Object-Oriented Software Engineering

Practical Software Development using UML and Java

Chapter 11:
Managing the Software Process

11.1 What is Project Management?

Project management encompasses all the activities needed to plan and execute a project:

- Deciding what needs to be done
- Estimating costs
- Ensuring there are suitable people to undertake the project
- Defining responsibilities
- Scheduling
- Making arrangements for the work
- *continued ...*

What is Project Management?

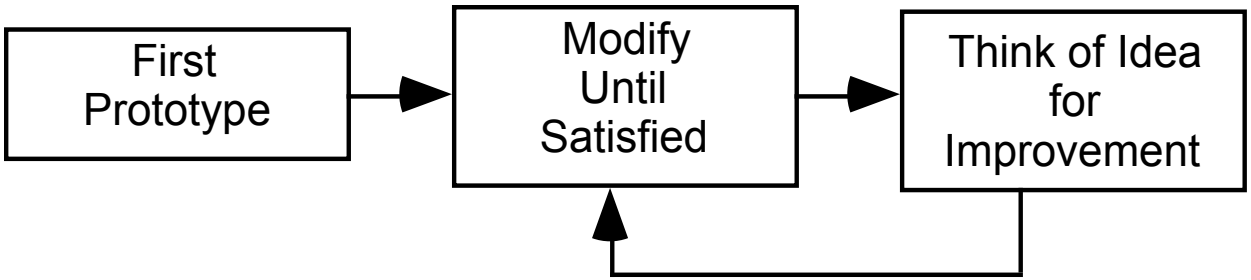
- Directing
- Being a technical leader
- Reviewing and approving decisions made by others
- Building morale and supporting staff
- Monitoring and controlling
- Co-ordinating the work with managers of other projects
- Reporting
- Continually striving to improve the process

11.2 Software Process Models

Software process models are general approaches for organizing a project into activities.

- Help the project manager and his or her team to decide:
  - —What work should be done;
  - —In what sequence to perform the work.
- The models should be seen as *aids to thinking*, not rigid prescriptions of the way to do things.
- Each project ends up with its own unique plan.

