IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

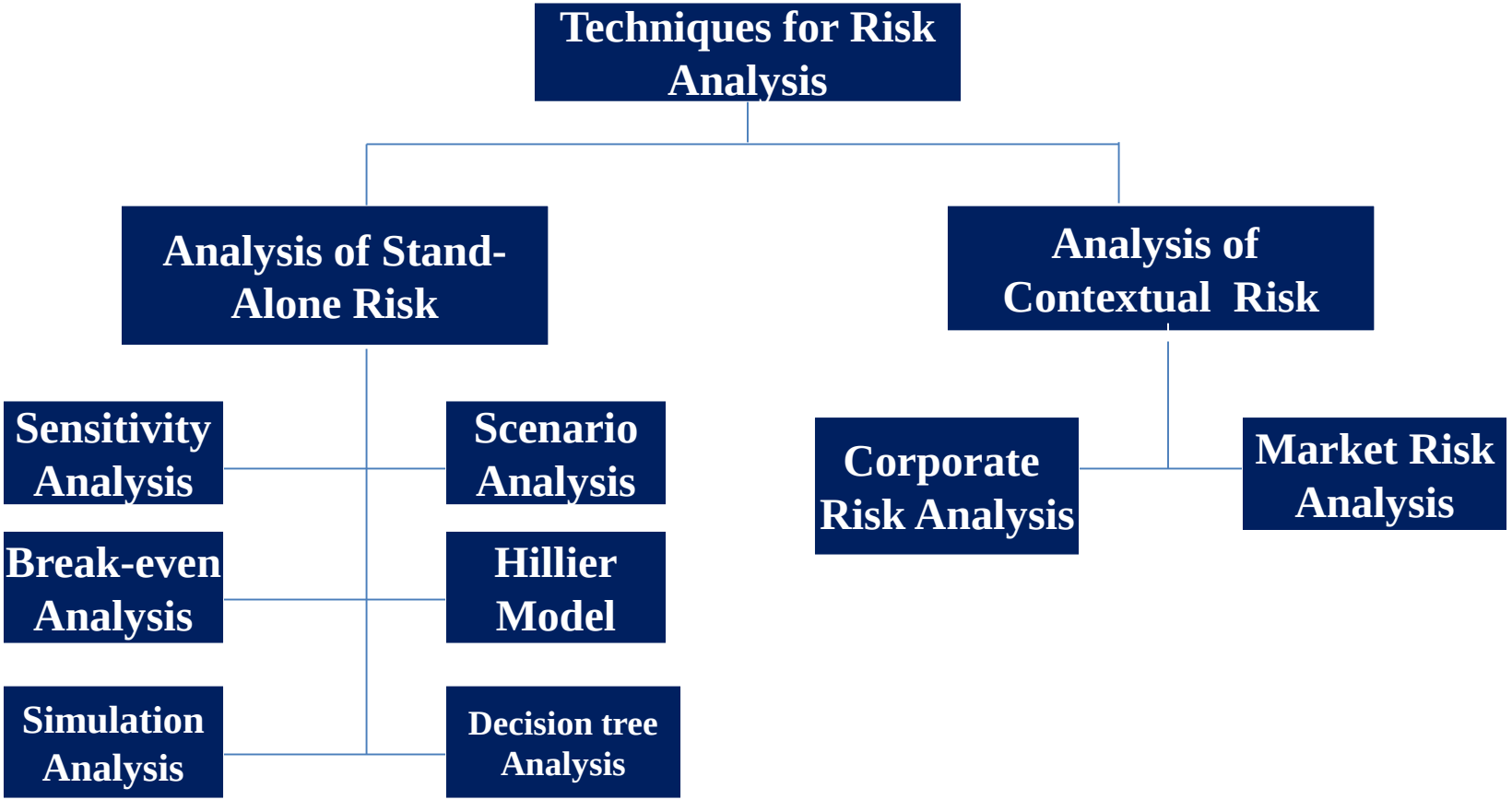
Lec – 26

Decision Tree Analysis- I

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee


Techniques for Risk Analysis
Analysis of Stand-Alone Risk
Analysis of Contextual Risk
Sensitivity Analysis
Scenario Analysis
Break-even Analysis
Hillier Model
Simulation Analysis
Decision tree Analysis
Corporate Risk Analysis
Market Risk Analysis

Decision Tree Analysis

- Decision tree analysis is a tool for analysing situations where sequential decision making in face of risk is involved.

-New molecule-pilot production-test market-mfg – small and large plant ,etc.

- The key steps in decision tree analysis are:

1.Identifying the problem and alternatives- Imaginative efforts –risk and uncertainty

2.Delineating the decision

3.Specifying probabilities and monetary outcomes

4.Evaluating various decision alternatives

Decision Tree

The decision tree, exhibiting the anatomy of the decision situation,shows :

- The decision points (also called decision forks) and the alternative options available for experimentation and action at these decision points.
- The chance points (also called chance forks) where outcomes are dependent on a chance process and the likely outcomes at these points.

The decision tree reflects in a diagrammatic form the nature of the decision situation in terms of alternative courses of action and chance outcomes which have been identified in the first step of the analysis.

Decision Tree

A decision tree can easily become very complex and cumbersome if an attempt is made to consider the myriad possible future events and decisions. Such a decision tree, however, is not likely to be a very useful tool of analysis. Over-elaborate, it may obfuscate the critical issues.

Hence an effort should be made to keep the decision tree somewhat simple so that the decision makers can focus their attention on major future alternatives without being drowned in a mass of trivia

Specification of Probabilities and Monetary Value of Outcomes

Once the decision tree is delineated, the following data have to be gathered :

- Probabilities associated with each of the possible outcomes at various chance forks, and
- Monetary value of each combination of decision alternative and chance outcome.

Specification of Probabilities and Monetary Value of Outcomes

The probabilities of various outcomes may sometimes be defined objectively. For example, the probability of a good monsoon may be based on objective, historical data. More often, however, the possible outcomes encountered in real life are such that objective probabilities for them cannot be obtained. How can you, for example, define objectively the probability that a new product like an electric moped will be successful in the market? In such cases, probabilities have to be necessarily defined subjectively.

Evaluation of Alternatives

Once the decision tree is delineated and data about probabilities and monetary values gathered, decision alternatives may be evaluated as follows :

1. Start at the right-hand end of the tree and calculate the expected monetary value at various chance points that come first as we proceed leftward.
2. Given the expected monetary values of chance points in step 1, evaluate the alternatives at the final stage decision points in terms of their expected monetary values.

Evaluation of Alternatives

3. At each of the final stage decision points, select the alternative which has the highest expected monetary value and truncate the other alternatives. Each decision point is assigned a value equal to the expected monetary value of the alternative selected at that decision point.
4. Proceed backward (leftward) in the same manner, calculating the expected monetary value at chance points, selecting the decision alternative which has the highest expected monetary value at various decision points, truncating inferior decision alternatives, and assigning values to decision points, till the first decision point is reached.

case

The scientists at a comapny have come up with an electric moped. The firm is ready for pilot production and test marketing. This will cost Rs.20 million and take six months. Management believes that there is a 70 percent chance that the pilot production and test marketing will be successful. In case of success, company can build a plant costing Rs.150 million. The plant will generate an annual cash inflow of Rs.30 million for 20 years if the demand is high or an annual cash inflow of Rs.20 million if the demand is moderate. High demand has a probability of 0.6; Moderate demand has a probability of 0.4. To analyse such situations where sequential decision making is involved decision tree analysis is helpful.

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 27

Decision Tree Analysis- II

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

case

The scientists at a comapny have come up with an electric moped. The firm is ready for pilot production and test marketing. This will cost Rs.20 million and take six months. Management believes that there is a 70 percent chance that the pilot production and test marketing will be successful. In case of success, company can build a plant costing Rs.150 million. The plant will generate an annual cash inflow of Rs.30 million for 20 years if the demand is high or an annual cash inflow of Rs.20 million if the demand is moderate. High demand has a probability of 0.6; Moderate demand has a probability of 0.4. To analyse such situations where sequential decision making is involved decision tree analysis is helpful.

Present value of an annuity of ₹ 1 paid for period t at a rate $k = [1 - 1/(1 + k)^t]/k$																				
	Rate																			
Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833
2	1.970	1.942	1.913	1.886	1.859	1.833	1.808	1.783	1.759	1.736	1.713	1.690	1.668	1.647	1.626	1.605	1.585	1.566	1.547	1.528
3	2.941	2.884	2.829	2.775	2.723	2.673	2.624	2.577	2.531	2.487	2.444	2.402	2.361	2.322	2.283	2.246	2.210	2.174	2.140	2.106
4	3.902	3.808	3.717	3.630	3.546	3.465	3.387	3.312	3.240	3.170	3.102	3.037	2.974	2.914	2.855	2.798	2.743	2.690	2.639	2.589
5	4.853	4.713	4.580	4.452	4.329	4.212	4.100	3.993	3.890	3.791	3.696	3.605	3.517	3.433	3.352	3.274	3.199	3.127	3.058	2.991
6	5.795	5.601	5.417	5.242	5.076	4.917	4.767	4.623	4.486	4.355	4.231	4.111	3.998	3.889	3.784	3.685	3.589	3.498	3.410	3.326
7	6.728	6.472	6.230	6.002	5.786	5.582	5.389	5.206	5.033	4.868	4.712	4.564	4.423	4.288	4.160	4.039	3.922	3.812	3.706	3.605
8	7.652	7.325	7.020	6.733	6.463	6.210	5.971	5.747	5.535	5.335	5.146	4.968	4.799	4.639	4.487	4.344	4.207	4.078	3.954	3.837
9	8.566	8.162	7.786	7.435	7.108	6.802	6.515	6.247	5.995	5.759	5.537	5.328	5.132	4.946	4.772	4.607	4.451	4.303	4.163	4.031
10	9.471	8.983	8.530	8.111	7.722	7.360	7.024	6.710	6.418	6.145	5.889	5.650	5.426	5.216	5.019	4.833	4.659	4.494	4.339	4.192
11	10.368	9.787	9.253	8.760	8.306	7.887	7.499	7.139	6.805	6.495	6.207	5.938	5.687	5.453	5.234	5.029	4.836	4.656	4.486	4.327
12	11.255	10.575	9.954	9.385	8.863	8.384	7.943	7.536	7.161	6.814	6.492	6.194	5.918	5.660	5.421	5.197	4.988	4.793	4.611	4.439
13	12.134	11.348	10.635	9.986	9.394	8.853	8.358	7.904	7.487	7.103	6.750	6.424	6.122	5.842	5.583	5.342	5.118	4.910	4.715	4.533
14	13.004	12.106	11.296	10.563	9.899	9.295	8.745	8.244	7.786	7.367	6.982	6.628	6.302	6.002	5.724	5.468	5.229	5.008	4.802	4.611
15	13.865	12.849	11.938	11.118	10.380	9.712	9.108	8.559	8.061	7.606	7.191	6.811	6.462	6.142	5.847	5.575	5.324	5.092	4.876	4.675
16	14.718	13.578	12.561	11.652	10.838	10.106	9.447	8.851	8.313	7.824	7.379	6.974	6.604	6.265	5.954	5.668	5.405	5.162	4.938	4.730
17	15.562	14.292	13.166	12.166	11.274	10.477	9.763	9.122	8.544	8.022	7.549	7.120	6.729	6.373	6.047	5.749	5.475	5.222	4.990	4.775
18	16.398	14.992	13.754	12.659	11.690	10.828	10.059	9.372	8.756	8.201	7.702	7.250	6.840	6.467	6.128	5.818	5.534	5.273	5.033	4.812
19	17.226	15.678	14.324	13.134	12.085	11.158	10.336	9.604	8.950	8.365	7.839	7.366	6.938	6.550	6.198	5.877	5.584	5.316	5.070	4.843
20	18.046	16.351	14.877	13.590	12.462	11.470	10.594	9.818	9.129	8.514	7.963	7.469	7.025	6.623	6.259	5.929	5.628	5.353	5.101	4.870

Airways Limited Case

Airways Limited has been set up to run an air taxi service in western India. The company is debating whether it should buy a turboprop aircraft or a piston engine aircraft. The turboprop aircraft costs 4000 and has a larger capacity. It will serve if the demand turns out to be high.

The piston engine aircraft costs 1800 and has a smaller capacity. It will serve if the demand is low, but it will not suffice if the demand is high.

The company believes that the chances of demand being high and low in year 1 are 0.6 and 0.4. If the demand is high in year 1, there is an 80 percent chance that it will be high in subsequent years (year 2 onward) and a 20 percent chance that it will be low in subsequent years.

Airways Limited Case

The technical director of Airways Limited thinks that if the company buys a piston engine aircraft now and the demand turns out to be high the company can buy a second-hand piston engine aircraft for 1400 at the end of year 1. This would double its capacity and enable it to cope reasonably well with high demand from year 2 onwards.

The payoffs associated with high and low demand for various decision alternatives are shown as. The payoffs shown for year 1 are the payoffs occurring at the end of year 1 and the payoffs shown for year 2 are the payoffs for year 2 and the subsequent years, evaluated as of year 2, using a discount rate of 12 percent which is the weighted average cost of capital for Airways Limited.

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 28

Abandonment Analysis

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Every project has a useful life, after which it is expected to end. But, sometimes, a project is ended before its useful life is over. Deciding to abandon the project before its planned life is called abandonment. This can be due to various reasons. The reasons are generally related to variables of project life, selling price, selling quantity, raw material availability and its price, salvage value, expected rate of return, etc

Product may loose charm- sale may decline- customer taste or some other reasons like competition or regulations.

Raw material non availability – spectrum , import regulations, reduced cultivation.

Offered price for the project may be lucrative for the project owner to abandon the project and he may feel beneficial to sell the project instead of continuing with it.

An increase in expected return also leads to abandonment. The increase in expected returns may be due to increased rate of interest or availability of better prospects for investment.

For example, a company expects a return of 14% from a project and the expected return was 12%, it will be a beneficial project but if due to some economic conditions like **increase in interest** rate which results in increase in expected **returns (16%),** then the project loses its feasibility and the firm may decide to abandon the project

Another common reason is availability of more lucrative project with higher returns. For example, an investor has invested money to yield a return of 10% with a bank and another bank offers 12% return.

There are some other reasons for abandonment. For example, a firm may decide to decrease its product line to concentrate on fewer products.

The question arises, when should a firm abandon a project or how to evaluate whether abandonment should be done?

We can certainly apply NPV method to evaluate the various alternatives and take the right decision.

The simple rule is, consider the offered abandon price as investment and consider only future cash flows of remaining project life and apply the current expected return as discounting factor.

The resultant NPV, if positive, means that the project should be continued rather than abandoned and vice versa. The past data should be ignored in abandonment analysis

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 29

Technical Analysis

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Outline

- Manufacturing process / technology
- Technical arrangements
- Materials and inputs
- Product mix
- Plant capacity
- Location and site
- Machineries and equipments
- Structures and civil works
- Environmental aspects
- Project charts and layouts
- Project implementation schedule
- Need for considering alternatives

Manufacturing Process/Technology

For manufacturing a product / service often two or more alternative technologies are available (Steel – Bessemer process or open hearth, Cement- Dry or wet, Soap – semi or fully boiled process).

Choice of Technology

The choice of technology is influenced by a variety of considerations:

- Plant capacity (relationship b/w capacity and technology???)
- Principal inputs: (quality of limestone – dry or wet process)
- Investment outlay and production cost (effect of alternative technologies on these two should be observed)
- Use by other units (how it is yielding profits)
- Product mix
- Latest developments (obsolescence should be minimized)
- Ease of absorption (high end tech may take long time and trained people)

Should we always use latest technology?

Appropriate:

Evaluate technology in terms of :

1. **Whether it utilizes local raw material and manpower**
2. **Whether it protects ecological balance**
3. **Whether it is harmonious with social and cultural conditions.**

Technical Arrangements

When collaboration is sought, the following aspects of the agreement must be worked out in detail??????.

Technical Arrangements

·The nature of support to be provided by the collaborators during the designing of the project, selection and procurement of equipment, installation and erection of the plant, operation and maintenance of the plant, and training of project personnel

· Process and performance guarantees in terms of plant capacity, product quality, and consumption of raw materials and utilities.

- The price of technology in terms of one time licensing fee and periodic royalty fee

- The continuing benefit of research and development work being done by the collaborator.

- The period of collaboration agreement

- The assistance to be provided and the restrictions to be imposed by the collaborator with respect to exports

- If the technical collaboration is backed by financial collaboration, the level of equity participation and the manner of sharing management control.

- Assignment of the agreement by either side in case of change of ownership

- Termination of the agreement or other remedies when either party fails to meet its obligation

Material Inputs and Utilities

An important aspect of technical analysis is concerned with defining the materials and utilities required, specifying their properties in some detail, and setting up their supply programme.

Materials and utilities may be classified into four broad categories:

- Raw materials (Agricultural products, mineral products, livestock or forest products, and marine product)
- Processed industrial materials and components (parts, components, sub-assemblies)
- Auxiliary materials and factory supplies (chemicals, packaging matl, oils, grease, paint, varnishes)
- Utilities (power, water, steam, fuel)

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 30

Product Mix and Plant Capacity Analysis

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Product Mix

- The choice of product mix is guided by market requirements. In the production of most of the items, variations in size and quality are aimed at satisfying a broad range of customers.

- While planning the production facilities of the firm, some flexibility with respect to the product mix must be sought.

Plant Capacity

- Plant capacity (also referred to as production capacity) refers to the volume or number of units that can be manufactured during a given period.
- Plant capacity may be defined in two ways : feasible normal capacity and nominal maximum capacity (Installed capacity)
- Several factors have a bearing on the capacity decision:

Plant Capacity

·**Investment cost:** (The investment cost per unit of capacity decreases as the plant capacity increases)

$C2 = C1 (Q2/Q1)^{\alpha}$

Where C2 is derived cost for Q2 units, C1 is the known cost for Q1 units of capacity, and α is factor reflecting capacity – cost relationship.

Ex: For 5000 units, the investment is Rs.1000,000. What would be the investment for 10,000 units. Given $\alpha = 0.6$.

Ex: For 5000 units, the investment is Rs.1000,000. What would be the investment for 10,000 units. Given $\alpha = 0.6$.

$C2 = 1000,000\ (2)^{0.6}$

Plant Capacity

·Technological requirement (cement plant – capacity of 300 tones per day- rotary kiln method, other wise use vertical shaft method for lower capacity)

·Input constraints: (power supply, raw material/ labor availability, etc.

·Market conditions: If favorable, then higher capacity of plant.

·Resources of the firm: Managerial and financial limit the capacity decision.

·Governmental policy :

Location and Site

Location refers to a broad area; site refers to a specific piece of land. The choice of location is influenced by a variety of considerations:

- **Proximity to raw materials and markets**
- **Availability of infrastructure**
- **Labour situation**
- **Governmental policies**
- **Other factors** **(climate conditions, general living conditions, proximity to ancillary, ease in coping up with pollution)**

Machineries and Equipment

- The requirement of machineries and equipment is dependent on production technology and plant capacity. It is influenced by the type of project.
- For a process-oriented industry, like a petrochemical unit, machineries and equipments required should be such that the various stages are matched well.
- The choices of machineries and equipment for a manufacturing industry is somewhat wider.

Structures and Civil Works

Structures and civil works may be divided into three categories:

- **Site preparation and development**: **(leveling, gardening, removal of existing structures, relocation of existing pipelines, cables, power lines, roads, reclamation of swamp, and draining and removal of standing water, connection of electric power, water, communication)**
- **Buildings and structures: (Factory building, stores, warehouse, laboratory, administrative building, staff welfare building, cafeteria, medical, etc)**
- **Outdoor works: (Handling and treatment of emission, wastages, effluents, transportation and traffic signals, out door lighting, boundary wall, fencing, gates, security posts)**

Environmental Aspects

The environmental aspects of projects have to be properly examined. The key issues that need to be considered in this respect are:

- What are the types of effluents and emissions generated ?
- What needs to be done for proper disposal of effluents and treatment of emissions ?
- Will the project be able to secure all environmental clearances and comply with all statutory requirements ?

Project Charts and Plant Layout

Once data is available on the principal dimensions (market size, plant capacity, production technology, building and civil works, etc.) of the project, project charts and layout may be prepared.

The important charts and layout drawings are :

(i) general functional layout,
(ii) material flow diagrams,
(iii) production line diagram,
(iv) transport layout,
(v) utility consumption points layout,
(vi) communication layout
(vii) organisational layout, and
(viii) plant layout

Plant Layout

The important considerations in preparing the plant layout are:

- **Consistency with production technology**
- **Smooth flow of goods from one stage to another**
- **Proper utilisation of space**
- **Scope for expansion**
- **Minimisation of production cost**
- **Safety of personnel**

Schedule of Project Implementation

As part of technical analysis, a project implementation schedule is also usually prepared. For preparing the project implementation schedule the following information is required:

- List of all possible activities from project planning to commencement of production
- The sequence in which various activities have to be performed
- The time required for performing various activities
- The resources normally required for performing various activities
- The implications of putting more resources or less resources than are normally required.

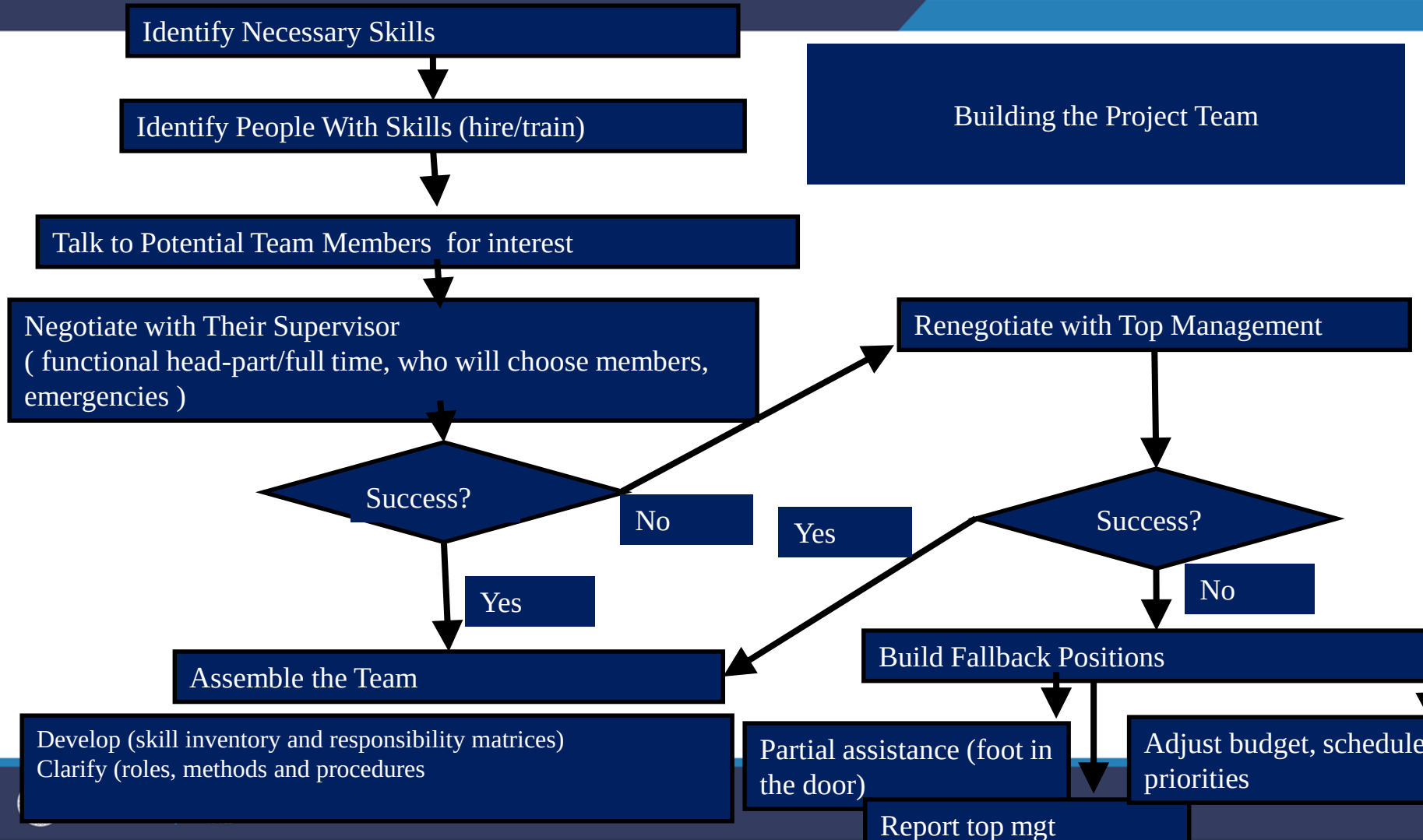
The Need for Considering Alternatives

There are alternative ways of transforming an idea into a concrete project. These alternatives may differ in one or more of the following aspects:

- Nature of project
- Production process
- Product quality
- Scale of operation and time phasing
- Location

Project Team Building, Conflict, and Negotiation

Building the Project Team



Effective Project Teams Should Have

- **Clear Sense of Mission:** Understanding of objectives.
- **Productive Interdependency:** degree of joint activity among team members required to complete project. (MIS,Engg, A/c,mkt, admin- give importance to interrelatedness of each others' efforts)
- **Cohesiveness:** Degree of mutual attraction that team members hold for each other and their task.
- **Trust:** Tam's **comfort level** with each individual member. How to build trust – PM – "what happens here stay here" (divulging of views and confidence betrayed). It takes time. It is 1 or 0, trust worthy or not (nothing like slightly trustworthy). Trust occurs at professional level, integrity level, and emotional level.

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 31

Project Team Building, Conflict and Negotiation

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Effective Project Teams Should Have

- **Clear Sense of Mission:** Understanding of objectives.
- **Productive Interdependency:** degree of joint activity among team members required to complete project. (MIS,Engg, A/c,mkt, admin- give importance to interrelatedness of each others' efforts)
- **Cohesiveness:** Degree of mutual attraction that team members hold for each other and their task.
- **Trust:** Tam's **comfort level** with each individual member. How to build trust – PM – "what happens here stay here" (divulging of views and confidence betrayed). It takes time. It is 1 or 0, trust worthy or not (nothing like slightly trustworthy). Trust occurs at professional level, integrity level, and emotional level.

- **Enthusiasm:** Is the key to creating the **energy and spirit** that drives effective project efforts. Project should be challenging, personally rewarding, supportive (each other).
- **Results Orientation:** Commitment to achieve project's goal.

Reasons Why Teams Fail

- **Poorly developed or unclear goals:** (a) Multiple interpretations, (b) member interprets in most advantageous way, (c) increase conflict.
- **Poorly defined project team roles & interdependencies:**
- **Lack of project team motivation:**
- **Poor communication:**

Reasons Why Teams Fail

- **Poor leadership:**
- **Turnover among project team members:** Should be low.
- **Dysfunctional behavior:** Disruptive acts of some team members due to personality issues, hidden agendas, or interpersonal problems.

Stages in Group Development???????

Stages in Group Development??????

1. **Forming** – Members become **acquainted**, members **unsure** about project's **goals**, may not **know** each other, **confused** about own assignments.
2. **Storming** – Conflict begins, they test **limits and constraints** placed on their **behavior**. **Leadership, reporting relationship, norms of work** and interpersonal behavior are challenged.
3. **Norming** – A norm is unwritten rule of behavior, members reach **agreement**, level of **openness and trust** they should have with each other, how conflicts will be resolved.
4. **Performing** – Members work together, in this stage team relationships are characterized by **high level of trust**, a mutual **appreciation** for one another's performance and contributions, and a **willingness to actively seek to collaborate**.
5. **Adjourning** – Group disbands

Virtual Project Teams

use electronic media to link members of a geographically dispersed project team

How Can Virtual Teams Be Improved?

- ✓ Use face-to-face communication when possible
- ✓ Don’t let team members disappear
- ✓ Establish a code of conduct
- ✓ Keep everyone in the communication loop
- ✓ Create a process for addressing conflict

Conflict Management: What % of time is spent on this

Conflict *is a* ***process*** *that begins when you* ***perceive*** *that someone has frustrated or is about to frustrate a major concern of yours.*

Categories or types of conflict : ?????

Categories of conflict

- **Goal-oriented:** Often results from multiple perceptions. Disagreement about **end results, scope, performance, priorities, specifications.**
- **Administrative:** Arises through management hierarchy, organizational structure or company philosophy. Example is matrix origination having two bosses.
- **Interpersonal:** Occurs due to personality differences between project team members and important ant stakeholders. Interpersonal conflict sources include- **difference in work ethics, behavioral styles, egos, and personalities of team members.**

Views

Traditional: Conflicts will have **negative** effects on origination, conflict is **bad**, should be **avoided and resolved** quickly and painlessly as possible when it does occur. Emphasis is on **suppression and elimination.**

Views

Behavioral: Views conflicts as **natural and inevitable** part of organization life. So, **manage conflicts effectively** rater than attempt to **suppress or eliminate them.**

Views

Interactionist: View **encourages** conflict to develop., it prevents originations to become **too stagnant and apathetic**. Conflict actually introduces an **element of tension that produces innovation, creativity, and higher productivity**.

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 32

HRM Issues and Time Management

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Sources of Conflict

Organizational:

- Reward systems: competitive processes, how evaluation is being done.
- Scarce resources:
- Uncertainty: over lines of authority.
- Differentiation: mind set, attitudes, time frame, value systems are different from department to department.

Interpersonal:

- Faulty communication
- Personal grudges & prejudices

Conflict Resolution

1.Mediate – defusion (focus is less on source of conflict, but is on **mutual acceptable solution**) / confrontation (look for **root cause** of conflict, more effective in long run)

Conflict Resolution

2.Arbitrate – PM imposes **impersonal judgment** on the warring parties.

Conflict Resolution

3.Control – cool down period

Conflict Resolution

4.Accept – unmanageable - even after project gets over.

Conflict Resolution

5. Eliminate – transfer the guilty person

Conflict is often evidence of progress!

	Conflict Intensity Ranking	
SOURCES OF CONFLICT	Thamhain & Wilemon	Posner
Conflict over project priorities	**2**	3
Conflict over administrative procedures	5	7
Conflict over technical opinions and performance trade-offs	4	5
Conflict over human recourses	**3**	4
Conflict over cost and budget	**7**	**2**
Conflict over schedules	**1**	**1**
Personality conflicts	6	6

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 33

Project Time Management - Introduction

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

PROJECT TIME MANAGEMENT

Project Time Management includes the processes required to manage the **timely completion** of the project.

1 Plan Schedule Management—The process of establishing the policies, procedures, and documentation for *planning*, *developing*, *managing*, *executing*, and *controlling* the project **schedule.**

2 Define Activities—The process of identifying and documenting the specific actions to be performed to produce the project deliverables.

3 Sequence Activities—The process of identifying and documenting relationships among the project Activities.

4 Estimate Activity **Resources—The** process of estimating the type and quantities of material, human resources, equipment, or supplies required to perform each activity.

5 Estimate Activity **Durations—The** process of estimating the number of work periods needed to complete individual activities with estimated resources.

6 Develop Schedule—The process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model.

7 Control Schedule—The process of monitoring the status of project activities to update project progress and manage changes to the schedule baseline to achieve the plan.

Project Time Management Overview

6.1 Plan Schedule Management

.1 Inputs
- .1 Project management plan
- .2 Project charter
- .3 Enterprise environmental factors
- .4 Organizational process assets

.2 Tools & Techniques
- .1 Expert judgment
- .2 Analytical techniques
- .3 Meetings

.3 Outputs
- .1 Schedule management plan

6.2 Define Activities

.1 Inputs
- .1 Schedule management plan
- .2 Scope baseline
- .3 Enterprise environmental factors
- .4 Organizational process assets

.2 Tools & Techniques
- .1 Decomposition
- .2 Rolling wave planning
- .3 Expert judgment

.3 Outputs
- .1 Activity list
- .2 Activity attributes
- .3 Milestone list

6.3 Sequence Activities

.1 Inputs
- .1 Schedule management plan
- .2 Activity list
- .3 Activity attributes
- .4 Milestone list
- .5 Project scope statement
- .6 Enterprise environmental factors
- .7 Organizational process assets

.2 Tools & Techniques
- .1 Precedence diagramming method (PDM)
- .2 Dependency determination
- .3 Leads and lags

.3 Outputs
- .1 Project schedule network diagrams
- .2 Project documents updates

6.4 Estimate Activity Resources

.1 Inputs
- .1 Schedule management plan
- .2 Activity list
- .3 Activity attributes
- .4 Resource calendars
- .5 Risk register
- .6 Activity cost estimates
- .7 Enterprise environmental factors
- .8 Organizational process assets

.2 Tools & Techniques
- .1 Expert judgment
- .2 Alternative analysis
- .3 Published estimating data
- .4 Bottom-up estimating
- .5 Project management software

.3 Outputs
- .1 Activity resource requirements
- .2 Resource breakdown structure
- .3 Project documents updates

6.5 Estimate Activity Durations

.1 Inputs
- .1 Schedule management plan
- .2 Activity list
- .3 Activity attributes
- .4 Activity resource requirements
- .5 Resource calendars
- .6 Project scope statement
- .7 Risk register
- .8 Resource breakdown structure
- .9 Enterprise environmental factors
- .10 Organizational process assets

.2 Tools & Techniques
- .1 Expert judgment
- .2 Analogous estimating
- .3 Parametric estimating
- .4 Three-point estimating
- .5 Group decision-making techniques
- .6 Reserve analysis

.3 Outputs
- .1 Activity duration estimates
- .2 Project documents updates

6.6 Develop Schedule

.1 Inputs
- .1 Schedule management plan
- .2 Activity list
- .3 Activity attributes
- .4 Project schedule network diagrams
- .5 Activity resource requirements
- .6 Resource calendars
- .7 Activity duration estimates
- .8 Project scope statement
- .9 Risk register
- .10 Project staff assignments
- .11 Resource breakdown structure
- .12 Enterprise environmental factors
- .13 Organizational process assets

.2 Tools & Techniques
- .1 Schedule network analysis
- .2 Critical path method
- .3 Critical chain method
- .4 Resource optimization techniques
- .5 Modeling techniques
- .6 Leads and lags
- .7 Schedule compression
- .8 Scheduling tool

.3 Outputs
- .1 Schedule baseline
- .2 Project schedule
- .3 Schedule data
- .4 Project calendars
- .5 Project management plan updates
- .6 Project documents updates

6.7 Control Schedule

.1 Inputs
- .1 Project management plan
- .2 Project schedule
- .3 Work performance data
- .4 Project calendars
- .5 Schedule data
- .6 Organizational process assets

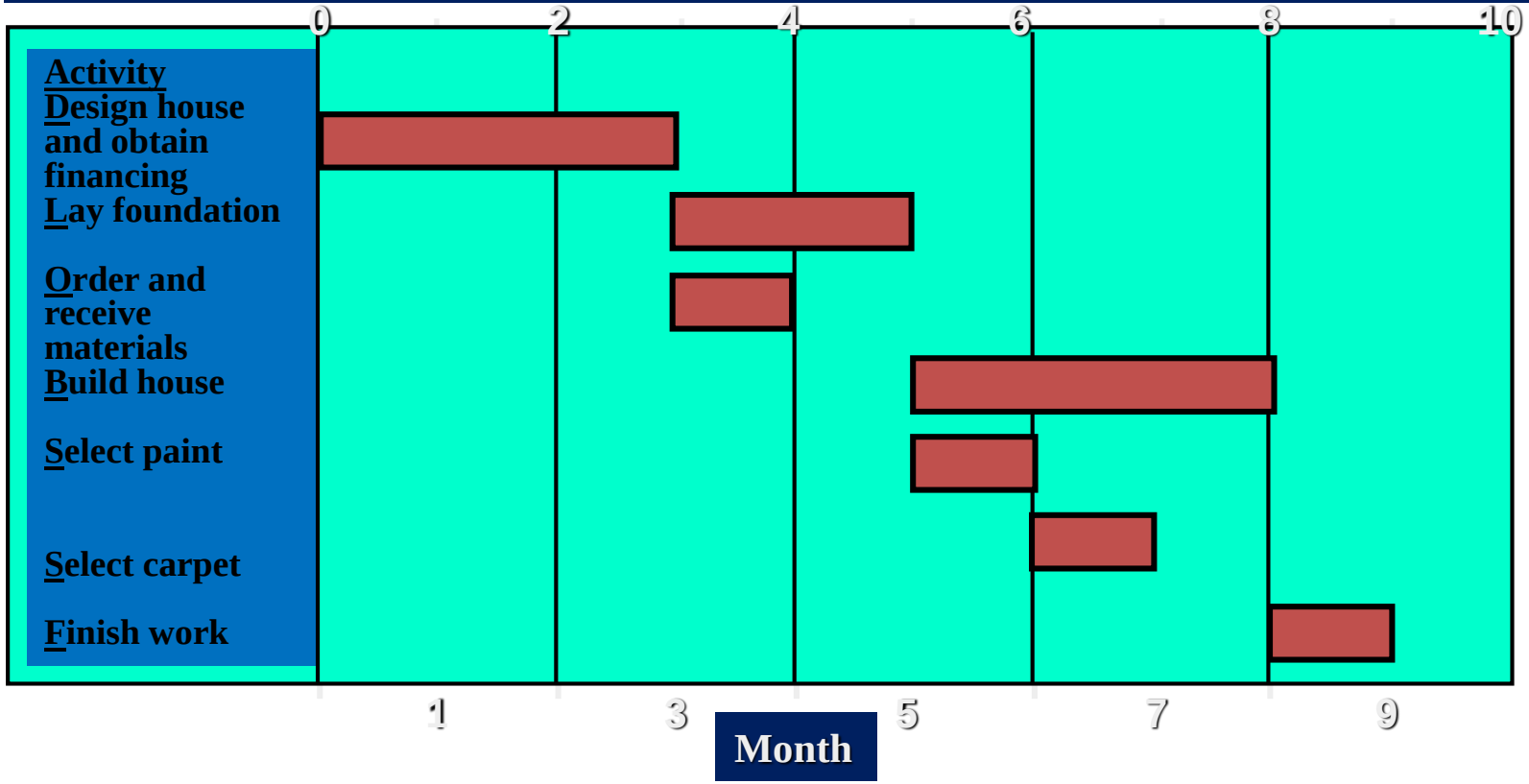
.2 Tools & Techniques
- .1 Performance reviews
- .2 Project management software
- .3 Resource optimization techniques
- .4 Modeling techniques
- .5 Leads and lags
- .6 Schedule compression
- .7 Scheduling tool

