Project Estimation Techniques

- Estimation of various project parameters is an important project planning activity.The different parameters of a project that need to be estimated includes-
  - Project Size
  - Efforts required to complete the project
  - Project Duration
  - Cost

Accurate estimation of these parameters is important for resource planning and scheduling. Estimation techniques can be classified as-

- Empirical Estimation Techniques
- Heuristic Estimation Techniques

Empirical Estimation Technique

- **Empirical Estimation Techniques are based on making an educated guess of the project parameters and common sense.**
- **This technique is based on prior experience of development of similar products and projects.**
- **An educated guess based on past experience.**
- **Two empirical estimation techniques are-**
    - **Expert Judgement Technique**
    - **Delphi Cost Estimation**

Empirical Estimation Technique

- **Expert Judgement-**
  - In this an expert makes an educated guess of the problem size after analyzing the problem thoroughly.
  - The expert estimates the cost of the different components of the system. E.g. GUI, database, communication module, billing module etc.
  - Combines them to arrive at the overall estimate
- **Delphi Cost Estimation-**
  - Is carried out by a team comprising of a group of experts and a coordinator
  - The coordinator provides each estimator with a copy if SRS document.
  - Estimators complete their individual estimates anonymously and submit to the coordinator.

Heuristic Estimation Technique

- In this techniques the relationship that exists among the different project parameters that can be modeled using suitable mathematical expressions.
- Once the independent parameters are known, the dependent parameters can be easily determined by substituting the values of the independent parameters in the corresponding mathematical expression.
- Assume that the characteristics to be estimated can be expressed in terms of some mathematical expression.
- Can be classified as a single variable and multivariable models
- Basic COCOMO Model is an example of Single Variable Cost Estimation Model
- Intermediate COCOMO Model is an example of multivariable Variable Cost Estimation Model.

COCOMO Model

- COnstructive COst MOdel (COCOMO)
- Used to calculate:
  - Effort(Manpower)
  - Development Time
  - Average Staff Size
  - Productivity
- Types of Models
  - Basic COCOMO
  - Intermediate COCOMO
  - Complete/Detailed COCOMO
- Modes to apply COCOMO
  - Organic
  - Semi-Detached
  - Embedded

Basic - Small Team Size
Intermediate - Intermediate deadlines with innovation
Complete - Very Large Project Size

Model	Project Size	Project Nature	Innovation	Deadline
Organic	2-50 KLOC	Small size and experienced developers	Little	Flexible (Not Tight)
Semi-Detached	50-300 KLOC	Medium Project size and Team	Medium	Medium
Embedded	Over 300 KLOC	Large Project	Significant	Tight

Basic COCOMO Model

- $E = a_b\,(KLOC)^{b_b}$ *Person Month*
- $D = c_b\,(E)^{d_b}$ *Months*
- $P = \frac{E}{D}$ *Persons*
- $Prod = \frac{KLOC}{Effort}$ *KLOC/Person Month*

Mode/Coefficients	a_b	b_b	c_b	d_b
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

Coefficients of Basic COCOMO Model

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Eg: Suppose project estimated to be of 400 KLOC. Calculate Effort, Dev Time, Staff Size and Productivity for each of the modes in Basic COCOMO Model

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Coefficients of Basic COCOMO Model

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Organic

$E = a_b\,(KLOC)^{b_b}$

E=2.4 $(400)^{1.05}$

E=1295.31 Person Month

$D = c_b\,(E)^{d_b}$

D=2.5$(1295.31)^{0.38}$

D=38.07 Months

$P = \frac{E}{D}$

P=1295.31/38.07

P=34.02 ~ 34 Persons

Prod=KLOC/Effort

Prod=400/1295.31

Prod=0.308 KLOC/PM

Intermediate COCOMO Model

- Extension of the Basic COCOMO Model
- Has 15 Additional predictors (cost drivers)
- Predictors are used to adjust the nominal cost of project to actual project environment
- Each Cost Driver is rated in terms of ***VERY LOW, LOW, NORMAL, HIGH, VERY HIGH, EXTRA HIGH***

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COST DRIVERS

Product Attributes

- Required s/w reliability (RELY)
- Database size (DATA)
- Product complexity (CPLX)

Computer Attributes

- Execution Time Constraint (TIME)
- Storage Constraints (STOR)
- Virtual Machine Volatility (VIRT)
- Turn Around Time (TURN)

Personal Attributes

- Analyst Capability (ACAP)
- Application Experience (AEXP)
- Programmer Capability (PCAP)
- Programming Language Experience (LEXP)
- Virtual Machine Experience (VEXP)

Project Attributes

- Modern Programming Practices (MODP)
- Use of S/W tools (TOOL)
- Required development Schedule (SCED)

Intermediate COCOMO Model

Cost Drivers	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
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	-
ACAP	1.46	1.19	1.00	0.86	0.71	-
AEXP	1.29	1.13	1.00	0.91	0.83	-
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	-	-

Cost Driver Effort Adjustment Factor

Cost Drivers	Very Low	Low	Nominal	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	-
SCED	1.23	1.08	1.00	1.04	1.10	-

Cost Driver Effort Adjustment Factor contd.

