Calibration of COCOMO II.2003

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Outline

• Characteristics of the current COCOMO II calibration data
  – Productivity
  – Age
  – Size

• Status of the 2003 model calibration
Post-Architecture Model

- General effort estimation equation

\[
\text{Person Months} = A \times (\text{Size})^E \times \prod_{i=1}^{n} EM_i
\]

where \( E = B + 0.01 \times \sum_{j=1}^{5} SF_j \)

- \( A = 2.94 \quad \text{B} = 0.91 \)
- Size (thousands of lines of code, KSLOC, or function points)
- EM: Effort Multipliers (17 for PA)
- SF: Scale Factors (5 for both models)
### COCOMO II Driver Values

<table>
<thead>
<tr>
<th>Cost_Driver</th>
<th>VL</th>
<th>L</th>
<th>N</th>
<th>H</th>
<th>VH</th>
<th>XH</th>
<th>PR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precedentedness (PREC)</td>
<td>6.20</td>
<td>4.96</td>
<td>3.72</td>
<td>2.48</td>
<td>1.24</td>
<td>0.00</td>
<td>1.33</td>
</tr>
<tr>
<td>Development Flexibility (FLEX)</td>
<td>5.07</td>
<td>4.05</td>
<td>3.04</td>
<td>2.03</td>
<td>1.01</td>
<td>0.00</td>
<td>1.26</td>
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<tr>
<td>Architecture and Risk Resolution (RESL)</td>
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<td>5.65</td>
<td>4.24</td>
<td>2.83</td>
<td>1.41</td>
<td>0.00</td>
<td>1.38</td>
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<tr>
<td>Team Cohesion (TEAM)</td>
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<td>4.38</td>
<td>3.29</td>
<td>2.19</td>
<td>1.10</td>
<td>0.00</td>
<td>1.29</td>
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<tr>
<td>Process Maturity (PMAT)</td>
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<td>6.24</td>
<td>4.68</td>
<td>3.12</td>
<td>1.56</td>
<td>0.00</td>
<td>1.43</td>
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<tr>
<td>Required Software Reliability (RELY)</td>
<td>0.82</td>
<td>0.92</td>
<td>1.00</td>
<td>1.10</td>
<td>1.26</td>
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<td>1.53</td>
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<tr>
<td>Data Base Size (DATA)</td>
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<td></td>
<td>1.14</td>
<td>1.28</td>
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<td>1.42</td>
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<tr>
<td>Product Complexity (CPLX)</td>
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<td>0.87</td>
<td>1.00</td>
<td>1.17</td>
<td>1.34</td>
<td>1.74</td>
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<tr>
<td>Develop for Reuse (RUSE)</td>
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<td>1.15</td>
<td>1.24</td>
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<td>1.31</td>
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<td>Documentation Match to Life Cycle Needs (DOCU)</td>
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<td>0.91</td>
<td>1.00</td>
<td>1.11</td>
<td>1.23</td>
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<td>1.52</td>
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<td>Time Constraint (TIME)</td>
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<td>Storage Constraint (STOR)</td>
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<td>Platform Volatility (PVOL)</td>
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<td>1.15</td>
<td>1.30</td>
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<td>1.50</td>
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<td>Analyst Capability (ACAP)</td>
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<tr>
<td>Personnel Continuity (PCON)</td>
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<tr>
<td>Applications Experience (AEXP)</td>
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<tr>
<td>Platform Experience (PEXP)</td>
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<td>0.85</td>
<td></td>
<td>1.40</td>
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<tr>
<td>Language and Tools Experience (LTEX)</td>
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<td>1.00</td>
<td>0.91</td>
<td>0.84</td>
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<td>1.43</td>
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<tr>
<td>Use of Software Tools (TOOL)</td>
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<td>1.00</td>
<td>0.90</td>
<td>0.78</td>
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<tr>
<td>Multi-Site Development (SITE)</td>
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<td>1.09</td>
<td>1.00</td>
<td>0.93</td>
<td>0.86</td>
<td>0.80</td>
<td>1.52</td>
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<tr>
<td>Required Development Schedule (SCED)</td>
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<td>1.14</td>
<td>1.00</td>
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<td>1.43</td>
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</table>
Productivity Analysis Definitions -1

