COCOMO Model

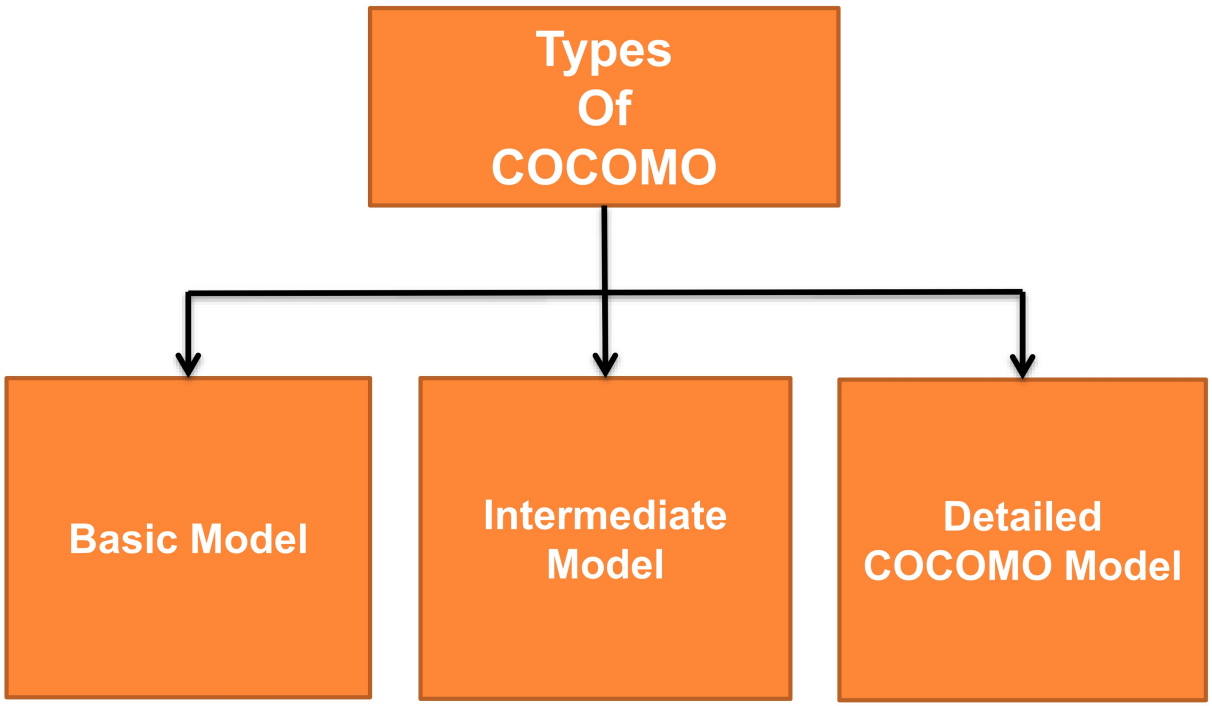
Wednesday, October 7, 2020 7:02 AM

Constructive Cost Model (COCOMO)

Definition:-

B.W. Boehm Introduced COCOMO model in his book Software Engineering Economics in 1981 COCOMO is a hierarchy of cost estimation models it includes basic , intermediate and detailed sub model.

Topic :- Constructive Cost Model (COCOMO)



Topic :- Constructive Cost Model (COCOMO)

BASIC MODEL

The basic model aims at estimating, in a quick and rough fashion, most of the small to medium sized software projects. Three modes of software development are considered in this model:

Organic: A small team of experienced developers develops software in a very familiar environment.

Embedded: The project has tight constraints, which might be related to the target processor.

Semidetached: It is an intermediate mode between the organic mode and embedded mode.

Depending on the problem at hand, the team might include a mixture of experienced and less experienced people with only a recent history of working together.

Topic :- Constructive Cost Model (COCOMO)

Comparison of three COCOMO modes

Mode	Project Size	Nature of Project	Innovation	Deadline of the Project	Development Environment
Organic	Typically 2 – 50 KLOC	Small Size Projects, experienced developers.	Little	Not tight	Familiar And In house
Semi-Detached	Typically 50 – 300 KLOC	Medium size project, average previous experience on similar projects.	Medium	Medium	Medium
Embedded	Typically over 300 KLOC	Large projects, complex interfaces, very little previous experience.	Significant	Tight	Complex Hardware / Customer interfaces required

Topic :- Constructive Cost Model (COCOMO)

The Basic COCOMO equations take the form:

$E = a_b (KLOC)^{bb}$

$D = c_b (E)^{db}$

$SS = E/D$ persons

$P = KLOC/E$

E = effort
D = Deployment time
SS = staff size
P = productivity
a_b, b_b, c_b, d_b = Coefficients

Basic COCOMO Co- efficients

Project	a_b	b_b	c_b	d_b
Organic mode	2.4	1.05	2.5	0.38
Semidetached mode	3.0	1.12	2.5	0.35
Embedded mode	3.6	1.20	2.5	0.32

Example :

Suppose that a project was estimated to be 400 KLOC. Calculate the effort and development time for each of the three modes i.e. organic , semidetached and embedded.

