Course Title – Software Engg.

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UNIT IV: Software Project Cost Estimation (Marks 12)

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Software Project Cost Estimation.

12 marks

(*) Software Project Estimation :- is process of finding an estimate / approximation which is value.

→ Estimation of the size of s/w is an essential part of s/w project Management.

→ The s/w cost estimation process contains basic steps

- identify project objectives & requirements
- plan activity
- estimate product size
- estimate cost & effort.
- estimate schedule.
- Risk Management.
- insect & approve.
- track estimate
- process measurement & improvement.

→ Various measures are used in project size estimation

i) lines of code
ii) Number of entities in ER diagram.
iii) Total number of processes in detailed data flow diagram
iv) function point.

(*) The Management Spectrum – 4P's.

→ The management spectrum describes the management/ hierarchy of people associated with a s/w project.

→ it is about turning the project from plan to reality

→ The management spectrum focuses on four P's.
people, product, process & project.

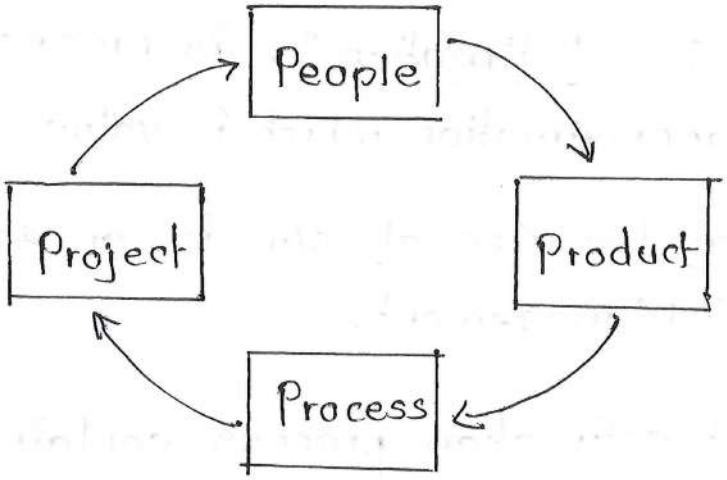

Fig. The Management Spectrum.

1) People :- The people of a project includes from manager to developer, from customer to end user.

→ It is so important to have highly skilled & motivated developers that the s/w Engg. institutes has developed a People Management Capability Maturity Model (PM-CMM).

→ People connected directly or indirectly are dynamic & live factor in project management.

→ People resources are as follow:

i) Stakeholders :- can be categorized into one of five

Senior Managers - who define business issue.
Project Managers - who must plan, motivate, organize & control the s/w work.
Practitioners - who deliver the technical skills that are necessary to product.
Customers - who specify the requirements for s/w.
End users - who interact with s/w.

ii) Team Leaders

iii) S/w Team — The "best" team structure depends on the management style of organization.

iv) Agile teams — A small, highly motivated project team also called an agile team.

2] The Product :→ The product is the ultimate goal of the project.

→ To develop a s/w product successfully, all the product objectives & scope should be established, alternative solutions should be considered & technical and management constraints should be idetified.

→ Lack of these infomation, it is impossible to define accurate estimation, assessment of risks, breakdown of project task & schedule.

3] The Process :→ The s/w process provides the framework from which plan for s/w development can be established.

→ The number of different tasks sets — tasks, milestones work products & quality assurance points — enables the framework activities.

4] The Project :- This includes requirement analysis, development, delivery, maintenance & updates.

→ The project manager of a project is resposible for managing the people, product & process.

→ A s/w project could be extremely complex & as per industry data the failure rate is high. it's merely dub to steps before development & sometime due to lack of maintanance.

(*) Barry Boehm's W5HH principles →

i) Why is the system being developed ?
ii) What will be done ?
iii) When will it be accomplished ?
iv) Who is responsible ?
v) Where are they organizationally located ?
vi) How will the job be done technically & Managerially ?
vii) How much of each resource is needed.?

(*) Metrics for Size Estimation :-

→ A software metric is a standard measure of a degree to which a s/w system / process possesses some property.

→ Estimating the size of the s/w to be developed is first step to make an effective estimation of the product.

→ S/w is estimated using methods Lines of code (LOC), function Points (FP).

i) Lines of Code :- (LOC)

→ LOC can be defined as "The number of delivered lines of code, excluding comments & blank lines".

→ Loc has also been used to predict program complexity, development effort, programmer performance.

→ In this metric, the project size is estimated by counting the no. of source instructions in program.

→ Header lines, comment lines should be ignored.

→ LOC count at the end of a project is a very simple job. but accurate estimation of LOC count at the beginning of project is very difficult.

→ lines of code also measured in KLOC (Kilo Lines Of Code)

2] Function Points :-

→ Function point metric was proposed by Albrecht (1983).

