PROJECT EVALUATION

Module 2_01

PROJECT EVALUATION

- Project evaluation is normally carried out in step 0 of stepwise
- Project evaluation is a step by step process of collecting, recording and organizing information about
  - Project results
  - short - term outputs (immediate results of activities or project deliverables)
  - Long – term outputs (changes in behaviour , practice or policy resulting from the result.

Why is project evaluation important:

- project evaluation is important for answering the following questions
  - what progress has been made?
  - were the desired outcomes achieved? Why?
  - whether the project can be refined to achieve better outcomes?
  - do the project results justify the project inputs?

What are the challenges in monitoring and evaluation?

- getting the commitment to do it.
- establishing base lines at the beginning of the project.
- identifying realistic quantitative and qualitative indicator.
- finding the time to do it and stricking to it.
- getting feedback from your stakeholders.
- reporting back to your stakeholders.

STRATEGIC ASSESSMENT

- WHAT IS STRATEGIC PLANNING?
  - Strategic planning is defined as an organization's process of defining its strategy , or direction and making decisions on allocating its resources to pursue this strategy, including its capital and people.
  - Strategic planning focuses on a business's future by understanding operational priorities and resource availability, setting out clear objectives for desired business results, and developing an action plan on how to achieve them.
    - it deals with:
      - what do we do?
      - for whom do we do it?
      - how do we excel?

STRATEGIC ASSESSMENT

- STRATEGIC ASSESSMENT is the first criteria for project evaluation
  – For evaluating and managing the projects, the individual projects should be seen as components of a programme. Hence need to do **programme management**.
- A program is a group of related projects managed in a coordinated manner to obtain benefits not available from managing them individually.
- Program management is the application of knowledge, skills, tools and techniques to meet program requirements.
- Organizations with mature program management are far more successful than those without it, according to our research.

Programme management:

- D.C. Ferns defined "a programme as a group of projects that are managed in a co-ordinated way to gain benefits that would not be possible were the projects to be managed independently".
- A programme in this context is a "collection of projects that all contribute to the same overall organization goals".
- Effective programme management requires that there is a "well defined programme goal and that all the organization's projects are selected and tuned to contribure to this goal"

Evaluating of project is depends on:

– How it contributes to programme goal.
– It is viability [capability of developing or useful].
– Timing.
– Resourcing.

STRATEGIC ASSESSMENT

- For successful strategic assessment, there should be a strategic plan which defines:
  - Organization's objectives.
  - Provides context for defining programme
  - Provides context for defining programme goals.
  - Provide context for accessing individual project.

STRATEGIC ASSESSMENT

- In large organization, programme management is taken care by programme director and programme executive , rather than, project manager, who will be responsible for the strategic assessment of project.
- Any potential software system will form part of the user organization's overall information system and must be evaluated within the context of existing information system and the organization's information strategy.
- If a well – defined information system does not exist then the system development and the assessment of project proposals will be based on a more "piece meal approach".
- Piece meal approach is one in which each project being individually early in its life cycle.

Typical issues and questions to be considered during strategic assessment

- Issue – 1: objectives:

  - How will the proposed system contribute to the organization's stated objectives? How, for example, might it contribute to an increase in market share?

- Issue – 2: is plan

  – How does the proposed system fit in to the IS plan? Which existing system (s) will it replace/interface with? How will it interact with systems proposed for the later development?

Typical issues and questions to be considered during strategic assessment

- Issue – 3: organization structure:

– What effect will the new system have on the existing departmental and organization structure?

– For example, a new sales order processing system overlap existing sales and stock control functions?

- Issue – 4: MIS:

– What information will the system provide and at what levels in the organization? In what ways will it complement or enhance existing management information system?

Typical issues and questions to be considered during strategic assessment

• Issue – 5: personnel:

– In what way will the system proposed system affect manning levels and the existing employee skill base? What are the implications for the organization's overall policy on staff development.

• Issue – 6: image:

– What, if any, will be the effect on customer's attitudes towards the organization? Will the adoption of, say, automated system conflict with the objectives of providing a friendly service?

Portfolio management

– Strategic and operational assessment carried by an organization on behalf of customer is called portfolio management [third party developers]

– They make use of assessment of any proposed project themselves.

– They ensure for consistency with the proposed strategic plan.

– They proposed project will form part of a portfolio of ongoing and planned projects

- Selection of projects must take account of possible effects on other projects in the portfolio(example: competition of resource) and the overall portfolio profile(example: specialization versus diversification).

Technical assessment

- It is the second criteria for evaluating the project.
- Technical assessment of a proposed system evaluates **functionality** against available:
  - Hardware
  - Software
- Limitations
  - Nature of solutions produced by strategic information systems plan
  - Cost of solution. Hence undergoes cost-benefit analysis.

Economic Assessment

COST BENEFIT ANALYSIS

- It is one of the important and common way of carrying "economic assessment" of a proposed information system.
- This is done by comparing the expected costs of development and operation of the system with its benefits.
- So it takes an account:
  - Expected cost of development of system
  - Expected cost of operation of system
  - Benefits obtained
- Assessment is based on:
  - Whether the estimated costs are executed by the estimated income.
  - And by other benefits
- For achieving benefit where there is scarce resources, projects will be prioritized and resource are allocated effectively.
- The standard way of evaluating economic benefits of any project is done by "cost benefit analysis"

Cost benefit analysis comprises of two steps:

- Step-1: identifying and estimating all of the costs and benefits of carrying out the project.
- Step-2: expressing these costs and benefits in common units.

Cost benefit analysis

- Step-1:
- It includes
  - Development cost of system.
  - Operating cost of system.
  - Benefits obtained by system.
- When new system is developed by the proposed system, then new system should reflect the above three as same as proposed system.
- Example: sales order processing system which gives benefit due to use of new system.

Cost benefit analysis

- Step-2:
  - Calculates net benefit.
  - Net benefit = total benefit = total cost.
  - (cost should be expressed in monetary terms).

Three types of cost

- **Development costs:** includes salary and other employment cost of staff involved.
- **Setup costs**: includes the cost of implementation of system such as hardware, and also file conversion, recruitment and staff training.
- **Operational cost**: cost require to operate system, after it is installed.

Three categories of benefits:

1) **Direct benefits**: directly obtained benefit by making use of/operating the system.
   - Example: reduction of salary bills, through the introduction of a new , computerized system.

2) **Assessable indirect benefits**: these benefits are obtained due to updation / upgrading the performance of current system. It is also referred as "secondary benefits".
   - Example: "use of user – friendly screen", which promotes reduction in errors, thus increases the benefit.

3) **Intangible benefits:** these benefits are longer term, difficult to quantify. It is also referred as "indirect benefits".
   - Example: enhanced job interest

Cost Benefit Evaluation techniques

Module 2_02

Cost Benefit Evaluation techniques

- It consider
  - the timing of the costs and benefits
  - the benefits relative to the size of the investment
- Common method for comparing projects on the basic of their cash flow forecasting.
  - **1) Net profit**
  - **2) Payback Period**
  - **3) Return on investment**
  - **4) Net present Value**
  - **5) Internal rate of return**

Net profit

- Net profit
  - calculated by subtracting a company's total expenses from total income.
  - showing what the company has earned (or lost) in a given period of time (usually one year).
  - **also called** net income or net earnings.

- **Net profit = total costs - total incomes**

Calculate net profit

Year	Project 1	Project 2	Project 3	Project 4
0	-100000	-1000000	-100000	-120000
1	10000	200000	30000	30000
2	10000	200000	30000	30000
3	10000	200000	30000	30000
4	20000	200000	30000	30000
5	100000	300000	30000	75000
Net Profit	50000	100000	50000	75000

- All the values are end of year totals (Rs)
- Cash flow take place at the end of each year.
- The value of year 0 represents the initial investment made at the start of the project.

Payback Period

- The payback period is the time taken to recover the initial investment.