- $E = a_b (KLOC)^{b_b} * EAF$ *Person Month*

Where EAF is Effort Adjustment Factor

- $D = c_b (E)^{d_b}$ *Months*

Mode/Coefficients	a_b	b_b	c_b	d_b
Organic	3.2	1.05	2.5	0.38
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Coefficients of Intermediate COCOMO Model

Intermediate COCOMO Model

A project size of 200 KLOC is to be developed. Software development team has nominal experience on similar type of projects and the project schedule is on high priority.

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Soln:

- Semidetached mode works best here as estimated size is 200 KLOC
- Software Dev Team Avg Experience: LEXP is Nominal, hence 1.00
- Project Schedule is high priority: SCED is high, hence 1.04
- Effort Adjustment Factor Calculation

  EAF=1.00*1.04=1.04

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- Effort Calculation

  $E = a_b\,(KLOC)^{b_b} * EAF$ *Person Month*

  $E=(3.0)(200)^{1.12} * 1.04$

  $E=1178.44$ *Person Month*

- Development Time Calculation

  $D = c_b\,(E)^{d_b}$ *Months*

  $D=(2.5)(1178.44)^{0.35}$

  $D=29.70$ *Months*

Detailed COCOMO Model

- Phase Sensitive
  - Planning And Requirement Gathering (PR)
  - System Design (SD)
  - Document Design (DD)
  - Code and Test (C)
  - Integration and Test (I)
- Cost Driver effect is calculated on each Phase to determine effort to complete each phase
- Ratings are given to drivers at that level where cost driver is affected the most
- Adjustment Factor (A) is calculated as reusability will affect the cost of development

  $A=0.4(DD)+0.3(C)+0.3(I)$
- The Cost of the software is calculated as:

  $Effort_d=\mu_p*E_i$

  $Development\ Time_d=\tau_p*D_i$

Note:

(i) In this model, we don't have single answer

(ii) μ_p and τ_p are the adjacency factors to above phases

Detailed COCOMO Model

Given a project with the following main components : Screen Edit, CLI, File I/P and O/P, Cursor Movement, Screen Movement. The size for these are estimated to be 4KLOC, 2KLOC, 1KLOC, 2KLOC and 3KLOC. Using detailed COCOMO determine

1. Overall cost and schedule estimates
2. Cost and schedule estimates for different phases

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1. Overall cost and schedule estimates
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Soln:

1. $E_i = a_i(KLOC)b_i * EAF$
   - Total KLOC = 4+2+1+2+3=12 KLOC

     Organic Mode is useful is this size
   - EAF Cost Drivers:

     Reliability – High – 1.15

     Language Experience – Low – 1.07

     Product Complexity – High – 1.15

Analyst Capability – High – 0.86

Hence EAF=1.15*1.07*1.15*0.86=1.216

$E_i = a_i(KLOC)b_i * EAF$

$E_i = (3.2)(12)^{(1.05)} * 1.216$

E_i=52.9 Person Month

$D_i = c_i(E)d_i$

$D_i = (2.5)(52.9)^{(0.38)}$

D_i=11.29 Months

Detailed COCOMO Model

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Cost Driver Effort Adjustment Factor

- $E = a_b (KLOC)^{b_b} * EAF$ *Person Month*

Where EAF is Effort Adjustment Factor

- $D = c_b (E)^{d_b}$ *Months*

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Cost Driver Effort Adjustment Factor contd.

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Coefficients of Intermediate COCOMO Model

Detailed COCOMO Model

Mode and Code Size	Plan and Reqmts	System Design	Document Design	Code and Test	Integrate and Test
Life Cycle Phase Value of μ_p					
Organic Small (2)	0.06	0.16	0.26	0.42	0.16
Organic Medium (32)	0.06	0.16	0.24	0.38	0.22
Semi Detached Medium (32)	0.07	0.17	0.25	0.33	0.25
Semi Detached Large (128)	0.07	0.17	0.24	0.31	0.28
Embedded Large (128)	0.08	0.18	0.25	0.26	0.31
Embedded XL (320)	0.08	0.18	0.24	0.24	0.34

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Semi Detached Large (128)	0.07	0.17	0.24	0.31	0.28
Embedded Large (128)	0.08	0.18	0.25	0.26	0.31
Embedded XL (320)	0.08	0.18	0.24	0.24	0.34

2. $Effort_d = \mu_p * E_i$

$Effort_d$ in Person Month in all phases individually

=0.06*52.9=3.174

=0.16*52.9=8.464

=0.26*52.9=13.754

=0.42*52.9=22.218

=0.16*52.9=8.464

Detailed COCOMO Model

Mode and Code Size	Plan and Reqmts	System Design	Document Design	Code and Test	Integrate and Test
Life Cycle Phase Value of τ_p					
Organic Small (2)	0.10	0.19	0.24	0.39	0.18
Organic Medium (32)	0.12	0.19	0.21	0.34	0.26
Semi Detached Medium (32)	0.20	0.26	0.21	0.27	0.26
Semi Detached Large (128)	0.22	0.27	0.19	0.25	0.29
Embedded Large (128)	0.36	0.36	0.18	0.18	0.28
Embedded XL (320)	0.40	0.38	0.16	0.16	0.30

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2. Development Time$_d$ = $\tau_p * D_i$

Development Time$_d$ in Month in all phases individually

=0.10*11.29=1.129

=0.19*11.29=2.145

=0.24*11.29=2.709

=0.39*11.29=4.403

=0.18*11.29=2.032