Lecture #31

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Service Processes & Systems
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Delphi Method

- Delphi is an archaeological site and a modern town in Greece. In ancient times it was the site of the most important oracle of the god Apollo.
- The oracle predicted the future based on the lapping water and leaves rustling in the trees.

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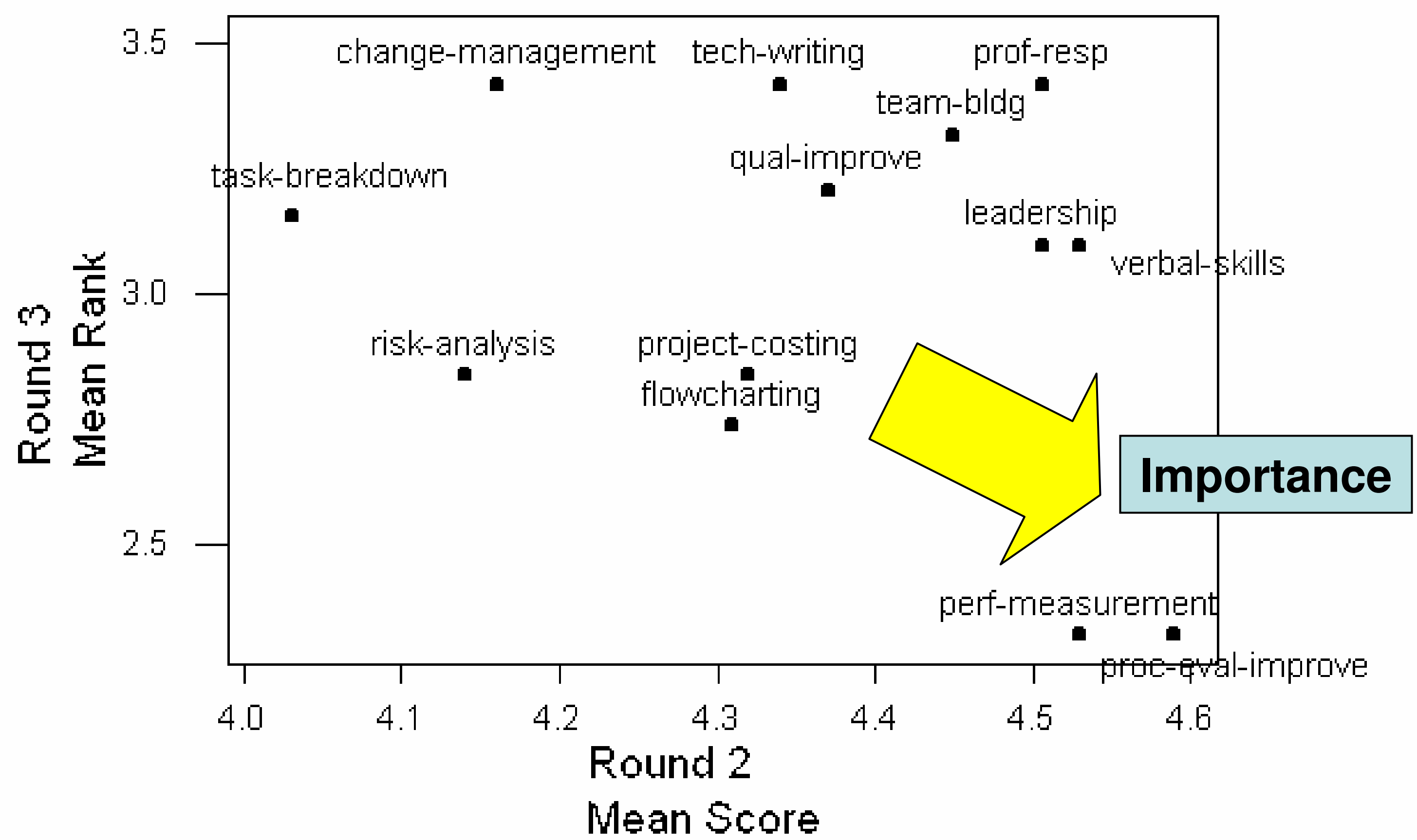
Delphi Study – Service Systems

- Recently completed a Delphi Study to define a Service Systems Engineering Curriculum
- Why?
  - Dominates the U.S. economy
    - Largest and fastest growing sector
    - 80% of the employment (14% manufacturing & 2% agriculture)
  - Little engineering expertise has been applied to the design and operation of service enterprises/ organizations – productivity low
- Multiple rounds…