.3 Outputs
- .1 Work performance information
- .2 Schedule forecasts
- .3 Change requests
- .4 Project management plan updates
- .5 Project documents updates
- .6 Organizational process assets updates

Project scheduling and controlling techniques

1. Bar charts
2. Life cycle curves
3. Line of balance (LOB)
4. Network techniques (PERT/CPM)

A Gantt / Bar Chart



Gantt Charts

- ✓ Establish a time-phased network
- ✓ Can be used as a tracking tool

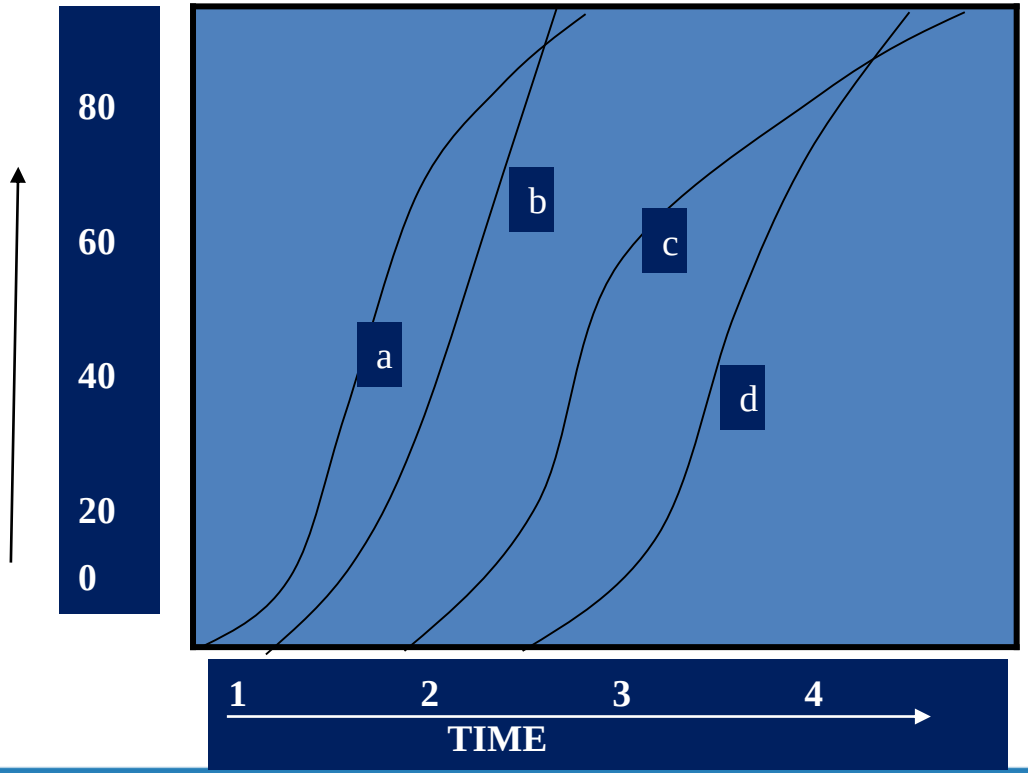
Benefits of Gantt charts

1. **Easy** to create and comprehend
2. Identify the schedule **baseline** network
3. Allow for **updating** and **control**
4. Identify **resource needs**

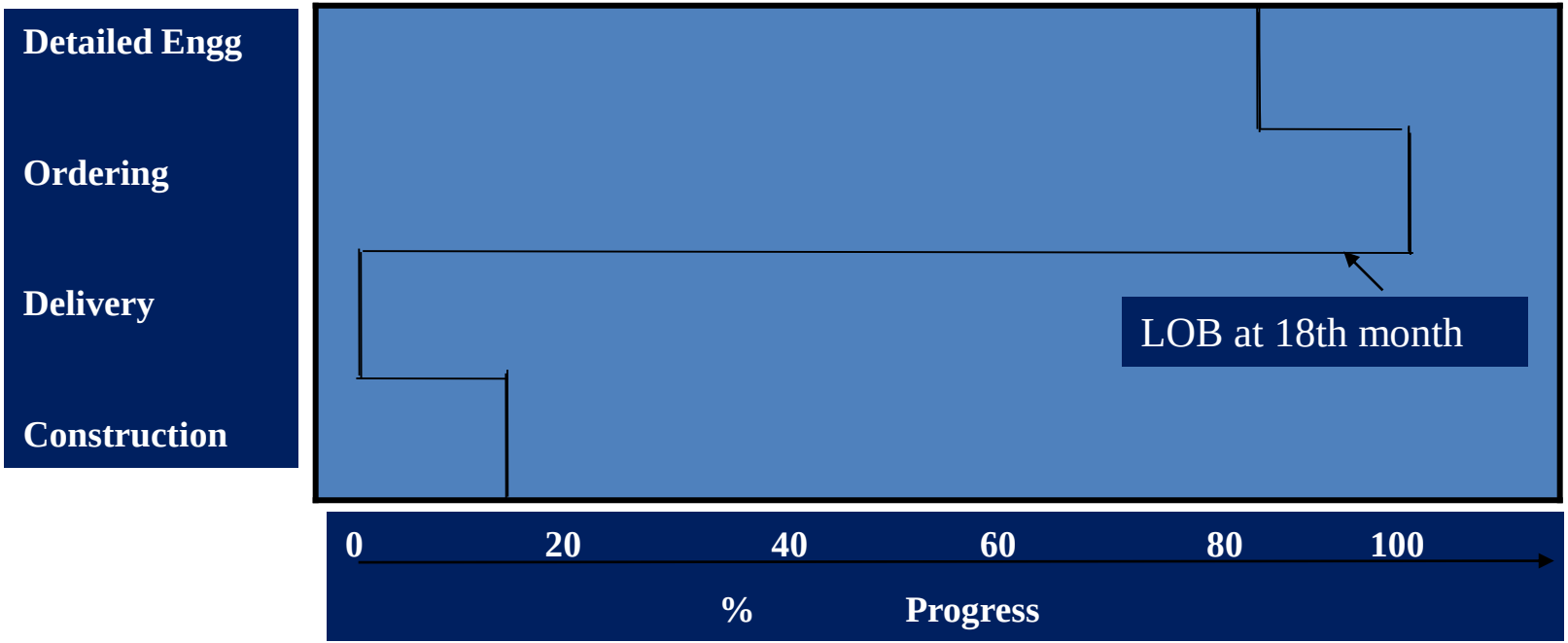
Create a Gantt chart based on the activities listed in the table.

Task	Time	Pred
Z	8	--
Y	5	Z
X	8	Z
W	4	Y,X
V	5	W
U	3	W
T	6	V
S	7	U,T
R	9	S

Life cycle curves



LINE OF BALANCE

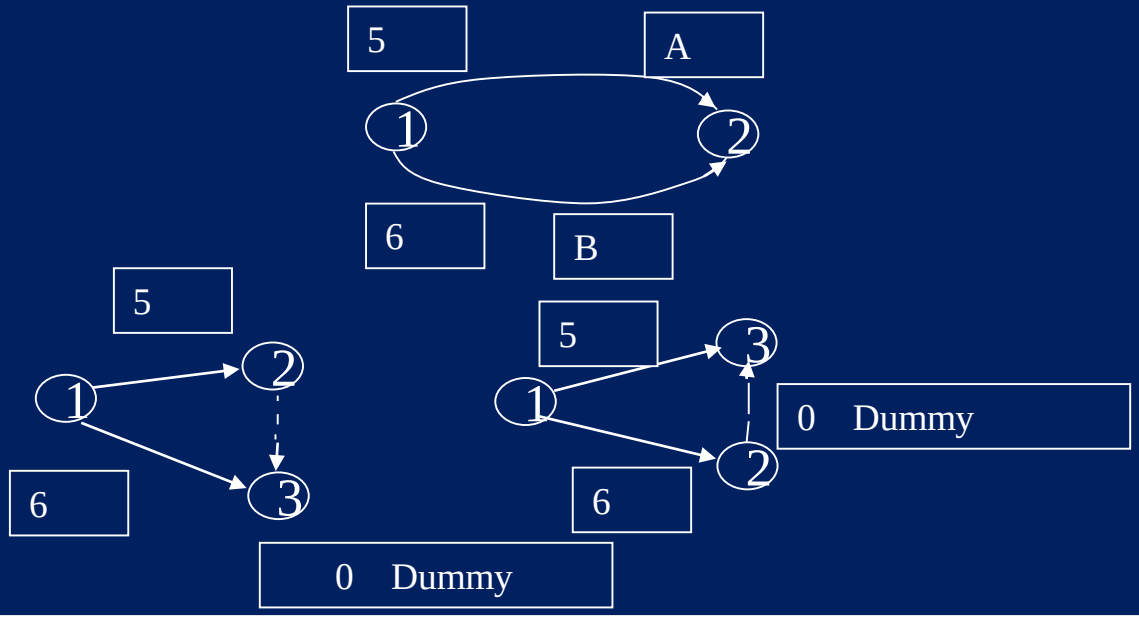


Network : We represent activities of a project through networks. It takes care of precedence relationships.

CPM	PERT
1.The time durations are **deterministic** (MBA degree).	1.The time durations are **probabilistic** (Ph. D. degree, DRDO,ISRO, CSIR Labs)
2.The duration of the project is fixed. And for a fixed duration it gives the most economical schedule.	2.There is expected duration of the project.
2.Looping and probabilistic events are not allowed in the network.	3.Simulation can be used to PERT network.

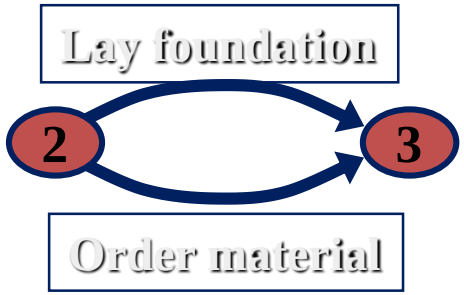
1. Each activity must be represented by one and only one arrow, an activity (i-j) “ i” is the staring node and “j” is terminal node.

2. No two activities should not have the same initial and same terminal nodes.

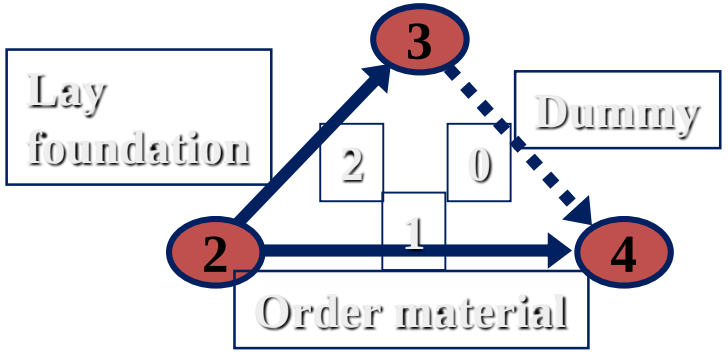


Dummy activity: does not consume time and resource

No two activities should have the same initial and same terminal nodes.



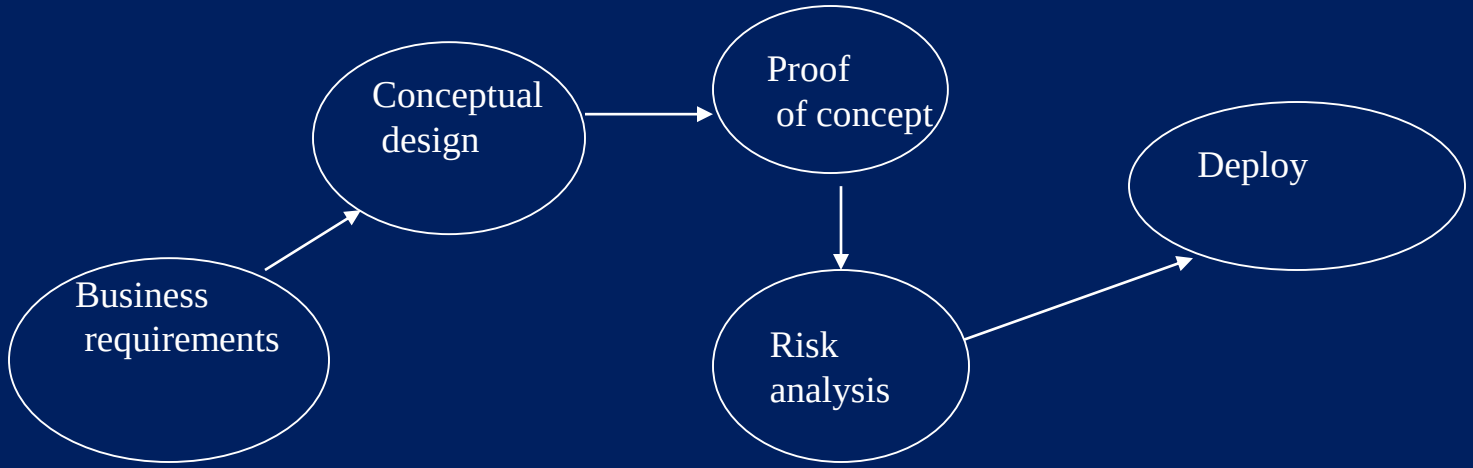
(a) Incorrect precedence relationship



(b) Correct precedence relationship

Software Project

Number	Event
1	Business requirements
2	Conceptual design
3	Proof of concept
4	Risk analysis
5	System requirements
6	Logical design
7	First build
8	Evaluation
9	Subsystem requirements
10	Physical design
11	Second build
12	Evaluation
13	Unit requirements
14	Final design
15	Final build
16	Test
17	Deploy

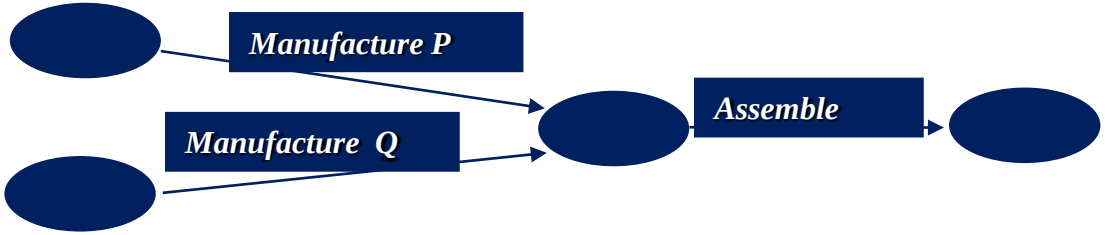


Event

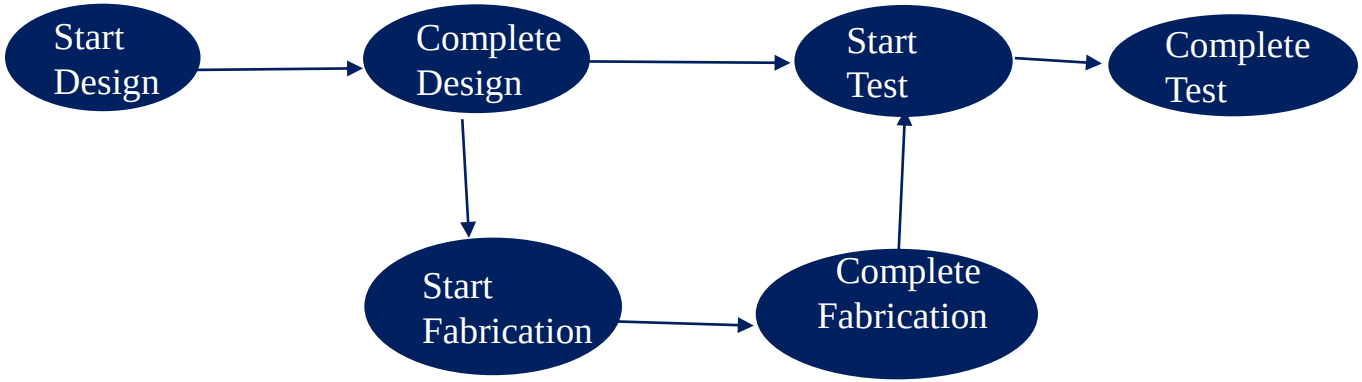
Activity

Event based network (PERT)

Activity based network (CPM)



Activity based network

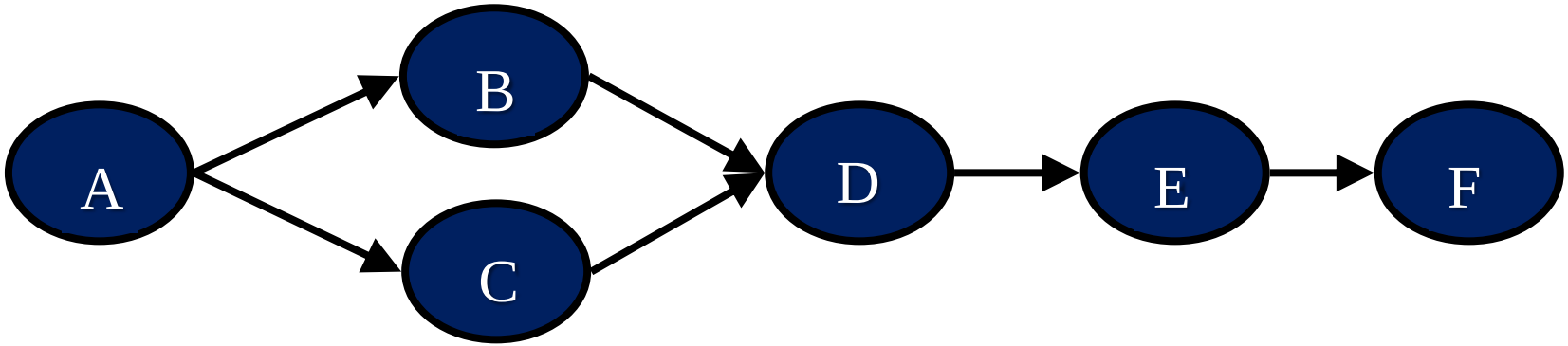


Event based network (PERT)

Project Scheduling Terms

- Successors
- Predecessors
- Network diagram
- Serial activities
- Concurrent activities

- Merge activities
- Burst activities
- Node
- Path



IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 34

Project Time Management (Project Scheduling)

Dr. M.K. Barua

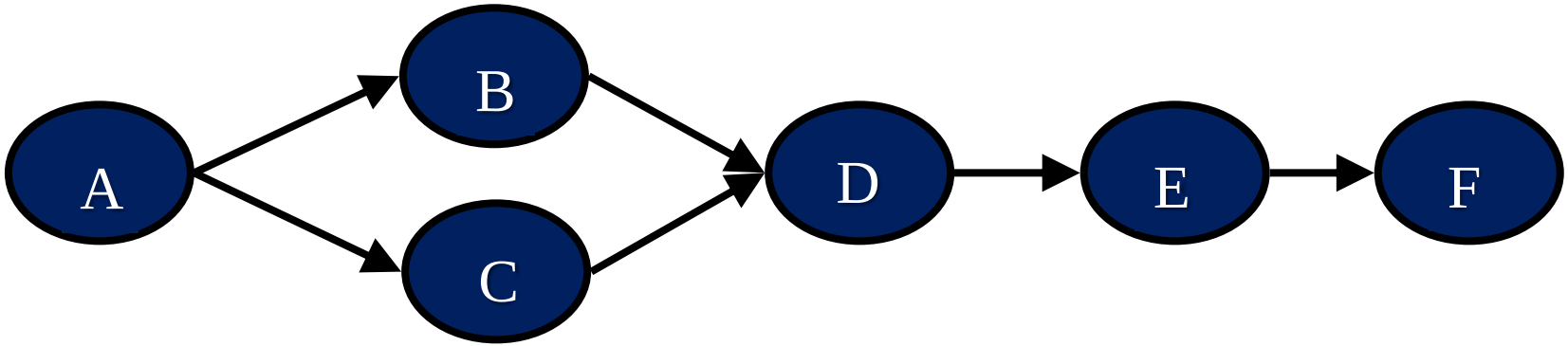
Department of Management

Indian Institute of Technology Roorkee

Project Scheduling Terms

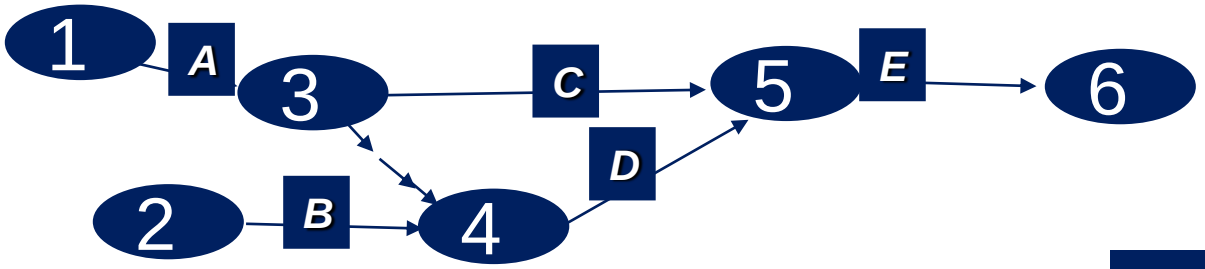
- Successors
- Predecessors
- Network diagram
- Serial activities
- Concurrent activities

- Merge activities
- Burst activities
- Node
- Path



Types of dummy activities

Job	Immediate predecessors
A	-
B	-
C	A
D	A,B
E	C,D

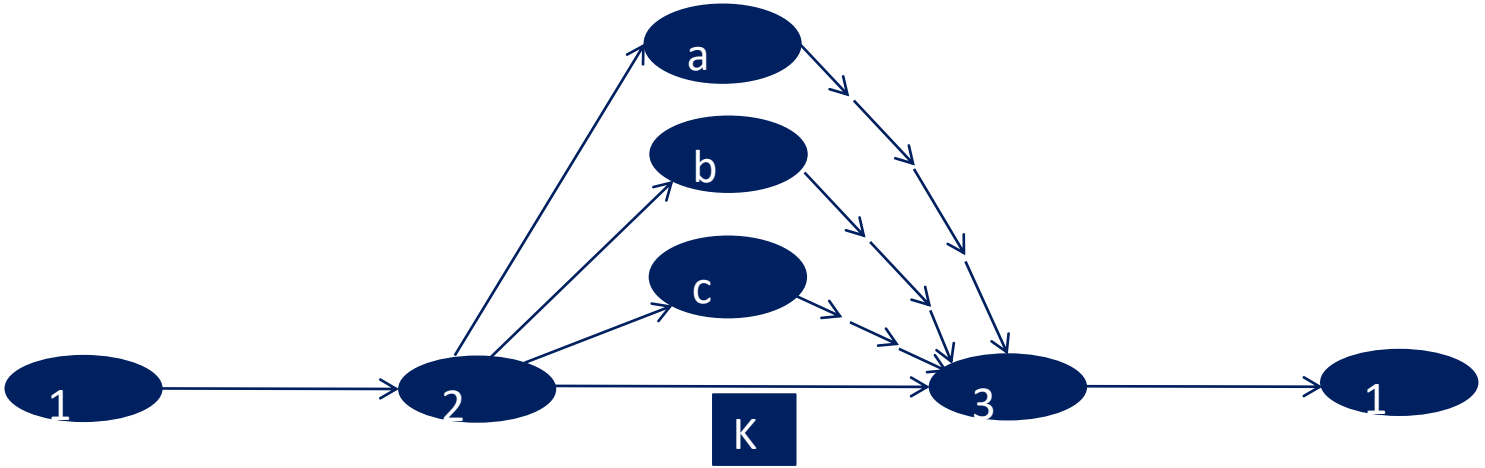


3-4 is a logical dummy activity

Apart from logical dummies one may be faced with situations where two or more activities have identical sets of predecessors and successors.

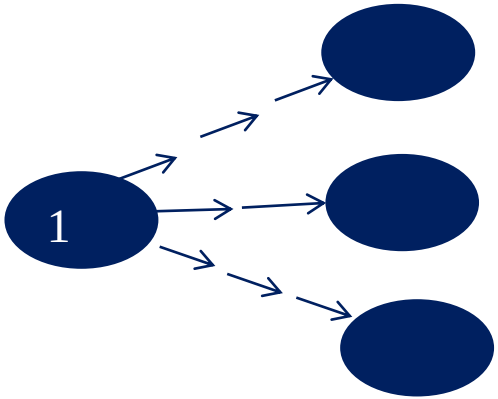
In this situation, the activities can be done in parallel or concurrently and their unique identification by referring to node numbers is *not* possible.

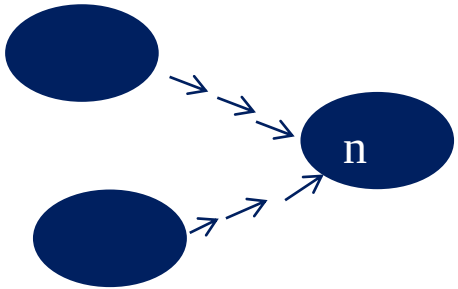
In such a situation , k parallel activities are modeled using k-1 dummies. The dummies so inserted are not logical dummies, but perform the function of dummies for unique representation



Dummies for unique representation of parallel activates

Another use of dummies is for creating a single source or single sink in a network which has multiple sources and/or sinks.



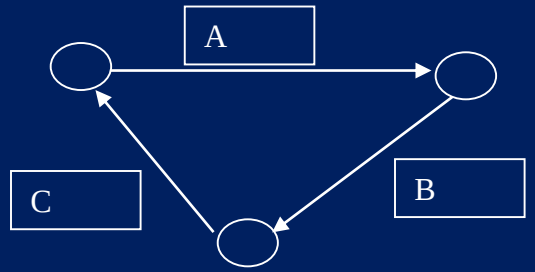


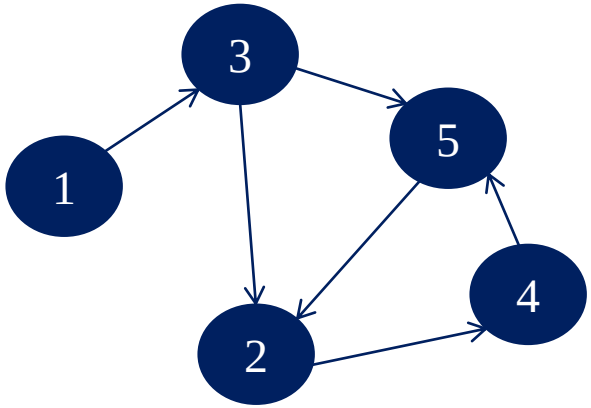
Dummies added for single source and sink

Types of network representation : A-O-N and A-O-A

It may be noted that if we use the A-O-N mode of representation where each activity is represented as a node, there is no need of adding any dummy activities to represent precedence or parallelism in activities since each activity would be well taken care of with suitable predecessors.

3. The arrow heads should not form a close loop/ consistency in project network





Adjacency matrix M

From node "i" to node "j"	1	2	3	4	5
1	0	0	1	0	0
2	0	0	0	1	0
3	0	1	0	0	1
4	0	0	0	0	1
5	0	1	0	0	0

M^2

From node "i"to node "j"	1	2	3	4	5
1	0	1	0	0	1
2	0	0	0	0	1
3	0	1	0	1	0
4	0	1	0	0	0
5	0	0	0	1	0

M^2 has all zeros on the diagonal, we compute M^3

From node "i"to node "j"	1	2	3	4	5
1	**0**	**1**	**0**	**1**	**0**
2	**0**	**1**	**0**	**0**	**0**
3	**0**	**0**	**0**	**1**	**1**
4	**0**	**0**	**0**	**1**	**0**
5	**0**	**0**	**0**	**0**	**1**

The appearance of 1^s to diagonal elements of nodes 2,4,5 indicates presence of loop and inconsistency . The loop is (2-4-5).

Hints for drawing networks:

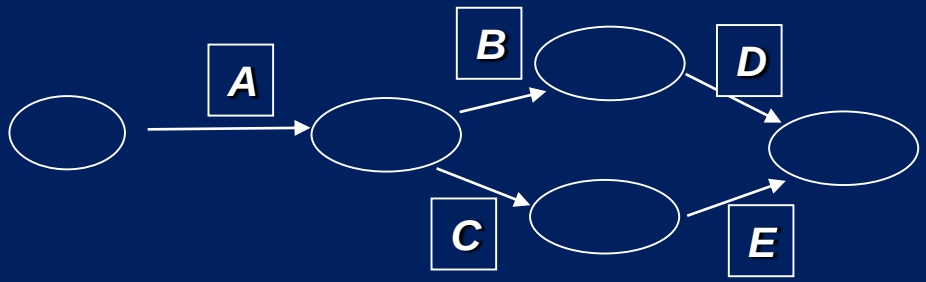
Example 1

-‘A’ precedes ‘B’ and ‘C’ or ‘B’ and ‘C’ follow ‘A’ or ‘B ‘and ‘C’ depend on ‘A’

- ‘D’ follows ‘B’

- E follows C

- D and E are terminal activities.



Hints for drawing networks:

Example 2

-‘A’ and ‘B’ start immediately

- ‘C’ follows both ‘A’ and ‘B’

- D follows A

- E follows D

- The project is complete when C and E are done

Hints for drawing networks:

Example 2

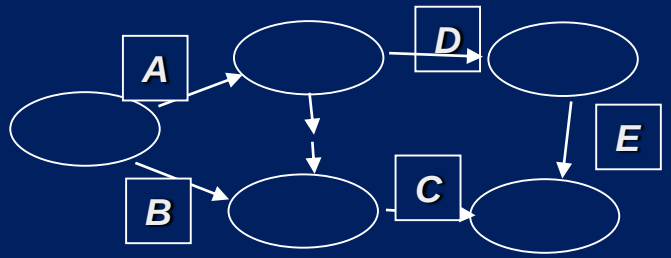
-'A' and 'B' start immediately

- 'C' follows both 'A' and 'B'

- D follows A

- E follows D

- The project is complete when C and E are done



Hints for drawing networks:

Example 3

- 'A' starts immediately

- 'B', 'C' and 'D' follow 'A'

- E follows B, C, and D

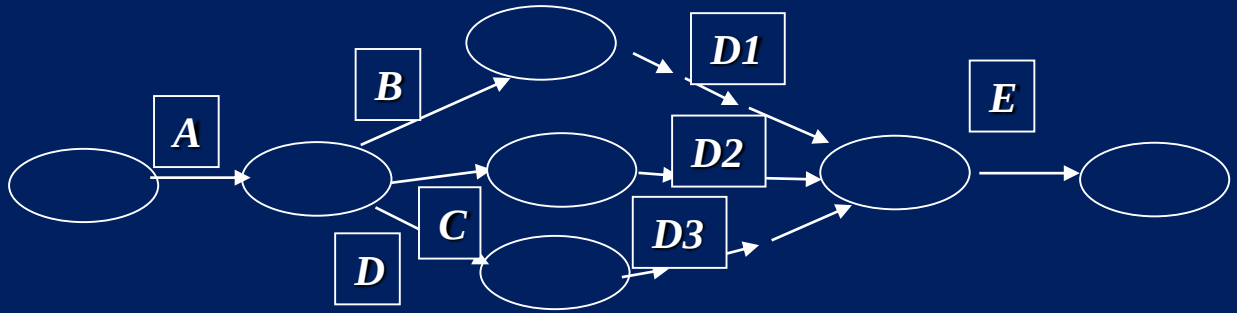
Hints for drawing networks:

Example 3

-'A' starts immediately

- 'B', 'C' and 'D' follow 'A'

- E follows B, C, and D



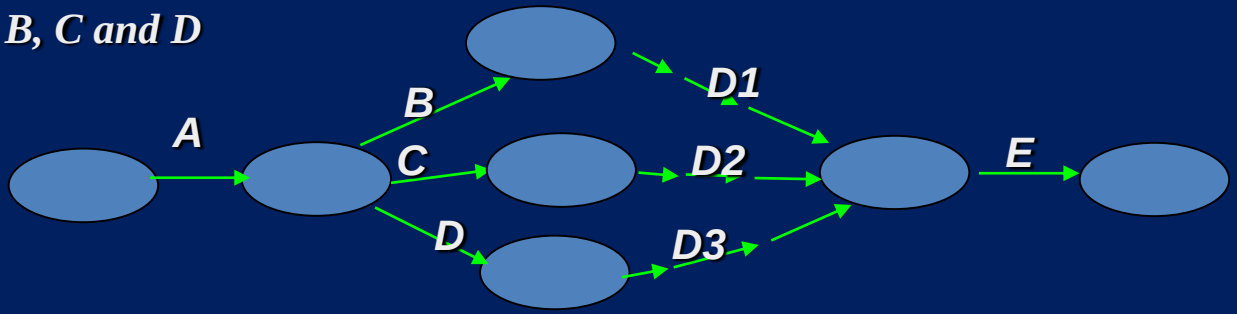
Hints for drawing networks:

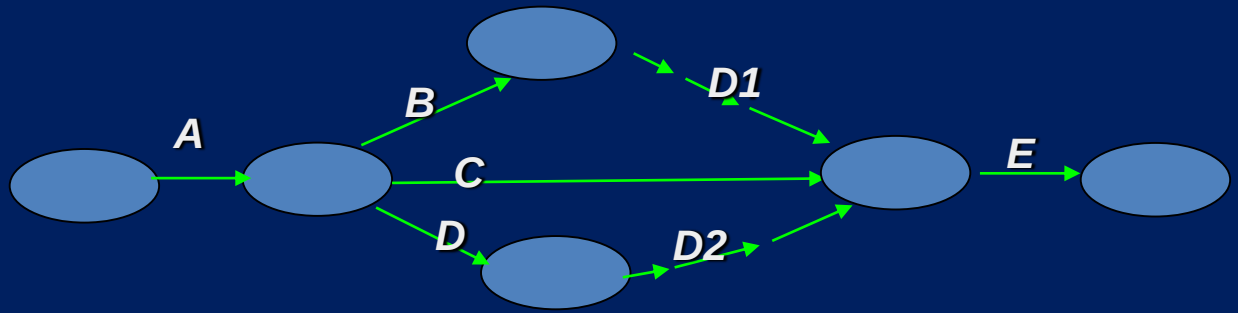
Example 3 Contd……

-'A' starts immediately

- 'B', 'C' and 'D' follow 'A'

- E follows B, C and D





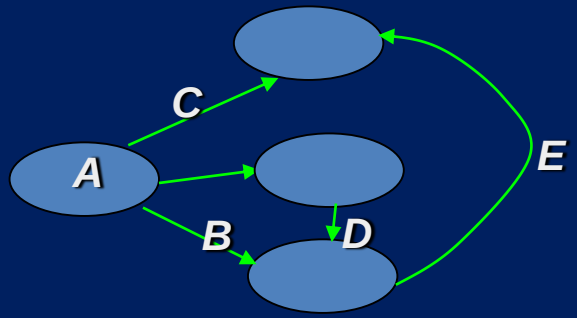
4. The arrows representing activities should be straight not curved.

- A,B and C start immediately

- D follows A

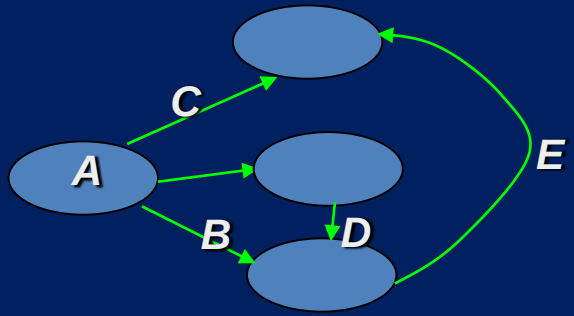
- E follows B and D

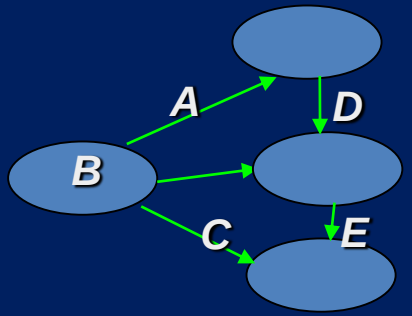
- C and E are terminal activities



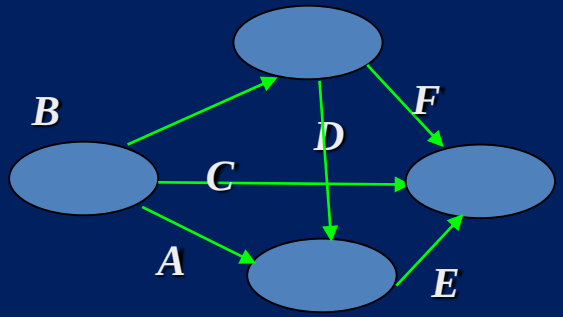
The arrows representing activities should be straight not curved.

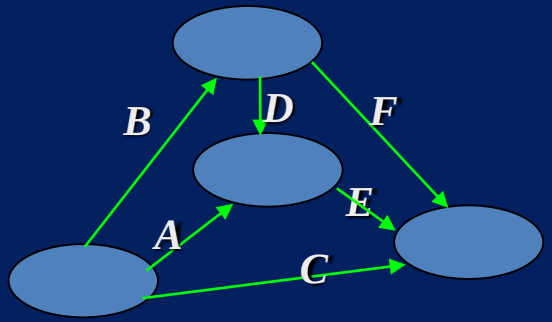
- *A, B and C start immediately*
- *D follows A*
- *E follows B and D*
- *C and E are terminal activities*





5. Avoid crossover of activities whenever possible.





Construct a network

- A and B are the first activities of the project start immediately,

- A precedes C and F,

- B precedes D and E ,

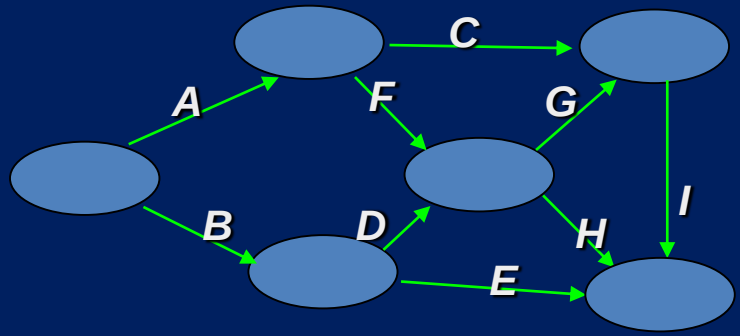
- F and D precede G and H,

- C and G precede I ,

- E , H and I are terminal activities.

