COCOMO II Overview

Barry Boehm, USC
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October 27, 1999

Outline

- COCOMO II Project Status and Plans
  - COCOMO II 2000 Calibration
  - COTS Integration (COCOTS)
  - Phase/Activity Distributions (COPSEMO)
  - Rapid Application Development Schedule (CORADMO)
  - Productivity Improvement (COPROMO)
  - Tool Effects
- COCOMO II Book and CD-ROM
USC-CSE Modeling Methodology

1. Analyze Existing literature
2. Perform Behavioral Analysis
3. Identify Relative Significance
4. Perform Expert-Judgment, Delphi Assessment
5. Gather Project Data
6. Determine Bayesian A-Posteriori Update
7. Gather more data: refine model

COCOMO II Calibration Approaches

- COCOMO II 2000 posteriori (weight determined by prior and sample variance)
- COCOMO II 1997 posteriori (10% weighted average approach)

Data
A-Priori

Application Experience (AEXP)

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### Calibration: COCOMO II.1997 Vs. 2000

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Project Data Points</td>
<td>63</td>
<td>83</td>
<td>161</td>
</tr>
<tr>
<td>Calibration PRED (.30) Values</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Effort - by Org'n</td>
<td>81%</td>
<td>52%</td>
<td>75%</td>
</tr>
<tr>
<td>Schedule - by Org'n</td>
<td>65%</td>
<td>61%</td>
<td>81%</td>
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</tbody>
</table>

Experts

10% Data, 90% Bayesian

* ISPA/SCEA 1999 Best Paper award for software track, overall conference

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**Diagrams:**

- Flexedness (PREC)
- Development Flexibility (FLEX)
- Architectural Risk (RESL)
- Team Cohesion (TEAM)

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USC COCOMO II.2000

- Same Bayesian parameter values as 1998-99
- Windows, Unix/Motif, Java versions
- Early Design model
- MBASE/RUP phase/activity distributions
- Experimental COCOTS model
- Extensive on-line help
  - User Manual, Model Definition Manual
- Related tools: Code Count, Bug tracking, Spreadsheet versions of Early Design, Post-Architecture, COSSEMO, CORADMO, COPROMO
### Status of Models

<table>
<thead>
<tr>
<th>Literature</th>
<th>Behavior</th>
<th>Signif.</th>
<th>Variables</th>
<th>Delphi</th>
<th>Data, Bayes</th>
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</thead>
<tbody>
<tr>
<td>COCOMO II</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>200</td>
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<tr>
<td>COTS</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>20</td>
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<tr>
<td>COQUALMO</td>
<td>Defects in</td>
<td>*</td>
<td>*</td>
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<td>2</td>
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<td></td>
<td>Defects out</td>
<td>*</td>
<td>*</td>
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</tr>
<tr>
<td>COSSEMO</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>CORADMO</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

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### COCOMO vs. COCOTS Cost Sources

**STAFFING**

1. **LCO**
   - Life Cycle Objects
2. **LCA**
   - Life Cycle Activities
3. **COTS Application Glide Code
   - Development and Test Separate from COTS Effect
4. **Increased Application Effort due to COTS Volatility**

**TIME**

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Integrated COQUALMO

Software Size estimate
Software product, process, computer and personnel attributes
Defect removal capability levels

Defect Removal Model
Defect Introduction Model

COCOMO II

Number of residual defects
Defect density per unit of size

Software development effort, cost and schedule estimate

COCOMO II RAD Extension

(CORADMO)

COCOMO II cost drivers (except SCED)
Language Level, experience...

COCOMO II Stage Distributions

Baseline effort, schedule
Effort, schedule by stage

CODADMO

RAD effort, schedule by stage

RVHL, BPRS, CLAB, RESL, PPOS
Productivity Improvement Model (COPROMO)

- Use COCOMO II model and extensions as assessment framework
  - Well-calibrated to 161 projects for effort, schedule
  - Subset of 106 1990's projects for current-practice baseline
  - Extensions for Rapid Application Development formulated
- Determine likely near-term (2006) and longer-term (2013) impact of technologies on model parameter settings
- Use these in models to assess impact of technologies on cost and schedule
  - Effort used as a proxy for cost

