Software Engineering Economics (CS656)

Economic Analysis – III

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Goals as Constraints

Example: TPS Failure Modes

- Option A1
  - Vendor supplied operating system in its extended System A Plus form
  - If one processor fails, system fails
    - Processor reliability: 0.99/hour
    - Mean time to repair: 30 min.
- System Reliability for N processors:
  - Rel (N) = $(0.99)^N$
- System Availability for N processors
  - Fraction of the time that the system is working

$$AV(N) = 1 - \frac{\text{(Prob. Of failure per time period) (Avg. down time per failure)}}{\text{Length of time period}}$$

$$= 1 - \frac{(1 - 0.99^{N})(30\ \text{min})}{60\ \text{min}} = 1 - 0.5(1 - 0.99^{N})$$

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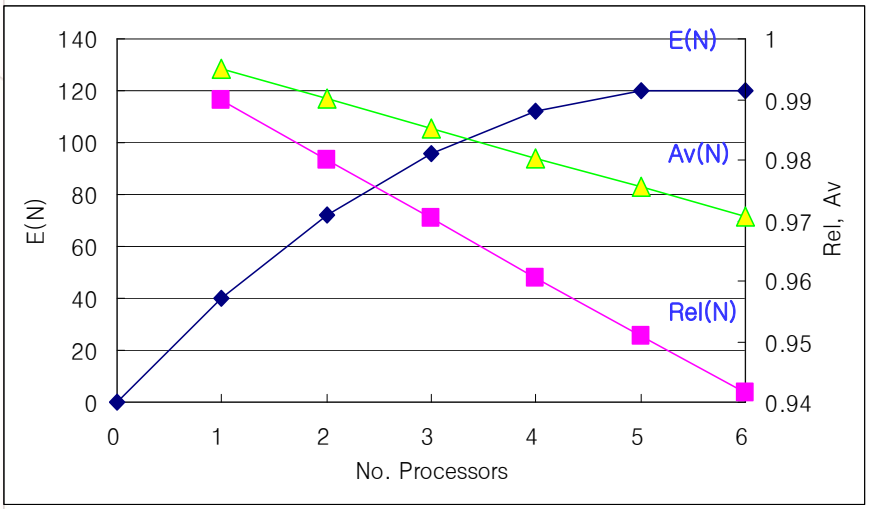
3