Construct a network

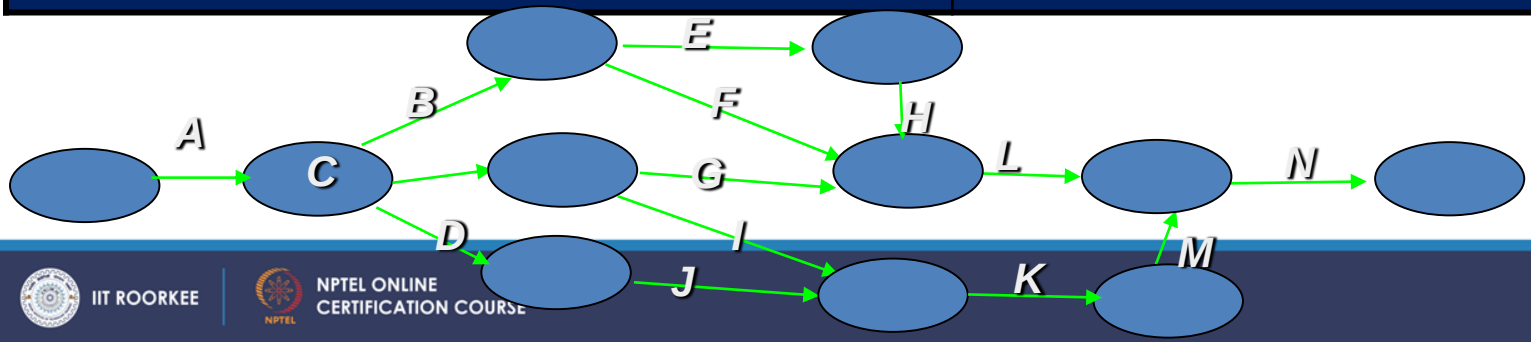
- A and B are the first activities of the project start immediately,
- A precedes C and F,
- B precedes D and E ,
- F and D precede G and H,
- C and G precede I ,
- E , H and I are terminal activities.



Construct a network

Activity	Depends on
A	None
B	A
C	A
D	A
E	B
F	B
H	E
G	C
I	C
J	D
K	I and J
L	F, G and H
M	K
N	L and M

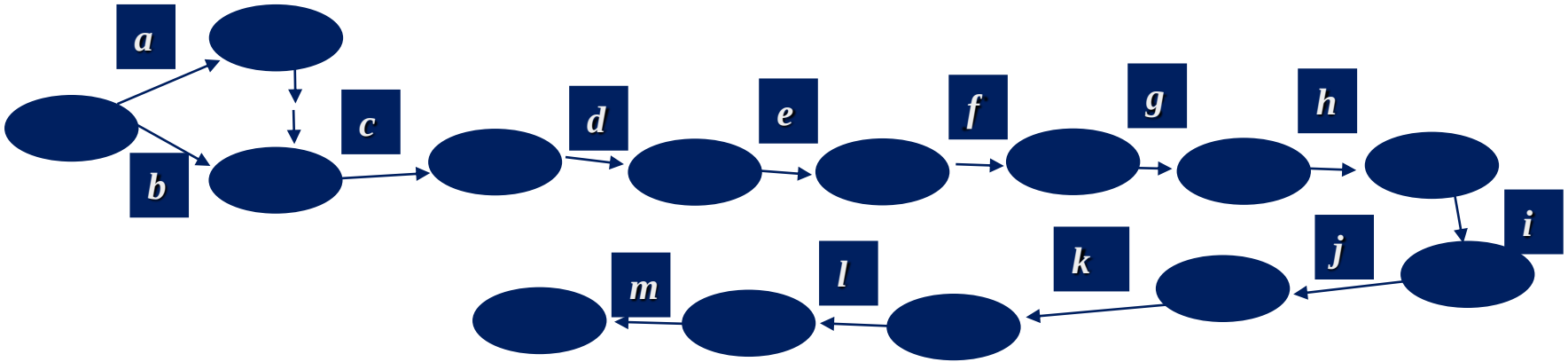
Activity	Depends on
A	None
B	A
C	A
D	A
E	B
F	B
H	E
G	C
I	C
J	D
K	I and J
L	F, G and H
M	K
N	L and M



a-review houses,
b-finalize requirements,
c-engage architect,
d-evaluate alternate designs,
e-finalize contractor,
f-foundations,

g-brickwork,
h-RCC,
i-plumbing,
j-wooden work,
k-organize party,
l-shift luggage,
m-settling in new house

Job	a	b	c	d	e	f	g	h	i	j	k	l	m
Predecessors	-	-	a,b	a,c	d	d,e	f	g	g,h	i	j	k	l



Activity on Arrow Network (A-O-A)

Activity on Node Network (A-O-N): Activities are represented on nodes and the arrows represent the precedence relation

a-review houses,
b-finalize requirements,
c-engage architect,
d-evaluate alternate designs,
e-finalize contractor,
f-foundations,

g-brickwork,
h-RCC,
i-plumbing,
j-wooden work,
k-organize party,
l-shift luggage,
m-settling in new house

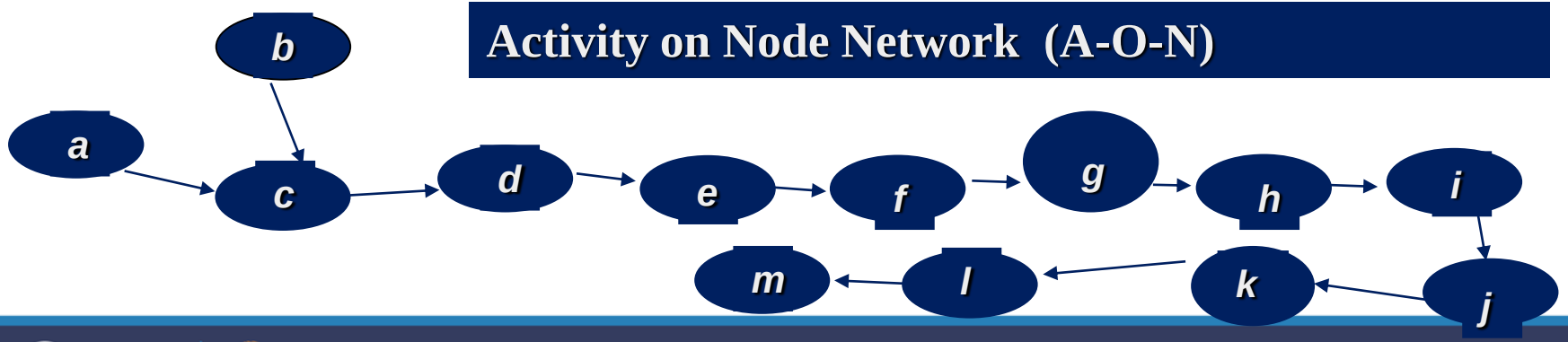
Job	a	b	c	d	e	f	g	h	i	j	k	l	m
Predecessors	-	-	a,b	a,c	d	d,e	f	g	g,h	i	j	k	l

Activity on Node Network (A-O-N): Activities are represented on nodes and the arrows represent the precedence relation

a-review houses,
b-finalize requirements,
c-engage architect,
d-evaluate alternate designs,
e-finalize contractor,
f-foundations,
g-brickwork,
h-RCC,
i-plumbing,
j-wooden work,
k-organize party,
l-shift luggage,
m-settling in new house

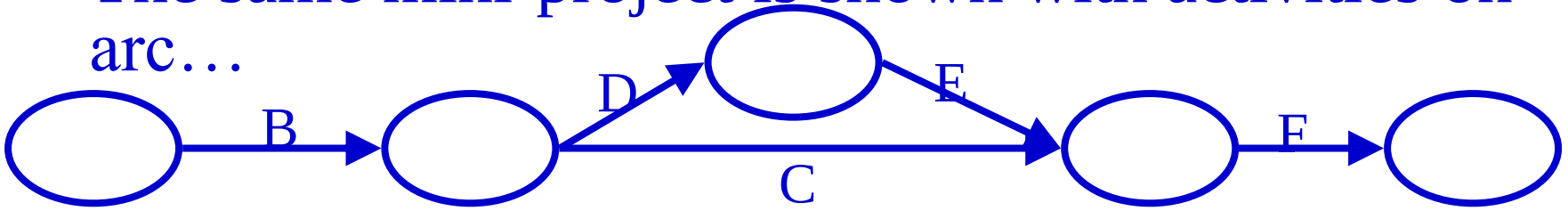
Job	a	b	c	d	e	f	g	h	i	j	k	l	m
Predecessors	-	-	a,b	a,c	d	d,e	f	g	g,h	i	j	k	l

Activity on Node Network (A-O-N)

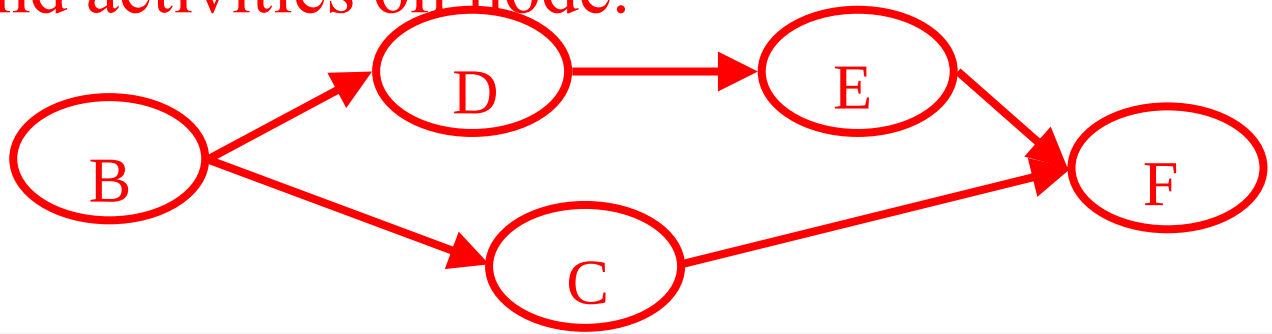


AOA Vs. AON

The same mini-project is shown with activities on arc…



…and activities on node.



IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 35

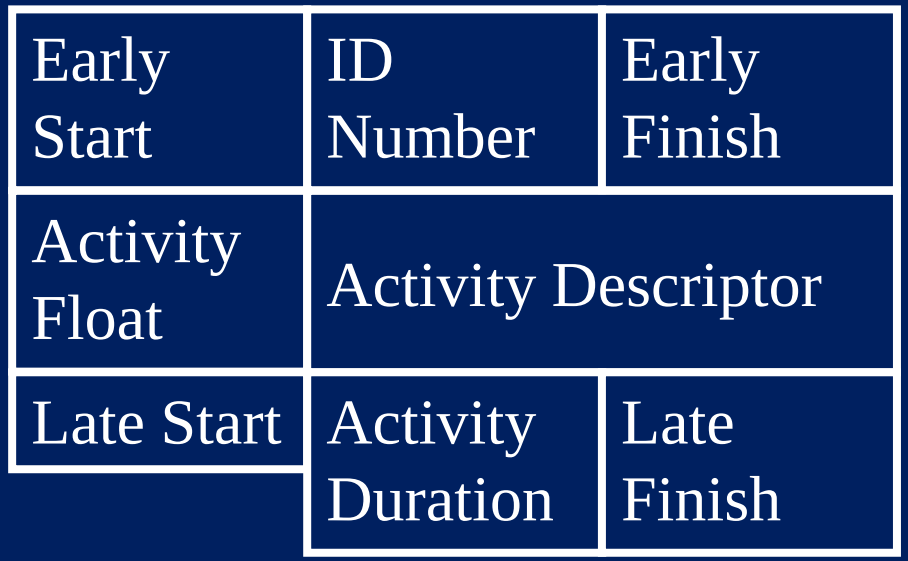
Project Time Management – Numbering of Nodes

Dr. M.K. Barua

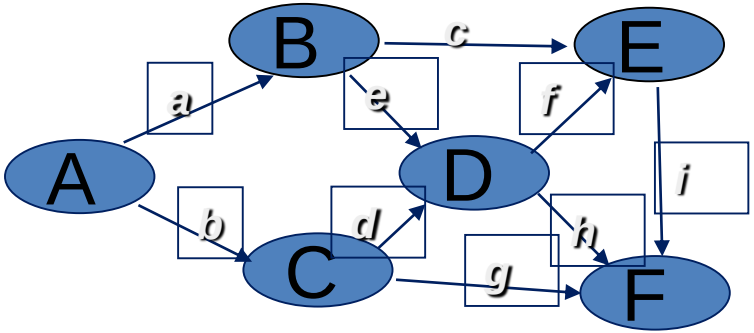
Department of Management

Indian Institute of Technology Roorkee

Node Label


Early Start
ID Number
Early Finish
Activity Float
Activity Descriptor
Late Start
Activity Duration
Late Finish

Numbering of events



Numbering the events : D. R . Fulkerson rule.

1. *An initial event is one which has arrows coming out of it and none entering it . In any network there will be one such event . Number it "1".*

2. *Delete all arrows emerging from event 1. This will create at least one more*

' initial event'.

3. *Number these initial events as 2,3,…….*

4. *Delete all emerging arrows from these numbered events which will create new initial events.*

5. *Follow step (3).*

6. *Continue until last event which has no arrows emerging from it is obtained.*

NUMBERING THE EVENTS

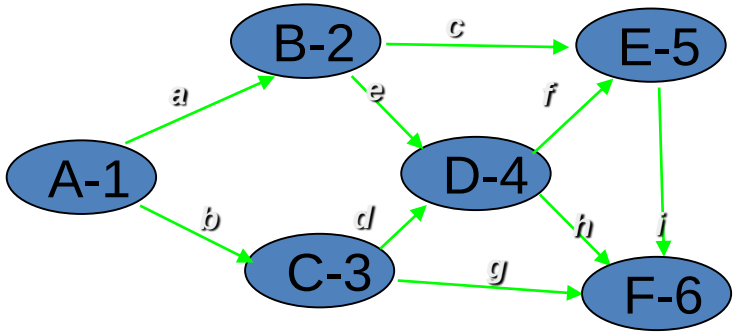
1.Number event A as 1, there is no incoming arrow.

2. Delete arrows a and b. Which will result in events B and C. Number B as 2 and C as 3.

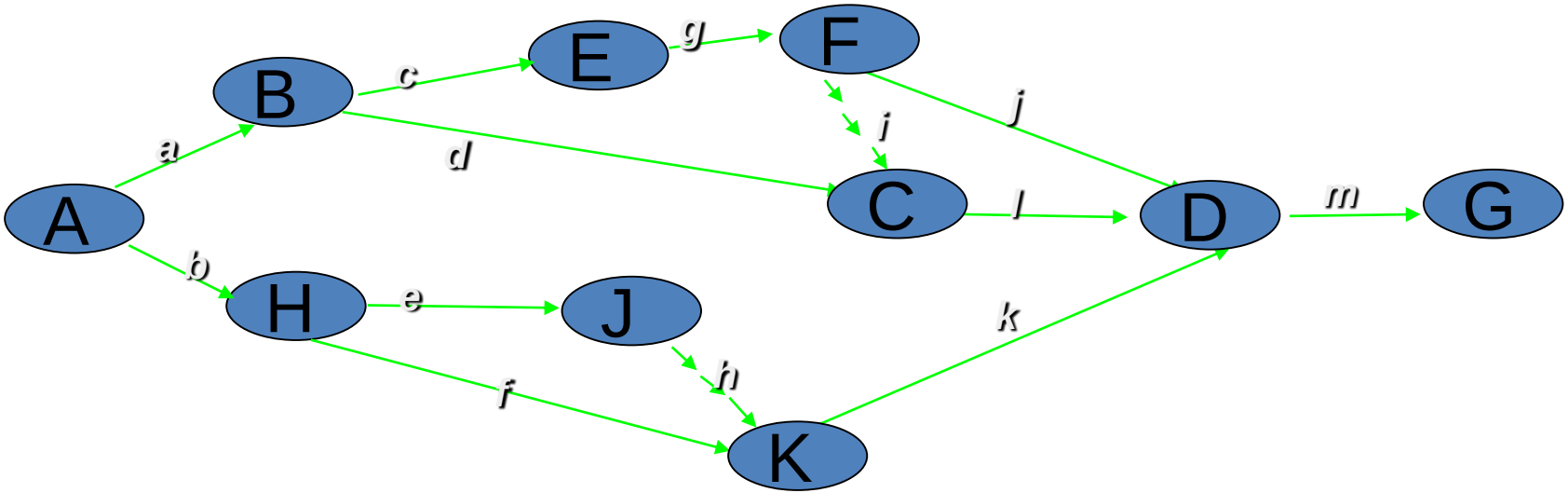
3. Delete arrows c & e and d & g. Which will result in events E, D and F. But events E and F have incoming arrows , number event D as 4.

4. Delete arrows f & h. Which will result in events E and F. But event F has an incoming arrow , number event E as 5.

5. Delete i, number F as 6.

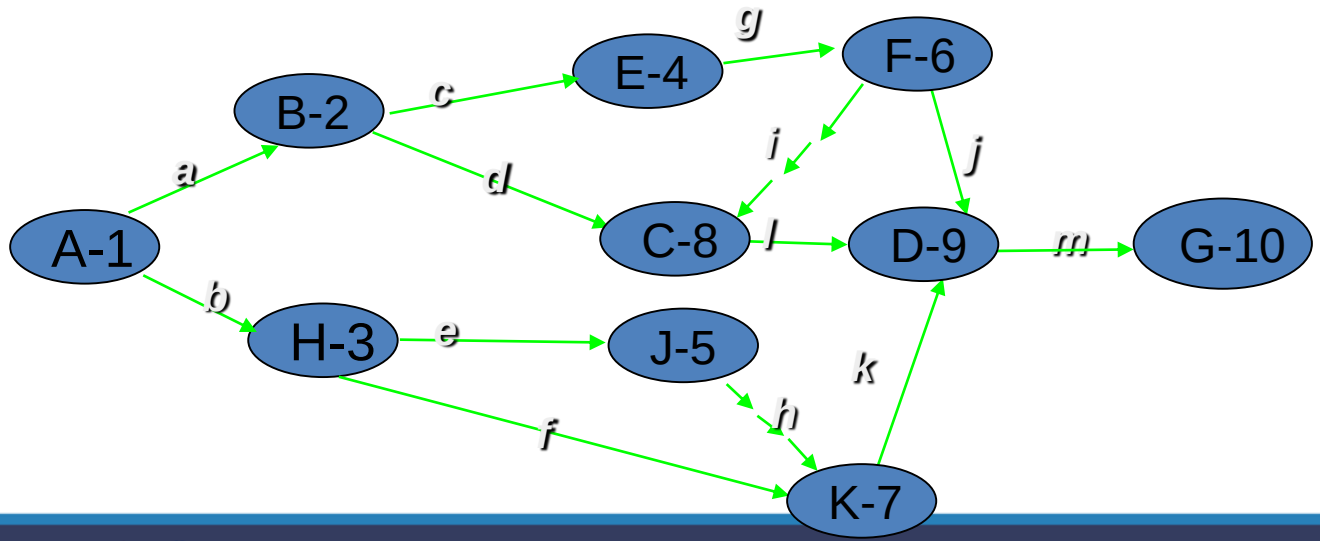


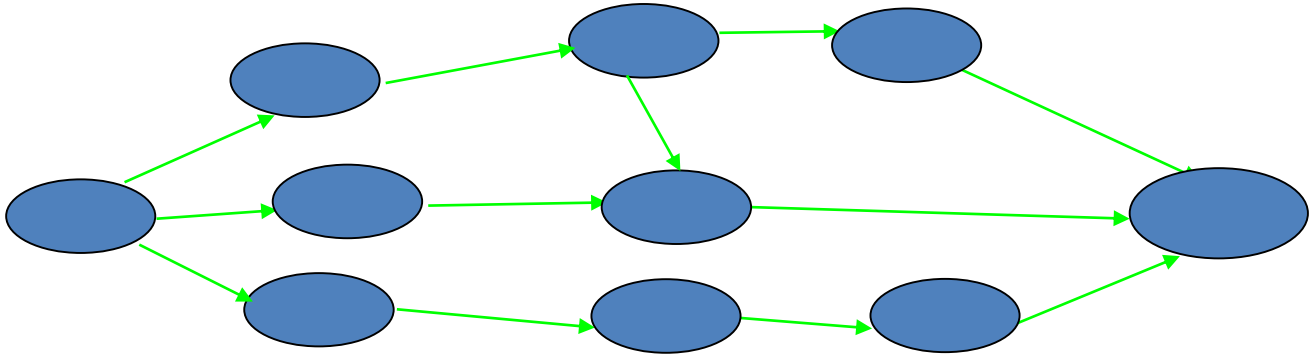
NUMBER THE EVENTS ?????????????

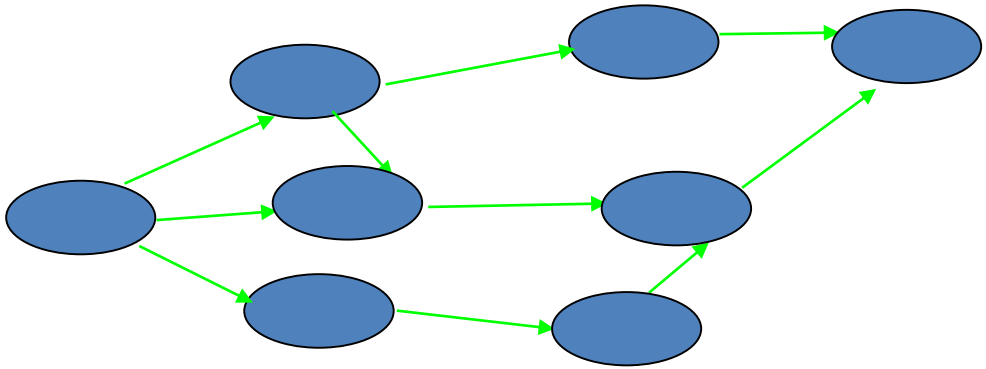


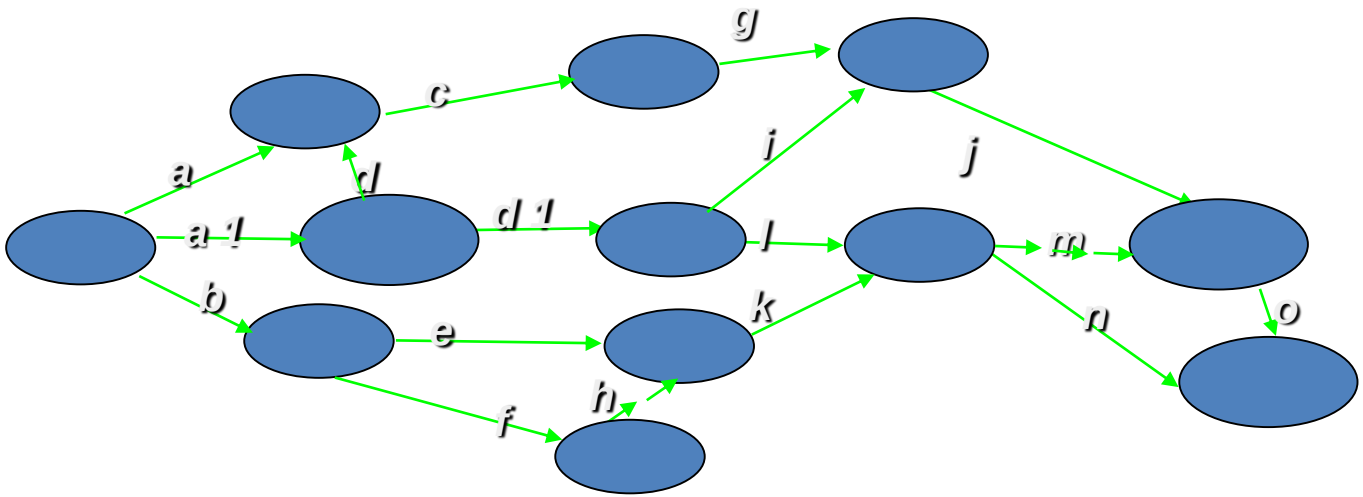
NUMBERING THE EVENTS

1. Number event A as 1, which has no incoming arrows.
2. Delete arrows ‘a’ and ‘b’. We will have events B and H, both do not have incoming arrows, number event B as 2 and event H as 3.
3. Delete arrows c, d, and e, f. Which will result in E & C and J &K , but events C and K have incoming arrows . Number events E as 4, and event J as 5
4. Delete arrows g, h . Which will result in events F and K . Number event F as 6 and K as 7 .
5. Delete arrows i, j, k . Which will result in event C and D, number C as 8 and D as 9.
6. Delete arrow m, number event G as 10.



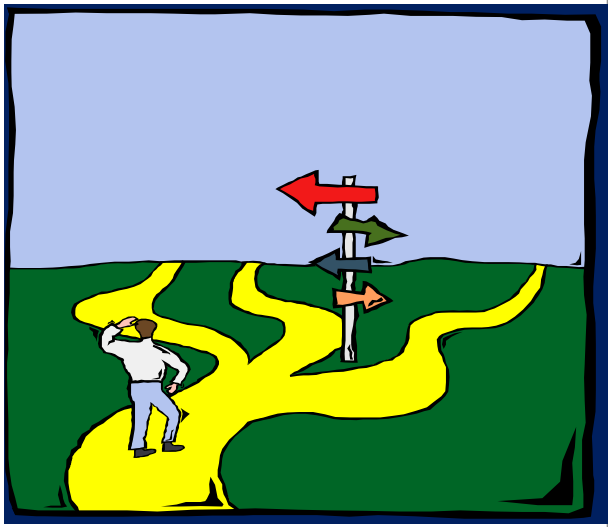





g
c
a
d
j
j
a 1
d 1
l
m
b
e
k
n
o
f
h

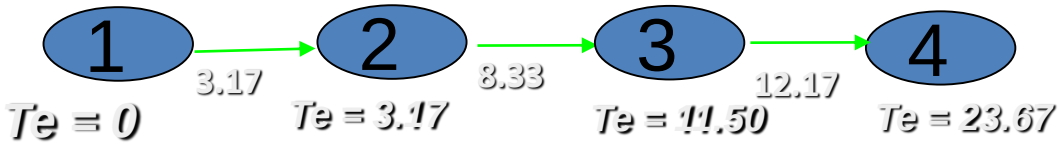
Critical Path

- ✓ ***A path is a sequence of connected activities running from start to end node in network***
- ✓ ***The critical path is the path with the longest duration in the network***
- ✓ ***Project cannot be completed in less than the time of the critical path***



To find critical path in a large network we compute two time estimates for every event.

Earliest expected time / Earliest start time (Te) : *Refers to the time when an event can be expected to start as early as possible. It is computed by adding the te's of the activity paths leading to that event*



We calculate "Te" in forward pass.

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 36

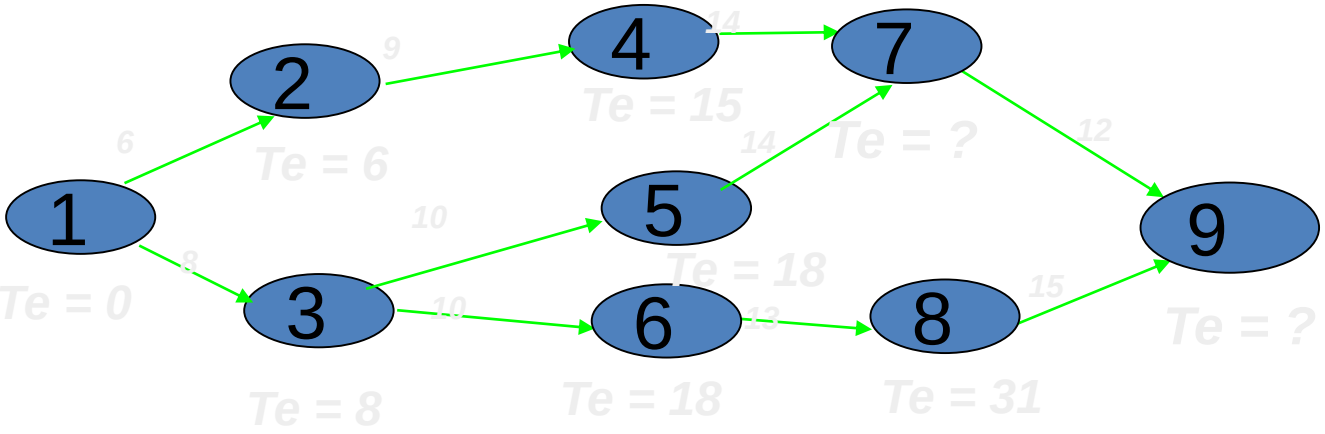
Project Time Management – PERT Networks

Dr. M.K. Barua

Department of Management

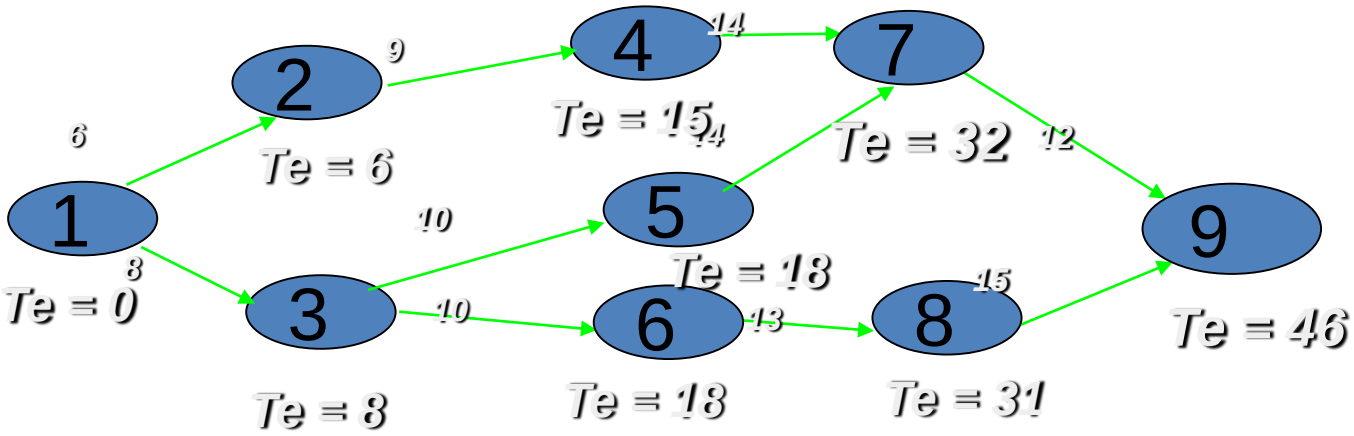
Indian Institute of Technology Roorkee

Earliest expected time/ Earliest start time (Te).



We calculate "Te" in forward pass.

Earliest expected time/ Earliest start time (Te).

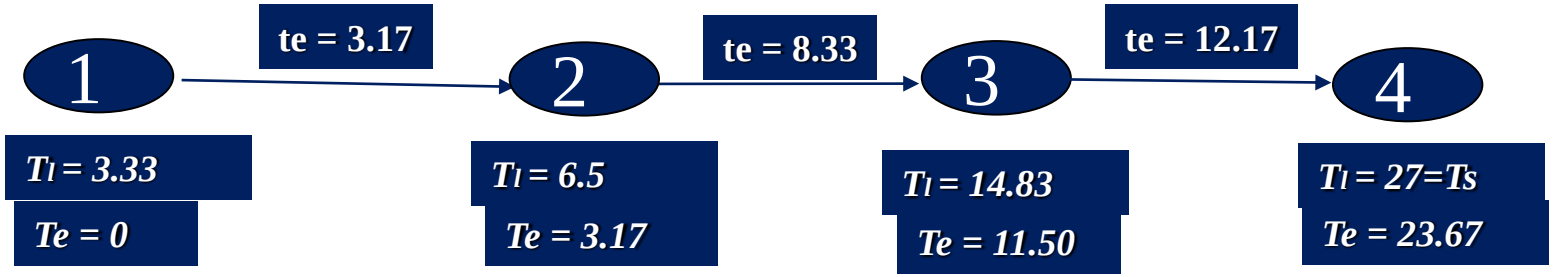


We calculate "Te" in forward pass.

Latest allowable occurrence time (Tl) / Latest completion time:

The latest time by which an event must occur to keep the project on schedule is known as latest allowable occurrence time.

To explain this, consider contractual obligation time (Ts)= 27



We calculate "Tl" in Backward pass.

Single Vs. Multiple Time Estimate.

Networks used in process and construction industries where vast experience has provided the basis for reliable and accurate time estimates, a single time estimate appears to be more reasonable.

We can appreciate the multiple time estimates in projects where research and development (cryogenic, nano tech, bio medical,) activities, technological breakthroughs have a considerable effect.

PERT Network and Time Estimates.

1. The Optimistic Time Estimate: This is the estimate of the shortest possible time in which an activity can be completed under ideal condition. (better than normal conditions are assumed to prevail during the execution of the project). This is represented by ‘to”.

2. The Pessimistic Time Estimate: This is the maximum possible time it could take to accomplish the job. If everything went wrong and abnormal situations prevailed, this would the time estimate for that activity. This is represented by‘tp’.

3. The Most Likely Time Estimate: This is the time estimate which lies between the optimistic and the pessimistic time estimates. This is represented by ‘tm’.

Multiple Time Estimate- By experts

Optimistic (to)

Pessimistic time(tp)

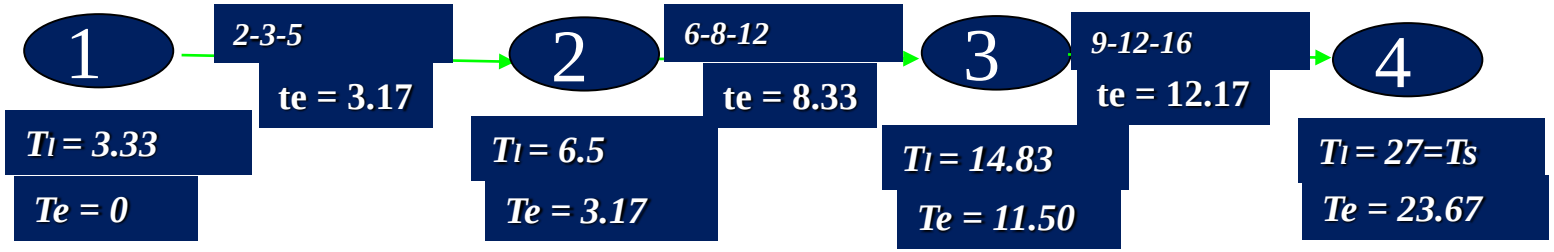
Most likely time(tm)

$te = (to + 4tm + tp)/6$

Latest allowable occurrence time (Tl) / Latest completion time:

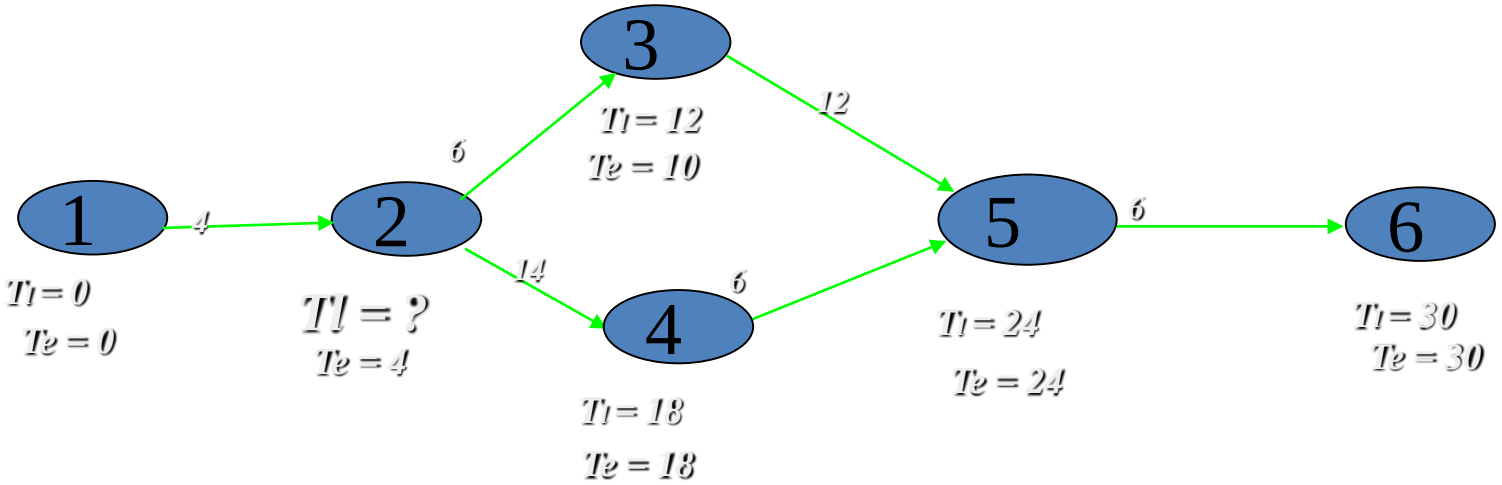
The latest time by which an event must occur to keep the project on schedule is known as latest allowable occurrence time.

To explain this, consider contractual obligation time (Ts)= 27



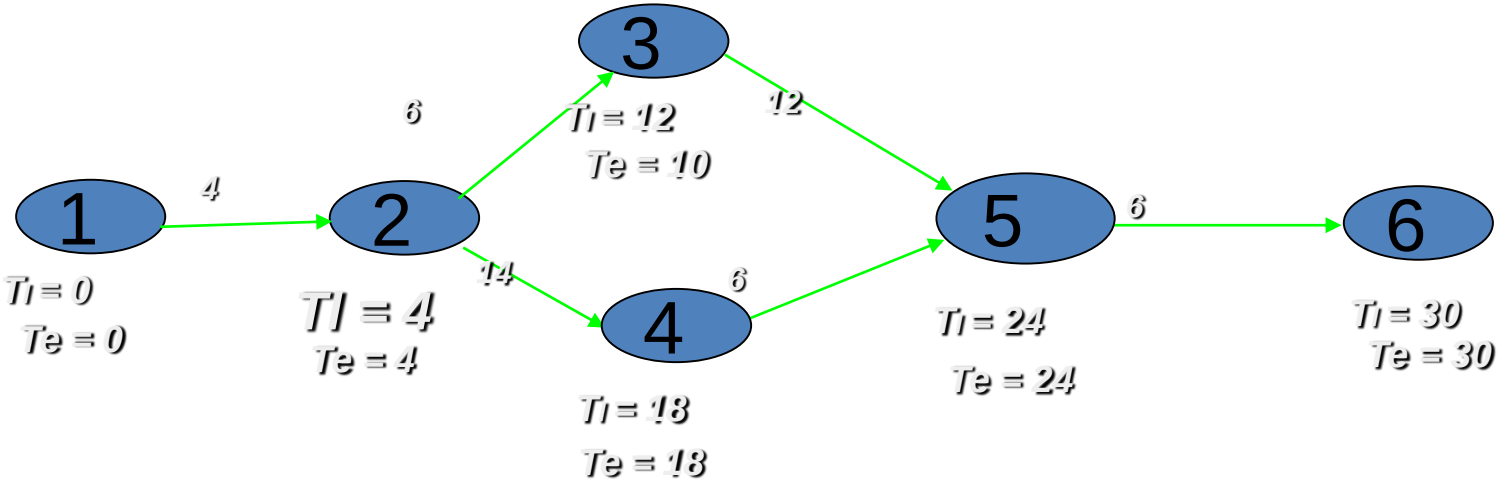
We calculate "Tl" in Backward pass.