The Opportunistic Approach - A Bad Approach

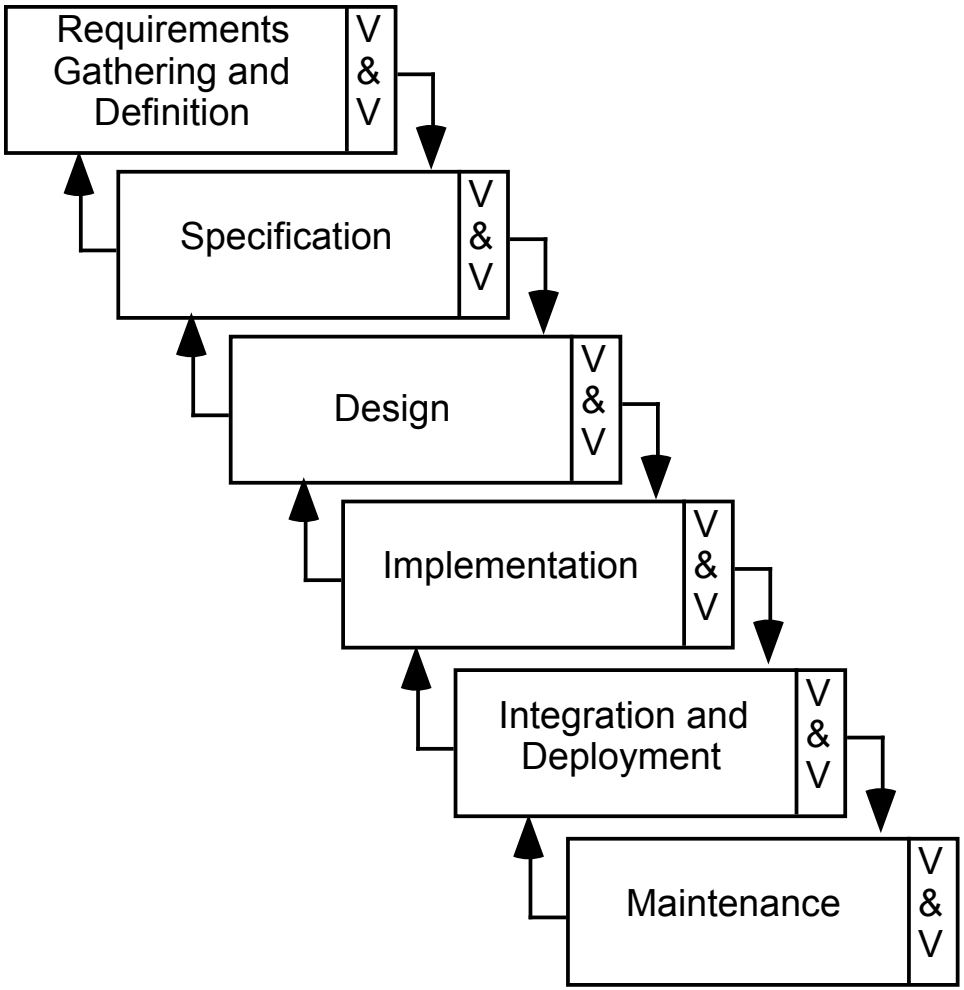


The Opportunistic Approach

… is what occurs when an organization does not follow good engineering practices.

- It does not acknowledge the importance of working out the requirements and the design before implementing a system.
- The design of software deteriorates faster if it is not well designed.
- Since there are no plans, there is nothing to aim towards.
