# Lecture #38

## Prof. John W. Sutherland

## April 19, 2006



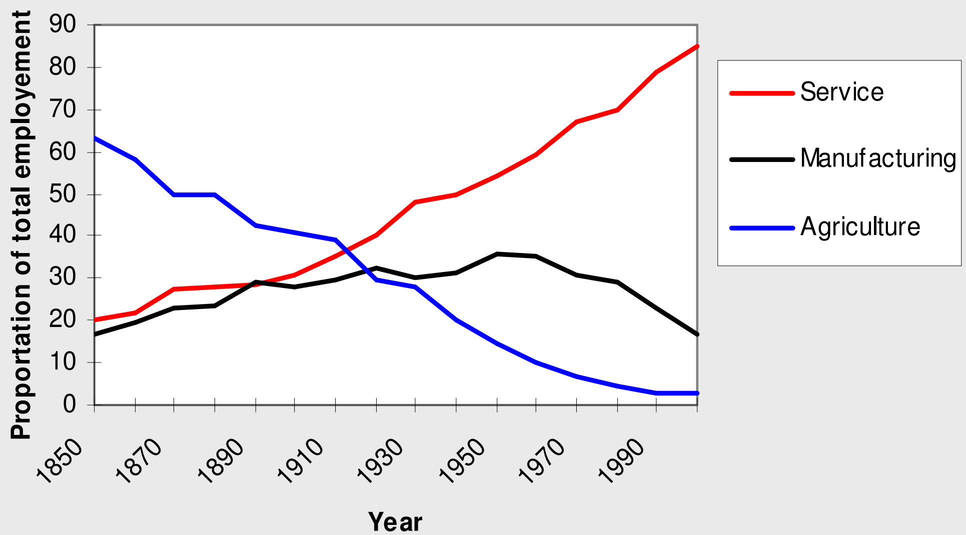
Service Processes & Systems
Dept. of Mechanical Engineering - Engineering Mechanics
Michigan Technological University

# Service Processes & Systems

## Wrap-up Session

# Review – Week 1

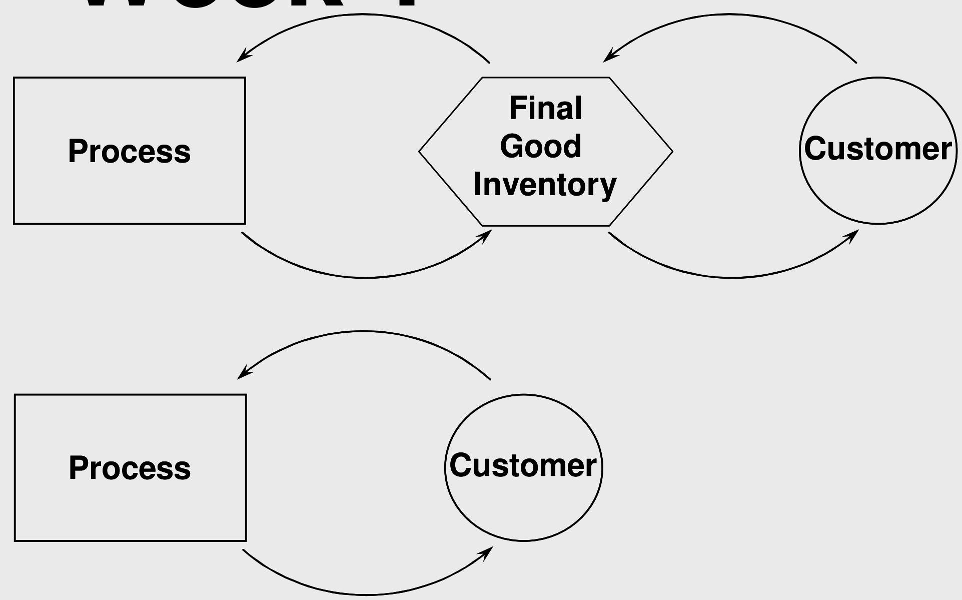
- Service Processes and Systems
  - History/Background

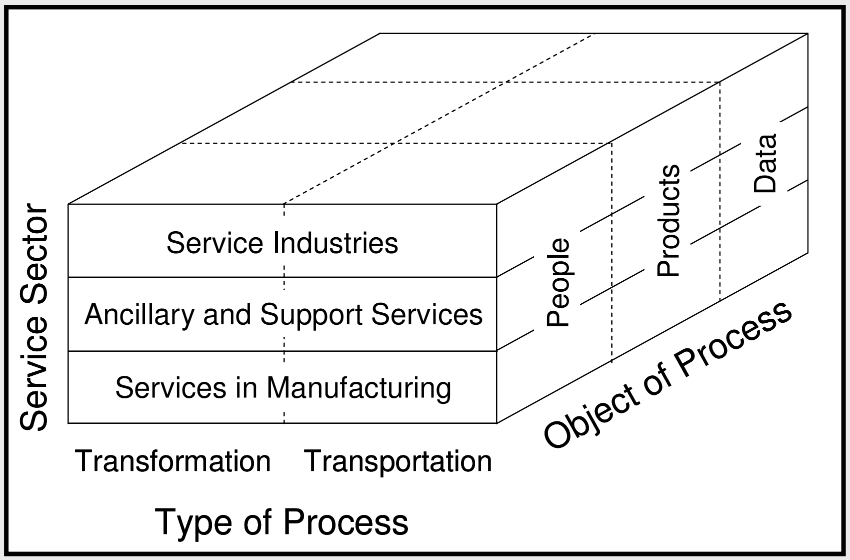



- Elements of Service Process

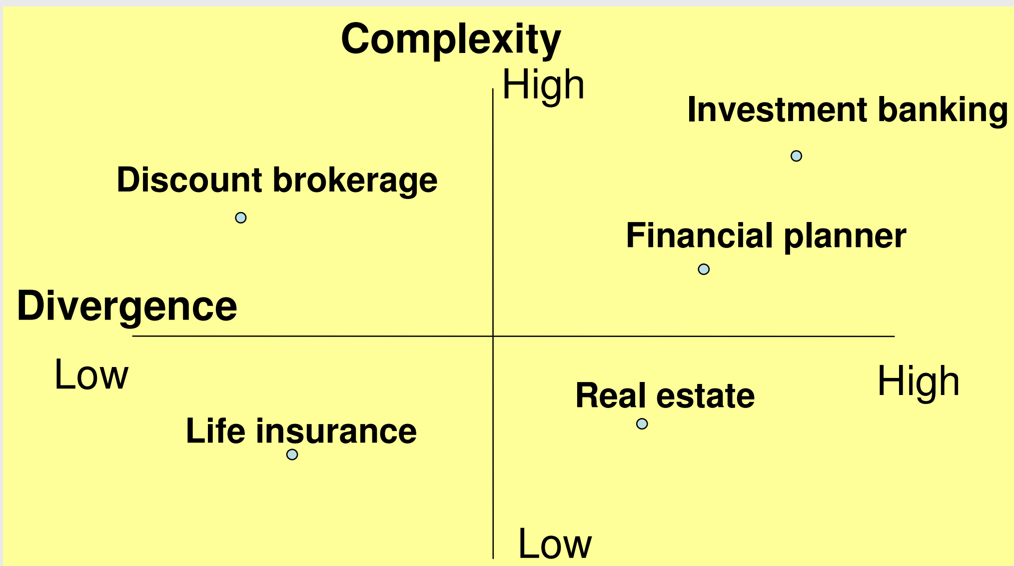
# Review – Week 1

- Comparison between Goods and Services
- Categorizing Services
- Service Classifications



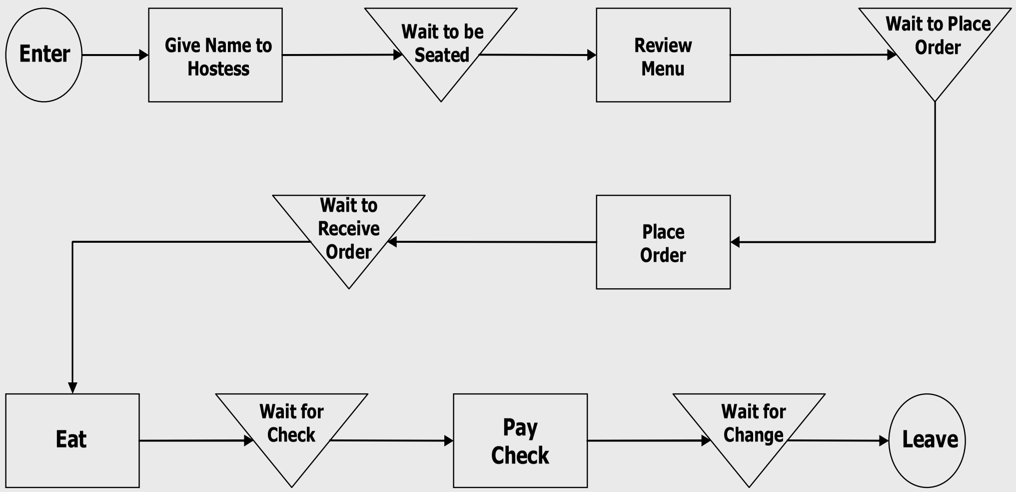



# Review – Week 2

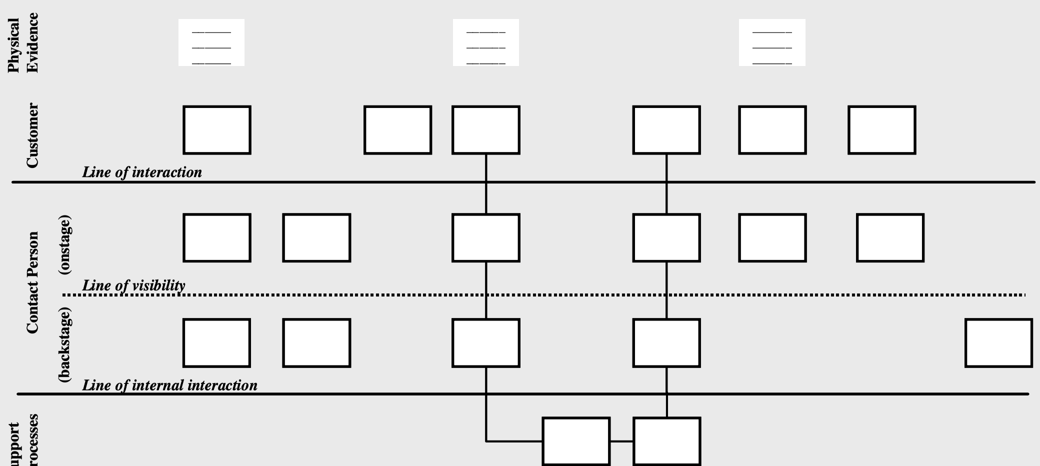


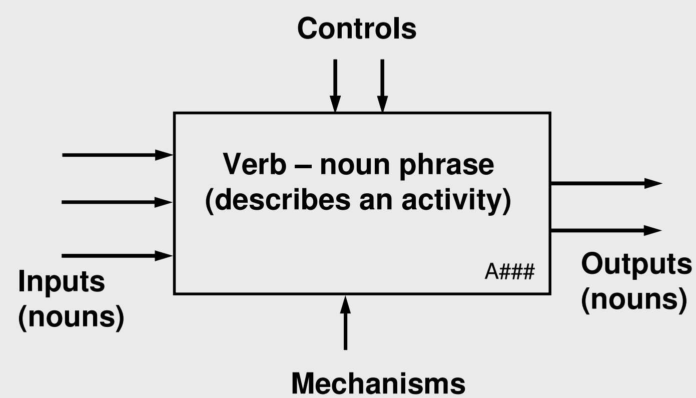

- Service Design Elements
- Generic Approaches to Service Design
- Generic Approaches to Service Design