Latest allowable occurrence time / Latest completion time (T_l).



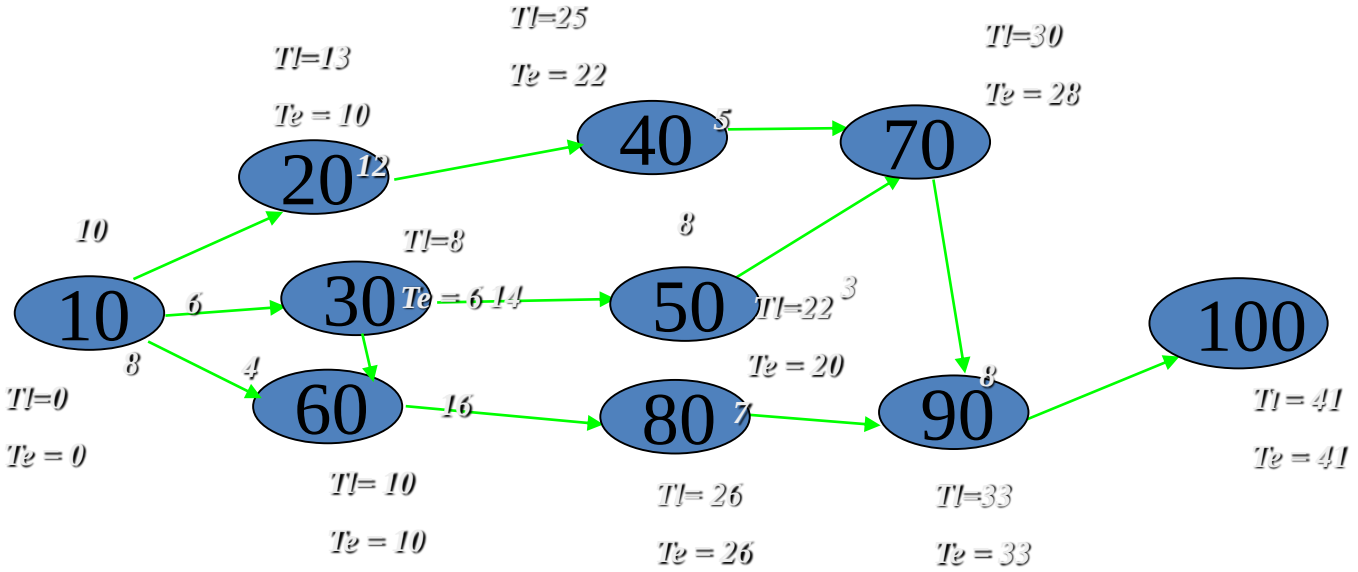
We calculate "Tl" in Backward pass.

Latest allowable occurrence time / Latest completion time (Tl).



We calculate "Tl" in Backward pass.

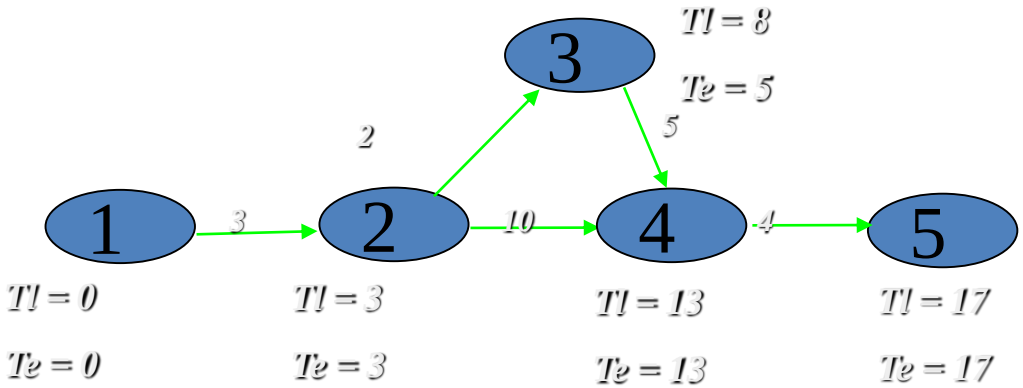
Example.



Nodes with Te = Tl form a critical path.

Critical path: Where Tl=Te

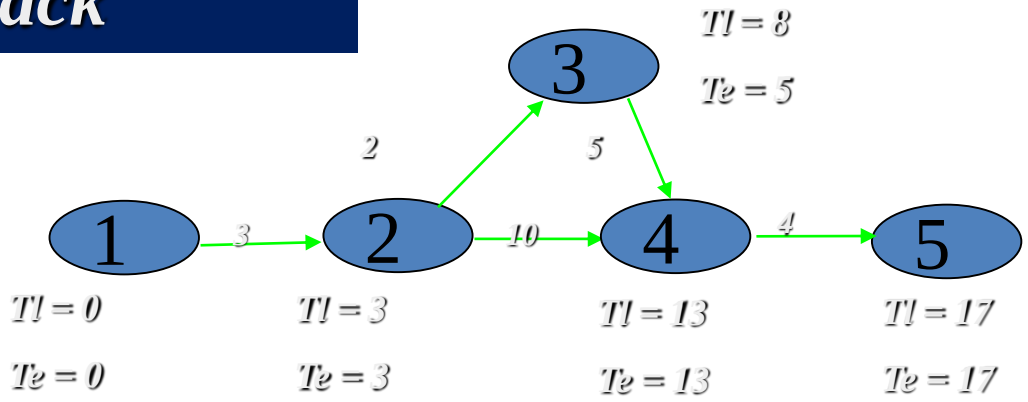
Slack - PERT



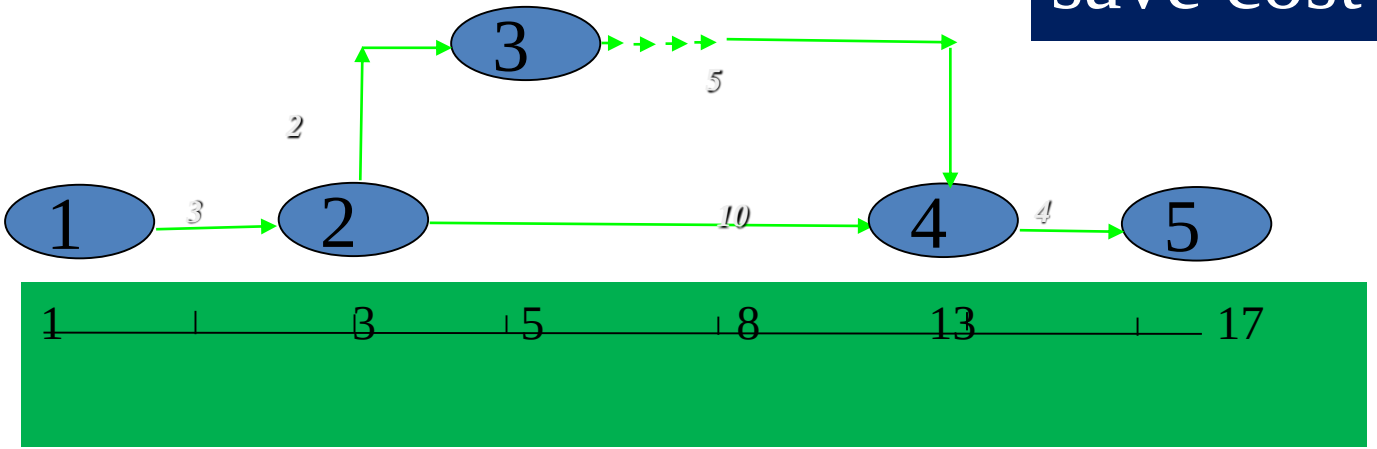
Critical path with zero slack

Node	Slack = Tl-Te
1	0
2	0
3	3
4	0
5	0

Slack



One can level men power and save cost also.



IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

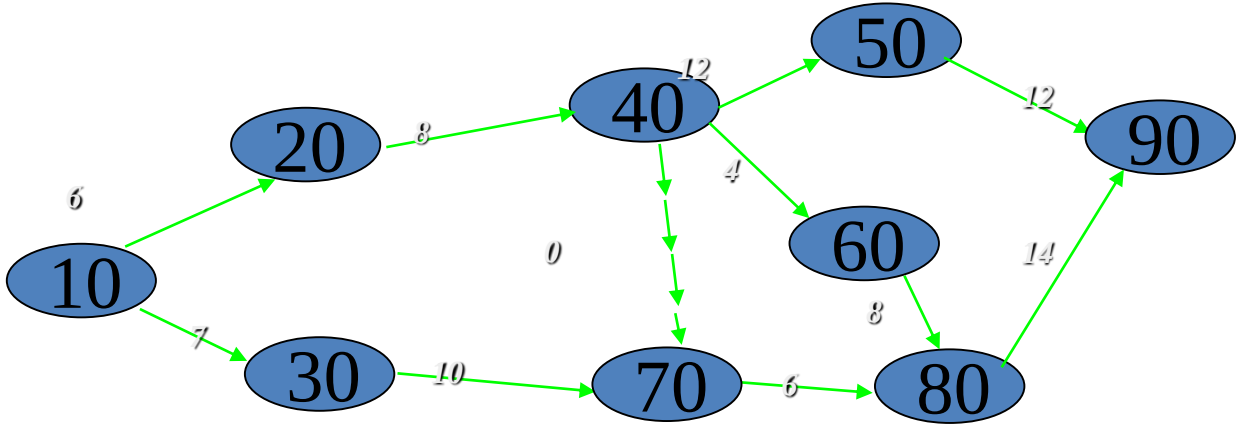
Lec – 37

Project Time Management – CPM

Dr. M.K. Barua

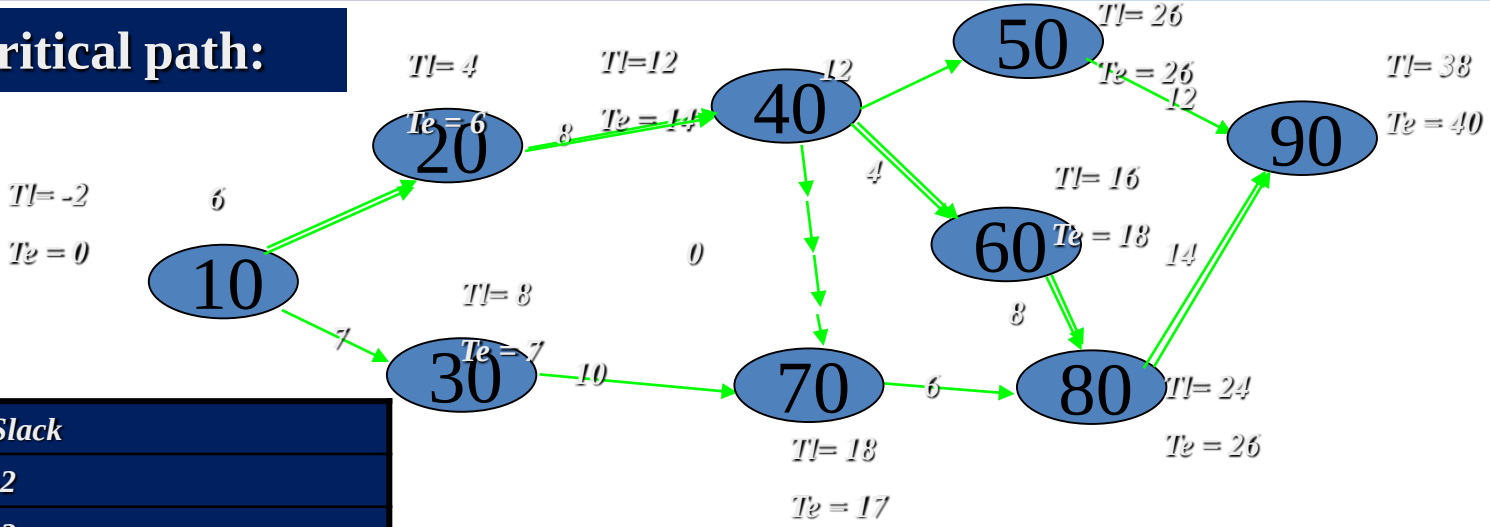
Department of Management

Indian Institute of Technology Roorkee



Find critical and Semi critical paths:

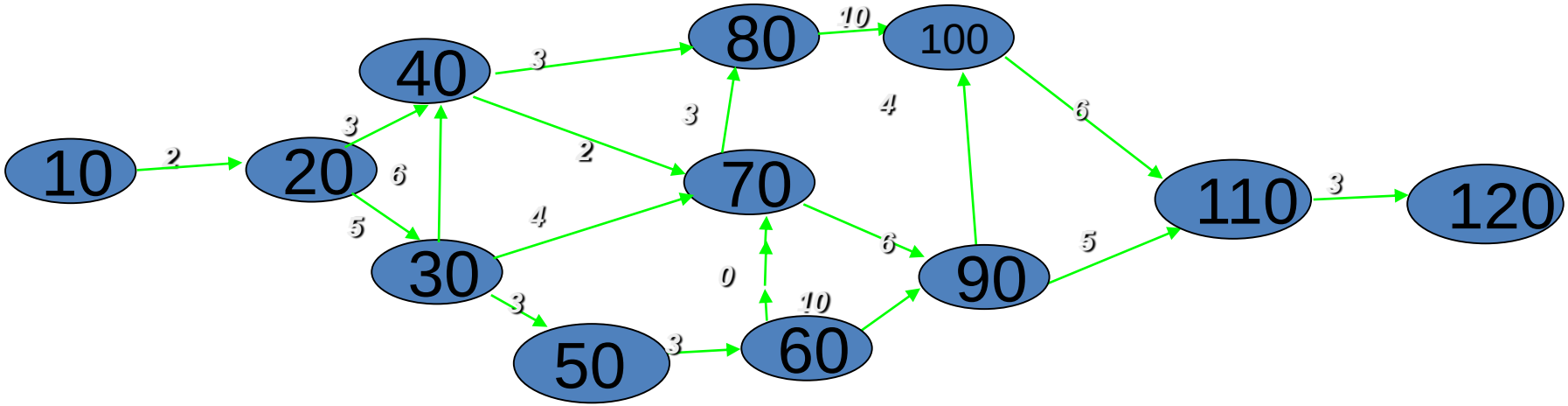
Semi critical path:



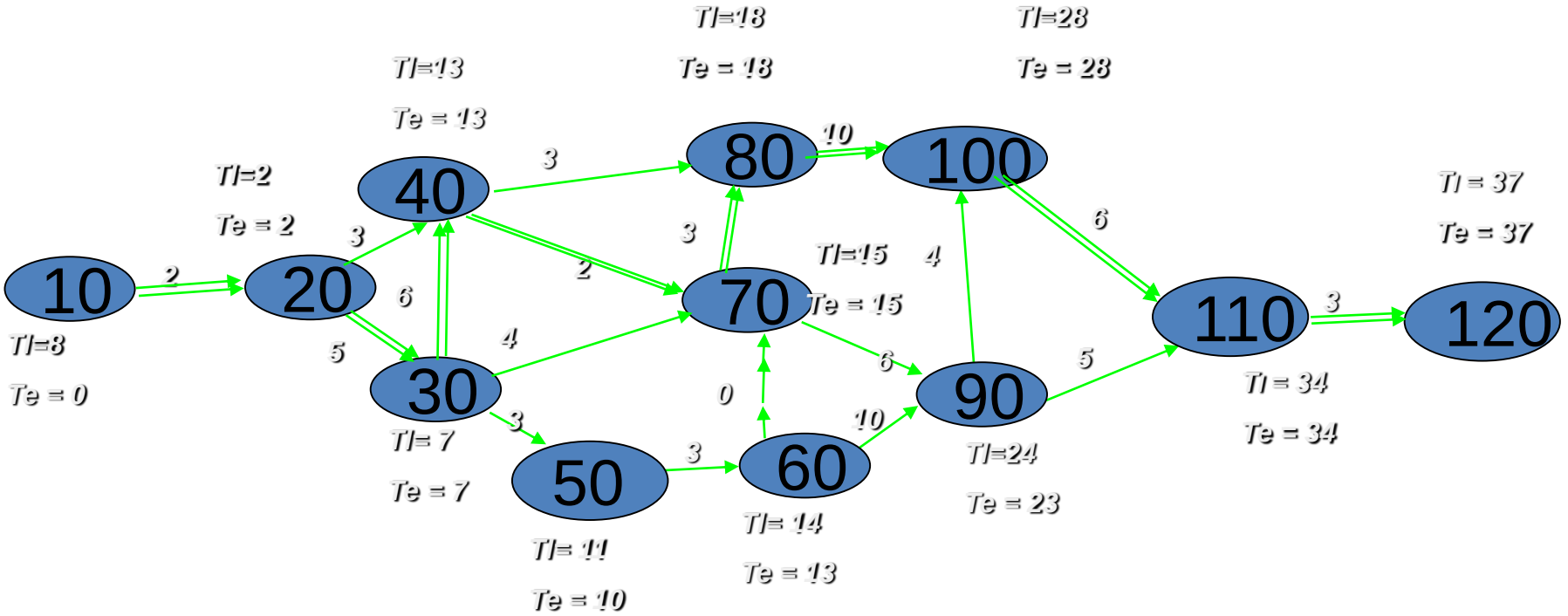
Node	Slack
10	-2
20	-2
30	1
40	-2
50	0
60	-2
70	1
80	-2
90	-2

Semi critical path: *Slack at node 50 is 0, which is connected to node 40 and 90. Semi critical path is 40-50-90.*

The other semi critical path is 30-70



Find critical and semi critical paths??

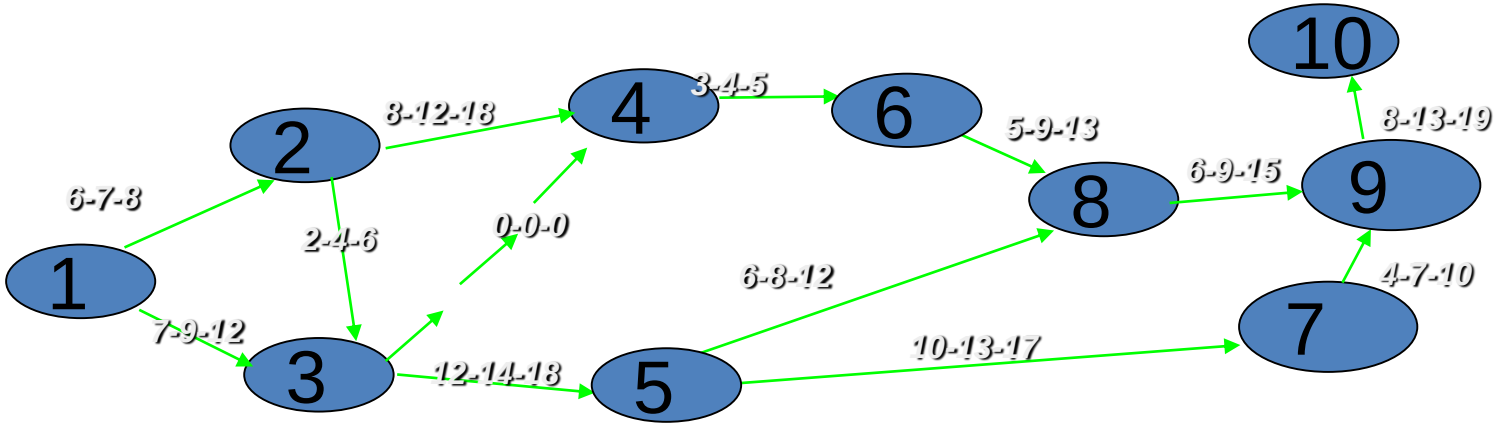

10
Tl=8
Te = 0
2
20
Tl=2
Te = 2
3
6
5
40
Tl=13
Te = 13
3
2
30
Tl= 7
Te = 7
4
3
50
Tl= 11
Te = 10
3
60
Tl= 14
Te = 13
0
3
70
Tl=15
Te = 15
4
6
80
Tl=18
Te = 18
10
90
Tl=24
Te = 23
10
100
Tl=28
Te = 28
6
5
110
Tl = 34
Te = 34
3
120
Tl = 37
Te = 37

PERT Network and Time Estimates.

1. The Optimistic Time Estimate:

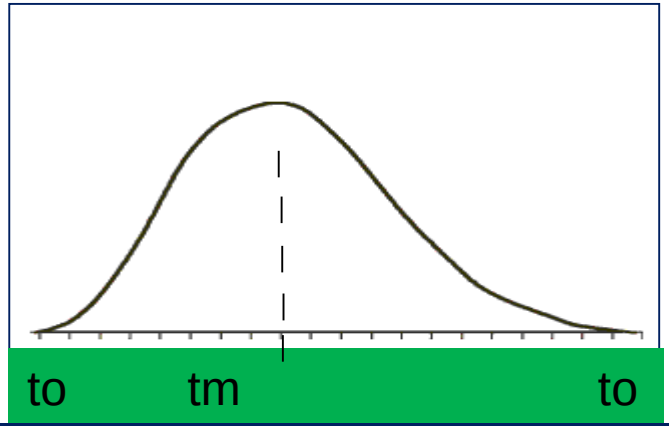
2. The Pessimistic Time Estimate:

3. The Most Likely Time Estimate:



Find critical and semi critical paths??

The Beta Distribution: The PERT analysts have found that the beta distribution curve happened to give fairly satisfactory results for most of the activities. (skewed to right- positively skewed curve- tails off toward high end of the scale)



For distribution of this type, the standard deviation is approximately one-sixth of the range.

$\sigma = (tp-to) / 6$

$(\sigma)^2 = ((tp-to) / 6)^2$

The Beta Distribution:

Consider the time estimates for two persons, x and y , for the execution of a particular job.

	to	tm	tp
Estimate by x	6	8	10
Estimate by y	5	7	11

Who is more uncertain.???????????

The Beta Distribution:

Consider the time estimates for two persons, x and y , for the execution of a particular job.

	to	tm	tp
Estimate by x	6	8	10
Estimate by y	5	7	11

Who is more uncertain.

$(\sigma x)^2 = ((tp - to) / 6)^2 = 0.44$

$(\sigma y)^2 = ((tp - to) / 6)^2 = 1$

EXPECTED TIME OR AVERAGE TIME.

After finding SD and variance, let us find average time taken for completion of a job.

In PERT, average time is called as expected time. There is 50-50 chance of getting the job done within that time.

$$te = 1/6\ (to) + 2/3\ (tm) + 1/6\ (tp)$$

$$= (to+4tm+tp)/\ 6$$

Lags in Precedence Relationships

The logical relationship between the start and finish of one activity and the start and finish of another activity.

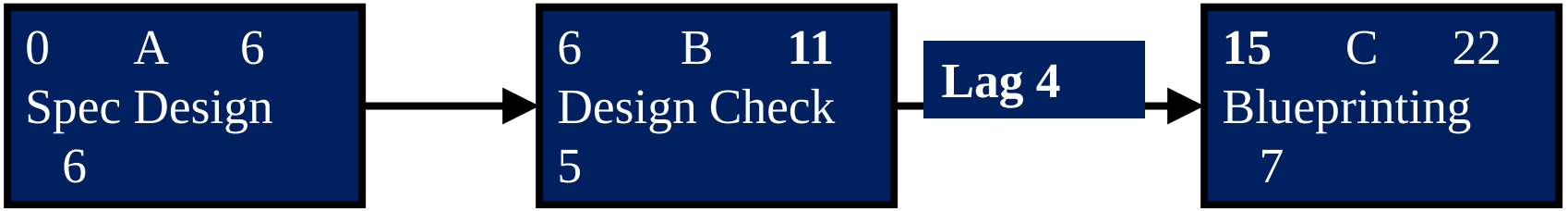
Four logical relationships between tasks

1. Finish to Start
2. Finish to Finish
3. Start to Start
4. Start to Finish

Finish to Start Lag: A **finish to start** lag of 4 days between completion of activity B and the start of activity C, as shown in figure. Three activities (A,B,C), activity C cant be started , as activity B is to be done by external supplier.

- Most common type of sequencing
- Shown on the line joining the nodes
  - Added during forward pass
  - Subtracted during backward pass

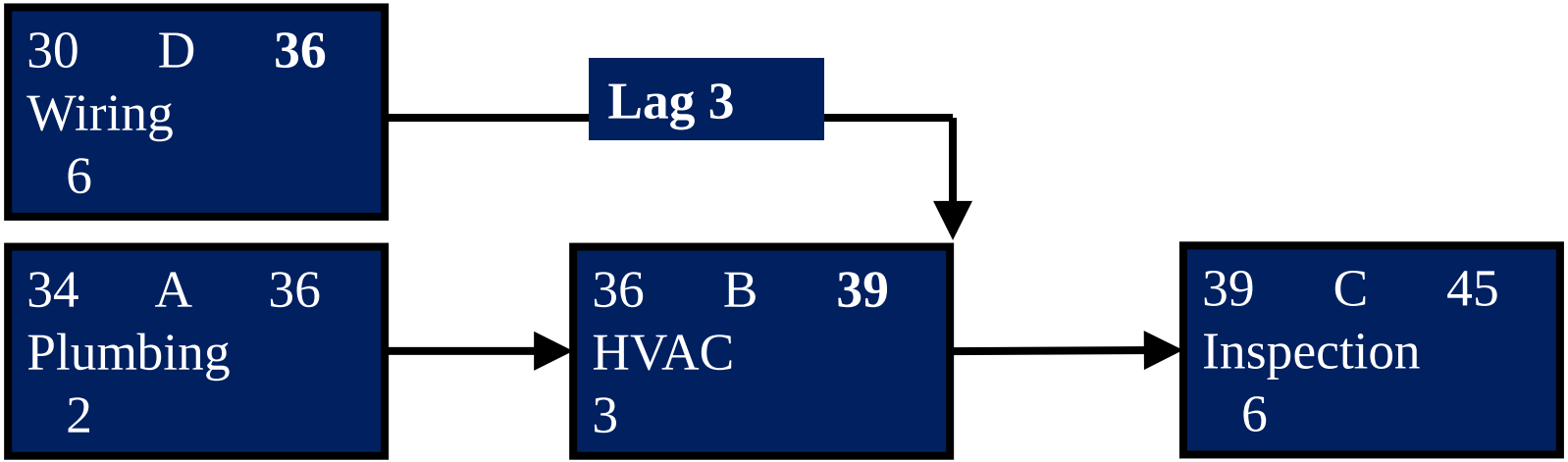
This lag is not the same as activity slack 15-11 =4



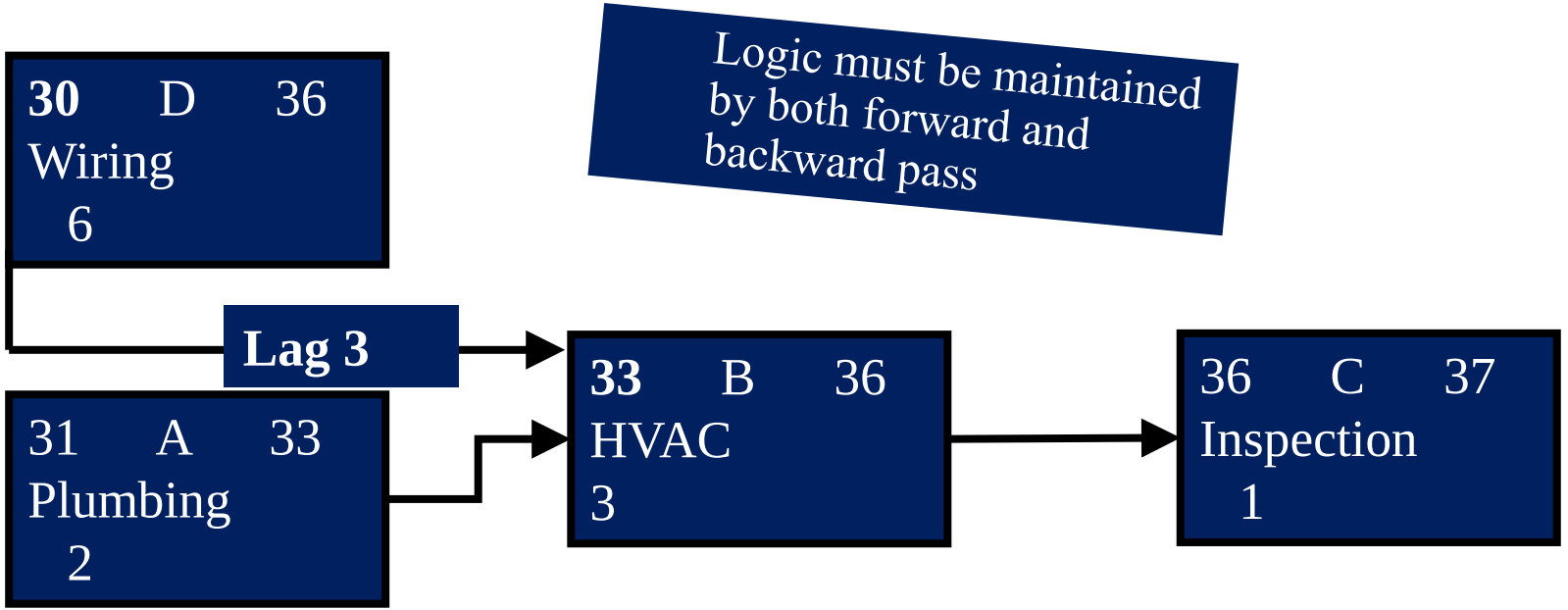
Finish to Finish Lag:

Two activities share a similar completion point

– The mechanical inspection cannot happen until wiring, plumbing, and HVAC installation are complete

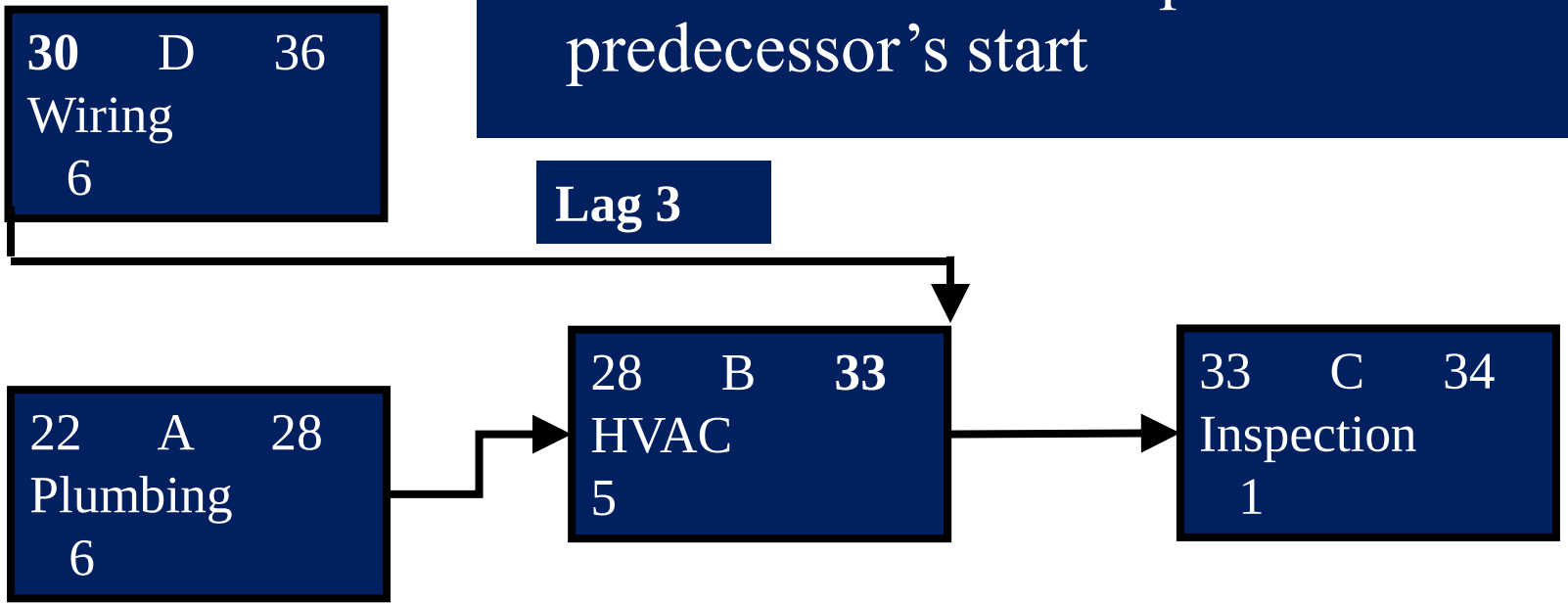


Start to Start Lag

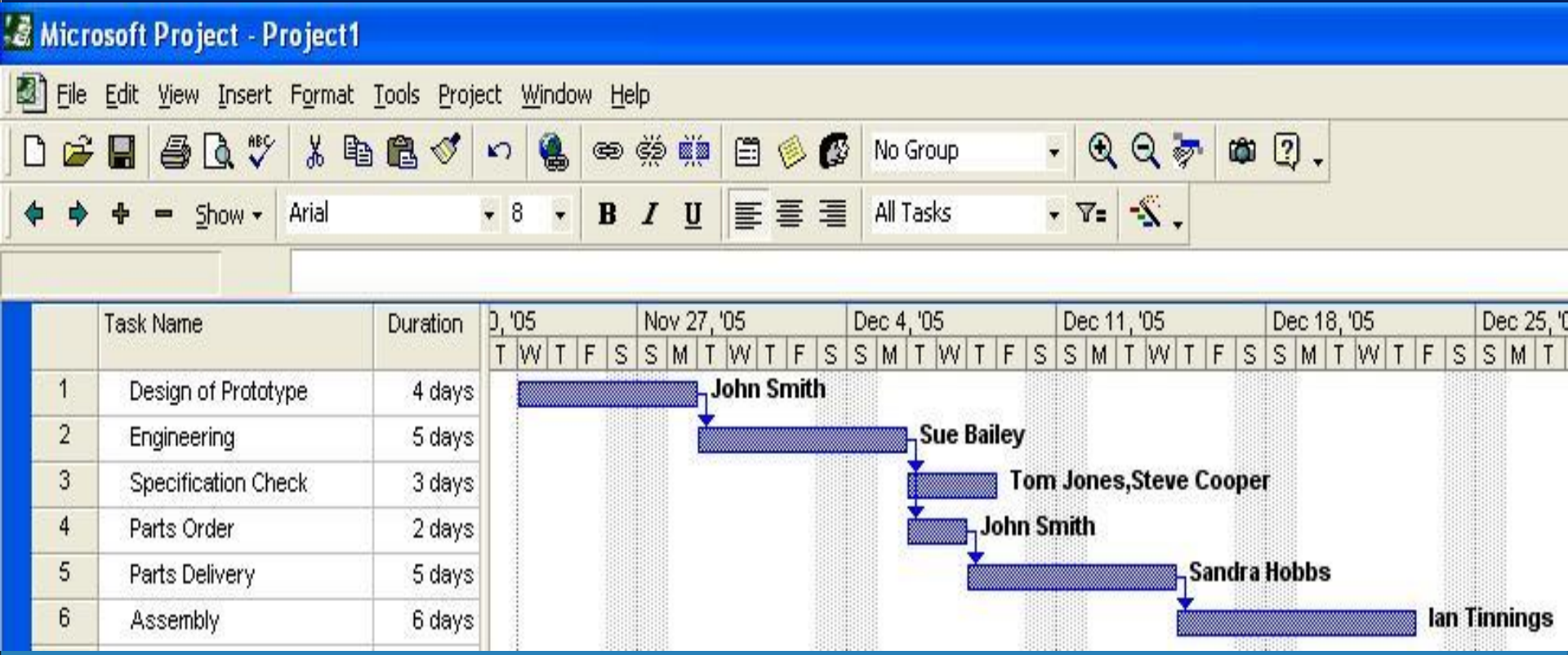


Start to Finish Lag

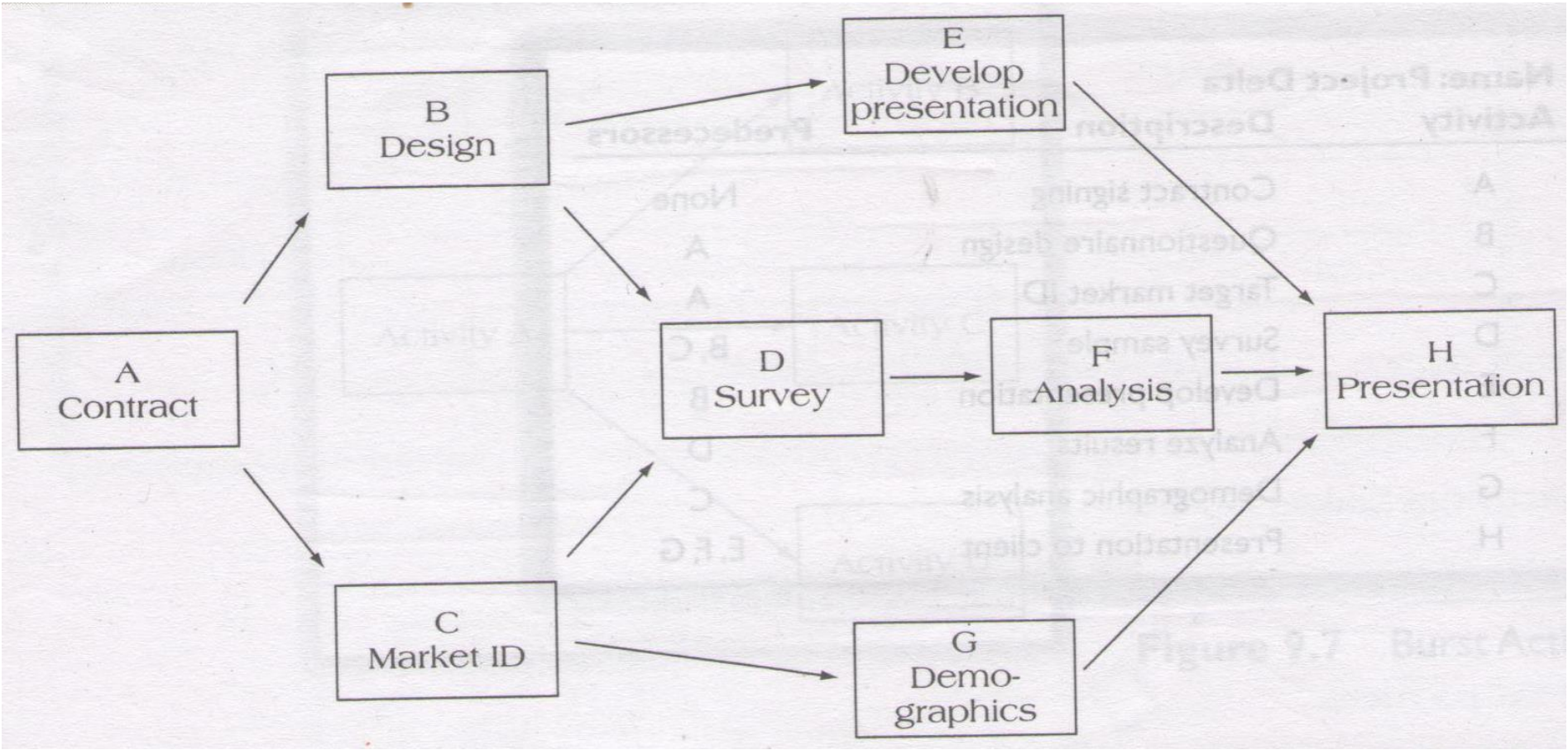
- Least common type of lag relationship
- Successor's finish dependent on predecessor's start