→ This metric overcomes many of the shortcomings of the LOC metric

→ This is in contrast to the LOC metric, where the size can be accurately determined only after the product has fully developed.

→ The size of a product in FP can be expressed as the weighted sum of five problem characteristics.

i) no. of inputs
ii) no. of outputs
iii) no. of inquiries
iv) no. of files
v) no. of interfaces

→ The number and type of functions supported by the software are utilized to find FPC (Function Point Count)

→ STEPS in FP analysis →

i) count the number of functions of each proposed type.
ii) compute the Unadjusted FP (UFP)
iii) find Total degree of influence (TDI)
iv) Compute Value adjustment Factor (VAF)
v) find the function point Count (FPC).

Step (i)

Parameter

i) no. of EI — i/p screen & tables
ii) no. of EO — o/p screen & reports
iii) no. of EQ — prompts & interrupts
iv) no. of ILF — Database & directories
v) no. of EIF — shared database & shared routines.

Step (ii) Compute UFP :-

→ categorize each of the five function types as simple, average or complex. based on their complexity.

→ Multiply count of each function type with its weighting factor and find the weighted sum.

Function Type	Simple	Average	Complex.
External Inputs (EI)	3	4	6
External Output (EO)	4	5	7
External Inquiries (EQ)	3	4	6
Internal Logical files (ILF)	7	10	15
External Interface files (EIF	5	7	10

Step (iii) find ∈TDI :-

→ Use the '14 general characteristics' of a system to find the degree of influence of each of them.

→ The sum of all 14 degrees of influences will give TDI

→ The range of TDI is 0 to 70.

→ 14 general characteristics are Data Communications, Distributed Data processing, Performance, Transaction Rate,

Heavily Used Configuration, On line Data entry, End user efficiency, Online Update, complex processing Reusability, Installation Ease, Operational Ease, Multiple Sites & Facilitate change.

(each of above characteristics is evaluated on a scale of 0-5).

Step (IV) Compute VAF :-

Use formula to calculate VAF

$$VAF = [TDI * 0.01] + 0.65$$

Step (V) find FPC

use formula to calculate FPC

$$FPC = UFP * V$$

(*) Project Cost Estimation Approaches

1) Heuristic Estimation :-

→ as techniques basically uses the concept of learning from the previous project and estimate the cost.

→ Similar to expertise based techniques, heuristic estimation technique take a different angle.

→ The objective is to find a similar system produced earlier and through knowing how the properties of new system vary from the existing one.

Two classes of different heuristic estimation Techniques.

i) Single variable Model

ii) Multi variable Model.

→ ① Single Variable Model :-

→ It provide a means to estimate the desired characteristics of a problem, using some previously estimated basic characteristic of s/w product such as its size

→ A single variable estimator model takes following form.

$$\text{Estimated Parameter} = c1 * e^{d1}$$

e = characteristic which already have been calculated.

c1 & D1 are constant - calculated from past project.

→ Estimated parameter (dependent parameter) could be effort, duration, staff size etc.

→ eg. cocomo.

→ ② Multivariable Cost Estimation Model :-

→

$$\text{Estimated Resource} = c1 * e1^{d1} + c2 * e2^{d2} + \cdots$$

e1 & e2 → id independent characteristics of the s/w.

c1, c2, d1, d2 are constants.

→ These constants are determined from historical data

→ more accurate than single variable model.

→ Eg. Intermediate Model of cocomo

⊛ Analytical Estimation :-

→ Analytical Estimation Techniques derive the required result starting with basic assumptions regarding the project.

→ it has scientific basis.

→ eg. Halstead's s/w science

⊛ Empirical Estimation :-

→ This technique are based on making an educated guess of the project parameters.

→ two popular empirical estimation techniques

(i) Expert Judgment Technique

(ii) Delphi cost estimation.

(i) Expert Judgment Tech :-

→ An expert estimates the cost of different components (modules or subsystem) of the system & then combines them to get overall estimate

→ This technique is subject to human errors & individual bias.

(ii) Delphi Cost Estimation :-

→ is carried out by a team comprising of group of experts & a co-ordinator.

→ The coordinator provides each estimator with a copy of s/w requirements specification (SRS) document.

→ Estimator complete their individual estimates anonymously & submit to the coordinator.

→ In their estimates, the estimators mention any unusual

characteristic of the product which has influenced ~~by~~ his estimation.

→ The co-ordinator prepares & distributes the summary of responses of all the estimators & includes any unusual rationale noted by any of the estimators.

→ Based on this summary, estimators re-estimate This process is iterated for several round.

→ After complition co-ordinator prepare final estimate.

⊛ COCOMO Model. (Constructive Cost Model).

