Software Project Management

Durga Prasad Mohapatra
Professor
CSE Deptt.
NIT Rourkela

Project Estimation Techniques cont …

- **Staffing Level Estimation**
  - **Putnam's Model**
  - **Jensen's Model**

Project duration and staffing

- As well as effort estimation, managers must estimate the calendar time required to complete a project and when staff will be required.
- Calendar time can be estimated using COCOMO 2 formula
  - $TDEV = 3 * (PM)^{(0.33+0.2*(B-1.01))}$
  - PM is the effort in person months and B is the exponent computed (B is 1 for the early prototyping model).
  - The time required is independent of the number of people working on the project.

Staffing requirements

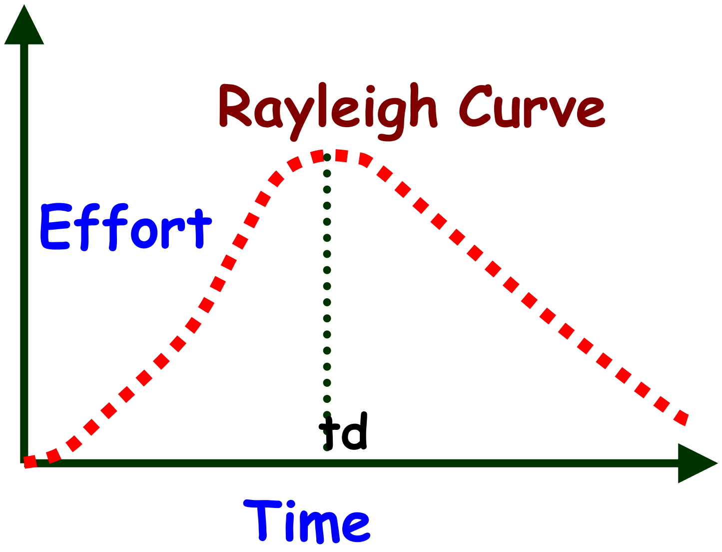
- Staff required can't be computed by diving the development time by the required schedule.
- The number of people working on a project varies depending on the phase of the project.
- The more people work on the project, the more total effort is usually required.
- A very rapid build-up of people often correlates with schedule slippage.

Staffing Level Estimation

- Number of personnel required during any development project:
  - not constant.
- Norden in 1958 analyzed many R&D projects, and observed:
  - Rayleigh curve represents the number of full-time personnel required at any time.

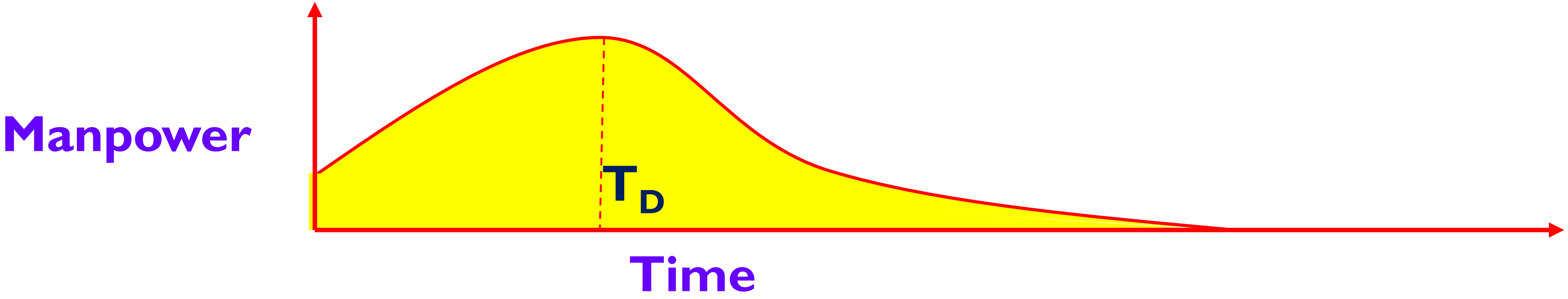
Rayleigh Curve

- Rayleigh curve is specified by two parameters:
  - t_d is the time at which the curve reaches its maximum
  - K is the total area under the curve.
- L=f(K, td)



Staffing

- Norden was one of the first to investigate staffing pattern:
  - Considered general research and development (R&D) type of projects.
- Norden concluded:
  - Staffing pattern for any R&D project can be approximated by the Rayleigh distribution curve



Putnam's Work

- In 1976, Putnam studied the problem of staffing of software projects:
  - observed that the level of effort required in software development efforts has a similar envelope.
  - found that the Rayleigh-Norden curve
    - relates the number of delivered lines of code to effort and development time.