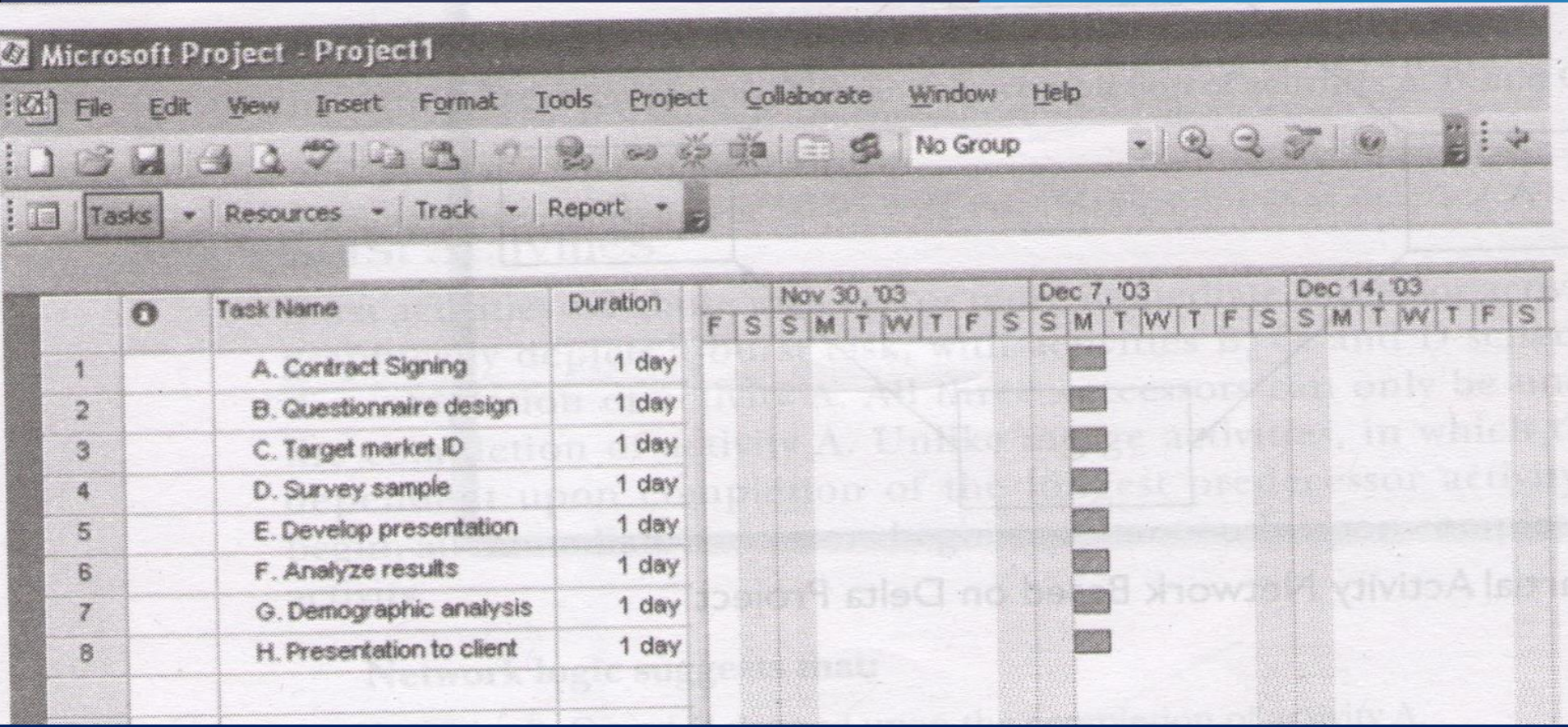


Gantt Chart With Resources in MS Project

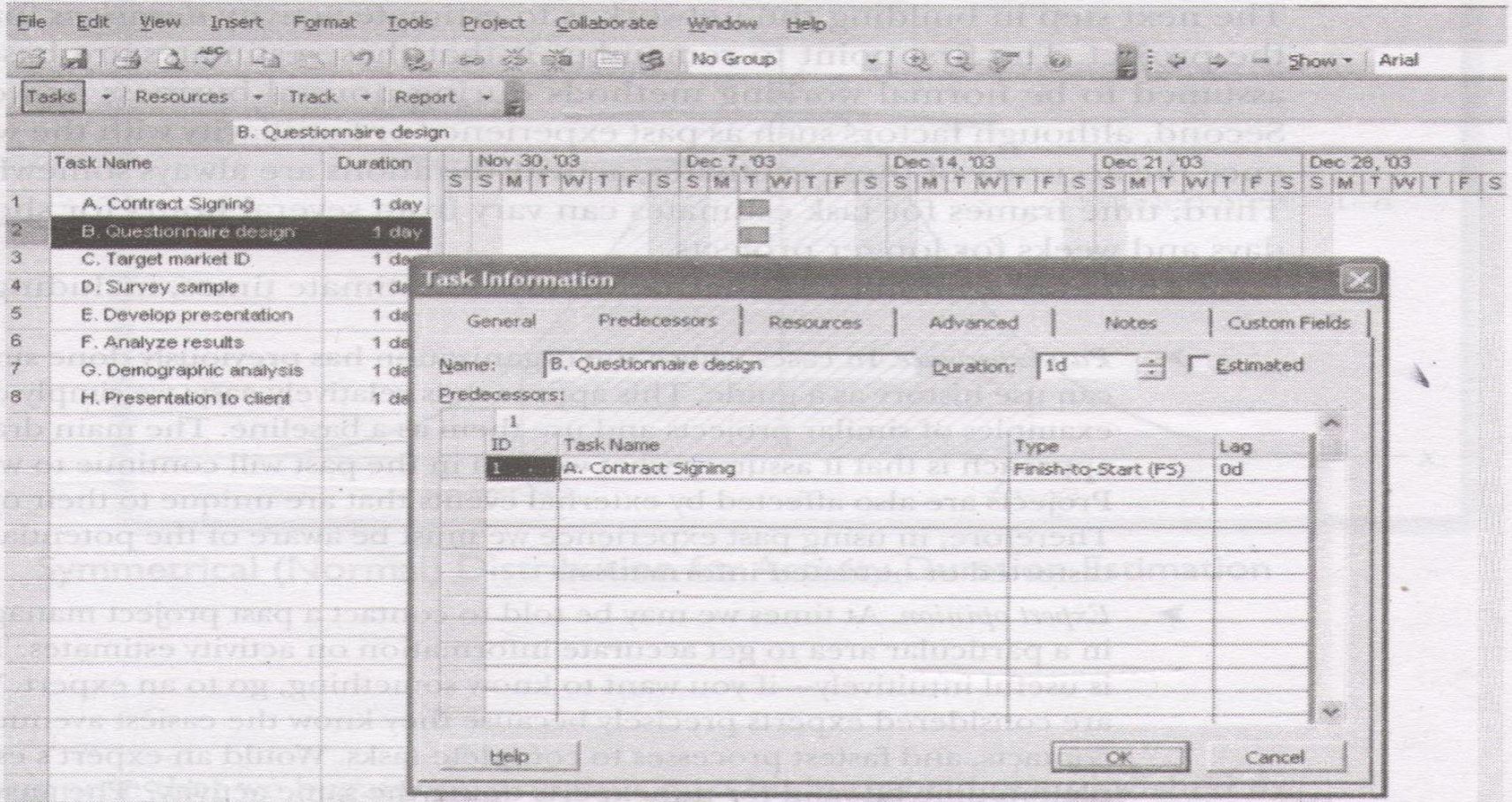


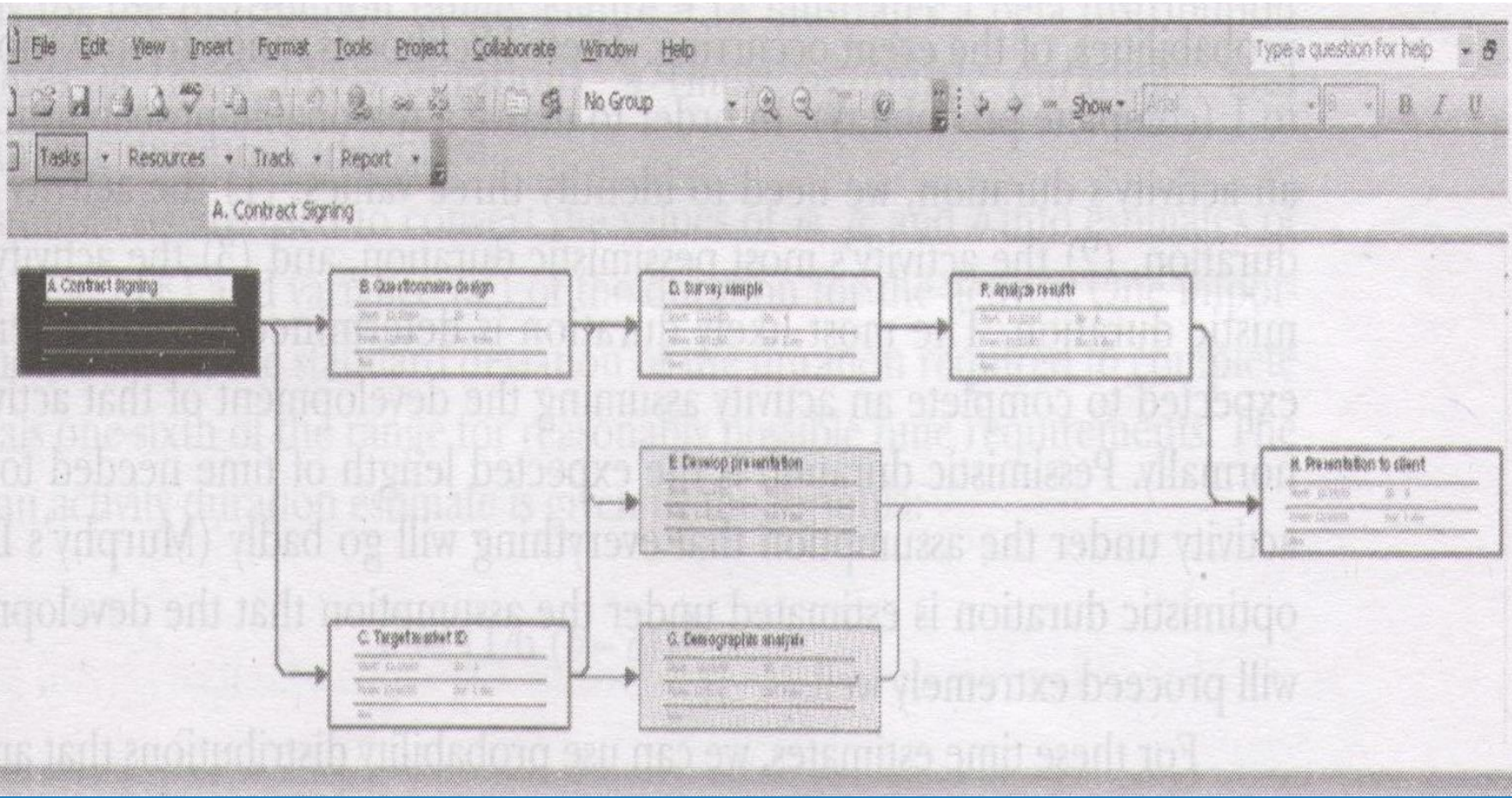
Activity	Description	Predecessors
A	Contract signing	None
B	Questionnaire design	A
C	Target market	A
D	Survey sample	B,C
E	Develop presentation	B
F	Analyze results	D
G	Demographic analysis	C
H	Presentation to client	E,F,G


A
Contract
B
Design
C
Market ID
D
Survey
E
Develop
presentation
F
Analysis
G
Demo-
graphics
H
Presentation



Duration is one day by default


File Edit View Insert Format Tools Project Collaborate Window Help
No Group
Show
Arial
Tasks
Resources
Track
Report
B. Questionnaire design
Task Name
Duration
1 A. Contract Signing 1 day
2 B. Questionnaire design 1 day
3 C. Target market ID
4 D. Survey sample
5 E. Develop presentation
6 F. Analyze results
7 G. Demographic analysis
8 H. Presentation to client
Nov 30, '03
Dec 7, '03
Dec 14, '03
Dec 21, '03
Dec 28, '03
Task Information
General
Predecessors
Resources
Advanced
Notes
Custom Fields
Name: B. Questionnaire design
Duration: 1d
Estimated
Predecessors:
ID
Task Name
Type
Lag
1 A. Contract Signing Finish-to-Start (FS) 0d
Help
OK
Cancel


File Edit View Insert Format Tools Project Collaborate Window Help
Type a question for help
No Group
Show
Tasks
Resources
Track
Report
A. Contract Signing
A. Contract Signing
B. Questionnaire design
D. Survey sample
F. analyze results
E. Develop presentation
H. Presentation to client
C. Target market ID
G. Demographic analysis

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 38

Project Time Management – Laddering in PERT/CPM

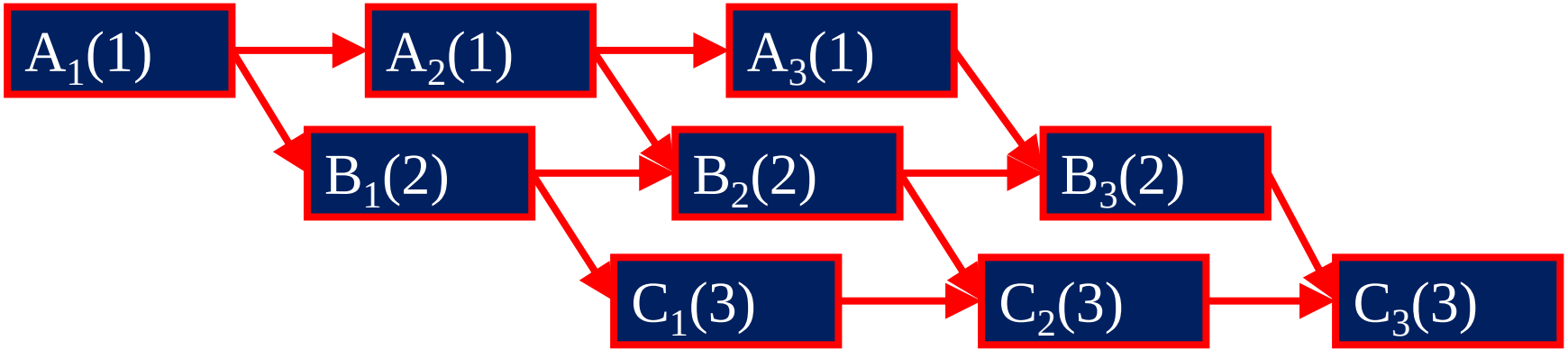
Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Laddering: Laddering is a technique that allows us to redraw the activity network to more closely sequence **project subtasks** to make the overall network **sequence more efficient**. It also helps in keeping project **resources fully employed.**

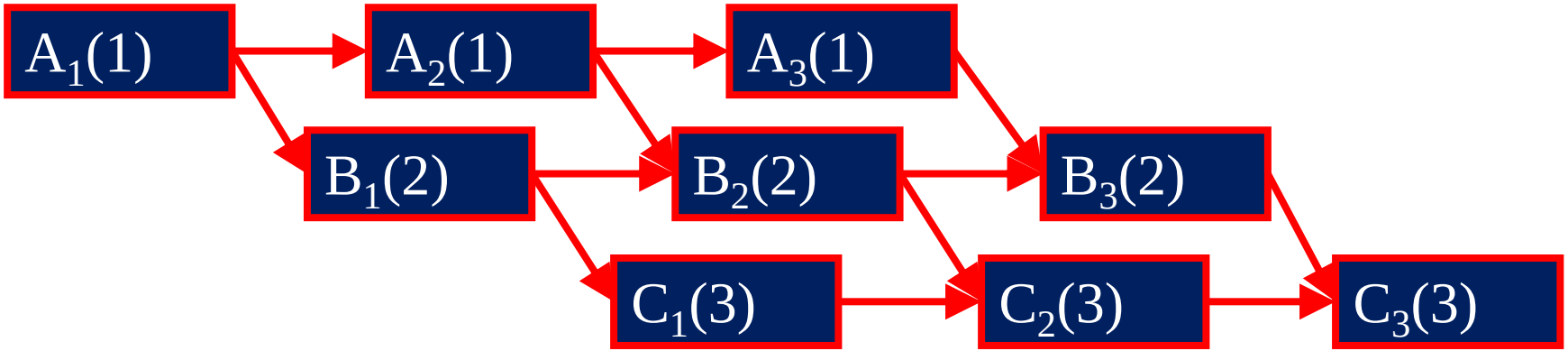
Project ABC (Design, Coding , Debugging) can be completed more efficiently if subtasks are used.



Laddered ABC=???? days

Project ABC (Design, Coding , Debugging) can be completed more efficiently if subtasks are used

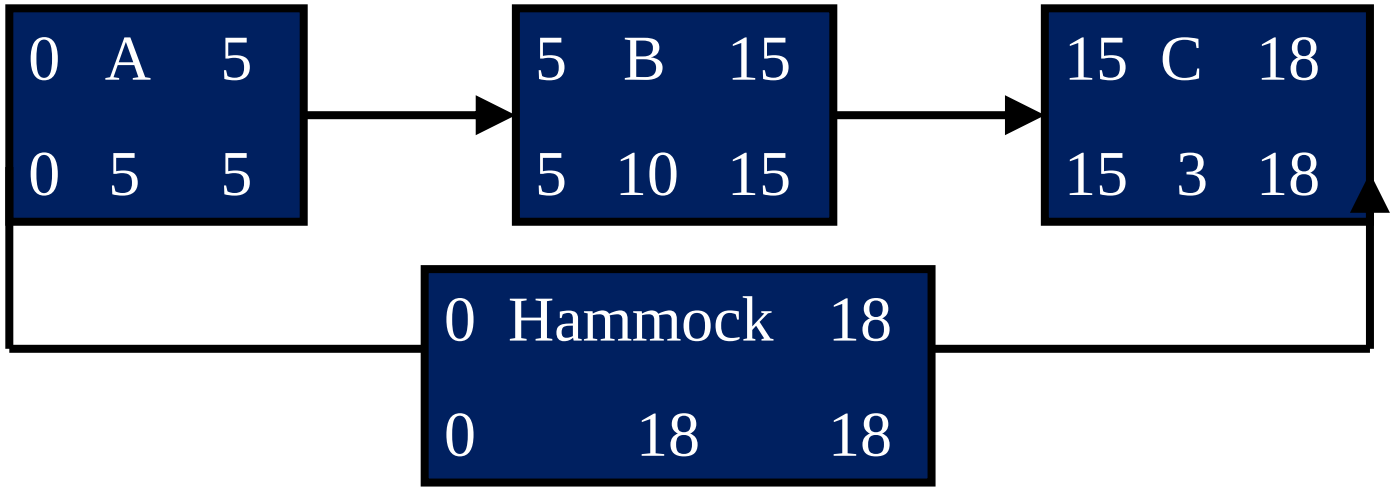
ABC=18 days



Laddered ABC=C1 can be only be started on 4 day (after 3 days)

= 3+3+3+3=12

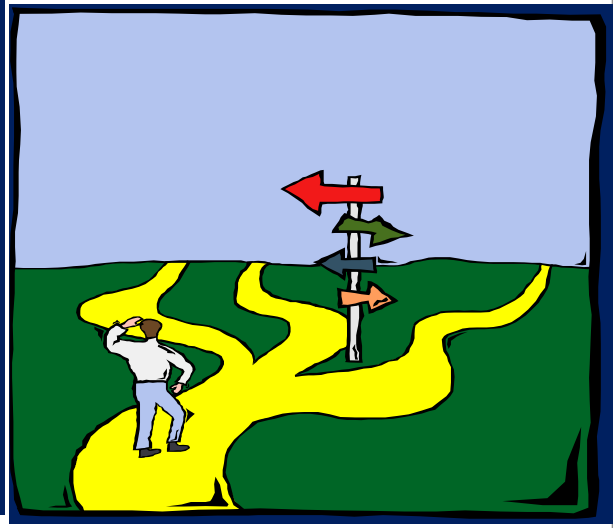
Hammock Activities: Can be used to summaries for some **subset of the activities** identified in the overall project network. It summarize tasks ,duration, and cost. The hammock is so named because it hangs **below**

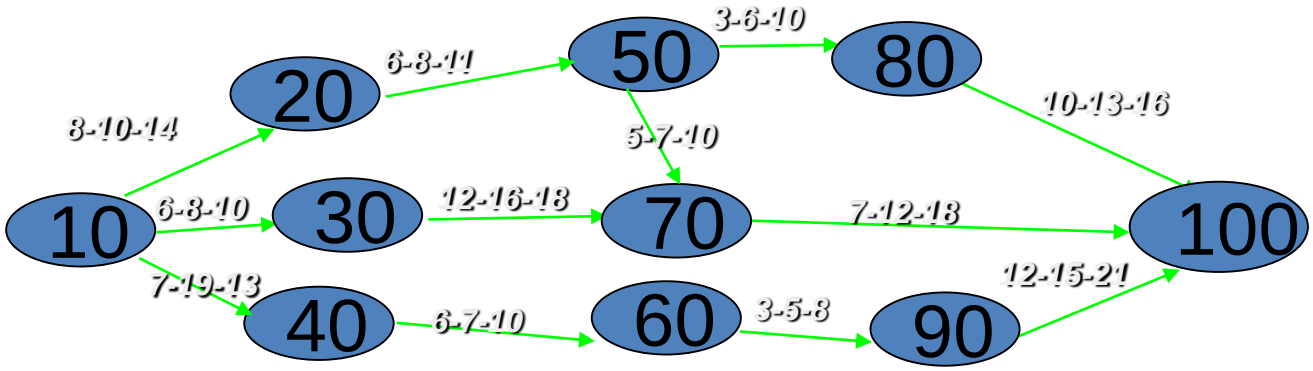


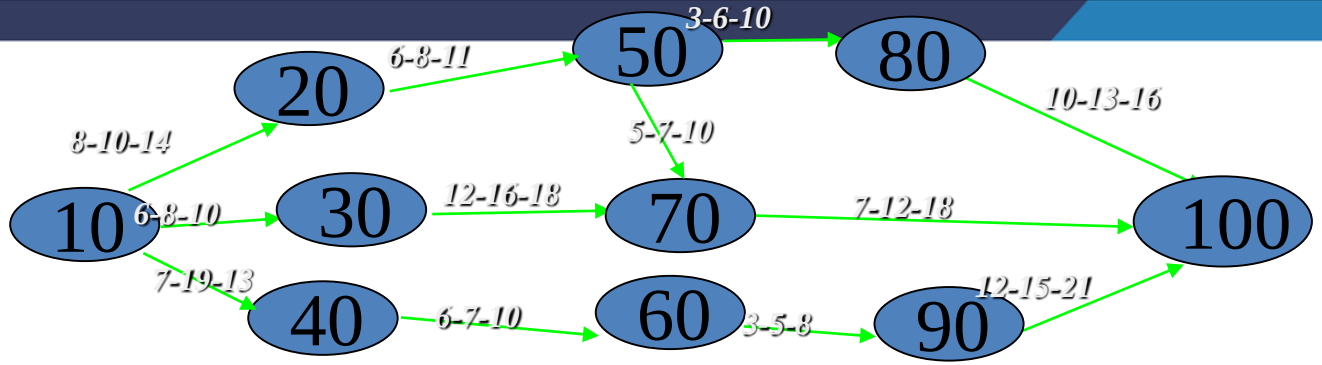
Useful with a complex project or one that has a shared budget

Critical Path

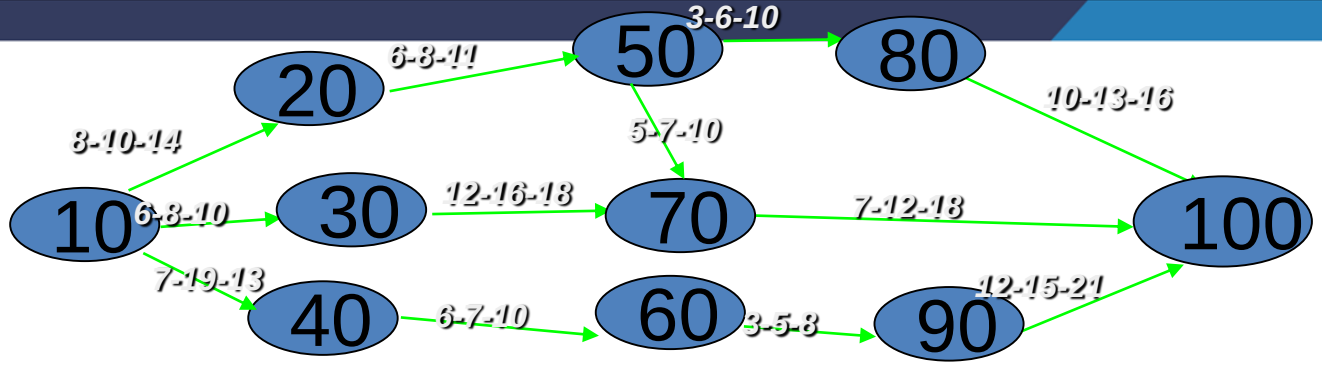
- ✓ ***A path is a sequence of connected activities running from start to end node in network***
- ✓ ***The critical path is the path with the longest duration in the network***
- ✓ ***Project cannot be completed in less than the time of the critical path***



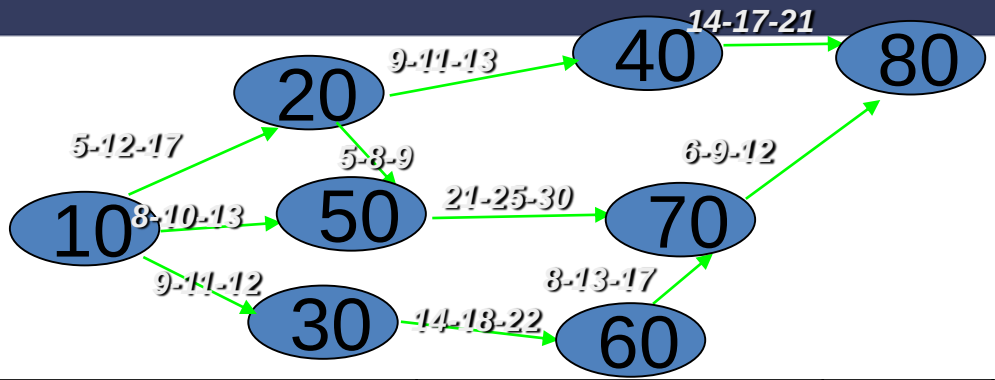

10
20
30
40
50
60
70
80
90
100
8-10-14
6-8-10
7-19-13
6-8-11
12-16-18
6-7-10
3-6-10
5-7-10
3-5-8
10-13-16
7-12-18
12-15-21



	Activity	to	tm	tp	te	Sum of - te's
Path - A	10-20	8	10	14	?	?
	20-50	6	8	11	?	
	50-80	3	6	10	?	
	80-100	10	13	16	?	
Path - B	10-20	8	10	14	?	?
	20-50	6	8	11	?	
	50-70	5	7	10	?	
	70-100	7	12	18	?	
Path - C	10-30	6	8	10	?	?
	30-70	12	16	18	?	
	70-100	7	12	18	?	
Path- D	10-40	7	9	13	?	?
	40-60	6	7	10	?	
	60-90	3	5	8	?	
	90-100	12	15	21	?	



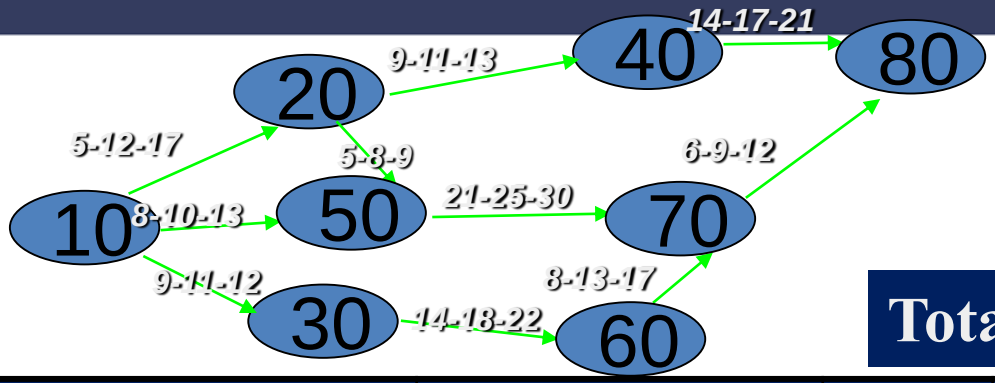
	Activity	to	tm	tp	te	Sum of - te's
Path - A	10-20	8	10	14	10.33	37.67
	20-50	6	8	11	8.17	
	50-80	3	6	10	6.17	
	80-100	10	13	16	13.00	
Path - B	10-20	8	10	14	10.33	37.84 (Critical Path)
	20-50	6	8	11	8.17	
	50-70	5	7	10	7.17	
	70-100	7	12	18	12.17	
Path - C	10-30	6	8	10	8.00	35.84
	30-70	12	16	18	15.67	
	70-100	7	12	18	12.17	
Path- D	10-40	7	9	13	9.34	37.34
	40-60	6	7	10	7.33	
	60-90	3	5	8	5.17	
	90-100	12	15	21	15.50	



$$te = (to+4tm+tp)/6$$

$$(\sigma)^2 = ((tp-to)/6)^2$$

Predecessor event	*Successor event*	*to*	*tm*	*tp*	*te*	$(\sigma)^2$
10	***20***	*5*	*12*	*17*	***?***	*?*
10	*30*	*9*	*11*	*12*	***?***	*?*
10	*50*	*8*	*10*	*13*	***?***	*?*
20	*40*	*9*	*11*	*13*	***?***	*?*
20	***50***	*5*	*8*	*9*	***?***	*?*
30	*60*	*14*	*18*	*22*	***?***	*?*
40	*80*	*14*	*17*	*21*	***?***	*?*
50	***70***	*21*	*25*	*30*	***?***	*?*
60	*70*	*8*	*13*	*17*	***?***	*?*
70	***80***	*6*	*9*	*12*	***?***	*?*



$$te = (to+4tm+tp)/ 6$$

$$(\sigma)^2 = ((tp-to)/6)^2$$

Total "te" along critical path??

Predecessor event	Successor event	to	tm	tp	te	(σ)2
10	20	5	12	17	11.66	4
10	30	9	11	12	10.83	.25
10	50	8	10	13	10.17	.69
20	40	9	11	13	11	.44
20	50	5	8	9	7.67	.44
30	60	14	18	22	18	1.78
40	80	14	17	21	17.17	1.36
50	70	21	25	30	25.18	2.25
60	70	8	13	17	12.83	2.25
70	80	6	9	12	9	1

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 39

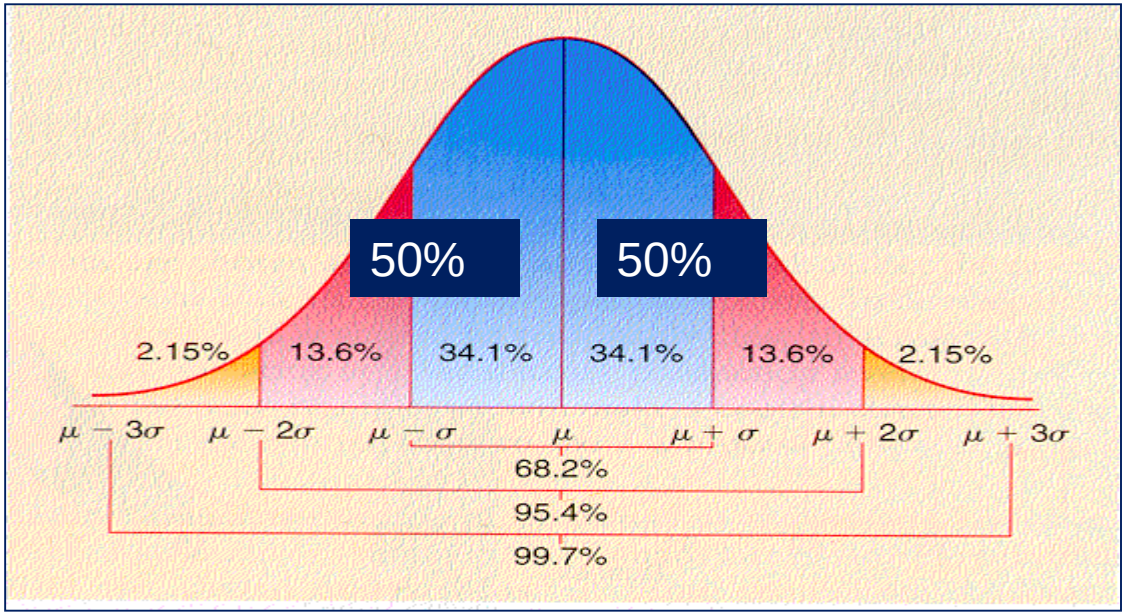
Probability Models in Networks - I

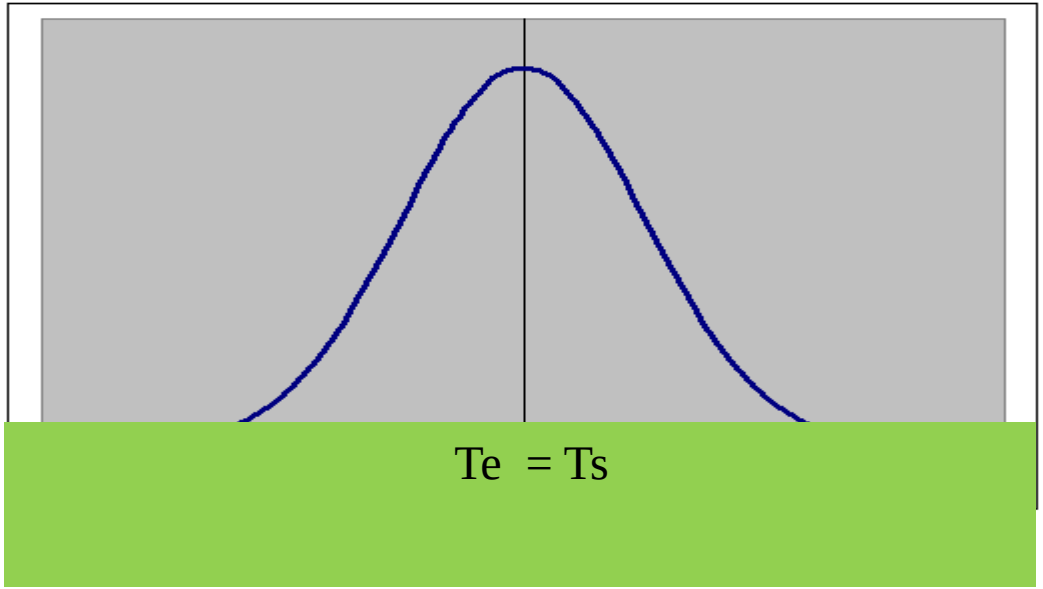
Dr. M.K. Barua

Department of Management

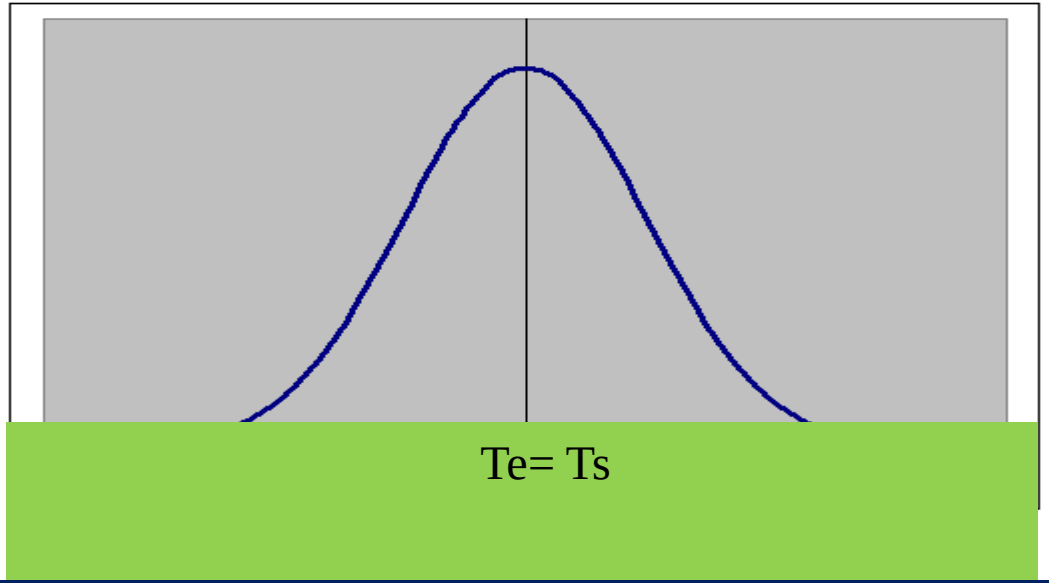
Indian Institute of Technology Roorkee

Probability of achieving a project on completion date.:



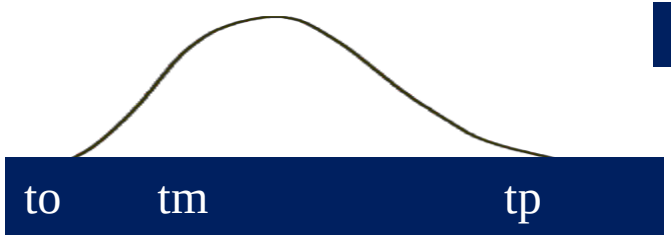


If Ts as “"1 σ” towards left of Te than the area under curve would be ????and if it is “1 σ” towards right of Te, the areas would be ?????%.