- Analysis of productivities across all projects used for calibration in the COCOMO Repository
- Size Definitions
  - E: COCOMO II Scale Factors \((0.91 + 0.01 \times (\text{PREC} + \text{FLEX} + \text{RESL} + \text{TEAM} + \text{PMAT}))\)
  - SLOC: size measure expressed as source lines of code for each project
  - TSLOC: new SLOC + adapted SLOC (with no adjustments)
  - Size: new SLOC + adapted SLOC adjusted with reuse model (ESLOC)
  - Size’: Size adjusted for the COCOMO II scale constant
    - \((\text{Size})^{0.91}\)
Productivity Analysis Definitions -2

• Effort Definitions
  – PM: completed project effort expressed as Person Months
  – PM’: PM adjusted with COCOMO II cost drivers
    • \((\text{PM}) / (\text{Product of all Cost Drivers})\)
  – PM’’: PM adjusted with COCOMO II cost and scale drivers (B)
    • \((\text{PM})/(\text{Product of all Cost and Scale Drivers})\)
Productivity Analysis -1

E = 0.91 + (0.01 * Sum(PREC + FLEX + RESL + TEAM + PMAT))

Productivity
Median: 279
Mean: 417
Stdev: 475
Min: 20
Max: 3034
Productivity Analysis -2

Productivity

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Median</td>
<td>275</td>
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<tr>
<td>Mean</td>
<td>334</td>
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<td>Stdev</td>
<td>238</td>
</tr>
<tr>
<td>Min</td>
<td>24</td>
</tr>
<tr>
<td>Max</td>
<td>1443</td>
</tr>
</tbody>
</table>

Size / PM

E

COOMO/SCM 17, October 2002
COCOMO II Reuse Model

\[
\text{ESLOC} = \frac{\text{ASLOC} \left[ \text{AA} + \text{AAF}(1 + 0.02(\text{SU})(\text{UNFM})) \right]}{100} \quad \text{AAF} \leq 0.5
\]

\[
\text{ESLOC} = \frac{\text{ASLOC} \left[ \text{AA} + \text{AAF} + (\text{SU})(\text{UNFM}) \right]}{100} \quad \text{AAF} > 0.5
\]

Where: \( \text{AAF} = 0.4 (DM) + 0.3 (CM) + 0.3 (IM) \)

\( \text{SU} = \) Software Understanding

(zero when \( DM = 0 \) & \( CM = 0 \))

\( \text{UNFM} = \) Programmer Unfamiliarity

\( \text{AA} = \) Assessment and Assimilation

\( \text{ASLOC} = \) Adapted SLOC

\( \text{ESLOC} = \) Equivalent new SLOC
Productivity Analysis -3

<table>
<thead>
<tr>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Stdev</td>
</tr>
<tr>
<td>Min</td>
</tr>
<tr>
<td>Max</td>
</tr>
</tbody>
</table>

Size / PM’

E

COCOMO/SCM 17, October 2002
Adjusting Effort for Cost Drivers

- Required Software Reliability (RELY)
- Database Size (DATA)
- Product Complexity (CPLX)
- Developed for Reusability (RUSE)
- Documentation Match (DOCU)
- Execution Time Constraint (TIME)
- Main Storage Constraint (STOR)
- Platform Volatility (PVOL)
- Analyst Capability (ACAP)
- Programmer Capability (PCAP)
- Personnel Continuity (PCON)
- Applications Experience (APEX)
- Language and Tool Experience (LTEX)
- Platform Experience (PLEX)
- Use of Software Tools (TOOL)
- Multi-site Development (SITE)
- Required Development Schedule (SITE)

\[ PM' = \frac{PM}{\text{Product(All Cost Driver Rating Values)}} \]
Productivity Analysis -3