# Review – Week 2




- Flow charts
- Blueprints
- IDEF

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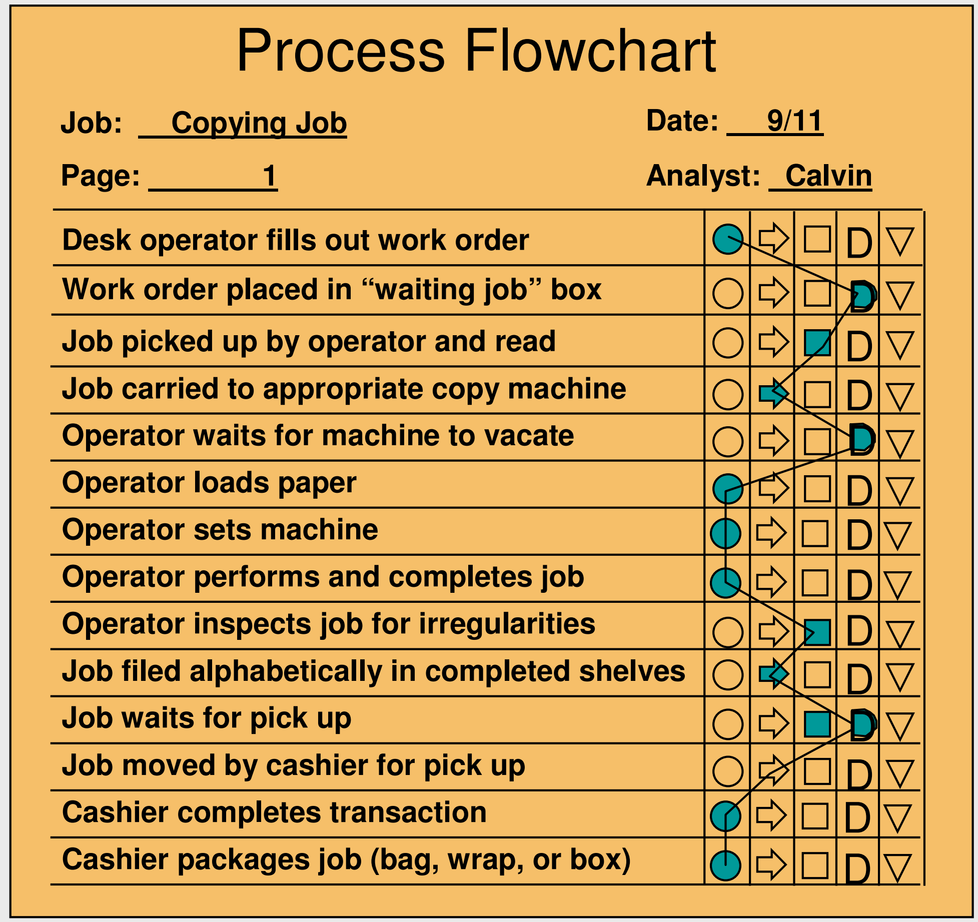
# Review – Week 3

- Motion Study
  - Therbligs
  - Task Description
- Work Measurement
  - Time Study

| Time Study Observation Sheet | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Identification of operation | | | | | | | | | | | | | Date | | | |
| | | Operator | | | | | | Approval | | | | | Observer | | | |
| | | Cycles | | | | | | | | | | | Summary | | | |
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | ∑t | t avg | RF | Nt |
| 1 | Search and grab 4 quarters wrappers and put them into an envelope, close it | t | | | | | | | | | | | | | | |
| | | R | | | | | | | | | | | | | | |
| 2 | Search and grab 5 dimes wrappers and put them into a different envelope, close it | t | | | | | | | | | | | | | | |
| | | R | | | | | | | | | | | | | | |
| 3 | Search and grab 2 nickels wrappers and put them into a third envelope, close it | t | | | | | | | | | | | | | | |
| | | R | | | | | | | | | | | | | | |
| 4 | Grab the three envelopes and take them to the table where the balloons are, put them on the table | t | | | | | | | | | | | | | | |
| | | R | | | | | | | | | | | | | | |
| 5 | Grab a balloon and blow it up until it reaches a measurement of 8 inches from edge to edge | t | | | | | | | | | | | | | | |
| | | R | | | | | | | | | | | | | | |
| 6 | Tie a knot in the balloon | t | | | | | | | | | | | | | | |
| | | R | | | | | | | | | | | | | | |

# Review – Week 3

- **Job Design**
  - HR
  - Worker analysis
  - Task analysis
  - Environmental analysis
  - MTM







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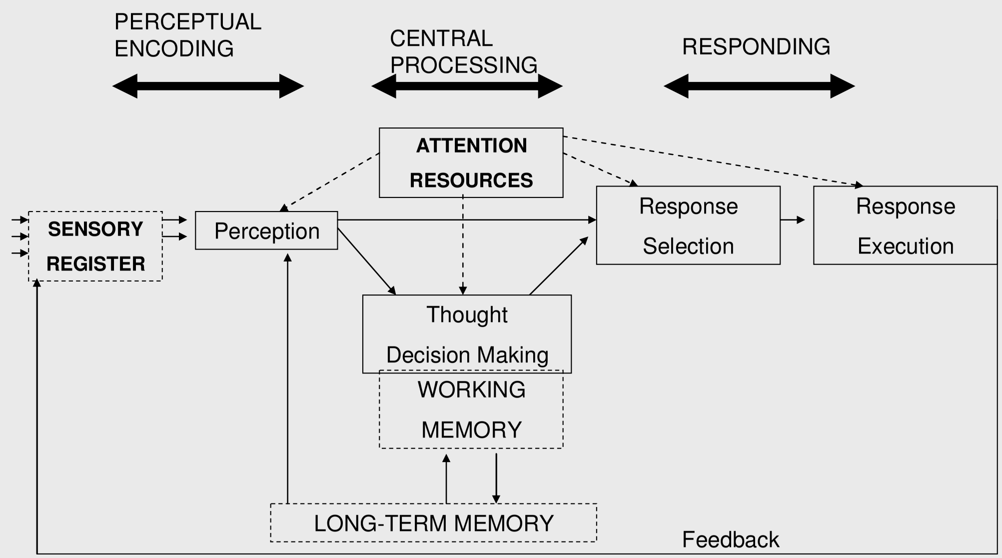
# Review – Week 4

- **Psychology**
  - Senses
- **Cognitive Science**
  - Mental Op
- **Information Processing**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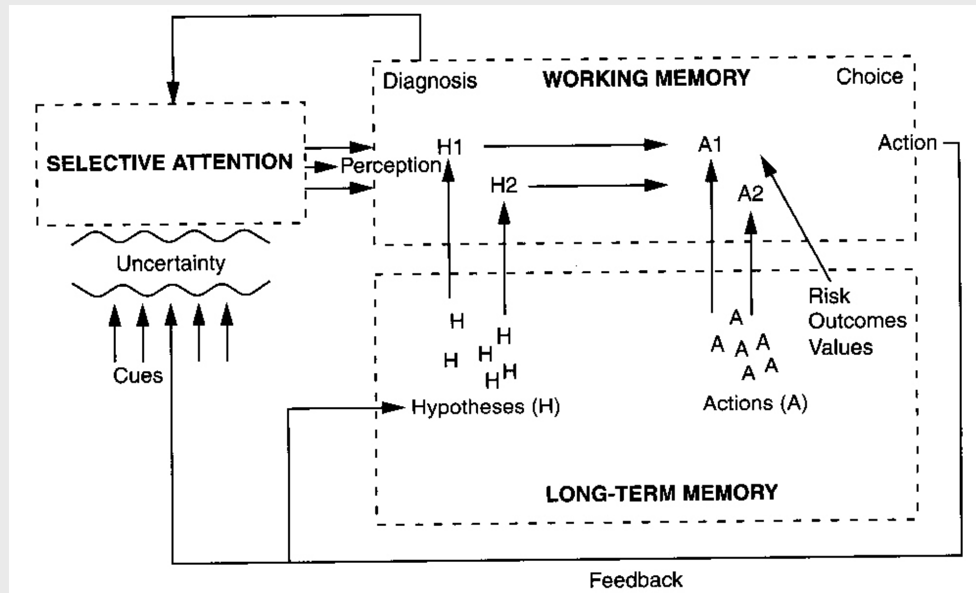
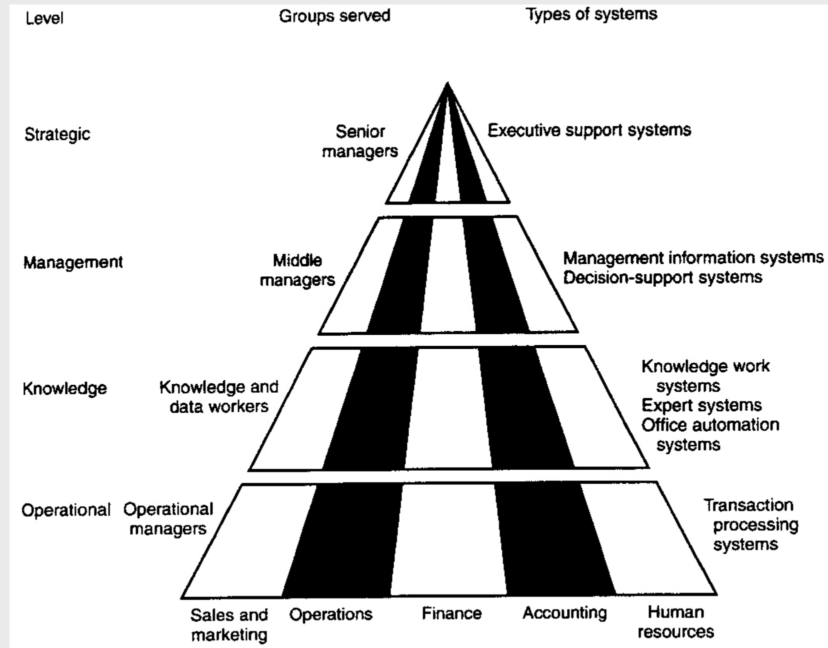
# Review – Week 4

- Selective Attention
- Perception
- Emotion
- Memory
  - Short-Term
  - Long-Term
- Decision Making
  - Multi-attribute utility theory
  - Expected Value Theory

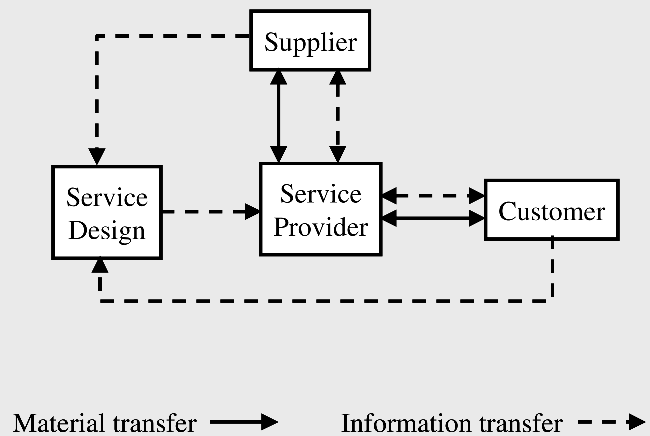


# Review – Week 5

- **Information Systems**









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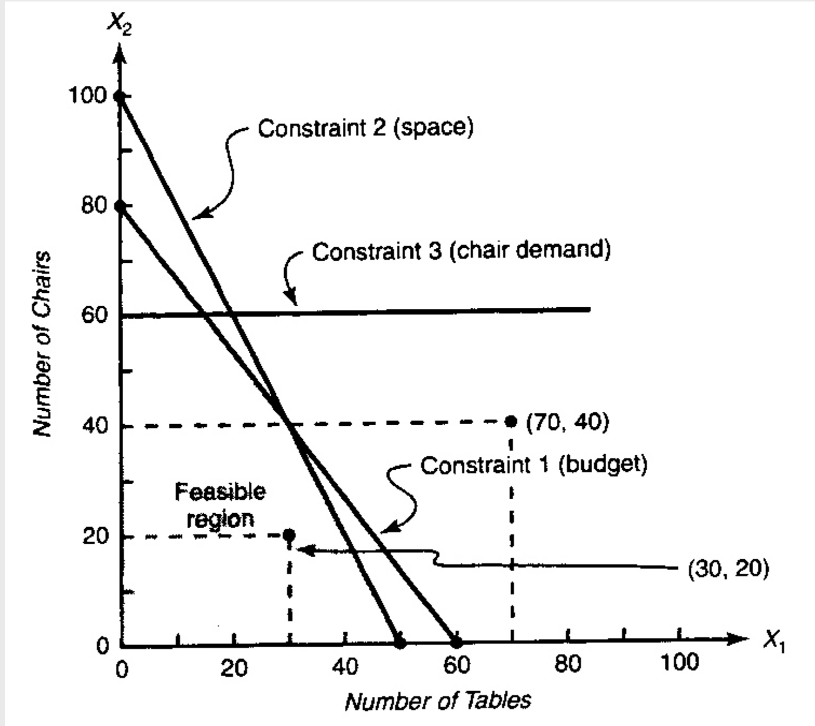
# Review – Week 5

