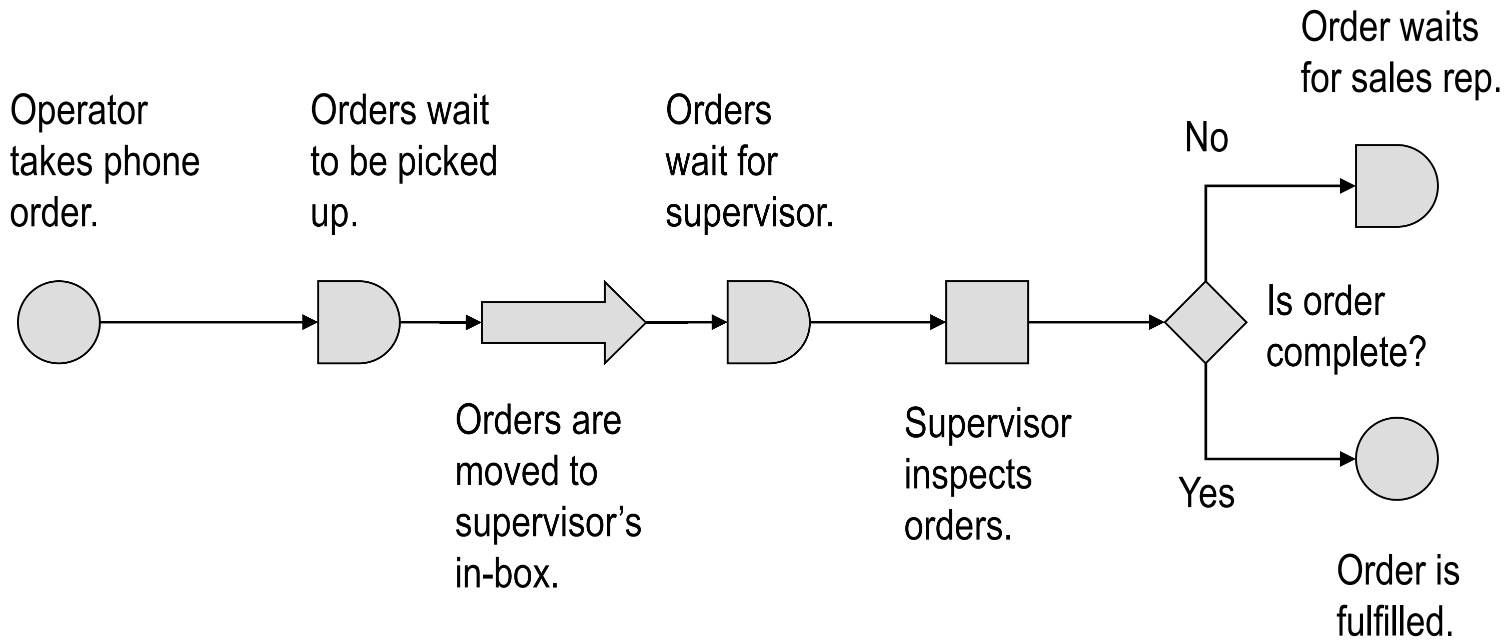


Material Flow: Flow Charts

- One of the fundamental graphical tools for process analysis and design
  - Typically depicts activities sequentially from left to right
  - Can help to identify, loops, multiple alternative paths, decision points etc.
- Symbols often used in flow charting



Material Flows: Flowcharts



Material Flows

- Just-In-Time
- Process Flow Diagrams
- Load-Distance Analysis
- Flow Charts
- Discrete/Continuous; Convergent/Divergent
- Work-In-Progress
- Batch Sizes

Material Flows: Categories

A process = A set of activities that transforms inputs to outputs

Two main methods for processing jobs

1. **Discrete processing** – each item is distinct
   - Examples: Cars, cell phones, tax files, etc.
2. **Continuous processing** – no individual items
   - Examples: Gasoline, electricity, consultancy duration etc.

Three main types of flow structures

1. **Divergent** – Several outputs derived from one input
   - Example: Dairy and oil products
2. **Convergent** – Several inputs put together to one output
   - Example: Car manufacturing, general assembly lines
3. **Linear** – One input gives one output
   - Example: Hospital treatment

Material Flows: Categories

Example in manufacturing, material flow names are given according to the shape of the dominant flow:

V-plant

- Process dominant by divergent flows

A-Plant

- A process dominant by converging flows

I-Plant

- A process dominant by linear flows

Flow rate is defined as the number of jobs per unit time

$R_i(t)$ = rate of incoming jobs through all entry points into the process
$R_o(t)$ = rate of outgoing jobs through all exit points from the process

Material Flows: Work-In-Progress

- WIP(t) comprises all jobs that have entered the process but not yet left it
  - including jobs waiting for the previous batch to be completed
- WIP(t) = Work in process at time t
  - WIP(t) increases when $R_i(t)>R_o(t)$
  - WIP(t) decreases when $R_i(t)<R_o(t)$
- WIP = Average work in process over time

Material Flows: Batch Sizes

One-at-a-time Processing

- Reduction of the batch size to the size of one unit
- By reducing batch sizes (and setup times) the throughput time and WIP can be minimized
- Two types of batches
  1. **Process batch**
     - All jobs being processed before the resource needs to be changed to process jobs of a different kind
  2. **Transfer batch**
     - Number of items/jobs transported together to the next resource for processing
     - Usually $\leq$ the process batch
     - By reducing the transfer batch total processing time and WIP are also reduced

Material Scheduling

- Material scheduling impacts material flow
- Importance of job scheduling
- Job scheduling in product-focused systems
  - Setup activities
  - Mixed-model assembly line sequencing

Material Scheduling (cont.)

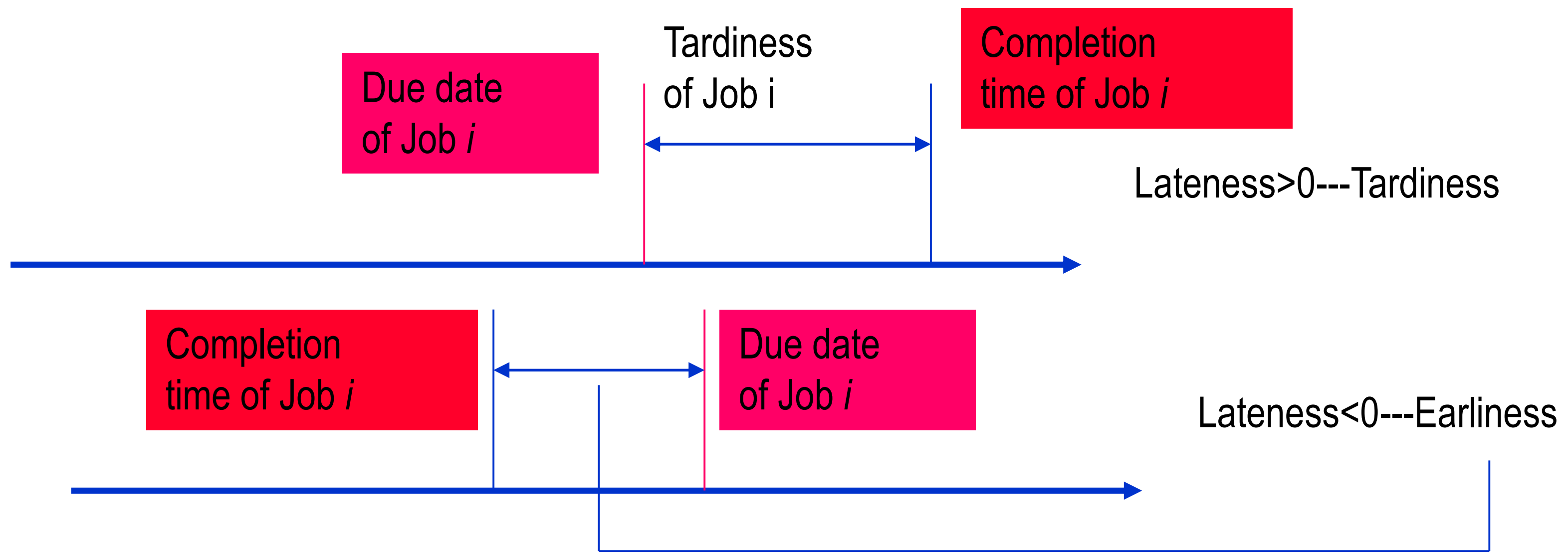
- Job scheduling in process-focused systems (cont.)
  - Dispatch rules
    - Earliest due date (EDD)
    - Shortest processing time (SPT)
    - Truncated SPT
    - First-come-first-served (FCFS)
    - Most-important-job-first
    - Etc.

Material Scheduling (cont.)

