Cornell University
Computing and Information Science

CS 5150 Software Engineering

Project Management

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Project Management: OS 360

The operating system for the IBM 360 was two years late.

Question: How does a project get two years behind schedule?

Answer: One day at a time!

Fred Brooks Jr., *The Mythical Man Month, 1972*

The Aim of Project Management

To complete a project:

- On time
- On budget
- With required functionality
- To the satisfaction of the client
- Without exhausting the team

To provide visibility about the progress of a project

The Challenge of Project Management

Clients wish to know:

Will the system do what was promised?

When will it be delivered? If late, how late?

How does the cost compare with the budget?

Often the software is part of a larger activity

- If the system is a product, marketing and development must be combined (e.g., Microsoft Office)
- If the system has to work with other systems, developments must be coordinated (e.g., embedded systems in an automobile)

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The Challenge of Project Management (continued)

BUT:

Every software system is different.

Most systems are not well specified, or the requirements change during development.

Estimating time and effort is full of errors, even when the system is well understood.

Aspects of Project Management

Planning

- Outline schedule during feasibility study (needed for CS 5150)
- Fuller schedule for each part of a project (e.g., each process step, iteration, or sprint)

Contingency planning

- Anticipation of possible problems (risk management)

Progress tracking

- Regular comparison of progress against plan
- Regular modification of the plan
- Changes of scope, etc. made jointly by client and developers

Final analysis

- Analysis of project for improvements during next project

Terminology

Deliverable

- Work product that is provided to the client (mock-up, demonstration, prototype, report, presentation, documentation, code, etc.)
- Release of a system or subsystem to customers or users

Milestone

Completion of a specified set of activities (e.g., delivery of a deliverable, completion of a process step)

Terminology

Activity

Part of a project that takes place over time (also known as a **task**).

Event

The end of a group of activities, e.g., agreement by all parties on the budget and plan

Dependency

An activity that cannot begin until some event is reached

Resource

Staff time, equipment, or other limited resources required by an activity.

Standard Approach to Project Management

- The scope of the project is defined early in the process.
- The development is divided into tasks and milestones.
- Estimates are made of the time and resources needed for each task.
- The estimates are combined to create a schedule and a plan.
- Progress is continually reviewed against the plan, perhaps weekly.
- The plan is modified by changes to scope, time, resources, etc.

Typically the plan is managed by a separate project management team, not by the software developers.

Agile Approach to Project Management

- Planning is divided into high level release forecasting and low level detailed planning.
- Release planning is a best guess, high level view of what can be achieved in a sequence of time-boxes.
- Release plans are continually modified, perhaps daily.
- Clients and developers take joint control of the release plans and choice of sprints.
- For each time-box, the team plans what it can achieve. The team may use Gantt charts or other conventional planning tools.

Estimating the Time for an Activity

With experienced staff, estimating the actual time to carry out a single task is usually fairly accurate, but ...

The little bits and pieces are underestimated.

- The time from almost "done" to completely "done" is much longer than anticipated. *(There's just one thing to tidy up. I need to put the comments into better shape. I really should get rid of that patch.)*
- The distractions are not planned for. *(My system crashed and I decided to upgrade the software. My child's school was closed because of snow. I spent the day interviewing job candidates.)*
- Some things have to be done twice.

Estimating: Analysis

Example

Administrative computing department at Dartmouth used activity graphs for the program design and implementation phases of major projects (plan developed after project was well-understood).

Experience:

Elapsed time to complete projects was consistently 30% to 40% longer than predicted by model.

Analysis:

- Some tasks not anticipated (incomplete understanding)
- Some tasks had to be redone (change of requirements, technical changes)
- Key personnel were on many activities (schedule conflicts)
- Non-billable hours

Team-based Estimating

- The team often has the best understanding of what it can achieve in a single time-box or sprint.
- The team commits to the outcome of a sprint.
- The team must have an internal schedule to allocate tasks within a sprint.
- Since different teams work at different speeds it is common to estimate effort to achieve a specific goal in a numeric scale, not as time.

A CS 5150 project can be thought of as a single sprint.

Start-up Time

On a big project, the start-up time is typically three to six months:

- Personnel have to complete previous projects (fatigue) or be recruited.
- Hardware and software has to be acquired and installed.
- Staff have to learn new domain areas and software (slow while learning).
- Clients may not be ready.

