ISM 270
Service Engineering and Management
Lecture 1: March 31, 2009
ISM 270: Service Engineering and Management

- Focus on Operations Decisions in the Service Industry
- Open to students with an undergraduate engineering/science degree
- Learn analytical tools and software for decision making
- Lectures, Case Analysis and Guests
- Text: Fitzsimmons & Fitzsimmons
  ‘Service Management’
  Operations, Strategy, Information Technology
Topics covered

- The nature of service enterprises
- Strategy for new service development
- Technology in services
- Quality in service encounters
- Forecasting demand
- Managing service capacity
- Supply chains in services
- Globalization and outsourcing
Skills / Tools Learned

**Analytical Tools**
- SAS Enterprise Miner
- Spreadsheet Programming
- Queuing Modeling
- Optimization Solvers
- Web Programming in a Browser

**Analytical Methods**
- Linear Programming
- Data Envelopment Analysis
- Statistics for Forecasting
- Capacity Management and Queuing Theory
- Project Management Under Uncertainty
- Theory of Service Supply Chains
ISM 270: Details

- 6 – 9:30pm, Tuesday evenings
- March 31– June 9 (Spring) 2009
- UCSC Silicon Valley Center
- Instructor: Anil Sahai
  - sahai@soe.ucsc.edu
  - 408.390.7252 Cell
  - 650.528.4030 Ext. 144 Office
  - Office Hours: 5.00-6.00PM Tues
- Teaching Assistant: TBD
Who is here?

- My background
- Brief introductions, student survey
Logistics

➢ Class website
  • http://www.soe.ucsc.edu/classes/ism270/Spring09/

➢ Reader : To be Available

➢ Text book

➢ Office hours
  • 5-6pm before class, or by appointment

➢ Fee for Case Reader
Class Plan

- Allotted class time = 3 hours
- Average adult attention span = 20 minutes
- ...

- Lecture / Case Analysis / Presentations
Computer issues

- Who has a laptop?
- Web access
- Finding research papers
- Excel, solver, …
Please...

- Bring:
  - Paper, pen, laptop, ...
  - Opinions
  - Questions
  - Interesting articles, stories, anecdotes

- Provide feedback!!!

- Make every effort to keep up with readings etc.
## Class Assessment

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Value</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
<td>Bi-Weekly</td>
</tr>
<tr>
<td>Case Reports</td>
<td>30%</td>
<td>Choose Any 3</td>
</tr>
<tr>
<td>Term Project</td>
<td>40%</td>
<td>June 9</td>
</tr>
<tr>
<td>Presentation</td>
<td>10%</td>
<td>June 9</td>
</tr>
</tbody>
</table>
Details

- **Homework**
  - Tools based

- **Case Report**
  - T Shape: Identify issues and expand one!

- **Term Project**
  - Major Project with a Company or
  - Business Plan for a Services Based “Company”

- **Presentation**
  - Presentation of Term Project
Questions and Break
Brief Contents

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17  Forecasting Demand for Services  495
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D  Equations for Selected Queuing Models  560

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Backgrounder

Probability and Statistics

Expectation of $X$

$E(X) = \sum_{i=1}^{n} x_i \Pr(x_i) = \int_{-\infty}^{\infty} x f(x) \, dx$

Expectation of a function of $X$

$E[g(X)] = \int_{-\infty}^{\infty} g(x) f(x) \, dx$

Variance

$\text{Var}(X) = E[(X - \mu_X)^2]$

$\text{Var}(X) = \sum_{i=1}^{n} [x_i - E(X)]^2 \Pr(x_i)$ or $\text{Var}(X) = \int_{-\infty}^{\infty} [x - E(X)]^2 f(x) \, dx$

Second moment

$E(X^2) = \sum_{i=1}^{n} x_i^2 \Pr(x_i) = \int_{-\infty}^{\infty} x^2 f(x) \, dx$

Marginal Probability

$P(Y = y) = \sum_{i=1}^{n} P(X = x_i, Y = y)$

Conditional Probability

$P(Y = y \mid X = x) = \frac{P(X = x, Y = y)}{P(X = x)}$

Conditional Expectation

$E(Y \mid X = x) = \sum_{y=1}^{n} y P(Y = y \mid X = x)$

Law of Iterated Expectations

$E[E(Y \mid X)] = E(Y)$

Definitions of Independence

$P(Y = y \mid X = x) = P(Y = y) \text{ or } P(X = x, Y = y) = P(X = x)P(Y = y)$

Covariance and Correlation

$\text{cov}(X, Y) = E[(X - \mu_X)(Y - \mu_Y)]$

$\text{cov}(X, Y) = \sum_{i=1}^{n} \sum_{j=1}^{n} (x_i - \mu_X)(y_j - \mu_Y)P(X = x_i, Y = y_j)$