- Job scheduling in process-focused systems (cont.)
  - Dispatch rules performance measures
    - Average flow time
    - Average queue time
    - Average job lateness
    - Average job tardiness
    - Makespan (The time it takes to finish a batch of jobs; measure of efficiency)

Tardiness and lateness

- Tardiness is the positive difference between the completion time and the due date of a job.
- Lateness refers to the difference between the job completion time and its due date and differs from tardiness in that lateness can be either positive or negative.
- If lateness is positive, it is tardiness; when it is negative, it is earliness



When the completion of Job is earlier than due date, the tardiness is 0

Material Flow Example: Distribution Centres

- Centralised production facilities
- Consolidated regional warehouses
- Reduced size of shipments
- Increased delivery frequencies
  - Increased throughput volumes
  - Decreased unpacking and repacking activities
  - Use of ICT such as RFID ***(Information flow!)***

Customer Flow and Work Flow

- Flowcharts
- Service System Mapping
- Activity Organisation
- Line Balancing
- Scheduling
- Cycle-time Analysis
- Capacity Analysis
- Queuing Behaviour

Work Flow: Flowcharts

- One of the fundamental graphical tools for process analysis and design
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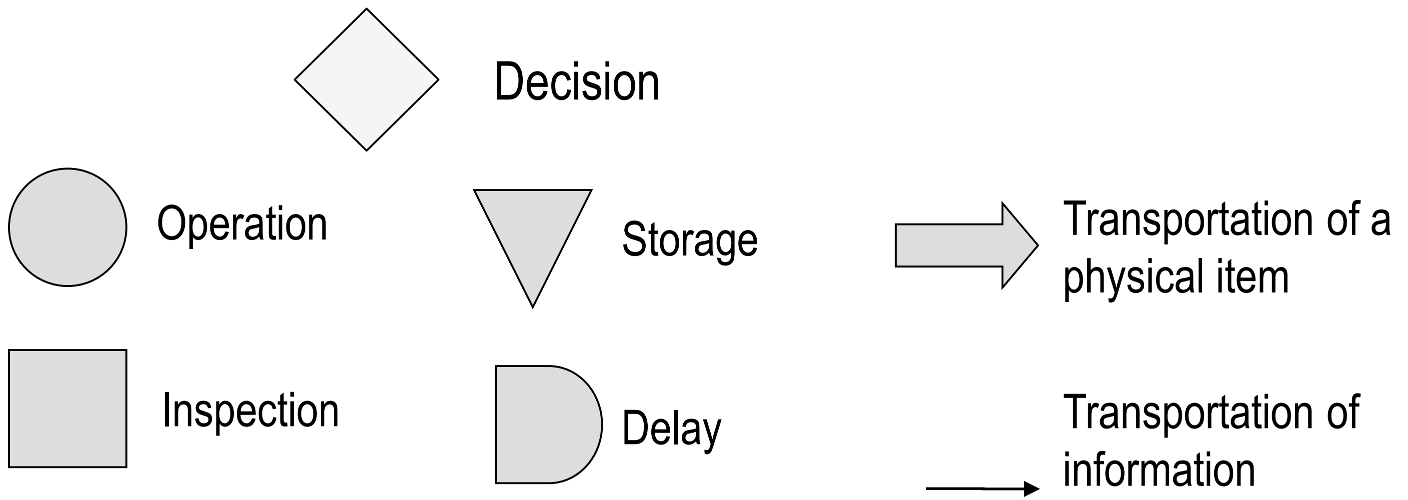


Work Flow: Service Capacity Utilisation

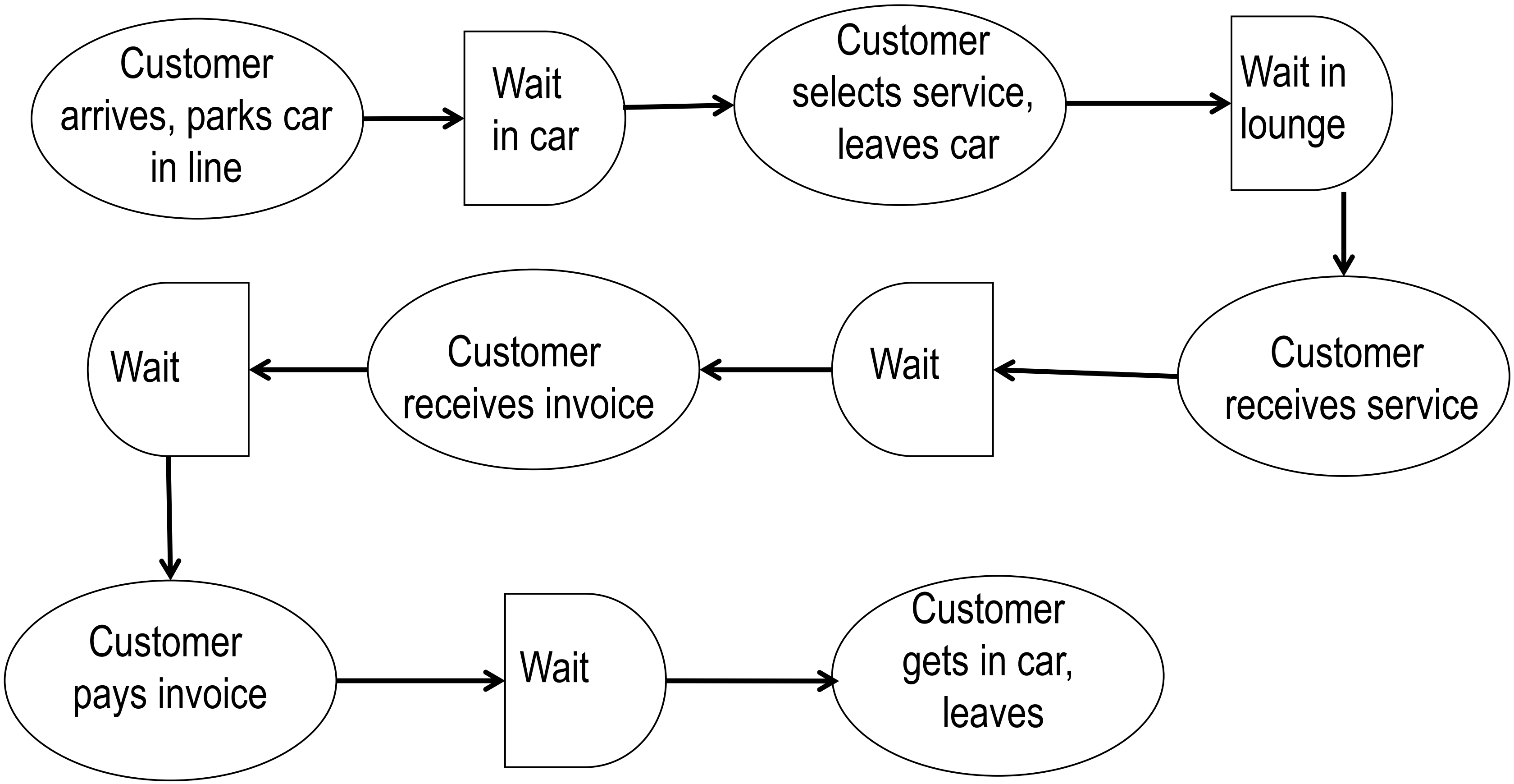
- Employee scheduling
  - Full-time, part time, change in daily requirements
- Capacity Sharing
  - E.g. passenger airline industry
    - Share gates, baggage-handling, ground personnel
- Cross training employees
  - Flexible workforce
- Self service
  - E.g. supermarkets
- Revenue Management
  - Overbooking (e.g. restaurants, airlines)
  - Differential Pricing

Managing Customer and Work Flows

- Important part of customer service processes and service providers
- Examples:
  - actual persons waiting in line, phone customers on hold or trying to navigate an automated answering system, ….
- For businesses, the aim is to ensure a smooth flow…

Customer Flow Mapping

Example: Lucy's Car Service 'while you wait'



Some potential problems

- Customers occasionally get out of car to find a service person
- Customers getting into the wrong lane for the required service
- Customers do not sit in the lounge area – they often wander out to the service area to talk to the car technicians
- Customers complain about the lengthy wait time prior to and during the service, …..

Customer Flow and Work Flow

- Flowcharts
- Service System Mapping
- Activity Organisation
- Line Balancing
- Scheduling
- Cycle-time Analysis
- Capacity Analysis
- Queuing Behaviour

Customer and Work Flow: Service Delivery System Design

- Consider objectives with desirable level of customer interaction
- Identify customer contact points
  - Customer contacting with staff intentionally and unintentionally

- Assess level of customer contact and controlling them
- Use Service Blueprinting

