

TOPICS

Overview

Metrics

Estimation

Planning

SOFTWARE PROJECT ESTIMATION

- **Overview**
- **Resources**
- **Decomposition Techniques**
- **Using LOC or FP to Estimate Effort**
- **Effort Estimation by Function**
- **Effort Estimation by Task**
- **Empirical Estimation Models**
- **COCOMO**
- **Putman Estimation Model**

Overview

Estimation of:

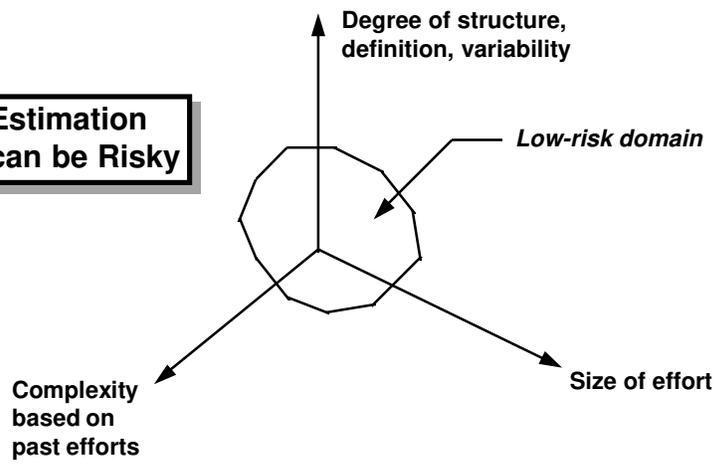
- resources
- costs
- schedules

Requires:

- experience
- historical information
- quantitative measures of qualitative data

Overview, Continued

**Estimation
can be Risky**



Resources

Planning Task 1: Software Scope

1. Statement of software scope must be bounded

2. Software scope describes:

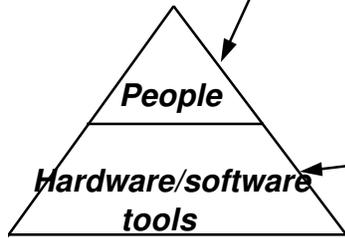
- ☐ function
 - ☐ performance
 - ☐ constraints
 - ☐ interfaces
 - ☐ reliability
- evaluated together*
-
- ```
graph LR; f[function] --> e[evaluated together]; p[performance] --> e; c[constraints] --> e;
```

## Resources, Continued

**Planning Task 2:  
Estimation of  
Needed  
Resources**

Specify:

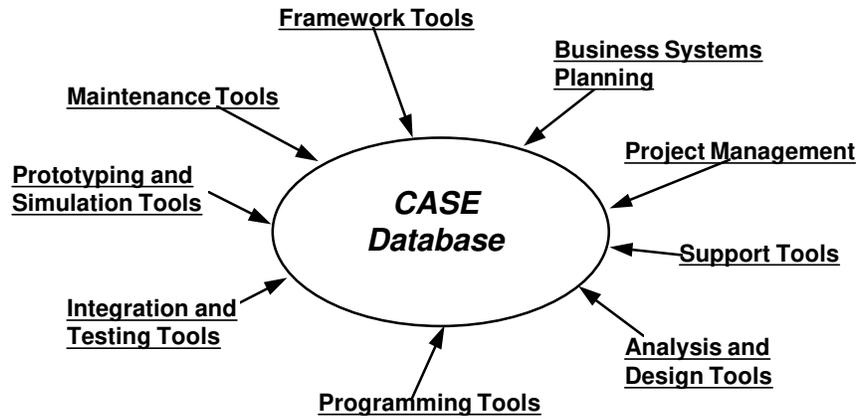
- Required skills
- Availability
- Duration of tasks
- Start date



Specify:

- Description
- Availability
- Duration of use
- Delivery date

## Resources, Continued



**CASE - Computer-Aided Software Engineering**

## Resources, Continued

### Reuse - A Resource

Two rules:

1. If existing software meets requirements, then

**acquire and use it!**

2. If existing software can meet requirements with some modification, then

**be careful!**

**The cost of modification can exceed the cost of new development!**

## Decomposition Techniques

- LOC and FP Estimation
- Effort Estimation

## Decomposition Techniques, Continued

### LOC and FP Estimation

The idea is that the person planning the software project:

- creates a bounded statement of the scope of the software
- decomposes the scope into smaller subfunctions
- estimates LOC or FP for each subfunction
- applies baseline productivity metrics (e.g., LOC/person-month) to LOC or FP estimates to produce a cost or effort estimate for each subfunction
- combines estimates for each subfunction to derive estimates for the entire project

## Decomposition Techniques, Continued

### Differences Between LOC and FP

- FP estimation techniques require less detail than LOC
- LOC is estimate directly while FP is estimated indirectly

## Using LOC or FP to Estimate Effort

1. Estimate LOC or FP values for each subfunction
  - Use historical data (or intuition, if necessary)
  - Three estimates: optimistic (o), most likely (m), and pessimistic (b)
2. Calculate expected value for each subfunction  $E = \frac{a + 4m + b}{6}$
3. Apply productivity data to get effort to be expended; two ways:
  1. Total expected LOC or FP for all subfunctions and divide this by the expected LOC or FP completed per person-month (estimated from past projects); example:  
$$\text{Effort} = 310 \text{ expected FP for project} / 5.5 \text{ expected FP per person-month}$$
$$= 56 \text{ person-months}$$
  2. Multiply each subfunction LOC or FP by the adjusted productivity value (based on the estimated complexity of the function) and sum the results for all subfunctions in the project