Putnam's Work cont…

- Putnam analyzed a large number of army projects, and derived the expression:

  $$L=C_k K^{1/3} t_d^{4/3}$$

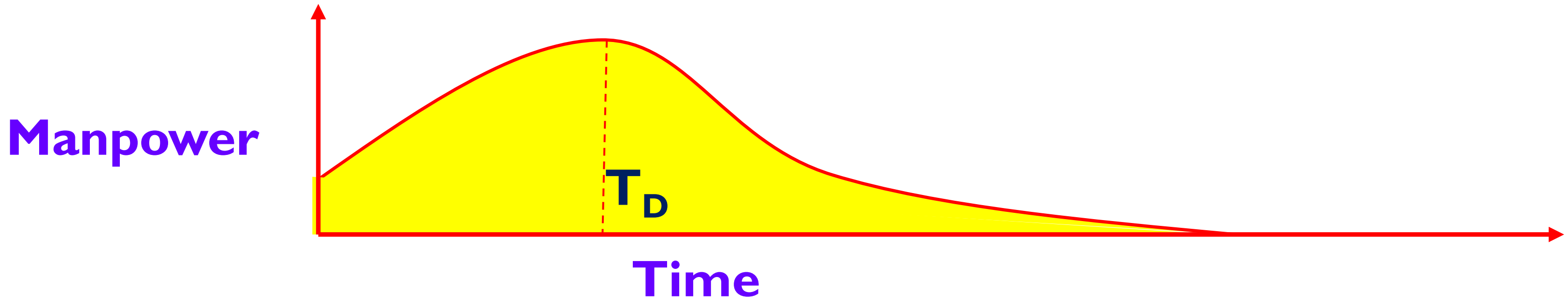
  - K is the effort expended and L is the size in KLOC.
  - t_d is the time to develop the software.
  - C_k is the state of technology constant
    - reflects factors that affect programmer productivity.

Putnam's Work cont…

- C_k =2 for poor development environment
  - no methodology, poor documentation, and review, etc.
- C_k =8 for good software development environment
  - software engineering principles used
- C_k =11 for an excellent environment

Rayleigh Curve cont …

- Very small number of engineers are needed at the beginning of a project
  - carry out planning and specification.
- As the project progresses:
  - more detailed work is required,
  - number of engineers slowly increases and reaches a peak.



Rayleigh Curve cont …

- Putnam observed that:
  - the time at which the Rayleigh curve reaches its maximum value
    - corresponds to system testing and product release.
  - After system testing,
    - the number of project staff falls till product installation and delivery.

Rayleigh Curve cont …

- From the Rayleigh curve we may observe that:
  - approximately 40% of the area under the Rayleigh curve is to the left of t_d
  - and 60% to the right.

Putnam's Model

Lines of code: S_S

Person years invested: K

Time to develop: t_d

Technology coefficient: C_k

Putnam's Model

Lines of code:

$$S_S = C_k K^{1/3} t_d^{4/3}$$

Person years invested:

$$K = \left(\frac{S_S}{C_k t_d^{4/3}} \right)^3$$

Time to develop:

$$t_d = \left(\frac{S_S}{C_k K^{1/3}} \right)^{3/4}$$

Putnam's Work

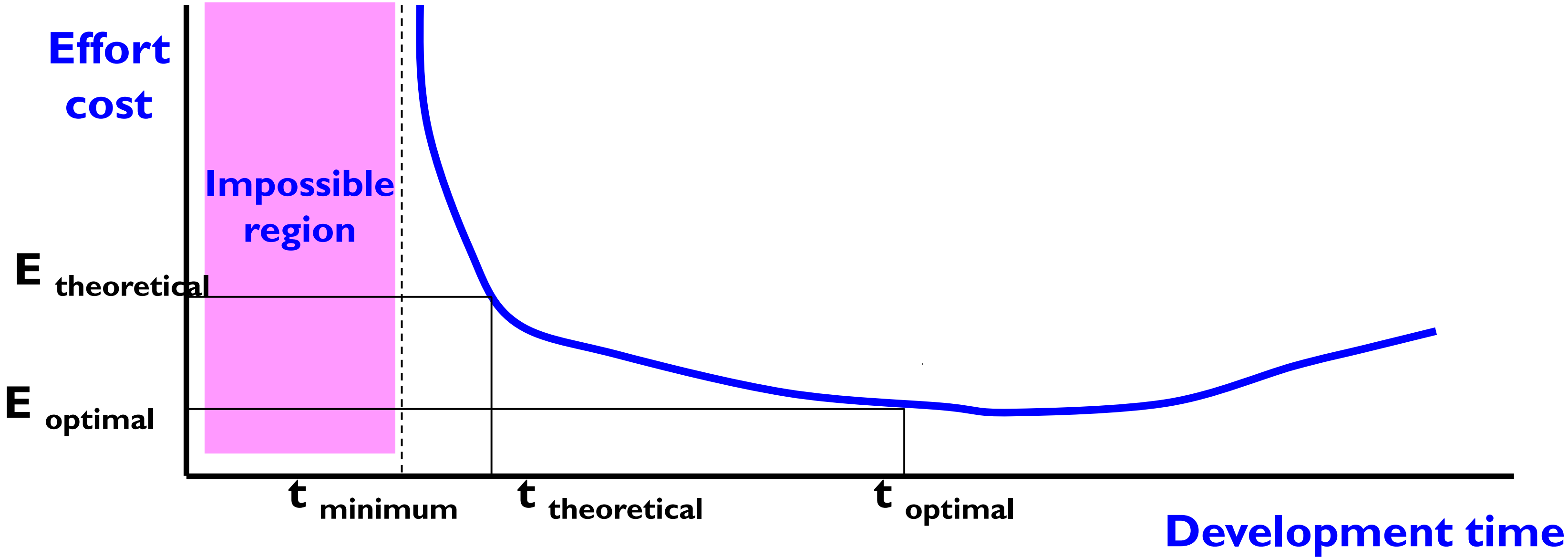
- Putnam adapted the Rayleigh-Norden curve:
  - Related the number of delivered lines of code to the effort and the time required to develop the product.
  - Studied the effect of schedule compression:

