Process Analysis

Learning Objectives

1. Recognize three basic types of processes: a serial flow process, parallel processes (such as what happens in a restaurant), and logistics processes.
2. Understand basic flowcharting of processes.
3. Explain how to analyze processes using Little's law.
4. Understand how to calculate process performance measures.

Process Analysis

- **Process**: any part of an organization that takes inputs and transforms them into outputs
- **Cycle time**: the average successive time between completions of successive units
- **Utilization**: the ratio of the time that a resource is actually activated relative to the time that it is available for use

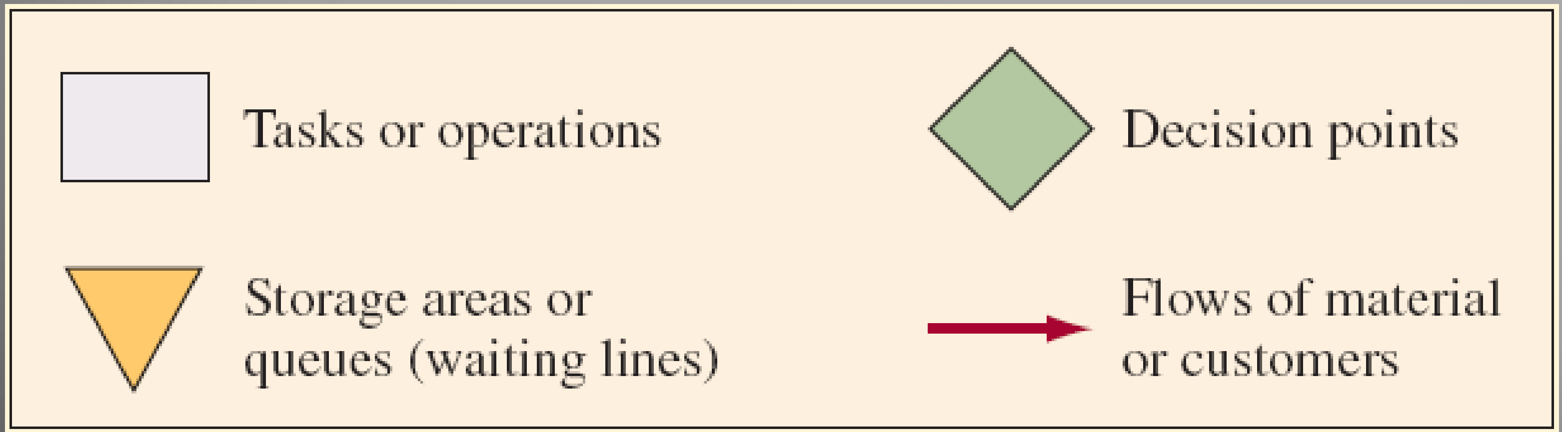
Analyzing a Las Vegas Slot Machine

1. Analyzing the mechanical slot machine
2. Analyzing the new electronic slot machine
3. Comparison
4. The slot machine is one of many casino processes

