Comparing IFPUG and COSMIC Measurements for Software Maintenance

Annual Research Review 2017

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Motivation

- Cost Models – SLOC for size input
- SLOC difficult to estimate
  - Especially maintenance
- Several size measures based on functionality
  - IFPUG FPs and SNAP
  - COSMIC FPs
- Which one is best?
Current Guidance


- Organization’s standard
- Manager’s/client’s suggestion
- Most familiar
- Most popular

Journal Article by Sheetz, Henderson, and Wallace

- Automation
- Calculation Ease
- Objectivity
- Data Availability
- Context Independence
- Lifecycle Applicability
- Standardization
- Sensitivity
- Intuitiveness
- Understandability
- Validity
# SLOC and FP Comparison

<table>
<thead>
<tr>
<th>Criteria</th>
<th>SLOC</th>
<th>FPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>Calculation Ease</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>Objectivity</td>
<td>✔</td>
<td>✗</td>
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<tr>
<td>Data Availability</td>
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<td>✗</td>
</tr>
<tr>
<td>Context Independence</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>Lifecycle Applicability</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>Standardization</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Intuitiveness</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>Understandability</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>Validity</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Dataset: Unified Code Count (UCC)

Project Description

• Maintained at USC
• Code metrics tool (logical SLOC, cyclomatic complexity)
• Implemented in C++
• 45 to 1425 logical SLOC
• 2010 to 2014
• Modularized architecture
• 4-month time-boxed increments

Project Types

• Add Functions
  • New language parsers
  • New features, such as GUI
• Modify Functions
  • Cyclomatic complexity support (modify existing language parsers with mathematical operation and algorithms)
Outline

Intro
- Motivation
- Dataset

Metrics
- IFPUG
- COSMIC
- Normalized Effort

Analyses Results
- IFPUG
- COSMIC

Ending
- Validity
- Conclusions
IFPUG Software Model
## IFPUG Function Points – 1/2

<table>
<thead>
<tr>
<th>Type of Component</th>
<th>Complexity of Components Multiplier Factor</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>External Inputs</td>
<td>3</td>
</tr>
<tr>
<td>External Outputs</td>
<td>4</td>
</tr>
<tr>
<td>External Inquiries</td>
<td>3</td>
</tr>
<tr>
<td>Internal Logical Files</td>
<td>7</td>
</tr>
<tr>
<td>External Interface Files</td>
<td>5</td>
</tr>
</tbody>
</table>

Total Number of Unadjusted Function Points
General System Characteristics

- Data Communications
- Distributed Data Processing
- Performance
- Heavily used Configuration
- Transaction Rate
- Online Data Entry
- End-user Efficiency
- Online Update
- Complex Processing

General System Characteristics Cndtd.

- Installation Ease
- Operational Ease
- Multiple Sites
- Facilitate Change

Equations

\[ VAF = 0.65 + \frac{\left( \sum C_i \right)}{100} \]
\[
EFP = \left[ (ADD + CHGA) \times VAFA \right] + (DEL \times VAFB)
\]
<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Complexity of Components Multiplier Factor</th>
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<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>Average</td>
<td>High</td>
</tr>
<tr>
<td>Data Entry Validation</td>
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<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Logical Operations</td>
<td></td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Mathematical Operations</td>
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<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Data Formatting</td>
<td></td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Internal Data Movements</td>
<td></td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>User Interface</td>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total Non-Functional Requirements Size</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Enhancement Project SNAP Points
ESP = ADD + CHG – DEL
COSMIC Software Model
# COSMIC Function Points

<table>
<thead>
<tr>
<th>Functional Processes</th>
<th>Data Groups</th>
<th>Transactions</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP 1</td>
<td>DG 1 ...... DG n</td>
<td>Entry Exit Read Write</td>
<td></td>
</tr>
<tr>
<td>FP 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FP 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>....</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FP n</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Software Totals
Normalized Effort

COCOMO model:

Effort (PM) = 2.94 \times Size^{1.0997} \times \prod_{i=1}^{17} EM_i

PM = 152 \text{ hours}

Normalized Effort (hours) = \frac{\text{Total Effort (hours)}}{\left(\prod EM_i\right)}
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- COSMIC

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Results: IFPUG FPs and SNAP

Adding New Functions
Adding New Functions

Normalized Effort (hrs) = 133.702 + (7.855 \times \text{EFP}) – (0.877 \times \text{ESP})
Results: IFPUG FPs and SNAP

Modifying Existing Functions
Modifying Existing Functions

Normalized Effort (hrs) = 48.701 + (0.305 x EFP) + (6.673 x ESP)

<table>
<thead>
<tr>
<th>ESP or EFP</th>
<th>SNAP Points</th>
<th>Function Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| R²         | 0.767       |
| p-value    | 0.0001      |
| PRED (20)  | 84.211      |
| PRED (25)  | 94.737      |
| PRED (30)  | 100         |
Results: COSMIC FP
Normalized Effort (hrs) = 81.354 + 9.097 \times \text{CFPs}^{1.842}

- Actual Data Points
- Power Regression

<table>
<thead>
<tr>
<th></th>
<th>Actual Data Points</th>
<th>Power Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>R²</td>
<td>0.478</td>
<td></td>
</tr>
<tr>
<td>PRED (20)</td>
<td>44.828</td>
<td></td>
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<tr>
<td>PRED (25)</td>
<td>48.276</td>
<td></td>
</tr>
<tr>
<td>PRED (30)</td>
<td>55.172</td>
<td></td>
</tr>
</tbody>
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Validity Considerations

Internal
- Reported effort may not be accurate
  - Forget to update timesheets
  - Show high productivity
  - Show excessive hours

External
- Segregation between adding functions and modifying functions
  - Test and verify on other datasets
- Linear relationship does not account for diseconomies of scale
  - Analyze on datasets with larger projects for scalable results
- Results might not be repeatable in full-time employee situations

Mitigation
- Members evaluated on ability to meet deadlines, adapt to problems, communicate clearly
Conclusions

- **IFPUG**
  - Function Points: Effective for inputs and outputs with minimal algorithms
  - SNAP: Effective for algorithms and mathematical operations
  - FPs + SNAP: Effective (2 separate models)

- **COSMIC**
  - Does not size data manipulation – algorithms, mathematical operations