COCOMO II Status and Extensions

Barry Boehm, USC
COCOMO / SCM Forum #13
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Outline

• COCOMO II.1998 Status and Plans
• Overview of Extensions
  – COTS Integration (COCOTS)
  – Quality: Delivered Defect Density (COQUALMO)
  – Stage Distributions (COSSEMO)
  – Rapid Application Development Schedule (CORADMO)
  – Productivity Improvement (COPROMO)
  – Tool Effects
  – UML-Based Sizing
• Next Steps
USC-CSE Modeling Methodology

1. Identify System Structure
2. Gather Expert Opinion
3. Determine Significance
4. A-PRIORI MODEL
5. SAMPLING DATA
6. A-POSTERIORI MODEL
7. GATHER PROJECT DATA
8. GATHER MORE DATA

USC-CSE Modeling Methodology

COCOMO II Calibration Approaches

- COCOMO II 1981 Posterior (weight determined by prior and sample evidence)
- COCOMO II 1987 Posterior (50% weighted average approach)

Application Experience (AEXP)

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Calibration: COCOMO II.1997 Vs. .1998

<table>
<thead>
<tr>
<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</td>
<td></td>
<td>10% Data, Bayesian</td>
<td>90% Experts</td>
</tr>
<tr>
<td>PRED (.30) Values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effort</td>
<td>81%</td>
<td>52%</td>
<td>75%</td>
</tr>
<tr>
<td>- by Org’n</td>
<td>64%</td>
<td>80%</td>
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<tr>
<td>Schedule</td>
<td>65%</td>
<td>61%</td>
<td>72%</td>
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<tr>
<td>- by Org’n</td>
<td>62%</td>
<td>81%</td>
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</tbody>
</table>

USC COCOMO II.1998

- New Bayesian parameter values
- Windows, Unix/ Motif, Java versions
- Feature and user interface cleanup
- Export to Excel (import underway)
- 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
COCOMO II Book

- Publication date now mid-1999
- Will use current calibration values as COCOMO II.1999
- Providing USC COCOMO II.1998.1 as beta-1 version of CD version for book
- Will add Early Design model for CD version

Process Maturity (PMAT) Effects

- Effort reduction per maturity level, 100 KDSI project
- Clark Ph.D. dissertation (112 projects)
  - Research model: 12-23% per level
  - COCOMO II subsets: 9-29% per level
- COCOMO II.1998 (161 projects)
  - 5-11% per level
- Recent data tending toward 10-15% per level
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  - Tool Effects
  - UML-Based Sizing
- Next Steps

Status of Models

<table>
<thead>
<tr>
<th>Literature</th>
<th>Behavior</th>
<th>Signif. Variables</th>
<th>Delphi</th>
<th>Data, Bayes</th>
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<tbody>
<tr>
<td>COCOMO II</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>161</td>
</tr>
<tr>
<td>COCOTS</td>
<td>#</td>
<td>#</td>
<td>#</td>
<td>~10</td>
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<tr>
<td>COQUALMO</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>1</td>
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<tr>
<td>COSSEMO</td>
<td>#</td>
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<tr>
<td>CORADMO</td>
<td>*</td>
<td>#</td>
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</tbody>
</table>

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COCOMO vs. COCOTS Cost Sources

Software Size estimate
Software product, process, computer and personal attributes
Detect removal capability levels

Integrated COQUALMO

Software development effort, cost and schedule estimate
Number of residual defects
Defect density per unit of size
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

CORADMO

rad effort, schedule by stage

COSSEMO Stage Distribution Model:
Early Design/ Post Architecture

<table>
<thead>
<tr>
<th>LCO</th>
<th>Elaboration</th>
<th>Construction</th>
<th>Total E&amp;C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort %</td>
<td>14</td>
<td>28</td>
<td>72</td>
</tr>
<tr>
<td>Schedule %</td>
<td>40</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>P / P</td>
<td>0.35</td>
<td>0.7</td>
<td>1.2</td>
</tr>
<tr>
<td>PM / M=P</td>
<td>32K</td>
<td>16.4/4.8 = 3.5</td>
<td>33.6/4.8 = 7</td>
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<tr>
<td></td>
<td>512K</td>
<td>361/13.7 = 26</td>
<td>722/13.7 = 53</td>
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CORADMO: Reuse and VHLL’s (RVHL)

- Standard 3GL module reuse: no adjustment
- Schedule compression in Inception and Elaboration stages due to faster prototyping, option exploration
  - effect depends on experience in doing this
  - compression/expansion doesn’t alter staff level

<table>
<thead>
<tr>
<th>Schedule Multipliers</th>
<th>Rapid Prototyping Experience</th>
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<tbody>
<tr>
<td></td>
<td>VL</td>
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<tr>
<td>Inception</td>
<td>1.05</td>
</tr>
<tr>
<td>Elaboration</td>
<td>1.03</td>
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<tr>
<td>Construction</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Productivity Improvement Model

- 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
## COCOMO II Tool Refinement

### COCOMO II Tool Rating Scale

<table>
<thead>
<tr>
<th>Rating</th>
<th>CASE Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>No Comparison of the Same Kind of Tools</td>
</tr>
<tr>
<td>Low</td>
<td>No Clear Definition of Tools</td>
</tr>
<tr>
<td>Medium</td>
<td>No Considerations of Interactions with Other Factors</td>
</tr>
<tr>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Very High</td>
<td></td>
</tr>
</tbody>
</table>

### 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**

### New Tool Rating Scale

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<tr>
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UML-Based Sizing

- In early exploration stages
- Exploring hierarchical approach

Number/properties of use cases

Number properties of intermediate views
- classes, objects, components, sequence/collaboration diagrams, state transition diagrams

Number/properties of source code statements

UML Sizing Challenges

- UML-view usage conventions
- View overlaps and double counting
- Size vs. complexity measures
- Counting attributes and relationships
- Data collection
Next Steps

- Discuss status and prospects in Workshop
  - Delphi exercises
- Determine data availability, priorities
- Use to prioritize projects
  - Committed to COCOTS, COQUALMO, TOOL effects

1997 Affiliate Priorities

21  • Improve accuracy of COCOMO II Model
15  • Cost/schedule/quality tradeoffs
12  • Sizing improvements
10  • COTS integration costs
  • Activity Distribution
  • Life cycle tradeoff models
Assessing Alternative Modeling Efforts

<table>
<thead>
<tr>
<th>Importance</th>
<th>COCOMO II</th>
<th>A</th>
<th>B</th>
<th>D</th>
<th>E</th>
</tr>
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<tbody>
<tr>
<td>Low</td>
<td></td>
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Difficulty to get 30 data points

List of Acronyms

COCOMO: Constructive Cost MOdel
COQUALMO: Constructive QUALity MOdel
COCOTS: Constructive COTS Integration Model
COSSEMO: Constructive Staged Schedule Effort Model
CORADMO: Constructive RAD MOdel
COPROMO: Constructive PROductivity Improvement MOdel
COTS: Commercial-Off-The-Shelf Software
IOC: Initial Operational Capability milestone
LCA: Life Cycle Architecture milestone
LCO: Life Cycle Objectives milestone
RAD: Rapid Application Development
UML: Unified Modeling Language