Or

- is the length of time required for cumulative incoming returns to equal the cumulative costs of an investment
- **Advantages**
  - simple and easy to calculate.
  - It is also a seriously flawed method of evaluating investments
- **Disadvantages**
  - It attaches no value to cashflows after the end of the payback period.
  - It makes no adjustments for risk.
  - It is not directly related to wealth maximisation as NPV is.
  - It ignores the time value of money.
  - The "cut off" period is arbitrary.

Calculate the payback period

Year	Project 1	Project 2	Project 3	Project 4
0	-100000	-1000000	-100000	-120000
1	10000	200000	30000	30000
2	10000	200000	30000	30000
3	10000	200000	30000	30000
4	20000	200000	**30000**	**30000**
5	**100000**	**300000**	30000	75000
Net Profit	50000	100000	50000	75000

- Project1 **=10,000+10,000+10,000+20,000+1,00,000**=1,50,000 (5th year)
- Project 2= **2,00,000+2,00,000+2,00,000+2,00,000+3,00,000=11,000,00 (5th Year)**
- Project 3= **30,000+30,000+30,000+30,000 +** 30,000 =1,95,000 (4th year)
- Project 4 = **30,000+30,000+30,000+30,000 +** 75,000 =1,95,000 (4th year)
- It ignores any benefits that occur after the payback period and, therefore, does not measure profitability.
- It ignores the time value of money.

RETURN ON INVESTMENT or ACCOUNTING RATE OF RETURN

- It provides a way of comparing the net profitability to the investment required.

Or

- A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments
- **Disadvantages**
  - It takes no account of the timing of the cash flows.
  - Rate of returns bears no relationship to the interest rates offered or changed by bank.

RETURN ON INVESTMENT

- $ROI = \frac{\textbf{average annual profit}}{\textbf{total investment}} * 100$
- $\textbf{average annual profit} = \frac{\textbf{net profit}}{\textbf{total no. of years}}$

RoI Calculations

- Calculate ROI for project 1.

  Ans: Total investment =1,00,000

  Net profit = 50,000

  Total no. of year = 5

Average annual profit=50,000/5=10,000rs

ROI= (10,000/1,00,000) *100 = **10%**

Net present value (NPV)

- **Discounted Cash Flow (DCF)** is a cash flow summary adjusted to reflect the time value of money. DCF can be an important factor when evaluating or comparing investments, proposed actions, or purchases. Other things being equal, the action or investment with the larger DCF is the better decision. When discounted cash flow events in a cash flow stream are added together, the result is called the **Net Present Value (NPV).**
- When the analysis concerns a series of cash inflows or outflows coming at different future times, the series is called a **cash flow stream**. Each future cash flow has its own value today (its own present value). The sum of these present values is the **Net Present Value** for the cash flow stream.
- The size of the discounting effect depends on two things: the amount of time between now and each future payment (the number of discounting periods) and an interest rate called the **Discount Rate.**

Calculation

- Formula to calculate the present value of any future cash flow
- $Present\ Value\ or\ DCF = \frac{Value\ in\ year\ t}{(1+r\%)^t}$
- $Discount\ Factor = \frac{1}{(1+r\%)^t}$
- r – discount rate expressed as decimal value & t – number of year into the future that the cash flow occurs.
- The NPV for a project is obtained by discounting each cash flow (both +ve and –ve) and summing the discount value.
- NPV > 0 -> accept; NPV < 0 -> Reject; NPV = 0 -> indifferent

Problem

Year	Project 1
0	-100000
1	10000
2	10000
3	10000
4	20000
5	**100000**

Assume a 10% discount rate, Calculate the NPV for the project 1.

Year	Project 1	Discount cash flow or Present Value	Discount factor @ 10%
0	-100000	-100000	1
1	10000	9090.90909	0.909091
2	10000	8264.46281	0.826446
3	10000	7513.14801	0.751315
4	20000	13660.2691	0.683013
5	100000	62092.1323	0.620921
SUM	50000	620.921323	
Net Profit	50000		
NPV	620.92		

Year 1 (t) , 10% discount rate (r), inflow cash 10000

Discount cash flow or Present Value=

$$\frac{10000}{(1+{}^{10}/_{100})^{1}} = \frac{10000}{(1+0.1)^{1}} = \frac{10000}{1.1} = 9090.90909$$

Discount factor @10%=

$$\frac{1}{(1+{}^{10}/_{100})^{1}} = \frac{1}{(1+0.1)^{1}} = \frac{1}{1.1} = .90901$$

Year 2 (t) , 10% discount rate (r), inflow cash 10000

Discount cash flow or Present Value=

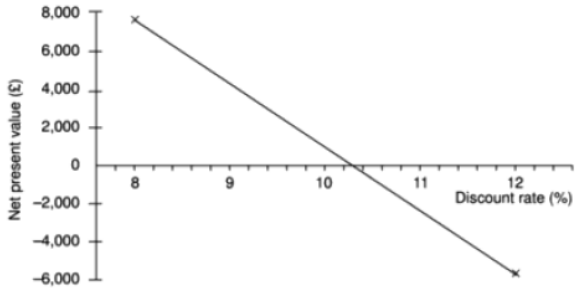
$$\frac{10000}{(1+{}^{10}/_{100})^{2}} = \frac{10000}{(1+0.1)^{2}} = \frac{10000}{1.21} = 8264.46281$$

Discount factor @10%=

$$\frac{1}{(1+{}^{10}/_{100})^{2}} = \frac{1}{(1+0.1)^{2}} = \frac{1}{1.21} = .826446$$

IRR (Internal Rate Return)

- The IRR compares returns to costs by asking: **"What is the discount rate that would give the cash flow stream a net present value of 0?"**
- The IRR may be estimated by plotting a series of guesses



Cont..

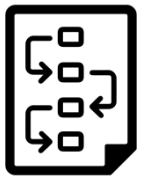
- For a particular project, a discount rate of 8% gives a positive NPV of 7,896.
- a discount rate of 12% gives a negative NPV of -5,829.
- The IRR is therefore somewhere between these two values.
- Plotting the two values on a chart and joining the points with a straight line suggests that the IRR is about 10.25%.
- The true IRR is 10.167%
- IRR as the decision criterion, the one with the **higher IRR is the better choice.**

Activity planning

Module:3

6.1 Introduction
An Schedule in a Project Plan [1/2]

- Ensure that the appropriate resources will be available precisely when required
- Avoid different activities competing for the same resources at the same time
- Produce a detailed schedule showing which staff carry out each activity



Objectives of Activity planning

- Produce an activity plan for a project
- Estimate the overall duration of a project
- Create a critical path and a precedence network for a project

6.2 The Objectives of Activity Planning

- Providing project and resource schedules
- *Feasibility assessment*: is a project possible within required timescales?
- *Resource allocation*: what are the most effective way of allocating resources?
- *Detailed costing*: How much will the project cost and when is that expenditure to take place?
- *Motivation*: Providing targets is an effective way of motivating staff
- *Coordination*: when do other staff (in other departments) need to be available?

6.3 When to Plan

- Planning is an ongoing process of refinement
  - Each iteration becoming more detailed and more accurate than the last
  - Over successive iterations, the emphasis and purpose of planning will shift
    - Timescales, risks, resource availability, cash flow control …

6.4 Project Schedules

- A project schedule is a detailed project plan showing dates when each activity should start and finish and when and how much of each resource will be required
- Creating a project schedule comprises four main stages

6.4 Project Schedule

Four Main Stages

1. Constructing an ideal activity plan
   - What activities need to be carried out and in what order
2. Risk analysis
   - Identifying potential problems
3. Resource allocation
   - The expected availability of resources might place constraints on when certain activities can be carried out
4. Schedule production

— publish a project schedule, which includes planned start and completion dates and a resource requirements statement for each activity.