Project Planning Tools

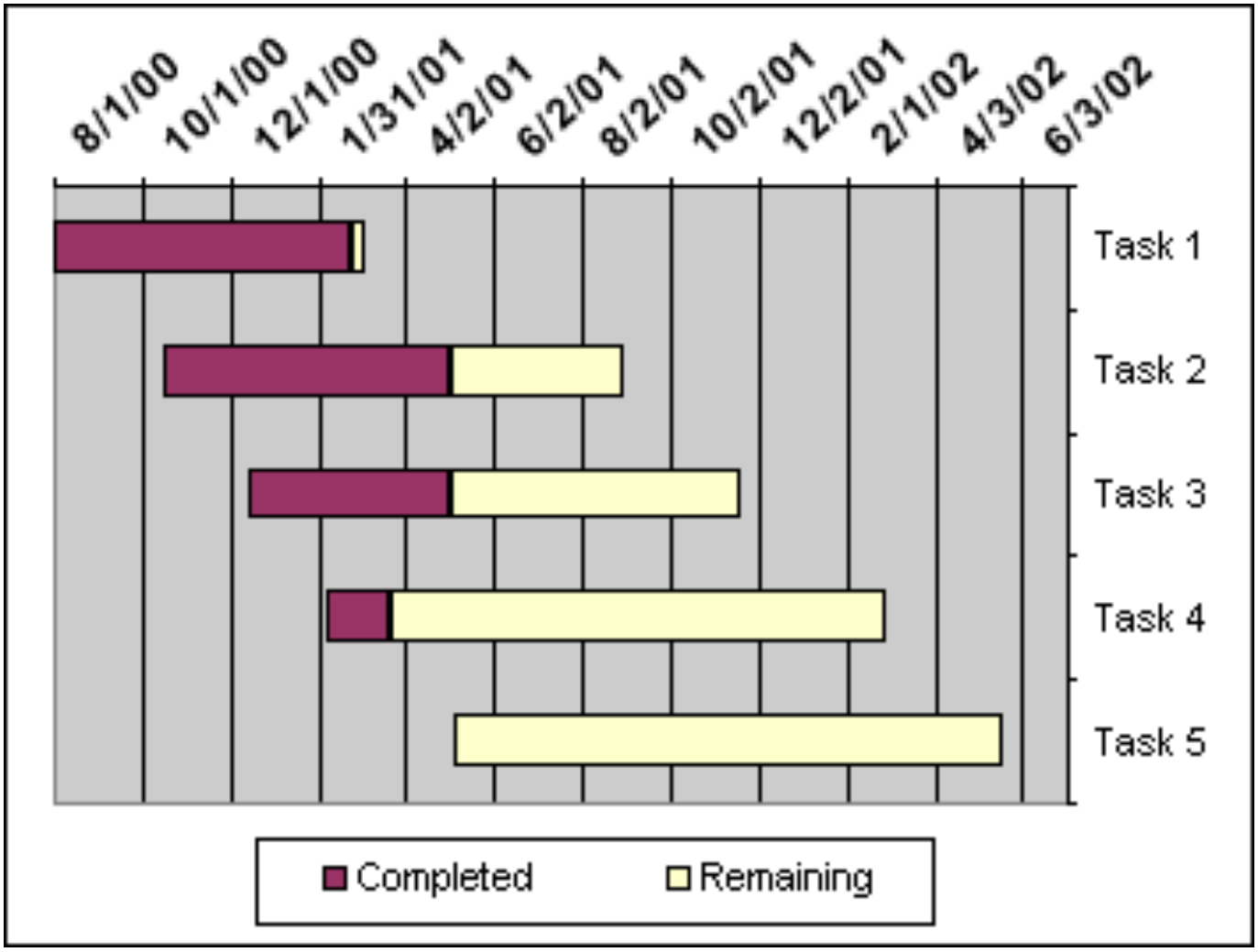
Critical Path Method, Gantt charts, Activity bar charts, etc.

- Build a work-plan from activity data.
- Display work-plan in graphical or tabular form.

Project planning software (e.g., Microsoft Project)

- Maintain a database of activities and related data
- Calculate and display schedules
- Manage progress reports