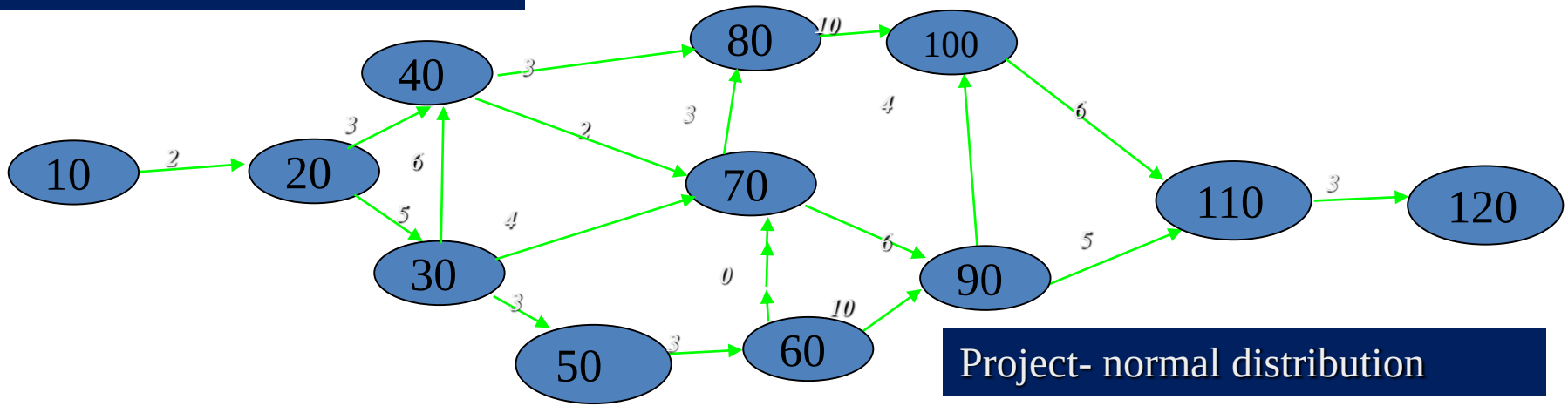


If Ts as 1 σ towards left of Te than area under the curve would be 15.9% and if it is 1 σ towards right of Te, the areas would be 84.1%.

Central limit theorem: Relationship b/w shape of population distribution and shape of sampling distribution of mean is called CLT.

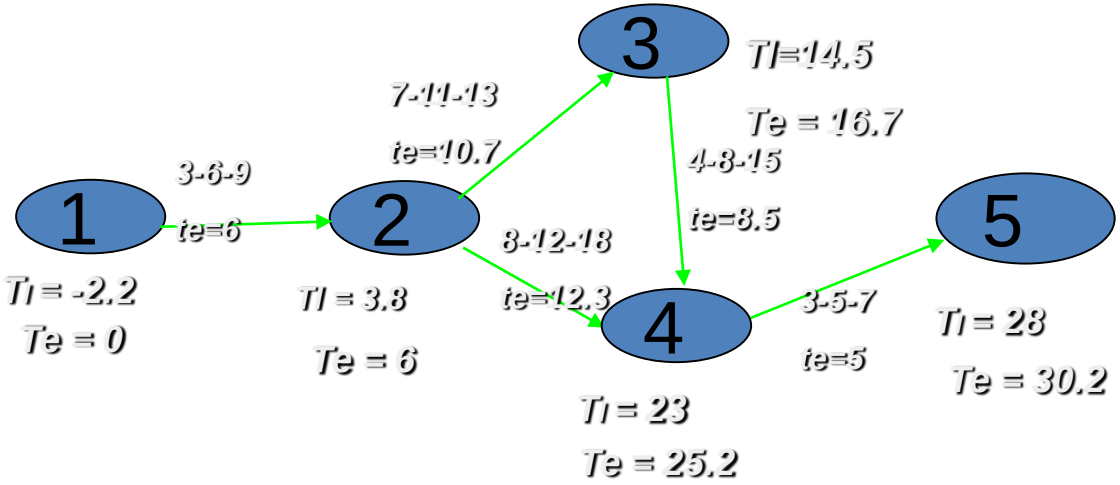


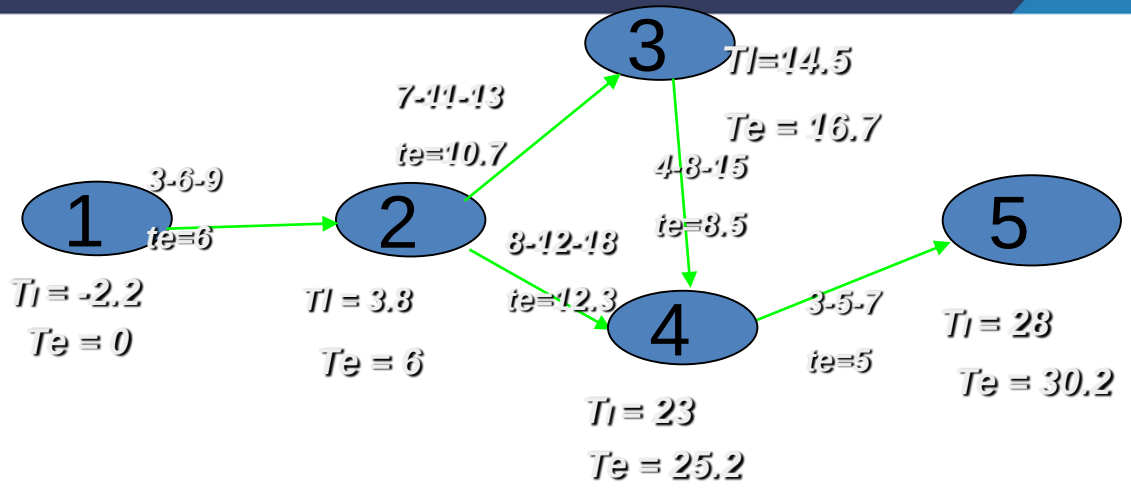
Activity –β distribution



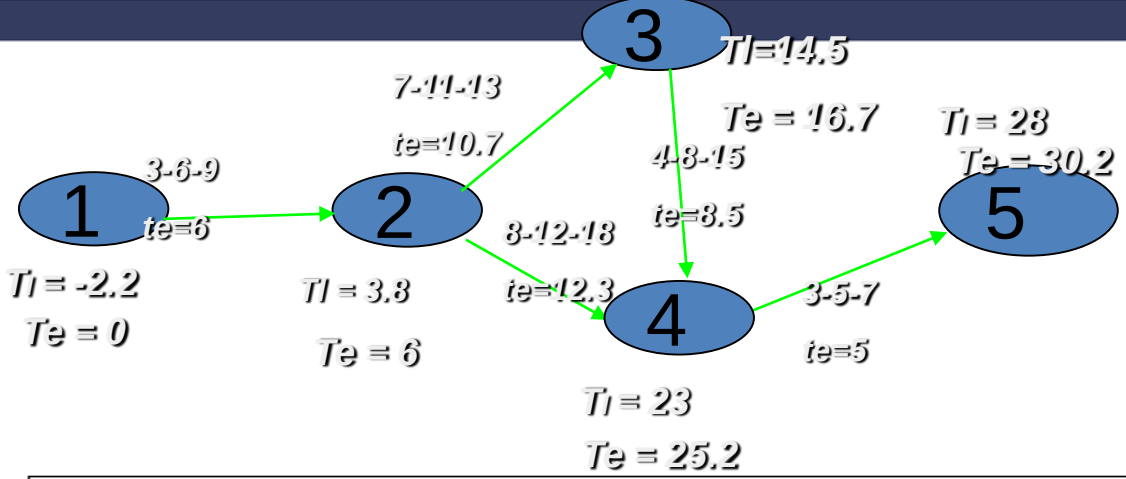
Project- normal distribution

Find critical path and variance along critical path. What is the probability that the project will be completed in 28 days?.

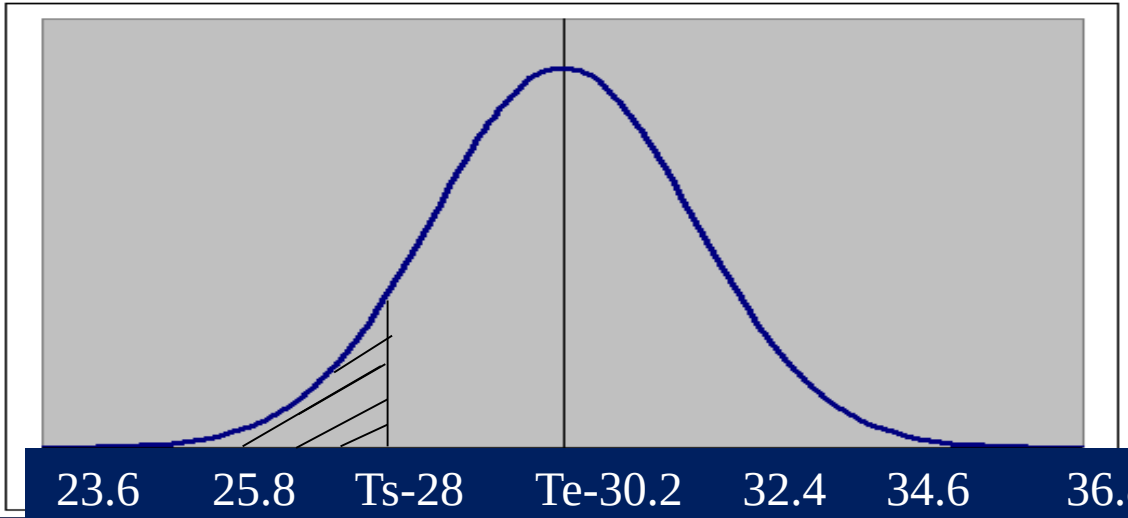




Activity	to	tp	$(\sigma)^2$
1-2	3	9	1
2-3	7	13	1
3-4	4	15	3.36
4-5	3	7	.44
Variance along Critical Path			5.8



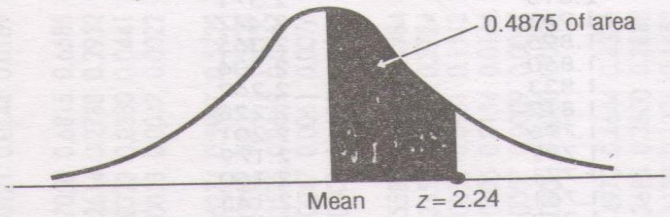
Activity	to	tp	(σ) 2
1-2	3	9	1
2-3	7	13	1
3-4	4	15	3.36
4-5	3	7	.44
Variance along Critical Path			5.8



23.6	25.8	Ts-28	Te-30.2	32.4	34.6	36.8
-3σ	-2	-1	μ	+1	+2	+3σ

Z = Ts-Te/ (σ) = -2.2/2.41 = -0.91

from z table the area under curve is 18.4%.



Appendix Table 1

Areas under the Standard Normal Probability Distribution between the Mean and Positive Values of z

Example: To find the area under the curve between the mean and a point 2.24 standard deviations to the right of the mean, look up the value opposite 2.2 and under 0.04 in the table; 0.4875 of the area under the curve lies between the mean and a **z** value of 2.24.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 40

Probability Models in Networks - II

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

The distributions of durations of different activities, as assessed by project incharge are as follows.

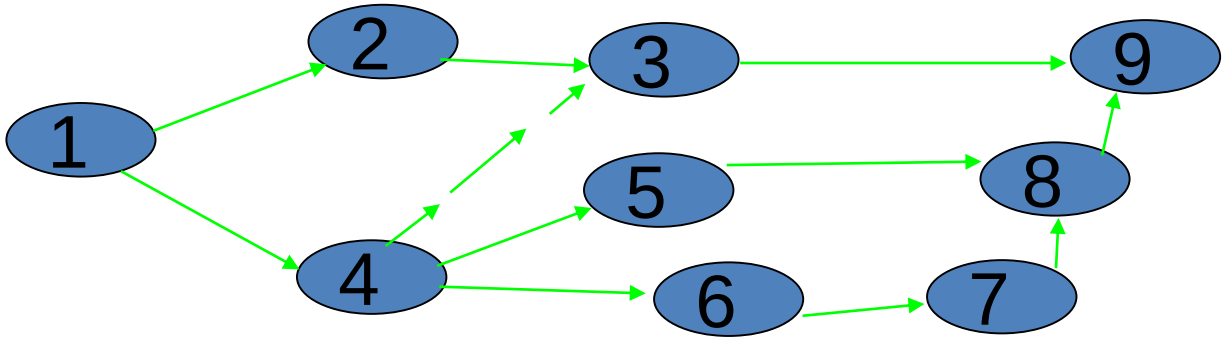
T12	has normal distribution with to = 3 and tp =9
T23	has normal distribution with to = 4 and tp =16
T39	has normal distribution with to = 8 and tp =16
T46	has normal distribution with to = 4 and tp =10
T58	has constant distribution (duration) with 5 days.
T89	has constant distribution (duration) with 4 days.
T34	is a dummy activity.

T45	Prob.
3	.2
4	.3
5	.4
6	.1

T14	Prob.
16	.25
17	.50
18	.25

T67	Prob.
4	.5
5	.5

T78	Prob.
5	.4
6	.6



Find critical path variance along it.

What is the probability that the project will be completed in less than or 40 days.

Find out expected value and variance for all the activities.

If we have an activity (i,j) assumed to have a normal distribution with tp = 9 and to = 3, then we fit normal distribution to the activity.

$\mu = E(X) = (tp+to)/2$ and $\sigma = (tp-to)/6$.

T12 has normal distribution with to = 3 and tp =9

Expected duration of $E(T12) = 6$ and $\sigma^2 = (9-6)/6 = 1$.

Similarly,

expected duration of E(T23) (4,16) = 10 and σ^2= 4

expected duration of E(T39) (8,16) = 12 and σ^2= 16/9

expected duration of E(T46) (4,10)= 7 and σ^2= 1

For the activities with constant duration, we have

E(T58) = 5 and σ^2 = 0.

E(T89) = 4 and σ^2 = 0, and for dummy E(T43) = σ^2 = 0,

Now find expected value and variance of an activity with discrete distribution.

E(T14) = 16*.25+17*.50+18*.25 = 17

T14	Prob.
16	.25
17	.50
18	.25

After finding E (T14) = 17, the variance of T14 is

$V^2\ 14 = E\ (\ T14- E(T14))^{\ 2}$

$= E\ (\ T14- 17)^{\ 2}$

$= E\ (\ 16-17)^2 = 1$

$= E\ (\ 17-17)^2 = 0$

$= E\ (\ 18-17)^2 = 1$

$(T14-17)^2$:	1	0	1
Prob.:	.25	.5	.25

$(V14)^2 = 1*.25+0*.5+1*.25 = 0.5$

T14	Prob.
16	.25
17	.50
18	.25

$E(T45) = .6 + 1.2 + 2 + .6 = 4.4$

$V^2\ 45 = E\ (T45 - E(T45))^2$

$= E\ (T45 - 4.4)^2$

$= E\ (3 - 4.4)^2 = 1.96$

$= E\ (4 - 4.4)^2 = .16$

$= E\ (5 - 4.4)^2 = .36$

$= E\ (6 - 4.4)^2 = 2.56$

T45	Prob.
3	.2
4	.3
5	.4
6	.1

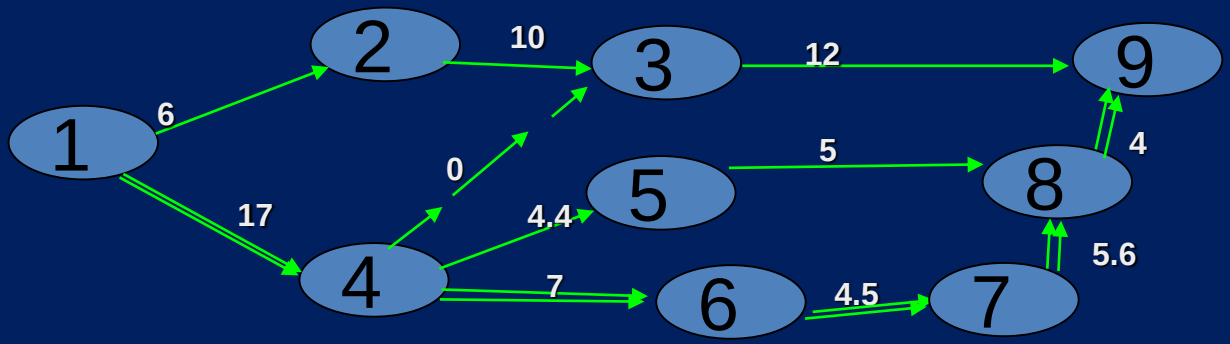
$(T45-4.4)^2$:	1.96	.16	.36	2.56
Prob.:	.2	.3	.4	.1

$V^2\ 45 = 1.96*.2 + .16*.3 + .6*.4 + 2.56*.1 = .84$

For activity 6-7, E(67) and V2 (67) = 4.5 and .25 and

for activity 7-8 , E(78) and V2 (78) = 5.6 and .24

After finding expected values and variance for all the activities find critical path.



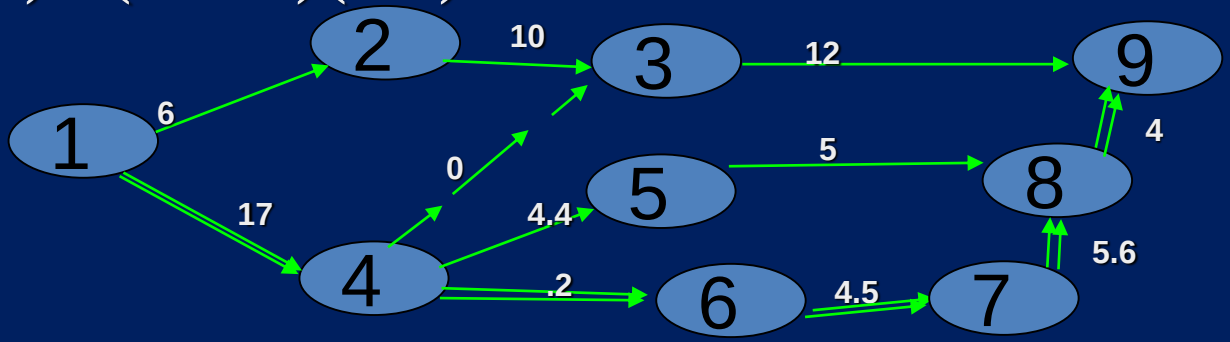
The project duration is 38.1

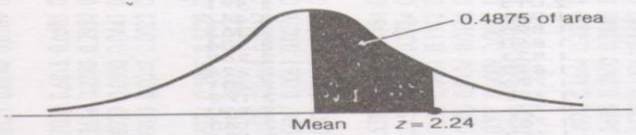
he project duration is : 1-4-6-7-8-9= 17+7+4.5+5.6+4= 38.1 and

Variance: 1-4-6-7-8-9

0.5+1+.25+0.24+0 =1.99 and Std Dev = 1.41

P (T<= 40) = (40-38.1)/(1.41) = 1.35



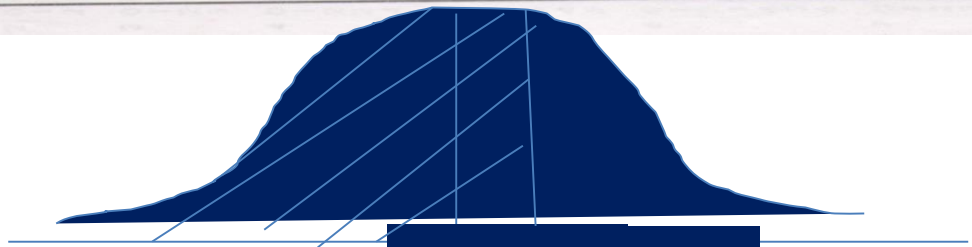


Appendix Table 1

Areas under the Standard Normal Probability Distribution between the Mean and Positive Values of z

Example: To find the area under the curve between the mean and a point 2.24 standard deviations to the right of the mean, look up the value opposite 2.2 and under 0.04 in the table; 0.4875 of the area under the curve lies between the mean and a z value of 2.24.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0,1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.37790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990



38.1 40

.50+0.4115=0.91 =91%

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 41

Probability Models in Networks - III

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 42

Probability Models in Networks - IV

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 43

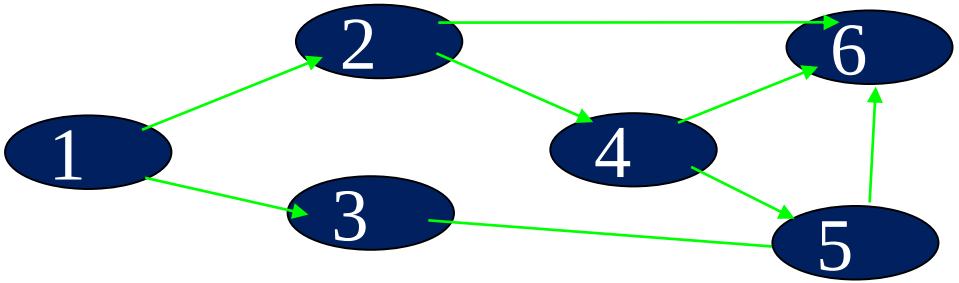
Simulation of Networks- I

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Simulation of PERT network.



The person in charge of the activity feels there is

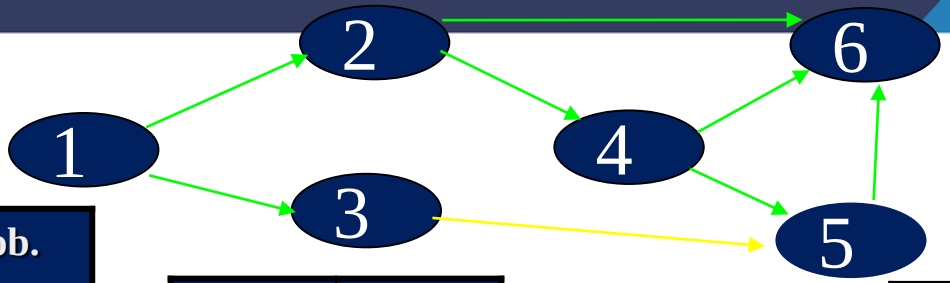
a chance of 20 % that the activity 1-2 will be over in 5 days,

and a 30% chance of completion in 6 days,

a 30% chance of completion in 7 days and

a 20% chance of completion in 8 days.

Let T_{1-2} be the random variable which denotes the duration of activity 1-2. The probability distribution of T_{1-2} is shown in table.



Find the duration of this project?

1-2	Prob.
5	0.2
6	0.3
7	0.3
8	0.2

1-3	Prob.
12	.05
13	0.2
14	0.5
15	0.2
16	0.05

2-4	Prob.
6	0.2
7	0.6
8	0.2

3-5	Prob.
4	0.15
5	0.7
6	0.15

2-6	Prob.
8	0.1
9	0.4
10	0.4
11	0.1

4-5	Prob.
6	0.3
7	0.6
8	0.1

5-6	Prob.
7	0.3
8	0.4
9	0.3

4-6	Prob.
13	0.1
14	0.2
15	0.5
16	0.1
17	0.1

Now we generate random sample for Tij. Let F ij(x) denote the cumulative distribution function (cdf) of Tij that is

$F_{ij}(x) = P(Tij \leq x)$

1-2	Prob.
5	0.2
6	0.3
7	0.3
8	0.2

From table we find that

$F_{12}(x) = 0 \quad x < 5$

$= .2 \quad 5 \leq x < 6$

$= .5 \quad 6 \leq x < 7$

$= .8 \quad 7 \leq x < 8$

$= 1.0 \quad 8 \leq x$ Equation (1)

Let “u” be the random variable which is distributed uniformly over (0,1). Since F ij(x) is uniformly distributed over (0,1) it can be proved that equation (1) implies

$0 \leq u < .2$ corresponds to Tij = 5

$.2 \leq u < .5$ corresponds to Tij = 6

$.5 \leq u < .8$ corresponds to Tij = 7

$.8 \leq u < 1$ corresponds to Tij = 8

.07	.01	.85	.24	.44	.72	.16	.11	.79	.18
.13	.62	.32	.74	.20	.96	.03	.96	.82	.82

The following will the times for activity 1-2 .

5	5	8	6	6	7	5	5	7	5
5	7	6	7	6	8	5	8	8	8

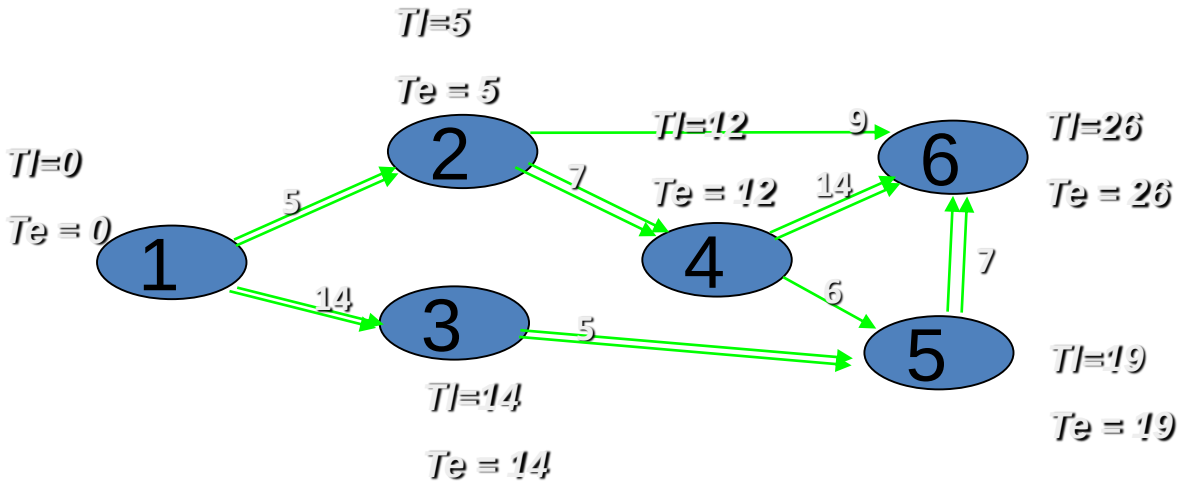
Similarly generate times for other activities.

SN	RN	T12
1	.07	5
2	.01	5
3	.85	8
4	.24	6
5	.44	6
6	.72	7
7	.16	5
8	.11	5
9	.79	7
10	.18	5
11	.13	5
12	.62	7
13	.32	6
14	.74	7
15	.20	6
16	.96	8
17	.03	5
18	.96	8
19	.82	8
20	.82	8

SN	RN	T12	RN	T13	RN	T24	RN	T35	RN	T26	RN	T45	RN	T46	RN	T56
1	.07	5	.54	14	.41	7	.19	5	.34	9	.09	6	.17	14	.21	7
2	.01	5	.26	14	.78	7	.19	5	.96	11	.23	6	.29	14	.33	8
3	.85	8	.26	14	.69	7	.34	5	.89	10	.71	7	.55	15	.89	9
4	.24	6	.62	14	.56	7	.90	6	.96	11	.10	6	.93	17	.88	9
5	.44	6	.90	15	.27	7	.17	5	.96	11	.07	6	.38	15	.88	9
6	.72	7	.53	14	.98	8	.76	5	.55	10	.60	7	.31	15	.21	7
7	.16	5	.34	14	.73	7	.94	6	.28	9	.62	7	.17	14	.47	8
8	.11	5	.83	15	.87	8	.15	5	.23	9	.27	6	.26	14	.72	9
9	.79	7	.44	14	.52	7	.54	5	.13	9	.99	8	.56	15	.75	9
10	.18	5	.82	15	.14	6	.30	5	.37	9	.73	7	.25	14	.44	8
11	.13	5	.99	16	.73	7	.33	5	.94	11	.71	7	.57	15	.39	8
12	.62	7	.26	14	.90	8	.02	4	.12	9	.08	6	.29	14	.04	7
13	.32	6	.89	15	.43	7	.38	5	.80	10	.00	6	.97	17	.44	8
14	.74	7	.53	14	.33	7	.73	5	.65	10	.99	8	.50	15	.27	7
15	.20	6	.42	14	.29	7	.37	5	.11	9	.23	6	.71	15	.58	8
16	.96	8	.38	14	.66	7	.81	5	.69	10	.63	7	.76	15	.98	9
17	.03	5	.55	14	.36	7	.77	5	.98	11	.09	6	.16	14	.71	9
18	.96	8	.63	14	.46	7	.37	5	.12	9	.41	7	.59	15	.59	8
19	.82	8	.91	15	.83	8	.42	5	.37	9	.98	8	.75	15	.71	9
20	.82	8	.59	14	.49	7	.79	5	.01	8	.06	6	.34	15	.78	9

For each case we find critical path and duration of completion of project.

SN	RN	T12	RN	T13	RN	T24	RN	T35	RN	T26	RN	T45	RN	T46	RN	T56
1	.07	5	.54	14	.41	7	.19	5	.34	9	.09	6	.17	14	.21	7



For serial no. 1 , the critical paths are 1-2-4-6 and 1-3-5-6 and the duration is 26. When we do it for 20 runs, we will find next table.

Critical paths for sr. no. 1 are :1-2-4-6 and 1-3-5-6

Sr.No.	1-2	1-3	2-4	3-5	2-6	4-5	4-6	5-6	T
1	1	1	1	1			1	1	26
2		1		1				1	27
3	1		1			1		1	31
4	1		1				1		30
5		1		1				1	29
6	1		1				1		30
7		1		1				1	28
8		1		1				1	26
9	1		1			1		1	31
10		1		1				1	28
11		1		1				1	29
12	1		1				1		29
13	1		1				1		30
14	1		1			1	1	1	29
15	1		1				1		28
16	1		1			1		1	31
17		1		1				1	28
18	1		1			1	1	1	30
19	1		1			1		1	33
20	1		1			1	1	1	30
Crit Ind.	.65	.40	.65	.40	.00	.35	.45	.75	Avg:29.3

Average duration of the project is 29.3 days .The critical index of the activity 5-6 is 0.75, it means that, if we under take this project 100 times, then 75 % of the times it will be a critical activity. From previous table.

T (Days)	26	27	28	29	30	31	32	33
Prob.	2/20	1/20	4/20	4/20	5/20	3/20	0/20	1/20

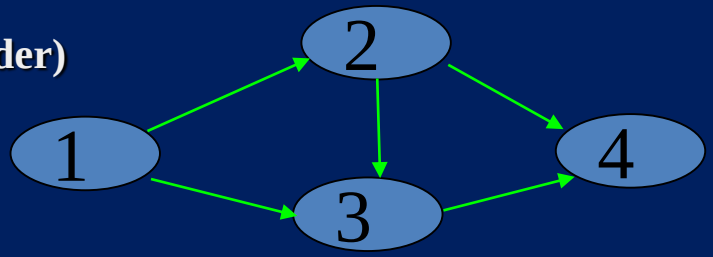
P (project will take more than 29 days) = 9/20.

This approach is better than traditional PERT approach.

Gives information about critical and semi critical activities.

A PERT network consists of five activities (1,2),(1,3),(2,3),(2,4) and (3,4) with following details.

Activity	Description	RN(to be used in order)
1-2	Constant with duration 5	
1-3	Constant with duration 2	
2-3	3/.3 4/.4 5/.3	.2, .1, .9, .3, .2
2-4	6/.3 7/.5 8/.2	.9, .0, .1, .5, .6
3-4	3/.2 4/.7 5/.1	.6, .2, .9, .1, .1



Simulate the network for five times and find

(a) Distribution of T the project duration,

(b) E (T) ,

(c) P(T ≤ 14) and

(d) Critical indexes of all the activities.

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 44

Simulation of Networks- II

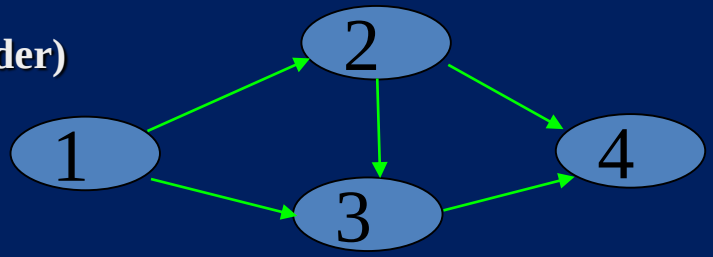
Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

A PERT network consists of five activities (1,2),(1,3),(2,3),(2,4) and (3,4) with following details.

Activity	Description	RN(to be used in order)
1-2	Constant with duration 5	
1-3	Constant with duration 2	
2-3	3/.3 4/.4 5/.3	.2, .1, .9, .3, .2
2-4	6/.3 7/.5 8/.2	.9, .0, .1, .5, .6
3-4	3/.2 4/.7 5/.1	.6, .2, .9, .1, .1



Simulate the network for five times and find

(a) Distribution of T the project duration,

(b) E (T) ,

(c) P(T ≤ 14) and

(d) Critical indexes of all the activities.

First of all we find the relations connecting Tij to random numbers.

For T23 : 3/.3 4/.4 5/.3

$0 \leq u < .3$	corresponds to T23 = 3
$.3 \leq u < .7$	corresponds to T23 = 4
$.7 \leq u < 1$	corresponds to T23 = 5

Similarly,

For T24: 6/.3 7/.5 8/.2

$0 \leq u < .3$	corresponds to T24 = 6
$.3 \leq u < .8$	corresponds to T24 = 7
$.8 \leq u < 1$	corresponds to T24 = 8

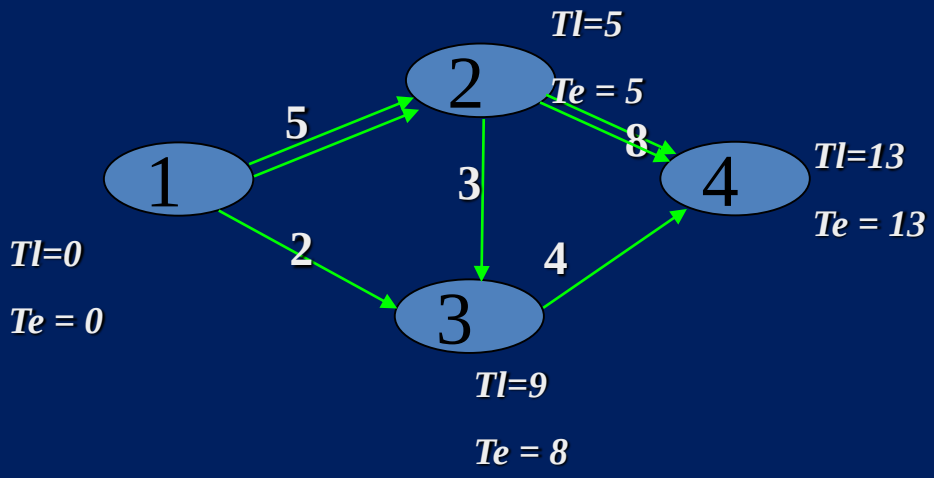
and

For T34: 3/.2 4/.7 5/.1

$0 \leq u < .2$	corresponds to T34 = 3
$.2 \leq u < .9$	corresponds to T34 = 4
$.9 \leq u < 1$	corresponds to T34 = 5

Activity	Description			RN(to be used in order)				
1-2	Constant with duration 5							
1-3	Constant with duration 2							
2-3	3/.3	4/.4	5/.3	.2,	.1,	.9,	.3,	.2
2-4	6/.3	7/.5	8/.2	.9,	.0,	.1,	.5,	.6
3-4	3/.2	4/.7	5/.1	.6,	.2,	.9,	.1,	.1

1st Simulation: T12 = 5, T13= 2, first random number for T23 is .2, the duration would be 3 days, similarly for T24 and T34 the durations would be 8 and 4 days.



$0 \le u < .3$	corresponds to T23 = 3
$.3 \le u < .7$	corresponds to T23 = 4
$.7 \le u < 1$	corresponds to T23 = 5

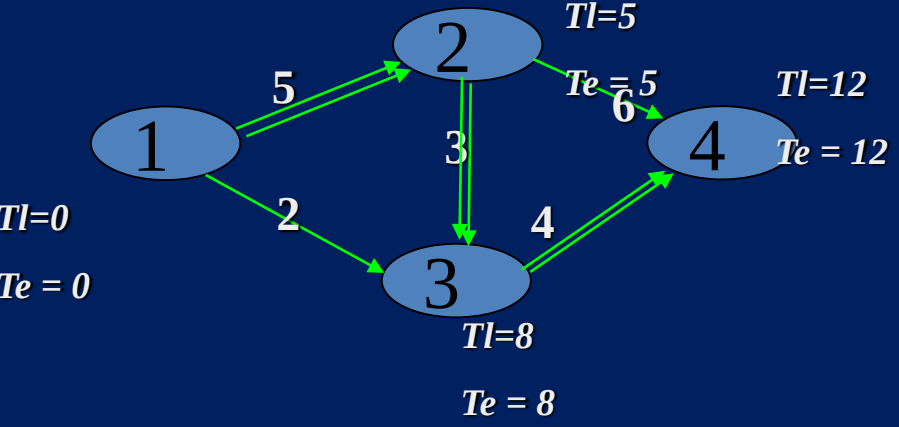
$0 \le u < .3$	corresponds to T24 = 6
$.3 \le u < .8$	corresponds to T24 = 7
$.8 \le u < 1$	corresponds to T24 = 8

$0 \le u < .2$	corresponds to T34 = 3
$.2 \le u < .9$	corresponds to T34 = 4
$.9 \le u < 1$	corresponds to T34 = 5

The critical path is 1-2-4 and the duration is 13.