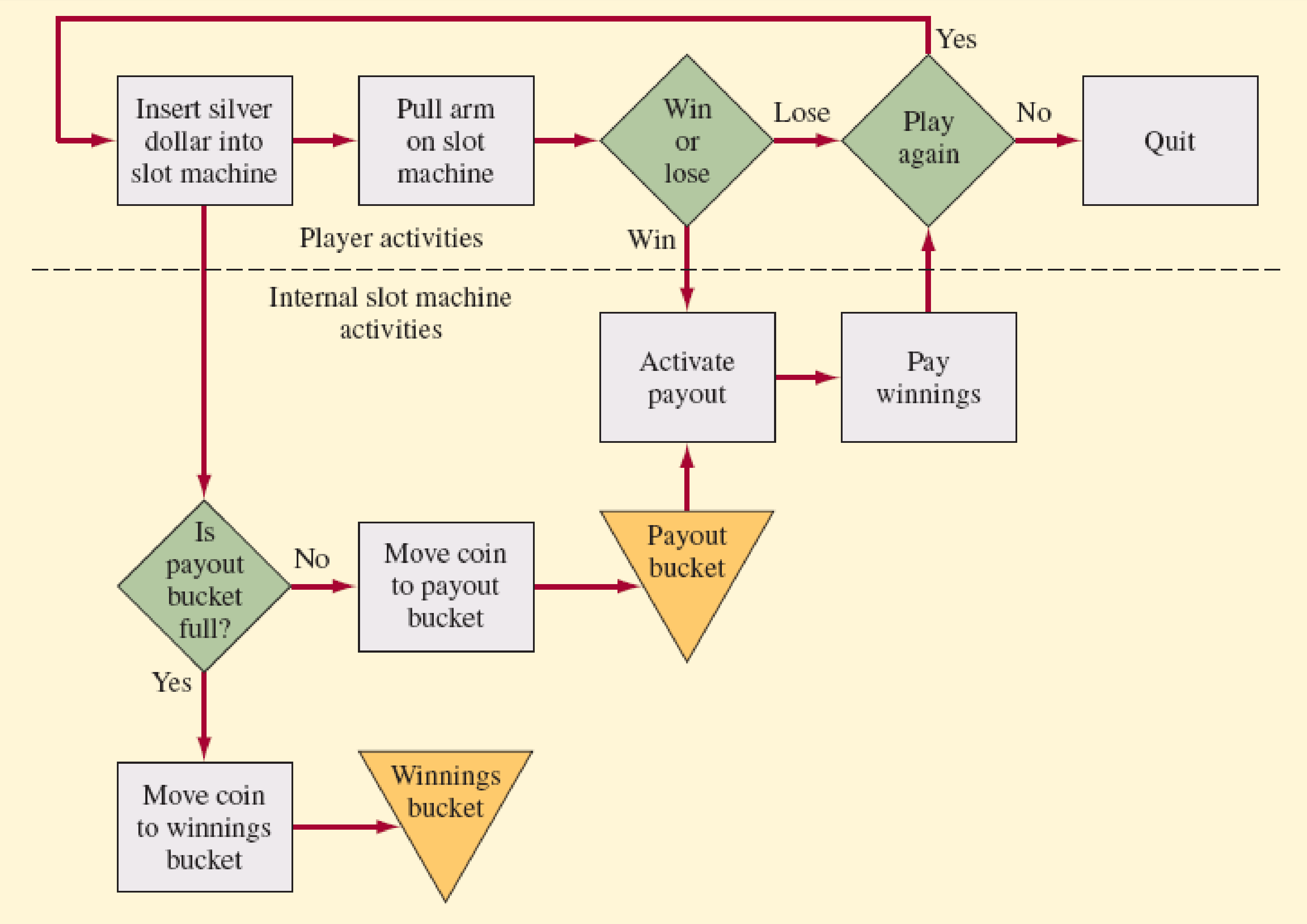
Process Flowcharting

- **Process flowcharting**: the use of a diagram to present the major elements of a process
- The basic elements can include tasks or operations, flows of materials or customers, decision points, and storage areas or queues
- It is an ideal methodology by which to begin analyzing a process

Flowchart Symbols

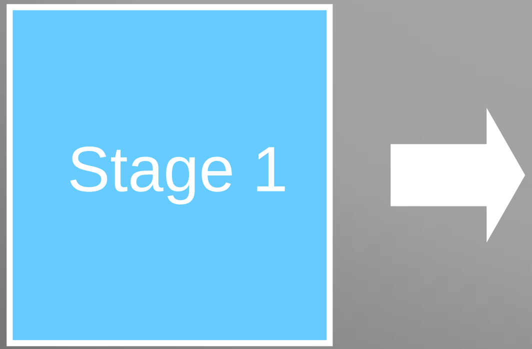


Process Flowchart Example (Slot Machine)