Solution The basic COCOMO equations take the form:

$$E = a_b (KLOC)^{bb}$$

$$D = c_b (E)^{db}$$

Estimated size of the project = 400 KLOC

1. **Organic Mode**

$$E = 2.4 (400)^{1.05} = 1295.31 \text{ PM}$$

$$D = 2.5 (1295.31)^{0.38} = 38.07 \text{ M}$$

2. **Semi detached Mode**

$$E = 3.0 (400)^{1.12} = 2462.79 \text{ PM}$$

$$D = 2.5 (2462.79)^{0.35} = 38.45 \text{ M}$$

3. **Embedded Mode**

$$E = 3.6 (400)^{1.20} = 4772.81 \text{ PM}$$

$$D = 2.5 (4772.81)^{0.32} = 37.59 \text{ M}$$

Topic :- Constructive Cost Model (COCOMO)

INTERMEDIATE MODEL

In the Intermediate model Boehm introduced an additional set of 15 predictors called cost drivers in the intermediate model to take account of the software development environment. Cost drivers are used to adjust the nominal cost of a project to the actual project environment, hence increasing the accuracy of the estimate.

The cost drivers are grouped into 4 categories:-

1. Product attributes
    a. Required software reliability (RELY)
    b. Database size (DATA)
    c. Product complexity (CPLX)
2. Computer attributes
    a. Execution time constraint (TIME)
    b. Main store constraint (STOR)
    c. Virtual machine volatility (VIRT)
    d. Computer turnaround time (TURN)

Topic :- Constructive Cost Model (COCOMO)

3. Personnel attributes
    a. Analyst capability (ACAP)
    b. Application experience (AEXP)
    c. Programmer capability (PCAP)
    d. Virtual machine experience (VEXP)
    e. Programming Language experience (LEXP)
4. Project attributes
    a. Morden programming practices (MODP)
    b. Use of software tool (TOOL)
    c. Required development schedule (SCED)

Each cost driver is rated for a given project environment. The rating uses a scale very low, low, nominal, high, very high, extra high which describes to what extent the cost driver applies to the project being estimated.

Topic :- Constructive Cost Model (COCOMO)

Multiplier Values For Effort Calculations

Cost Drivers	Ratings					
	Very Low	Low	Nominal	High	Very High	Extra High
Product attributes						
RELY	0.75	0.88	1.00	1.15	1.40	-
DATA	-	0.94	1.00	1.08	1.16	-
CPLX	0.70	0.85	1.00	1.15	1.30	1.65
Computer attributes						
TIME	-	-	1.00	1.11	1.30	1.66
STOR	-	-	1.00	1.06	1.21	1.56
VIRT	-	0.87	1.00	1.15	1.30	-
TURN	-	0.87	1.00	1.07	1.15	-

Topic :- Constructive Cost Model (COCOMO)

Multiplier Values For Effort Calculations

Cost Drivers	Ratings					
	Very Low	Low	Nominal	High	Very High	Extra High
Personnel attributes						
ACAP	1.46	1.19	1.00	0.86	0.71	-
AEXP	1.29	1.13	1.00	0.91	0.82	-
PCAP	1.42	1.17	1.00	0.86	0.70	-
VEXP	1.21	1.10	1.00	0.90	-	-
LEXP	1.14	1.07	1.00	0.95	-	-
Project attributes						
MODP	1.24	1.10	1.00	0.91	0.82	-
TOOL	1.24	1.10	1.00	0.91	0.83	-
SCED	1.23	1.08	1.00	1.04	1.10	-

Topic :- Constructive Cost Model (COCOMO)

The Intermediate COCOMO equations take the form:

$E = a_i (KLOC)^{bi} * EAF$

$D = c_i (E)^{di}$

SS = E/D persons

P = KLOC/E

EAF = Effort Adjustment factor
E = effort
D = Deployment time
SS = staff size
P = productivity
a_i , b_i , c_i , d_i = Coefficients

Co- efficients for Intermediate COCOMO

Project	a_i	b_i	c_i	d_i
Organic mode	3.2	1.05	2.5	0.38
Semidetached mode	3.0	1.12	2.5	0.35
Embedded mode	2.8	1.20	2.5	0.32

Topic :- Constructive Cost Model (COCOMO)

Example :

A new project with estimated 400 KLOC embedded system has to be developed. Project manager has a choice of hiring from two pools of developers : with very high application experience and very little experience in the programming language being used or developers of very low application experience but a lot of experience with the programming language. What is the impact of hiring all developers from one or the other pool.