Customer and Work Flow: Service System Mapping

An extension of traditional flowcharting

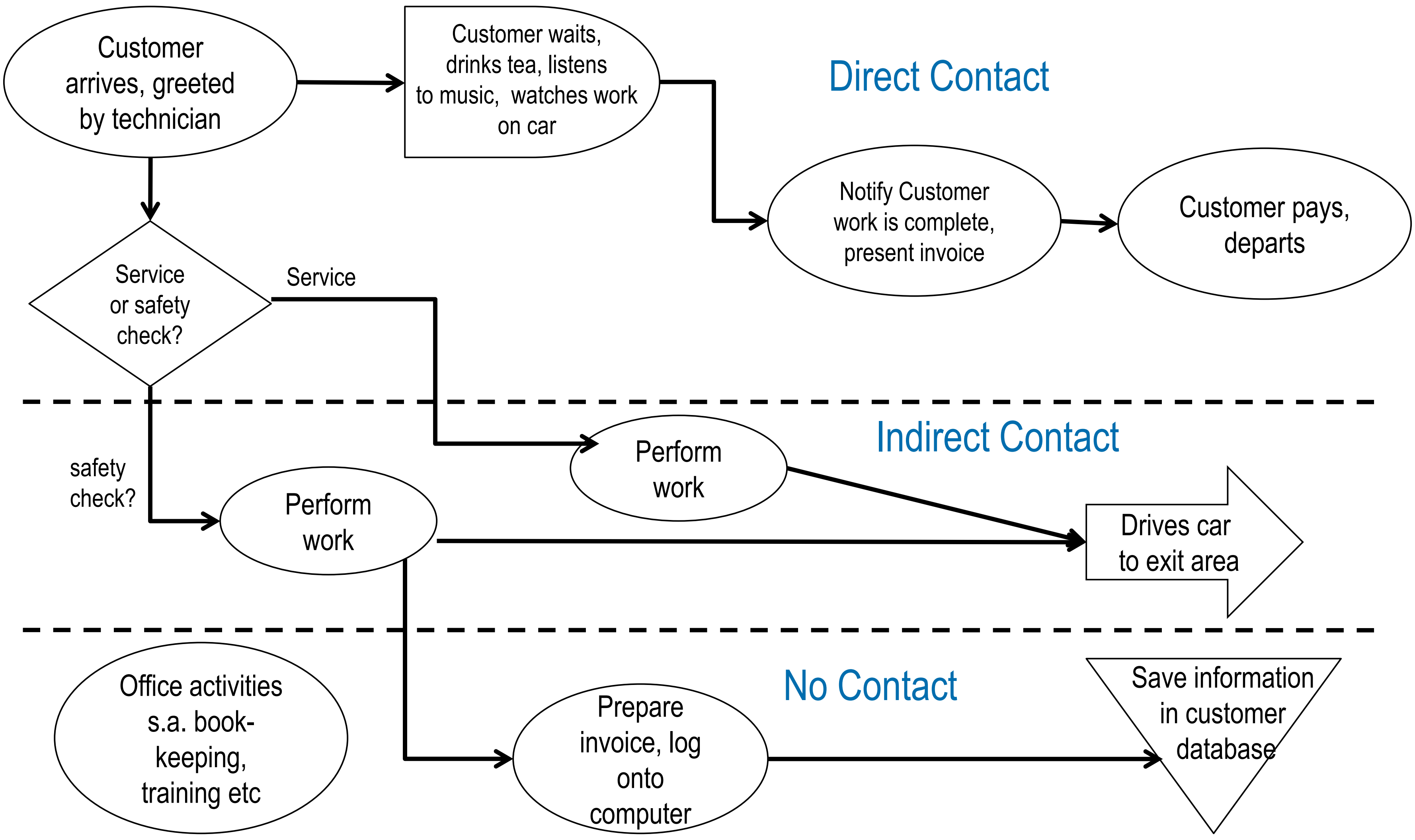
SSM Horizontal Bands

- The purpose is to organize activities according to the people or “players in the process. – Who does what?
- A SSM typically consists of 5 bands
  1. Customer band – end user
  2. Frontline or distribution channel band
  3. Back-room activity band
  4. Centralized support or information systems band
  5. Vendor or supplier band

SSM Process Segments

- A process segment or sub process is a set of activities that produces a well defined output given some input

Service Blueprint for Lucy's Car Service 'while you wait'



Customer Flow and Work Flow

- Flowcharts
- Service System Mapping
- Activity Organisation
- Line Balancing
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- Queuing Behaviour

Work Flow: Activity Organization

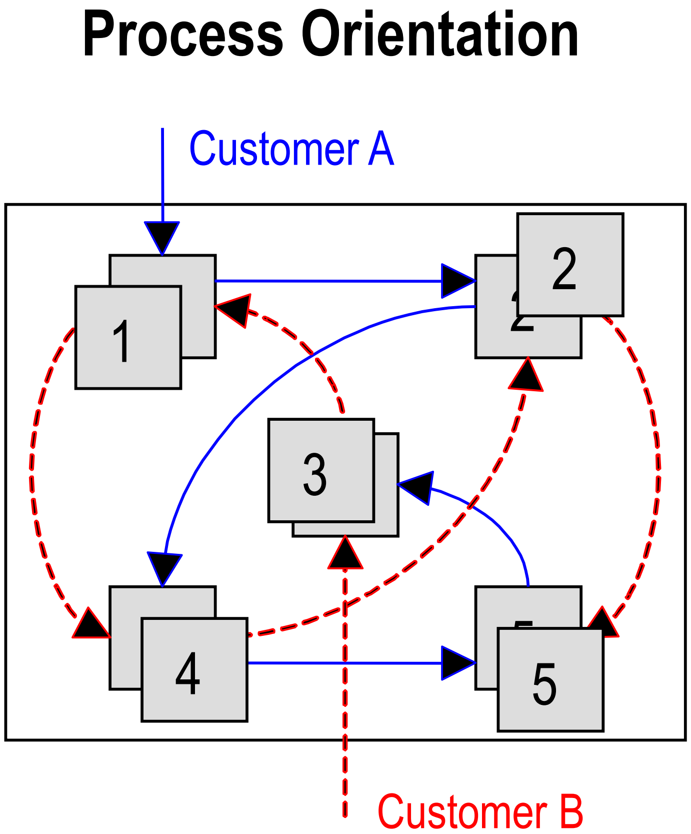
- Two basic ways of organizing activities
  1. By process (Process Orientation)
  2. By product (Product Orientation)

1. Process orientation (functional layout) groups activities or workstations according to function
   - Most common when the same activity is used for producing different products or services or when serving many different customers
   - Utilization of equipment and personnel tends to be high

Work Flow: Activity Organization

2. Product orientation
   - groups all necessary activities to complete a finished product into an integrated sequence of work nodes or work stations
     - A typical example is an assembly/production line for making a particular car model
   - Activities are organized around the route (needs) of a particular product or service
   - Advantages with product orientation include
     - Faster processing rate
     - Less handoffs
     - Shorter critical path
     - Less transportation time
   - A capital intensive way of organizing activities

Work Flow: Activity Organisation



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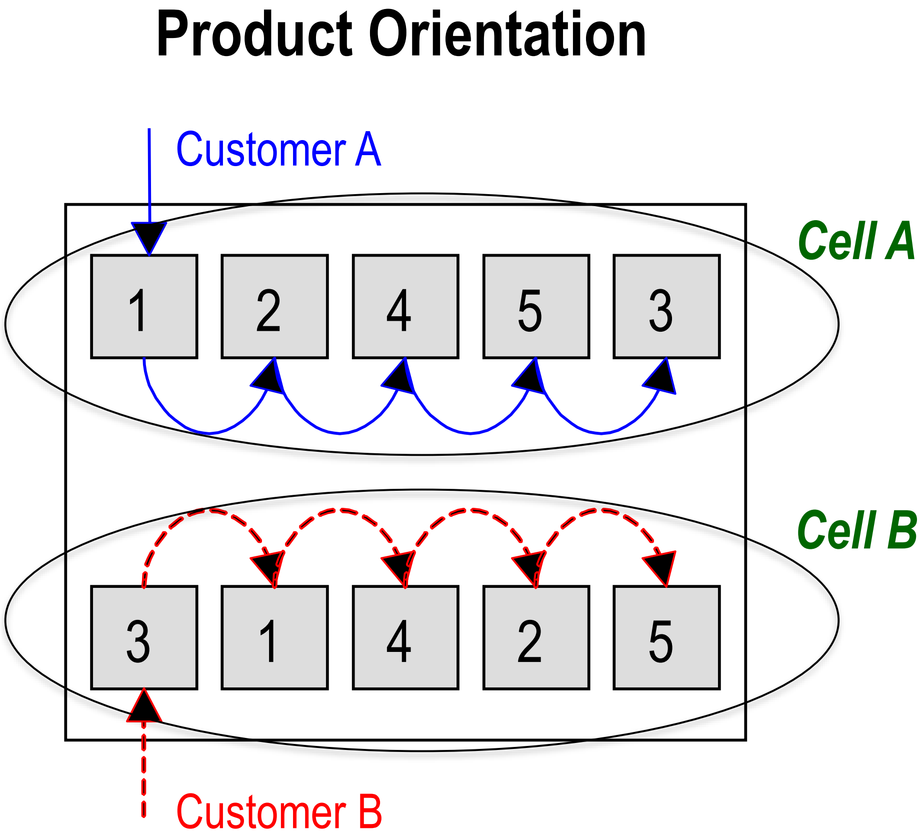
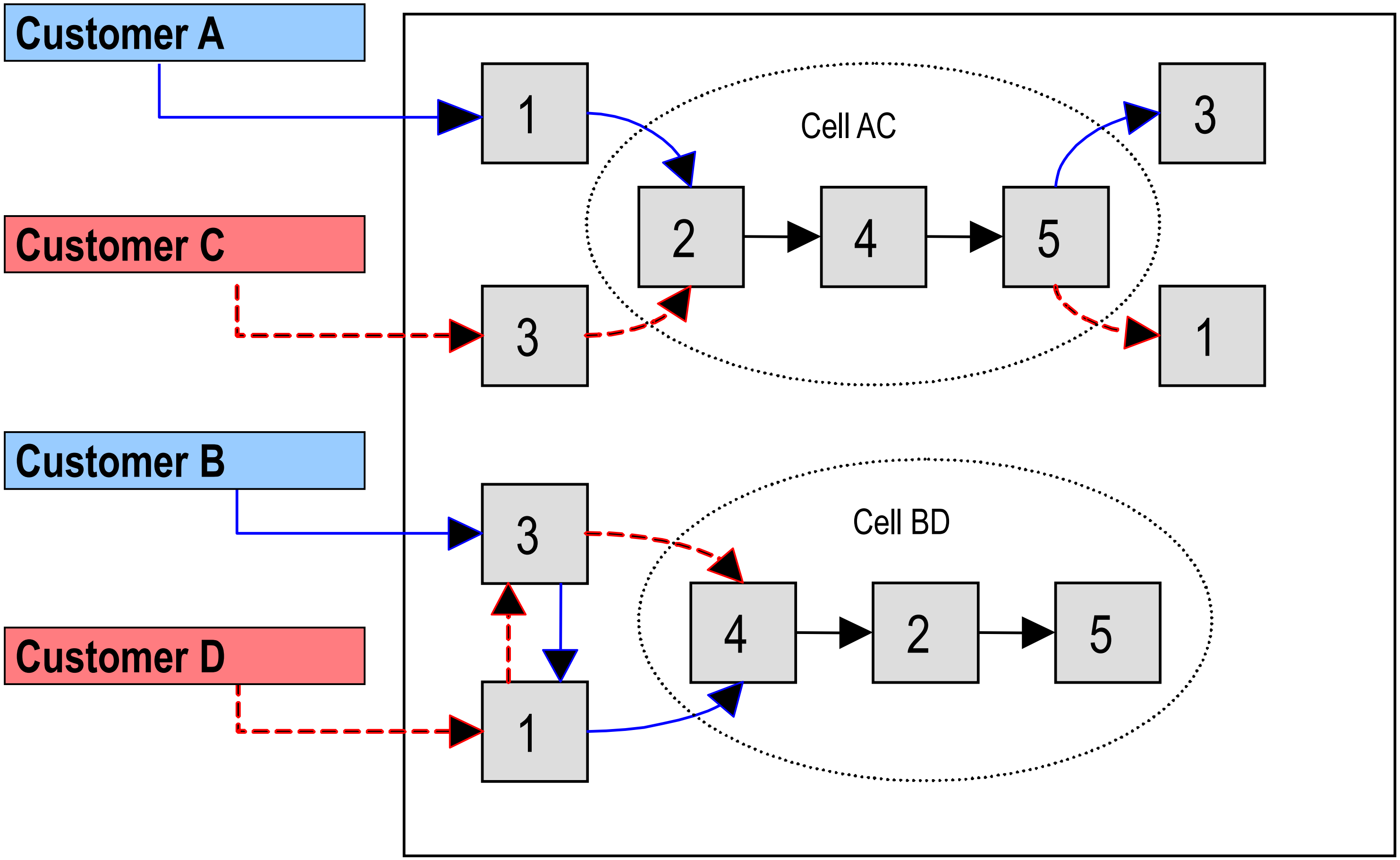