Topics

- How an organization works
- Psychology – creativity, innovation
- Resource Allocation
- Customer/client relations
- Service systems – measurement, metrics
- Leadership and change management
- Management/management philosophy
- How does an individual make decisions?
- Organizational decision-making
- Identifying organizational processes
- Documenting how processes work
- Reference Models (SCORE, ITIL)
- Performance Metrics
- Benchmarking
- Six Sigma, Reliability
- Quality Assurance
- Perfect Order Performance
- Decision making
- Modeling processes
- Data collection/management/analysis
- Statistical work
- Supporting metrics with tools
- Domain knowledge
- Optimization/networks
- Queuing
- Simulation
- Legal issues
- Project management
- Scheduling
- Risk assessment, insurance
- Estimation, bidding
- Government issues
- Regulations/compliance
- Budgeting/accounting
- Finance/economic justification
- Algorithms/computing

Important Service System Elements



Last Class…

- We have discussed the first category of forecasting methods which is subjective or qualitative models.
- Today we will focus on the other categories: causal and time series.

Causal Models

- Causal models – based on the underlying "mechanistic" relations between independent variables and dependent variable (demand).
- Data (demand) follows an identifiable pattern over time – identifiable relationship exists between the information we wish to forecast and other factors.
  - Known model for behavior
  - Regression models

Regression Models

- A regression model is a relationship between the factor being forecasted, which is designated as Y, and the independent variables (X_i) that "drive" Y. If there are n independent variables, then a linear model for Y as a function of X_i is
  - $Y = a_0 + a_1X_1 + a_2X_2 + \ldots + a_nX_n$
  - $a_0, a_1, a_2, \ldots a_n$ are the model coefficients.

Example: La Quinta Motor Inns

- A study to determine the direction of its expansion efforts
- Which factors determine a profitable hotel location and allow management to screen available real estate for new hotel sites.
- In total 35 factors (independent variables).

Name	Description
	Competitive factors
INNRATE	Inn price
PRICE	Room rate for the inn
RATE	Average competitive room rate
RMS1	Hotel rooms within 1 mile
RMSTOTAL	Hotel rooms within 3 miles
ROOMSINN	Inn rooms
	Demand generators
CIVILIAN	Civilian personnel on base
COLLEGE	College enrollment
HOSP1	Hospital beds within 1 mile
HOSPTOTL	Hospital beds within 4 miles
HVYIND	Heavy industrial employment
LGTIND	Light industrial acreage
MALLS	Shopping mall square footage
MILBLKD	Military base blocked
MILITARY	Military personnel
MILTOT	MILITARY + CIVILIAN
OFC1	Office space within 1 mile
OFCTOTAL	Office space within 4 miles
OFCCBD	Office space in central business district
PASSENGER	Airport passengers enplaned
RETAIL	Scale ranking of retail activity
TOURISTS	Annual tourists
TRAFFIC	Traffic count
VAN	Airport van
	Area demographics
EMPLYPCT	Unemployment percentage
INCOME	Average family income
POPULACE	Residential population
	Market awareness
AGE	Years inn has been open
NEAREST	Distance to nearest inn
STATE	State population per inn
URBAN	Urban population per inn
	Physical attributes
ACCESS	Accessibility
ARTERY	Major traffic artery
DISTCBD	Distance to downtown
SIGNVIS	Sign visibility

- A preliminary statistical evaluation of all 35 variables – four critical factors: STATE, PRICE, INCOME, and COLLEGE – used to establish forecast model.
- Selected dependent variable, Y, is operating margin.

Example

- **Calculated coefficients:**
  - $a_0 = 39.05$
  - $a_1 = -5.51$
  - $a_2 = 5.86$
  - $a_3 = -3.09$
  - $a_4 = 1.75$
- **So model becomes:**
  - Y = 39.05 – 5.51*STATE + 5.86*PRICE – 3.09*INCOME + 1.75*COLLEGE
- **Regression models are appropriate for making medium and long term forecasts.**

Time Series Models

- Applicable for making short-term forecasts when the values of observations occur in an identifiable pattern over time.
  - N-Period Moving Average
  - Exponential Smoothing

N-Period Moving Average

- 100-room hotel in a college town
- Saturday occupancy
- Owner has noted increased occupancy for the last two Saturdays and wishes to prepare for the coming weekend (i.e., September 12), perhaps by tweaking hotel rates.
  - Do recent occupancy figures indicate a change in the underlying avg. occupancy?

