Software Cost/Quality Modeling
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COCOMO II Affiliates’ Meeting
March 10, 1997

Presentation Outline

=> Motivation

- The Software Defect Introduction and Removal Model
- A-Priori Software Quality Model
- Plans
Motivation

- Insight on Determining Ship Time
- Assessment of Quality Investment Payoffs
- Understanding of Quality Strategy Interactions

Presentation Outline

- Motivation
  -> The Software Defect Introduction and Removal Model
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‘The S/W Defect Introduction and Removal Model’ (SEE, Barry Boehm) or ‘Tank and Pipe Model’ (Capers Jones)

‘Defects conceptually flow into a holding tank through various defect-source pipes & are drained off through various defect-elimination pipes’.

Defects introduced during software development:

<table>
<thead>
<tr>
<th>Defects introduced</th>
<th>Jones</th>
<th>Thayer &amp; others</th>
<th>Boehm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall rate</td>
<td>30-50KOSI</td>
<td>40-80KOSI</td>
<td>60-85KOSI</td>
</tr>
<tr>
<td>Percentage by component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirements</td>
<td>15%</td>
<td>50%</td>
<td>15-20%</td>
</tr>
<tr>
<td>Functional Design</td>
<td>20</td>
<td>25-35</td>
<td></td>
</tr>
<tr>
<td>Coding</td>
<td>35</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td>55</td>
<td>17-20</td>
<td></td>
</tr>
</tbody>
</table>

Defects removed:

<table>
<thead>
<tr>
<th>Automated requirements audits</th>
<th>Functional specifications review</th>
<th>Simulation</th>
<th>Design Language</th>
<th>Design Standards</th>
<th>Logic specifications review</th>
<th>Module logic inspection</th>
<th>Module code inspection</th>
<th>Code standards auditor</th>
<th>Source analyzer</th>
<th>Unit test</th>
<th>Function test</th>
<th>Component test</th>
<th>Subsystem test</th>
<th>System test</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>25</td>
<td>20</td>
<td>40</td>
<td>65</td>
<td>75</td>
<td>65</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

* Equivalent figure. Reported rate (10-20KOSI) covered only post integration test defects discovered.


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Two Different Approaches being researched at USC

Presentation Outline

- Motivation
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=> A-Priori Software Quality Model

- Plans
A-Priori Software Quality Model

- Defect Introduction Model
  - Baseline rates for each type of artifact
  - Rates adjusted via COCOMO II cost-drivers + DISC (Disciplined Methods)
  - Initial model ready for review and iteration

- Defect Removal Model
  - Rates for each type of artifact determined from project's defect removal activity levels
  - Reviews, inspections, analysis tools, tests
  - Initial Model TBD

- Evolve to a-posteriori model via data collection/analysis

*Types of Artifacts: Requirements, design, code, documentation

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A-Priori Defect Introduction Model

- For each type of artifact \( j \)

\[
\text{Number of Defects Introduced} = A_j \times (\text{Size})^B \times QAF_j
\]

\( QAF_j = \text{Quality Adjustment Factor for } j\text{th artifact} = \sum_{i=1}^{N} DRM_{ij} \)

\( B = \text{Provisionally set to 1} \)

\( DRM_{ij} = \text{Defect Rate Multiplier for each} \)

COCOMO cost driver and type of artifact \( j \)

\( N = 23 \times (7+1+5) \) for post-architecture model

\( N = 13 \times (7+1+5) \) for early-design model

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### Modeling effects of COCOMO cost drivers

<table>
<thead>
<tr>
<th>Defects Inserted/ KDSI or 100%</th>
<th>Requirements</th>
<th>Design</th>
<th>Code</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>5</td>
<td>25</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Now, IF ACAP < VH & RELY < VH

As compared to ACAP-VL & RELY-VL

This leads to A-Priori Software-Quality Model

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### Defect Introduction Rate Sensitivity Example

<table>
<thead>
<tr>
<th>ACAP (Analyst Capability)</th>
<th>Requirements</th>
<th>Design</th>
<th>Code</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>5</td>
<td>25</td>
<td>15</td>
<td>15</td>
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</tbody>
</table>

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Defect Introduction Rate
Sensitivity Example
RELY (Required Software Reliability)

Quality Range (Reqs Defects)
Candidate Defect Removal Activities
(Red to COCOMO II Data Collection Questionnaire)

- Project Reviews
- Artifact Inspections, Peer Reviews
- Prototyping
- Simulation
- Automated Reqs. Aids
- Automated Design Aids
- Design Standards
- Unit Testing
- Coverage Testing
- Integration Testing
- Stress Testing
- System Testing
- Beta Testing
- Cleanroom
- etc.

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Defect Data Reporting Scheme

<table>
<thead>
<tr>
<th>Defects of Type</th>
<th>Detected / Resolved in Phase</th>
<th>Cost to Resolve by Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rqts</td>
<td>Design</td>
</tr>
<tr>
<td>Rqts</td>
<td>50/30/10</td>
<td>20/30/10</td>
</tr>
<tr>
<td>Design</td>
<td>200/100</td>
<td>100/50</td>
</tr>
<tr>
<td>Code</td>
<td>200/100</td>
<td>100/50</td>
</tr>
<tr>
<td>Documentation</td>
<td>200/100</td>
<td>100/50</td>
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=> Plans

Plans

- Iterate A-Priori Model with Affiliates
  - Would like feedback on Modeling effects of COCOMO cost drivers, proposed defect removal model
  - Initiating Delphi process for iterating multiplier values
- Exploratory data collection & analysis
- Refinement of Model
  - Identify and Consolidate highly correlated model parameters
- Calibration & iteration of model
  - Statistically determine estimates of consolidated model parameters from data (Poisson regression techniques)
  - Use data-determined model parameters to adjust a-priori model parameters