Process Oriented Approach to Software Cost Estimation

presented by
Richard E. Fairly
Professor of Information Technology
George Mason University
Fairfax, VA
Cost Estimation Techniques

- Expert Judgment
- Product-Oriented Models
- Work Breakdown Model
Work Breakdown Structure
DEVELOPMENT WBS

Task Structure
## WORK PACKAGE SPECIFICATIONS

<table>
<thead>
<tr>
<th>Activity Number:</th>
<th>27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity Name:</td>
<td>ARCH-SS-XYZ</td>
</tr>
<tr>
<td>Activity Descr:</td>
<td>Specify the architectural structure of subsystem XYZ</td>
</tr>
</tbody>
</table>

| Estimated Duration: | 5 weeks |
| Resources Required: | Personnel: 2 senior telecomm designers |
|                    | 1 half-time secretary/librarian |
|                    | Skills: designers familiar with X25 protocols |
|                    | secretary familiar with Unix libraries |
|                    | Tools: one Sun workstation running IDE |
|                    | one vt100 access to 785 |
|                    | Travel: one 3 day design review in San Diego |

| Risks: availability of senior designers |
| Preconditions: an approved architectural concept for the system |
| Completion Criteria: PDR sign-off for subsystem XYZ |

Personnel Assigned: |
Starting Date: |
Completion Date: |
Cost (budget/actual): |
Legacy Comments:
Work Package Effort Estimates

• Assume a Normal distribution of effort
  • best guess: (50% prob, m)
  • worst case: (95% prob, m + 2*s)

• Calculate completion probabilities

Example

best guess: 12 person-months
worst case: 15 person-months

<table>
<thead>
<tr>
<th>Effort (PM)</th>
<th>Prob of Compl</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.111</td>
</tr>
<tr>
<td>12</td>
<td>0.500</td>
</tr>
<tr>
<td>14</td>
<td>0.889</td>
</tr>
<tr>
<td>16</td>
<td>0.992</td>
</tr>
<tr>
<td>17</td>
<td>0.997</td>
</tr>
</tbody>
</table>
DISTRIBUTION OF EFFORT

Mean = \( E_T = 12 \)

Standard deviation =

\( (V_T)^n = 1.654 \)

\( 3(V_T)^n = 5.0 \)
CUMULATIVE PROBABILITY DISTRIBUTION

cumulative probability

project effort in person-months
PERT ESTIMATES

Optimistic time

Most likely time

Pessimistic time

\[ t_o = \frac{a + 4m + b}{6} = \text{mean} \]

\[ \sqrt{V_t} = \frac{b - a}{3.2} = \text{standard deviation} \]
Effort Distribution Table
Work Package Duration Probabilities

1. Generate the effort distribution table of personnel, P, versus duration, D.

2. Specify the number of personnel, P.

3. Calculate the probability distribution of duration, D, using the effort distribution table.

4. Tabulate (or plot) the cumulative probability of completion for different durations using the specified number of personnel, P.

Work Package Personnel Probabilities

1. Generate the effort distribution table of personnel, P, versus duration, D.

2. Specify the duration, D.

3. Calculate the probability distribution of personnel, P, using the effort distribution table.

4. Tabulate (or plot) the cumulative probability of completion within the specified duration, D, for different numbers of personnel.
Solution Constraints

For Effort = 12 Person-Months, values of P/D are:

\[ P/D = 12/1; 6/2; 4/3; 3/4; 2/6; 1/12 \]

To avoid the Brook's phenomenon, set an upper bound on P/D.

To avoid schedule overrun, set a lower bound on P/D.

Example:

\[ \frac{1}{3} \leq P/D \leq 2 \]
Effort Distribution of a Parent Task

1. The mean, $m$, of the effort distribution for a parent task is the sum of the means of the subtasks.

2. The std. dev., $s$, of the effort distribution for a parent task is the sum of the std. devs. of the subtasks.

People Distribution of a Parent Task

1. Fix the duration of each subtask.

2. Calculate the probability distribution of people for each subtask.

3. For parallel subtasks, the mean of the people distribution for a parent task is the sum of the means of the subtasks and the std. dev. is the sum of the std. devs. of the subtasks.

4. For serial subtasks, the mean of the people distribution for a parent task is the mean of the max worst case subtask and the std. dev. is the std. dev. of the max worst case subtask. (worst case $= m + 2*s$).
Duration Distribution of a Parent Task

1. Fix the number of people for each subtask.

2. Calculate the probability distribution of duration for each subtask.

3. For parallel subtasks, the mean of the duration distribution for a parent task is the mean of the max worst case subtask and the std. dev. is the std. dev. of the max worst case subtask. (worst case = m + 2*s).

4. For serial subtasks, the mean of the duration distribution for a parent task is the sum of the means of the subtasks and the std. dev. is the sum of the std. devs. of the subtasks.
Statistical Concerns

- Independence of random variables
- Validity of using the Normal distribution
- Joint probability distributions
- Estimates vs schedule commitments
Sample Work Breakdown Structure

PROCES Project

Requirements

Data Flow Diagrams
dsi = 300
dsi = 800
200
dsi = 600
100
dsi = 400
eff = 30
eff = 80
20
staff = 5
duration = 10
10
staff = 2
duration = 5

Proto-type

Design

Arch. Design

dsi = 300
dsi = 800
200
dsi = 600
100
dsi = 400
eff = 30
eff = 80
20
staff = 5
duration = 10
10
staff = 2
duration = 5

Detailed Design

Code

WBS

dsi = 800
dsi = 300
600
dsi = 200
400
dsi = 100
eff = 80
eff = 30
60
staff = 5
duration = 5
40
staff = 2
duration = 5
10
staff = 5
duration = 5

Cost

Estimate
Figure 1: Touring the PROCES Window
**Figure 4:** Go State Report Format

<table>
<thead>
<tr>
<th>Current Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable to Estimate: EFFORT</td>
</tr>
<tr>
<td>Calculation Mode: PROBABILISTIC</td>
</tr>
<tr>
<td>Estimate 5% $\rightarrow$ 10.5</td>
</tr>
<tr>
<td>Estimate 30% $\rightarrow$ 40.0</td>
</tr>
<tr>
<td>Estimate 50% $\rightarrow$ 60.5</td>
</tr>
<tr>
<td>Estimate 70% $\rightarrow$ 88.9</td>
</tr>
<tr>
<td>Estimate 95% $\rightarrow$ 107.6</td>
</tr>
</tbody>
</table>

Welcome to Go State
Quit Help HereCalc Copy_To_File
**Current Parameters**

Variable to Estimate: EFFORT  
Calculation Mode: PROBABILISTIC

Estimation Value = 56  
Probability Value = 0.8

Welcome to MoreCalc State

 Quit Help Probability Value Copy_To_File

---

**Figure 5:** MoreCalc State Report Format