A Simple Gantt Chart



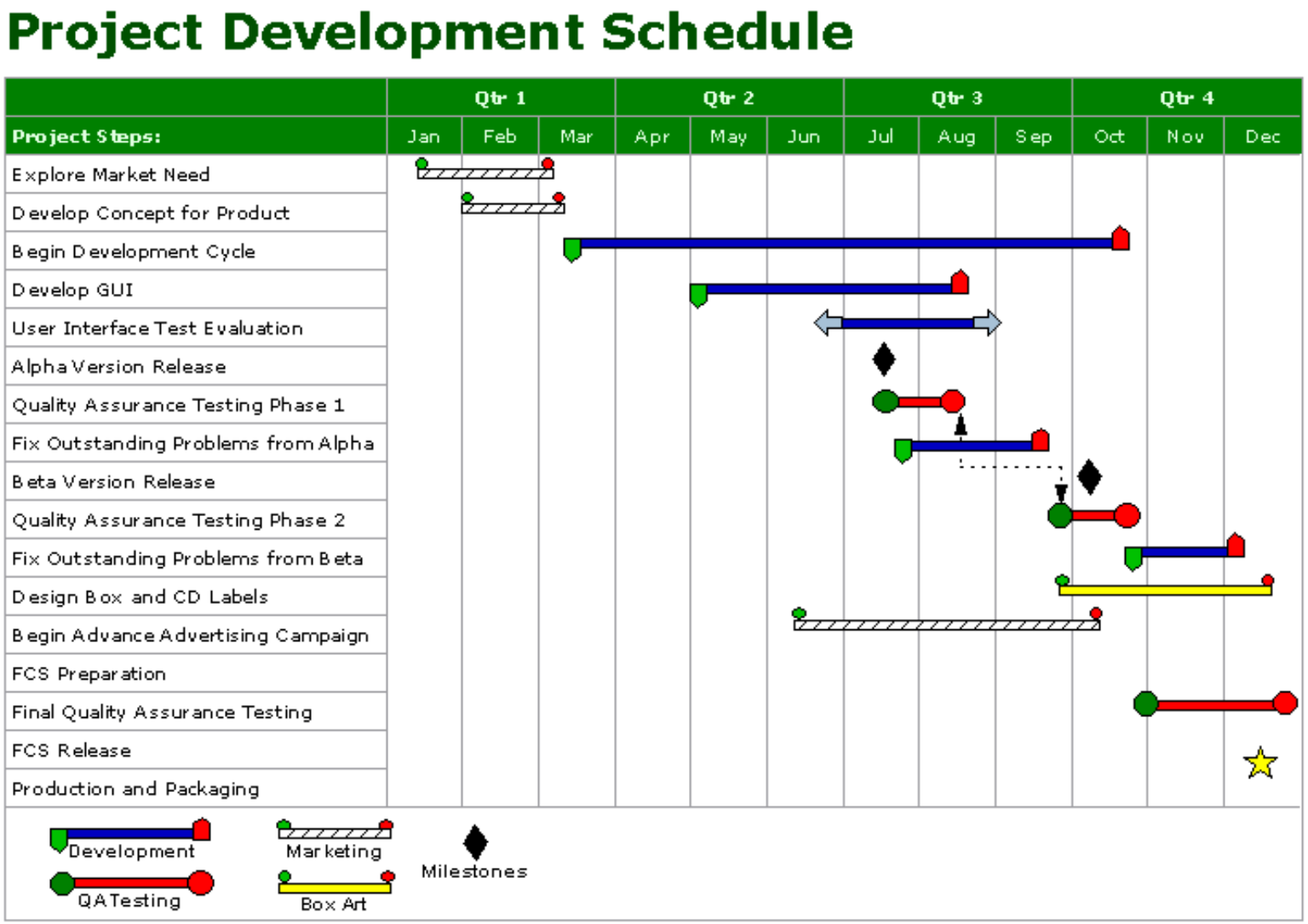
Source: Microsoft using Excel

Gantt Charts

Used for small projects, single time-boxes, and sprints

- Dates run along the top (days, weeks, or months).
- Each row represents an activity. Activities may be sequential, in parallel or overlapping.
- The schedule for an activity is a horizontal bar. The left end marks the planned beginning of the task. The right end marks the expected end date.
- The chart is updated by filling in each activity to a length proportional to the work accomplished.
- Progress to date can be compared with the plan by drawing a vertical line through the chart at the current date.

A More Complex Gantt Chart



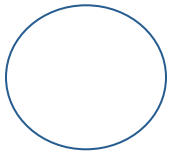
Source: SmartDraw

Activity Graph

A group of scheduling techniques that emphasizes dependencies

An activity (task)