(b)

A Hybrid Orientation

- To justify a product orientation from a resource utilization perspective the product/service volumes must be quite high.
- A popular hybrid between product and process orientation in manufacturing is known as *Group Technology* (or product clustering)
  - Groups products with similar characteristics into families and organizes activities around these families instead of around the individual products
  - "Product Family" orientation
- The equivalent in business processes would be to group jobs with similar characteristics into families.
- The hybrid orientation simplifies customer routings, reduces process time and can be justified even if the volumes of individual products/services are not that large

Illustration of a Hybrid Orientation



Workflow Design Principles and Tools

Buffer Elimination

- Buffers are put in place to protect against variability in demand, processing times, etc.
  - Jobs stacked up at different parts of the process, waiting to be processed.
- WIP = Work In Process inventories.
  - All jobs currently in the process, i.e. in queues/buffers, under transportation or under processing.
- Buffers tend to cause logistical and communication problems due to slower information feedback.
  - Implies the need for advanced tracking systems to identify what job is in which buffer.
- Product orientation implies less WIP but needs to be well balanced in order to minimize buffers.

Workflow Design Principles and Tools

One-at-a-time Processing

- Reduction of the batch size to the size of one unit
- By reducing batch sizes (and setup times) the throughput time and WIP can be minimized
- Two types of batches

  1. **Process batch**
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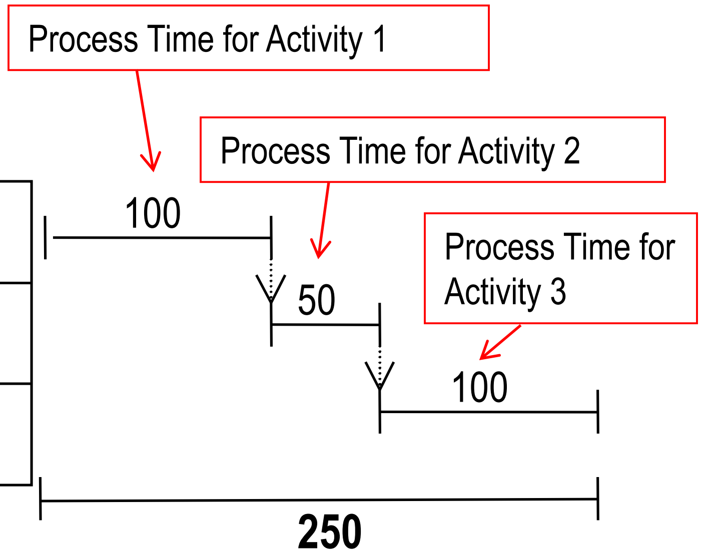
     - Usually $\leq$ the process batch
     - By reducing the transfer batch total processing time and WIP are also reduced

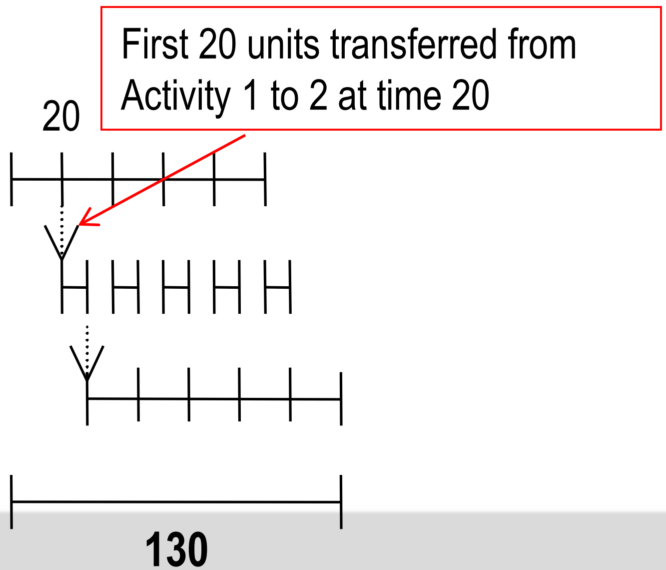
Example – Effect of Reducing Batch Sizes

- Three activities in sequence 1, 2 & 3
- Processing times: 1 h/job in 1&3 and 0.5 h/job in activity 2
- Consider the total throughput time for a batch of 100 units when the transfer batch size is: A) 100 B) 20

	Process Batch	Transfer Batch
1	100	100
2	100	100
3	100	100



	Process Batch	Transfer Batch
1	100	20
2	20	20
3	100	20



- large batch size needs fewer set ups
- small batch size requires more set ups but can reduce WIP inventory

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Workflow Design Principles and Tools

Balancing bottleneck flows

- Linked to the OM principle known as *Theory of Constraints (TOC)* popularized by Eliyahu Goldrat in his book *The Goal*
  - Balance flow not capacity!
  - Keep bottlenecks fed!
- Historically manufacturers had tried to balance capacity across processes to match market demands
  - Making all activity capacities the same makes sense only if processing times are constant or display marginal variability
  - Variation in processing times causes inventory build up and idleness at different parts of the process
- Only two ways of handling variation
  - Increase WIP to smooth variation
  - Differentiate/balance capacity according to the job flows

Work Flow: Line Balancing

Line Balancing

- A useful approach when processing times are fairly constant
  - Should not be used when processing times display high variability
- The goal is to balance the capacity of the different workstations constituting the production line (the process)

Procedure

1. Specify sequential (precedence) relationships among the activities using a precedence diagram
2. Use market demand to determine the line's desired cycle time per work station (C)

$$C = \frac{\text{Process time per day}}{\text{Market demand per day (in \# of jobs)}}$$

Work Flow: Line Balancing

Line Balancing Procedure (continued)

3. Determine the theoretical minimum # of workstations (TM)

$$TM = \frac{\text{Sum of activity times}}{C}$$

4. Select a primary rule to assign activities to workstations and a secondary rule to break ties
5. Assign activities one at a time to workstation 1 as long as the sum of activity times $\leq$ C. Repeat this for workstations 2,3, …
   – Must satisfy the activities' precedence relationships
6. Evaluate the ***line efficiency = Total process time / (C * #stations)***

