## **Project Management**

### **Introduction to CPM and PERT**

**Project Management** involves planning, scheduling, and controlling resources to achieve specific project goals within time, cost, and scope constraints.

Two of the most widely used techniques in project scheduling and analysis are:

* **CPM (Critical Path Method)**
* **PERT (Program Evaluation and Review Technique)**

#### **1. CPM – Critical Path Method**

* Developed for **deterministic** activity times (fixed and known).
* Used for projects where **activity duration is predictable**.
* Focuses on **time-cost trade-offs** (crashing).

#### **2. PERT – Program Evaluation and Review Technique**

* Developed for **probabilistic** activity durations.
* Suitable for **R&D and uncertain environments**.
* Uses **three time estimates**:  
  + Optimistic time (O)
  + Most likely time (M)
  + Pessimistic time (P)
* Expected time (TE) is calculated as:  
   TE=O+4M+P6TE = \frac{O + 4M + P}{6}

### **Basic Differences Between CPM and PERT**

| **Aspect** | **CPM** | **PERT** |
| --- | --- | --- |
| Type of Activity Time | Deterministic (fixed) | Probabilistic (uncertain) |
| Application | Construction, maintenance, production | Research, development, planning |
| Focus | Time-cost optimization | Time uncertainty and risk analysis |
| Estimates Used | One (fixed) | Three (O, M, P) |
| Critical Path Emphasis | High – used for crashing | High – used for estimating project time |
| Slack Computation | Available | Available |

### **CPM/PERT Network Components and Precedence Relationship**

**Components of a Network Diagram:**

1. **Activity (Arrow or Node):**
   * Represents a task to be completed.
   * In **AOA (Activity on Arrow)**, activities are arrows.
   * In **AON (Activity on Node)**, activities are nodes (preferred in modern tools).
2. **Event (Node):**
   * Represents the start or completion of an activity (AOA only).
3. **Dummy Activity:**
   * A logical connector showing dependency, without time or cost.

**Precedence Relationships:**

* **Finish-to-Start (FS):** Task B starts after Task A finishes (most common).
* **Start-to-Start (SS):** Task B starts after Task A starts.
* **Finish-to-Finish (FF):** Task B finishes after Task A finishes.
* **Start-to-Finish (SF):** Task B finishes after Task A starts (rare).

### **Critical Path Analysis**

The **Critical Path** is the **longest path** through the project network and determines the **minimum project duration**. Activities on the critical path have **zero slack**, meaning any delay will delay the project.

#### **1. Forward Pass Method (Earliest Times)**

Calculates the **Earliest Start (ES)** and **Earliest Finish (EF)** times:

* ES for first activity = 0
* EF = ES + Activity Duration
* ES of next activity = Maximum EF of all predecessor activities

#### **2. Backward Pass Method (Latest Times)**

Calculates the **Latest Start (LS)** and **Latest Finish (LF)** times:

* LF of last activity = Project duration
* LS = LF - Activity Duration
* LF of preceding activity = Minimum LS of all successors

**Slack or Float:**

Slack=LS−ES=LF−EF\text{Slack} = LS - ES = LF - EF

* If Slack = 0 → Activity is **critical**