Activity	Description	RN(to be used in order)
1-2	Constant with duration 5	
1-3	Constant with duration 2	
2-3	3/.3 4/.4 5/.3	.2, .1, .9, .3, .2
2-4	6/.3 7/.5 8/.2	.9, .0, .1, .5, .6
3-4	3/.2 4/.7 5/.1	.6, .2, .9, .1, .1

2nd Simulation: T12 = 5, T13= 2, second random number for T23 is .1, the duration would be 3 days, similarly for T24 and T34 the durations would be 6 and 3 days.

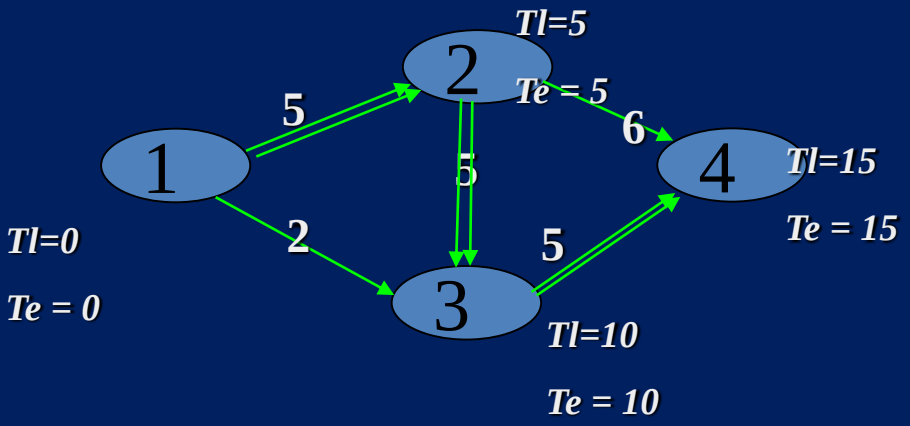


The critical path is 1-2-3-4 and the duration is 12.

$0 \le u < .3$	corresponds to T23 = 3
$.3 \le u < .7$	corresponds to T23 = 4
$.7 \le u < 1$	corresponds to T23 = 5
$0 \le u < .3$	corresponds to T24 = 6
$.3 \le u < .8$	corresponds to T24 = 7
$.8 \le u < 1$	corresponds to T24 = 8
$0 \le u < .2$	corresponds to T34 = 3
$.2 \le u < .9$	corresponds to T34 = 4
$.9 \le u < 1$	corresponds to T34 = 5

Activity	Description	RN(to be used in order)
1-2	Constant with duration 5	
1-3	Constant with duration 2	
2-3	3/.3 4/.4 5/.3	.2, .1, .9, .3, .2
2-4	6/.3 7/.5 8/.2	.9, .0, .1, .5, .6
3-4	3/.2 4/.7 5/.1	.6, .2, .9, .1, .1

3rd Simulation: T12 = 5, T13= 2, third random number for T23 is .9, the duration would be 5 days, similarly for T24 and T34 the durations would be 6 and 5 days.



The critical path is 1-2-3-4 and the duration is 15.

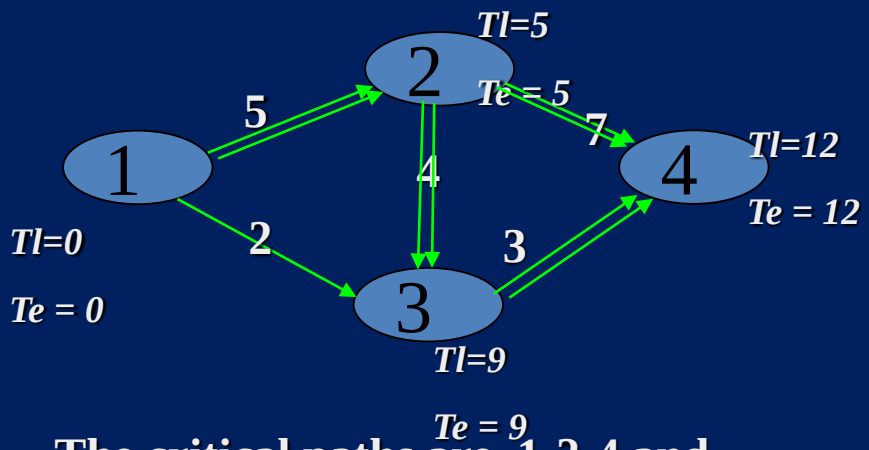
$0 \le u < .3$	corresponds to T23 = 3
$.3 \le u < .7$	corresponds to T23 = 4
$.7 \le u < 1$	corresponds to T23 = 5

$0 \le u < .3$	corresponds to T24 = 6
$.3 \le u < .8$	corresponds to T24 = 7
$.8 \le u < 1$	corresponds to T24 = 8

$0 \le u < .2$	corresponds to T34 = 3
$.2 \le u < .9$	corresponds to T34 = 4
$.9 \le u < 1$	corresponds to T34 = 5

Activity	Description	RN(to be used in order)
1-2	Constant with duration 5	
1-3	Constant with duration 2	
2-3	3/.3 4/.4 5/.3	.2, .1, .9, .3, .2
2-4	6/.3 7/.5 8/.2	.9, .0, .1, .5, .6
3-4	3/.2 4/.7 5/.1	.6, .2, .9, .1, .1

4th Simulation: T12 = 5, T13= 2, fourth random number for T23 is .3, the duration would be 4 days, similarly for T24 and T34 the durations would be 7 and 3 days.



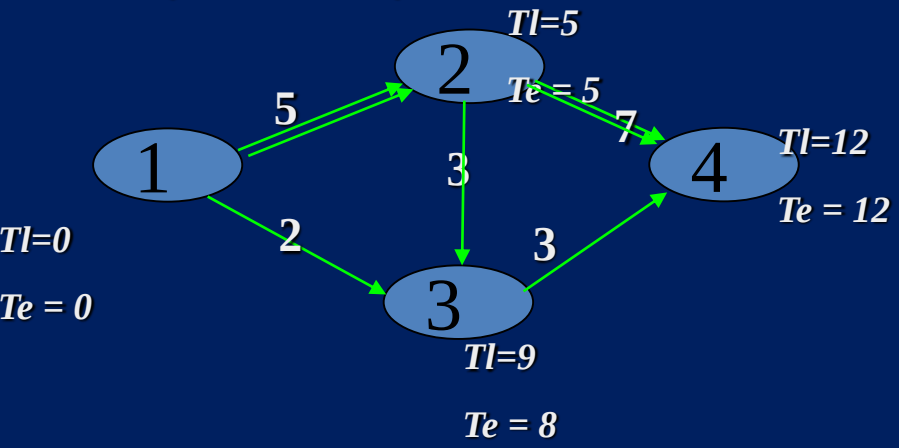
0 ≤ u < .3	corresponds to T23 = 3
.3 ≤ u < .7	corresponds to T23 = 4
.7< u < 1	corresponds to T23 = 5
0 ≤ u < .3	corresponds to T24 = 6
.3 ≤ u < .8	corresponds to T24 = 7
.8≤ u < 1	corresponds to T24 = 8
0 ≤ u < .2	corresponds to T34 = 3
.2 ≤ u <.9	corresponds to T34 = 4
.9≤ u < 1	corresponds to T34 = 5

The critical paths are 1-2-4 and

1-2-3-4 the duration is 12.

Activity	Description	RN(to be used in order)
1-2	Constant with duration 5	
1-3	Constant with duration 2	
2-3	3/.3 4/.4 5/.3	.2, .1, .9, .3, .2
2-4	6/.3 7/.5 8/.2	.9, .0, .1, .5, .6
3-4	3/.2 4/.7 5/.1	.6, .2, .9, .1, .1

5th Simulation: T12 = 5, T13= 2, fifth random number for T23 is .2, the duration would be 3 days, similarly for T24 and T34 the durations would be 7 and 3 days.



The critical paths are 1-2-4 and the duration is 12.

$0 \le u < .3$	corresponds to T23 = 3
$.3 \le u < .7$	corresponds to T23 = 4
$.7 \le u < 1$	corresponds to T23 = 5
$0 \le u < .3$	corresponds to T24 = 6
$.3 \le u < .8$	corresponds to T24 = 7
$.8 \le u < 1$	corresponds to T24 = 8
$0 \le u < .2$	corresponds to T34 = 3
$.2 \le u < .9$	corresponds to T34 = 4
$.9 \le u < 1$	corresponds to T34 = 5

From above

(a) Distribution of T is

T	12	13	15
Prob.	3/5=.6	1/5=.2	1/5=.2

(b) E(T)

12* . 6+13* .2+15* .2 = 12. 8

(c) P (T ≤ 14)

.6+.2 = .8

(d) Critical index.

SN	1-2	1-3	2-3	2-4	3-4	T
1	1			1		13
2	1		1		1	12
3	1		1		1	15
4	1		1	1	1	12
5	1			1		12
Critical Index	1	0	.6	.6	.6	12.8

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 45

Slacks & Floats- I

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Slack is the maximum delay possible for an event without affecting its overall duration.

Floats for activities are the same as slacks are for events.

So, we can define float as maximum delays possible for an activity without changing the project duration.

There are four types of floats:

1. Total float: It is the maximum delay possible for an activity without considering any delay in its precedence or succeeding activity.

2. Free float: It is the maximum delay possible for activities which will **not a**ffect the float of the successor activity.

3. Independent float: It is the maximum delay possible for an activity with used floats of preceding activities and will not affect the floats of succeeding activities.

4.Safety float: Let the preceding job finish at its latest possible time and the succeeding job finish as late as possible time.

The characteristics of float are:

Independent float <=Free float <=Total float

Only independent float can be negative, the rest two floats are always positive or zero.

Activities with all floats = 0 are critical activities.

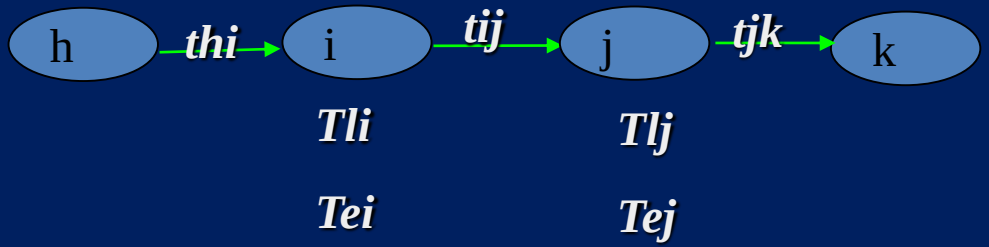
The applications of floats are as follows:

1.It identifies the critical activities as well as quantify maximum delays possible for all not critical activities.

2.It is very important in crashing of a network (reducing the time and/or cost of overall project).

3.It helps in resource allocation and smoothing.

Float: We can define following for a given activity i-j.



Earliest start time (Tei): This is the earliest occurrence time for the event from which the activity arrow originates.

Earliest finish time : Tei + tij

Latest finish time: The latest occurrence time for the node at which the activity arrow terminates, Tlj

Latest start time : Tlj - t Ij

Maximum time available = Tlj – Tei

Total float:= Total float for job i-j is the difference between maximum time available and the actual time it takes.

TF =Tlj – Tei – tij

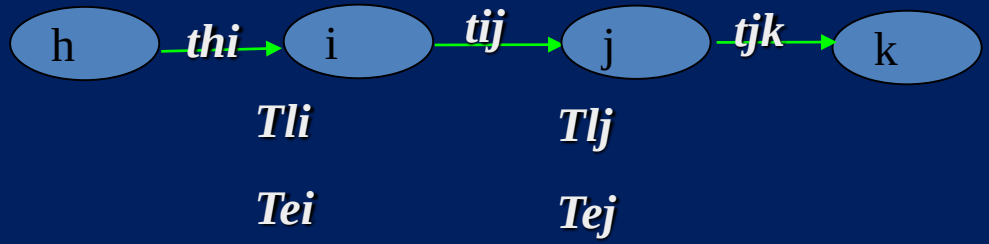
Free float: This is based on the possibility that all events occur at their earliest times, i.e. all activities start as early as possible. It is the difference between earliest finish time and earliest start time.

FF= Tej-Tei – tij

		Successor	
		Early	**Late**
Predecessor	Early	Free	Total
	Late	Independent	Safety

Independent float: Let the preceding job h-i finish at its latest possible time Tli and the succeeding job j-k start at its earliest possible time , which is Tej.

IF= Tej-Tli-tij.

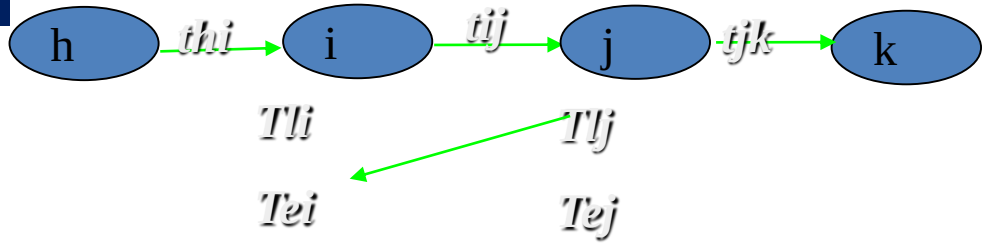


Successor

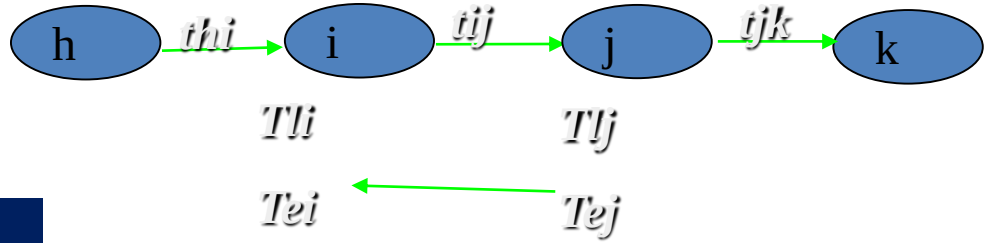
Predecessor	Early	Late
Early	Free	Total
Late	Independent	Safety

Safety float: Let the preceding job finish at its latest possible time and the succeeding job finish as late as possible time.

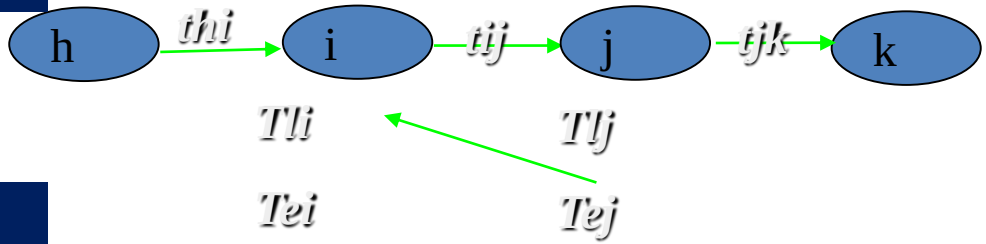
Total float



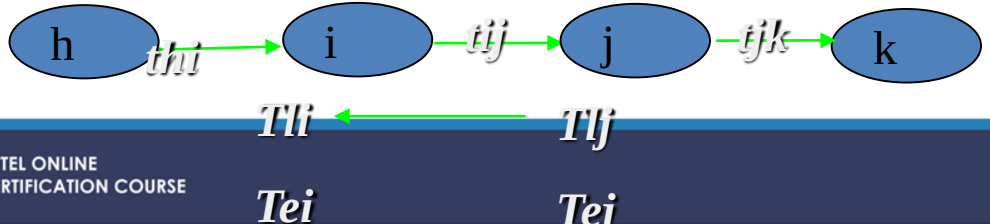
Free float

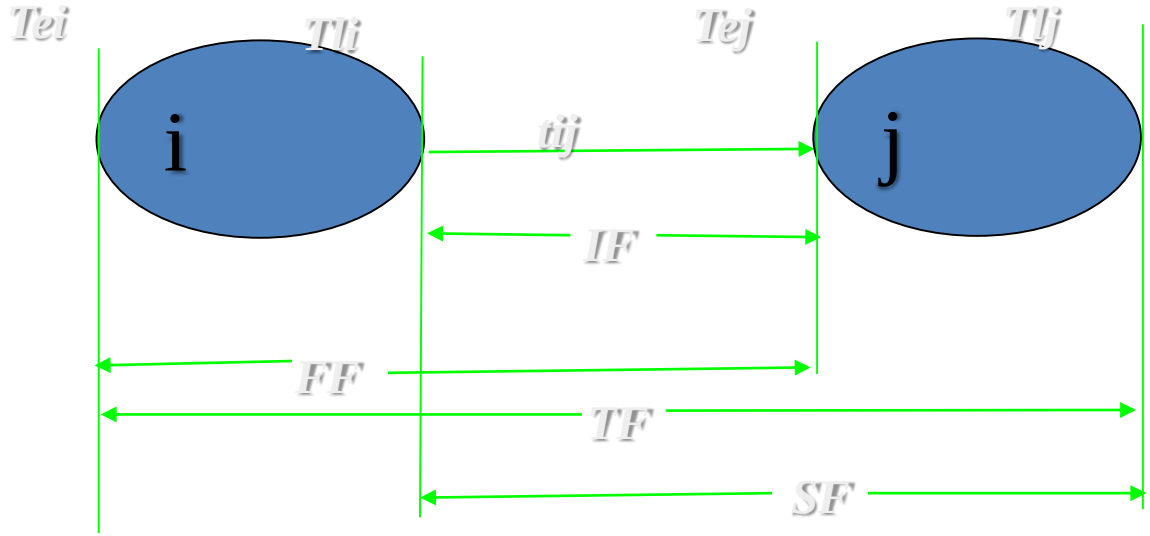


Independent float



Safety float





TF =Tlj – Tei – tij

FF= Tei-Tei – tii

IF= Tej-Tli-tij

SF=Tlj-Tli-tij

Successor

	Early	**Late**
Predecessor		
Early	Free	Total
Late	Independent	Safety

Ex: Work out couple of examples

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec- 46

Slacks & Floats- II

Dr. M.K. Barua

Department of Management

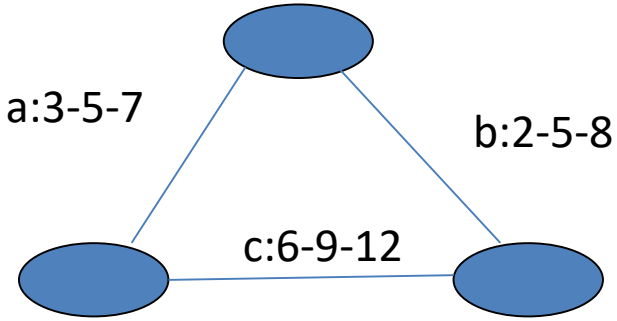
Indian Institute of Technology Roorkee

Limitations of Networks: There are some assumptions in networks, which may not be practical. Some of them are: **No activity can be repeated**, though at times many activities have to be repeated, when scope is not met or quality of work is not satisfactory.

All immediate precedence activities have to be completed before starting the activity; although at **times even after completion of few precedence activities, the later activity can start and go concurrently** with predecided precedence activity.

This is common in the situation of a research project or when some other adjustment is made due to delay situations. The critical path is the longest path, but in the situations of probabilistic times, **many paths with little slack become critical path** because there time becomes pessimistic and critical path activities are completed in estimated time or in another situation when activities of critical path are completed in optimistic times, but the activity on a non-critical path are completed in estimated times. Generally, this situation arrives when there is a minor difference between time of critical path and other noncritical path.

Let us understand this through an example as depicted by a network in Figure below. Limitations of PERT. The critical path is a-b in normal circumstance but if activity ‘c’ is finished in pessimistic time of 12 days and activities ‘a’ and ‘b’ are completed in estimated time, then path c will become critical



It is assumed that in probabilistic events, it will follow **beta distribution** but it may not follow the beta distribution and then the average time will be in accordance with the **distribution**.

It is assumed that a project will have only one **ending event**, but there are chances of **partial success** which may lead to more than one ending events.

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 47

Time and Cost Relationship

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Time and Cost Relationship

Crashing : Process of reducing time of the project.

Elements of costs

(i)Material
(ii)Labour
(iii) Expenses

Material

Direct : Raw material and components

Indirect: consumable stores, lubricants, cotton waste, cleaning material, stationary , etc.

(ii) Labour

Direct : Employees engaged in manufacturing/activity of a project.

Indirect: Store clerk, material handling staff, supervisors, foremen, works manager etc.

(iii) Expenses :

Direct- Payments made to consultants, designers, hiring charges of m/cs, cost of rework.

Indirect- Rent of building, telephone bills, insurance, lighting expenses.

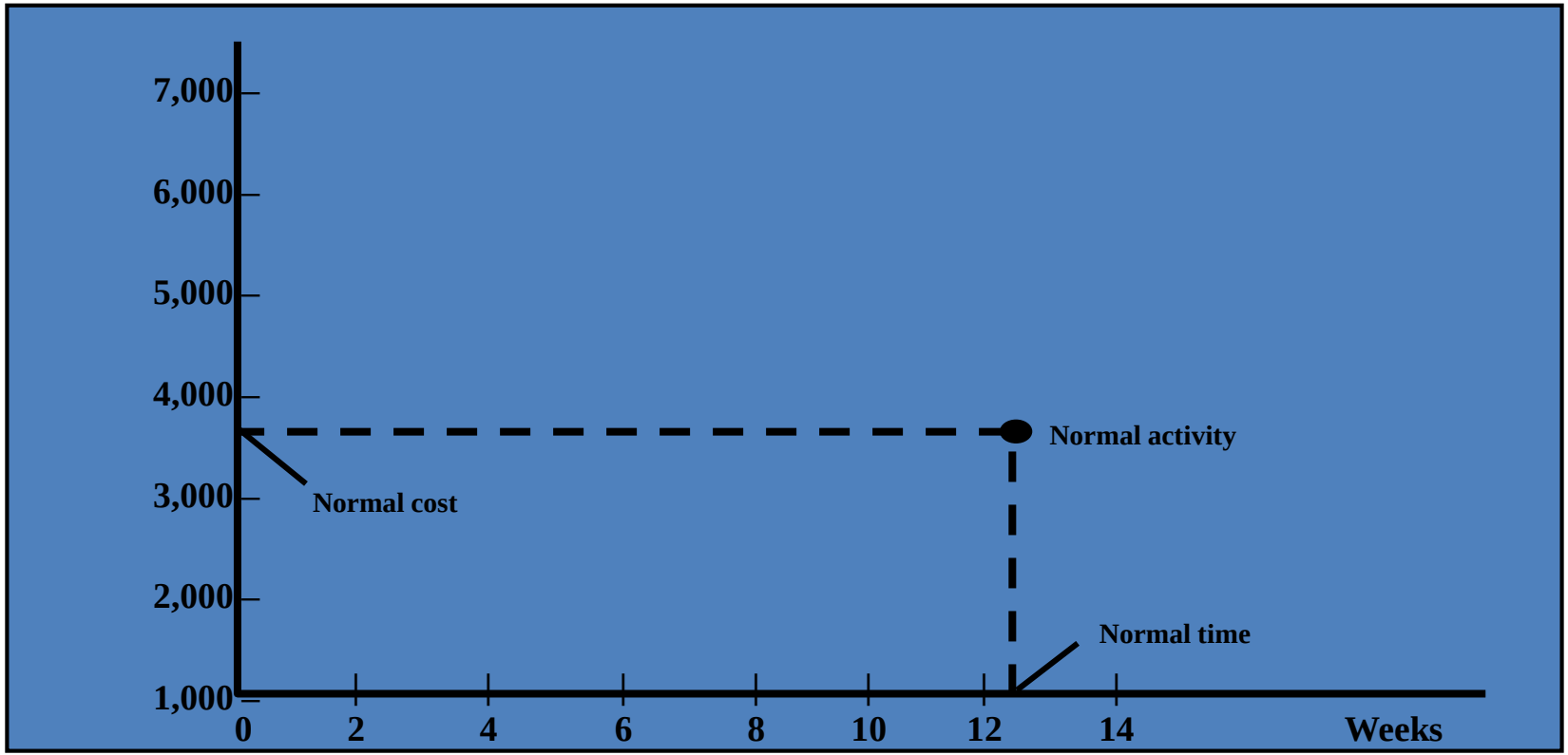
Crashing of a Project

Crashing : Process of reducing time of the project.

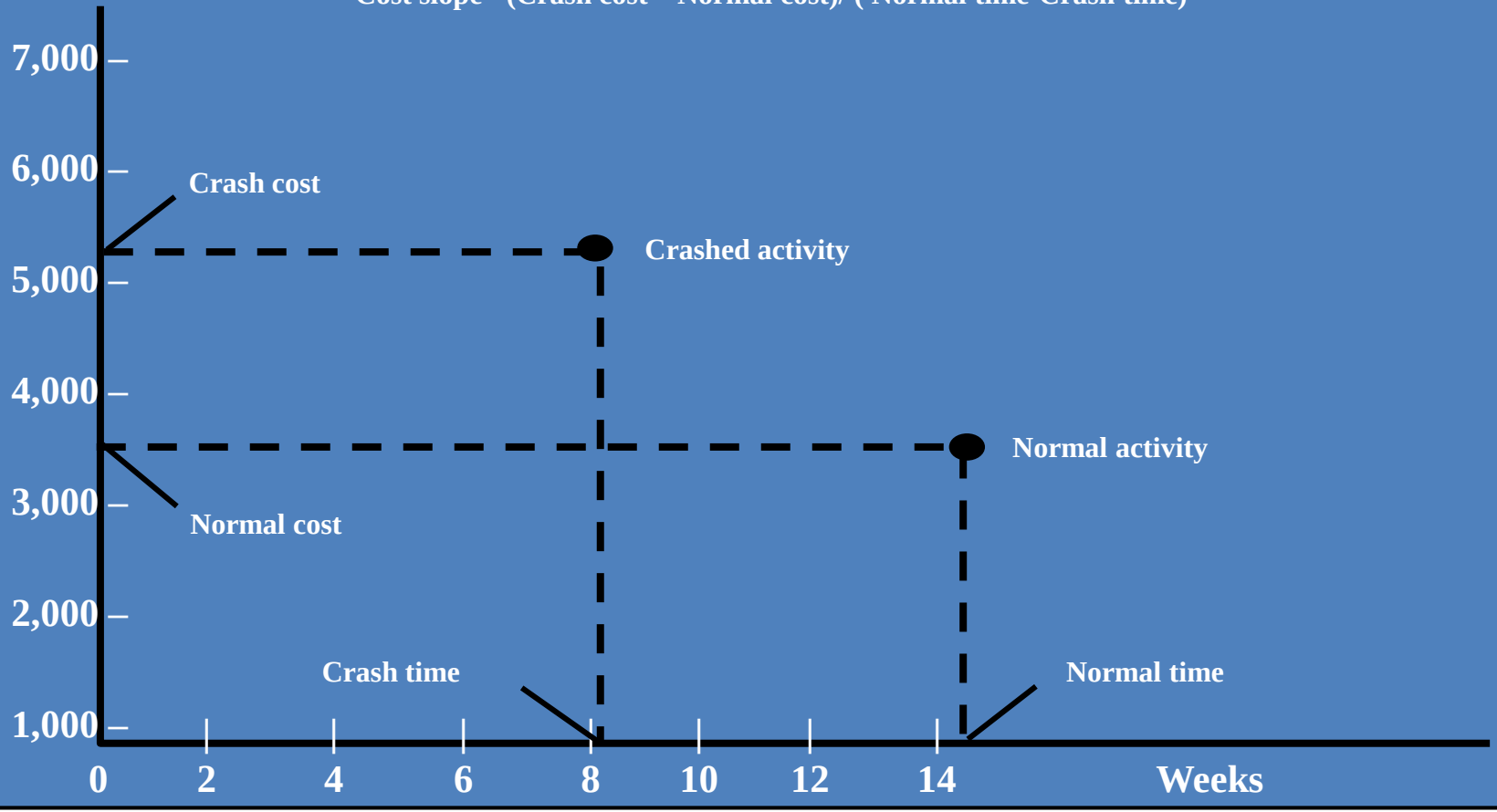
Direct cost: Cost of resources required to for an activity (men, material, etc).

Indirect cost: Indirect costs associated with material , labor and expenses.

Crashing of a Project

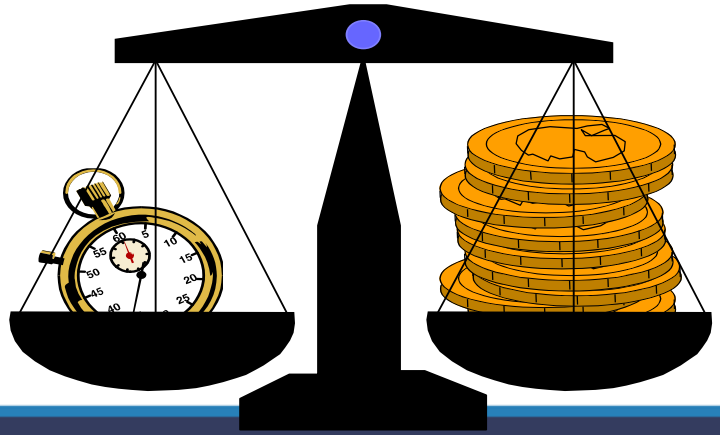


Cost slope= (Crash cost – Normal cost)/ (Normal time-Crash time)

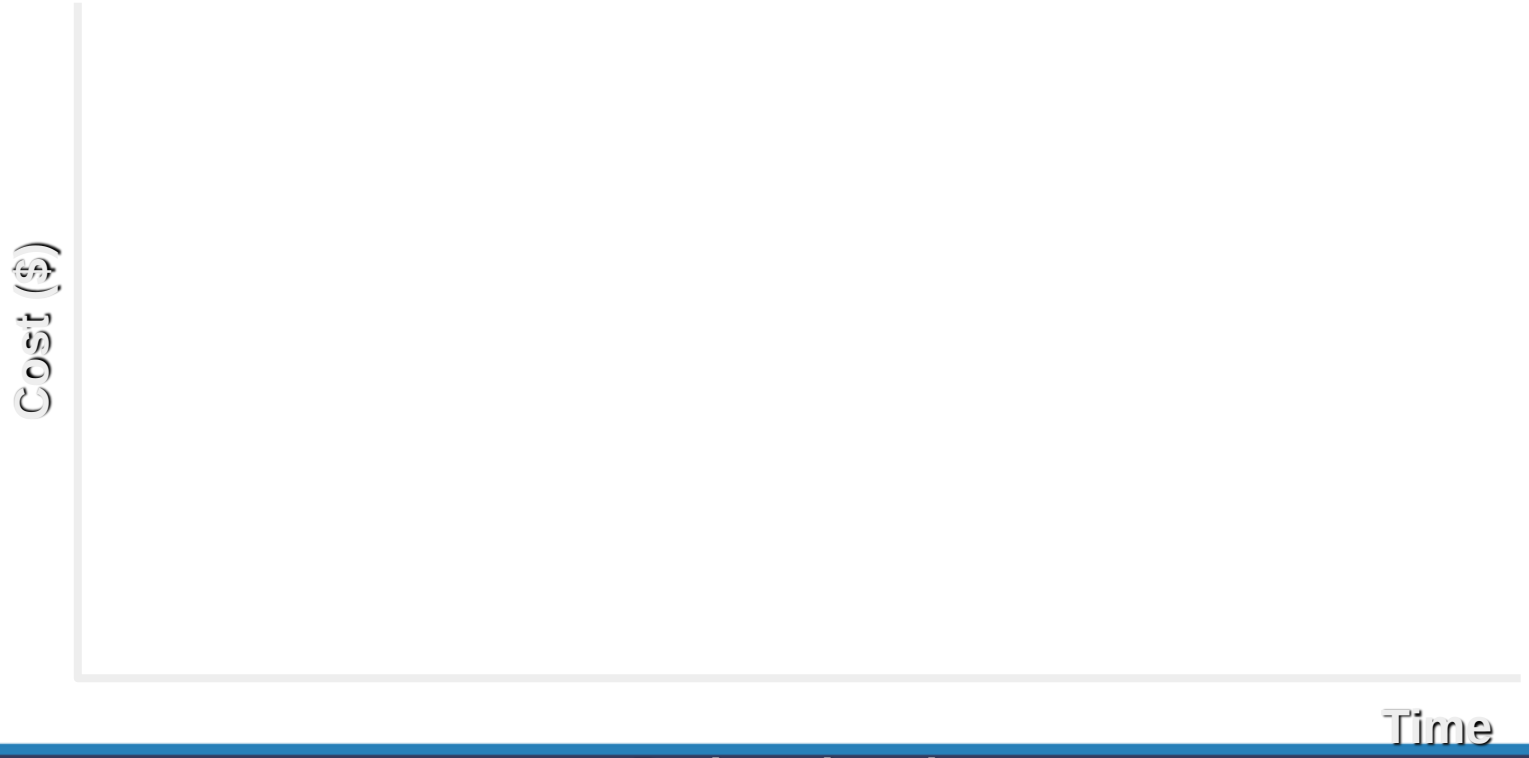


Time-Cost Relationship

- ✓ *Direct costs increase as project duration decreases*
- ✓ *Indirect costs increase as project duration increases and vice versa*
- ✓ *Reduce project length as long as crashing costs are less than indirect costs*

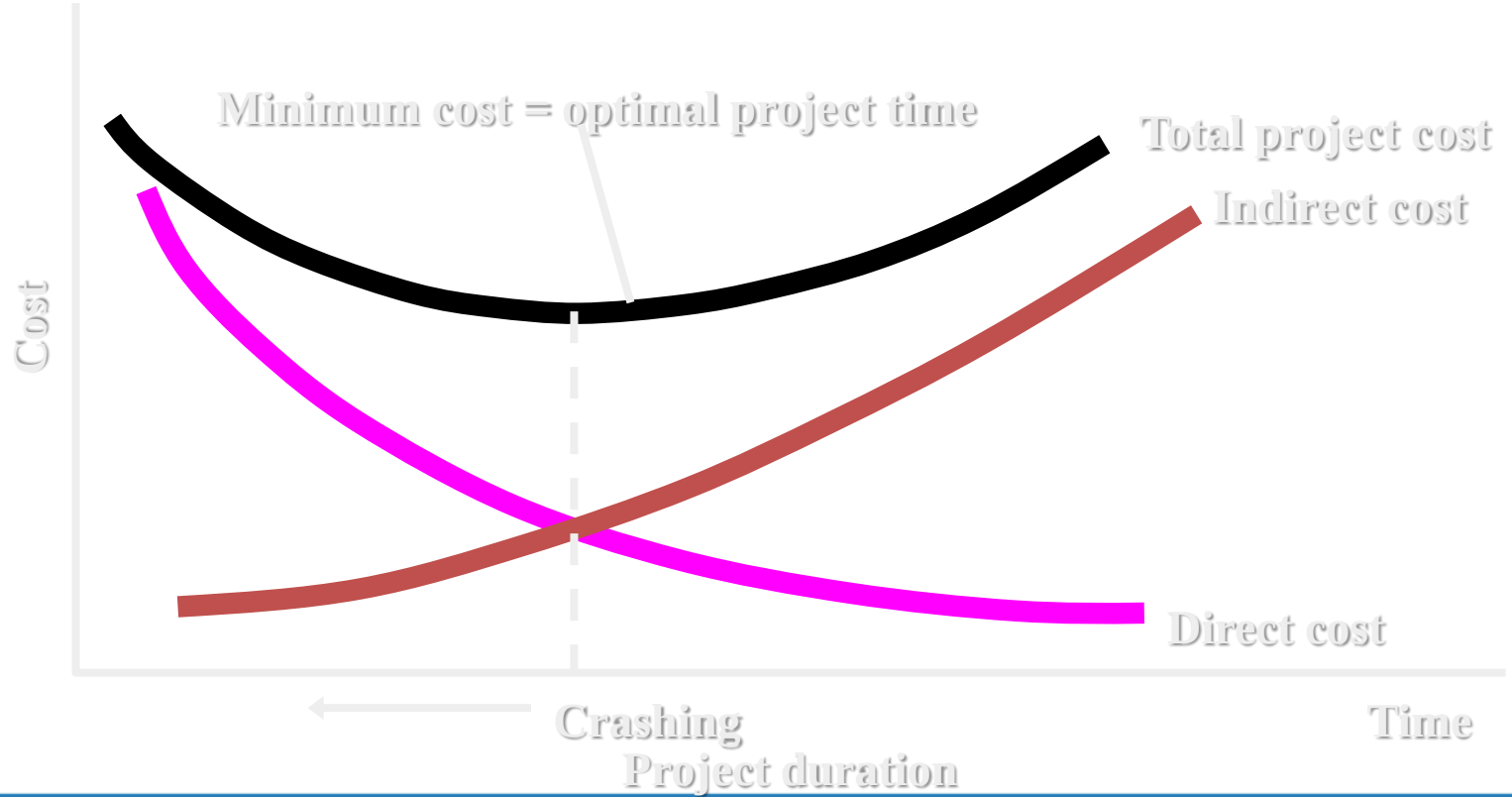


Time-Cost Tradeoff



Project duration

Time-Cost Tradeoff



Rule 1: Crash only those activities whose **slope** (increased direct cost/unit time) is more than **indirect cost per unit time**. Now suppose **painting** is not a critical activity. Then the overall project duration would not decrease by decreasing activity time for painting as project duration is the sum total of duration of critical activities.

So, we reach the second rule for crashing.

Rule 2: Crash only those activities which **are on critical path**. There are many activities which are critical in a project, which qualify the second rule. There may many of them which follow the first rule as well. Now the question arises which activity should be preferred for crashing. This is given by third rule. Rule 3: Preference should be given to the activity with the **least slope**.

There may be situations where two or more critical activities have the **same** slope.

Then we should use a subsidiary rule.

Subsidiary rule 1: Preference should be given to the activity with the **least additional** cost in the situation when there is a tie between slopes of critical activities.

Another situation can be seen when there **is more than one critical path**. Then we can use another subsidiary rule. Subsidiary rule 2: Preference should be given to **common activity** on the critical path if there is more than one critical path.

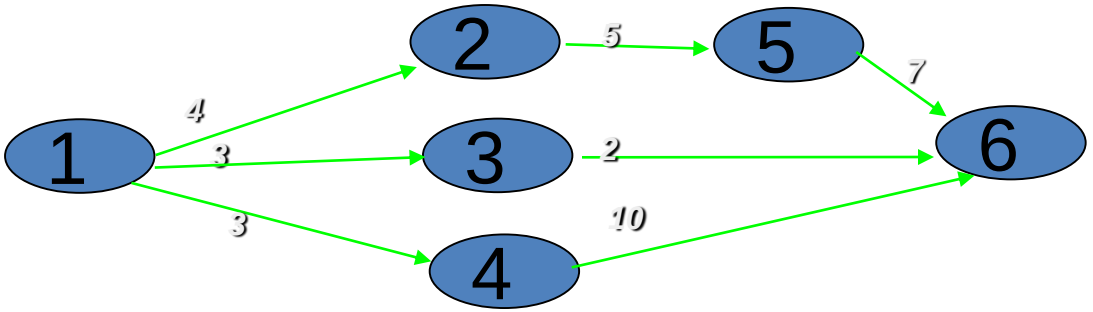
In the absence of any qualifying activity, which is common to all the critical paths, we should stick to the rule **of lowest slope** amongst all critical activities

Example: Find optimum schedule.