TPS Reliability, Availability, &



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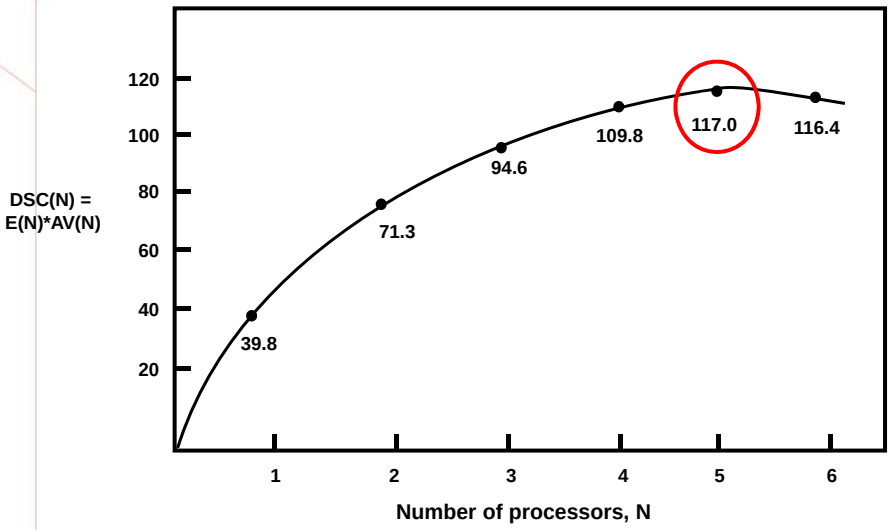
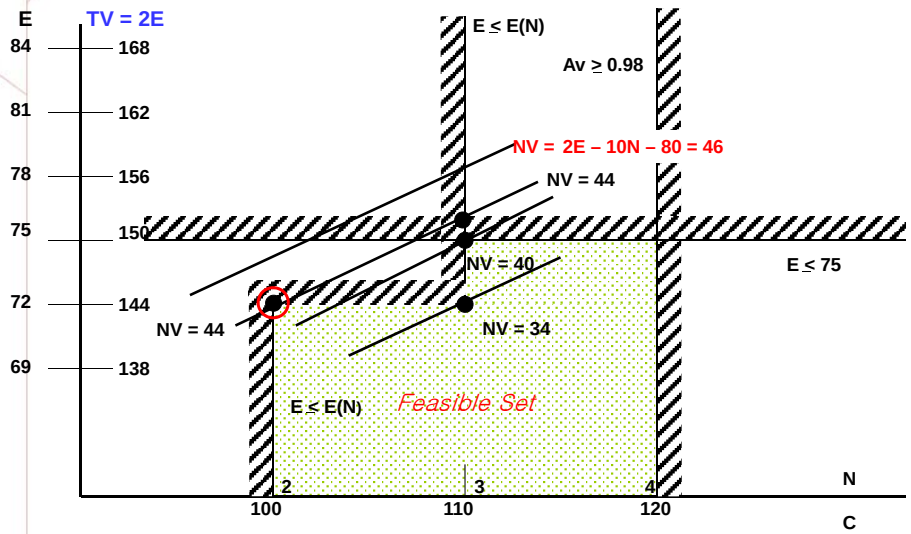
TPS Delivered System Capability



Goals as Constraints

- e.g._1: Can't afford to have a system with
  AV < 0.98
  - Choose N that gives max E(N) subject to AV(N) >= 0.98
  - N = 4 processors with AV(N) = 0.98 E(N) =112 tr/sec
- e.g._2: Can't afford to have a system with
  E(N) < 90tr/sec
  - Choose N to give us the maximum availability such that E(N) >=90tr/sec
  - N = 3 processors with DC = 96tr/sec, Av(3) = 0.985
- e.g._3: Choose N to maximize E(N) subject to
  AV(N) >= .98 and E(N) <= 75
  - N = 2 with E(N) = 72 AV(N) = .99

Feasible Sets and Cost-Value Contours (TV=2E)



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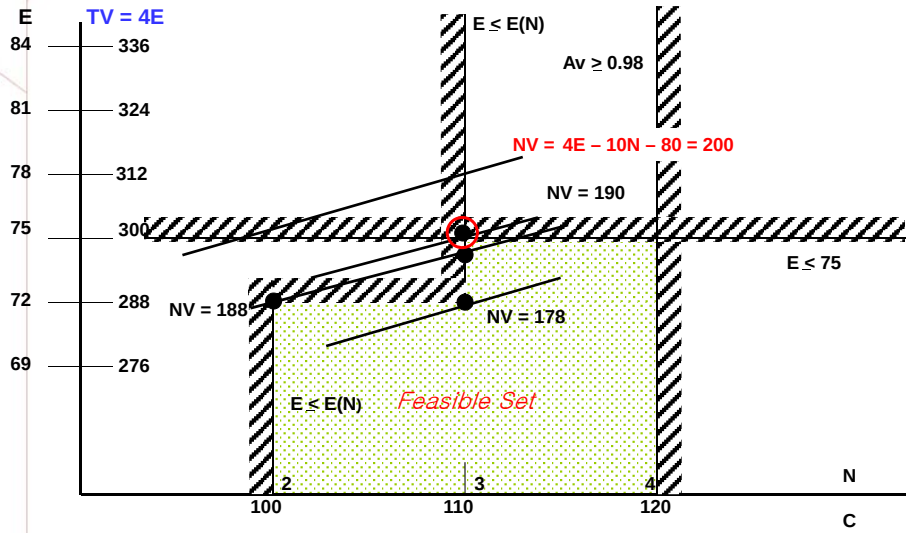
Feasible Sets and Cost-Value Contours (TV=4E)



