Lecture 14: Cost Estimation

Overview
- Project management activities
  - Project costing
  - Project scheduling and staffing
  - Project monitoring and review
- General cost estimation rules
- Algorithmic Cost Modeling
  - Function point model
  - COCOMO

Components of Project Cost
- Tools (both HW and SW)
- Facility, utility, communication, etc.
- Travel, training, etc.
- Acquisition
- Development personnel (cost of person-hours)

Why Estimating Software Personnel Cost
- A big portion of overall IS project cost
- Allocate and control budget
  - Justify project value
  - A significant component in economic feasibility study
- Product pricing
  - Fixed vs. variable cost

Cost Estimation Methods
- Boehm (1981)
  - Algorithm cost modeling
    • Develop a model using historical cost information
    • Use software metric as input
  - Expert judgment
    • Expert on development technique and application domain
    • Arrive conclusion by consensus
  - Estimation by analogy
    • Other projects in the same project domain
- Parkinson's Law
  • Work expends to fill the time available
  • The cost is determined by available resources rather than by objective assessments
- Pricing to win
  • Based on how much the customer can afford
Estimation Trade-offs

- **Size**
  - Function points
  - Lines of code

- **Effort**
  - Person-months

- **Time**
  - Months

Function Points

Function Point Model

- Derive cost directly from analysis documents such as DFD and ERD
- Identify five Factors
  - Sizing Data Functions
    1. Files
    2. Program interfaces
  - Sizing Transactional Functions
    3. External Inputs
    4. External Outputs
    5. External Queries

Function Points Estimation

1. Total Unadjusted Function Points (TUF)
2. Project Complexity (PC)
3. Adjusted Project Complexity (PCA)
   \[ PCA = 0.65 + 0.01 \times PC \]
4. Total Adjusted Function Points (TAFP)
   \[ TAFP = TUF \times PCA \]

Lines of Code

- Conversion:
  \[ LOC = k \times TAFP \]
  \( k \) is the LOC to FP conversion factor
- Example:
  - 100 Function Points
  - C: 13,000 Lines
  - VB: 3,000 Lines

COCOMO Estimation Calculation

- Effort (in person-months) = 1.4 \times \text{thousand LOC}

Estimating Schedule Time

- Rule of thumb for estimation
  \[ \text{Schedule Time} = 3.0 \times \text{Effort}^{1/3} \]
COCOMO

COnstructive COst MOdel

- Use final project size (in terms of lines of code) as model input
- Classify project into three types
  - Organic, semi-detached, embedded
  - Depends on how many other systems to interface with
- Has three forms
  - Basic, intermediate, and detailed

COCOMO-Basic Form

- Three project types
  - Effort
    - PM = 2.4 (KLOC)\(^{1.05}\)
    - PM = 3.0 (KLOC)\(^{1.12}\)
    - PM = 3.6 (KLOC)\(^{1.20}\)
  - Schedule
    - TDEV = 2.5(PM)\(^{0.38}\)
    - TDEV = 2.5(PM)\(^{0.35}\)
    - TDEV = 2.5(PM)\(^{0.32}\)

- Limitations
  - Does not accommodate highly sequential forms of incremental development
  - Calculate average staff level in each phases
  - Does not incorporate the effect of other software cost drivers

COCOMO-Detailed Model

- Improvements
  - Phase-sensitive effort multiplier
    - In addition to Size
    - Reliability
    - Application experience
    - Interactive development
  - Three-level product hierarchy
    - Module level
    - Subsystem level
    - System level

Cost-Effectiveness Analysis

Performance Models

- Transaction Processing System
  - N = Number of processors
  - S = Processor Speed (Kops/sec)
  - P = Processor Overhead (Kops/sec)
  - M = Multiprocessor overhead factor


– $T = \text{Number of operations required per transaction in Kops}$

**Performance Models**

* Performance

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**Production Function**

* Economies of Scale
  – More efficient to produce large quantities than small quantities

* Diseconomies of Scale on large software projects
  – Interpersonal communications
  – Software gold-plating
  – Hardware software
  - Modularity

**Gold Plating**

* Software gold plating
  – Instant response
  – Pinpoint accuracy
  – Unbalanced systems
  – Artificial intelligence (AI) features
  – Interactive multicolor vector graphics
  – “Everything for Everybody” systems

* Usually Not gold plating
  – Humanized Input Preprocessors
  – Humanized Output Postprocessors
  – Modularity and Information hiding
  – Measurement and diagnostic, backup and recovery capabilities

* Sometimes gold plating
  – High generalized control and data structure
  – Sophisticated user command languages
  – General-purpose utilities and support software
  – Automatic trend analysis

**Choosing Among Alternatives**

* Decision Criteria
  – Maximum Available Budget
  – Maximum Performance requirement
  – Minimum Performance requirement
  – Maximum Effectiveness/Cost Ratio
  – Maximum Effectiveness-Cost difference

* Composite options
Risk Analysis

Complete Uncertainty
- No knowledge for chance of success
- Decision Rules
  - Maximin (Most pessimistic)
    - Determine the minimum payoff for each alternative
    - Choose the alternative to maximize the minimum payoff
  - Maximax (Most optimistic)
    - Determine the maximum payoff for each alternative
    - Choose the alternative to maximize the maximum payoff
  - Laplace or Equal-Probability Rule
    - All states of nature are equally likely
    - Determine the expected payoff for each alternative
    - Choose the alternative to maximize the expected payoff
  - Subjective Probabilities
  - Breakeven Analysis

Value of Information
- The prototype approach