

UNIT 2

Software Project Scheduling

(8 Hours) — Software Project Management (CAC407)

NOTE: These notes may contain errors. Please verify important points, definitions and calculations with your textbook and teacher before relying on them.

2.1 Objectives of Activity Planning

Activity planning (scheduling) converts the project scope into a timed sequence of activities, so that everybody knows what is to be done, when, and by whom. A project plan is not just a list of tasks, it is a time-based model of how the project is expected to run.

- **Feasibility assessment** — check whether the project can be completed by the required date with the available resources.
- **Resource allocation** — decide when each person, machine or tool is needed.
- **Detailed costing** — know when money will be spent (cash flow) once the timing is known.
- **Motivation** — clear targets and milestones keep the team focused.
- **Co-ordination** — dependencies between teams and tasks are visible, so people know when to start and hand over.
- **Monitoring and control** — actual progress can be compared with the planned dates, and corrective action taken.

2.2 Work Breakdown Structure (WBS)

A **Work Breakdown Structure** is a hierarchical decomposition of the total scope of work into smaller, more manageable parts, down to the level of **work packages**. It is *product- or deliverable-oriented*: it shows *what* must be produced, not the order in which it is done.

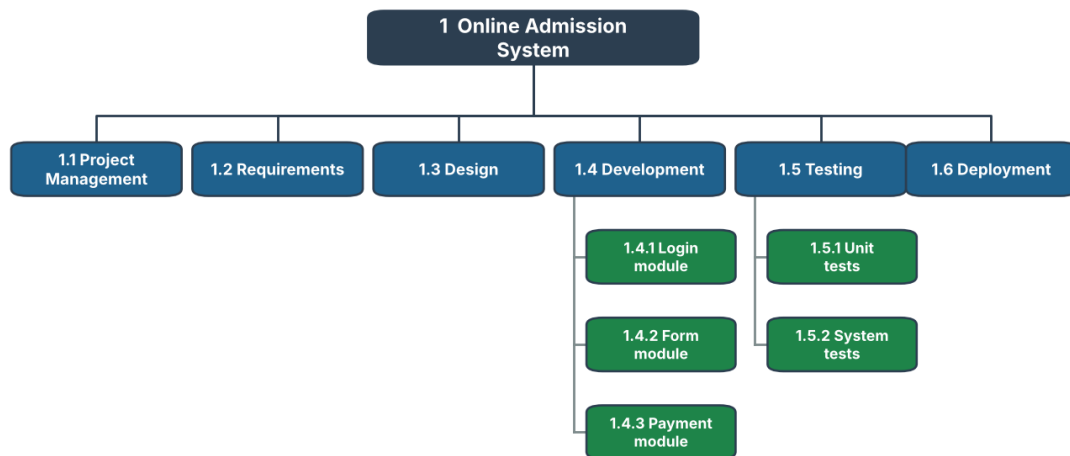


Figure 2.1 — Sample WBS for an online admission system

2.2.1 Rules for a good WBS

- The **100% rule**: the children at each level must cover all the work of their parent, and nothing more.
- Elements should be **mutually exclusive** (no overlap, so no double counting).
- The lowest level (work package) should be small enough to estimate, assign to one owner and track.
- Use nouns (deliverables) for elements; use verbs when the elements are turned into activities.

2.2.2 Uses of WBS

- Basis for estimating effort and cost.
- Basis for activity identification and scheduling.
- Assigning responsibility.
- Progress tracking and scope control.

2.3 Network Planning Models

A **network model** shows the activities of a project and the dependencies between them as a diagram. It is used to compute the shortest possible project duration and to find which activities cannot be delayed.

Term	Meaning
Activity	A task that consumes time and resources.
Event/Node	A point in time marking the start or end of activities (in activity-on-arrow diagrams).
Dependency	A logical relationship: an activity cannot begin until its predecessor allows.
Path	A continuous sequence of activities from start to finish.
Critical path	The longest path through the network; it determines the project duration.
Dummy activity	Zero-duration activity used only to show a dependency (activity-on-arrow).