→ is a procedural s/w cost estimation model developed by Barry W. Boehm. in 1981. & based on study of 63 projects.

→ parameters which define quality of s/w.

Effort : Amount of labor that required to complete a task.
It is measured in person-months units.

Schedule :→ Time required for completion of job.
→ measured in units of time i.e weeks, months

→ Boehm's def^n of Organic, Semidetached & embedded system

a) Organic :- → team size small
→ team members have nominal experience
→ the problem well understood.
→ & solved in the past.

b) Semidetached :-

Software project is said to be semidetached type if the vital characteristics such as team size, experience, knowledge of the various programming environment lie in between that of organic & Embedded.

→ less familiar & difficult to develop.
→ require more experience, better guidance & creativity.

eg. Compilers, Embedded system

c) Embedded :-

→ A software project with requiring highest level of complexity, creativity & experience requirement fall fall under this category.
→ larger team size.

(*) Types of Models :-

i) Basic cocomo Model :-

→ The Basic model equations are :-

(1) i) Effort (E) = $a(KLOC)^b$ person-months (PM).

(2) Development time (D) = $c(Effort)^d$ months

(3) Average Staff Size (P) = $\frac{Effort}{Development\ time}$ Persons

$$\text{Productivity} = \frac{\text{KLOC}}{\text{Effort}} \quad \text{KLOC/PM.}$$

where a, b, c & d depends on the type of project (Organic, Semi-detached, Embedded).

Mode	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

Ex. Que. Software project using semi-detached mode with 30,000 lines of code. Calculate Effort Estimation, Development time & staff size.

→ given, system = Semi-detached.

lines of code = 30,000 = 30KLOC.

i) Effort Estimation

$E = a\,[KLOC]^b$

$E = 3.0\,[30]^{1.12}$

$E = 135$ person-months.

ii) Duration estimation.

$D = c(E)^d$

$D = 2.5\,(135)^{0.35}$

$D = 14$ months.

iii) Person estimation

$P = E/D$

$P = 135/14$

$P = 10$ persons approximately.

Que :- Using cocomo, Estimate time required for the following

(i) Semi-detached model 2000 lines

(ii) An embedded model of 30,000 lines.

(iii) An organic model of one lakh lines

(iv) An organic model of 10 Lakh lines.

→ (i) given that system = semi-detached

LOC = 2000 = 2KLOC

$E = a(KLOC)^b$

$= 3.0(2)^{1.12}$

$= 6.52$ person-months.

$D = c(E)^d$

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

$= 5.1$ months.

$P = E/D$

$= 6.52/5.1$

$P = 1.2 \approx 1$ person.

(ii) given that system = Embbeded.

Lines of code = 30,000 = 30KLOC

$E = a(KLOC)^b$

$E = 3.6(30)^{1.20}$

$E = 213$ person-month

$D = c(E)^d$

$= 2.5(E)^{0.32}$

$= 13.90 \approx 14$ months.

$P = E/D$

$= 213/14$

≈ 15 persons.

(iii) Given, system = organic

LOC = 1 Lack = 100 KLOC

$E = a(KLOC)^b$

$= 2.4(100)^{1.05}$

≈ 302 person-months

$D = c(E)^d$

$= 2.5(302)^{0.38}$

≈ 21 months.

$P = E/D$

$= 302/21$

≈ 14 persons.

(iv) system = organic

LOC = 10 Lack = 1000 KLOC

$E = a(KLOC)^b$

$= 2.4(1000)^{1.05}$

≈ 3390 person-months

$D = c(E)^d$

$= 2.5(3390)^{0.38}$

≈ 55 months.

$P = E/D$

$= 3390/55$

≈ 61 persons.

⊛ cocomo II :-

→ Revised version of original cocomo & is developed at University of Southern Califonia.

→ advanced model for
- modern software development.
- object-oriented development.
- Reusable components

→ cocomo-II consists of three sub models

1) Application Composition Model.
   → used in early prototyping stage.
   → Based on object points
   → suitable for GUI Based / Rapid development.

2) Early Design Model.
   → used when high level design is ready,
   → estimates cost using function points.
   → uses 7 cost drivers & 5 scale factors.

3) Post-Architecture Model.
   → used when full architecture is ready,
   → most detailed & accurate,
   → uses 17 cost drivers & 5 scale factors.

cocomo	cocomo-II.
(i) it is basic model	(i) it is an extension model of basic model.
(ii) it follows waterfall model	(ii) it follows three phases concept
(iii) 15 cost drivers attributes	(iii) 17 cost drivers attributes.
(iv) re-engineering concept follows	(iv) Reusability is used in it.

(v) Provide estimates of effort and schedule. (vi) it is measured in KDSI (Kilo Delivered Source Instruction)	(v) Provide estimate that represents deviation around (vi) it is measured in KLOC

(*) Risk Analysis & Management :-

→ is a critical activity in S/w Engg.