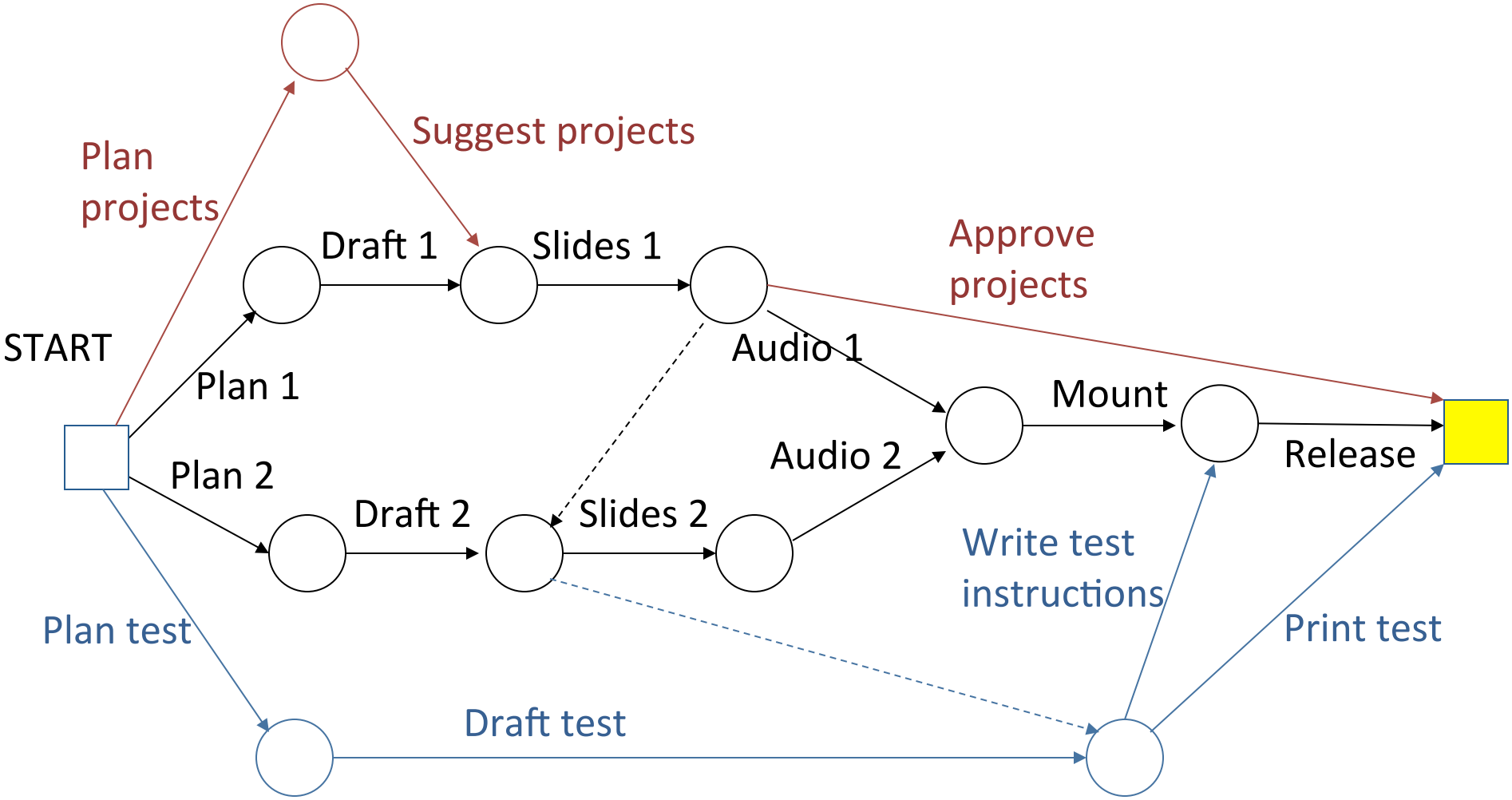
A dummy activity (dependency)



An event

A milestone

Example: Activity Graph for first Part of a Distance Learning Course



Scheduling using Activity Graphs: History

PERT

Program Evaluation and Review Technique introduced by the U.S. Navy in 1957 to support the development of its Polaris submarine missile program.

PERT/Time

Activity graph with three time estimates (shortest, most probable, longest) on each activity to compute schedules.

Because of the difficulty of obtaining good time estimates, usually only one estimate is made. This is called the **Critical Path Method.**

PERT/Cost

Added scheduling of resources (e.g., facilities, skilled people, etc.)