Two styles of drawing exist: **Activity-on-Arrow (AOA)**, where arrows are activities and nodes are events, and **Activity-on-Node (AON)**, where nodes are activities and arrows are dependencies. AON is simpler (no dummies) and is used in the examples below.

2.4 Critical Path Method (CPM)

CPM was developed in the late 1950s (DuPont and Remington Rand) for industrial projects. It uses **deterministic** (single-value) time estimates for each activity and finds the critical path and the float of every activity.

2.4.1 Forward pass and backward pass

Forward pass — gives the earliest times. Start at the first activity with $ES = 0$.

- **$EF = ES + \text{Duration}$**
- **ES** of an activity = the **largest EF** among all its predecessors.
- Project duration = the largest EF of the last activity.

Backward pass — gives the latest times. Start at the last activity with $LF = \text{project duration}$.

- **$LS = LF - \text{Duration}$**
- **LF** of an activity = the **smallest LS** among all its successors.

2.4.2 Float (slack) and critical activities

Type of float	Formula / meaning
Total float	$LS - ES$ (or $LF - EF$): how long the activity can be delayed without delaying the project end.
Free float	Earliest ES of successors – EF of the activity: delay possible without affecting any successor.

Type of float	Formula / meaning
Interfering float	Total float – free float.

*Note: Critical activities are those with **zero total float**. They form the critical path (there may be more than one). Any delay in a critical activity delays the whole project.*

Example 2.1 — CPM calculation

A project has the following activities (durations in days):

A (3, no predecessor); B (4, after A); C (2, after A); D (5, after B); E (4, after C); F (3, after D and E); G (2, after F).

Find the project duration, the critical path and the float of each activity.

Solution

Forward pass: A: ES 0, EF 3. B: 3–7. C: 3–5. D: 7–12. E: 5–9. F: ES = max(EF of D, EF of E) = max(12, 9) = 12, EF 15. G: 15–17.

Project duration = **17 days**.

Backward pass: G: LF 17, LS 15. F: LF 15, LS 12. D: LF 12, LS 7. E: LF 12, LS 8. B: LF 7, LS 3. C: LF = LS of E = 8, LS 6. A: LF = min(LS of B, LS of C) = min(3, 6) = 3, LS 0.

Act.	Dur.	Pred.	ES	EF	LS	LF	Float	Critical?
A	3	—	0	3	0	3	0	Yes
B	4	A	3	7	3	7	0	Yes
C	2	A	3	5	6	8	3	No
D	5	B	7	12	7	12	0	Yes
E	4	C	5	9	8	12	3	No
F	3	D, E	12	15	12	15	0	Yes
G	2	F	15	17	15	17	0	Yes

Result

Critical path: **A → B → D → F → G** (zero float), duration **17 days**. Activities C and E have 3 days of float.

