

COCOMO – I Model of Estimation

COCOMO – I Model

- Constructive Cost Model.
- Proposed by Barry Boehm in 1981.
- Good for software engineering started using OOD (Object Oriented Development), component technology, reusable strategy and automated tool for code generation, testing etc.
- COCOMO model uses exponential components in estimation as the size of the software increases, the development team size increases. Increasing system development overhead namely communication, configuration management, integration etc.

COCOMO – I Model ...

- COCOMO considers software product attributes, development team attributes and project management attributes and weigh them suitably to improve the estimation.
- The latest version of COCOMO is COCOMO-II, released in 1997. The model used 161 data points and uses Bayesian Statistical Analysis of Empirical Data of completed project and expert opinion.
- Regression model based on LOC i.e. number of Lines of Code.
- Procedural Cost Estimate Model for Software Projects.

COCOMO – I Model ...

- Used as the process of reliably predicting the various parameters associated with making a project like
 - Size
 - Effort
 - Cost
 - Time
 - Quality

COCOMO – I Model ...

- COCOMO is one of the most generally used software estimation models
- COCOMO predicts the efforts and schedule of a software product based on the size of the software

Types of Projects in COCOMO – I Model

- Organic
- Semidetached
- Embedded

Organic Projects in COCOMO – I Model

- The project deals with developing a well-understood application program
- The size of the development team is reasonably small
- Team members are experienced in developing similar types of projects
- Examples are
 - Business System
 - Inventory Management System
 - Data Processing System

Semidetached Projects in COCOMO – I Model

- The development consists of a mixture of experienced and inexperienced staff.
- Team members may have limited experience in related systems but may be unfamiliar with some aspects of the order being developed.
- Example are
 - Developing a new Operating System (OS)
 - Database Management System (DBMS)
 - Complex Inventory Management System

Embedded Projects in COCOMO – I Model

- The software being developed is strongly coupled to complex hardware
- Stringent regulations on the operational method exist
- Examples are
 - ATM
 - Air Traffic Control System

Projects in COCOMO – I Model

- Boehm 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
 - Refreshment breaks etc.

Cost Factors in COCOMO – I Model

- The cost factors are divided into four categories.
- They are
 - Product
 - Hardware
 - Personnel
 - Project

Attributes of Cost Factors in COCOMO – I Model

- Product b_1
 - Required software reliability extent
 - Size of the application database
 - The complexity of the product
- Hardware i.e. b_2
 - Run-time performance constraints
 - Memory constraints
 - The volatility of the virtual machine environment
 - Required turnabout time

Attributes of Cost Factors in COCOMO – I Model ...

- Personnel i.e. a_1
 - Analyst capability
 - Software engineering capability
 - Applications experience
 - Virtual machine experience
 - Programming language experience
- Project i.e. a_2
 - Use of software tools
 - Application of software engineering methods
 - Required development schedule

Attributes of Cost Factors in COCOMO – I Model ...

Product Attributes						
	Very Low	Low	Normal	High	Very High	Extra High
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

Attributes of Cost Factors in COCOMO – I Model ...

Hardware Attributes						
	Very Low	Low	Normal	High	Very High	Extra High
TIME			1.00	1.11	1.30	1.66
STOR			1.00	1.06	1.21	1.56
VIRT/ VOL		0.87	1.00	1.15	1.30	
TURN		0.87	1.00	1.07	1.15	

Attributes of Cost Factors in COCOMO – I Model ...

Personal Attributes						
	Very Low	Low	Normal	High	Very High	Extra High
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		

Attributes of Cost Factors in COCOMO – I Model ...

Project Attributes						
	Very Low	Low	Normal	High	Very High	Extra High
MODP	1.24	1.10	1.00	0.91	0.82	
TOOL	1.24	1.10	1.00	0.91	0.83	
SECD	1.24	1.10	1.00	1.04	1.10	

COCOMO – I Model

- Boehm says that the , software cost estimation should be done through three stages
 - Basic Model
 - Intermediate Model
 - Detailed Model

Basic Model

- The basic COCOMO model provide an accurate size of the project parameters.
- The expressions for the basic COCOMO estimation model are
 - **Effort**= a_1 *(**KLOC**) * a_2 Man Month Effort (or Person Month)
 - T_{dev} = b_1 *(**Effort**)* b_2 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

Basic Model ...

- T_{dev} is the estimated time to develop the software, expressed in months
- Effort is the total effort required to develop the software product, expressed in Man Month Effort or Person Month (PM).

Basic Model: Estimation of Development Effort

- The expression for the estimation of the effort based on the code size are
 - Organic
 - Effort = $2.4 * (\text{KLOC}) * 1.05$ MME or PM
 - Semi-detached
 - Effort = $3.0 * (\text{KLOC}) * 1.12$ MME or PM
 - Embedded
 - Effort = $3.6 * (\text{KLOC}) * 1.20$ MME or PM

Basic Model: Estimation of Development Time

- The expression for the estimation of the development time based on the effort are
 - Organic
 - $T_{dev} = 2.5 * (Effort) * 0.38$ Months
 - Semi-detached
 - $T_{dev} = 2.5 * (Effort) * 0.35$ Months
 - Embedded
 - $T_{dev} = 2.5 * (Effort) * 0.32$ Months

Basic Model: Estimation of Development Time

- Suppose a project was estimated to be 500 KLOC. Calculate the effort and development time for each of the three model i.e., organic, semi-detached & embedded.
 - Organic
 - Effort = $2.4 * (500) * 1.05$ MME or PM = 1260
 - Organic
 - $T_{dev} = 2.5 * (1260) * 0.38$ Months = 1197

Intermediate Model

- The basic COCOMO model considers that the effort is only a function of the number of lines of code and some constants calculated according to the various software systems.
- The intermediate COCOMO model recognizes these facts and refines the initial estimates obtained through the basic COCOMO model by using a set of 15 cost factors based on various attributes of software engineering.

Intermediate Model ...

- Intermediate COCOMO equation:
- $\text{Effort} = a_i * (\text{KLOC})^{b_i} * \text{EAF}$
- $\text{Development Time} = c_i * (\text{Effort})^{d_i}$

Intermediate Model ...

Project	a_i	b_i	c_i	d_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

Cost Attributes

- Product Attributes
- Hardware Attributes
- Personnel Attributes
- Project Attributes

Product Attributes

- Required software reliability extent
- Size of the application database
- The complexity of the product

Hardware Attributes

- Run-time performance constraints
- Memory constraints
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- Required turnabout time

Personnel Attributes

- Analyst capability
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- Applications experience
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- Programming language experience

Project Attributes

- Use of software tools
- Application of software engineering methods
- Required development schedule

Detailed COCOMO Model

- Detailed COCOMO incorporates all qualities of the standard version with an assessment of the cost drivers effect on each method of the software engineering process.
- The detailed model uses various effort multipliers for each cost driver property.
- In detailed COCOMO, the whole software is differentiated into multiple modules, and then we apply COCOMO in various modules to estimate effort and then sum the effort.
- The Six phases of detailed COCOMO are:

Detailed COCOMO Model ...

- The Six phases of detailed COCOMO are:
 - Planning and Requirements
 - System Structure
 - Complete Structure
 - Module Code and Testing
 - Integration and Testing
 - Cost Constructive Model

Detailed COCOMO Model ...

- The effort is determined as a function of program estimate, and a set of cost drivers are given according to every phase of the software lifecycle.

Working of COCOMO – I Model

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