6.5 Projects And Activities

Defining Project and Activities [1/2]

- A project is composed of a number of interrelated activities
- A project may start when at least one of its activities is ready to start
- A project will be completed when all of the activities it encompasses have been completed

6.5 Projects And Activities
Defining Project and Activities [2/2]

- An activity must have a clearly defined start and a clearly defined end-point
- If an activity requires a resource then that resource requirement must be forecastable
- The duration of an activity must be forecastable
- Some activities might require that others are completed before they can begin

6.5 Projects And Activities
Identifying Activities

Three approaches to identifying the activities or tasks that make up a project.

1. Activity-based approach
2. The product-based approach
3. Hybrid approach

6.5 Projects And Activities
The Activity-Based Approach

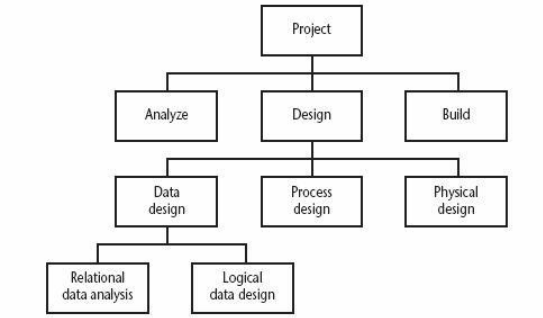
- Consists of creating a list of all the activities
  - A brainstorming session involving the whole project team
  - An analysis of past projects
- When listing activities, it might be helpful to sub-divide the project into the main life-style stages and consider each of these separately

6.5 Projects And Activities
Work Breakdown Structure (WBS) [1/3]

- Creating a WBS is a much favored way of generating a task list
- Involves identifying the main (or high level) tasks required to complete a project and then breaking each of these down into a set of lower-level tasks

6.5 Projects And Activities
Work Breakdown Structure (WBS) [2/3]

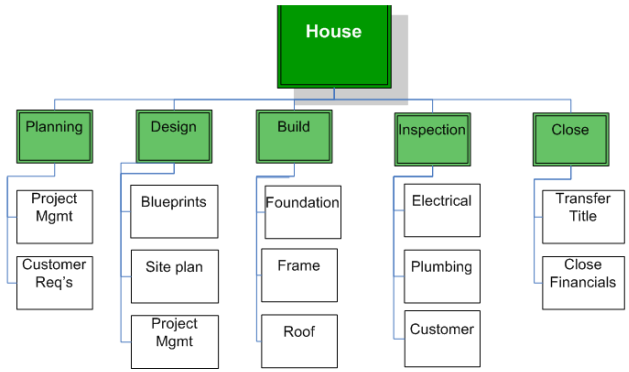
- A fragment of an activity-based Work Breakdown Structure



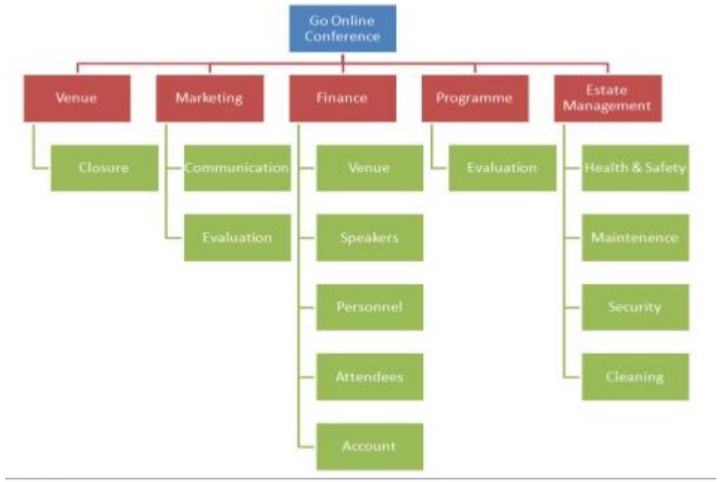
6.5 Projects And Activities
Work Breakdown Structure (WBS) [3/3]

- Need to consider the final level of detail or depth of the structure
  - Too great of depth will result in a large number of small tasks
  - Too shallow structure will provide insufficient detail for project control
- Each branch should be broken down at least to a leaf where each leaf may be assigned to an individual or responsible team

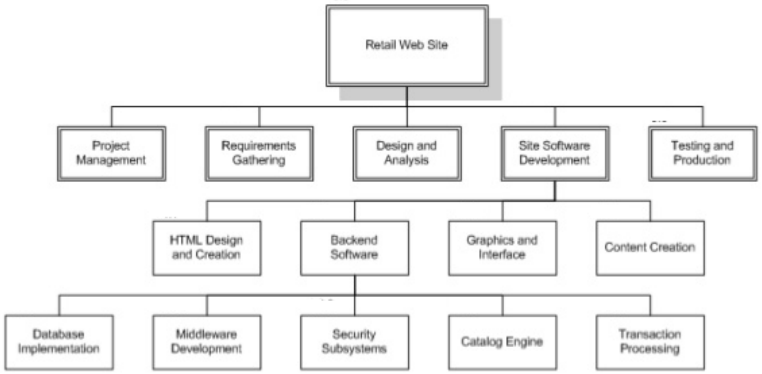
WBS - Examples



WBS - Examples



WBS - Examples



6.5 Projects And Activities

Advantages of WBS

- Much more likely to result in a task catalog that is complete and is composed of non-overlapping activities
- Represents a structure that may be refined as the project proceeds

6.5 Projects And Activities

2. The Product-Based Approach [1/3]

- Consists of producing a Product Breakdown Structure (PBS) and a Product Flow Diagram (PFD)
- The PFD indicates, for each product, which other products are required as inputs
  - Easily transformed into an ordered list of activities

6.5 Projects And Activities

The Product-Based Approach [2/3]

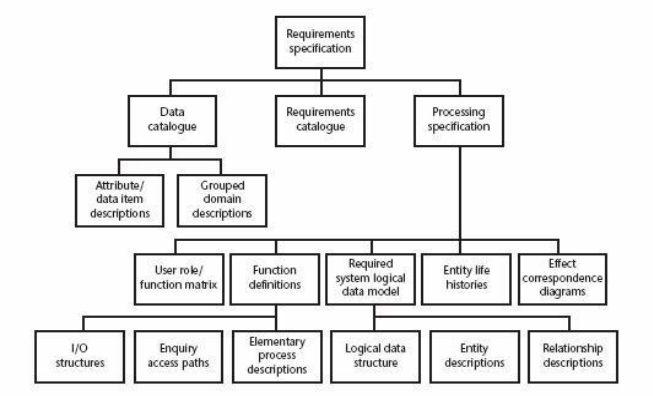
- Proponents claim that it is less likely that a product will be left out of a PBS than that an activity might be omitted from an unstructured activity list
- Particularly appropriate if using a life cycle methodology such as waterfall
  - Clearly specifies, for each step or task, each of the products required and the activities required to produce it

6.5 Projects And Activities

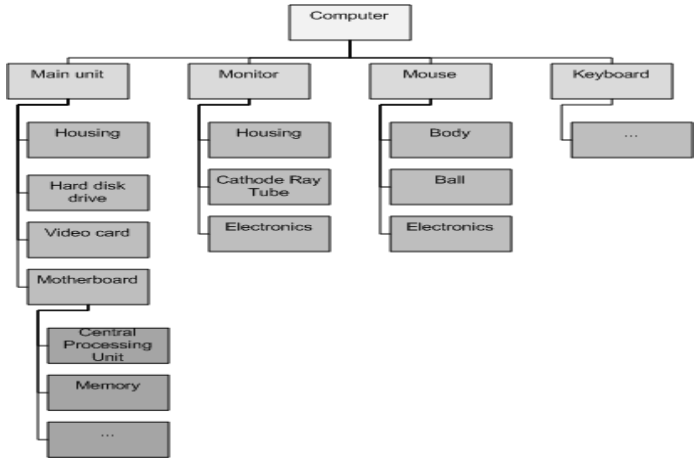
The Product-Based Approach [3/3]