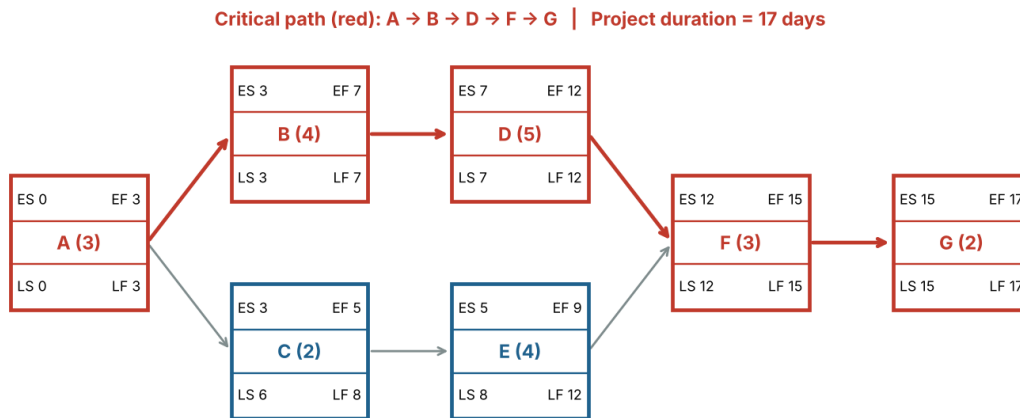


Figure 2.2 — AON network with ES, EF, LS, LF for Example 2.1

2.5 Program Evaluation and Review Technique (PERT)

PERT was developed in 1958 by the US Navy (Polaris missile programme) for projects with **uncertain** activity durations. Instead of a single estimate, three estimates are used for every activity:

Estimate	Symbol	Meaning
Optimistic	o (a)	Shortest time if everything goes well.
Most likely	m	Most probable duration.
Pessimistic	p (b)	Longest time if things go badly (excluding disasters).

Using the Beta distribution assumption:

- **Expected time:** $t_e = (o + 4m + p) / 6$
- **Variance:** $\sigma^2 = ((p - o) / 6)^2$
- Project expected duration = sum of t_e along the critical path; project variance = sum of variances of critical activities.
- $Z = (T - T_e) / \sigma$ where T is the target date; the probability is read from the normal table.

Example 2.2 — PERT

The same network as Example 2.1 has the three-point estimates below (days). Find the expected duration and the probability of finishing within 19 days.

Act.	o	m	p	t_e	σ^2	Critical
A	1	3	5	3	0.444	Yes

Act.	o	m	p	t_e	σ^2	Critical
B	2	4	6	4	0.444	Yes
C	1	2	3	2	0.111	No
D	3	5	7	5	0.444	Yes
E	2	4	6	4	0.444	No
F	2	3	4	3	0.111	Yes
G	1	2	3	2	0.111	Yes

Solution

Every t_e equals the CPM duration, so the critical path is again $A \rightarrow B \rightarrow D \rightarrow F \rightarrow G$ and $T_e = 17$ days.

Variance of critical path = $0.444 + 0.444 + 0.444 + 0.111 + 0.111 = 1.556$.

Standard deviation $\sigma = \sqrt{1.556} = 1.247$ days.

$Z = (19 - 17) / 1.247 = 1.60$.

From the normal table $P(Z \leq 1.60) \approx \mathbf{0.946}$, i.e. about 94.6% chance of finishing within 19 days.

2.5.1 CPM vs PERT

Basis	CPM	PERT
Time estimate	Single, deterministic	Three estimates, probabilistic
Orientation	Activity-oriented	Event-oriented (originally)
Best for	Repetitive, well-known projects	Research, new/uncertain projects
Cost	Time-cost trade-off (crashing) included	Mainly time; cost not central
Origin	DuPont, 1957–58	US Navy, 1958

2.6 Precedence Diagramming Method (PDM)

PDM is an AON technique that allows richer relationships than 'finish-to-start' and allows **lag** or **lead** time between activities. This better reflects real software work, where tasks often overlap.

Relationship	Meaning	Example
Finish-to-Start (FS)	B cannot start until A finishes.	Coding must finish before system testing starts.

Relationship	Meaning	Example
Start-to-Start (SS)	B cannot start until A has started.	Writing test cases can start soon after design starts.
Finish-to-Finish (FF)	B cannot finish until A finishes.	Documentation cannot be completed until coding is complete.
Start-to-Finish (SF)	B cannot finish until A starts (rare).	Old system is shut down only after new system starts.