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General Decision Problems w/

- Choose values of the decision variables
  - $X_1, X_2, \cdots, X_n$
- So as to maximize the objective function
  - $f(X_1, X_2, \cdots, X_n)$
- Subject to the constraints
  - $g_1 (X_1, X_2, \cdots, X_n) <= b,$
  - $g_2 (X_1, X_2, \cdots, X_n) <= b_2$
  - $\cdots$
  - $g_m (X_1, X_2, \cdots, X_n) <= b_m$

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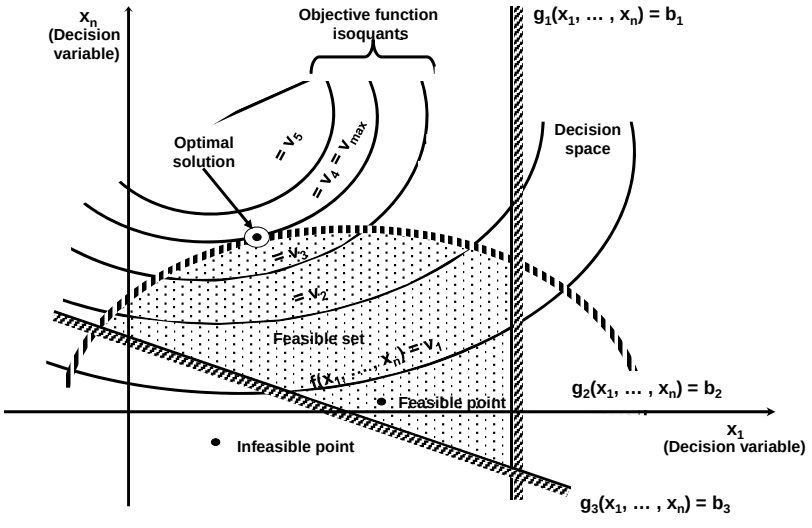
Constrained Optimization Problem



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Necessary and Sufficient Conditions for *an Optimal Solution*

- The optimal solution $(X_1, X_2, \ldots, X_n)_{max}$
- And the optimal value V_{max}
- Are characterized by the necessary and sufficient conditions
  - **$(X_1, X_2, \cdots, X_n)_{max}$ is a feasible point on the isoquant $f(X_1, X_2, \cdots, X_n) = V_{max}$**
  - **If $V > V_{max}$, then its isoquant $f(X_1, X_2, \cdots, X_n) = V$ does not contain any feasible points**

Linear Programming

- If the objective function *f* is a linear function of the decision variables $x_1, x_2, \ldots, x_n$
  - $f(x1,x2, \cdots,xn) = c_1x_1+c_2x_2+ \cdots + c_nx_n$
- Constraint functions g_i: linear functions
- Optimal decision problem → a linear programming

- Choose the decision variables: $x_1, x_2, \ldots, x_n$
- So as to maximize: $c_1x_1 + c_2x_2 + \ldots + c_nx_n$
- Subject to the constraints
  - $a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n <= b_1$
  - $a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n <= b_2$
  - $\cdots$
  - $a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n <= b_m$
  - $x_1 >= 0, x_2 >= 0, \cdots, x_n >= 0$