Critical Path Method

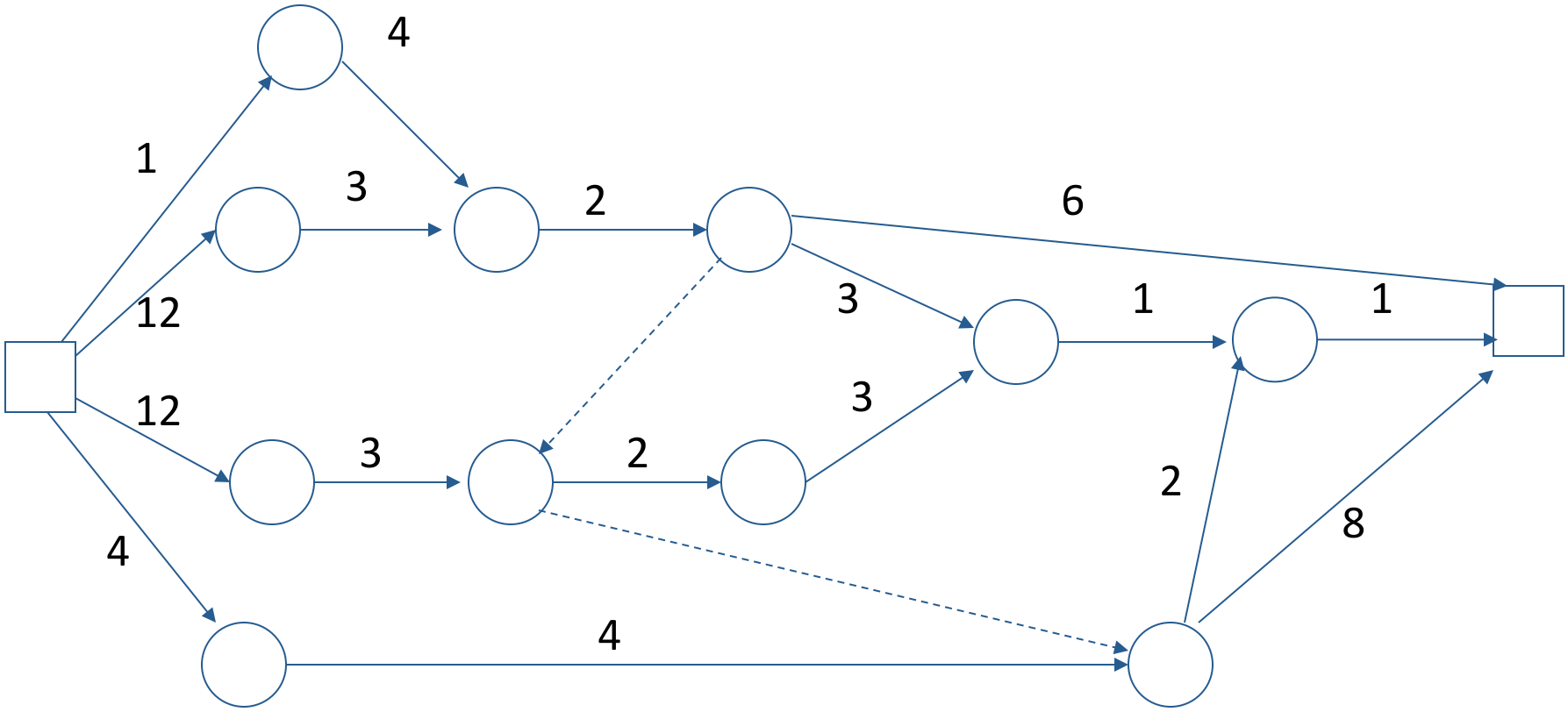
Uses an **Activity Graph** with single time estimate for each activity.

A standard method for managing large construction projects.

On big projects, activity graphs with more than 10,000 activities are common.

The following slides work through the calculations in using the critical path method for the example.

Time Estimates for Activities (Weeks)



Earliest Event Dates and Earliest Start Dates

Earliest start date: the earliest date that it is possible to start an activity.