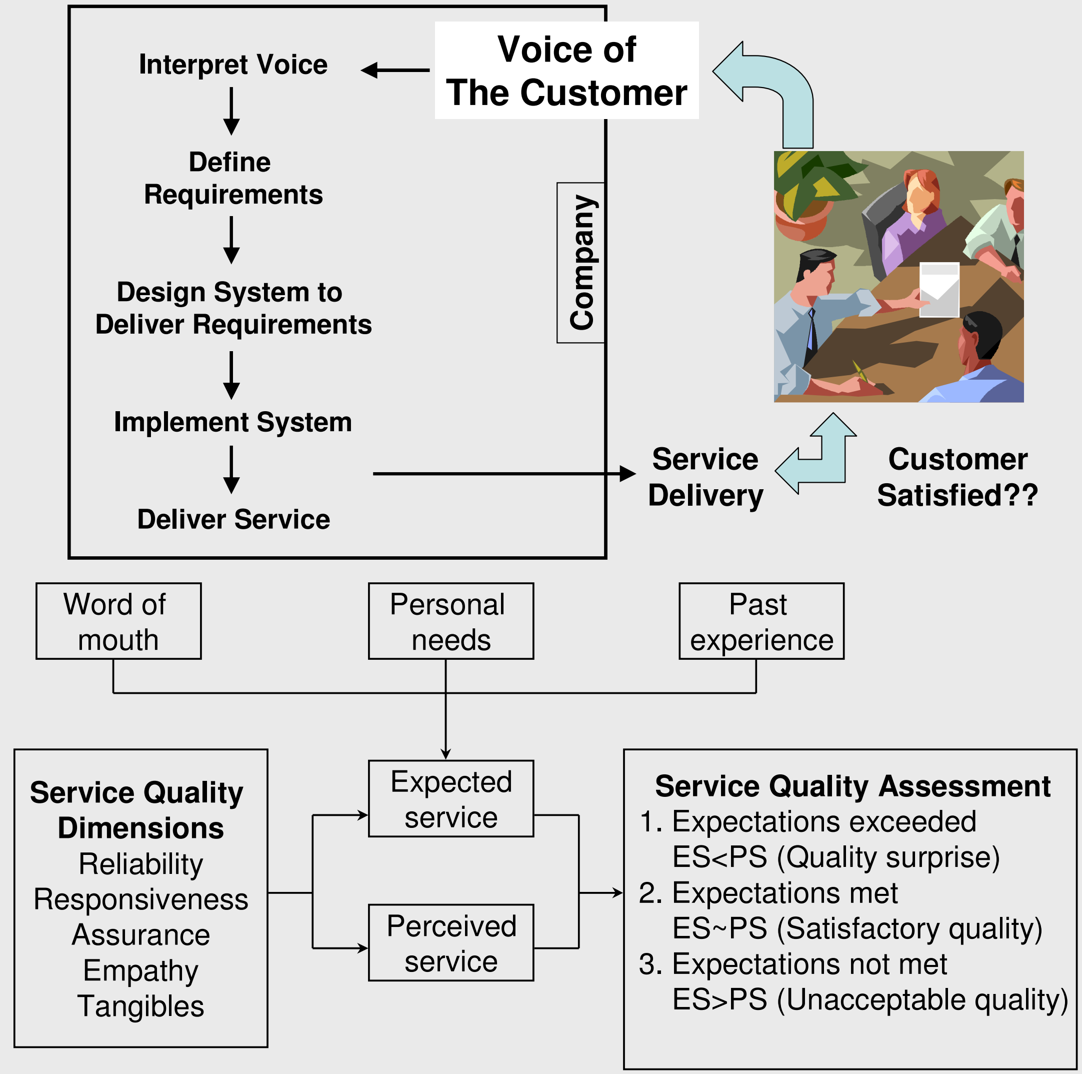
| Strategic Focus | Competitive Use of Information<br>On-line<br>(Real time) | <br>Off-line<br>(Analysis) |
|---|---|---|
| External<br>(Customer) | *Creation of barriers to entry:*<br>Reservation system<br>Frequent user club<br>Switching costs | *Data base asset:*<br>Selling information<br>Development of services<br>Micro-marketing |
| Internal<br>(Operations) | *Revenue generation:*<br>Yield management<br>Point of sale<br>Expert systems | *Productivity enhancement:*<br>Inventory status<br>Data envelopment<br>analysis (DEA) |

- **Linear Programming**



# Review – Week 6

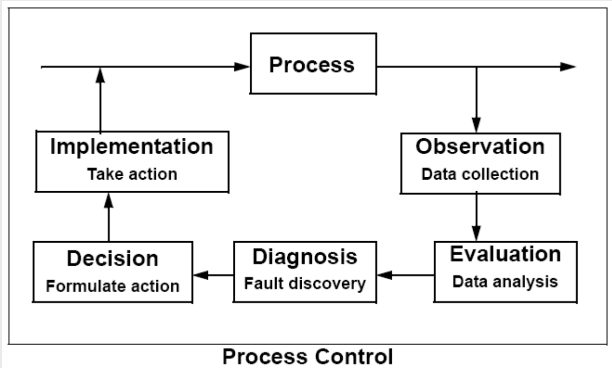
- Performance
- Customer perception and satisfaction
- Quality



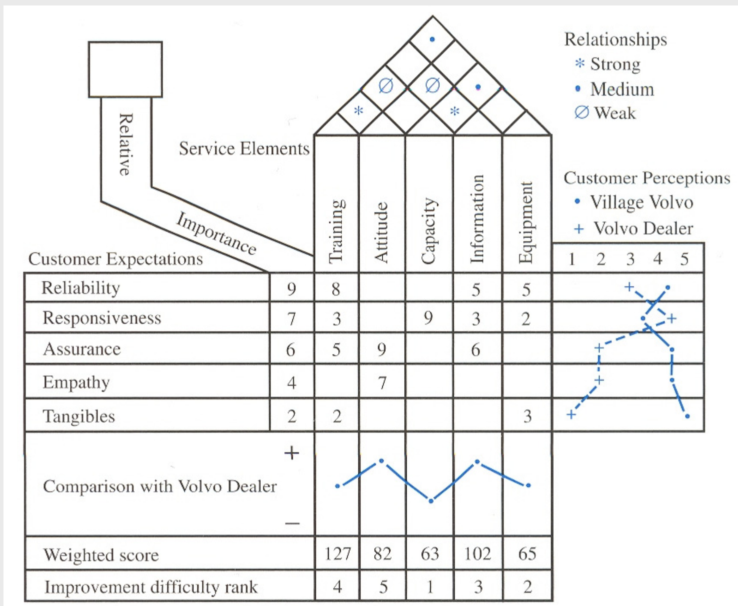
# Review – Week 6

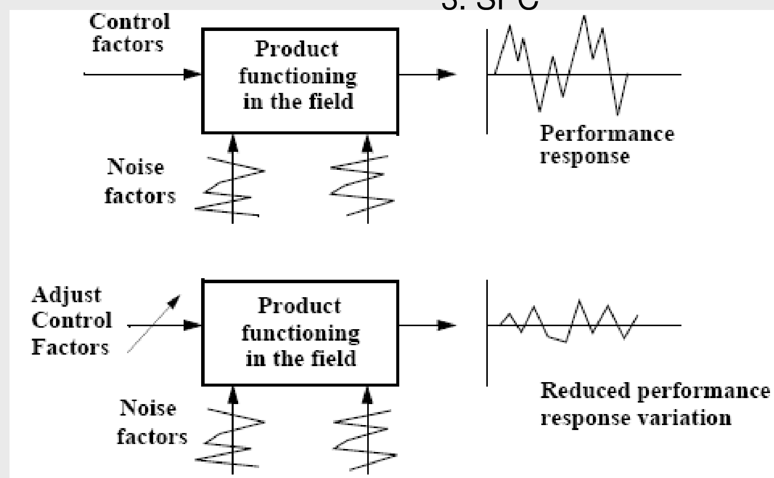
Customer → 1. QFD → Requirements → 2. DOE → Delivery