- There is no explicit recognition of the need for systematic testing and other forms of quality assurance.
- The above problems make the cost of developing and maintaining software very high.

The Waterfall Model



The Waterfall Model - Positive Features

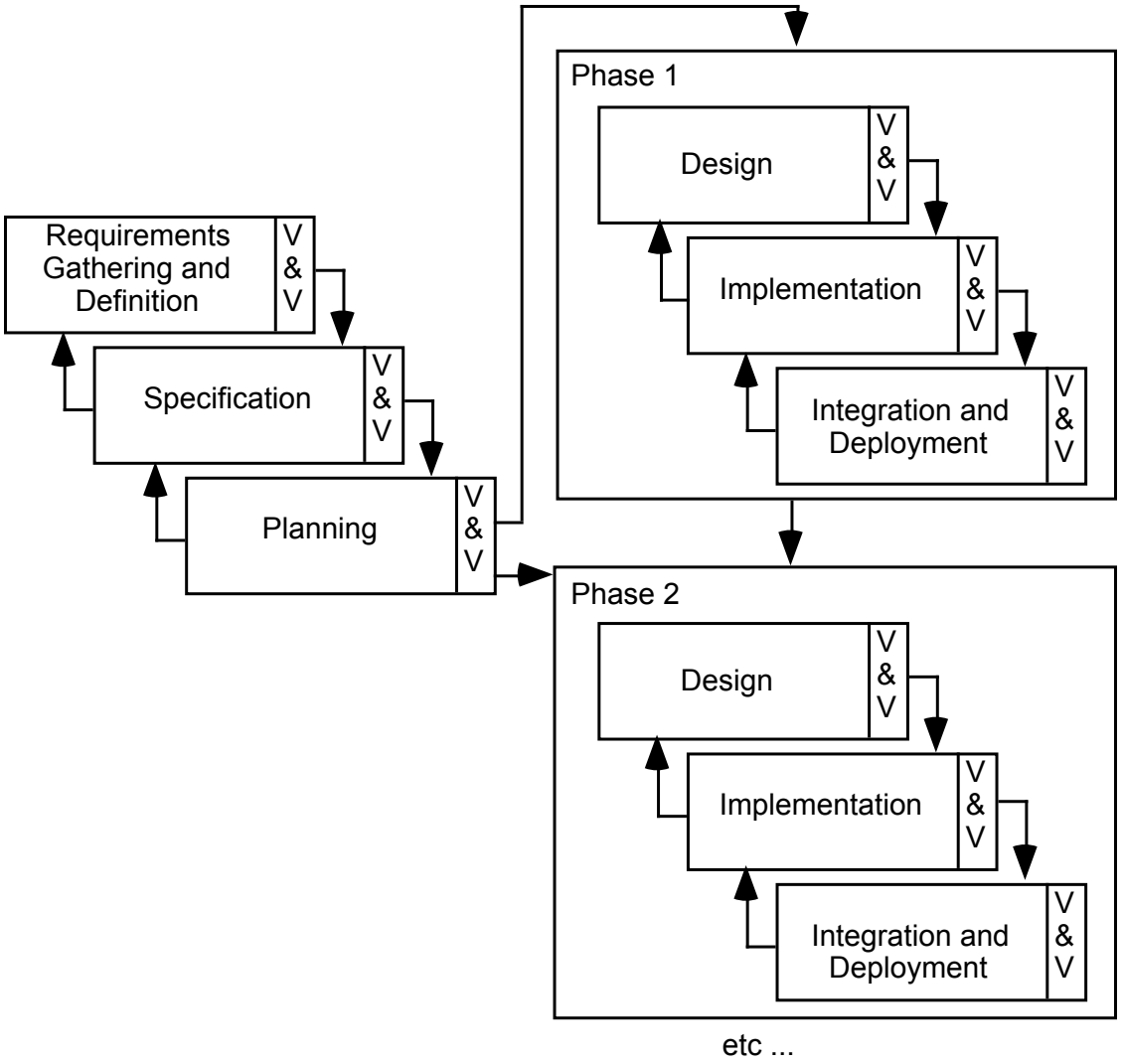
The classic way of looking at S.E. that accounts for the importance of requirements, design and quality assurance.