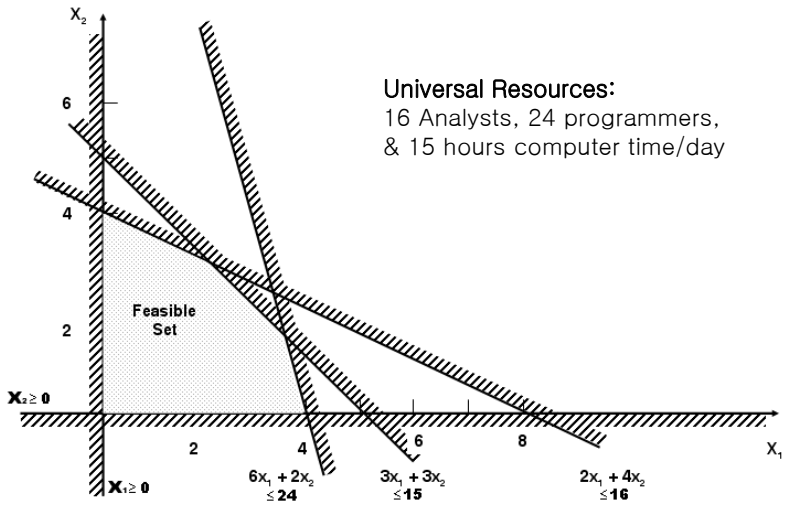
LP Example: Universal Software,

- 16 analysts, 24 programmers, a computer available 15 hrs/day
- Each Text-processing system project
  - Requires 2 analysts, 6 prog'rs, 3 hr/day computer time, $20K profit
- Each Process control system
  - Requires 4 analysts, 2 prog'rs, 3 hr/day computer time,$30K profit
- How many of each should Universal develop to maximize profit?
  - Available labor force and computer time constraints

Five Step Sequence to the Solution

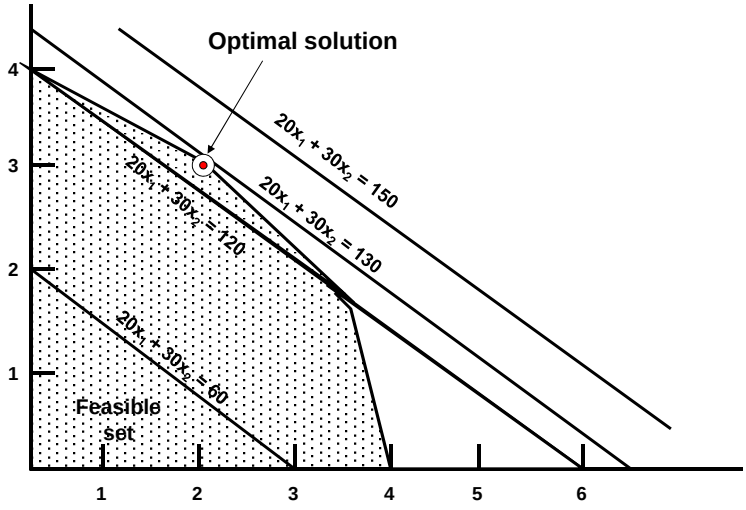
1. What objective are we trying to optimize?
2. What decisions do we control which affect the objective?
3. What items dictate constraints on our range of choices?
4. How are the values of the objective function related to the values of the decision variables?
5. What decision provides us with the optimal value of the objective function?

Feasible Set: Universal Software

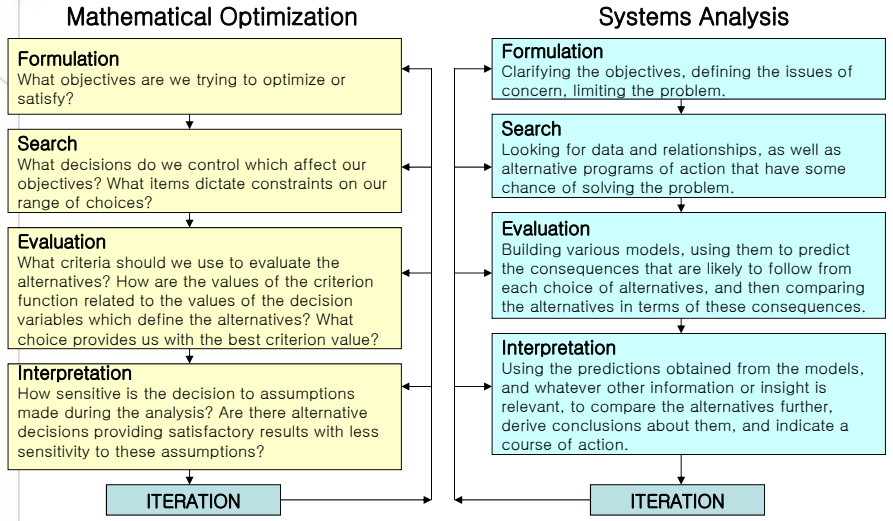


Universal Resources:
16 Analysts, 24 programmers,
& 15 hours computer time/day

Optimal Solution: Universal Software



Comparison of Mathematical Optimization & Systems Analysis



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Coping with Unreconcilable & Unquntifiable Goals

