Topics:

- Software Cost Estimation Model: COCOMO Model

COCOMO Model

Boehm proposed COCOMO (Constructive Cost Model) in 1981. The COCOMO is one of the most generally used software estimation models in the world. COCOMO predicts the efforts and schedule of a software product based on the size of the software.

The necessary steps in this model are:

1. Get an initial estimate of the development effort from evaluation of thousands of delivered lines of source code (KDLOC).
2. Determine a set of 15 multiplying factors from various attributes of the project.
3. Calculate the effort estimate by multiplying the initial estimate with all the multiplying factors i.e., multiply the values in step1 and step2.

The initial estimate (also called nominal estimate) is determined by an equation of the form used in the static single variable models, using KDLOC as the measure of the size. To determine the initial effort E_i in person-months is shown below:

$$E_i = a*(KDLOC)^b$$

The value of the constant a, and b are depends on the project type.

In COCOMO, projects are categorized into three types:

1. Organic
2. Semidetached
3. Embedded

1. Organic:

A development project can be treated of the organic type, if the project deals with developing a well-understood application program, the size of the development team is reasonably small, and the team members are experienced in developing similar methods of projects. Examples of this type of projects are simple business systems, simple inventory management systems, and data processing systems.

2. Semidetached:

A development project can be treated with semidetached type if the development consists of a mixture of experienced and inexperienced staff. Team members may have finite experience in related systems but may be unfamiliar with some aspects of the order being developed. **Example of Semidetached system includes developing a new operating system (OS), a Database Management System (DBMS), and complex inventory management system.**

3. Embedded:

A development project is treated to be of an embedded type, if the software being developed is strongly coupled to complex hardware. For Example: ATM, Air Traffic control.

For three product categories, Bohem provides a different set of expression to predict effort (in a unit of person month) and development time from the size of estimation in KLOC(Kilo Line of code) efforts estimation takes into account the productivity loss due to holidays, weekly off, coffee breaks, etc.

According to Boehm, software cost estimation should be done through three stages:

1. Basic Model
2. Intermediate Model
3. Detailed Model

1. **Basic COCOMO Model:**

The basic COCOMO model provides an accurate size of the project parameters. The following expressions give the basic COCOMO estimation model:

Effort = a_1*(KLOC)^{a2} PM

Tdev=b_1*(Efforts)^{b2} Months

Where, **KLOC** is the estimated size of the software product indicate in Kilo Lines of Code, a_1,a_2, b_1, b_2 are constants for each group of software products,

Tdev is the estimated time to develop the software, expressed in months,

Effort is the total effort required to develop the software product, expressed in **person months (PMs)**.

Estimation of development effort

For the three classes of software products, the formulas for estimating the effort based on the code size are shown below:

Organic: Effort = $2.4(KLOC)^{1.05}$ Person-Months

Semi-detached: Effort = $3.0(KLOC)^{1.12}$ Person-Months

Embedded: Effort = $3.6(KLOC)^{1.20}$ Person-Months

Estimation of development time

For the three classes of software products, the formulas for estimating the development time based on the effort are given below:

Organic: Tdev = $2.5(Effort)^{0.38}$ Months

Semi-detached: Tdev = $2.5(Effort)^{0.35}$ Months

Embedded: Tdev = $2.5(Effort)^{0.32}$ Months

Example 1: Suppose a project was estimated to be 400 KLOC. Calculate the effort and development time for each of the three model i.e., organic, semi-detached & embedded.

Solution: The basic COCOMO equation takes the form:

$Effort=a_1*(KLOC)^{a2}$ Person-Months
$Tdev=b_1*(efforts)^{b2}$ Months
Estimated Size of project= 400 KLOC

(i) Organic Mode

$E = 2.4 * (400)^{1.05} = 1295.31$ Person-Months

$D = 2.5 * (1295.31)^{0.38}=38.07$ Months

(ii) Semidetached Mode

$E = 3.0 * (400)^{1.12} = 2462.79$ Person-Months
$D = 2.5 * (2462.79)^{0.35} = 38.45$ Months

(iii) Embedded Mode

$E = 3.6 * (400)^{1.20} = 4772.81$ Person-Months
$D = 2.5 * (4772.8)^{0.32} = 38$ months

Example 2: A project size of 200 KLOC is to be developed. Software development team has average experience on similar type of projects. The project schedule is not very tight. Calculate the Effort, development time, average staff size, and productivity of the project.

Solution: The semidetached mode is the most appropriate mode, keeping in view the size, schedule and experience of development time.

Hence $E=3.0(200)^{1.12}=1133.12$ PM

$D=2.5(1133.12)^{0.35}=29.3$ PM

$$\text{Average Staff Size (SS)} = \frac{E}{D} \text{ Persons}$$

$$= \frac{1133.12}{29.3} = 38.67 \text{ Persons}$$

$$\text{Productivity} = \frac{KLOC}{E} = \frac{200}{1133.12} = 0.1765 \text{ KLOC/PM}$$

COCOMO Model

P = 176 LOC/PM