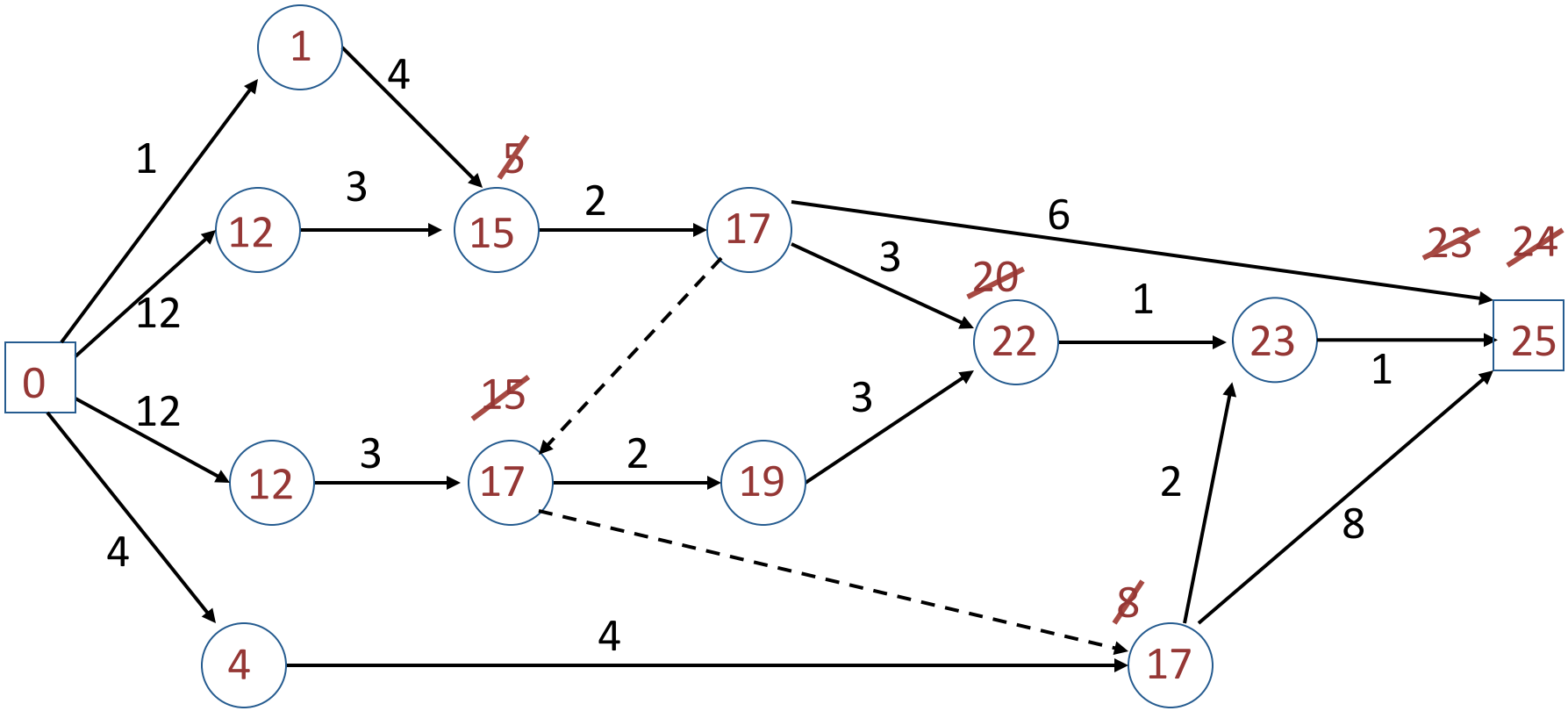
Earliest event date: the date that all the activities ending at that node will be completed, assuming that every activity begins at its earliest start date.

Earliest project completion date: the date on which the project is completed assuming that every activity begins on its earliest start date.

These calculations all depend on the dependencies represented by the activity graph and the accuracy of the estimates of the time to carry out the individual tasks.

Earliest Event Dates and Earliest Start Dates

Earliest dates for an event are in red



Latest Event Dates and Latest Start Dates

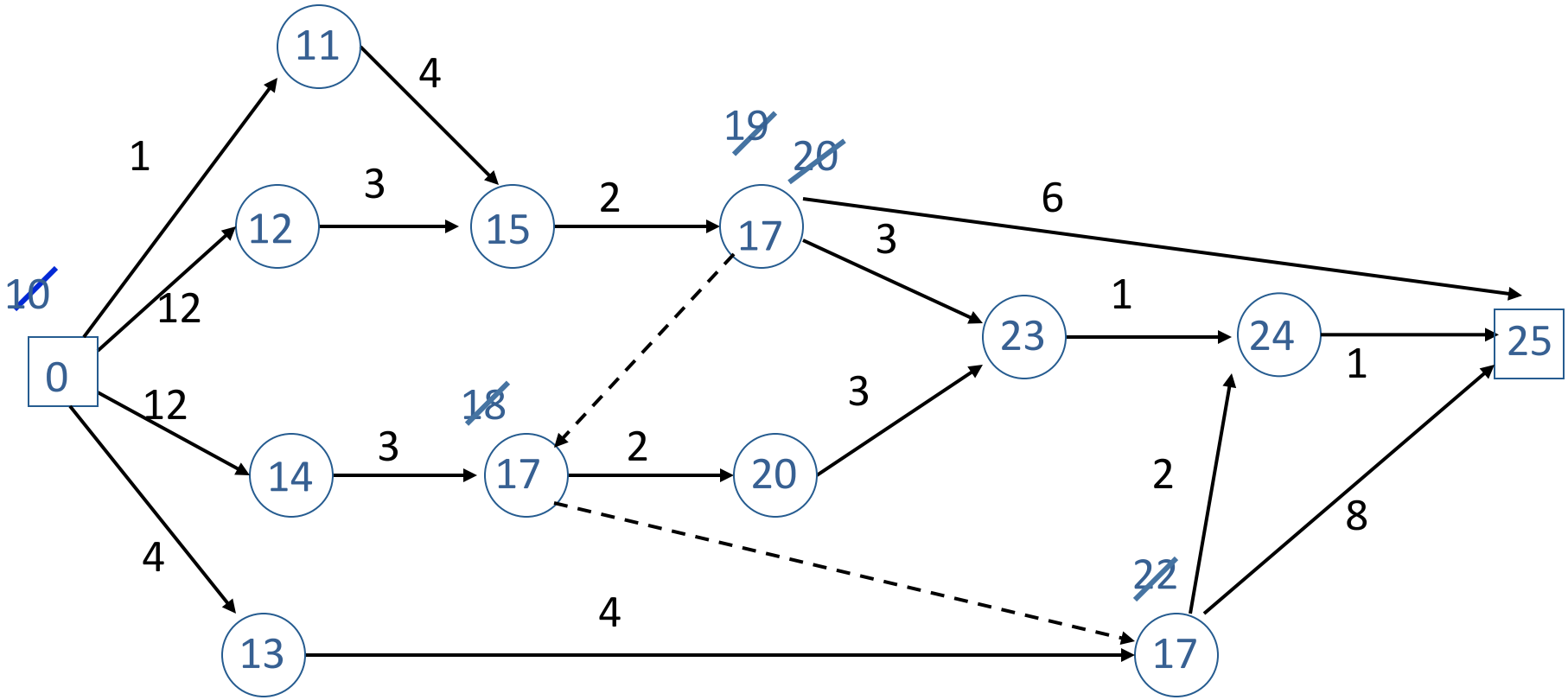
Latest start date: the latest date that it is possible to start an activity and still complete the project by the earliest project completion date.