- A set of generic PBS for each stage in SSDAM

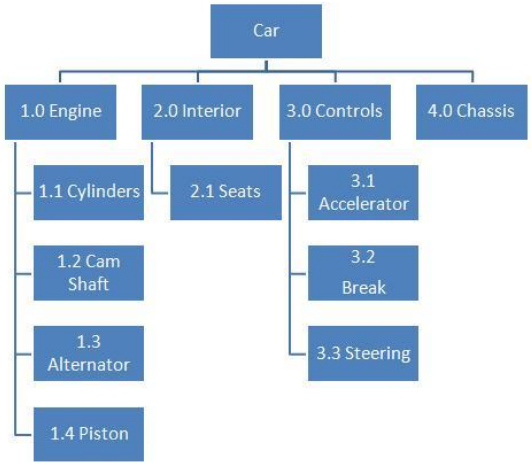
(Structured Systems Analysis and Design Method)



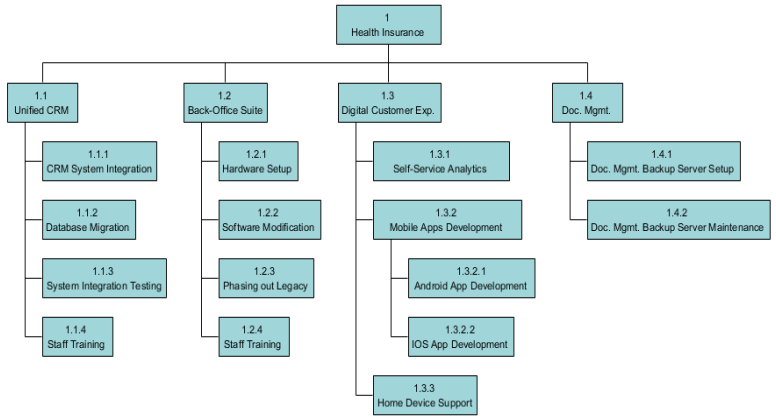
PBS Examples



PBS Examples



More Examples

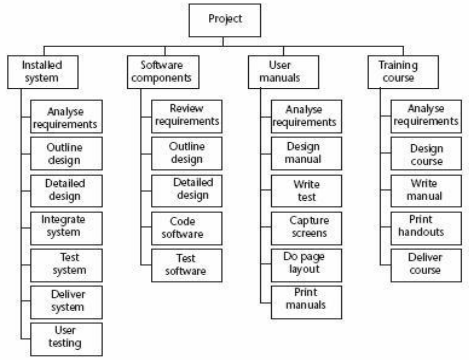


6.5 Projects And Activities
3. The Hybrid Approach [1/3]

- An alternative WBS based on
  - A simple list of final deliverables
  - For each deliverable, a set of activities required to produce that product
- As with a purely activity-based WBS, having identified the activities, we are then left with the task of sequencing them

6.5 Projects And Activities
The Hybrid Approach [2/3]

- A WBS based on deliverables



6.5 Projects And Activities
The Hybrid Approach [3/3]

- IBM recommended the following five levels for WBS
  - *Level 1: Project*
  - *Level 2: Deliverables – such as software, manuals and training courses*
  - *Level 3: Components - modules and tests required to produce the system software*
  - *Level 4: Work-packages - major work items or collections of related tasks, required to produce a component*
  - *Level 5: Tasks - responsibility of a single person*

6.7 Network Planning Models

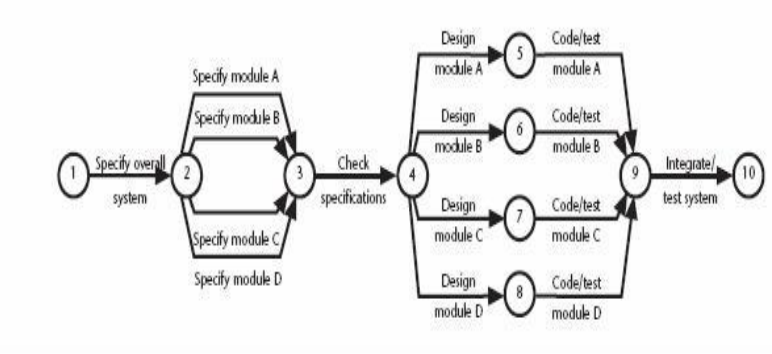
- Sequencing the tasks according to their logical relationship, and then scheduling them taking into account resources and other factor
- Modeling the project's activities and their relationship as a network
  - Time flows from left to right
  - Originally developed in the 1950's
  - Two best known: CPM (Critical Path Method) and PERT (Program Evaluation Review Technique)
  - Recent Approach is Precedence Network.

6.7 Network Planning Models
Activity-On-Arrow [1/2]

- Used by CPM (Critical Path Method) and PERT (Program Evaluation Review Technique) to visualize the project as a network
  - Activities are drawn as arrow joining circles, or nodes, which represent the possible start and/or completion of an activity or set of activities

6.7 Network Planning Models
Activity-On-Arrow [2/2]

- Project activity network fragment represented as a CPM network

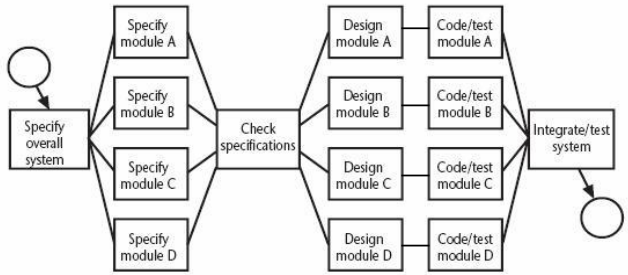


6.7 Network Planning Models
Activity-On-Node [1/2]

- Used by *precedence (sequence)networks*
  - Has become popular
  - Widely adopted
- Activities are represented as nodes
- The links between nodes represent precedence (or sequencing) requirements

6.7 Network Planning Models
Activity-On-Node [2/2]

- Fragment of a network developed as an activity-on-node network



6.8 Formulating A Network Model

Constructing Precedence Network Rules [1/2]

- A project network should have only one start node
  - More than one activity starting at once? Invent a 'start' activity with zero duration
- A project network should have only one end node
  - If necessary, invent an 'end' activity
- A node has duration
- Links normally have no duration

6.8 Formulating A Network Model

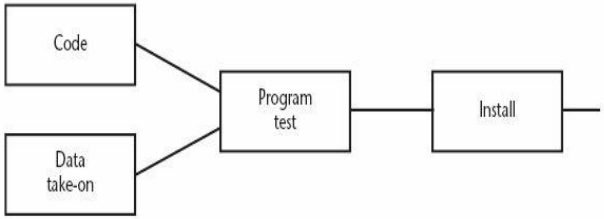
Constructing Precedence Network Rules [2/2]

- Precedents are the immediate preceding activities
  - All have to be completed before an activity can be started
- Time moves from left to right
- A network may not contain loops
- A network should not contain dangles
  - If necessary, connect to the final node

6.8 Formulating A Network Model

Fragment of Precedence Network

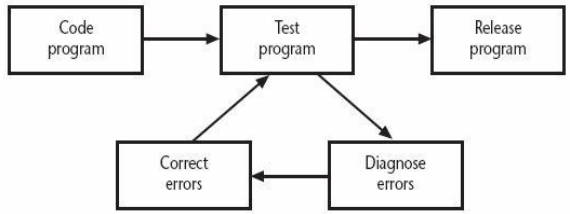
- Installation cannot start until program testing is completed
- Program test cannot start until both code and data take-on have been completed



6.8 Formulating A Network Model

Network Contains Loop

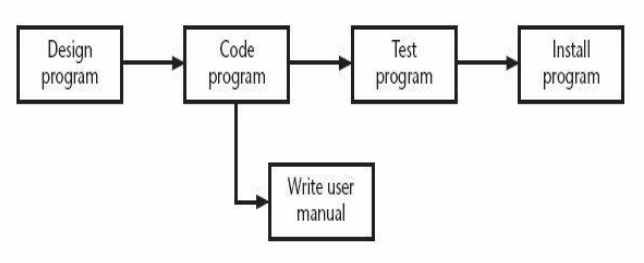
- A loop is an error in that it represents a situation that cannot occur in practice
  - Program testing cannot start until errors have been corrected?