$$\boxed{pm_{new} = pm_{org} \times \left(\frac{td_{org}}{td_{new}} \right)^4}$$

Effort Applied vs. Delivery Time

- There is a nonlinear relationship between effort applied and delivery time (Putnam-Norden-Rayleigh Curve)
  - Effort increases rapidly as the delivery time is reduced

Effort Applied vs. Delivery Time



Effect of Schedule Change on Cost

- Using the Putnam's expression for L,

$$K = L^3 / C_k^3 t_d^4$$

Or, $K = C1 / t_d^4$

- For the same product size, $C1 = L^3 / C_k^3$ is a constant.
- Or, $K1/K2 = t_{d2}^4 / t_{d1}^4$

Effect of Schedule Change on Cost cont…

- Observe:
  - A relatively small compression in delivery schedule
    - can result in substantial penalty on human effort.
- Also, observe:
  - benefits can be gained by using fewer people over a somewhat longer time span.

Example

- If the estimated development time is 1 year, then in order to develop the product in 6 months,
  - the total effort and hence the cost increases 16 times.
  - In other words,
    - The relationship between effort and the chronological delivery time is highly nonlinear.

Putnam's Model

Example:

given S_S =100,000

C_k =10,040

t_d = varies

compute K

t_d	K
1	988 person-month
1.5	195 person-month
2	62 person-month

Limitations of Putnam's Model

- Putnam model indicates extreme penalty for schedule compression
  - and extreme reward for expanding the schedule.
- Putnam estimation model works reasonably well for very large systems,
  - but seriously overestimates the effort for medium and small systems.

Effect of Schedule Change on Cost cont…

- Boehm observed:
  - “There is a limit beyond which the schedule of a software project cannot be reduced by buying any more personnel or equipment.”
  - This limit occurs roughly at 75% of the nominal time estimate.

Effect of Schedule Change on Cost cont…

- If a project manager accepts a customer demand to compress the development time by more than 25%
  - very unlikely to succeed.
    - every project has only a limited amount of parallel activities
    - sequential activities cannot be speeded up by hiring any number of additional engineers.
    - many engineers have to sit idle.

Jensen Model

- Jensen model is very similar to Putnam model.
  - attempts to soften the effect of schedule compression on effort
  - makes it applicable to smaller and medium sized projects.

Jensen Model cont …

- Less sensitive to schedule compression than Putnam
- makes it applicable to smaller and medium sized projects.

$$S_S = C_{te} * t_d * K^{1/2}$$

$$\text{So, } K1/K2 = t_{d2}^2/t_{d1}^2$$

  - C_{te} is the effective technology constant,
  - t_d is the time to develop the software, and
  - K is the effort needed to develop the software.

Effect of Schedule Change on Cost

- If the estimated development time is 1 year, then in order to develop the product in 6 months,
  - the total effort and hence the cost increases 4 times.
  - Much less in comparison to Putnam's model.

Summary

- Explained Rayleigh Curve.
- Discussed Putnam's model for staffing level estimation.
- Also discussed Jensen's model for staffing level estimation.
- Presented the effect of schedule change on the effort / cost.

References :

1. B. Hughes, M. Cotterell, R. Mall, *Software Project Management*, Sixth Edition, McGraw Hill Education (India) Pvt. Ltd., 2018.
2. R. Mall, *Fundamentals of Software Engineering*, Fifth Edition, PHI Learning Pvt. Ltd., 2018.

Thank you