Types of Processes

Single-stage Process

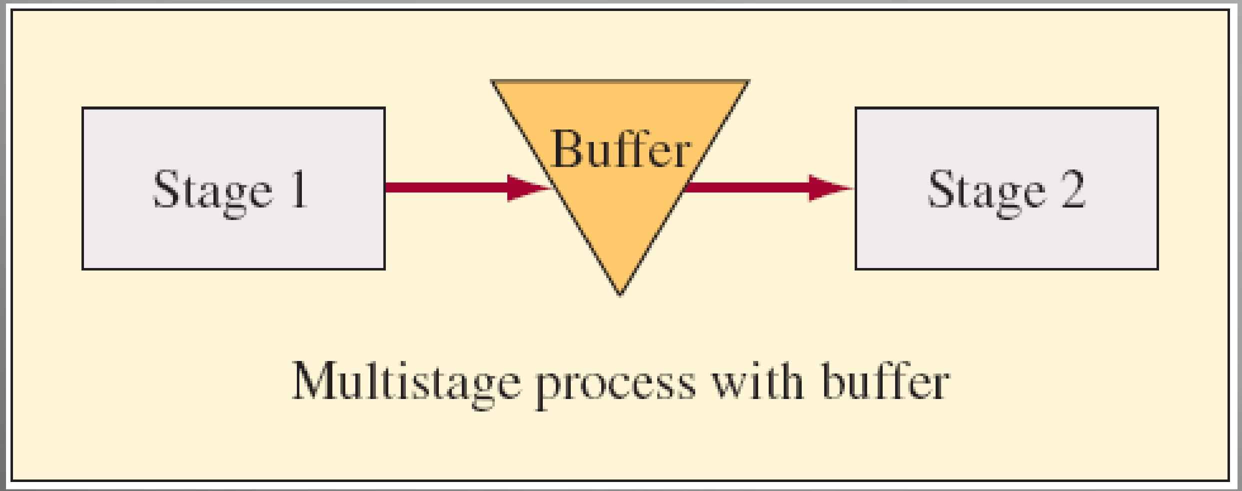


Multi-stage Process

Buffering, Blocking, and Starving

- **Buffer**: a storage area between stages where the output of a stage is placed prior to being used in a downstream stage
- **Blocking**: occurs when the activities in a stage must stop because there is no place to deposit the item
- **Starving**: occurs when the activities in a stage must stop because there is no work
- **Bottleneck**: stage that limits the capacity of the process