$\text{cov}(X, Y) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} (x - \mu_X)(y - \mu_Y)f(x, y) \, dx \, dy$

$\rho = \frac{\text{cov}(X, Y)}{\sigma_X \sigma_Y}$

Means, Variances, and Covariances of Sums of Random Variables

$E(a + bX + cY) = a + b\mu_X + c\mu_Y$

$\text{var}(a + bX + cY) = b^2 \sigma_X^2$

$\text{cov}(aX + bY + cZ) = a b \sigma_X \sigma_Y + b c \sigma_Y^2$

$E(Y^2) = \sigma_Y^2 + \mu_Y^2$

$\text{cov}(aX + bY + cZ) = b c \sigma_Y^2$

$E(XY) = \sigma_{XY} + \mu_X \mu_Y$

Some useful estimators

Sample Mean: $\bar{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$

Sample Variance: $s_X^2 = \frac{1}{n-1} \sum_{i=1}^{n} (X_i - \bar{X})^2$

Sample Covariance: $s_{XY} = \frac{1}{n-1} \sum_{i=1}^{n} (X_i - \bar{X})(Y_i - \bar{Y})$

Sample Correlation: $r_{XY} = \frac{s_{XY}}{s_X s_Y}$

Properties of the sample mean

$E(\bar{X}) = \mu_X$ and $\text{Var}(\bar{X}) = \frac{s_X^2}{n}$
Remaining in Lecture 1

- Services in the Economy

- Data Envelopment Analysis
  - Linear Programming
  - Excel
Perspective

- World-wide trends
- Personalization trends
Text Chapter 1: Role of Services in an Economy

Service Management
Professor James Fitzsimmons
University of Texas at Austin
Quiz Question

- Name the top 10 USA companies by revenue in 2007
- How many would you describe as service companies?
Top 10 ()

1. Wal-Mart Stores.
2. Exxon Mobil
3. General
4. Chevron
5. ConocoPhillips
6. General Electric
7. Ford Motor
8. Citigroup
9. Bank of America
10. American Intl. Group
Definitions

- What are services?
- Service enterprises?
Service Definitions

Intangible goods?

Services are deeds, processes, and performances.
Valarie Zeithaml & Mary Jo Bitner

A service is a time-perishable, intangible experience performed for a customer acting in the role of a co-producer.
James Fitzsimmons

Folks doing things for folks for Money
Paul Magio
Definition of Service Firms

Service enterprises are organizations that facilitate the production and distribution of goods, support other firms in meeting their goals, and add value to our personal lives.

James Fitzsimmons
Services Science, Management and Engineering

…the application of science, management, and engineering disciplines to tasks that one organization beneficially performs for and with another

• (Wikipedia)
Role of Services in an Economy

VALUE ADDED SERVICES
- Financing
- Leasing
- Insurance

INFRASTRUCTURE SERVICE
- Communications
- Transportation
- Utilities
- Banking

MANUFACTURING
Services inside company:
- Finance
- Accounting
- Legal
- R&D and design

PERSONAL SERVICES
- Healthcare
- Restaurants
- Hotels

BUSINESS SERVICES
Supporting manufacturing:
- Consulting
- Auditing
- Advertising
- Waste disposal

DISTRIBUTION SERVICES
- Wholesaling
- Retailing
- Repairing

CONSUMER (Self-service)

GOVERNMENT SERVICES
- Military
- Education
- Judicial
- Police and fire protection
### Percent Service Employment for Selected Nations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>67.1</td>
<td>71.0</td>
<td>74.3</td>
<td>74.2</td>
</tr>
<tr>
<td>Canada</td>
<td>67.2</td>
<td>70.8</td>
<td>74.8</td>
<td>74.1</td>
</tr>
<tr>
<td>Israel</td>
<td>63.3</td>
<td>66.0</td>
<td>68.0</td>
<td>73.9</td>
</tr>
<tr>
<td>Japan</td>
<td>54.5</td>
<td>58.8</td>
<td>59.9</td>
<td>72.7</td>
</tr>
<tr>
<td>France</td>
<td>56.9</td>
<td>63.6</td>
<td>66.4</td>
<td>70.8</td>
</tr>
<tr>
<td>Italy</td>
<td>48.7</td>
<td>57.7</td>
<td>60.2</td>
<td>62.8</td>
</tr>
<tr>
<td>Brazil</td>
<td>46.2</td>
<td>50.0</td>
<td>51.9</td>
<td>56.5</td>
</tr>
<tr>
<td>China</td>
<td>13.1</td>
<td>17.8</td>
<td>21.2</td>
<td>40.6</td>
</tr>
</tbody>
</table>
Trends in U.S. Employment by Sector