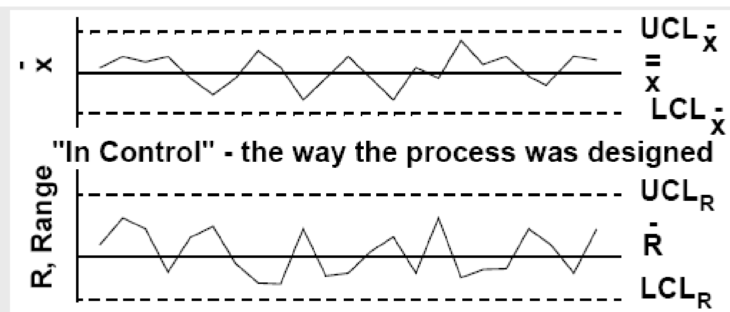
3. SPC



Process Control

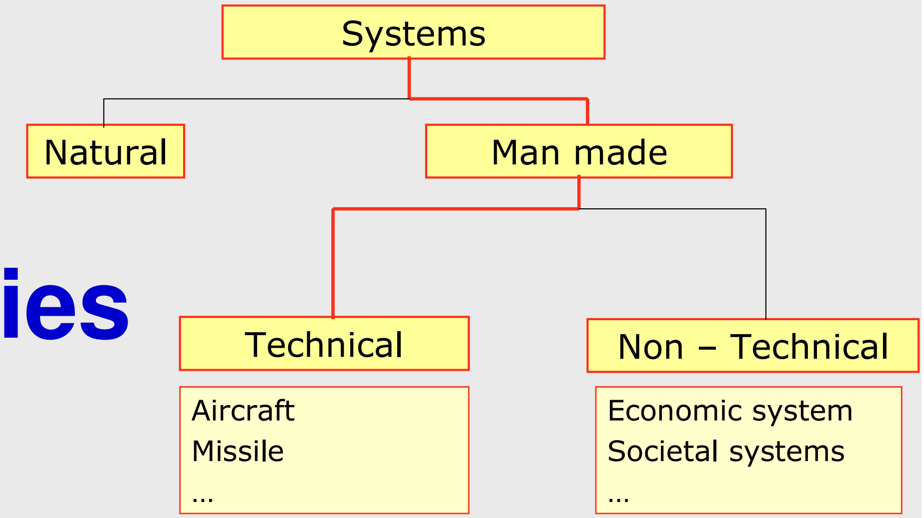


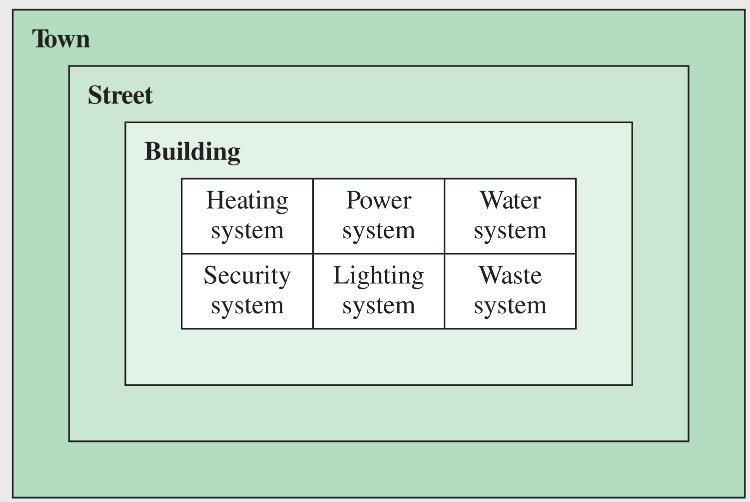



# Review – Week 7

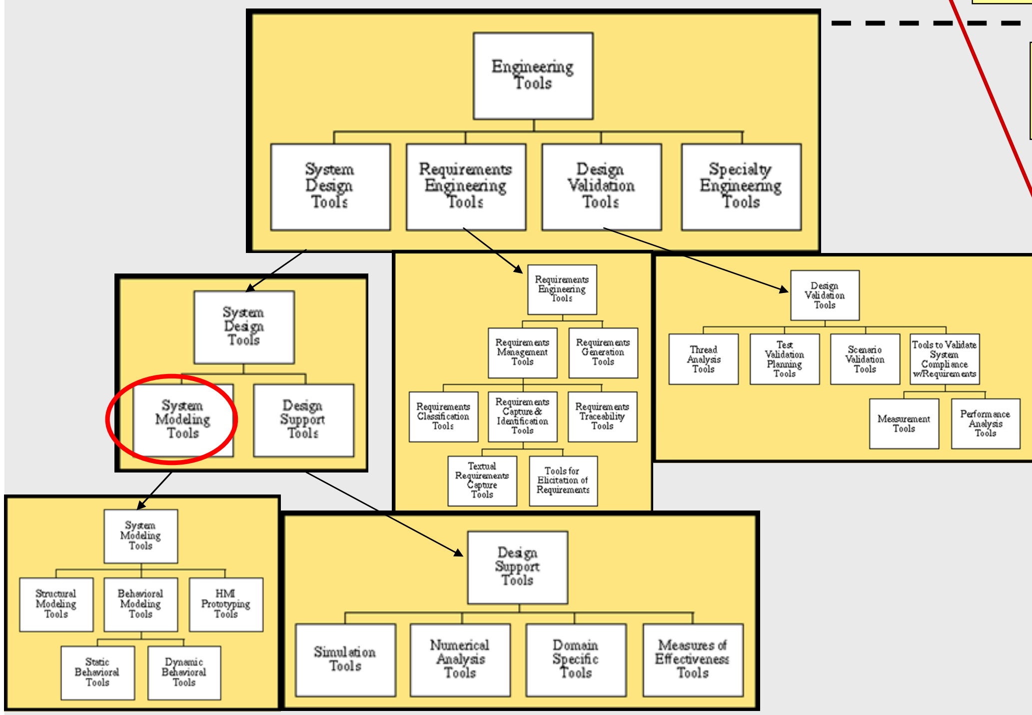
- Systems
- Emergent Properties
  - Performance
  - Reliability
  - Safety
  - Security
  - Usability

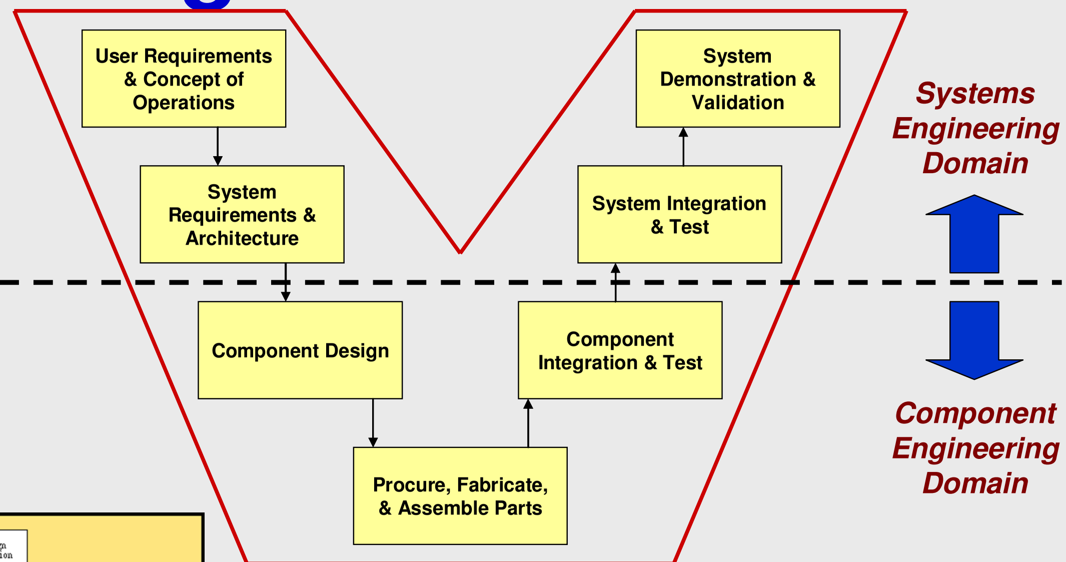


# Review – Week 7

- Systems Engineering

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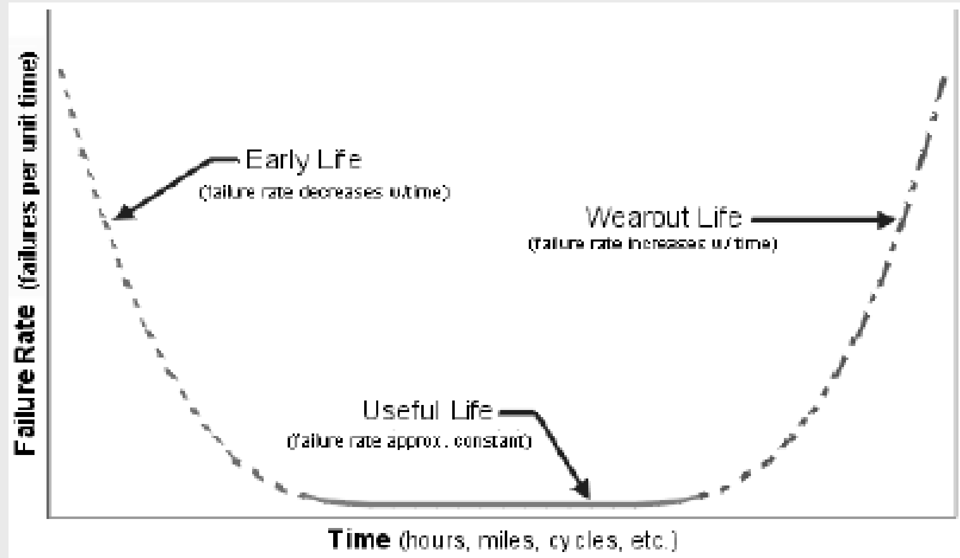
# Review – Week 7

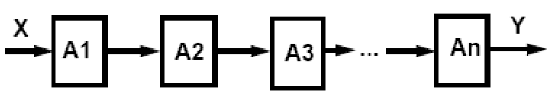
- **System Reliability**

$$F(t) = P(T \le t) = \int_0^t f(x)dx$$

$$h(t) = \frac{f(t)}{R(t)}$$



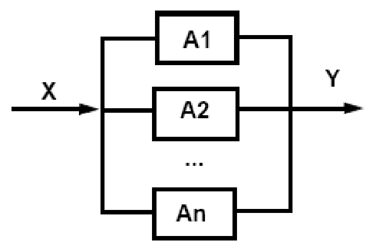

**Series System**




$$R_{system} = \prod_{i=1}^{n} R_i$$

$R_i$ is probability component i will survive for design life.

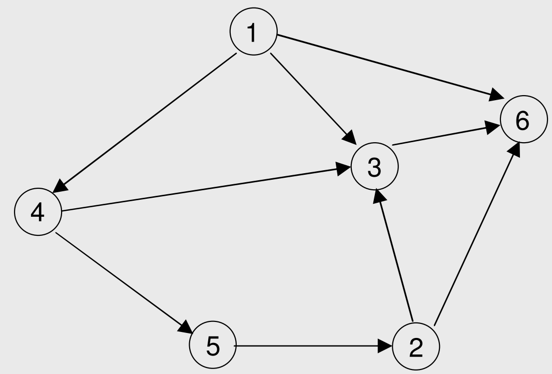
**Parallel System**

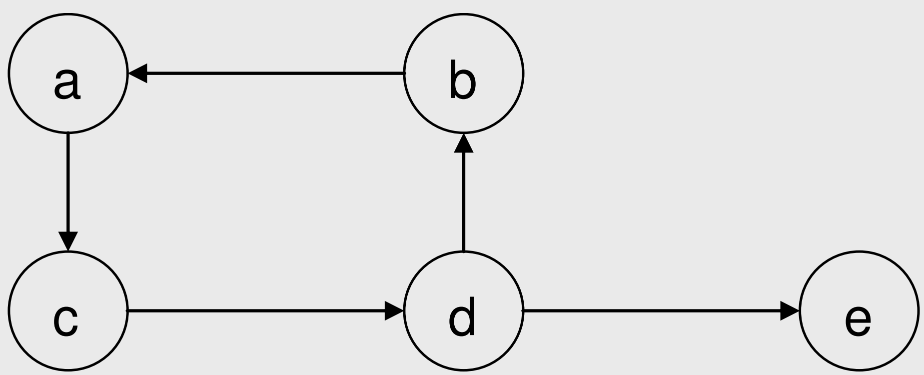



$$R_{system} = 1 - \prod_{i=1}^{n} (1 - R_i)$$

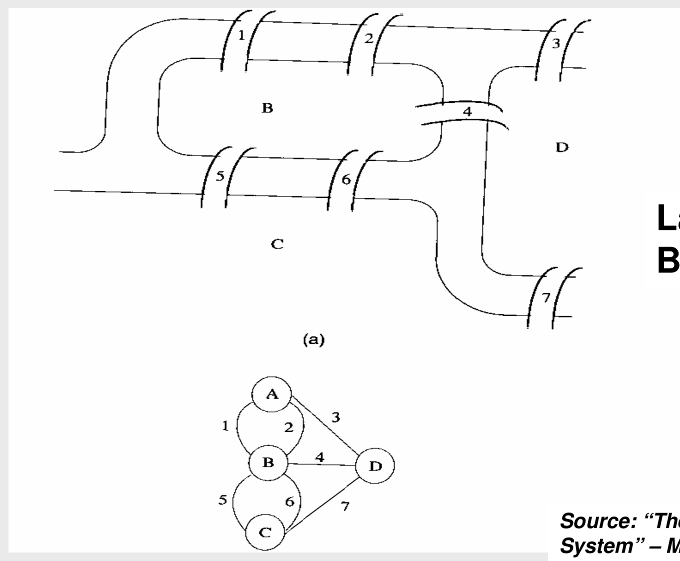
# Review – Week 8

- **Graphs**
  - Directed
  - Undirected




Digraph with a walk (d-b-a-c-d-e), closed walk, path, and a cycle (a-c-d-b)




Land: Nodes
Bridges: Edges

*Source: "The Engineering Design of System" – Models and Methods - Buede*

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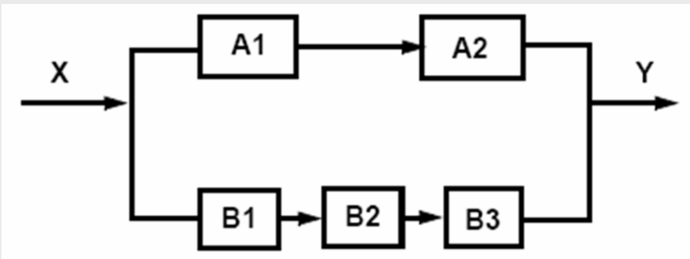
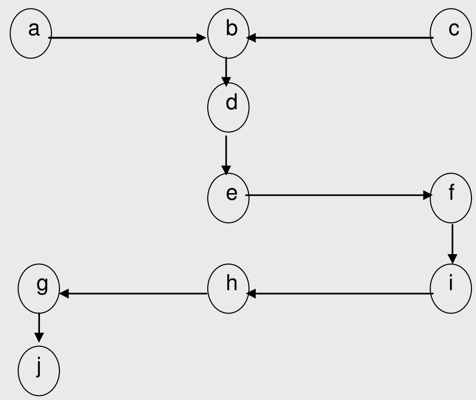
# Review – Week 8