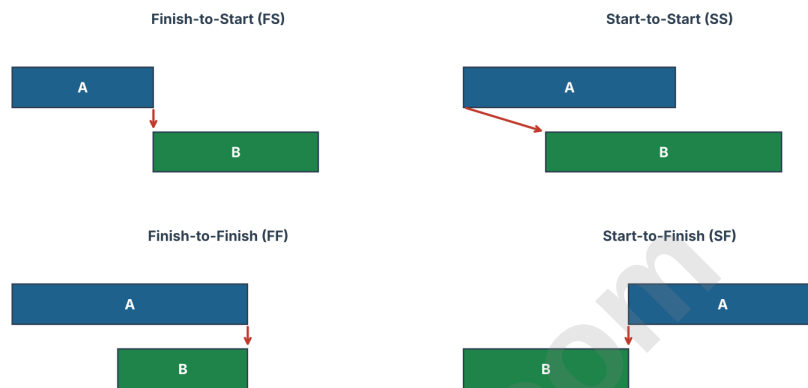


Figure 2.3 — The four dependency types in PDM

*Note: A **lag** adds a delay (e.g. FS + 2 days); a **lead** allows overlap (e.g. FS – 2 days). Forward and backward passes work as usual, but the type and lag of each link is used when computing ES/EF/LS/LF.*

2.7 Shortening Project Duration

If the calculated duration is longer than required, it can only be reduced by shortening the **critical path**. Shortening a non-critical activity has no effect on the end date. Common options:

- **Crashing** — add resources (overtime, more staff) to critical activities at extra cost.
- **Fast tracking** — do activities in parallel that were planned in sequence (increases risk and rework).
- Reduce scope or remove optional features.
- Use more experienced staff or better tools; reuse existing components.
- Remove unnecessary dependencies or review the logic of the network.

When a critical path is shortened, another path may become critical, so the network must be recalculated after each change. Crash the activity with the **lowest cost slope** first, where $\text{cost slope} = (\text{crash cost} - \text{normal cost}) / (\text{normal time} - \text{crash time})$.

Example 2.3 — Crashing

In Example 2.1 the following critical activities can be crashed:

A: 3→2 days, extra Rs. 400. B: 4→3 days, extra Rs. 200. D: 5→3 days, extra Rs. 600. F: 3→2 days, extra Rs. 150.

Reduce the project duration by 2 days at least cost.

Solution

Cost slopes per day: A = 400, B = 200, D = $600 / 2 = 300$, F = 150.

Step 1: crash F (cheapest, Rs. 150) → duration 16 days. Other path A–C–E–F–G = $3+2+4+2+2 = 13$, still not critical.

Step 2: crash B (next cheapest, Rs. 200) → duration 15 days. Path A–C–E–F–G is still only 13 days.

New duration = 15 days; extra cost = 150 + 200 = Rs. 350.

2.8 Identifying Critical Activities

- Perform forward and backward passes and compute total float.
- Activities with **total float = 0** are critical; the chain of such activities from start to end is the critical path.
- Activities with small float are *near-critical* and need watching, since a small delay can make them critical.
- Managers give critical activities the best resources and the closest monitoring.

2.8.1 Gantt chart and milestones

A **Gantt chart** is a bar chart of activities against a calendar. It is easy to read and good for showing progress, but it shows dependencies poorly compared with a network diagram. A **milestone** is a zero-duration event marking completion of a key deliverable (for example, 'SRS approved').

Key Takeaways

- ✓ Activity planning turns scope into a timed, resourced schedule that can be monitored.
- ✓ WBS decomposes deliverables (100% rule); network diagrams show activity order.
- ✓ CPM: forward pass → ES, EF; backward pass → LS, LF; float = LS – ES; critical path = zero float.
- ✓ PERT: $t_e = (o + 4m + p)/6$, $\sigma^2 = ((p - o)/6)^2$, then Z-value gives the probability of meeting a date.
- ✓ PDM supports FS, SS, FF and SF relationships with lag and lead.
- ✓ Only shortening the critical path shortens the project; crash cheapest slope first, and recheck the network.

— End of Unit 2 —

bcalink.com