7. Rebalance using a different priority rule in case the efficiency is unsatisfactory

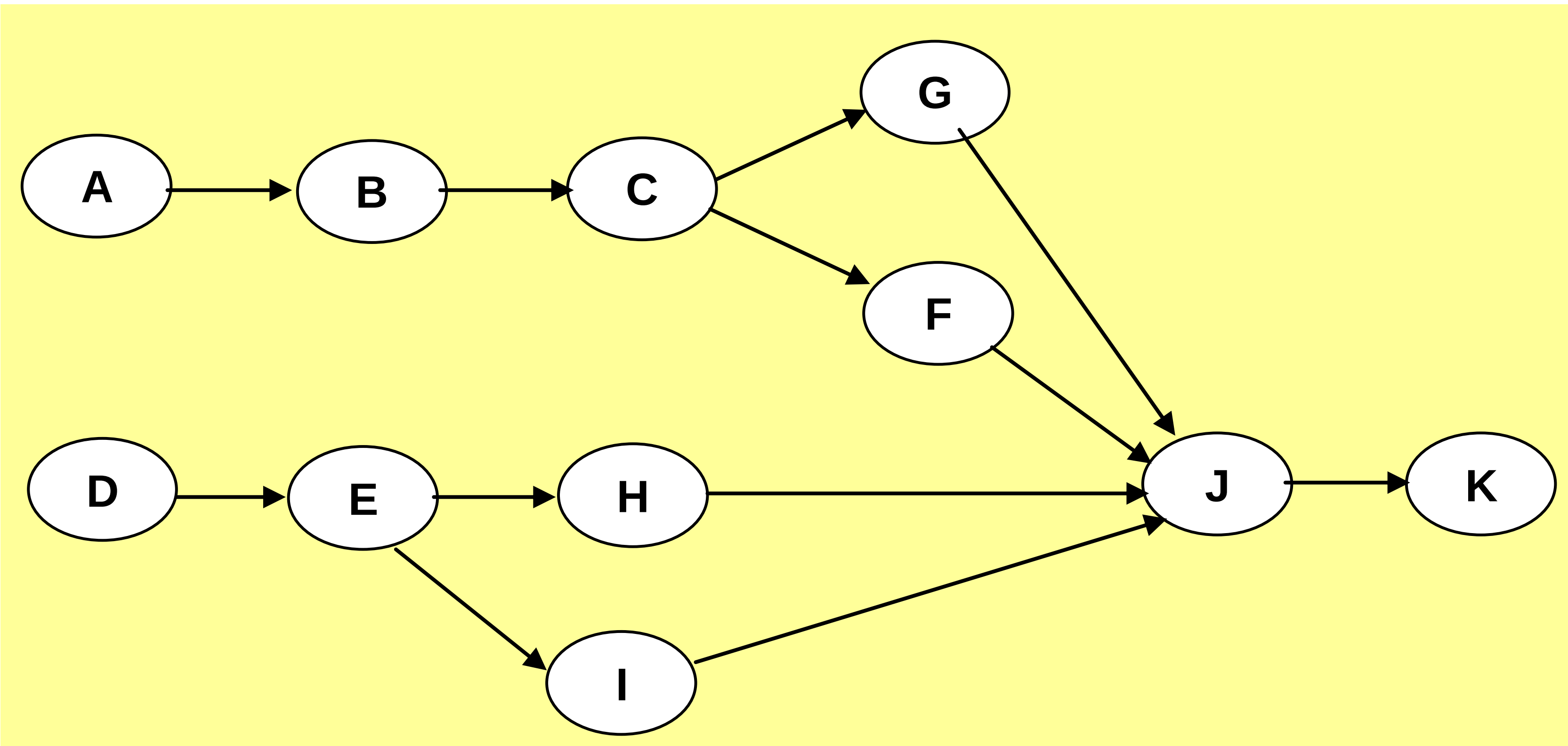
Example: Line balancing

Consider the table below, a market demand of 25 requests per day, and a 420-minute working day. Find the balance that minimizes the number of workstations.

Activity	Time (min)	Immediate Predecessor
A	2	-
B	11	A
C	4	B
D	5	-
E	7	D
F	6	C
G	2	C
H	10	E
I	2	E
J	8	F,G,H,I
K	6	J

Example continued

Step 1 Precedence diagram



Example continued

2. C = 420/25 = 16.8 min/request
3. TM = 63/16.8 = 4 stations (rounded up)
4. Primary rule: largest number of followers; Secondary rule: longest activity time.

Activity	No of Followers
A	6
B and D	5
C and E	4
F,G,H and I	2
J	1
K	0

Example continued

Step 5 – Assign activities to workstations

Station	Activity	Station Idle Time (min)	Feasible Activities	Activities with Most Followers	Activities with Longest Time
1	A	14.8	B,D	B,D	B
	B	3.8	None		
2	D	11.8	C,E	C,E	E
	E	4.8	C,I	C	
	C	0.8	None		
3	H	6.8	F,G,I	F,G,I	F
	F	0.8	None		
4	G*	14.8	I		
	I	12.8	J		
	J	4.8	None		
5	K	10.8			

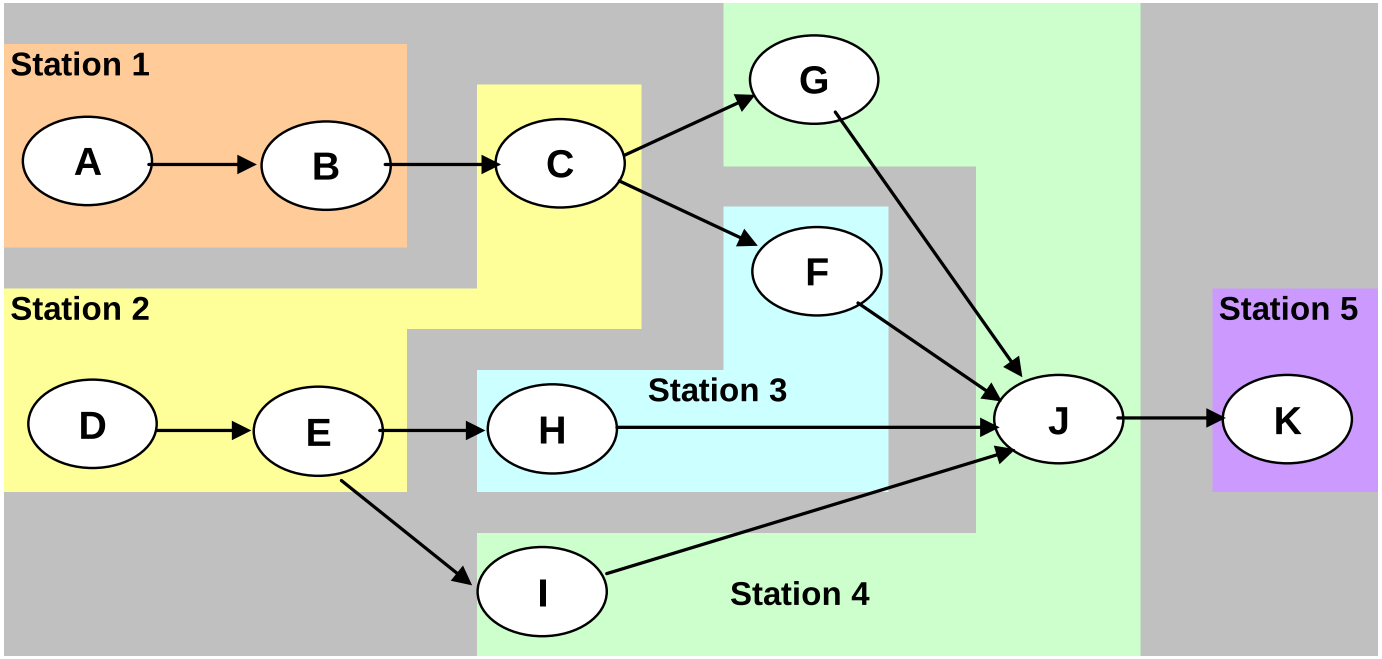
Example continued

6. Efficiency

   = 63/(16.8*5) = 75%

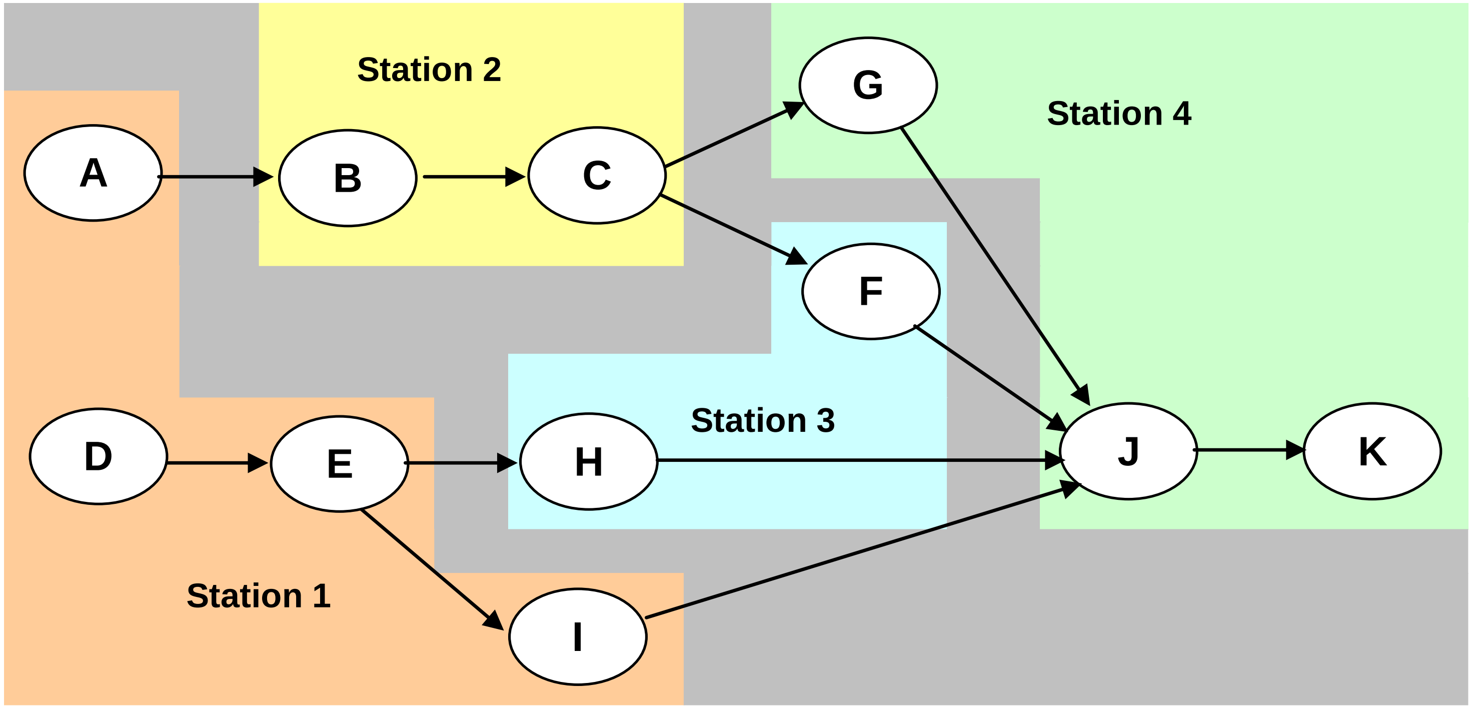
   => 25% idle time

7. Is a better balance possible? Yes.



Example continued

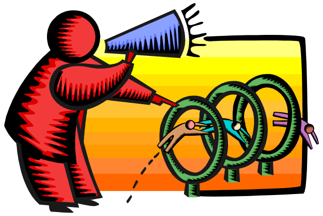
- A More Efficient Solution:
- Primary rule: longest activity time
- Secondary rule: largest number of followers