- The model suggests that software engineers should work in a series of stages.
- Before completing each stage, they should perform quality assurance (verification and validation).
- The waterfall model also recognizes, to a limited extent, that you sometimes have to step back to earlier stages.

Limitations of the Waterfall Model

- The model implies that you should attempt to complete a given stage before moving on to the next stage
  - —Does not account for the fact that requirements constantly change.
  - —It also means that customers can not use anything until the entire system is complete.
- The model makes no allowances for prototyping.
- It implies that you can get the requirements right by simply writing them down and reviewing them.
- The model implies that once the product is finished, everything else is maintenance.

The Phased-Release Model

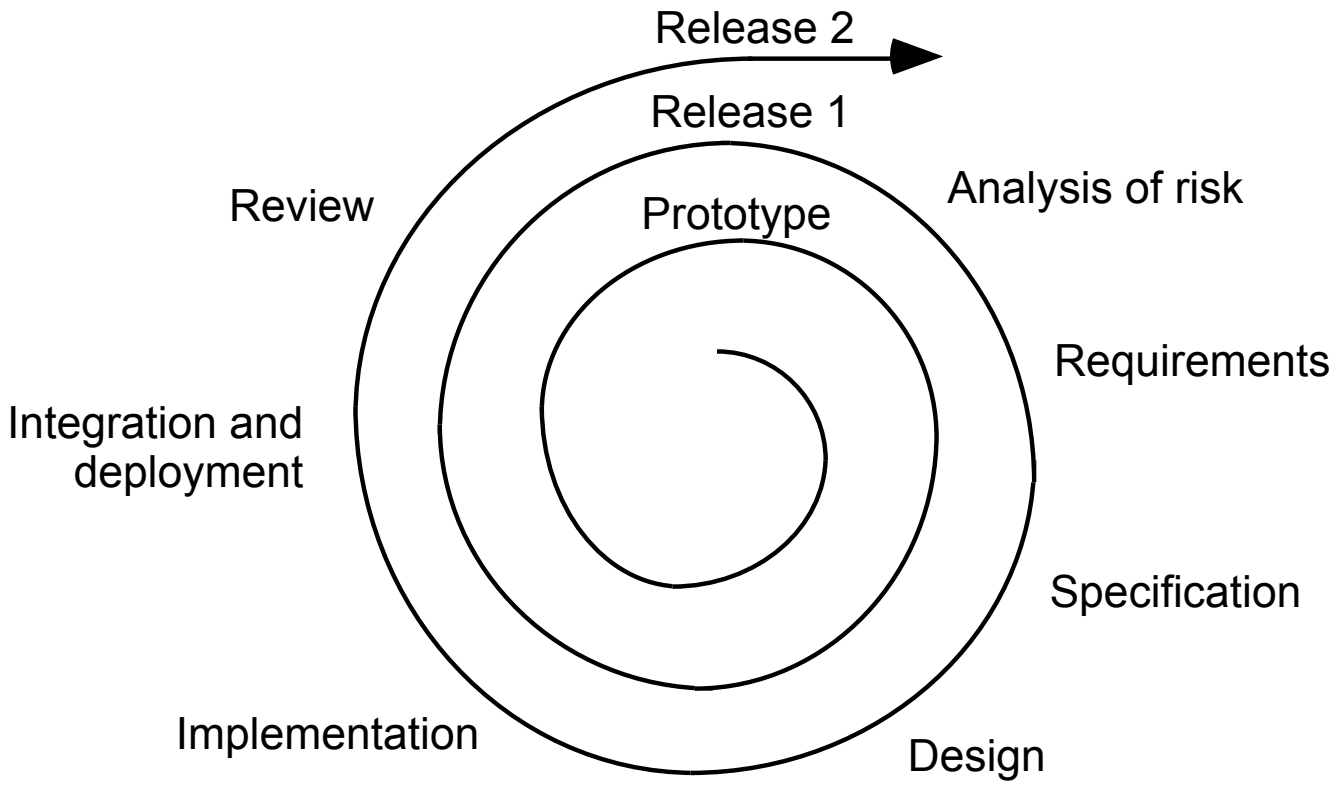


The Phased-Release Model - New Ideas

It introduces the notion of *incremental* development.

- After requirements gathering and planning, the project should be broken into separate subprojects, or *phases*.
- Each phase can be released to customers when ready.
- Parts of the system will be available earlier than when using a strict waterfall approach.
- However, it continues to suggest that all requirements be finalized at the start of development.

The Spiral Model

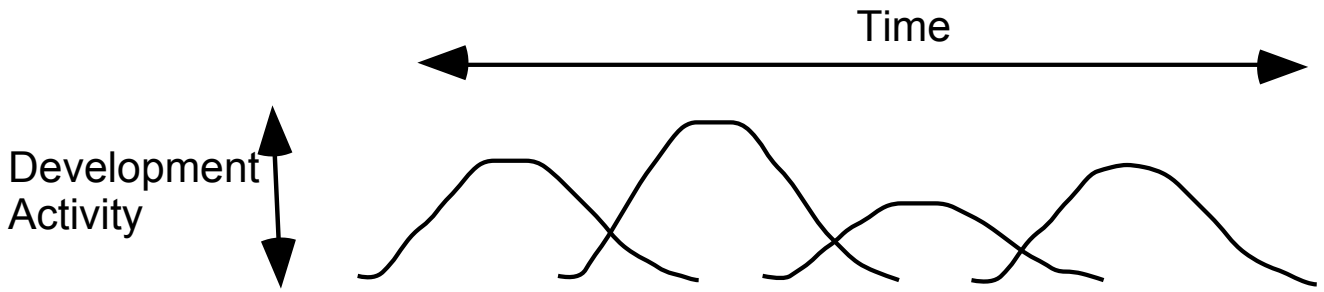


The Spiral Model - New Ideas

It explicitly embraces prototyping and an *iterative* approach to software development.

- Start by developing a small prototype.
- Followed by a mini-waterfall process, primarily to gather requirements.
- Then, the first prototype is reviewed.
- In subsequent loops, the project team performs further requirements, design, implementation and review.
- The first thing to do before embarking on each new loop is risk analysis.
- Maintenance is simply a type of on-going development.