Latest event date: the latest date that all the activities ending at that node must be completed, in order to complete the project by the earliest project completion date.

Latest Event Dates and Latest Start Dates

Latest event dates in blue

Each event must be achieved by the date shown or the final date will not be met.

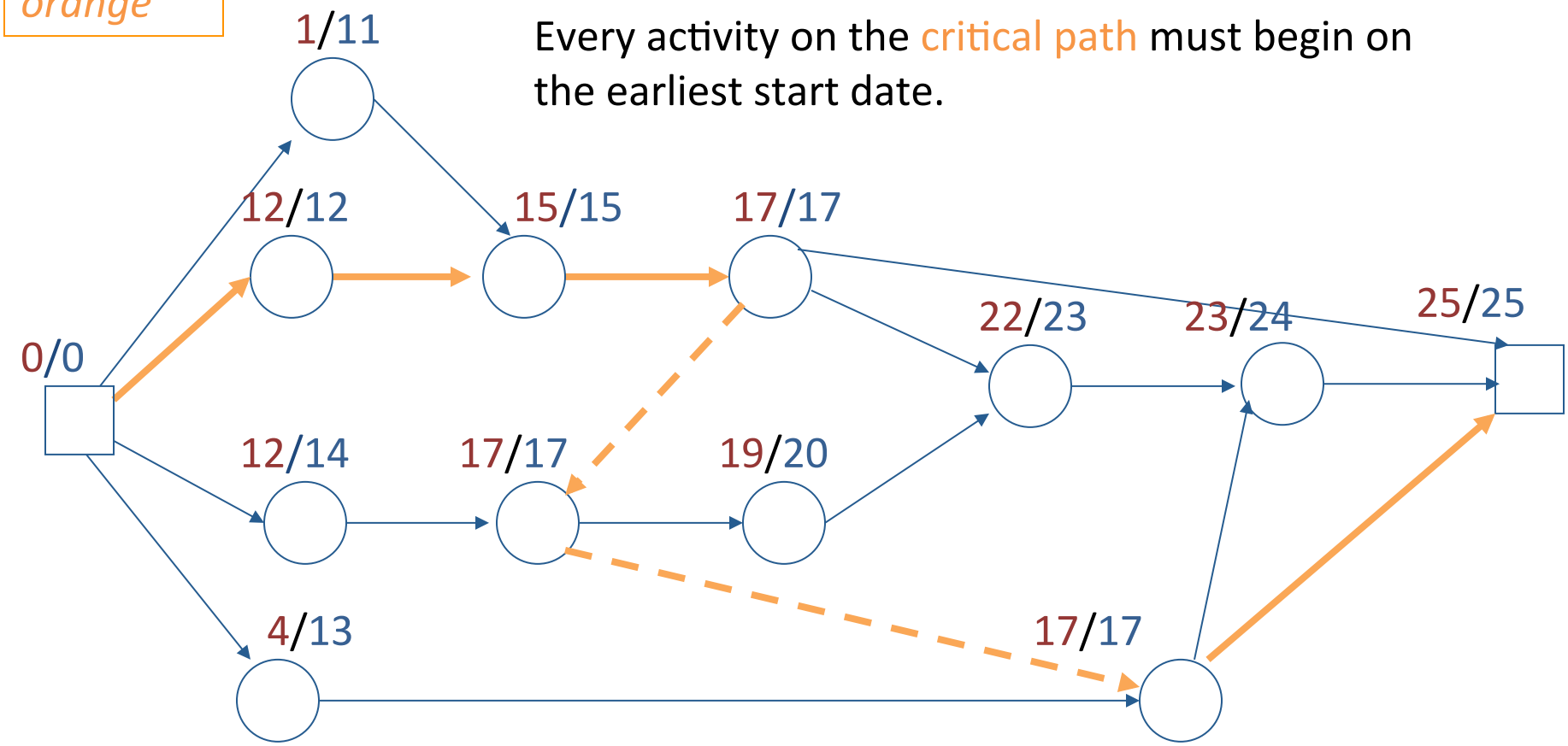


Critical Path

Critical path in orange

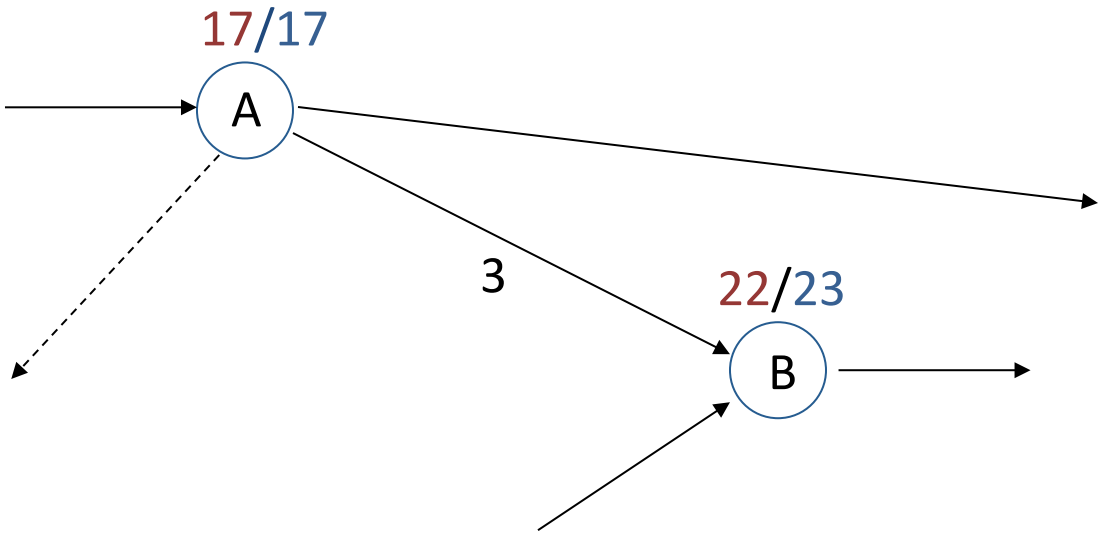
Events on the critical path have the earliest event date equal to the latest event date.

Every activity on the critical path must begin on the earliest start date.



Slack

Activities not on the critical path have **slack**.



The earliest start date for this activity is 17. It must be completed by week 23. Since its duration is 3 weeks, it can be started any time between week 17 and 20. This give a slack of 3 weeks.

Slack and Critical Path

Slack: the difference between the latest start date and the earliest start date of an activity

Slack = $(\text{latest event})_{\text{end}}$ - $(\text{earliest event})_{\text{begin}}$ - (time estimate)

Critical path: a path through the graph where every activity has zero slack

If an activity on the critical path is not started on its earliest start date or takes longer than the predicted time to complete, then the project completion date is delayed.

The earlier that a problem is known, the easier it is to fix.

Example

Purchase key item of equipment earlier than anticipated.

Adding Resources to Activity Graph or Gantt Chart

Each activity is labeled with resources, e.g.,

