COCOMO Model
SOFTWARE PROJECT PLANNING

COCOMO

Reading Overview of COCOMO

- http://www.softstarsystems.com/overview.htm
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COCOMO MODEL

- **COCOMO (Constructive Cost Model)** (Boehm, 1981)
- COCOMO is a model based on inputs relating to the size of the system and a number of cost drivers that affect productivity.
- Updated version, called **COCOMO II**, accounts for recent changes in software engineering technology, including object-oriented software, software created via spiral or evolutionary development models, software reuse and building new systems using off-the-shelf software components.

COCOMO MODEL

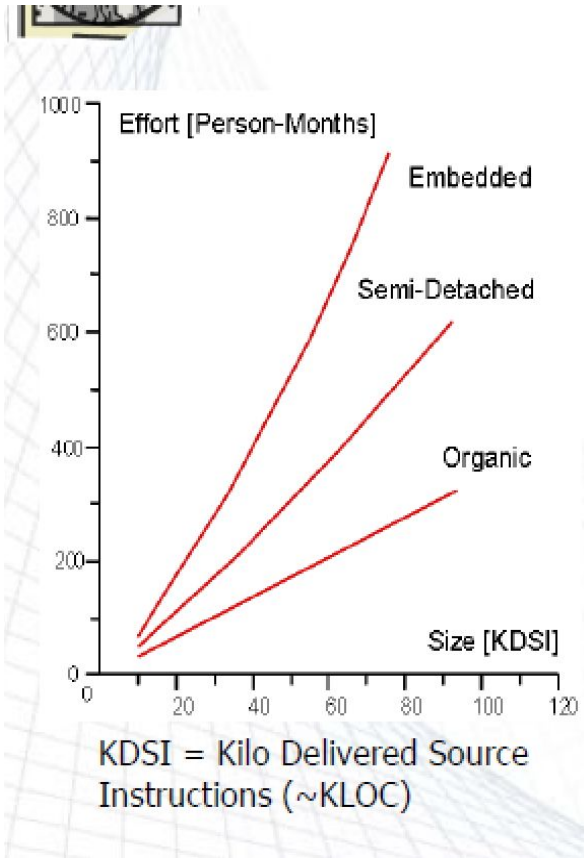
- The original COCOMO is a collection of three models:
  - ***Basic model*** that is applied early in the project
  - ***Intermediate model*** that is applied after requirements acquisition
  - ***Advanced model*** that is applied after design is complete
- All three models take the form:

$$E = aS^b \times EAF \qquad T_{dev} = cE^d$$

where

- E is effort in person months
- T_{dev} is the development time
- S is size measured in KLOC
- EAF is an effort adjustment factor (1 in the Basic model)
- Factors a, b, c and d depend on the ***development mode***.

COCOMO MODEL



COCOMO has three development modes:

- **Organic mode:** small teams, familiar environment, well-understood applications, no difficult non-functional requirements (EASY)
- **Semi-detached mode:** project team may have experience mixture, system may have more significant non-functional constraints, organization may have less familiarity with application
- **Embedded mode:** hardware/software systems, tight constraints, unusual for team to have deep application experience

Development Mode	Project Characteristics			
	Size	Innovation	Deadline/constraints	Dev. Environment
Organic	Small	Little	Not tight	Stable
Semi-detached	Medium	Medium	Medium	Medium
Embedded	Large	Greater	Tight	Complex hardware/ customer interfaces

Table 1: development modes

COCOMO BASIC MODEL

- The Basic COCOMO model computes effort (person-month) as a function of program size. The Basic COCOMO equation is:

$$E_{nom} = a(KLOC)^b$$

$$EAF = 1$$

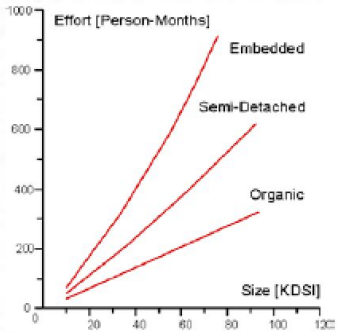
- The factors a and b for the Basic model are shown in the table.
- T_{dev} is not defined