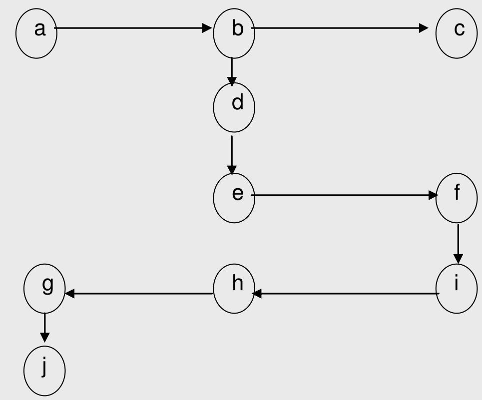
## Acyclic Digraph



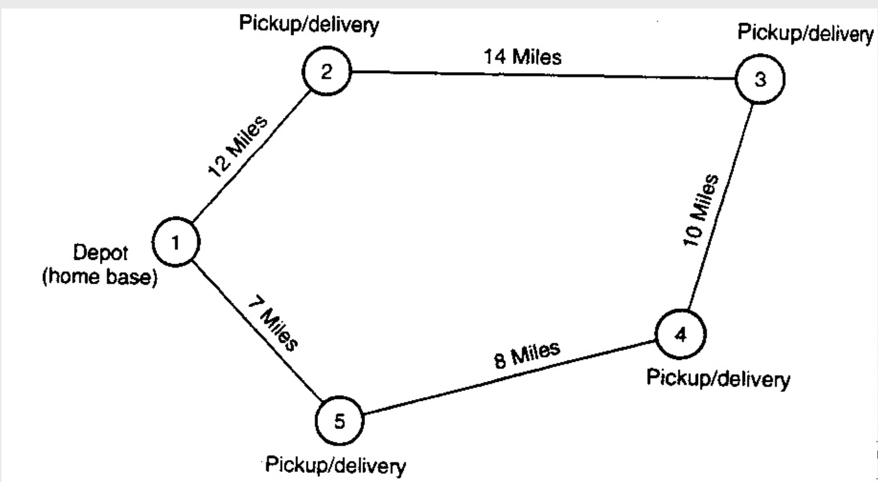

**Non-directed Tree**




**Directed Tree**




## Routing Network Example





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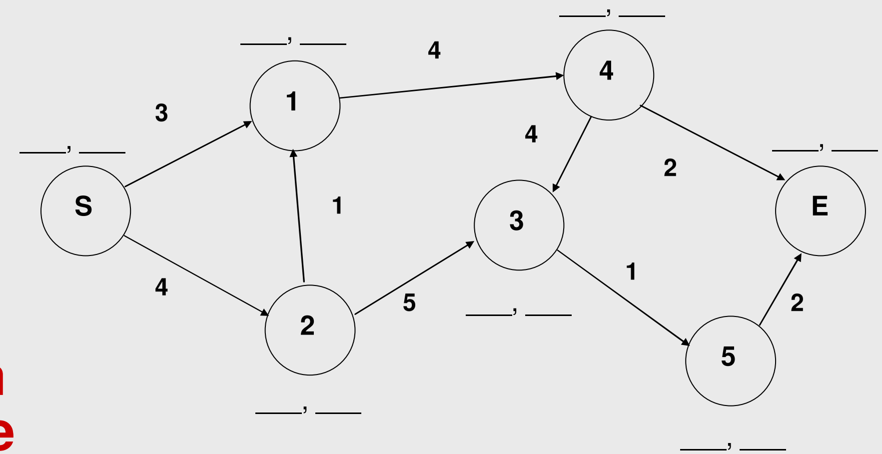
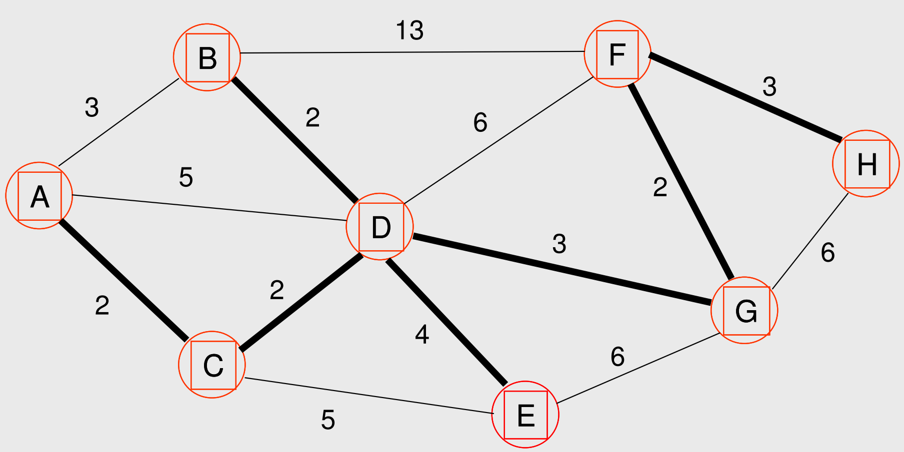
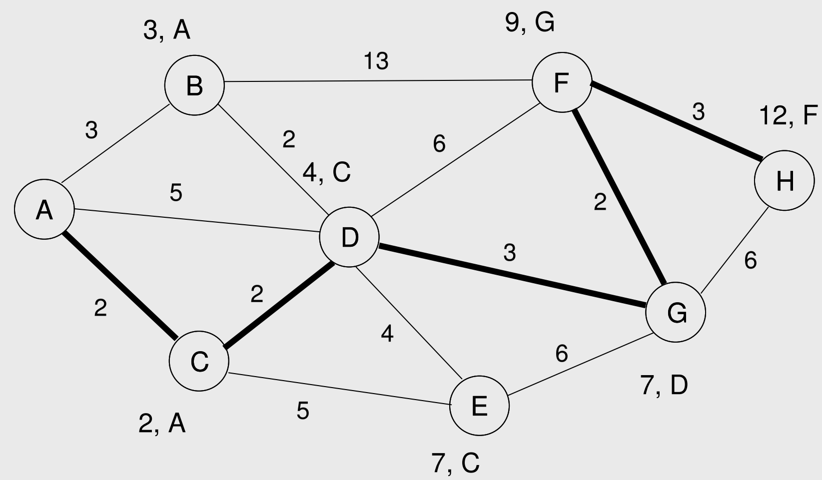
# Review – Week 9

- **Project Management**
  - WBS
  - Scheduling (Gantt)
  - CPM
  - PERT
- **Routing Problems**
  - Shortest Route Problem
  - Minimum Spanning Tree





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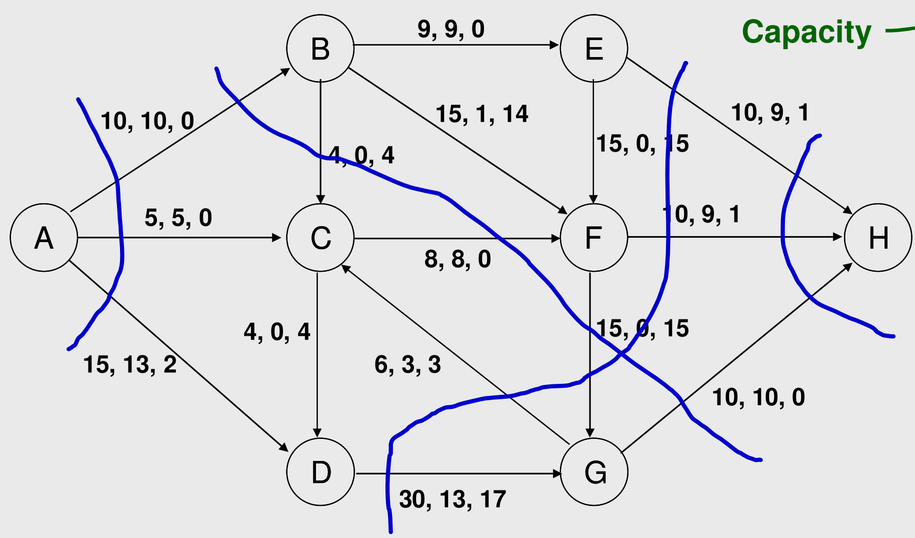
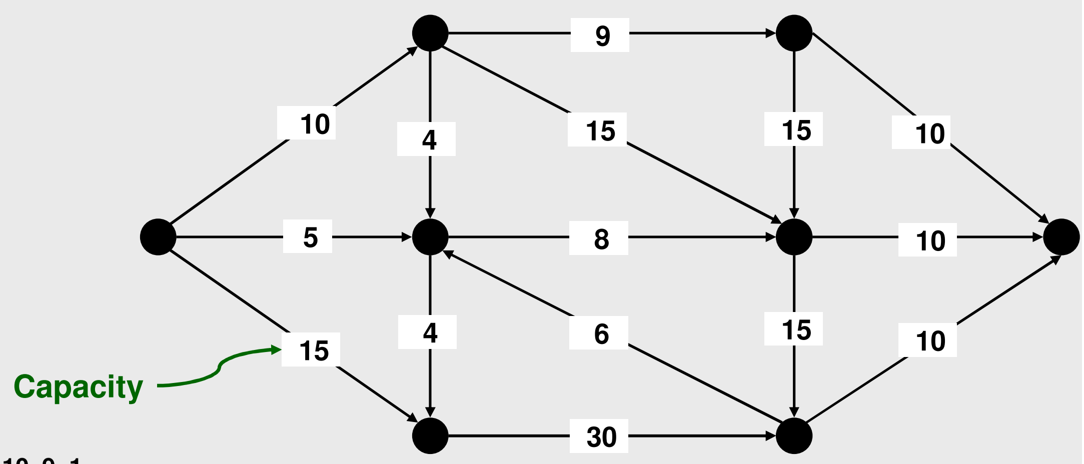
# Review – Week 9