Year

Proportion of total employment

1850 1870 1890 1910 1930 1950 1970 1990

Service
Manufacturing
Agriculture
# Stages of Economic Development

<table>
<thead>
<tr>
<th>Society</th>
<th>Game</th>
<th>Predominant activity</th>
<th>Use of human labor</th>
<th>Unit of social life</th>
<th>Standard of living measure</th>
<th>Structure</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Industrial</td>
<td>Against Nature</td>
<td>Agriculture</td>
<td>Raw muscle</td>
<td>Extended household</td>
<td>Subsistence</td>
<td>Routine</td>
<td>Simple hand tools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mining</td>
<td>power</td>
<td></td>
<td></td>
<td>Traditional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>Against fabricated</td>
<td>Goods</td>
<td>Machine</td>
<td>Quantity of goods</td>
<td>Bureaucratic</td>
<td>Machines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nature</td>
<td>production</td>
<td>tending</td>
<td></td>
<td>Hierarchical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-industrial</td>
<td>Among Persons</td>
<td>Services</td>
<td>Artistic</td>
<td>Quality of life in terms of</td>
<td>Inter-dependent</td>
<td>Information</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Creative Intellectual</td>
<td>Community</td>
<td>health, education,</td>
<td>Global</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>recreation</td>
<td></td>
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</table>

Anil Sahai
ISM 270 – Spring 2009
## The New Experience Economy

<table>
<thead>
<tr>
<th>Economy</th>
<th>Agrarian</th>
<th>Industrial</th>
<th>Service</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Extract</td>
<td>Make</td>
<td>Deliver</td>
<td>Stage</td>
</tr>
<tr>
<td>Nature</td>
<td>Fungible</td>
<td>Tangible</td>
<td>Intangible</td>
<td>Memorable</td>
</tr>
<tr>
<td>Attribute</td>
<td>Natural</td>
<td>Standardized</td>
<td>Customized</td>
<td>Personal</td>
</tr>
<tr>
<td>Method of supply</td>
<td>Stored in bulk</td>
<td>Inventoried</td>
<td>Delivered</td>
<td>Revealed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>on demand</td>
<td>over time</td>
</tr>
<tr>
<td>Seller</td>
<td>Trader</td>
<td>Manufacturer</td>
<td>Provider</td>
<td>Stager</td>
</tr>
<tr>
<td>Buyer</td>
<td>Market</td>
<td>User</td>
<td>Client</td>
<td>Guest</td>
</tr>
</tbody>
</table>
Source of Service Sector Growth

- **Innovation**
  - Push theory (e.g. Post-it)
    - Product looking for a problem
  - Pull theory (e.g. Cash Management)
    - Need drives innovation

- **Services derived from products (Video Rental)**
  - Information driven services
  - Difficulty of testing service prototypes

- **Social Trends**
  - Aging of the population
  - Two-income families
  - Growth in number of single people
  - Home as sanctuary
Question:
What has engineering got to do with all of this?
Discussion Topics

➢ Describe the work that you do from a service perspective

➢ Illustrate how the type of work you do influences a person’s lifestyle.
Sample LP: Product Mix Problem

- How much beer and ale to produce from three scarce resources:
  - 480 pounds of corn
  - 160 ounces of hops
  - 1190 pounds of malt

- A barrel of ale consumes 5 pounds of corn, 4 ounces of hops, 35 pounds of malt
- A barrel of beer consumes 15 pounds of corn, 4 ounces of hops and 20 pounds of malt
- Profits are $13 per barrel of ale, $23 for beer
Sample LP: Transportation Problem

- A firm produces computers in Singapore and Hoboken.
- Distribution Centers are in Oakland, Hong Kong and Istanbul
- Supply, demand and costs summary:

<table>
<thead>
<tr>
<th></th>
<th>Oakland</th>
<th>Hong Kong</th>
<th>Istanbul</th>
<th>Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore</td>
<td>85</td>
<td>37</td>
<td>119</td>
<td>500</td>
</tr>
<tr>
<td>Hohboken</td>
<td>53</td>
<td>189</td>
<td>94</td>
<td>300</td>
</tr>
<tr>
<td>Demand</td>
<td>350</td>
<td>250</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>
Other LP examples