6.8 Formulating A Network Model

A Dangle

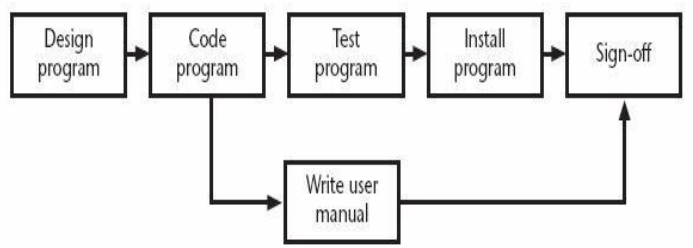
- A dangling activity such as “write user manual” should not exist as it is likely to lead to errors in subsequent analysis



6.8 Formulating A Network Model

Resolving The Dangle

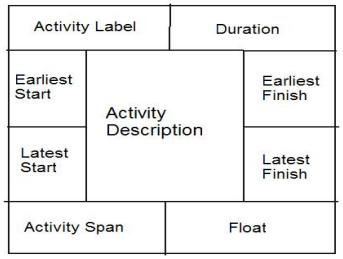
- The figure implies that the project is complete once the software has been installed and the user manual written
  - We should redraw the network with a final completion activity



6.8 Formulating A Network Model

Labelling Convention

- There are a number of differing conventions that have been adopted
- Example



6.9 Adding The Time Dimension

- The critical path approach
  - Planning the project in such way that it is completed as quickly as possible
  - Identifying delayed activities
- The method requires the estimation of duration of each activity
  - *Forward pass*: calculate the earliest dates at which activities may commence and the project completed
  - *Backward pass*: calculate the latest start dates for activities and the *critical path*

6.9 Adding The Time Dimension

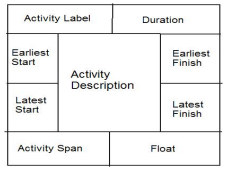
Example of Estimated Activity Duration of A Project

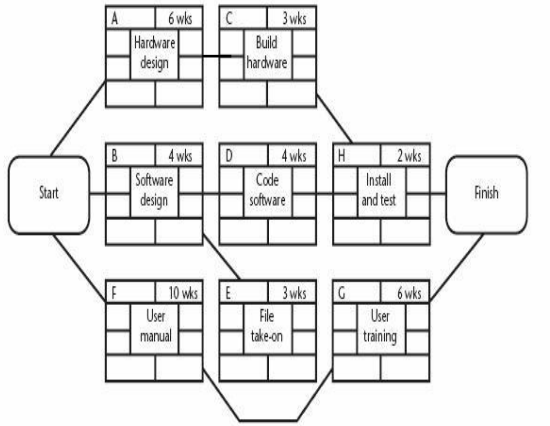
Activity		*Duration (weeks)*	*Precedents*
A	Hardware selection	6	
B	Software design	4	
C	Install hardware	3	A
D	Code & test software	4	B
E	File take-on	3	B
F	Write user manuals	10	
G	User training	3	E, F
H	Install & test system	2	C,D

6.9 Adding The Time Dimension

The Precedence Network of The Example Project

Activity	Precedence	Duration (week)
A	-	6
B	-	4
C	A	3
D	B	4
E	B	3
F	-	10
G	E,F	3
H	C,D	2





6.10 The Forward Pass

The Calculation of Earliest Start Date [1/4]

- Activities A, B and F may start immediately
  - The earliest date for their start is zero
- Activity A will take 6 weeks
  - The earliest it can finish is week 6
- Activity B will take 4 weeks
  - The earliest it can finish is week 4
- Activity F will take 10 weeks
  - The earliest it can finish is week 10

6.10 The Forward Pass

The Calculation of Earliest Start Date [2/4]

- Activity C can start as soon as A has finished
  - Its earliest start date is week 6
  - It will take 3 weeks, so the earliest it can finish is week 9
- Activities D and E can start as soon as B is complete
  - The earliest they can each start is week 4
  - Activity D will take 4 weeks, so the earliest it can finish is week 8
  - Activity E will take 3 weeks, so the earliest it can finish is week 7

6.10 The Forward Pass

The Calculation of Earliest Start Date [3/4]

- Activity G cannot start until both E and F have been completed
  - It cannot start until week 10 - the later of weeks 7 (activity E) and 10 (for activity F)
  - It takes 3 weeks and finishes in week 13
- Similarly, activity H cannot start until week 9 – the later of the two earliest finished dates for the preceding activities C and D

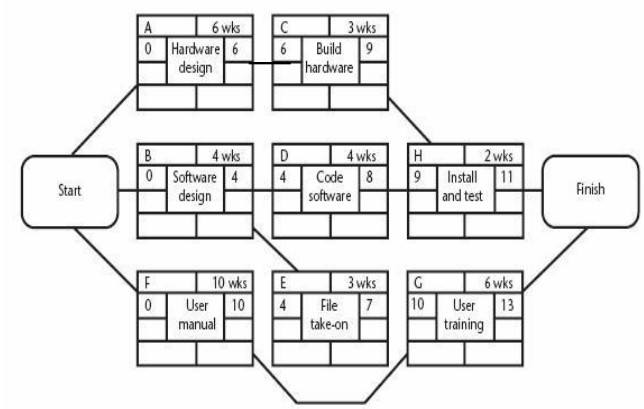
6.10 The Forward Pass

The Calculation of Earliest Start Date [4/4]

- The project will be complete when both activities H and G have been completed
  - The earliest project completion date will the later of weeks 11 and 13 – that is, week 13

6.10 The Forward Pass

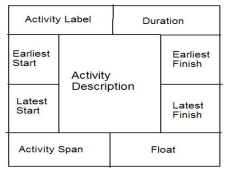
The Network After The Forward Pass

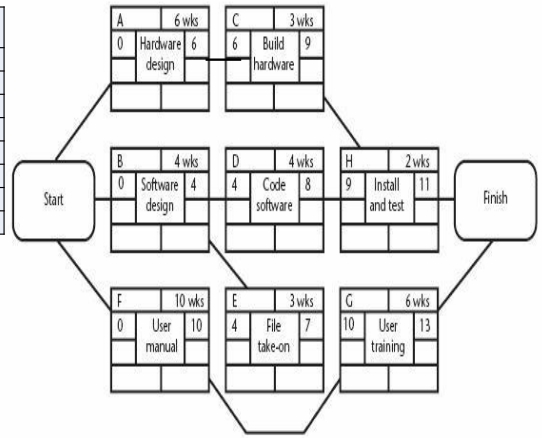


6.10 The Forward Pass

The Network After The Forward Pass

Activity	Precedence	Duration (week)
A	-	6
B	-	4
C	A	3
D	B	4
E	B	3
F	-	10
G	E,F	3
H	C,D	2





6.11 The Backward Pass
The Latest Activity Dates Calculation [1/3]

- The latest completion date for activities G and H is assumed to be week 13
- Activity H must therefore start at week 11 at the latest (13-2) and the latest start date for activity G is week 10 (13-3)
- The latest completion date for activities C and D is the latest date at which activity H must start – that is week 11
  - The latest start date of week 8 (11-3), and week 7 (10-3) respectively