## Effort Estimation by Function

### CAD Program Example

| <i>Function</i>         | <i>Optimistic</i> | <i>Most Likely</i> | <i>Pessimistic</i> | <i>Expected</i> | <i>\$/Line</i> | <i>Line/Month</i> | <i>Cost</i> | <i>Months</i> |
|-------------------------|-------------------|--------------------|--------------------|-----------------|----------------|-------------------|-------------|---------------|
| User interface control  | 1800              | 2400               | 2650               | 2,340           | \$14           | 315               | \$ 32,760   | 7.4           |
| 2-D geometric analysis  | 4100              | 5200               | 7400               | 5,380           | \$20           | 220               | \$107,600   | 24.4          |
| 3-D geometric analysis  | 4600              | 6900               | 8600               | 6,800           | \$20           | 220               | \$136,000   | 30.9          |
| Data structure mgmt     | 2950              | 3400               | 3600               | 3,350           | \$18           | 240               | \$ 60,300   | 13.9          |
| Graphics display        | 4050              | 4900               | 6200               | 4,950           | \$22           | 200               | \$108,900   | 24.7          |
| Peripheral control      | 2000              | 2100               | 2450               | 2,140           | \$28           | 140               | \$ 59,920   | 15.2          |
| Design analysis         | 6600              | 8500               | 9800               | 8,400           | \$18           | 300               | \$151,200   | 28.0          |
| <b>Estimated Effort</b> |                   |                    |                    | 33,360          |                |                   | \$656,680   | 144.5         |

**Estimated Cost: \$ 656,680**

**Estimated Effort: 144.5 person-months**

## Effort Estimation by Task

### CAD Program Example

| <i>Function</i>        | <i>RA</i>     | <i>Design</i>  | <i>Code</i>    | <i>Test</i>    | <i>Total</i>   |
|------------------------|---------------|----------------|----------------|----------------|----------------|
| User interface control | 1.0           | 2.0            | 0.5            | 3.5            | 7.0            |
| 2-D geometric analysis | 2.0           | 10.0           | 4.5            | 9.5            | 26.0           |
| 3-D geometric analysis | 2.5           | 12.0           | 6.0            | 11.0           | 31.5           |
| Data structure mgmt    | 2.0           | 6.0            | 3.0            | 4.0            | 15.0           |
| Graphics display       | 1.5           | 11.0           | 4.0            | 10.5           | 27.0           |
| Peripheral control     | 1.5           | 6.0            | 3.5            | 5.0            | 16.0           |
| Design analysis        | 4.0           | 14.0           | 5.0            | 7.0            | 30.0           |
| <b>Total</b>           | <b>14.5</b>   | <b>61.0</b>    | <b>26.5</b>    | <b>50.5</b>    | <b>152.5</b>   |
| <b>Rate (\$)</b>       | <b>5200</b>   | <b>4800</b>    | <b>4250</b>    | <b>4500</b>    |                |
| <b>Cost (\$)</b>       | <b>75,400</b> | <b>292,800</b> | <b>112,625</b> | <b>227,250</b> | <b>708,075</b> |

**Estimated Cost: \$ 708,075**

**Estimated Effort: 152.5 person-months**

## Empirical Estimation Models

- **Static single-variable model (example: COCOMO)**

$$\text{Resource} = cx^d$$

where

x is the estimated characteristic (LOC, FP, effort, etc.)

c and d are constants derived from data collected from past projects

- **Static multivariable model**

$$\text{Resource} = cx + dy + \dots$$

where

x, y, ... and c, d, ... are as above

- **Dynamic multivariable model**

Project resource requirements are determined over a series of time steps

- **Theoretical (example: Putman Estimation Model)**

Uses equations derived from hypothesized expenditure curves

## COCOMO

- Involves basic, intermediate, and advanced models
- Basic model:

$$\text{Effort} = a(b)KLOC^{b(b)} \text{ person - months}$$

$$\text{Development _ Time} = c(b)\text{Effort}^{d(b)} \text{ months}$$

$a(b)$ ,  $b(b)$ ,  $c(b)$ , and  $d(b)$  are determined from the table:

| <i>Software Project</i> | <i>a(b)</i> | <i>b(b)</i> | <i>c(b)</i> | <i>d(b)</i> |
|-------------------------|-------------|-------------|-------------|-------------|
| Organic                 | 2.4         | 1.05        | 2.5         | 0.38        |
| Semidetached            | 3.0         | 1.12        | 2.5         | 0.35        |
| Embedded                | 3.6         | 1.20        | 2.5         | 0.32        |

## COCOMO, Continued

Example of COCOMO basic model on the CAD program:

$$\text{Effort} = 3.0 (\text{LOC})^{1.12}$$

$$= 3.0 (33.3)^{1.12}$$

$$= 152 \text{ person-months}$$

$$\text{Development Time} = 2.5 (\text{Effort})^{0.35}$$

$$= 2.5 (152)^{0.35}$$

$$= 14.5 \text{ months}$$

Thus, estimated number of people N is:

$$N = \text{Effort} / \text{Development Time}$$

$$= 152 / 14.5$$

$$= 11 \text{ people}$$

## Putman Estimation Model

- Data is derived from large projects
- Model is applicable to smaller projects as well
- The distribution of effort is described by the Rayleigh-Norden curve