Solution

This is the case of embedded mode

Hence $E = a_i (KLOC)^{b_i} * EAF$ $D = c_i (E)^{d_i}$

Case 1: Developers are with very high application experience and very little experience in the programming language being used.

$EAF = 0.82 * 1.14 = 0.9348$

$E = 2.8(400)^{1.20} * 0.9348 = 3470$ PM

$D = 2.5 (3470)^{0.32} = 33.9$ M

Case 2: developers of very low application experience but a lot of experience with the programming language.

$EAF = 1.29 * 0.95 = 1.22$

$E = 2.8 (400)^{1.20} * 1.22 = 4528$PM

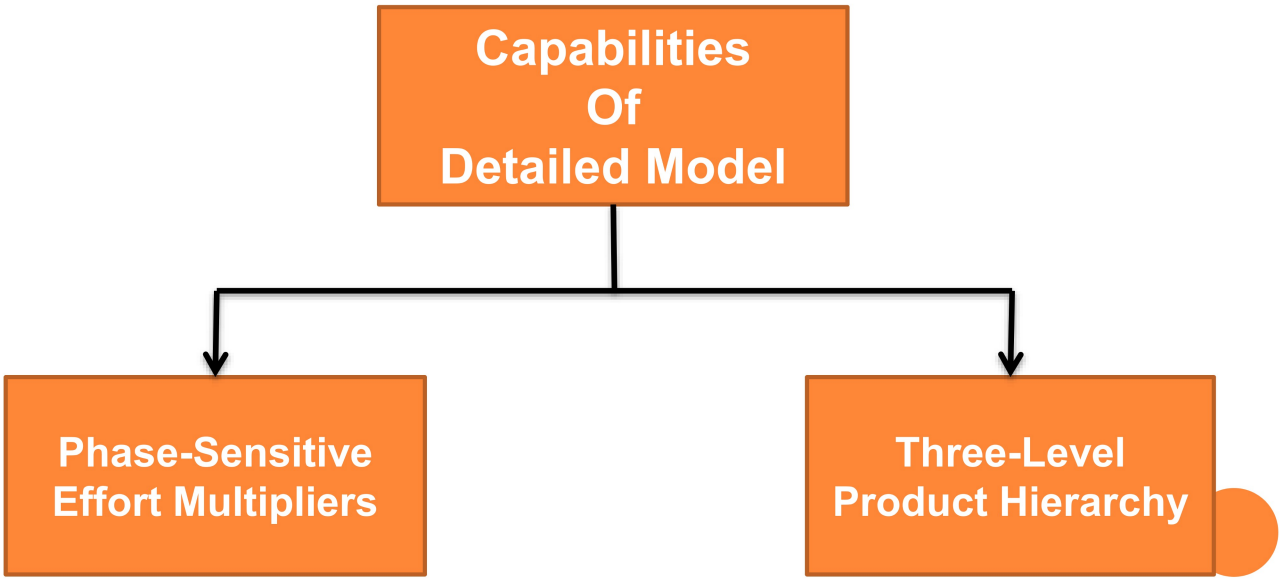
$D = 2.5 (4528)^{0.32} = 36.9$ M

Case 2 requires more effort and time. Hence, low quality application experience but a lot of programming language experience could not match with the very high application experience and very little programming language experience.

Topic :- Constructive Cost Model (COCOMO)

DETAILED COCOMO MODEL

A large amount of work is done by Boehm to capture all significant aspects of a software development. It offers a means for processing all the project characteristics to construct a software estimate.



Phase-Sensitive Effort Multipliers:

Some phases (design, programming, integration/test) are more affected than others by factors defined by the cost drivers. This helps in determining the man power allocation for each phase of the project.

Three-Level Product Hierarchy:-

Three product levels are defined. These are module, subsystem and system levels. The rating of the cost drivers are done at appropriate level; that is, the level at which it is most susceptible to variation.

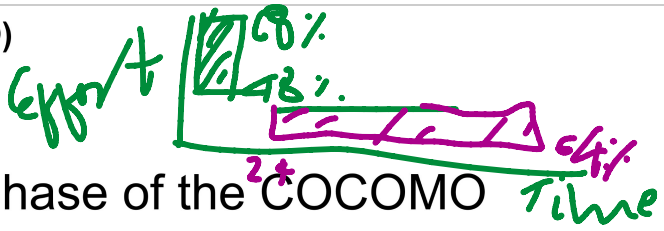
DEVELOPMENT PHASE

A software development is carried out in four successive phases:-

1. **Plan/ requirements:** This is the first phase of the development cycle. The requirement is analyzed, the product plan is set up and a full product specification is generated. This phase consumes from 6% to 8% of the effort and 10% to 40% of the development time.