Workflow Design Principles and Tools

Potential Line Balancing Complications

- Market demand may require a work station cycle time shorter than the longest activity time $\Rightarrow$ Need to change the process in some way!
- Approaches
  - Split the activity
  - Use parallel workstations
  - Train the workers or upgrade machinery for faster processing time
  - Work overtime
  - Redesign the entire process



Workflow Design Principles and Tools

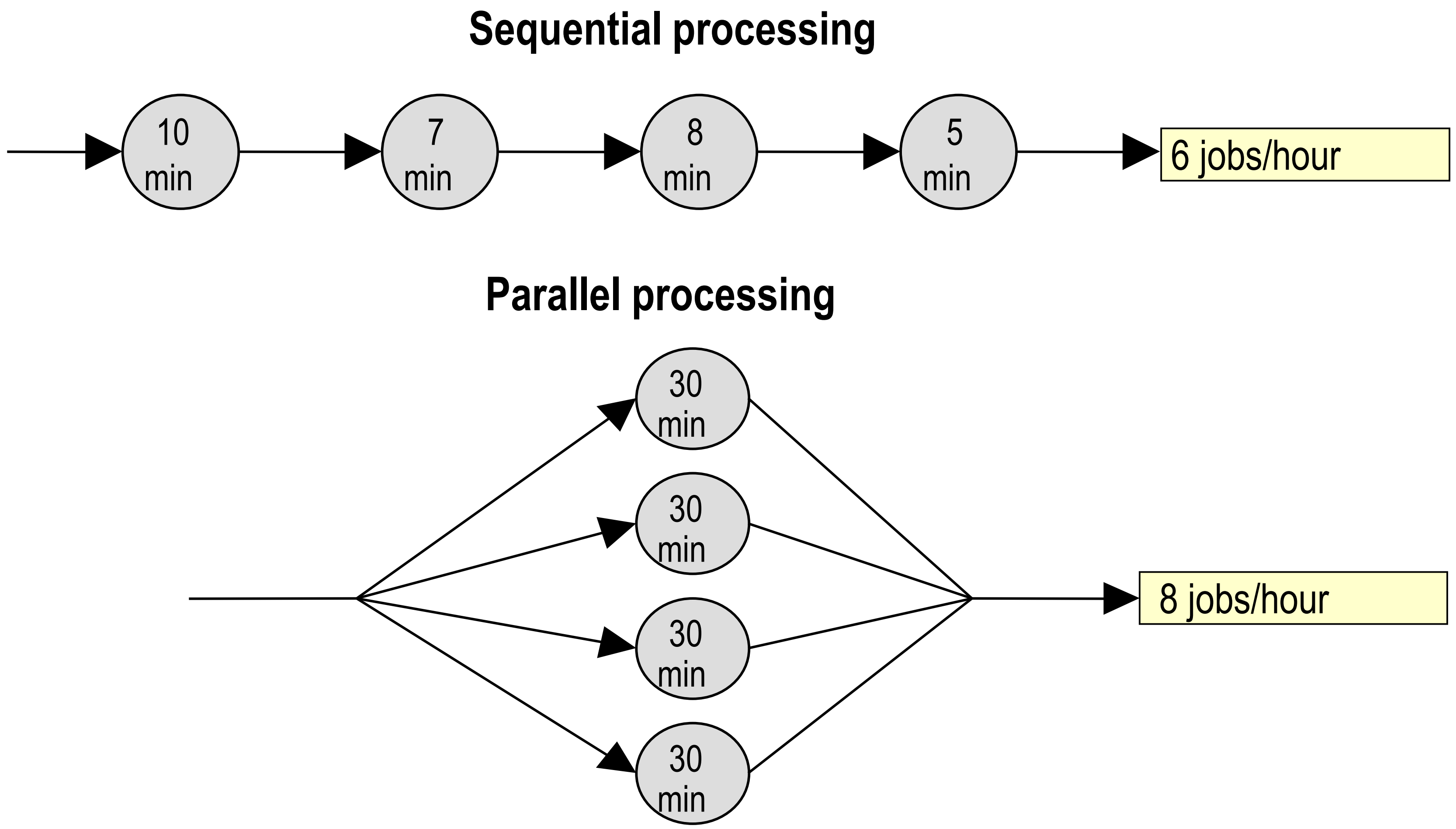
Minimize Sequential Processing and Handoffs

- Sequential processing implies longer process throughput time
  - Operations are dependent $\Rightarrow$ constrained by the slowest activity
  - No one person is responsible for the entire service encounter

Illustrative example (see figure on next slide)

- A process with 4 activities, throughput time 30 minutes and processing times 10, 7, 8 & 5 minutes in the 4 activities
- Sequential set up – each individual performs a different activity
  - The process output is 60/10=6 jobs per hour
  - The efficiency = (10+7+8+5)/(10*4) = 75%
- Parallel set up – each individual performs all 4 activities
  - The process output is now 4*(60/30) = 8 jobs per hour
  - The efficiency = 30/30 = 100%

Illustrative Example
Sequential v.s. Parallel Processing



Work Flow: Scheduling

Scheduling based on job characteristics

- Scheduling involves sequencing the order at which a number of different jobs are to pass through a workstation or process with limited capacity
  - Becomes more important as the diversity of jobs increases
- Characteristics that are commonly used as a basis for scheduling
  - Arrival time
  - Estimated processing time
  - Due date
  - Importance

Work Flow: Scheduling

- Finding the “right”objective function and the best scheduling characteristic to satisfy this objective is tricky
- Three common overall objectives
  - Maximize process output over a given time period
  - Satisfying customer desires for quality and promptness
  - Minimizing current out-of-pocket costs

- Common surrogate objectives that are easier to quantify
  - Minimize the make span (the throughput time for a defined set of jobs)
  - Minimize total (or average weighted) tardiness (the time by which the completion time surpasses the due date)
  - Minimize the maximum tardiness
  - Minimize the number of tardy jobs

- The weighted tardiness (or delay) is obtained as the product between the tardiness value and the importance weight of the job in question

Work Flow: Cycle Time Analysis

- The task of calculating the *average* cycle time for an entire process or process segment
  - Assumes that the average activity times for all involved activities are available
- In the simplest case a process consists of a sequence of activities on a single path
  - The average cycle time is just the sum of the average activity times involved
- … but in general we must be able to account for
  - Rework
  - Multiple paths ***(Critical Path)***
  - Parallel activities

Work Flow: Cycle Time Efficiency

- Measured as the percentage of the total cycle time spent on value adding activities.

$$\text{Cycle Time Efficiency} = \frac{\text{Theoretical Cycle Time}}{\text{CT}}$$

- Theoretical Cycle Time = the cycle time which we would have if only value adding activities were performed
  - That is if the activity times, which include waiting times, are replaced by the processing times

Work Flow: Capacity Analysis

- Focus on assessing the capacity needs and resource utilization in the process
  1. Determine the **number of jobs** flowing through different process segments
  2. Determine **capacity requirements** and **utilization** based on the flows obtained in 1.
- The capacity requirements are directly affected by the process configuration
  - ⇒ Flowcharts are valuable tools
  - ⇒ Special features to watch out for
    - Rework
    - Multiple Paths
    - Parallel Activities
- Complements the cycle time analysis!

Work Flow: Capacity Analysis

- ❖ Capacity is related to resources not to activities!
- ▪ The process capacity is determined by the bottleneck
  - – The bottleneck is the resource or resource pool with the smallest capacity (the slowest resource in terms of jobs/time unit)
  - – The slowest resource will limit the process throughput

Capacity Utilization

- ▪ The theoretical process capacity is obtained by focusing on processing times as opposed to activity times
  - – Delays and waiting times are disregarded

$\Rightarrow$ ***The actual process throughput $\leq$ The theoretical capacity***!

$$\text{Capacity Utilization} = \frac{\text{Actual Throughput}}{\text{Theoretical Process Capacity}}$$

Customer Flow: Queuing Behaviour

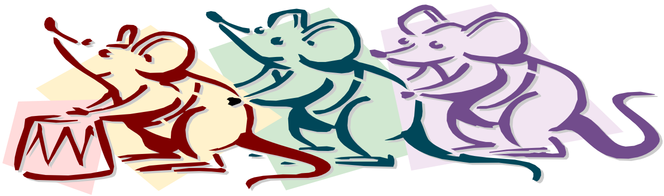
- Commercial Queuing Systems
  - Organizations serving external customers
    - Eg. Dentist, bank, ATM, gas stations, plumber, garage …
- Transportation service systems
  - Vehicles are customers or servers
  - E.g. Vehicles waiting at toll stations and traffic lights, trucks or ships waiting to be loaded, taxi cabs, fire engines, elevators, buses …

Customer Flow: Queuing Behaviour

- Business-internal service systems
  – Processes serving internal customers
    - Human resources, IT services, finance,…
- Social service systems
  – E.g. Judicial process, the ER at a hospital, waiting lists for organ transplants or student dorm rooms …

Customer Flow: Queuing Behaviour

- The queue configuration
  - Specifies the number of queues
    - Single or multiple lines to a number of service stations
  - Their location
  - Their effect on customer behavior
    - Balking and reneging
  - Their maximum size (# of jobs the queue can hold)
    - Distinction between infinite and finite capacity



Information Flows

- Workflow Management Software
- Business Process Reengineering
- Check Sheets
- Kanban
- Flowcharts
- Control Chart
- MRP/ERP

Information Flow: Workflow Management

The automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules.