The Evolutionary Model

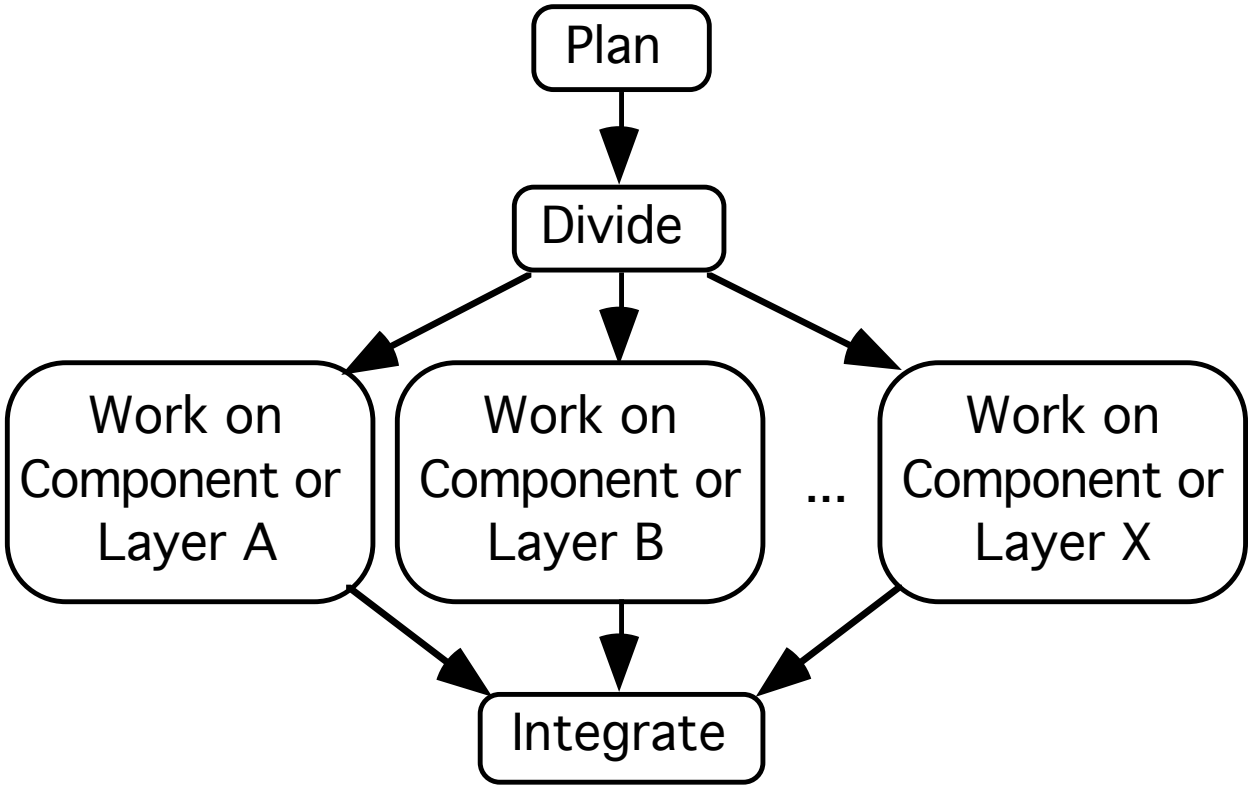


The Evolutionary Model - New Ideas

It shows software development as a series of hills, each representing a separate loop of the spiral.

- Shows that loops, or releases, tend to overlap each other.
- Makes it clear that development work tends to reach a peak, at around the time of the deadline for completion.
- Shows that each prototype or release can take
  - —different amounts of time to deliver;
  - —differing amounts of effort.

The Concurrent Engineering Model



The Concurrent Engineering Model - New Ideas

It explicitly accounts for the divide and conquer principle.

- Each team works on its own component, typically following a spiral or evolutionary approach.
- There has to be some initial planning, and periodic integration.