2. **Product Design:** The second phase of the COCOMO development cycle is concerned with the determination of the product architecture and the specification of the subsystem. This phase requires from 16% to 18% of the nominal effort and can last from 19% to 38% of the development time.

Topic :- Constructive Cost Model (COCOMO)



3. **Programming:** The third phase of the COCOMO development cycle is divided into two sub phases: detailed design and code/unit test. This phase requires from 48% to 68% of the effort and lasts from 24% to 64% of the development time.

4. **Integration/test:** This phase of the COCOMO development cycle occurs before delivery. This mainly consist of putting the tested parts together and then testing the final product this phase requires from 16% to 34% of the nominal effort and can last from 18% to 34% of the development time

this phase requires from 16% to 34% of the nominal effort and can last from 18% to 34% of the development time.

Topic :- Constructive Cost Model (COCOMO)

Effort and schedule fractions occurring in each phase of lifecycle

Mode and code size	Plan and requirement	System design	Detail design	Module code and test	Integration and test
Lifecycle Phase Value of μ_b					
Organic Small S ≈ 2	0.06	0.16	0.26	0.42	0.16
Organic Medium S ≈ 32	0.06	0.16	0.24	0.38	0.22
Semidetached Medium S ≈ 32	0.07	0.17	0.25	0.33	0.25
Semidetached Large S ≈ 128	0.07	0.17	0.24	0.31	0.28
Embedded Large S ≈ 128	0.08	0.18	0.25	0.26	0.31
Embedded Extra Large S ≈ 320	0.08	0.18	0.24	0.24	0.34
Lifecycle Phase Value of □$_b$					
Organic Small S ≈ 2	0.10	0.19	0.24	0.39	0.18
Organic Medium S ≈ 32	0.12	0.19	0.21	0.34	0.26
Semidetached Medium S ≈ 32	0.20	0.26	0.21	0.27	0.26
Semidetached Large S ≈ 128	0.22	0.27	0.19	0.25	0.29
Embedded Large S ≈ 128	0.36	0.36	0.18	0.18	0.28
Embedded Extra Large S ≈ 320	0.40	0.38	0.16	0.16	0.30

Topic :- Constructive Cost Model (COCOMO)

The Detailed COCOMO equations take the form:

$E = a_i (KLOC)^{bi} * EAF$
$D = c_i (E)^{di}$
$E_p = \mu_p E$
$D_p = \square_p D$
SS = E/D persons
P = KLOC/E

EAF = Effort Adjustment factor
E = effort
D = Deployment time
SS = staff size
P = productivity
μ_p = Used for effort
$\square_p$ = Used for schedule

Topic :- Constructive Cost Model (COCOMO)

Example :

Consider a project to develop a full screen editor. The major components identified are (1) Screen edit, (2) Command Language Interpreter, (3) File input and output, (4) Cursor movement and (5) Screen movement. The sizes for these are estimated to be 4K, 2K, 1K, 2K and 3K delivered source code lines. Use COCOMO model to determine:

(a) Overall cost and schedule estimates (assume values for different cost drivers, with at least three of them being different from 1.0).

(b) Cost and schedule estimates for different phases.

Solution

Size of 5 modules are:-

Screen edit	= 4KLOC
Command Language Interpreter	= 2KLOC
File input and output	= 1KLOC
Cursor movement and	= 2KLOC
Screen movement	= 3KLOC
total	**= 12KLOC**

Topic :- Constructive Cost Model (COCOMO)

Let us assume that significant cost drivers are

(1) Required software reliability is high i.e.	1.15
(2) Product complexity is high i.e.	1.15
(3) Analyst capability is high i.e.	0.86
(4) All other drivers are nominal i.e.	1.00

Hence

$$EAF = 1.15 * 1.15 * 0.86 = 1.1373$$

(a) The initial effort estimate for the project

$$E = a_i (KLOC)^{bi} * EAF$$

$$=3.2(12)^{1.05} * 1.1373 = 49.449 \text{ PM}$$

$$D = c_i (E)^{di}$$

$$= 2.5(49.44)^{0.38} = 11.007 \text{ M}$$

Topic :- Constructive Cost Model (COCOMO)

(b) Phase wise cost and schedule estimates

$$E_p = \mu_p E$$

$$D_p = \square_p D$$

Since size is only 12 KLOC, it is an organic small model.

Phase wise effort distribution is given below:

System Design = 0.16 * 49.449 = 7.911
Detailed Design = 0.26 * 49.449 = 12.856
Module code and test = 0.42 * 49.449 = 20.768
Integration and test = 0.16 * 49.449 = 7.911

Phase wise development time duration is:

System Design = 0.19 * 11.007 = 2.091
Detailed Design = 0.24 * 11.007 = 2.641
Module code and test = 0.39 * 11.007 = 4.292
Integration and test = 0.18 * 11.007 = 1.981