Definitions

- A workflow management system (WFMS) is a software package that can be used to support the definition, management and execution of workflow processes.
- A workflow system (WFS) is a system based on a WFMS that supports a specific set of business processes through the execution of computerized process definitions

Goal

- To manage the flow of work such that the work is done at the right time by the proper person.

Information Flow: Check Sheets

Equipment	Worker	Mon		Tue		Wed		Thur		Fri	
		am	pm	am	pm	am	pm	am	pm	am	pm
Machine 1											
Machine 2											

☆ Surface Scratch   ▢ Wrong Shape

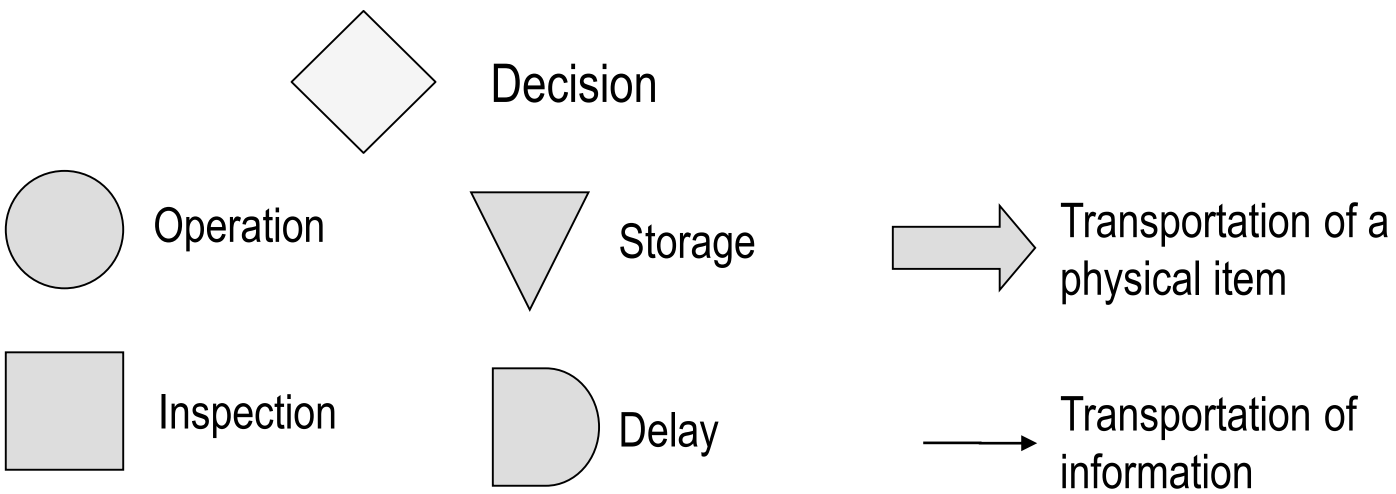
○ Defective Finish   **S** Others

Information Flow: Kanban System

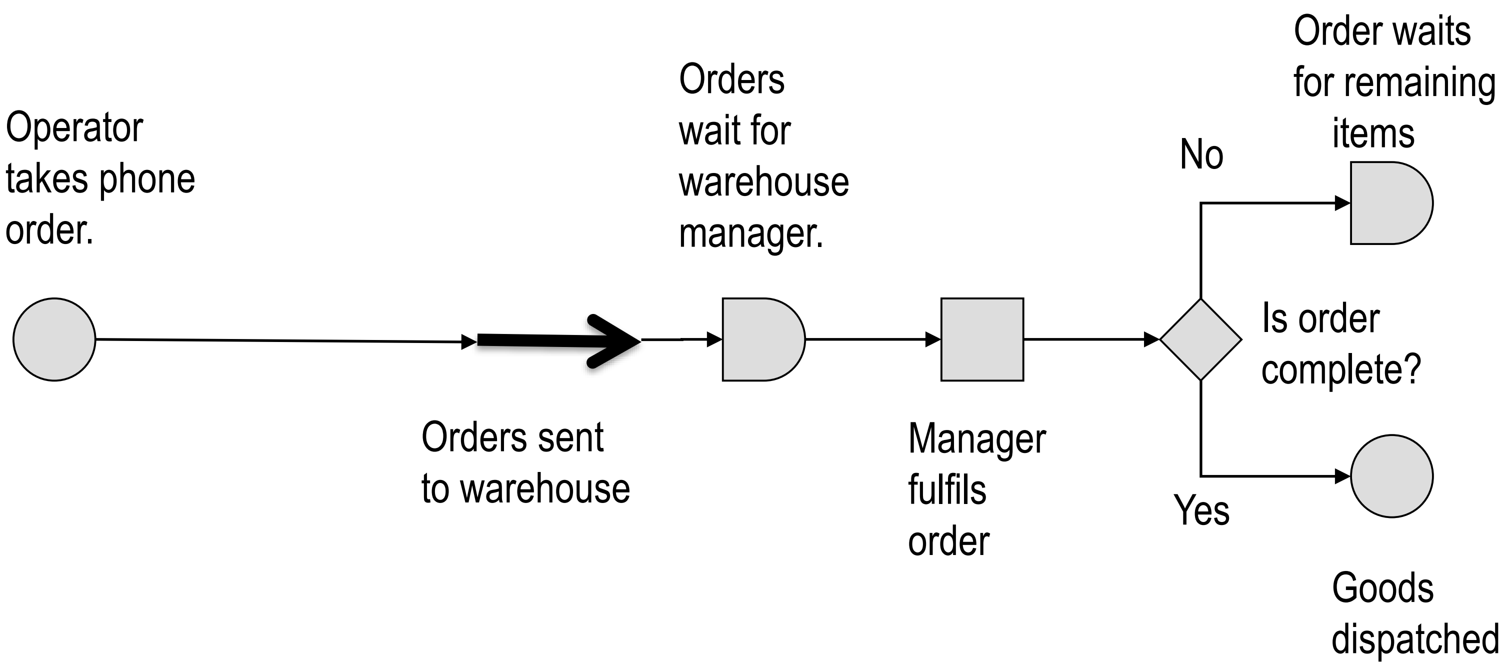
- Pull system: customer needs a signalling device to inform supplier of need
- Kanban
  - Device for customer to inform supplier of its need
  - Card attached to an output flow in the buffer between customer and supplier processes
  - Contains information on
    - Customer process
    - Supplier process
    - Parts description
    - Production quantity
  - As customer withdraws output flow units, attached kanban goes back to supplier, signalling supplier to produce the listed quantity

Information Flow: Flow Charts

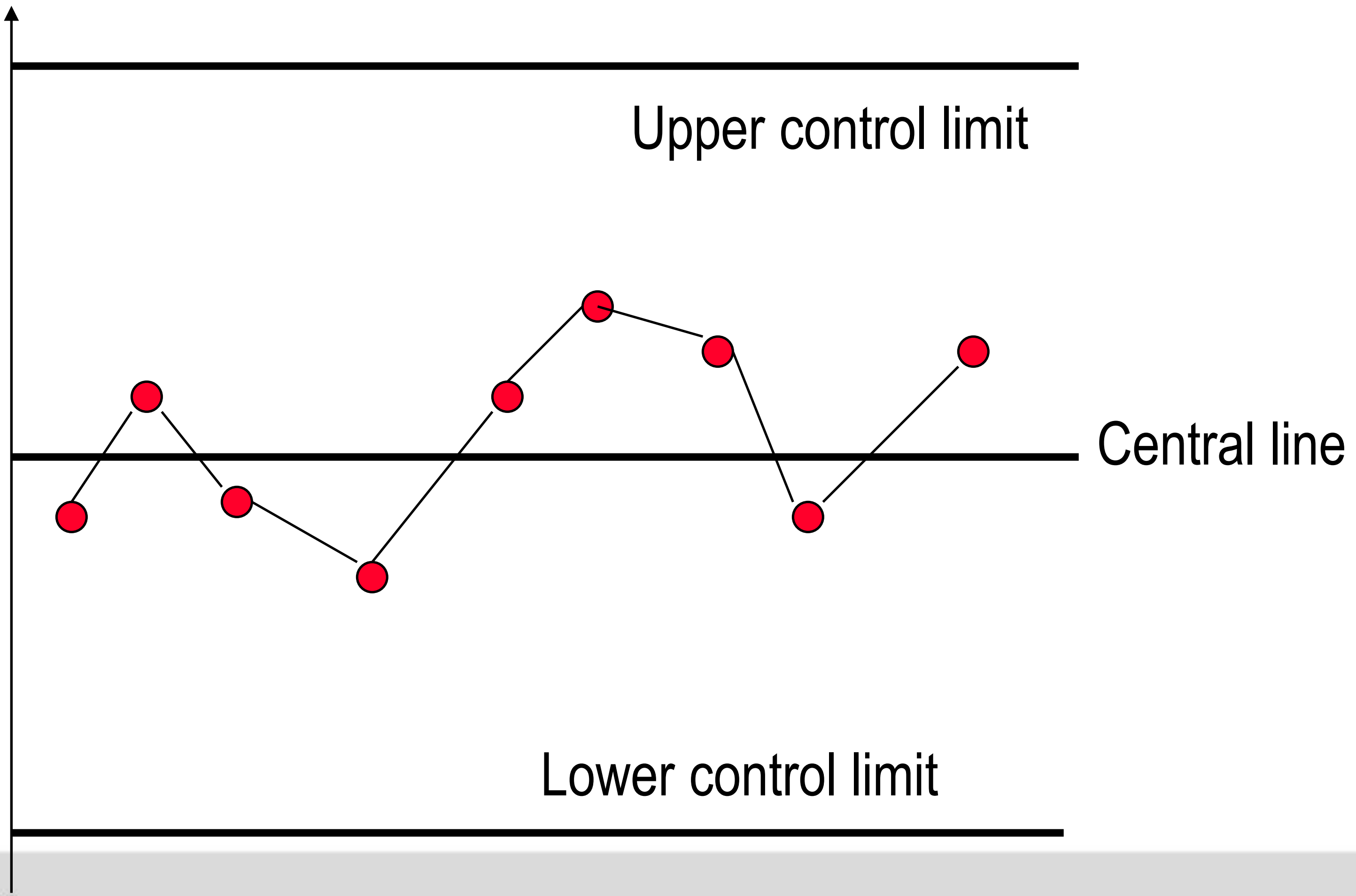
- One of the fundamental graphical tools for process analysis and design
  - Typically depicts activities sequentially from left to right
  - Can help to identify loops, multiple alternative paths, decision points etc.
- Symbols often used in flow charting