Mode	*a*	*b*
Organic	2.4	1.05
Semi-detached	3.0	1.12
Embedded	3.6	1.20

Organic:
PM = 2.4 (KDSI) $^{1.05}$

Semi-detached:
PM = 3.0 (KDSI) $^{1.12}$

Embedded:
PM = 3.6 (KDSI) $^{1.20}$



KDSI = Kilo Delivered Source Instructions (~KLOC)

COCOMO BASIC MODEL

- Organic mode project: 32 KLOC
  - PM = 2.4 (32) $^{1.05}$ = 91 person-months
  - Development time: don't know

- Embedded mode project: 128 KLOC
  - PM = 3.6 (128)$^{1.2}$ = 1216 person-months
  - Development time: don't know

Cost

- Cost = E * Labour Rate

Eample

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

Software Product Type	a	b	c	d
Organic	2.4	1.05	2.5	0.38
Semi-detached	3.0	1.12	2.5	0.35
Embedded	3.6	1.20	2.5	0.32

Eample

1. **Organic:**

Effort = **a (KLOC)^{b}** person month

= **2.4 (400)$^{1.05}$** person month

= **1295** person month

Time = **c (Effort)^{d}** Months

= **2.5 (1295)$^{0.38}$** Months

= **38** Months

2. **Semi-detached**

Effort = **a (KLOC)^{b}** person month

= **3 (400)$^{1.12}$** person month

= **2462** person month

Time = **c (Effort)^{d}** Months

= **2.5 (2462)$^{0.35}$** Months

= **38.4** Months

= **38.4** Months

3. **Embedded**

Effort = **a (KLOC)^{b}** person month

= **3.6 (400)$^{1.2}$** person month

= **4772** person month

Time = **c (Effort)^{d}** Months

= **2.5 (4772)$^{0.32}$** Months

= **38** Months

COCOMO INTERMEDIATE MODEL

- The Intermediate COCOMO model computes effort as a function of program size and a set of cost drivers. The intermediate COCOMO equation is:

$$E = a\left(KLOC\right)^{b} \times EAF$$

$$T_{dev} = cE_{nom}^{d}$$

- The factors a, b, c and d for the intermediate model are shown in the table.

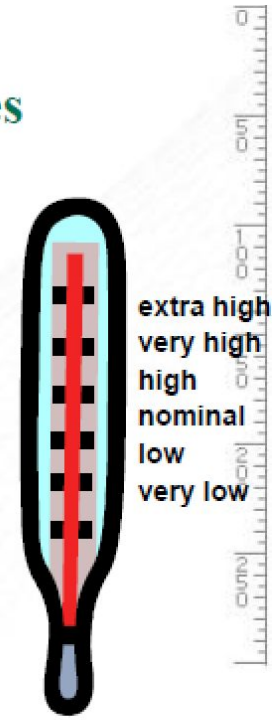
Mode	*a*	*b*
Organic	3.2	1.05
Semi-detached	3.0	1.12
Embedded	2.8	1.20

Mode	*c*	*d*
Organic	2.5	0.38
Semi-detached	2.5	0.35
Embedded	2.5	0.32

The effort adjustment factor (EAF) is calculated using 15 cost drivers.

