Bahria University-Karachi Campus

Software Project Management

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Week 11

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WEEK 11 - AGENDA

- Intermediate Constructive Cost Model (COCOMO)

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CONSTRUCTIVE COST MODEL

- COCOMO is a model used in software engineering to estimate the *cost*, effort, and duration of a software development project.
- Developed by Barry Boehm in the 1970s, it helps in predicting the effort and cost required for a software project based on various parameters such as size, complexity, and other factors.

CONSTRUCTIVE COST MODEL

- COCOMO has three variations:
  1. Basic COCOMO: This model estimates the effort based on the size of the software to be developed.
  2. Intermediate COCOMO: It considers various project attributes and cost drivers to estimate effort and schedule.
  3. Detailed COCOMO: This is a more complex model, taking into account a higher number of project parameters to create a more accurate estimation.
- These models help in providing a framework for project managers to understand the resources required for software development, aiding in better planning and management.

CONSTRUCTIVE COST MODEL

- COCOMO (Constructive Cost Model) categorizes software projects into three different types based on their complexity and size. These types are referred to as modes:

1. Organic Mode:

- A software project is said to be an organic type if:
  - The project is small and simple.
  - The project team is small with prior experience.
  - The problem is well understood and has been solved in the past.
  - Requirements of projects are not rigid, such a mode example is the payroll processing system.

CONSTRUCTIVE COST MODEL

2. Semi-Detached Mode:

- A software project is said to be a Semi-Detached type if:
  - The project has complexity.
  - Project team requires more experience, better guidance, and creativity.
  - The project has an intermediate size and has mixed rigid requirements such a mode example is a transaction processing system which has fixed requirements.
  - It also includes the elements of organic mode and embedded mode.
  - A few such projects are a Database Management System(DBMS), a new unknown operating system, difficult inventory management system.

CONSTRUCTIVE COST MODEL

3. Embedded Mode:

- A software project is said to be an Embedded mode type if:
  - A software project has *fixed* requirements for resources.
  - Product is developed within very tight constraints.
  - A software project requiring the highest level of complexity, creativity, and experience requirement falls under this category.
  - Such mode software requires a larger team size than the other two models.

CONSTRUCTIVE COST MODEL

Mode	a	b	c	d
Organic	2.4	1.05	2.5	0.38
Semidetached	3.0	1.12	2.5	0.35
Embedded	3.6	1.2	2.5	0.32

Effort	**a(KLOC)^b** *Person-Month*
Development Time	**c(Effort)^d** *Month*
Average Staff Size	**Effort/Dev. Time** *Persons*
Productivity	**KLOC/Effort** *KLOC/P-M*

Problem:

Suppose that a project was estimated to be 400 KLOC. Calculate effort and time for each of 3 modes of development:

1. *Organic*
2. *Semidetached*
3. *Embedded*

COCOMO Effort

Size	Appl	Util	Sys
5K	13.0	18.2	24.8
10K	26.9	39.5	57.1
15K	41.2	62.2	92.8
20K	55.8	86.0	131.1
25K	70.5	110.4	171.3
30K	85.3	135.3	213.2
35K	100.3	160.8	256.6
40K	115.4	186.8	301.1
45K	130.6	213.2	346.9
50K	145.9	239.9	393.6

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COCOMO MODEL

1. Organic:
   - Effort = 2.4 $(400)^{1.05}$ = 1295 PM
   - Dev. Time = 2.5$(1295)^{0.38}$ = 38 Months
2. Semi-detached:
   - Effort = 3 $(400)^{1.12}$ = 2462 PM
   - Dev. Time = 2.5$(2462)^{0.35}$ = 38.4 Months
3. Embedded:
   - Effort = 3.6 $(400)^{1.2}$ = 4772 PM
   - Dev. Time = 2.5$(4772)^{0.32}$ = 38 Months

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COCOMO MODEL

Boehm also determined that in his project data, there was a standard development time based on the type of project and the size of the project. The following are the formulas for development time (TDEV) in programmer-months:

1. Application programs: TDEV $= 2.5 * (PM)^{0.38}$
2. Utility programs: TDEV $= 2.5 * (PM)^{0.35}$
3. Systems programs: TDEV $= 2.5 * (PM)^{0.32}$

EXAMPLE
Calculate the standard TDEV using the COCOMO formulas for projects from 5 to 50 KDSI