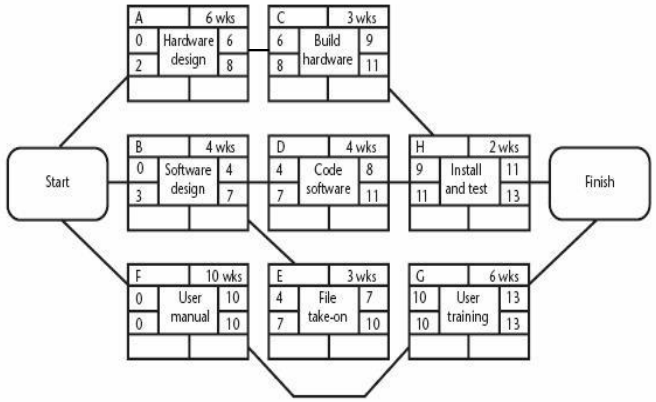
6.11 The Backward Pass
The Latest Activity Dates Calculation [2/3]

- Activities E and F must be completed by week 10
  - The earliest start dates are weeks 7 (10-3) and 0 (10-10) respectively
- Activity B must be completed by week 7 (the latest start date for both activities D and E)
  - The latest start is week 3 (7-4)

6.11 The Backward Pass
The Latest Activity Dates Calculation [3/3]

- Activity A must be completed by week 8 (the latest start date for activity C)
  - Its latest start is week 2 (8-6)
- The latest start date for the project start is the earliest of the latest start dates for activities A, B and F
  - This week is week zero
  - It tells us that if the project does not start on time it won't finish on time

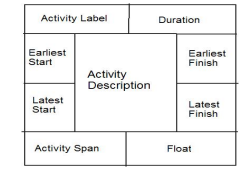
6.11 The Backward Pass
The Network After The Backward Pass

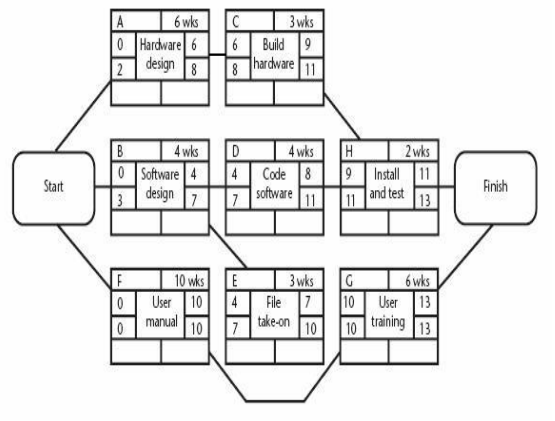


6.11 The Backward Pass

The Network After The Backward Pass

Activity	Precedence	Duration (week)
A	-	6
B	-	4
C	A	3
D	B	4
E	B	3
F	-	10
G	E,F	3
H	C,D	2





6.12 Identifying The Critical Path

The Critical Path [1/3]

- *Critical path*: One path through the network that defines the duration of the project
- Any delay to any activity of this critical path will delay the completion of the project

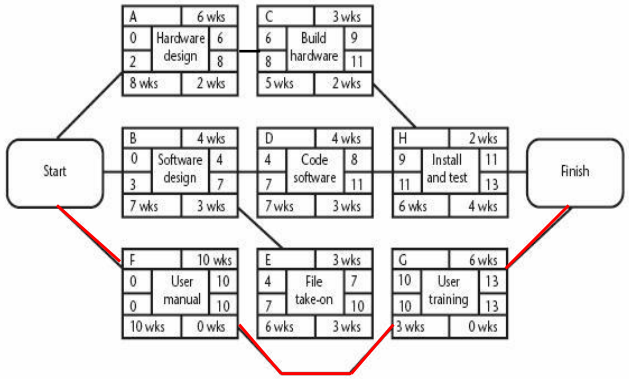
6.12 Identifying The Critical Path

The Critical Path [2/3]

- Activity's *float*: the difference between an activity's earliest start date and its latest start date (or, equally, the difference between its earliest and latest finish dates)
  - A measure of how much the start date or completion of an activity may be delayed without affecting the end date of the project
- *Activity span*: the difference between the earliest start date and the latest finish date
  - Measure of maximum time allowable for the activity

6.12 Identifying The Critical Path

The Critical Path [3/3]



6.12 Identifying The Critical Path

The Significance of The Critical Path

- In managing the project, we must pay particular attention to monitoring activities on the critical path
  - The effects on any delay or resources unavailability are detected and corrected at the earliest opportunity
- In planning project, it is the critical path that we must shorten if we are to reduce the overall duration of the project

6.13 Activity Float

Other Measures of Activity Float

- *Free float*: the time by which an activity may be delayed without affecting subsequent activity
  - The difference between the earliest completion for the activity and the earliest date of the succeeding activity
- *Interfering float*: the difference between total float and free float
  - Tells us how much the activity may be delayed without delaying project end date

6.14 Shortening The Project Duration

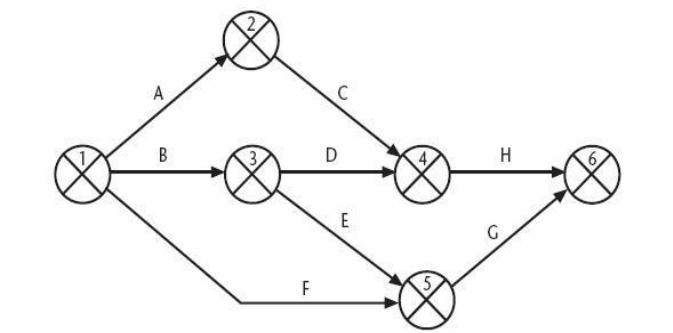
- Reduce activity duration
  - Applying more resources to the task
    - Working overtime
    - Procuring additional staff
- The critical path indicates where we must look to save time
  - From previous example, we can complete the project in week 12 by reducing the duration of activity F by one week

6.16 Activity-On-Arrow Networks

- Originally used by CPM and PERT methods
- Now less common than activity-on-node, still used and introduces an additional useful concept – that of *events*
- Activities are represented by links (or arrows) and the nodes represent events

6.16 Activity-On-Arrow Networks

Activity-On-Arrow Network of the Example Project



6.16 Activity-On-Arrow Networks

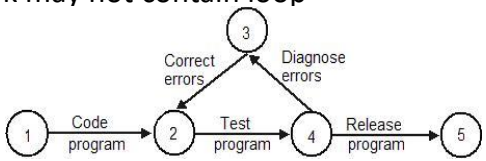
Activity-On-Arrow Rules and Conventions [1/2]

- A project network may have only one start node
- A project network may have only one end node
- A link has duration
- Nodes have no duration
- Time moves from left to right
- Nodes are numbered sequentially

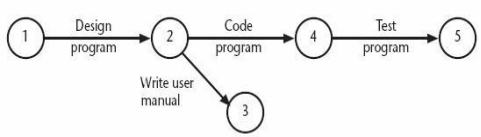
6.16 Activity-On-Arrow Networks

Activity-On-Arrow Rules and Conventions [2/2]

- A network may not contain loop



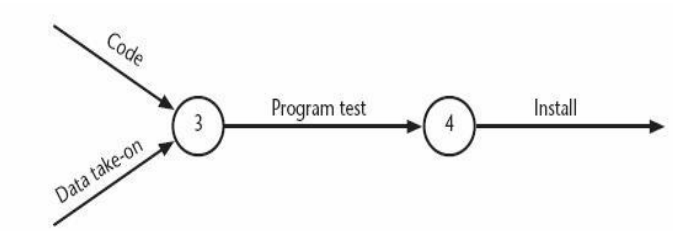
- A network may not contain dangle



6.16 Activity-On-Arrow Networks

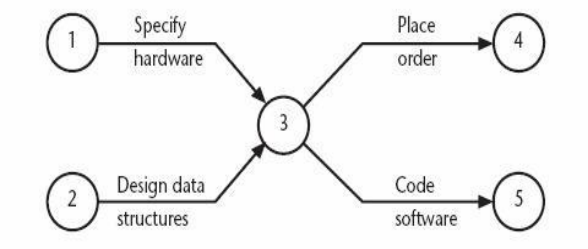
Fragment of A CPM Network - Events

- Node 3 is the event that both ‘coding’ and ‘data take-on’ have been completed and activity ‘program test’ is free to start