Activity	Normal		Crash	
	Time	Cost	Time	Cost
1-2	4	100	1 (up to 1 day)	130
1-3	3	140	1	160
1-4	3	200	1	240
2-5	5	100	2	200
3-6	2	50	1	80
4-6	10	150	9	180
5-6	7	200	5	250

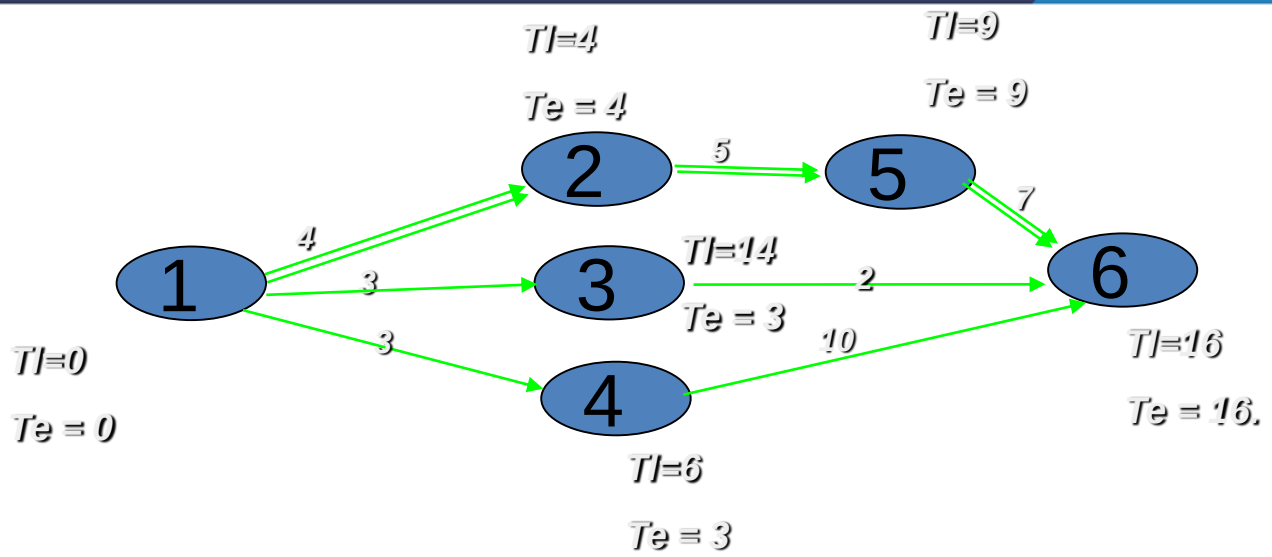
Indirect cost = 50 per day.

Activity	Time
1-2	4
1-3	3
1-4	3
2-5	5
3-6	2
4-6	10
5-6	7



Activity	Normal		Crash		Slope = (Crash cost – Normal cost) / (Normal time-Crash time)		
	Time	Cost	Time	Cost	Δt	Δc	Δc/Δt
1-2	4	100	1	130	3	30	10
1-3	3	140	1	160	2	20	10
1-4	3	200	1	240	2	40	20
2-5	5	100	2	200	3	100	34
3-6	2	50	1	80	1	30	30
4-6	10	150	9	180	1	30	30
5-6	7	200	5	250	2	50	25
		940					

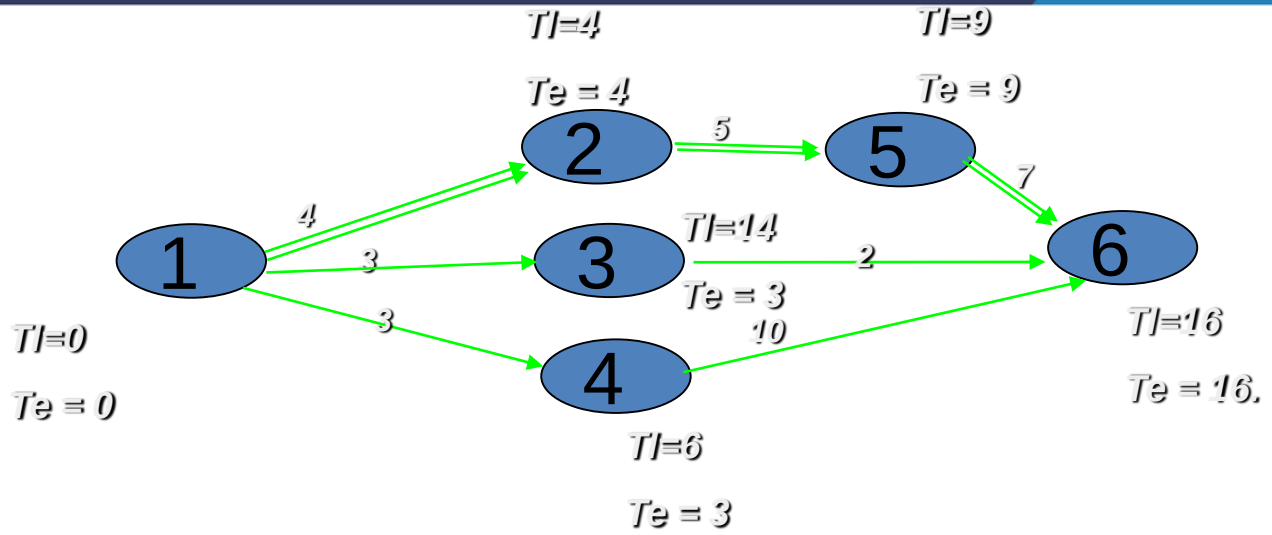
Indirect cost = 50 per day.



Critical path: 1-2-5-6

Direct Cost = ???, Indirect cost =????

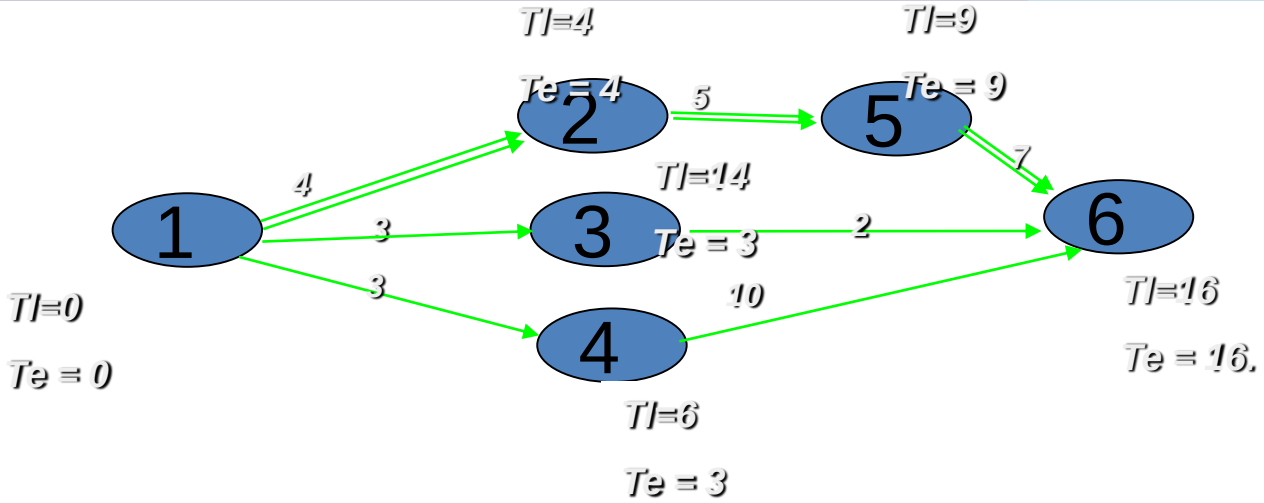
Total time = 16



Critical path: 1-2-5-6

Direct Cost = 940, Indirect cost = 50*16 =800

Total time = 16

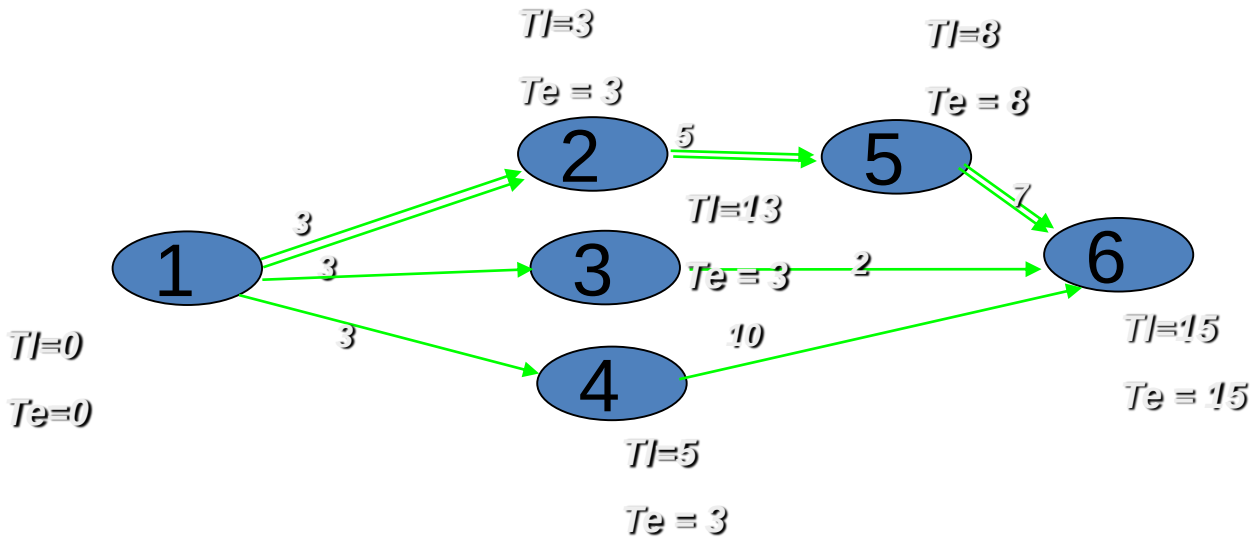


To reduce the duration of the project, reduce critical activities by one time unit. Select that critical activity which has the <u>least</u> slope.

Critical path : 1 2 5 6

Cost slope : <u>10</u> 34 25

Crash Limit : 3 3 2



Critical path: 1-2-5-6

Direct Cost : 940+10=950

Total time = 15

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

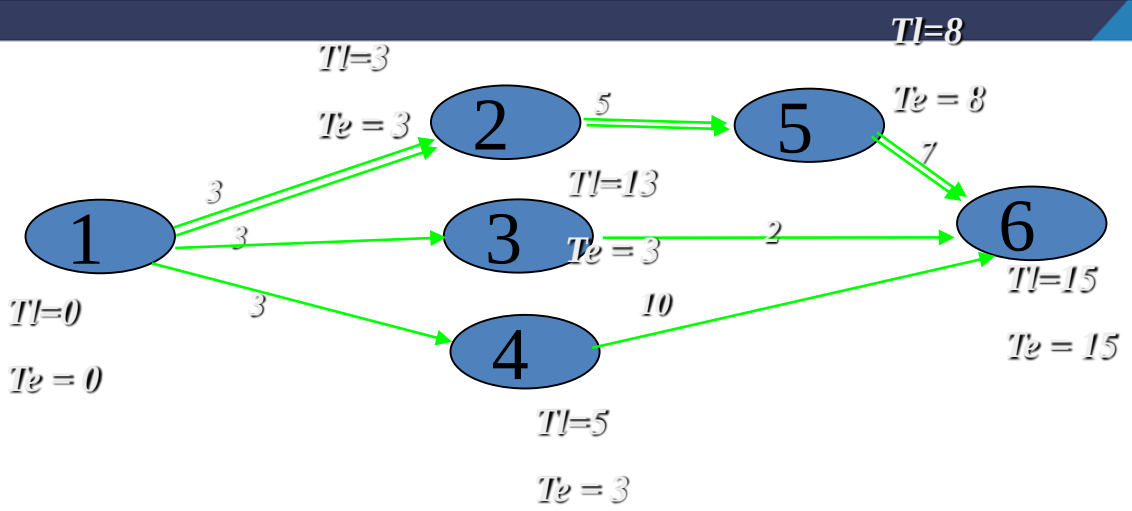
Lec – 48

Crashing of Networks- I

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

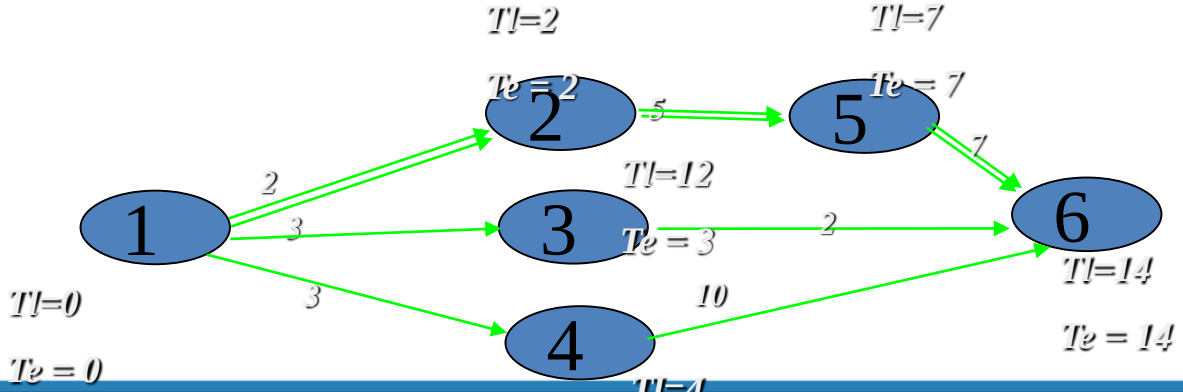


Critical path: 1-2-5-6

Direct Cost : 950

Total time = 15

Again reduce activity 1-2 by one unit.

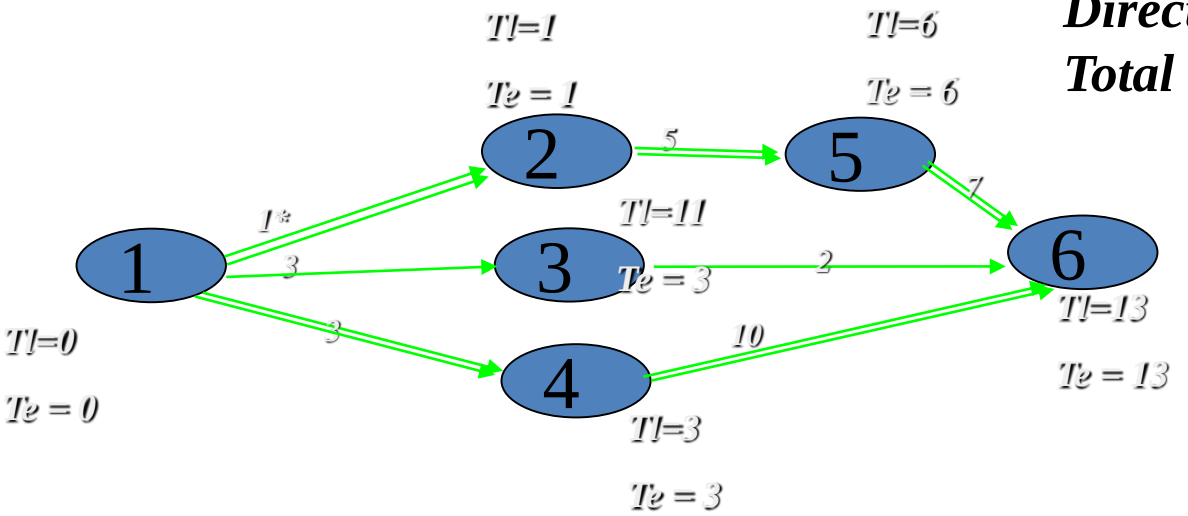


Critical path: 1-2-5-6

Direct Cost : 960

Total time = 14

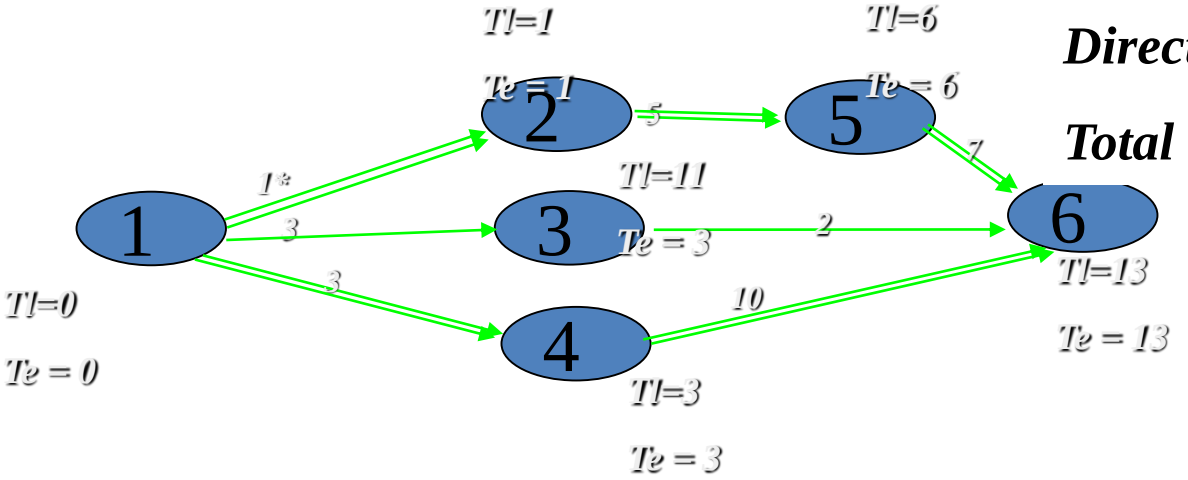
Again reduce activity 1-2 by one unit.



Critical path: 1-2-5-6&1-4-6
Direct Cost : 970
Total time = 13

Two critical paths ??????????,

Again reduce activity 1-2 by one unit.



Critical path: 1-2-5-6 &1-4-6

Direct Cost : 970

Total time = 13

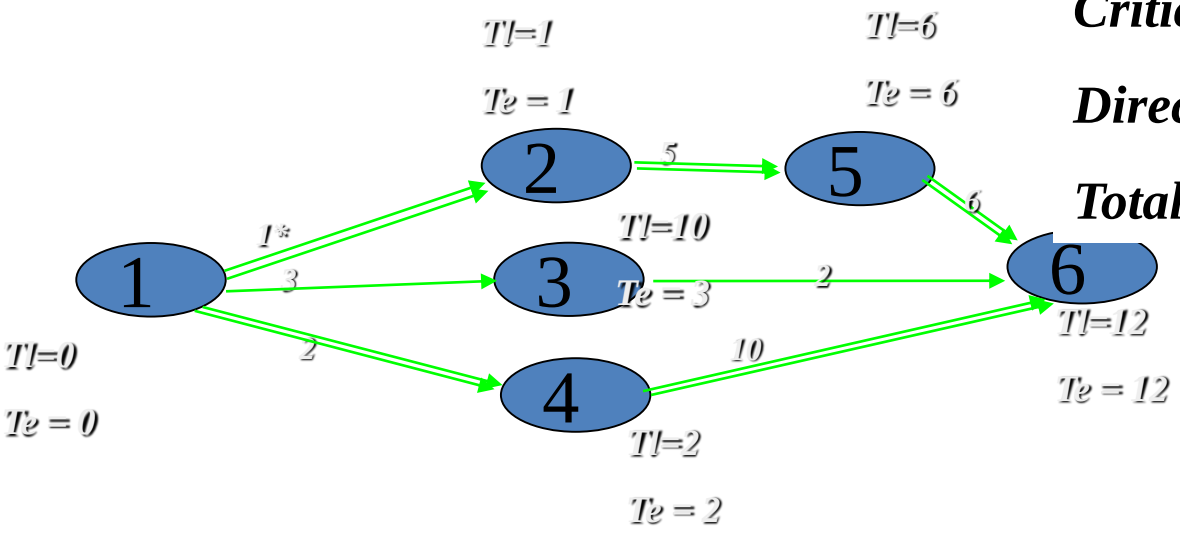
Two critical paths, reduce them simultaneously,

Critical paths : 1 2 5 6 and 1 4 6

Cost slope : 10 34 25 20 30

Crash Limit : 0 3 2 2 1

Reduce activities 5-6 and 1-4 by 1 day.



Critical path: 1-2-5-6 &1-4-6

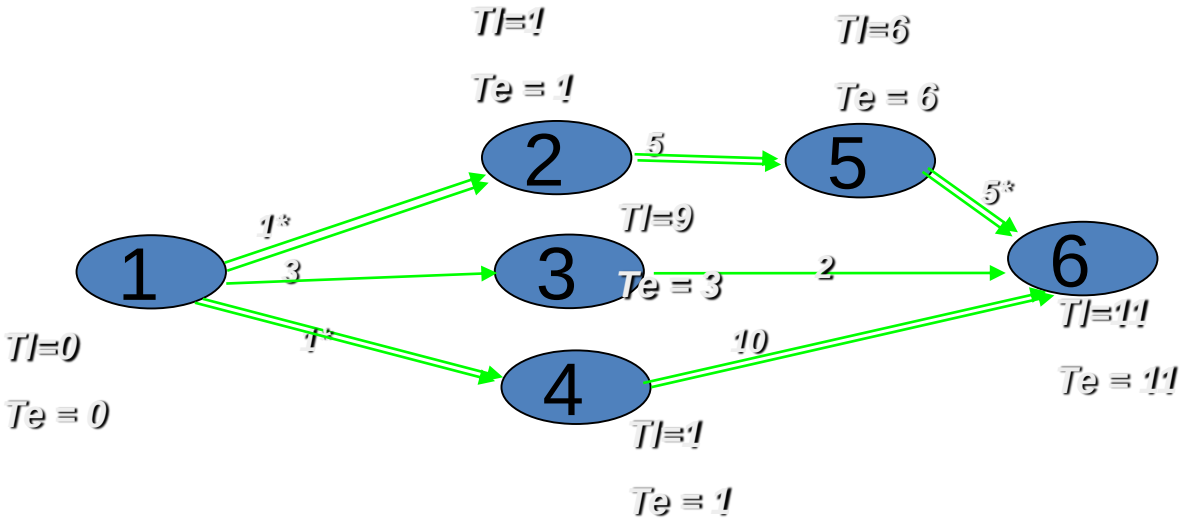
Direct Cost : 970 +45=1015

Total time = 12

Two critical paths, reduce them simultaneously,

Critical path :	***1***		***2***		***5***		***6***	***and***	***1***	***4***	***6***
Cost slope :		***10***		***34***		***25***			***20***		***30***
Crash Limit :		***0***		***3***		***1***			***1***		***1***

Reduce activities 5-6 and 1-4 by 1 day again.



Critical path: 1-2-5-6&1-4-6

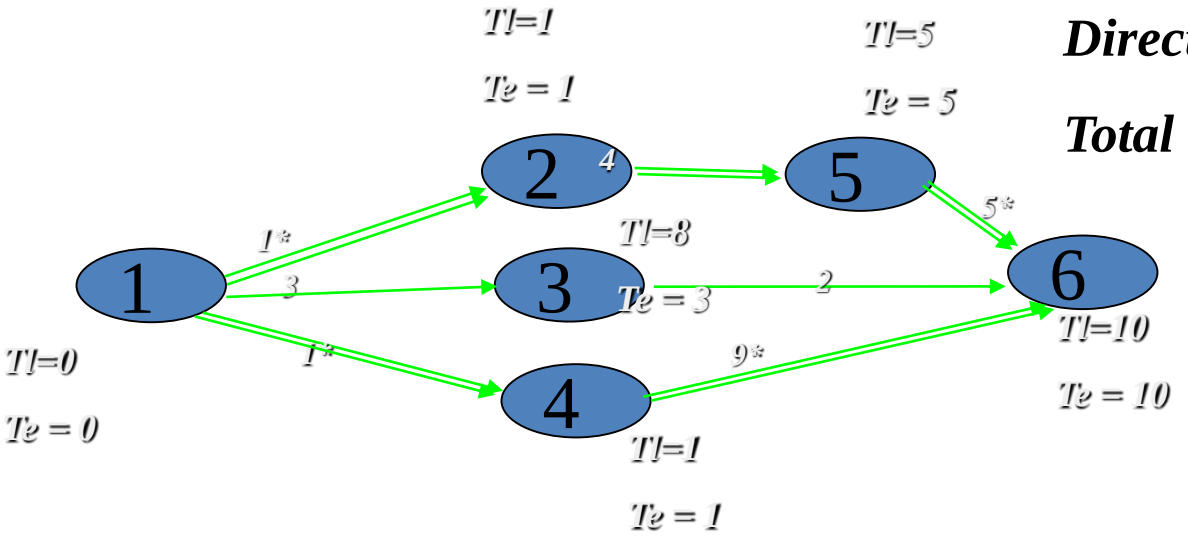
Direct Cost : 1015+45=1060

Total time = 11

Two critical paths, reduce them simultaneously,

Critical path :	***1***		***2***		***5***		***6***	***and***	***1***	***4***	***6***
Cost slope :		***10***		***34***		***25***			***20***		***30***
Crash Limit :		***0***		***3***		***0***			***0***		***1***

Reduce activities 2-5 and 4-6 by 1 day.



Critical path: 1-2-5-6&1-4-6

Direct Cost : 1060+64=1124

Total time = 10

Critical paths can not be reduced further.

Optimum schedule:

Days	*DC*	*IDC*	*TC*
16	*940*	*800*	*1740*
15	*950*	*750*	*1700*
14	*960*	*700*	*1660*
13	*970*	*650*	*1620*
12	*1015*	*600*	*1615*
11	**1060**	**550**	**1610**
10	1124	500	1624

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 49

Crashing of Networks- II

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee

Example 1: Find optimum schedule by FF method?

Activity	Normal		Crash		Slope = (Crash cost – Normal cost) / (Normal time-Crash time)		
	Time	Cost	Time	Cost	Δt	Δc	Δc/Δt
1-2	5	200	2	260	3	60	20
1-3	6	220	3	310	3	90	30
2-4	4	310	2	390	2	80	40
2-6	7	250	4	400	3	150	50
3-5	5	350	3	390	2	40	20
4-5	4	150	2	230	2	80	40
4-6	6	300	3	420	3	120	40
5-6	7	200	4	290	3	90	30
		1980					

Float: We can define following for a given activity i-j.

Earliest start time (Tei): This is the earliest occurrence time for the event from which the activity arrow originates.

Earliest finish time : Te i + t i-j

Latest finish time: The latest occurrence time for the node at which the activity arrow terminates, Tl j

Latest start time : Tl j - t I j

Maximum time available = Tlj – Tei

Total float: Total float for job i-j is the difference between maximum time available and the actual time it takes.

TF =Tlj – Tei – tij

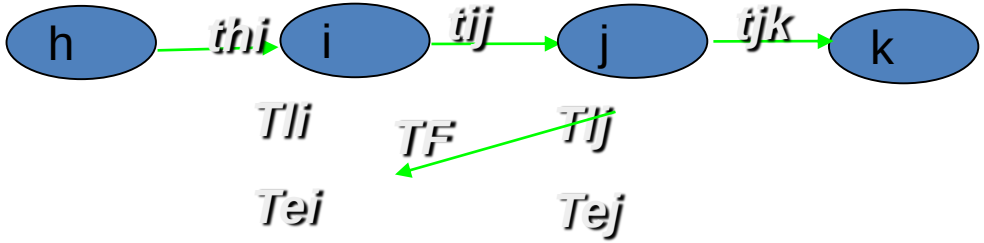
Free float: This is based on the possibility that all events occur at their earliest times, i.e. all activities start as early as possible. It is the difference between earliest finish time and earliest start time.

FF= Tej-Tei – tij

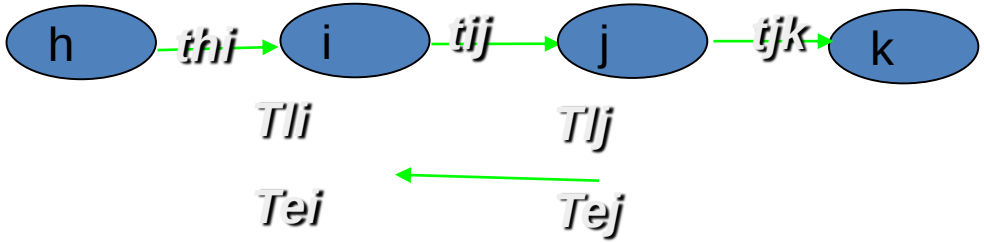
Independent float: Let the preceding job h-i finish at its latest possible time Tli and the succeeding job j-k start at its earliest possible time , which is Tej.

IF= Tej-Tli-tij.

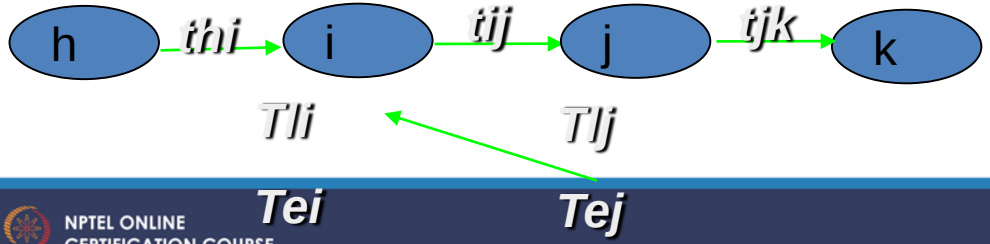
Total float



Free float

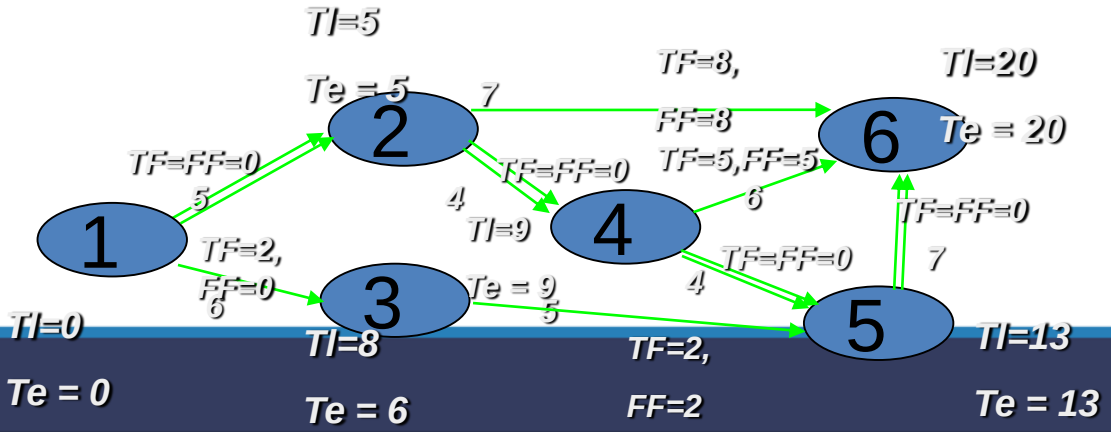


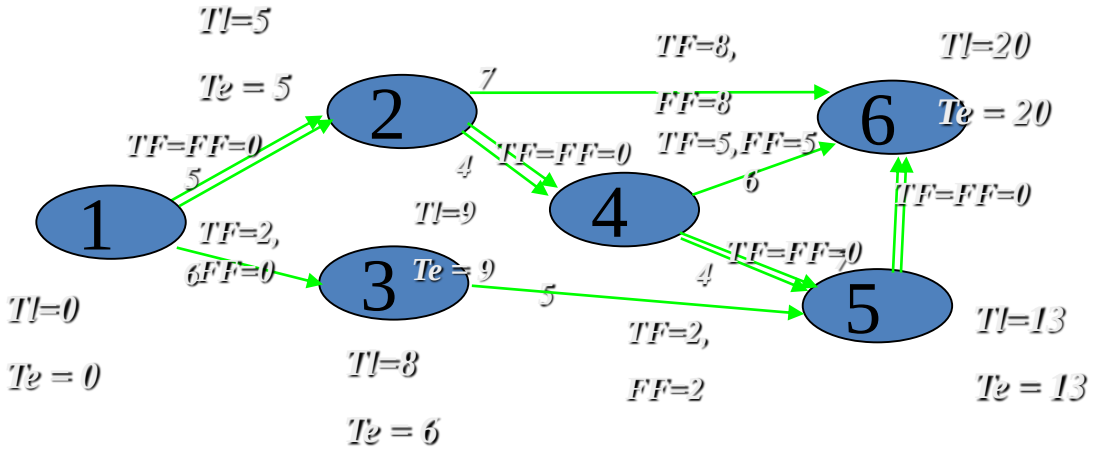
Independent float



Example 1: Find optimum schedule by FF method? If indirect cost is 40 per day

Activity	Normal		Crash		Slope = (Crash cost – Normal cost) / (Normal time-Crash time)		
	Time	Cost	Time	Cost	Δt	Δc	Δc/Δt
1-2	5	200	2	260	3	60	20
1-3	6	220	3	310	3	90	30
2-4	4	310	2	390	2	80	40
2-6	7	250	4	400	3	150	50
3-5	5	350	3	390	2	40	20
4-5	4	150	2	230	2	80	40
4-6	6	300	3	420	3	120	40
5-6	7	200	4	290	3	90	30
		1980					

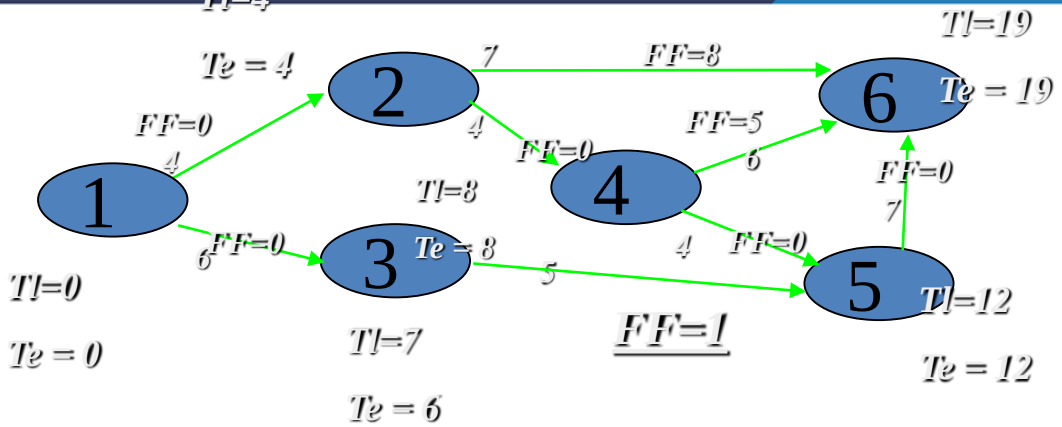




Critical path is a path having TF=0. Find FF for all the activities.

Critical path : 1 2 4 5 6
Slope : 20 40 40 30
Crash limit : 3 2 2 3
The decision is to compress 1-2. Initially by one day and see the change in values of FF of non critical activities.

Test step : **Which non critical activities are associated with activity 1-2.**



*When we reduced activity 1-2 by one unit , **FF of non critical activity 3-5 reduced from 2 to 1**, if we reduce activity 1-2 by 2 units then **FF of 3-5 will become zero** and a new critical path may develop.*

*FF guards against a **non critical activity becoming critical**.*

It is better to find crash limit first .

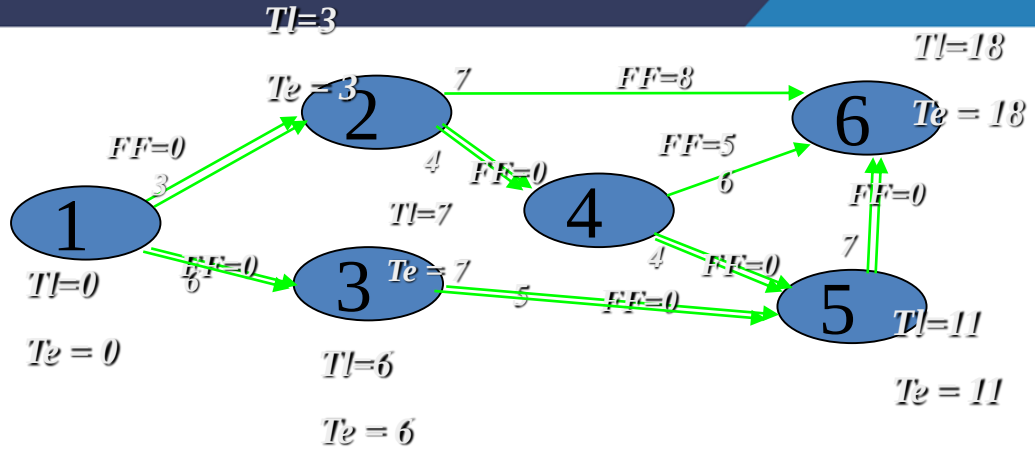
***FF limit** of the activity 1-2 = Min (FF 3-5) = Min (2) = 2*

*and the **crash limit** (CL) is 5 – 2 =3*

***Compression limit** is Min of FF and CL = Min (2,3)= 2.*

Take a decision to compress activity 1-2 by 2 days.

1-2	20
1-3	30
2-4	40
2-6	50
3-5	20
4-5	40
4-6	40
5-6	30



When we have reduced activity 1-2 by 2 days. A new critical path has developed 1-3-5-6.
Now to reduce total project duration reduce both the paths simultaneously.

Critical paths: 1 2 4 5 6 and 1 3 5 6

Slope	:	*20*	*40*	*40*	*30*	*30*	*20*	*30*
Crash limit		*1*	*2*	*2*	*3*	*3*	*2*	*3*

Either crash activities 1-2 and 3-5 simultaneously (Rs 40) or common activity 5-6 (Rs.30). Take 5-6 common activity for compression, its crash limit is 3 , we need a test step (reduce it by one day and see the FF of non critical activates).

IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Project Management for Managers

Lec – 50

Crashing of Networks- III (Free Float Method)

Dr. M.K. Barua

Department of Management

Indian Institute of Technology Roorkee