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COCOMO MODEL

Mode	Effort	Schedule
Organic	$E=2.4*(KDSI)^{1.05}$	$TDEV=2.5*(E)^{0.38}$
Semidetached	$E=3.0*(KDSI)^{1.12}$	$TDEV=2.5*(E)^{0.35}$
Embedded	$E=3.6*(KDSI)^{1.20}$	$TDEV=2.5*(E)^{0.32}$

COCOMO Development Time

Size	Appl	Util	Sys
5K	6.63	6.90	6.99
10K	8.74	9.06	9.12
15K	10.27	10.62	10.66
20K	11.52	11.88	11.90
25K	12.60	12.97	12.96
30K	13.55	13.93	13.91
35K	14.40	14.80	14.75
40K	15.19	15.59	15.53
45K	15.92	16.33	16.25
50K	16.61	17.02	16.92

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INTERMEDIATE COCOMO

- 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 drivers based on various attributes of software engineering.

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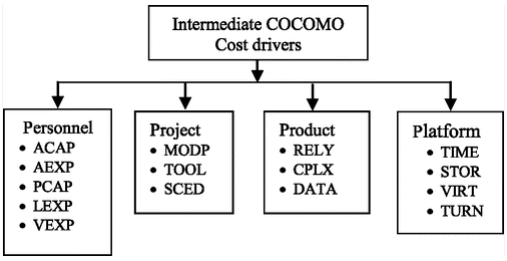
Classification of Cost Drivers and their Attributes



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Classification of Cost Drivers and their Attributes

1. **Product attributes**
   a. Required software reliability (RELY)
   b. Size of the application database (DATA)
   c. The complexity of the product (CPLX)

2. **Hardware attributes**
   a. Run-time performance constraints (TIME)
   b. Memory/Main storage constraints (STOR)
   c. The volatility of the virtual machine environment (VIRT)
   d. Computer required turnabout time (TURN)

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Classification of Cost Drivers and their Attributes

3. **Personnel attributes**
   a. Analyst capability (ACAP)
   b. Programmer capability (PCAP)
   c. Applications experience (AEXP)
   d. Virtual machine experience (VEXP)
   e. Programming language experience (LEXP)

4. **Project attributes**
   a. Use of software tools (TOOL)
   b. Modern programming practices (MODP)
   c. Required development schedule (SCED)

Classification of Cost Drivers and their Attributes

- Multiplier values for effort calculation:

COST DRIVERS	RATINGS					
PRODUCT ATTRIBUTES	Very Low	Low	Nominal	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
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	..

Classification of Cost Drivers and their Attributes

- Multiplier values for effort calculation:

COST DRIVERS	RATINGS					
Personnel Attributes	Very Low	Low	Nominal	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	..	..
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	0.04	1.10	..

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Classification of Cost Drivers and their Attributes

- Example:

Cost Driver	Situation	Rating	Effort Multiplier
RELY	Local use of system. No serious recovery problems	Nominal	1.00
DATA	20,000 bytes	Low	0.94
CPLX	Communications processing	Very high	1.30
TIME	Will use 70% of available time	High	1.11
STOR	45K of 64K store (70%)	High	1.06
VIRT	Based on commercial micropro-cessor hardware	Nominal	1.00
TURN	Two-hour average turnaround time	Nominal	1.00
ACAP	Good senior analysts	High	0.86
AEXP*	Three years	Nominal	1.00
PCAP	Good senior programmers	High	0.86
VEXP	Six months	Low	1.10
LEXP	Twelve months	Nominal	1.00
MODP	Most techniques in use over one year	High	0.91
TOOL	At basic minicomputer tool level	Low	1.10
SCED	Nine months	Nominal	1.00
	Effort adjustment factor (product of effort multipliers)		1.17

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CLASSIFICATION OF COST DRIVERS AND THEIR ATTRIBUTES

- Coefficients for Intermediate COCOMO:

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

The Intermediate COCOMO equations take the form:
$E = a_i (KLOC)^{b_i} * EAF$
$D = c_i (E)^{d_i}$
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

CLASSIFICATION OF COST DRIVERS AND THEIR ATTRIBUTES

- Equations:

  - **Intermediate COCOMO Model:** The effort equation is as follows:-

$$\mathbf{E = a * (KLOC)^b * EAF}$$

Where:

E = effort applied by per person per month

KLOC = estimated thousands of lines of code delivered for the project

EAF = It is Effort Adjustment Factor whose typical range from 0.9 to 1.4

To be continued...

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