<table>
<thead>
<tr>
<th>Productivity</th>
<th>Median</th>
<th>Mean</th>
<th>Stdev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size / PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Median: 252
- Mean: 264
- Stdev: 104
- Min: 94
- Max: 737
Adjusting for Cost and Scale Factors

Cost Drivers +
Scale Drivers

Precedentness (PREC)
Development Flexibility (FLEX)
Architecture and Risk Resolution (RESL)
Team Cohesion (TEAM)
Process Maturity (PMAT)

Effort Adjustment Factors = Product(All Cost Driver Rating Values)
Scale Factor Influence = Product(Size^{0.01*PREC} + Size^{0.01*FLEX} + ...)

PM'' = PM / Effort Adjustment Factors * Scale Factor Influence
Size’ = Size^{0.91}
Productivity Analysis -4

Productivity

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Median</td>
<td>341</td>
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<tr>
<td>Mean</td>
<td>361</td>
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<tr>
<td>Stdev</td>
<td>117</td>
</tr>
<tr>
<td>Min</td>
<td>120</td>
</tr>
<tr>
<td>Max</td>
<td>802</td>
</tr>
</tbody>
</table>

\[
(1 / 341) \times 1000 = 2.94
\]
COCOMO II Data Age -1

Productivity

Median
Mean
Stdev
Min
Max

70 - 80
85 - 99

335
345
336
372
75
130
207
120
531
802
COCOMO II Data Age –2

Age Distribution of Data Points

Year Development Ended


4 9 35 0 18 30 65
Data Size versus Productivity -1

![Graph showing data size versus productivity with a scatter plot and a trend line.]
Data Size versus Productivity -2
Outline

• Characteristics of the current COCOMO II calibration data

• Status of the 2003 model calibration
Objective

• Derive numerical adjustments for each of COCOMO II driver’s rating level.
• Derive new multiplicative (A) and scaling (B) constants

\[ PM = A \times \text{Size}^{(B + 0.01 \sum SF)} \times \text{RELY} \times \text{CPLX} \times \text{DATA} \times \ldots \times \text{SCED} \]

Improved accuracy

\[ \begin{align*}
0.82 & \\
0.92 & \\
1.0 & \\
1.1 & \\
1.26 & \\
\end{align*} \]

2.94 0.91
Data Collection and Storage

• Data Collection
  – Paper collection form (most desirable because of detail)
  – From the USC COCOMO software tool estimation files

• Historical - whole project

• New data entered into a separate database from calibration data and evaluated.

• Data storage
  – Data is labeled with generic identifier
  – Stored in locked room
  – Access limited to 3 researchers
New Data for Calibration

- Quality of data impacts the quality of the model
- Collected data has challenges
  - Level of detail
  - Consistency (project size, scope, units, ratings)
  - Violation of known relationships
- Currently screening data for incorporation into calibration database
  - 35 project data points have been qualified for inclusion into the repository
- Affiliate Organizations provide the majority of data
2002 Calibration Data Status

• Had planned to release calibration results during the 17th COCOMO/SCE Forum (Fall 2002)
• We need more project data
  – If you calibrate the COCOMO II model locally - would you consider letting us use your data to calibrate the scale / cost drivers?
  – If you have recently completed projects, would you consider filling out one of our data questionnaires? We can conduct a data collection interview over the phone.
Calibration Handbook

• Every college coach faces this problem:
  – Your players will eventually graduate

• Documenting the procedures for calibrating COCOMO II (coach’s playbook)
  – Storing and retrieving repository data
  – Performing linear regression
  – Performing Bayesian calibration using prior information
  – Model performance analysis
For More Information

• E-mail: cocomo-info@sunset.usc.edu
  Brad@Software-Metrics.com

• Website
  – http://sunset.usc.edu/research/COCOMOII/index.html
  – Software for COCOMO II and COCOMO 81 models
  – Data collection form
  – Upcoming COCOMO events (Forum in Oct 2002)