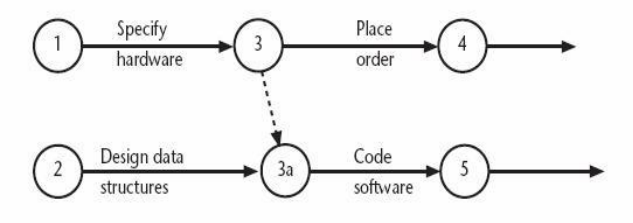
6.16 Activity-On-Arrow Networks
Using Dummy Activities [1/3]

- A logical error occurs when two paths ('specify hardware' and 'design data structure') within a network have a common event although they are independent



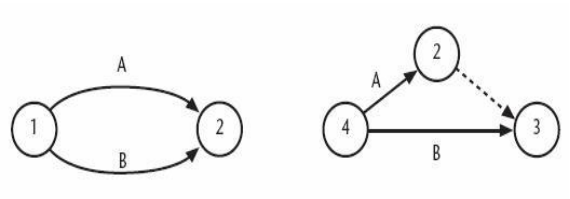
6.16 Activity-On-Arrow Networks
Using Dummy Activities [2/3]

- Separating the two independent paths and introducing a dummy activity to link the completion of 'specify hardware' to the start of the activity 'code software'



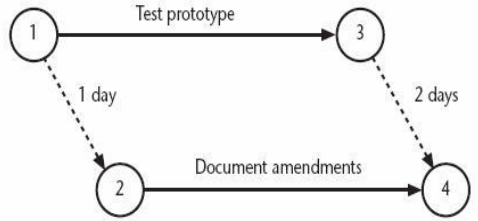
6.16 Activity-On-Arrow Networks
Using Dummy Activities [3/3]

- Dummy activities, shown as dotted lines on the network diagram, have zero duration and use no resources
- They are often used to aid in the layout of network



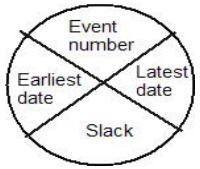
6.16 Activity-On-Arrow Networks
Representing Lagged Activities

- When parallel activities have time lag, we can represent them with pairs of dummy activities



6.16 Activity-On-Arrow Networks
Activity Labelling

- Typically the diagram is used to record information about the events rather than activities
- One of the more common is to divide the node circle in quadrants

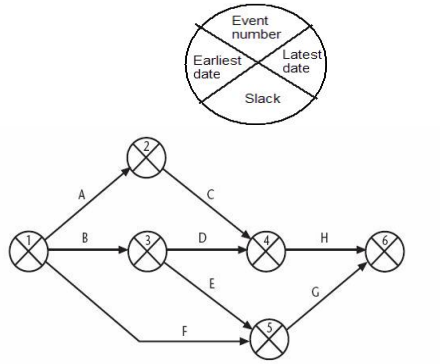


6.16 Activity-On-Arrow Networks
Network Analysis

- Analysis proceeds in the same way as with activity-on-node networks
  - The discussion places emphasis on the events rather than activity start and completion time
- Stages
  - The forward pass
  - The backward pass
  - Identifying the critical path

Activity-On-Arrow Networks

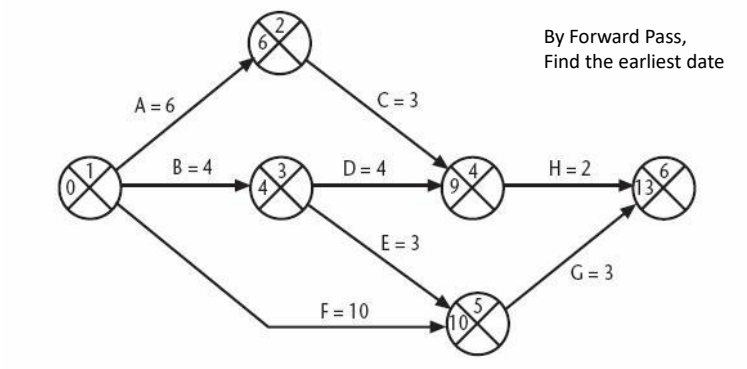
Activity		*Duration (weeks)*	*Precedents*
A	Hardware selection	6	
B	Software design	4	
C	Install hardware	3	A
D	Code & test software	4	B
E	File take-on	3	B
F	Write user manuals	10	
G	User training	3	E, F
H	Install & test system	2	C,D



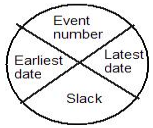
Initial Network Diagram

Initial activity table

Activity	Duration (week)	Earliest start date	Latest start date	Earliest finish date	Latest finish date	Total float
A	6					
B	4					
C	3					
D	4					
E	3					
F	10					
G	3					
H	2					



Activity	Precedence	Duration (week)
A	-	6
B	-	4
C	A	3
D	B	4
E	B	3
F	-	10
G	E,F	3
H	C,D	2



6.16 Activity-On-Arrow Networks

The Forward Pass [1/4]

- Activities A, B and F may start immediately
  - The earliest date for event 1 is zero
  - The earliest start date for these three activities is also zero
- Activity A will take 6 weeks
  - The earliest it can finish is week 6
  - The earliest we can achieve event 2 is week 6

6.16 Activity-On-Arrow Networks

The Forward Pass [2/4]

- Activity B will take 4 weeks
  - The earliest it can finish and the earliest we can achieve event 3 is week 4
- Activity F will take 10 weeks
  - The earliest it can finish is week 10
  - We cannot tell whether or not this is also the earliest date that we can achieve event 5 since we have not, as yet, calculated when activity E will finish

6.16 Activity-On-Arrow Networks

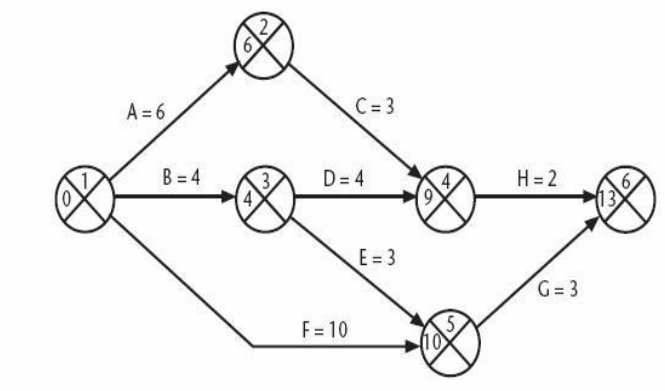
The Forward Pass [3/4]

- Activity E can start as early as week 4 (the earliest date for event 3)
  - It is forecasted to take 3 weeks, it will be completed, at the earliest, at the end of week 7
- Event 5 may be achieved when both E and F have been completed, that is week 10 (the later of 7 and 10)

6.16 Activity-On-Arrow Networks
The Forward Pass [4/4]

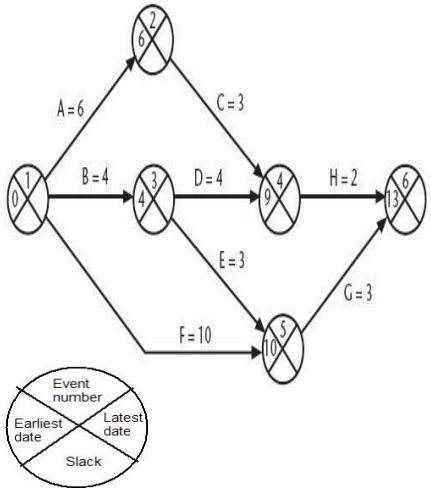
- Similarly, we can reason that event 4 will have an earliest date of week 9
  - The later of the earliest finish for activity D (week 8) and the earliest finish for activity C (week 9)
- The earliest date for the completion of the project, event 6, is therefore the end of week 13
  - The later of 11 (the earliest finish for H) and 13 (the earliest finish for G)