N-Period Moving Average

Saturday Occupancy at a 100-room Hotel

Saturday	Period	Occupancy	Three-period Moving Average	Forecast
Aug. 1	1	79		
8	2	84		
15	3	83	82	
22	4	81	83	82
29	5	98	87	83
Sept. 5	6	100	93	87
12	7			93

- **This method may be used in this simple example to smooth out random variations and produce a reliable estimate of the underlying avg. occupancy.**

N-Period Moving Average

Let : MA_T = The N period moving average at the end of period T
A_T = Actual observation for period T

Then: $MA_T = (A_T + A_{T-1} + A_{T-2} + \ldots\ldots + A_{T-N+1})/N$

Characteristics:

- Need N observations to make a forecast
- Very inexpensive and easy to understand
- Gives equal weight to all observations
- Does not consider observations older than N periods

N-Period Moving Average

- If we select N equal to 3, then we cannot begin our calculation until period 3 (i.e., August 15), at which time we add the occupancy figures for the three most recent Saturdays (i.e., August 1,8, and 15) and divide the sum by 3 to arrive at the three-period moving average of [(83+84+79)/3] = 82.
- We use this value to forecast occupancy for the following Saturday (i.e., August 22)

N-Period Moving Average

- The moving-average forecast has smoothed out the random fluctuations to track better the average occupancy, which then is used to forecast the next period.
- Each three-period moving-average forecast thus involves simply adding the three most recent occupancy values and dividing by 3.
  - e.g. to arrive at the moving avg. for Aug 22, we drop the value for Aug 1, add the value for Aug 22, and recalculate the avg. = 83

N-Period Moving Average

- Although our N-period moving avg. has identified a change in the underlying avg. occupancy, this method is slow to react because old data are given the same weight (i.e., 1/N) as new data in calculating the averages. More recent data may be better indicators of change; therefore, we may wish to assign more weight to recent observations.

Simple Exponential Smoothing

- SES also "smoothes out" blips in the data, but its power over the N-period moving avg. is threefold:
  - Old data are never dropped or lost
  - Older data are given progressively less weight
  - The calculation is simple and requires only the most recent data.

Simple Exponential Smoothing

- It is based on the concept of feeding back the forecast error to correct the previous smoothed value.
  - $S_t = S_{t-1} + \alpha (A_t - S_{t-1})$
    - S_t smoothed value for period t – serves as forecast for time (t+1)
    - A_t actual observed value for period t
    - α smoothing constant between 0.1-0.5

Simple Exponential Smoothing

- $(A_t – S_{t-1})$ represents the forecast error because it is the difference between the actual observation and the forecast – calculated in the prior period.
- A fraction α of this forecast error is added to the previous smoothed value to obtain the new smoothed value S_t
- Let’s analyze the same example

Simple Exponential Smoothing

Saturday Hotel Occupancy (α =0.5)

Forecast Saturday	Period t	Actual Occupancy A_t	Smoothed Value S_t	Forecast F_t	Error $\|A_t - F_t\|$
Aug. 1	1	79	79.00		
8	2	84	81.50	79	5
15	3	83	82.25	82	1
22	4	81	81.63	82	1
29	5	98	89.81	82	16
Sept. 5	6	100	94.91	90	10
					MAD = 6.6

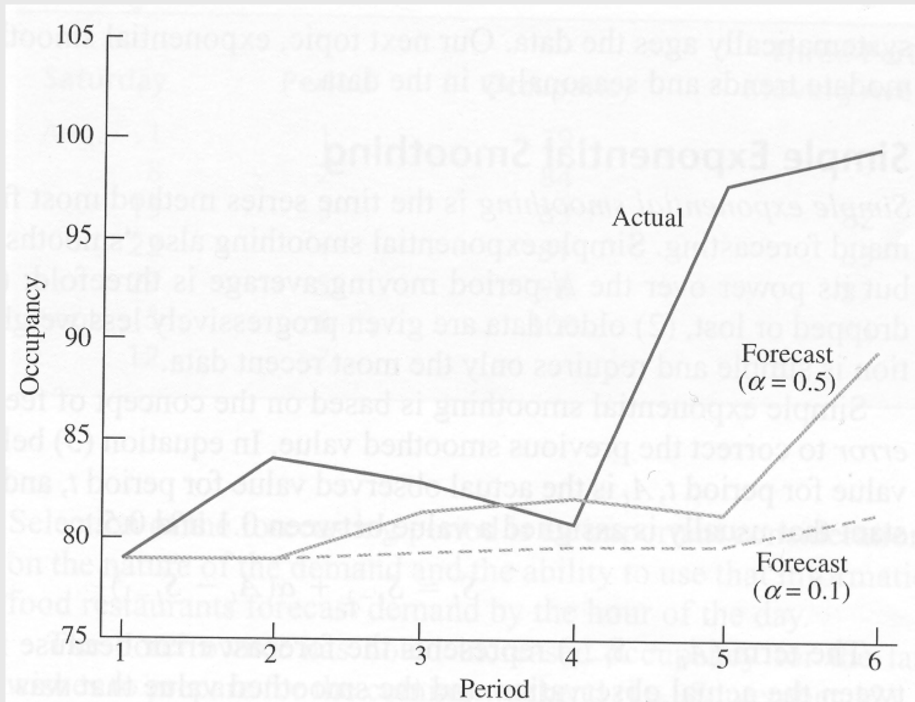
Forecast Error (Mean Absolute Deviation) = $\Sigma|A_t - F_t|/n$