New TOOL Rating Scale

- Basis of Tool Rating Scale
  - Breadth of Process Support
    - Specification, Analysis, Design, Programming, Test, CM, QA, Management, etc.
  - CMM Tool maturity and support
  - Degree of Tool Integration
- Initial Delphi, Bayesian Analysis
- Jongmoon Balk
Bayesian Analysis - Step 6

\[ g(\theta | y) = \frac{f(y | \theta) g(\theta)}{f(y)} \rightarrow g(\theta | y) = l(\theta | y) g(\theta) \]

\[
b'' = \left[ \frac{1}{\sigma^2} \frac{1}{H'} \right]^{-1} \times \left[ \frac{1}{\sigma^2} \frac{1}{X'XL} \right]^{-1}
\]

\[
\text{Var}(b'') = \left[ \frac{1}{\sigma^2} \frac{1}{X'XL} \right]^{-1}
\]

<table>
<thead>
<tr>
<th>Prior (Expert-judged)</th>
<th>Sample</th>
<th>Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>( b_1 )</td>
<td>( b_2 )</td>
<td>( b_1 )</td>
</tr>
<tr>
<td>Mean 0.205</td>
<td>0.32</td>
<td>0.563</td>
</tr>
<tr>
<td>Variance 0.0001</td>
<td>0.0029</td>
<td>0.02087</td>
</tr>
</tbody>
</table>

\[ \text{TOOL} = 0.444 \cdot \text{TCOV} + 0.207 \cdot \text{TINT} + 0.349 \cdot \text{TMAT} \]

<table>
<thead>
<tr>
<th>Prior (3 Dimensional TOOL)</th>
<th>Sample w/o prior (3 Dimensional TOOL)</th>
<th>Posterior (3 Dimensional TOOL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{PRED}(.10) )</td>
<td>67 %</td>
<td>87 %</td>
</tr>
</tbody>
</table>

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COCOMO II Book

- Final text at Prentice Hall
- Publication date now 2Q 2000
- Uses current calibration values as COCOMO II.2000
- Plan new editions with recalibrated model
  - Every 2-3 years
  - Intermediate experimental versions available to Affiliates

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Table of Contents:
Software Cost Estimation with COCOMO II

1 Introduction to COCOMO II
2 Model Definition
   - Decision Analysis Examples
3 Application Examples
   - Transaction Processing
   - Airborne Radar
4 Calibration
5 Emerging Extensions
   - Applications Composition
   - COCOTS
   - COQUALMO
   - COPSEMO, CORADMO, COPROMO
6 Future Trends
COCOMO II Book Appendices

A. Assumptions and Phase/Activity Distributions
B. Estimating for Incremental Development
C. Data Collection Forms and Guidelines
D. Affiliates' Program
F. Content of CD-ROM

COCOMO II Book CD-ROM Content

- USC COCOMO II.2000 (Windows 95/NT and up)
  - Users' Manual
  - Model Definition Manual
  - Guided Tutorial
- Demo versions of commercial COCOMO II tools
  - COSTAR, CostXpert, Estimate Pro
- Short overview videos
  - Boehm, Brown, Madachy, Reifer (?)
- Spreadsheet models
  - COCOMO II 2000, CORADMO, COPROMO
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>COCOMO</td>
<td>COnstructive COst MOdel</td>
</tr>
<tr>
<td>COQUALMO</td>
<td>COnstructive QUALity MOdel</td>
</tr>
<tr>
<td>COCOTS</td>
<td>COnstructive COTS Integration Model</td>
</tr>
<tr>
<td>COSEMO</td>
<td>COnstructive Phased Schedule Effort Model</td>
</tr>
<tr>
<td>CORADMO</td>
<td>COnstructive RAD MOdel</td>
</tr>
<tr>
<td>COPROMO</td>
<td>COnstructive PROductivity Improvement MOdel</td>
</tr>
<tr>
<td>COTS</td>
<td>Commerical -Off-The-Shelf Software</td>
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<tr>
<td>IOC</td>
<td>Initial Operational Capability milestone</td>
</tr>
<tr>
<td>LCA</td>
<td>Life Cycle Architecture milestone</td>
</tr>
<tr>
<td>LCO</td>
<td>Life Cycle Objectives milestone</td>
</tr>
<tr>
<td>RAD</td>
<td>Rapid Application Development</td>
</tr>
<tr>
<td>UML</td>
<td>Unified Modeling Language</td>
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</table>