6.16 Activity-On-Arrow Networks
The CPM Network After The Forward Pass



Update the activity table

Activity	Duration (week)	Earliest start date	Latest start date	Earliest finish date	Latest finish date	Total float
A	6	0		6		
B	4	0		4		
C	3	6		9		
D	4	4		8		
E	3	4		7		
F	10	0		10		
G	3	10		13		
H	2	9		11		



6.16 Activity-On-Arrow Networks
The Activity Table After The Forward Pass

Activity	*Duration (week)*	*Earliest start date*	*Latest start date*	*Earliest finish date*	*Latest finish date*	*Total float*
A	6	0		6		
B	4	0		4		
C	3	6		9		
D	4	4		8		
E	3	4		7		
F	10	0		10		
G	3	10		13		
H	2	9		11		

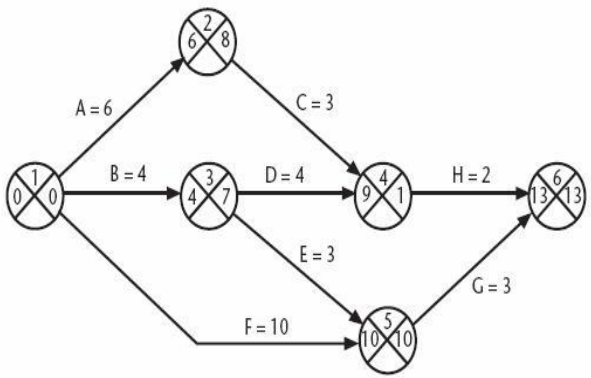
6.16 Activity-On-Arrow Networks

The Backward Pass

- Calculate the latest date at which each event may be achieved, each activity started and finished, without delaying the end of the project
- The latest date for an event is the latest date by which all immediately following activities must be started for the project to be completed on time

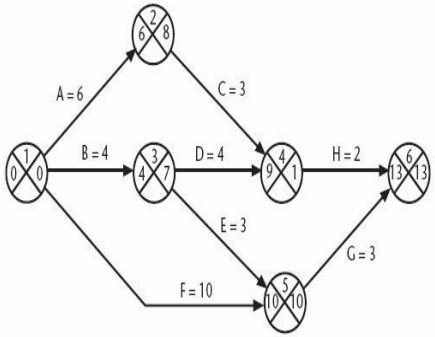
6.16 Activity-On-Arrow Networks

The CPM Network After the Backward Pass

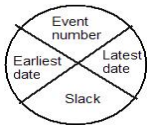


Update the activity table

Activity	Duration (week)	Earliest start date	Latest start date	Earliest finish date	Latest finish date	Total float
A	6	0	8-6=2	6	8	
B	4	0	7-4=3	4	7	
C	3	6	11=3=8	9	11	
D	4	4	11-4=7	8	11	
E	3	4	10-3=7	7	10	
F	10	0	10-10=0	10	10	
G	3	10	13-3=10	13	13	
H	2	9	13-2=11	11	13	



In Backward Pass, for node 1 (out of 2/3/0), and node 3(out of 7/7), The earliest of the latest start dates is picked.



6.16 Activity-On-Arrow Networks

The Activity Table After the Backward Pass

Activity	*Duration (week)*	*Earliest start date*	*Latest start date*	*Earliest finish date*	*Latest finish date*	*Total float*
A	6	0	2	6	8	
B	4	0	3	4	7	
C	3	6	8	9	11	
D	4	4	7	8	11	
E	3	4	7	7	10	
F	10	0	0	10	10	
G	3	10	10	13	13	
H	2	9	11	11	13	

6.16 Activity-On-Arrow Networks

Identifying The Critical Path

- The critical path is identified in a way similar to that used in activity-on-node networks
- A different concept is used: *slack*
- A *slack* is the difference between the earliest date and the latest date for an event
  - It is a measure of how late an event may be

6.16 Activity-On-Arrow Networks

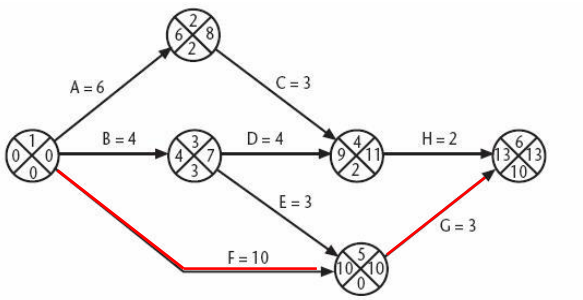
The Activity Table After the Backward Pass

Activity	*Duration (week)*	*Earliest start date*	*Latest start date*	*Earliest finish date*	*Latest finish date*	*Total float*
A	6	0	2	6	8	8-6=2
B	4	0	3	4	7	7-4=3
C	3	6	8	9	11	11-9=2
D	4	4	7	8	11	11-8=3
E	3	4	7	7	10	10-7=3
F	10	0	0	10	10	**10-10=0**
G	3	10	10	13	13	**13-13=0**
H	2	9	11	11	13	13-11=2

6.16 Activity-On-Arrow Networks

The Critical Path

- The critical path is the path joining all nodes with a zero slack



6.17 Conclusion [1/3]

- Activity plan tells us the order in which we should execute activities and the earliest and latest we can start and finish them
- The critical path method and precedence networks can be used to obtain an ideal activity plan

6.17 Conclusion [2/3]

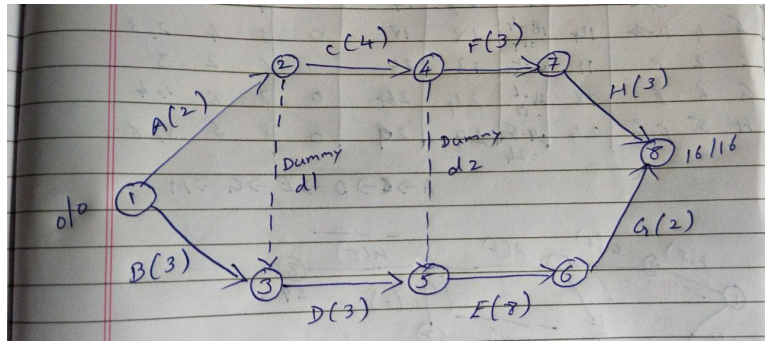
- The critical path method and precedence networks techniques helps us to identify which activities are critical to meeting a target completion date
- In order to manage the project we need to turn the activity plan into schedule that will specify precisely when each activity is scheduled to start and finish

6.17 Conclusion [3/3]

- Before we can do scheduling, we must consider what resources will be required and whether or not they will be available at appropriate times
- The allocation of resources to an activity may be affected by how we view the importance of the task and the risks associated with it

SOME MORE Ex.

Activity	Predecessor	Duration	Earliest start	Latest start=Latest Finish-Duration	Earliest Finish=duration + earliest start	Latest Finish	total float
A	-	2	0	2-2=0	2	2	0
B	-	3	0	3-3=0	3	3	0
C	A	4	2	6-4=2	6	6	0
D	A,B	3	3	6-3=3	6	6	0
E	D,C	8	6	14-8=6	14	14	0
F	C	3	6	13-3=10	9	13	4
G	E	2	14	16-2=14	16	16	0
H	F	3	9	16-3=13	12	16	2



Critical Path 1 : 1->2->4->5->6->8
Critical Activity: A, C, d2(dummy), E,G

Critical Path 2 : 1->3->5->6->8
Critical Activity: B,D,E,G