Multi-stage Process with Buffer

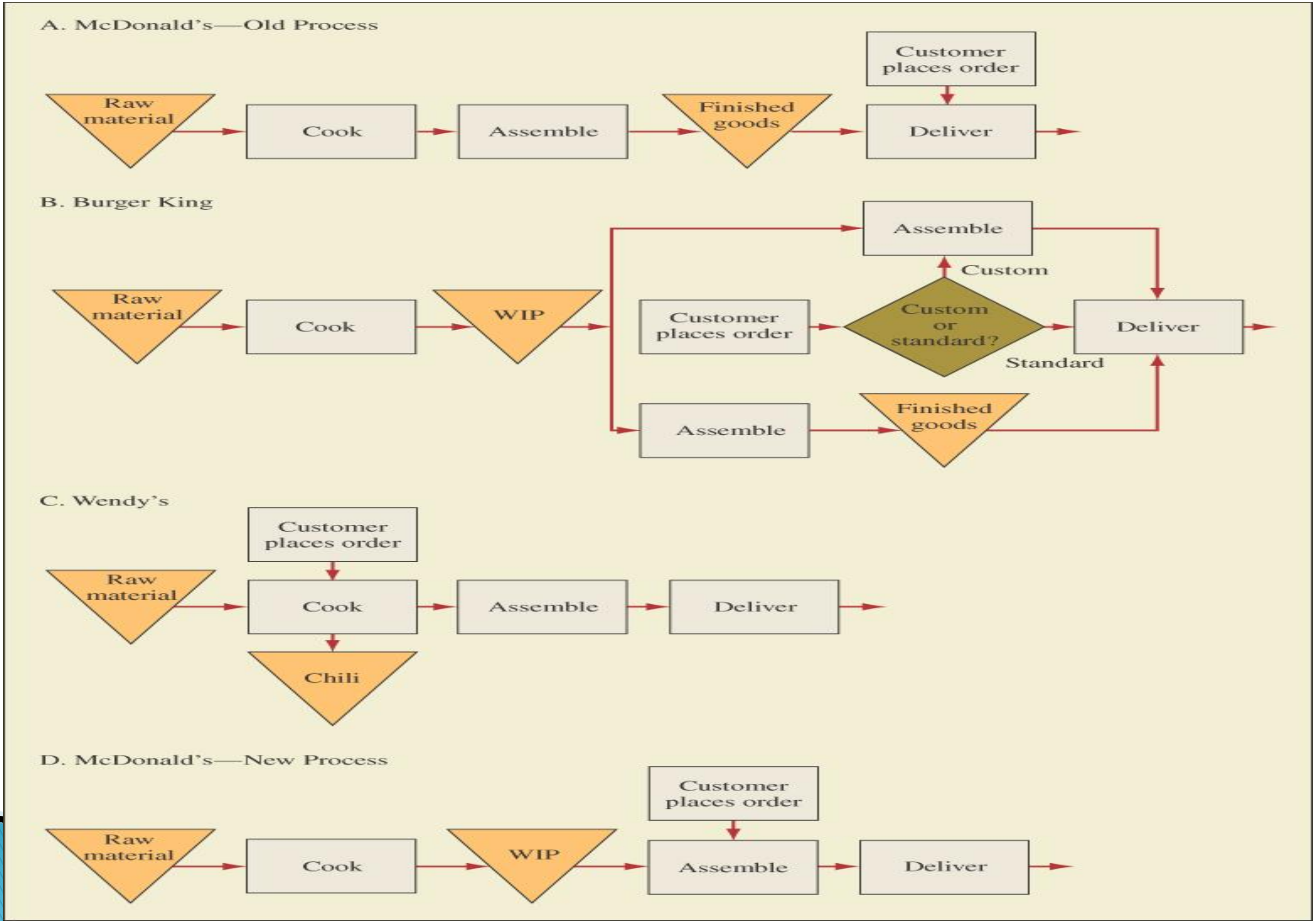


Other Types of Processes

- **Serial flow process**: a single path for all stages of production
- **Parallel process**: Some of production has alternative paths where two or more machines are used to increase capacity
- **Logistics processes**: the movement of things such as materials, people, or finished goods

Make-to-Stock versus Make-to-Order

- Make-to-order
  - Only activated in response to an actual order
  - Both work-in-process and finished goods inventory kept to a minimum
- Make-to-stock
  - Process activated to meet expected or forecast demand
  - Customer orders are served from target stocking level
- Hybrid
  - Combine the features of both make-to-order and make-to-stock


A. McDonald's—Old Process
Raw material
Cook
Assemble
Finished goods
Customer places order
Deliver
B. Burger King
Raw material
Cook
WIP
Assemble
Custom
Customer places order
Custom or standard?
Deliver
Standard
Assemble
Finished goods
C. Wendy's
Customer places order
Raw material
Cook
Assemble
Deliver
Chili
D. McDonald's—New Process
Customer places order
Raw material
Cook
WIP
Assemble
Deliver

Process Performance Metrics

- Capacity: maximum output of a process or resource measured in units/time: a *rate* (sometimes called throughput rate)
- Operation time = Setup time + Run time
- *Setup time*: the length of time required to changeover from one product to another (assumes products are produced in *batches*)
- Flow time or Throughput time = Average time for a unit to move *through* the system

Process Performance Metrics (Continued)

- Cycle time = Average time between completion of units
- Throughput rate = $\dfrac{1}{\text{Cycle time}}$
- Utilization of an operation =
- Time activated/time available or

  Demand/Capacity

Cycle Time Example

Suppose you had to produce 600 units in 80 hours to meet the demand requirements of a product. What is the cycle time to meet this demand requirement?

Answer: There are 4,800 minutes (60 minutes/hour x 80 hours) in 80 hours. So the average time between completions would have to be: Cycle time = 4,800/600 units = 8 minutes.

Production Process Mapping and Little's Law

- Total average value of inventory
  - Sum of the value of raw materials, work-in-process, and finished goods inventory
- Inventory turns
  - Cost of goods sold divided by the average inventory value
- Days-of-supply
  - Inverse of inventory turns scaled to days
- Little's law
  - There is a long-term relationship between inventory, throughput, and flow time
  - Inventory = Throughput rate X Flow time

Example: Car Batteries

- Average cost $45
- 12 hours to make a car
- Assembles 200 cars per 8 hour shift
  - Currently one shift
- Holds on average 8,000 batteries in raw material inventory

Example: Average Inventory

- WIP = Throughput x flow time
- WIP = 25 batteries x 12 hours
- WIP = 300 batteries