- Number of people (e.g., 2 Java programmers)
- Key personnel (e.g., chief system architect)
- Equipment (e.g., 3 servers with specified software)
- Facilities (e.g., video conference center)

Each resource is labeled with availability, e.g.,

- Hiring and training
- Vacations
- Equipment availability

Using Activity Graphs for Resources

Assume every activity begins at earliest start date:

In each time period, calculate:

- resources required
- resources available

Identify shortage / surplus resources

Adjust schedule

- acquire extra staff (e.g., consultants)
- rearrange schedule (e.g., change vacations)
- change order of carrying out activities

Key Personnel: The Mythical Man Month

In computing, not all people are equal

- The best are at least five times more productive.
- Some tasks are too difficult for everybody.

Adding more people adds communications complexity

- Some activities need a single mind.
- Sometimes, the elapsed time for an activity can not be shortened.
- Adding more people may increase the time to complete a project.

What happens to the project if a key person is sick or quits?

The Project Manager

- Create and maintain the schedule.
- Track progress against schedule.
- Keep some slack in the schedule (minimize risk).
- Continually make adjustments:

  Start activities before previous activity complete

  Sub-contract activities

  Renegotiate deliverables

- Keep senior management informed (visibility).

The project manager needs the support of the head of the development team and the confidence of the team members.