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Example: TPS Option B

- Proceed with the Option B of two step composite approach
  - A special purpose operating system with reduced multiprocessor overhead
    - Long range delivered capacity with 180tr/sec
  - Goals of improved system reliability and availability through switchover and restart capabilities ➔ $150K
- Vendor Proposal: Cost of option B OS : $135K
- Which should we choose? (unquantifiable criteria)
  - *Availability of key personnel*
  - *Staff morale and growth*
  - *Controllability*
  - *Ease of maintenance*

Presentation Techniques

- Unquantifiable criteria

	#CRIT	#ALT's
– Criterion summaries	2-10	2-3
– Preference table	2-20	2-5
– Screening matrix	5-30	2-10

- Mixed Criteria
  - Tabular methods
  - Cost vs. capability graph
  - Polar graph
  - Bar charts

Preference Table

In-House Development	Vendor Development
❖ Vendor development involves procurement costs and delays ❖ Provides career growth for in-house personnel ❖ Provides expert staff for maintenance ❖ More control over system development directions	❖ Costs $135K (versus $150K for in-house) ❖ Frees in-house personnel for other tasks ❖ Provides superior measurement and diagnostic capabilities

- Also called "pros & cons table"
- Provides a good deal more focus for decision-makers
- May be cumbersome with a large number of alternatives and a large number of criteria

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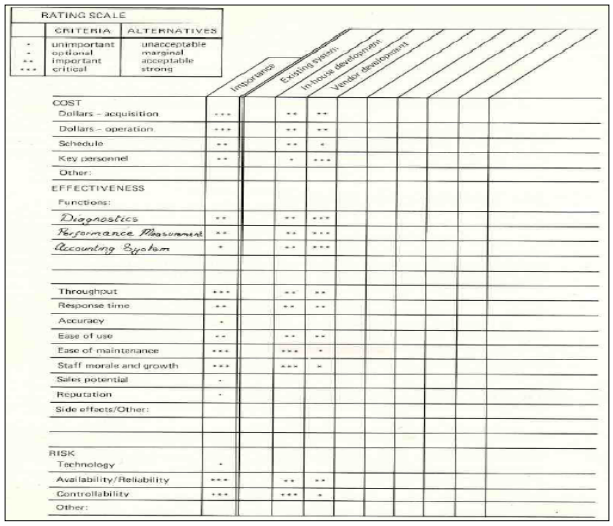
Screening Matrix



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22

Tabular Methods

Objectives	Desired Value	Acceptable Value	Expected Value: COCOMO	Expected Value: SOFTCOST	Rating: C	Rating: S	Rating: Imp.
Five-year life-cycle cost	$150K	$325K	$179–284K	$295–430K	***	*	***
Acquisition cost	25K	75K	55K	45K	**	**	***
Five-year O&M cost	125K	250K	124–229K	250–385K	***	*	***
Accuracy	±20%, 80% of time	±20%, 66% of time	72%	50–75%	**	*	***
Privacy	In-house control	Proven third party	In-house	Third party	***	*	***
Schedule (months)	3	9	5	1	**	***	**
Maintainability	In-house control	2x in-house cost, response	In-house	2x in-house	***	*	**
Detail	By phase, activity, subsystem, labor-grade, dollars/MM	By phase, subsystem	By phase, activity, subsyst, MM	By phase, dollars, some activity	**	**	**
Staff growth	In-house cost expertise	Basic knowledge	Potential expertise	Basic	**	*	**