COCOMO INTERMEDIATE MODEL

- The effort adjustment factor (*EAF*) is calculated using 15 cost drivers. ← **project related features**
- The cost drivers are grouped into 4 categories: ***product***, ***platform***, ***personnel***, and ***project***.
- Each cost driver is rated on a 6 point ordinal scale ranging from *very low* to *extra high* importance. Based on the rating, the ***effort multiplier (EM)*** is determined (Boehm, 1981). The product of all effort multipliers is the EAF.



$$E = E_{nom} \times EAF \qquad EAF = \prod_{i=1}^{15} EM_i$$

COCOMO INTERMEDIATE MODEL

15 Cost Drivers

- *Product Factors*
  - Reliability (RELY)
  - Data (DATA)
  - Complexity (CPLX)
- *Platform Factors*
  - Time constraint (TIME)
  - Storage constraint (STOR)
  - Platform volatility (PVOL)
- *Personnel factors*
  - Analyst capability (ACAP)
  - Program capability (PCAP)
  - Applications experience (APEX)
  - Platform experience (PLEX)
  - Language and tool experience (LTEX)
  - Personnel continuity (PCON)
- *Project Factors*
  - Software tools (TOOL)
  - Multisite development (SITE)
  - Required schedule (SCED)

COST DRIVER RATING

1. Product

	Description	*Very Low*	*Low*	*Nominal*	*High*	*Very High*	*Extra High*
RELY	Required software reliability	0.75	0.88	1.00	1.15	1.40	-
DATA	Database size	-	0.94	1.00	1.08	1.16	-
CPLX	Product complexity	0.70	0.85	1.00	1.15	1.30	1.65

COST DRIVER RATING

2. Platform

	Description	*Very Low*	*Low*	*Nominal*	*High*	*Very High*	*Extra High*
TIME	Execution time constraint	-	-	1.00	1.11	1.30	1.66
STOR	Main storage constraint	-	-	1.00	1.06	1.21	1.56
VIRT	Virtual machine volatility	-	0.87	1.00	1.15	1.30	-
TURN	Computer turnaround time	-	0.87	1.00	1.07	1.15	-

COST DRIVER RATING

3. Personnel

	Description	*Very Low*	*Low*	*Nominal*	*High*	*Very High*	*Extra High*
ACAP	Analyst capability	1.46	1.19	1.00	0.86	0.71	-
AEXP	Applications experience	1.29	1.13	1.00	0.91	0.82	-
PCAP	Programmer capability	1.42	1.17	1.00	0.86	0.70	-
VEXP	Virtual machine experience	1.21	1.10	1.00	0.90	-	-
LEXP	Language experience	1.14	1.07	1.00	0.95	-	-

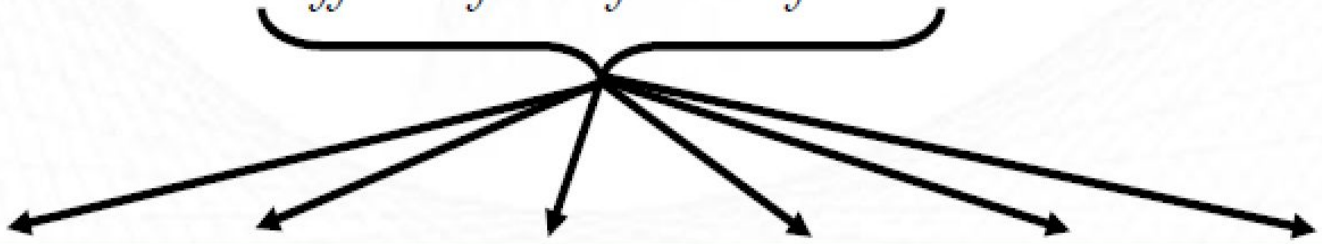
COST DRIVER RATING

4. Project

	Description	*Very Low*	*Low*	*Nominal*	*High*	*Very High*	*Extra High*
MODP	Modern programming practices	1.24	1.10	1.00	0.91	0.82	-
TOOL	Software Tools	1.24	1.10	1.00	0.91	0.83	-
SCED	Development Schedule	1.23	1.08	1.00	1.04	1.10	-