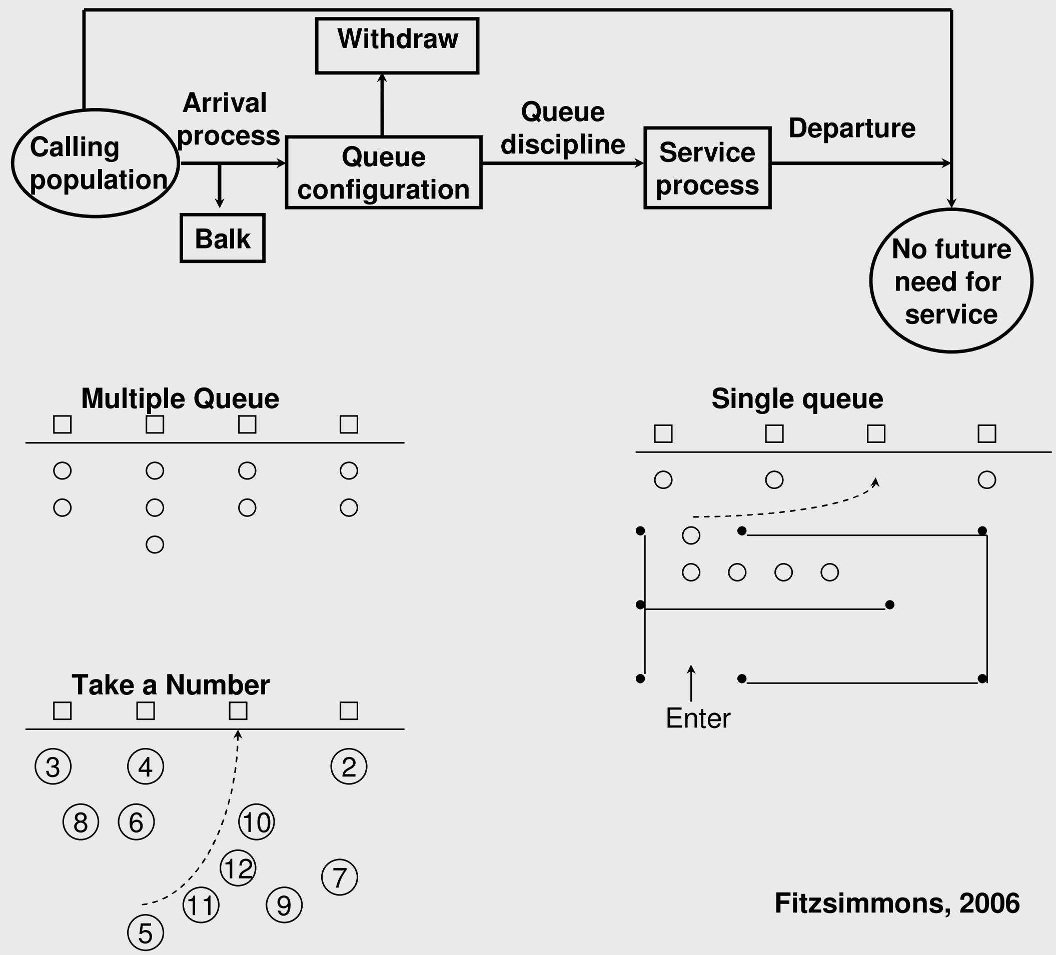
- Flow Network
  - Max Flow



# Review – Week 10

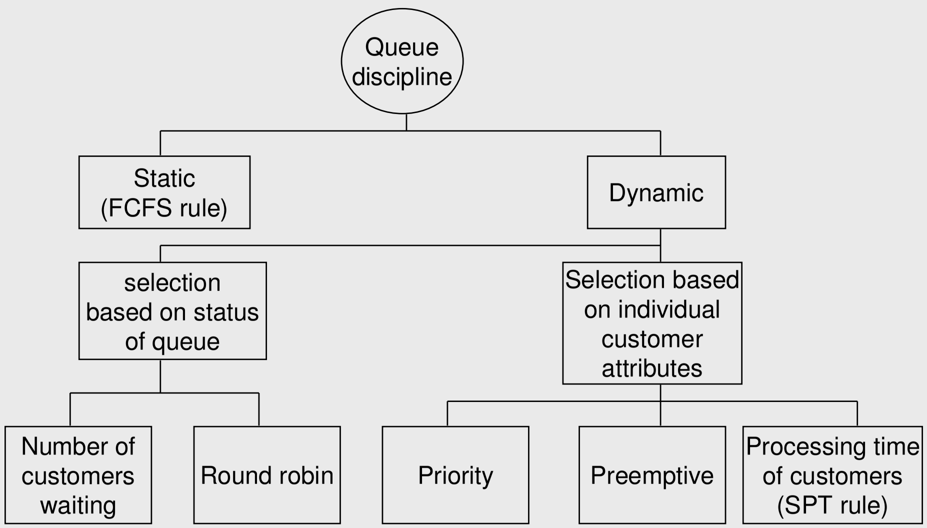
- Queuing Systems
  - Arrivals
    - Exponential Dist.
    - Poisson Dist.
- Queue Configuration




Fitzsimmons, 2006

# Review – Week 10

- **Queue Discipline**
- **Simple (M/M/1) Model Equations**



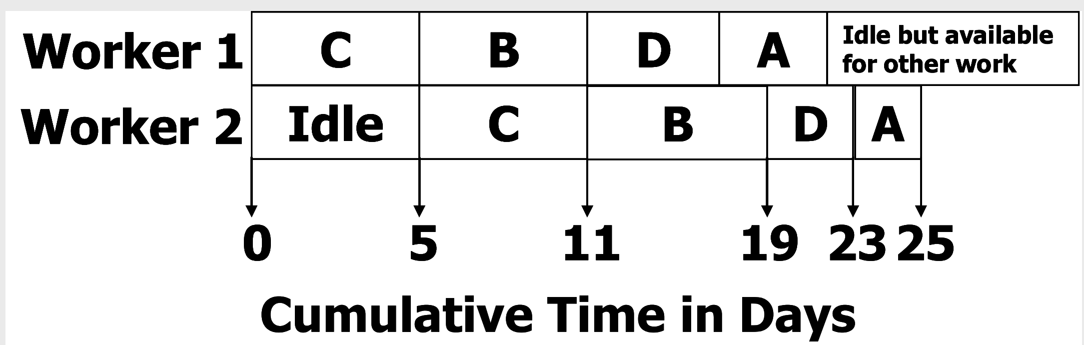

| | |
|---|---|
| Average number of units in system | $L_s = \dfrac{\lambda}{\mu - \lambda}$ |
| Average time in system | $W_s = \dfrac{1}{\mu - \lambda}$ |
| Average number of units in queue | $L_q = \dfrac{\lambda^2}{\mu(\mu - \lambda)}$ |
| Average queue time | $W_q = \dfrac{\lambda}{\mu(\mu - \lambda)}$ |
| System utilization | $\rho = \dfrac{\lambda}{\mu}$ |

# Review – Week 10

- ServiceModel Software
  - Running Demos
  - Building a Simple Model
    - "A small office (flow)"

# Review – Week 11

- **Scheduling Work**
  - FCFS rule schedule
  - SPT rule schedule
  - EDD rule schedule
  - LCFS rule schedule
  - STR rule schedule
  - Johnson’s rule



# Review – Week 11

- **Scheduling**
  - Workers
- **Forecasting**
  - Subjective models
    - Delphi Method
    - Cross-Impact Analysis
    - Historical Analogy

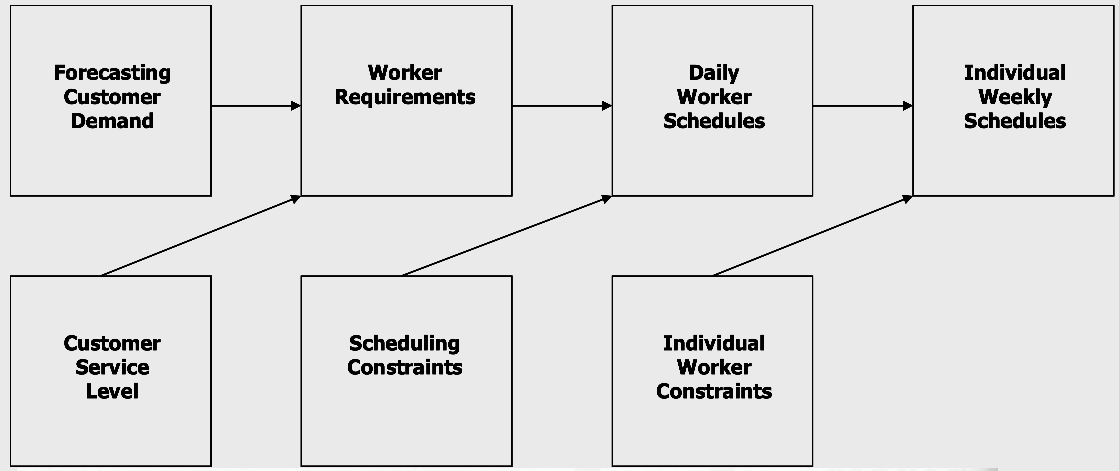
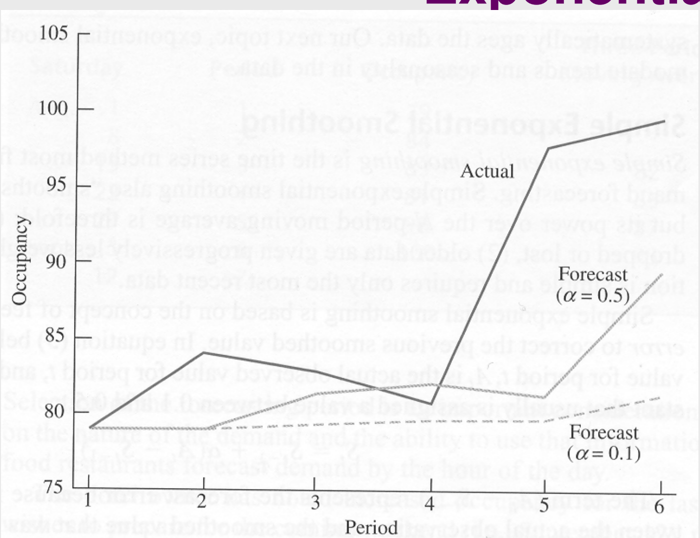


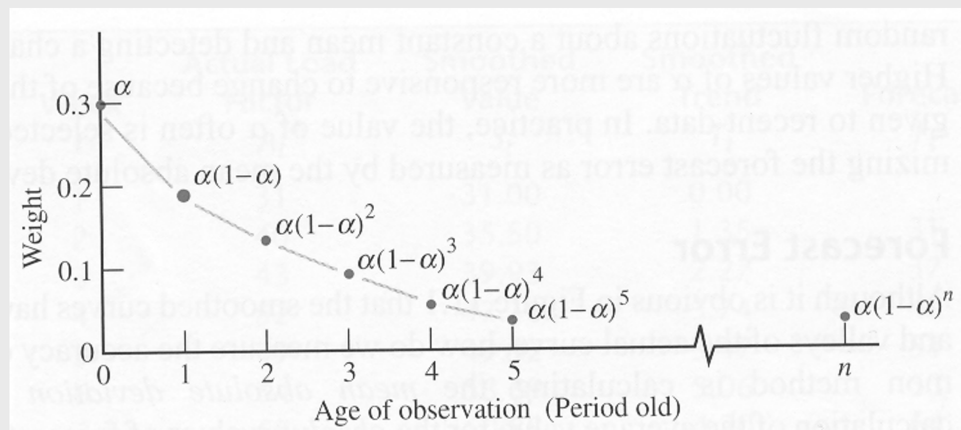

TABLE 11.1 **Characteristics of Forecasting Methods**

| Method | Data Required | Relative Cost | Forecast Horizon | Application |
|---|---|---|---|---|
| *Subjective models:* | | | | |
| Delphi method | Survey results | High | Long term | Technological forecasting |
| Cross-impact analysis | Correlations between events | High | Long term | Technological forecasting |
| Historical analogy | Several years of data for a similar situation | High | Medium to long term | Life cycle demand projection |
| *Causal models:* | | | | |
| Regression | All past data for all variables | Moderate | Medium term | Demand forecasting |
| Econometric | All past data for all variables | Moderate to high | Medium to long term | Economic conditions |
| *Time series models:* | | | | |
| Moving average | *N* most recent observations | Very low | Short term | Demand forecasting |
| Exponential smoothing | Previous smoothed value and most recent observation | Very low | Short term | Demand forecasting |

# Review – Week 12

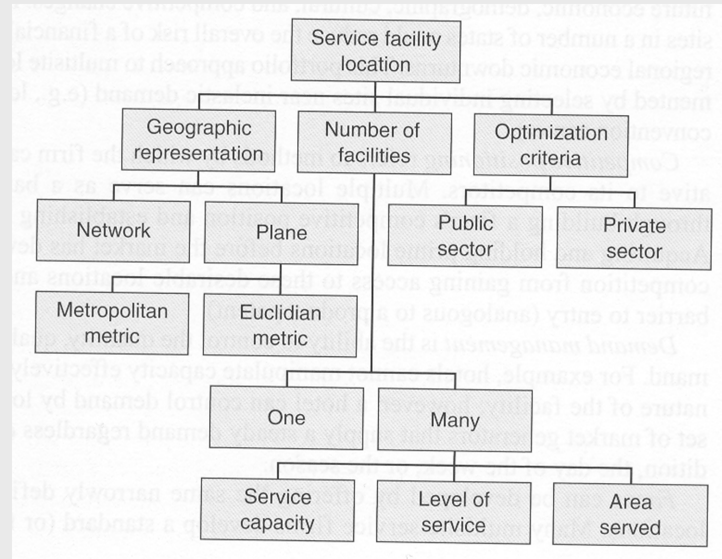
- **Forecasting**
  - **Causal Models**
    - **Regression Models**
      - Time Series Models
        - – N-Period Moving Average
        - – Exponential Smoothing