→ it helps in identifying potential problems (Risk) Before they happen.

→ There are two characteristics of the risks.

(i) uncertainty - the risk may or may not happen.

(ii) Loss :- unwanted consequences or loss occure

Types of Risk

i) Project Risk :- Delay in schedule, cost overrun.

ii) Technical Risk :- Technology failure, software bugs.

iii) Business Risk - product not accepted by users

iv) Resource Risk - Lack of skilled staff, key person leaves

v) External Risk - Change in government policy, market changes.

i) Risk Identification :-

→ This is the first step in risk management.

→ It involves finding out what can go wrong in a project.

→ Risk identification is systematic attempt to specify threats to the project plan.

→ By identifying predictable risks, the project manager takes a first step towards avoiding them when possible & controlling them when necessary.

② Risk Assessment / Risk Analysis

→ once risks are identified, the next step is to analyze them

→ checking

probability (P) - How likely is the risk to occur?

impact (I) - How much damage will it cause.

· Risk Exposure (RE) = Probability × Impact.

→ Risks are then prioritized based on their RE value.

→ Higher RE means more dangerous risk.

③ Risk Management & Monitoring :-

→ Risk Management means planning how to deal with risks

→ Risk management strategies

(i) Reactive → react after its appearance

(ii) Pro-active → planning before its appearance

→ Steps of Risk Management

- Recognize Risk - what can go wrong ?
- Analyze Risk - What sort of damage it does
- Rank Risk - according to impact.
- Develop plan - to manage risk

→ Risk monitoring means :-

→ checking regularly if the risk is about to occur.

→ keeping an eye on the "early warnings signs" or "risks triggers".

(4) Risk Refinement & Mitigation :-

→ Risk Refinement means breaking down a big risk into smaller risks to manage them better.

→ Risk mitigation means creating a plan to reduce the changes / impact of the risk.

(*) RMMM Plan :- (Risk Mitigation, Monitoring & Management Plan).

→ This is formal document that contains detailed risk strategies.

→ An effective strategy must consider three issues: risk avoidance, risk monitoring & risk management

(i) Risk Mitigation :-

→ is a problem avoidance activity.

→ To mitigate this risk, you would develop a strategy for reducing turnover.

possible steps :-

→ involve creating a proactive plan before the risk occurs.

strategies

- provide training to team members.
- use alternative technologies
- make backup plans.

(ii) Risk Monitoring :-

→ keep track of risk indicators or triggers.

→ Identify the signs that a risk is becoming real.

→ example

- Regular status Meeting
- Performance reports
- Tracking key project parameters.

③ Risk Management :-

→ Take action when the risk actually occurs.

→ if mitigation failed & risk happens

- follow the prepared response plan.
- minimize damage & recover quickly.
- Assign responsible person/team to handle it.

(*) RMMM Plan include different section.

i) Risk ID
ii) Risk Description
iii) probability
iv) impact
v) Priority
vi) Mitigation strategy
vii) Monitoring Plan.
viii) Management Plan.
ix) Responsible Person.

20/6/25

Question Bank

Unit-IV Software Project Cost Estimation

2 Marks Questions

1. Define Risk. List two characteristics of risk**.** **(W-25)**
2. State any two advantages of Work Breakdown Structure (WBS). **(W-25)**
3. State different types of estimations in Software Projects. **(W-24)**
4. Define reactive risk strategies. **(S-24)**

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4 Marks Questions

5. State and explain with examples four broad categories of software.
   Describe Earned Value Analysis with formula and interpretation of:
   i) Schedule Variance (SV)
   ii) Cost Variance (CV)
   iii) Schedule Performance Index (SPI)
   iv) Cost Performance Index (CPI) **(W-25)**
6. Explain Management Spectrum. **(W-25)**
7. Describe 4 P's of management spectrum. **(W-24)**
8. Explain Work Breakdown Structure with suitable diagram. **(W-24)**
9. Describe Function Point Metrics for size estimation. **(W-24)**
10. Describe RMMM strategy. **(W-24)**
11. State and describe project cost estimation approach. (Any two) **(W-24)**
12. Describe following project cost estimation approaches:
    i) Heuristic
    ii) Empirical **(S-24)**
13. With an example, explain Line of Code (LOC) based estimation. **(S-24)**

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6 Marks Questions

14. Suppose a project was estimated to be 400 KLOC. Calculate Effort and Development Time for:
    a. Organic Mode
    b. Semi-detached Mode
    c. Embedded Mode **(W-25)**
15. Use COCOMO model to calculate Efforts, Development Time, Average Staff Size and Productivity for 400 KLOC Organic Model. **(W-24)**