COST DRIVER RATING EXAMPLE

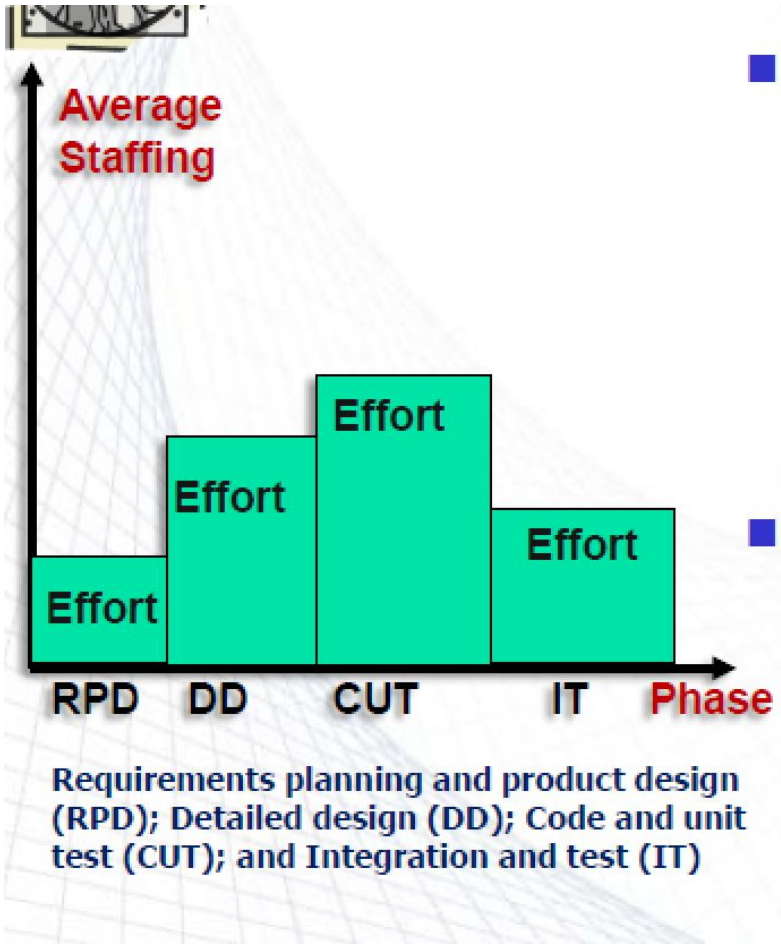
- **Example: Required Software Reliability (RELY)**
  - Measures the extent to which the software must perform its intended function over a period of time.
  - Ask: What is the *effect of a software failure*?



	Very Low	Low	Nominal	High	Very High	Extra High
RELY	slight inconvenience	low, easily recoverable losses	moderate, easily recoverable losses	high financial loss	risk to human life	
	0.75	0.88	1.00	1.15	1.39	

ie. A PATIENT MONITORING SYSTEM

COCOMO ADVANCE MODEL



- Advanced COCOMO model computes effort as a function of program size and a set of cost drivers ***weighted according to each phase of software lifecycle***.
- Advanced model applies the intermediate model at the component level, and then a phase-based approach is used to consolidate the estimate.

COCOMO ADVANCE MODEL

- The 4 phases used in the detailed COCOMO model are: requirements planning and product design (RPD), detailed design (DD), code and unit test (CUT), and integration and test (IT).
- Each cost driver is broken down by phase as in the table below.
- Estimates made for each module are combined into subsystems and eventually an overall project estimate.

Cost Driver	Rating	RPD	DD	CUT	IT
ACAP (Analyst capability)	Very Low	1.80	1.35	1.35	1.50
	Low	0.85	0.85	0.85	1.20
	Nominal	1.00	1.00	1.00	1.00
	High	0.75	0.90	0.90	0.85
	Very High	0.55	0.75	0.75	0.70

ACAP Intermediate
1.46 – Very Low
1.19 – Low
1.00 – Nominal
0.86 – High
0.71 – Very High

Staff Size

- For example
- Duration =8.54 moths
- Effort =25.39 PM
- **Staff Size** = E/Duration
- =25.39/8.54 = 2.97 persons = 3 persons