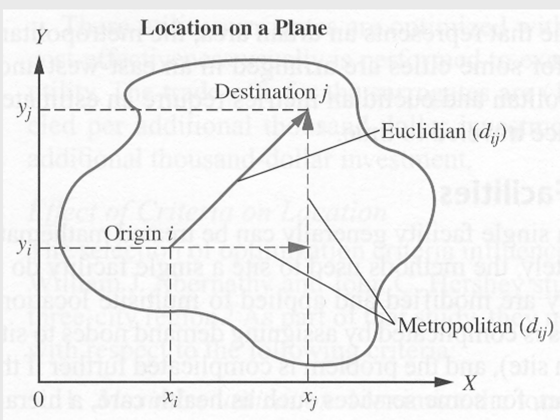


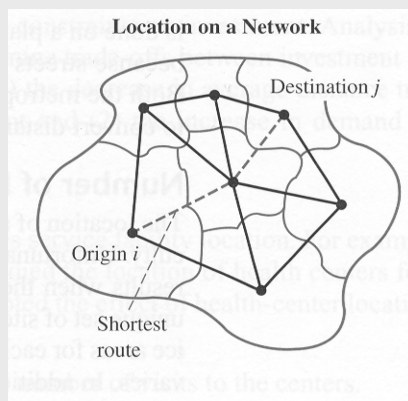



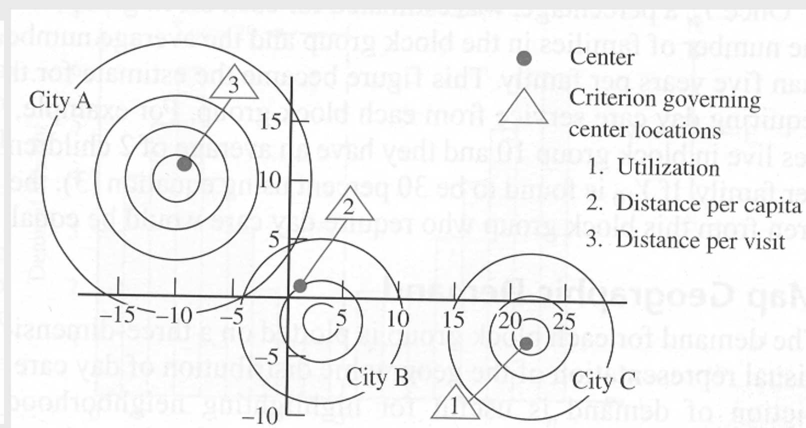
# Review – Week 12

- **Facility Location**
  - **Geographical Representation**
    - **Plane**
    - **Network**
  - **Criteria**



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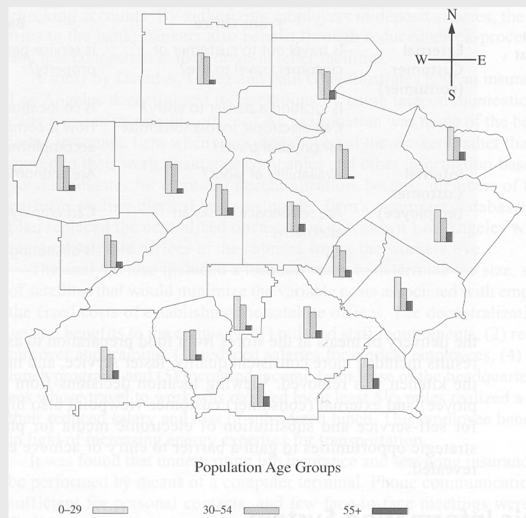
# Review – Week 12

- **Locating Techniques**
  - **Huff Analysis**

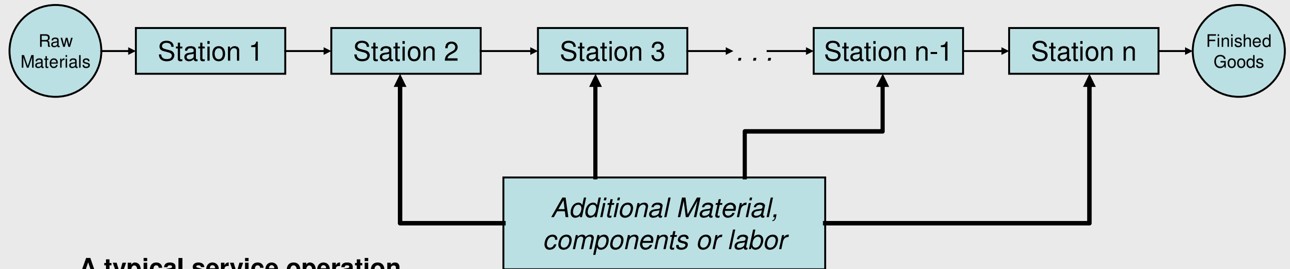
$$A_{ij} = \frac{S_j}{T_{ij}^{\lambda}} \longrightarrow P_{ij} = \frac{A_{ij}}{\sum_{j=1}^{n} A_{ij}} \longrightarrow E_{jk} = \sum_{j=1}^{m}\left(P_{ij} C_i B_{ik}\right) \longrightarrow M_{jk} = \frac{E_{jk}}{\sum_{i=1}^{m}(C_i B_{ik})}$$

  - **GIS**

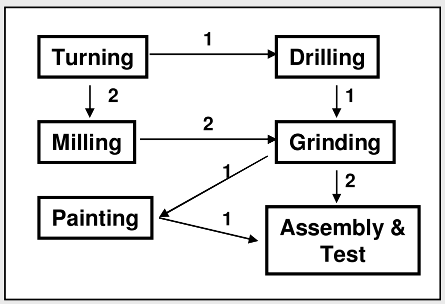


# Review – Week 13

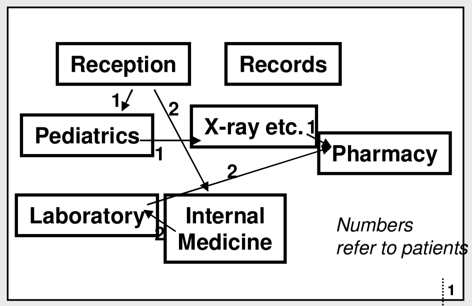
- Facility Layout
  - Product
  - Process
  - Cellular

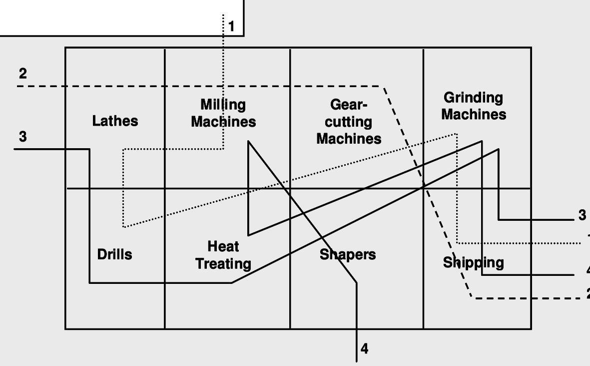



A typical job shop/batch production shop

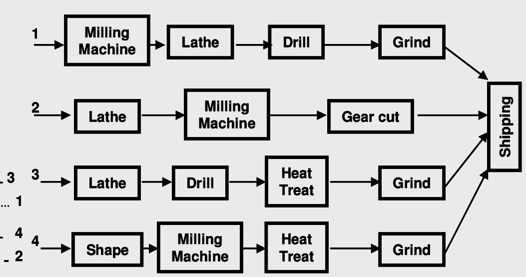



A typical service operation




Process Layout




Cellular Layout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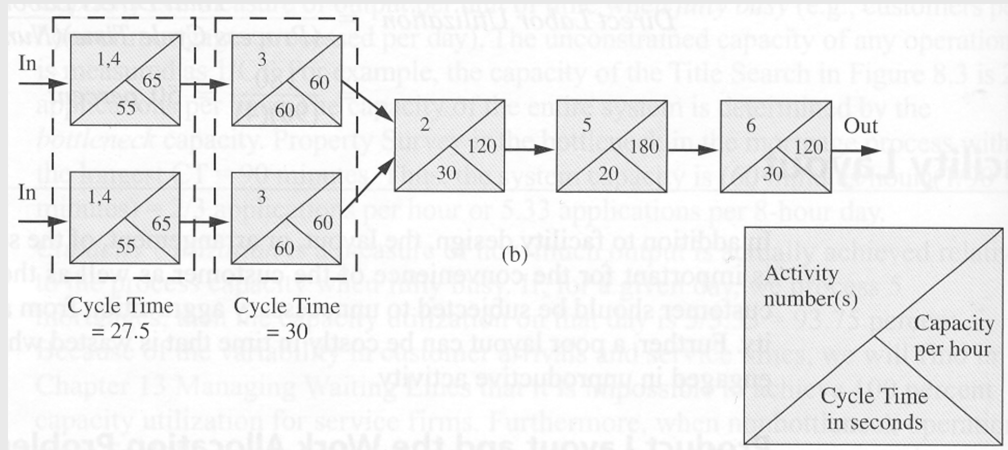
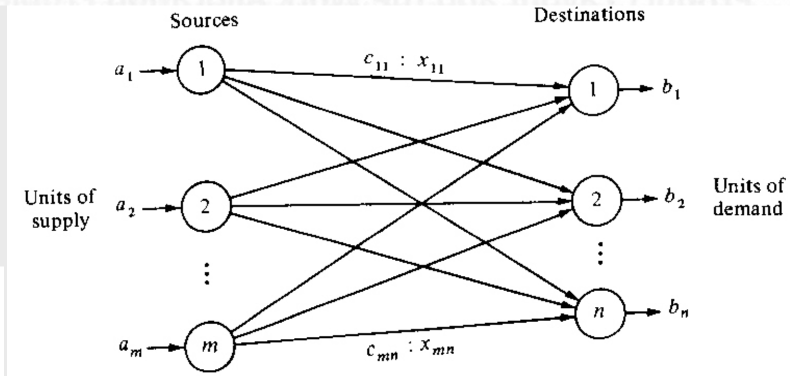
# Review – Week 13

- Product Layout and the Work Allocation Problem
  - Line Balancing
- Transportation Model




$$\text{minimize } z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

subject to

$$\sum_{j=1}^{n} x_{ij} \le a_i, \qquad i = 1, 2, \ldots, m$$

$$\sum_{i=1}^{m} x_{ij} \ge b_j, \qquad j = 1, 2, \ldots, n$$

$$x_{ij} \ge 0 \qquad \text{for all } i \text{ and } j$$

# Review – Week 13

- Tableau solution
- The Assignment Model

|  |  | Machine 1 | 2 | ... | $n$ |  |
|---|---|---|---|---|---|---|
| Job | 1 | $c_{11}$ | $c_{12}$ | ... | $c_{1n}$ | **1** |
|  | 2 | $c_{21}$ | $c_{22}$ | ... | $c_{2n}$ | **1** |
|  | ⋮ | ⋮ | ⋮ |  | ⋮ | ⋮ |
|  | $m$ | $c_{m1}$ | $c_{m2}$ | ... | $c_{mn}$ | **1** |
|  |  | **1** | **1** | ... | **1** |  |

$$x_{ij} = \begin{cases} 0 & \text{if the } j\text{th job is } \textit{not} \text{ assigned to the } i\text{th machine} \\ 1 & \text{if the } j\text{th job is assigned to the } i\text{th machine} \end{cases}$$

The model is thus given by:

$$\text{minimize } z = \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij} x_{ij}$$

subject to

$$\sum_{j=1}^{n} x_{ij} = 1, \qquad i = 1, 2, \ldots, n$$

$$\sum_{i=1}^{n} x_{ij} = 1, \qquad j = 1, 2, \ldots, n$$

$$x_{ij} = 0 \quad \text{or} \quad 1$$

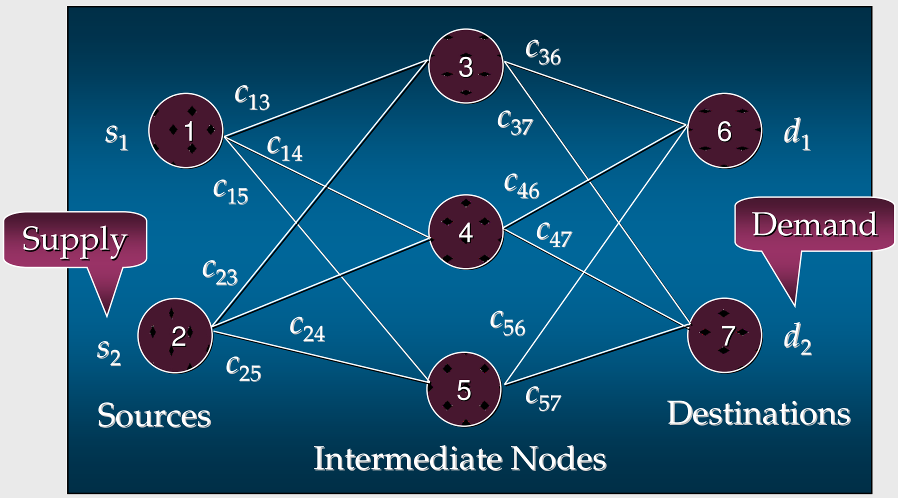
**Table 5-1**

| Sources | Denver (1) | Miami (2) | Supply |
|---|---|---|---|
| Los Angeles (1) | cost 80; $x_{11}$ 1000 | cost 215; $x_{12}$ 0 | 1000 |
| Detroit (2) | cost 100; $x_{21}$ 1300 | cost 108; $x_{22}$ 200 | 1500 |
| New Orleans (3) | cost 102; $x_{31}$ 0 | cost 68; $x_{32}$ 1200 | 1200 |
| Demand | 2300 1300 | 1400 200 |  |

| Job | Machine 1 | Machine 2 | Machine 3 |  |
|---|---|---|---|---|
| 1 | 5; **1** | 7 | 9 | **1** |
| 2 | 14 | 10; **1** | 12 | **1** |
| 3 | 15 | 13 | 16; **1** | **1** |
|  | **1** | **1** | **1** |  |