- Total = 8,000 + 300 = 8,300 batteries

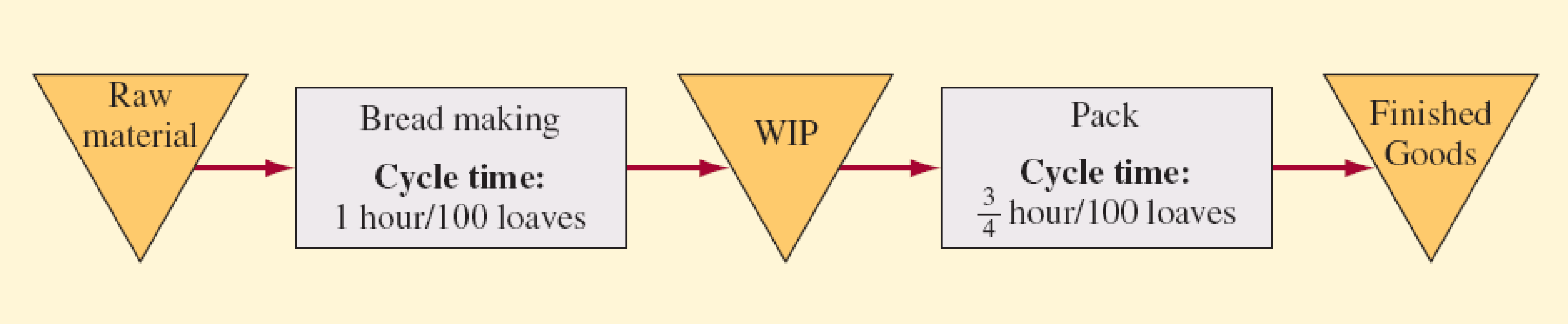
Example: Value and Flow Time

- Value = 8,300 x $45 = $375,000

- Flow time = Inventory / Throughput
  Flow time = 8,000 / 200 = 40 days

Example: Bread Making

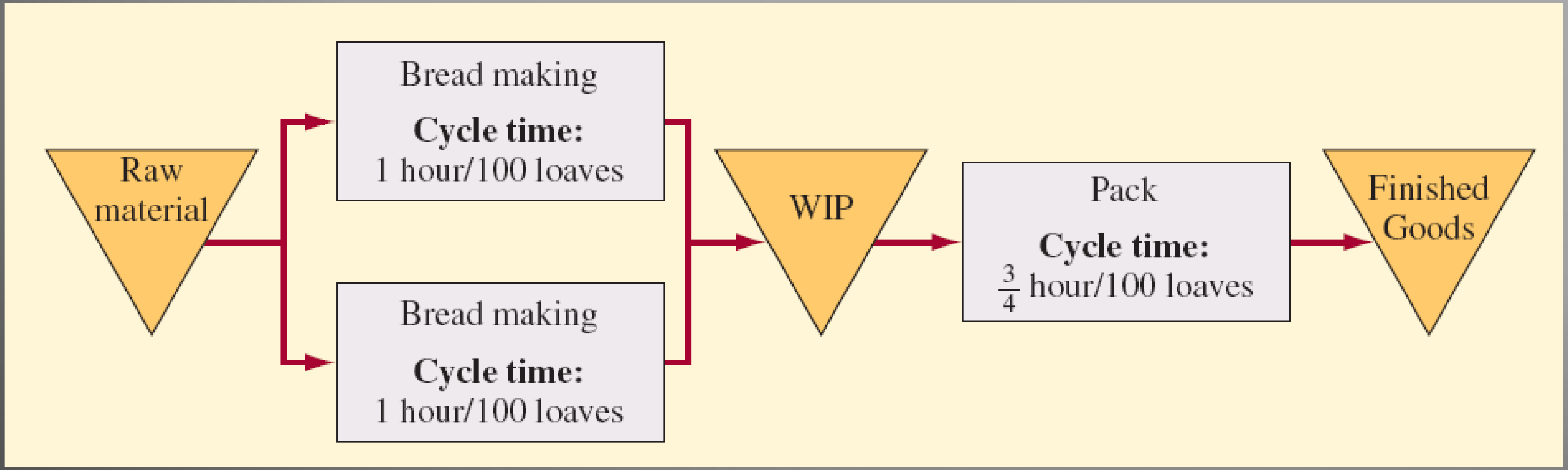
Current Layout



Example: Running at 100 Loaves Per Hour

- Both bread making and packaging operate the same amount of time
- Capacity is 100 loaves per hour
- Packaging idle for a quarter hour
  - Has 75 percent utilization
- Flow time (throughput time) is 1.75 hours (no inventory buildup)

Example: Bread Making on Two Parallel Lines



Example: one shift

- Bread making: 200 loaves/hour
- Packaging: 133/33 loaves/hour -- bottleneck
- Capacity is 133.33 loaves/hour

Example: Multiple Shifts

- Bread making runs two shifts
  - Produces 200 x 8 x 2 = 3,200
- Packaging runs three shifts
  - Produces 133.3 x 8 x 3 = 3,200
- Capacities are roughly equal (ignores first hour idle time for packaging)
- Packaging is still the bottleneck so throughput rate is 133 1/3 per hour

Flow Time

- After two shifts, 3200 loaves made but only 1331/3 * 15 = 2000 packaged
- So average inventory over first two shifts is:
- ½ x 1200 = 600
- For third shift, inventory drops from 1200 to 0 so it also averages 600
- Using Little's Law: Inventory = Throughput rate X Flow time:
- 600 = 133 1/3 x flow time, so
- Flow time = 4.5 hours for work in process
- Total flow time = 4.5 + 1.75 (processing time) = 6.25 hrs

Process Flow Time Reductions

1. Perform activities in parallel
2. Change the sequence of activities
3. Reduce interruptions