- Blending problem
- Diet problem
- Assignment problem
Key terms of LP

- Variables
- Parameters
- Objective function
- Constraints
Standard Form
(according to Hillier and Lieberman)

\[
\begin{align*}
\text{max } & \quad c_1 x_1 + c_2 x_2 + \ldots + c_N x_N \\
\text{subject to } & \quad a_{11} x_1 + a_{12} x_2 + \ldots + a_{1N} x_N \leq b_1 \\
& \quad a_{21} x_1 + a_{22} x_2 + \ldots + a_{2N} x_N \leq b_2 \\
& \quad \ldots \\
& \quad a_{M1} x_1 + a_{M2} x_2 + \ldots + a_{MN} x_N \leq b_M \\
& \quad x_j \geq 0, \ j = 1..N
\end{align*}
\]

Concise version:

\[
\begin{align*}
\text{max } & \quad c'x \\
\text{subject to } & \quad Ax \leq b \\
& \quad x \geq 0
\end{align*}
\]

A is an \(m\) by \(n\) matrix: \(n\) variables, \(m\) constraints.
Geometry of LP

Consider the plot of solutions to a LP

\[ 3x_1 - 5x_2 \leq 15 \]
\[ 2x_1 + 3x_2 \leq 12 \]
\[ x_1, x_2 \geq 0 \]
\[ \text{max } x_1 + x_2 \]
Data Envelopment Analysis (DEA)

- Method for evaluating efficiency of similar venues/products
  - Incorporates inputs and outputs – not just one dimensional
  - Uses LINEAR PROGRAMMING (LP)

- KEY IDEA:
  - Weight the inputs and outputs to make one unit as efficient as possible, relative to all others
  - If this is 100% efficient, then the unit is on the frontier of efficiency;
  - If less than 100%, there are other units that could utilize the SAME inputs for MORE outputs
DEA Example

- Unit 1 produces 100 pieces of items per day, and the inputs are 10 dollars of materials and 2 labour-hours
- Unit 2 produces 80 pieces of items per day, and the inputs are 8 dollars of materials and 4 labour-hours
- Unit 3 produces 120 pieces of items per day, and the inputs are 12 dollars of materials and 1.5 labour-hours
- To calculate the efficiency of unit 1, we define the objective function as maximize Efficiency = \((u_1 \times 100) / (v_1 \times 10 + v_2 \times 2)\)
- Efficiency = \(u_1 \times 100\)
- subject to the efficiency of
  - unit 1: \((u_1 \times 100) - (v_1 \times 10 + v_2 \times 2) \leq 0\)
  - unit 2: \((u_1 \times 80) - (v_1 \times 8 + v_2 \times 4) \leq 0\)
  - unit 3: \((u_1 \times 120) - (v_1 \times 12 + v_2 \times 1.5) \leq 0\)
  - subject to \(v_1 \times 10 + v_2 \times 2 = 1\) with all \(u\) and \(v\) \(\geq 0\).
# Productivity of Burger Palace Service Units

<table>
<thead>
<tr>
<th>Service Unit</th>
<th>Meals Sold</th>
<th>Labor Hours</th>
<th>Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>2</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>4</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>8</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>
**DEA summary of terms**

- **Define variables**
  - $E_k =$ efficiency of unit $k$
  - $u_j =$ coefficient for output $j$ (relative decrease in efficiency per unit reduction of output value)
  - $v_i =$ coefficient for input $i$ (relative increase in efficiency per unit decrease of input value)
  - $O_{jk} =$ observed output $j$ units generated by service unit $k$ during one time period
  - $I_{ik} =$ no. units input used by service unit $k$ during one period

- **Note:**
  - $k=1..K =$ service unit counter
  - $j=1..M =$ output counter
  - $i=1..N =$ input counter
DEA Objective and constraints

\[
\max E_e = \frac{u_1 O_{1e} + u_2 O_{2e} + \ldots + u_M O_{Me}}{v_1 I_{1e} + v_2 I_{2e} + \ldots + v_N I_{Ne}} \\
\text{s.t.} \\
u_1 O_{1k} + u_2 O_{2k} + \ldots + u_M O_{Mk} \leq 1, k = 1, \ldots, K \\
v_1 I_{1k} + v_2 I_{2k} + \ldots + v_N I_{Nk} \leq 1, k = 1, \ldots, K \\
u_j \geq 0, j = 1, 2, \ldots, M \\
v_i \geq 0, i = 1, 2, \ldots, N
\]

Evaluating unit e
Trick = Rescaling to get linear equations

\[
v_1 I_{1e} + v_2 I_{2e} + \ldots + v_N I_{Ne} = 1 \\
\text{s.t.} \\
u_1 O_{1k} + u_2 O_{2k} + \ldots + u_M O_{Mk} - (v_1 I_{1k} + v_2 I_{2k} + \ldots + v_N I_{Nk}) \leq 0, k = 1, \ldots, K
\]