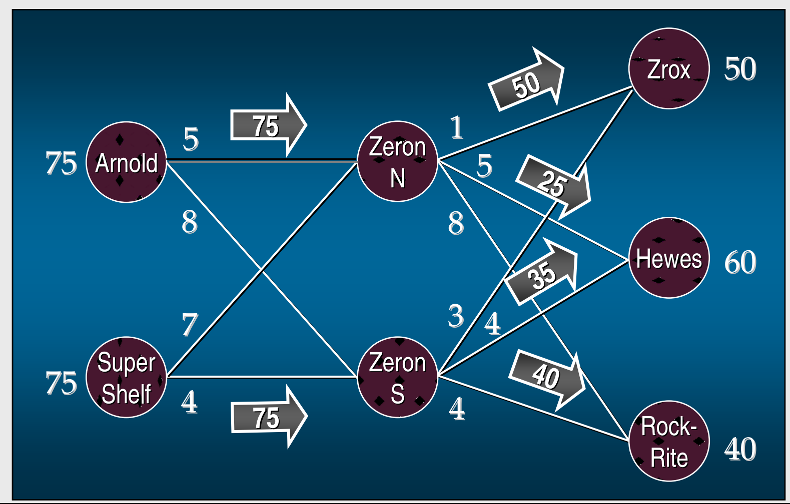
# Review – Week 13

## ❖ Transshipment Model




- Linear Programming Formulation
  $x_{ij}$ represents the shipment from node $i$ to node $j$

| | | |
|---|---|---|
| Min | $\sum_i \sum_j c_{ij} x_{ij}$ | |
| s.t. | $\sum_j x_{ij} \le s_i$ | for each origin $i$ |
| | $\sum_i x_{ik} - \sum_j x_{kj} = 0$ | for each intermediate node $k$ |
| | $\sum_i x_{ij} = d_j$ | for each destination $j$ |
| | $x_{ij} \ge 0$ | for all $i$ and $j$ |

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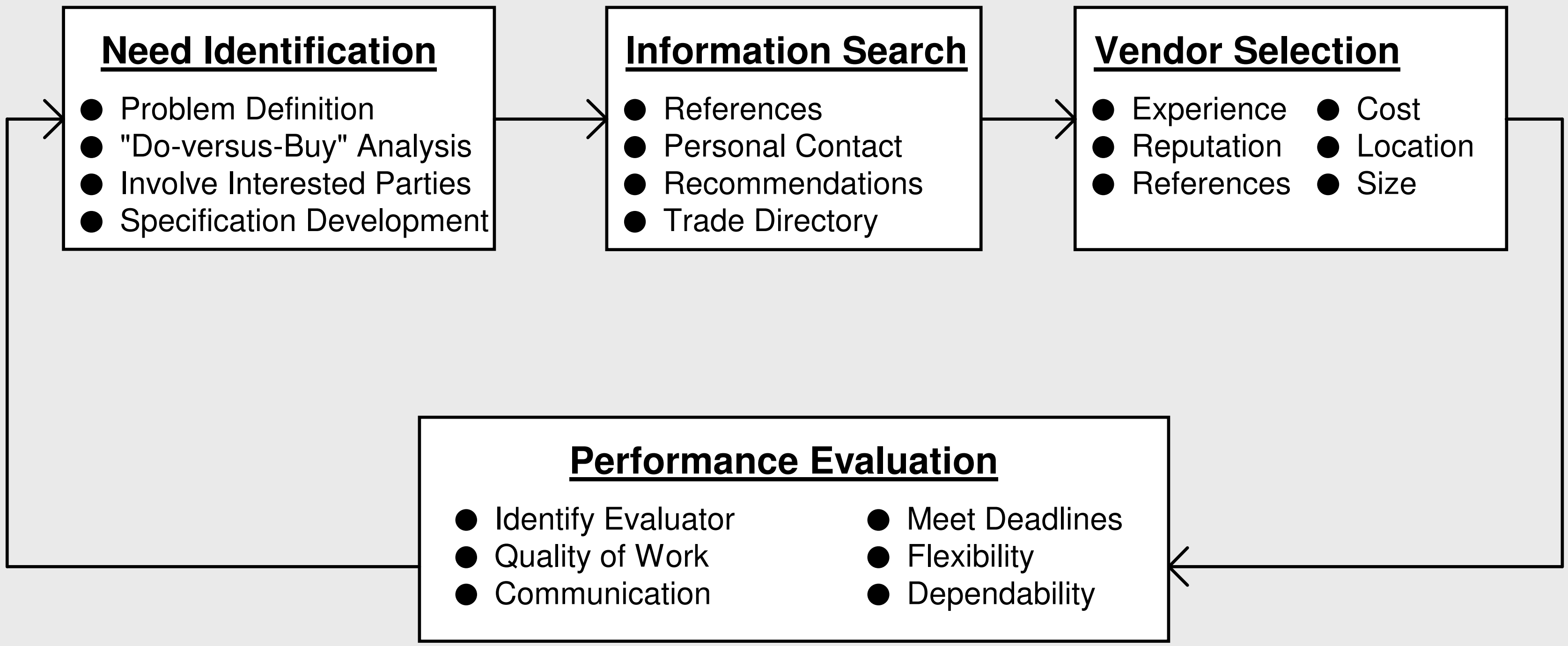
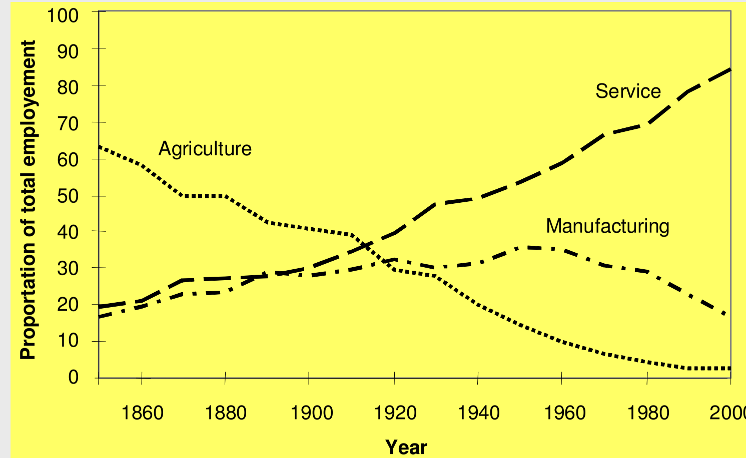
# Review – Week 13

## ❖ Outsourcing



# Review – Week 14

- **Servicizing**
  - i) selling product use,
  - ii) tangible good to service conversion,
  - iii) value-upgrade to service.

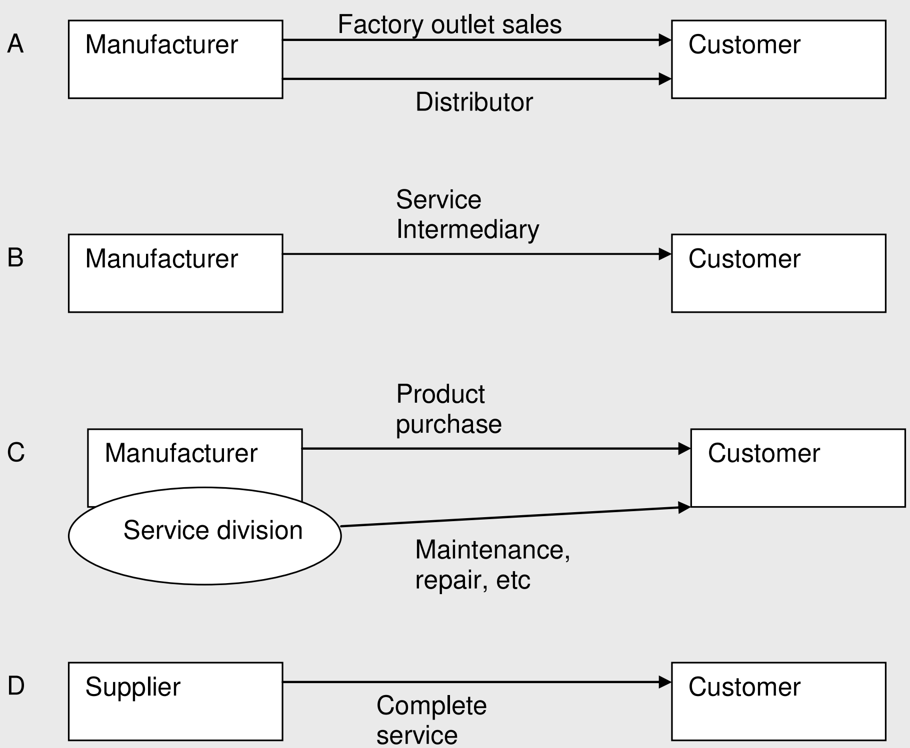



| Servicizing Type | Examples |
|---|---|
| Sell Product use | Car rental, Laundromats |
| Good to service conversion | E-mail, Music Downloads |
| Value-upgrade service | Computer with upgrades |

**Traditional U.S. Economy: Product Based**
- Buy washer/dryer
- Buy copier
- Buy chemicals
- Buy cars

**New U.S. Economy: Service Based**
- Buy cleaning services
- Buy printing services
- Buy chemical management services
- Buy 'Mobility' services

# Review – Week 14




| Company | Product characteristic prior to servicizing | Product characteristic after servicizing | Utilization | Product Degradability | Does outsourcing apply? | Main Driver | Secondary Driver |
|---|---|---|---|---|---|---|---|
| Dell | Tangible PC acquisition | Contract for upgrading | High | No | No | Customer | Environment |
| AB Electrolux | Tangible machine acquisition | Product use fee | Medium | No | No | Environment | Customer |
| IBM | Tangible PC acquisition | Service network | High | No Tangible | Yes | Market | E-business |
| Honda | Car acquisition and ownership | Fee for rides from place to place | Low | No | Yes | Customer | Space problems (environment) |
| City CarShare | Car acquisition and ownership | Online leasing | Low | No | Yes | Customer | Space problems (environment) |
| e-Bay | Retail Stores | Website to buy and sell products | Low | Vary | Yes | Technology | Environment |
| Elsevier | Hardcopy articles in libraries | Access to softcopy articles under contract | Low/High | Yes | No | Technology | Environment |
| Ruckus | Retail Music Stores | Membership fees –students share music electronically | High | N/A | Yes | Music Piracy | Customer |
| Coro | Warehouses and moving companies | Moving and storing furniture, also disposal | Low | Yes | Yes | Customer | Environment |
| Phillips | Selling the devices | Selling devices plus remote maintenance | High | No | Yes | Customer | Market |
| Odin | Third party needed (supermarket) | Food provided straight from the fields to household | High | Yes | No | Customer | Environment |
| Memory Stick | Single use film needed | Reusable device to store pictures | Low/High | No | No | Technology | Customer |