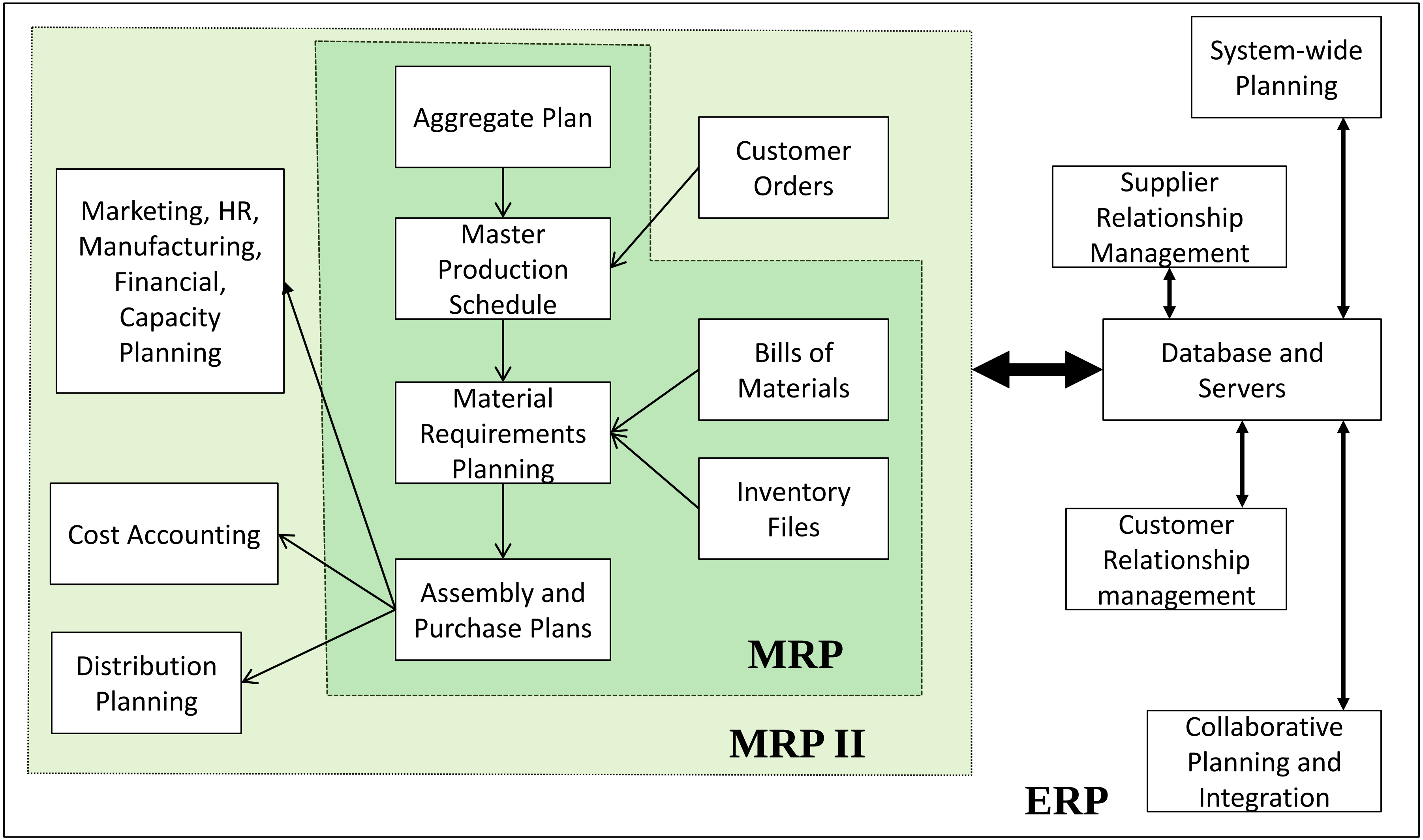
Information Flow: Flowcharts



Information Flow: Control Charts



Information Flow: MRP/ERP



MONASH University

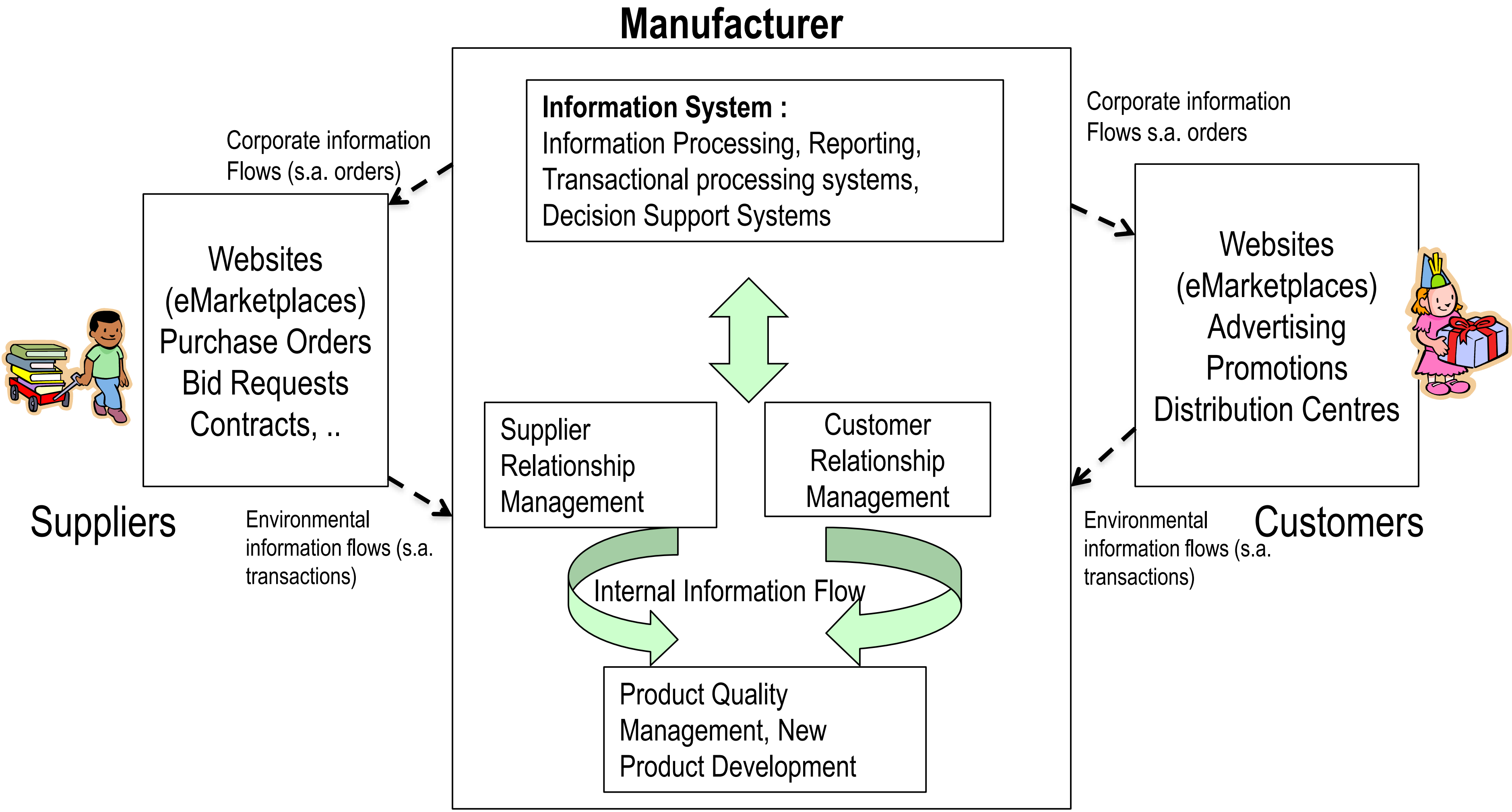
Flexible Manufacturing

- Central computer, computer numerically controlled (CNC) machines, automated material handling system with automated conveyors, automated guided vehicles, automated storage and retrieval system
- Uses CAD, CAM, Group Technology
- Small batches, reduced lead times, reduced scrap, quickly change product mix, routing and machining sequence ***(Material Flows!)***

Information Flow Mapping

- Helps managers to identify how information is transmitted from one point to another both within firm and externally to suppliers and customers
- Steps
  1. Information audit to determine stakeholders and their information usage
  2. Map the information flows of the business
  3. Identify needs not satisfied (may involve discussions amongst stakeholders)
  4. Add new information flows as needed

A Map of Internal and External Information Flows for a Manufacturer



Summary

Consolidation of concepts of material flows, customer flow, workflow and information flow