Acronyms: O&M: Operations and Maintenance
MM: Man-months
K: Thousands
Imp: Importance

***: Desired or Better
**: Intermediate
*: Acceptable
-: Unacceptable

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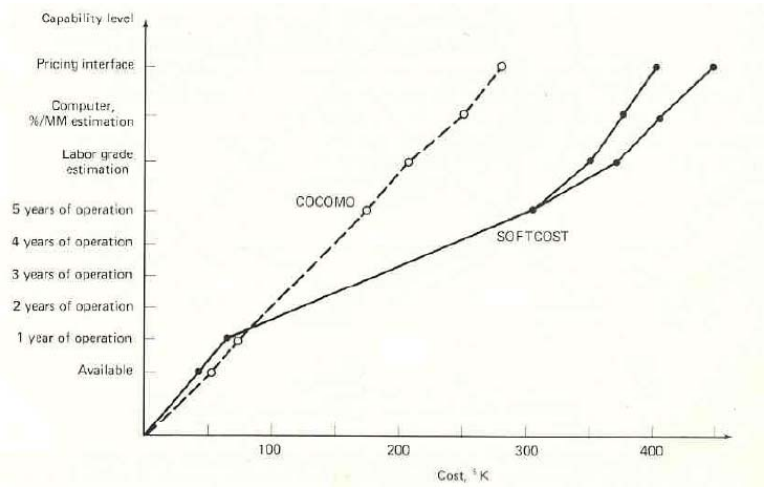
Cost vs. Capability Graph



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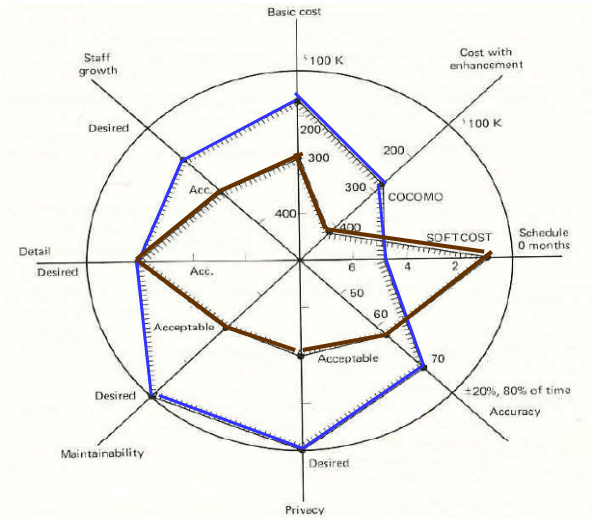
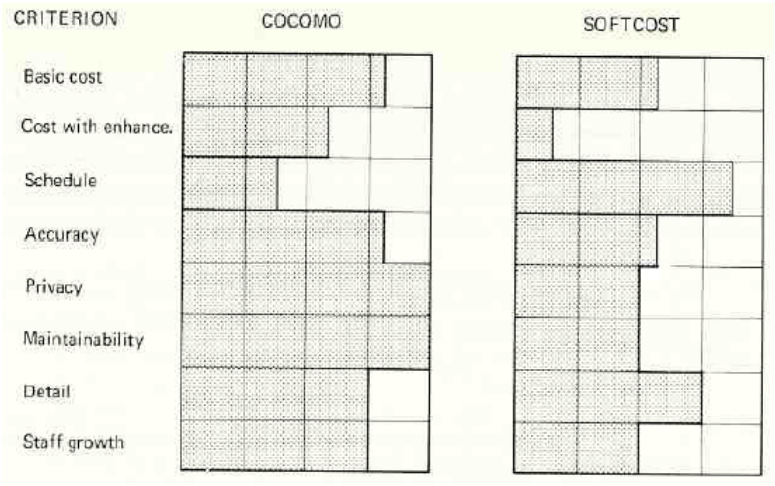
Polar Graphs (or Kiviat Graphs)



Bar Charts



Q & A