Simple Exponential Smoothing

- Let the first observed, or actual, value A_t in a series of data equal the first smoothed value S_t. Therefore, S_1 for Aug 1 equals A_1 for Aug. 1, or 79.00.
- The smoothed value for Aug. 8 (S_2) then may be derived from the actual value for Aug. 8 (A_2) and the previous smoothed value for Aug. 1 (S_1).
- We have selected an $\alpha = 0.5$
- For Aug. 8:
  - $S_2 = S_1 + \alpha\,(A_2 - S_1)$
  - $= 79.00 + 0.5(84 - 79.00)$
  - $= 81.50$
- And similar calculations are made to determine S_3, S_4, S_5, S_6 for successive periods.

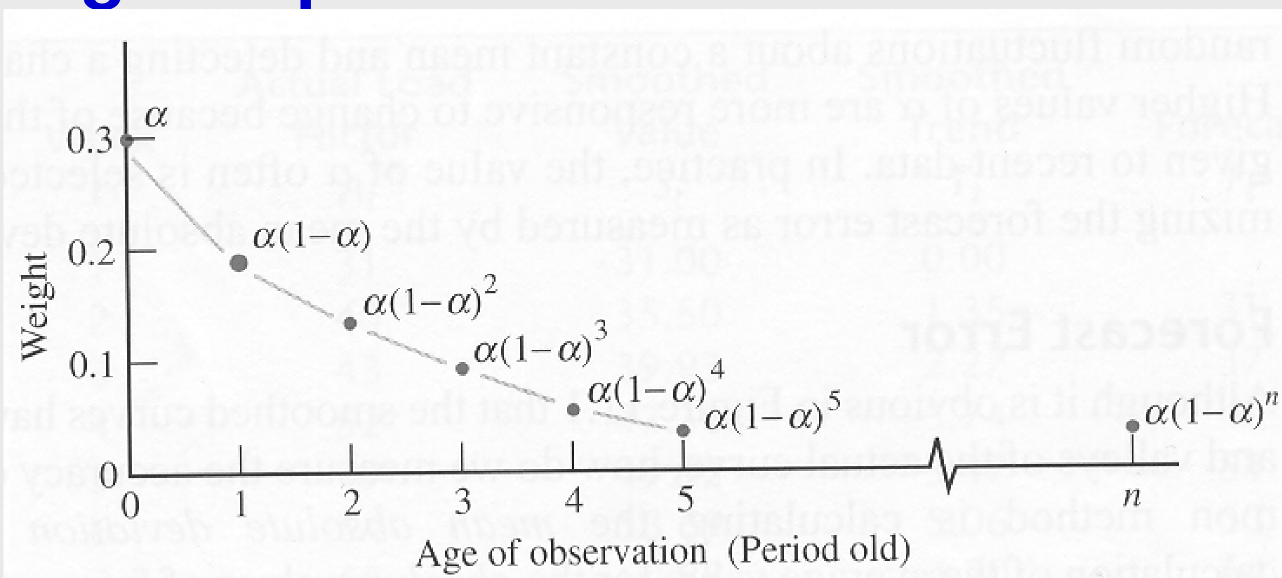
Simple Exponential Smoothing

- If we wish to make the smoothed values less responsive to the latest data, we can assign a smaller value to α



Simple Exponential Smoothing

- In general, actual value A_{t-n} is given a weight $\alpha (1-\alpha)^n$. Older observations never disappear entirely from the calculation of S_t, but they do assume progressively decreasing importance. So for $\alpha = 0.3$, the distribution of weight given past data would be:



Final Example

- Assume that the number of calls into a call center on Mondays between 10 am and 11 am is relatively stable and a smoothing constant (α) of 0.05 is considered appropriate.
- Assume that last month's forecast (S_{t-1}) was 1050 calls, and 1000 were actually received (A_{t-1}), rather than 1050.
  - The forecast for this month would then be calculated as follows:
  - $S_t = S_{t-1} + \alpha (A_t – S_{t-1})$
  - $= 1050 + 0.05(1000-1050)$
  - $= 1047.5$ calls
- Because the smoothing coefficient is relatively small, the reaction of the new forecast to an error of 50 calls is to decrease the next month's forecast by only 2.5 calls.