Choosing a Process Model

- From the waterfall model:
  - —Incorporate the notion of stages.
- From the phased-release model:
  - —Incorporate the notion of doing some initial high-level analysis, and then dividing the project into releases.
- From the spiral model:
  - —Incorporate prototyping and risk analysis.
- From the evolutionary model:
  - —Incorporate the notion of varying amounts of time and work, with overlapping releases.
- From concurrent engineering:
  - —Incorporate the notion of breaking the system down into components and developing them in parallel.

Reengineering

Periodically project managers should set aside some time to re-engineer part or all of the system

- The extent of this work can vary considerably:
  - —Cleaning up the code to make it more readable.
  - —Completely replacing a layer.
  - —*Re-factoring* part of the design.
- In general, the objective of a re-engineering activity is to increase maintainability.

11.3 Cost Estimation

To estimate how much software-engineering time will be required to do some work.

- *Elapsed time*
  - —The difference in time from the start date to the end date of a task or project.
- *Development effort*
  - —The amount of labour used in *person-months* or *person-days*.
  - —To convert an estimate of development effort to an amount of money:

    You multiply it by the *weighted average cost* (*burdened* cost) of employing a software engineer for a month (or a day).

Principles of Effective Cost Estimation 1

Principle 1: Divide and conquer.

- To make a better estimate, you should divide the project up into individual subsystems.
- Then divide each subsystem further into the activities that will be required to develop it.
- Next, you make a series of detailed estimates for each individual activity.
- And sum the results to arrive at the grand total estimate for the project.

Principles of Effective Cost Estimation 2

Principle 2: Include all activities when making estimates.

- The time required for *all* development activities must be taken into account.
- Including:
  - Prototyping
  - Design
  - Inspecting
  - Testing
  - Debugging
  - Writing user documentation
  - Deployment.

Principles of Effective Cost Estimation 3

Principle 3: Base your estimates on past experience combined with knowledge of the current project.

- If you are developing a project that has many similarities with a past project:
  - You can expect it to take a similar amount of work.
- Base your estimates on the *personal judgement* of your experts

  or
- Use *algorithmic models* developed in the software industry as a whole by analyzing a wide range of projects.
  - They take into account various aspects of a project's size and complexity, and provide formulas to compute anticipated cost.

Algorithmic Models

Allow you to systematically estimate development effort.

- Based on an estimate of some other factor that you can measure, or that is easier to estimate:
  - —The number of use cases
  - —The number of distinct requirements
  - —The number of classes in the domain model
  - —The number of widgets in the prototype user interface
  - —An estimate of the number of lines of code

Algorithmic Models

- A typical algorithmic model uses a formula like the following:
  - —COCOMO:

$$E = a + bN^c$$

  - —Functions Points:

$$S = W_1F_1 + W_2F_2 + W_3F_3 + \ldots$$

Principles of Effective Cost Estimation 4

Principle 4: Be sure to account for *differences* when extrapolating from other projects.

- Different software developers
- Different development processes and maturity levels
- Different types of customers and users
- Different schedule demands
- Different technology
- Different technical complexity of the requirements
- Different domains
- Different levels of requirement stability

Principles of Effective Cost Estimation 5

Principle 5: Anticipate the worst case and plan for contingencies.

- **Develop the most critical use cases first**
  - **If the project runs into difficulty, then the critical features are more likely to have been completed**
- **Make three estimates:**
  - **Optimistic (O)**
    - **Imagining a everything going perfectly**
  - **Likely (L)**
    - **Allowing for typical things going wrong**
  - **Pessimistic**
    - **Accounting for everything that could go wrong**

Principles of Effective Cost Estimation 6

Principle 6: Combine multiple independent estimates.

- Use several different techniques and compare the results.
- If there are discrepancies, analyze your calculations to discover what factors causing the differences.
- Use the Delphi technique.
  - —Several individuals initially make cost estimates in private.
  - —They then share their estimates to discover the discrepancies.
  - —Each individual repeatedly adjusts his or her estimates until a consensus is reached.

Principles of Effective Cost Estimation 7

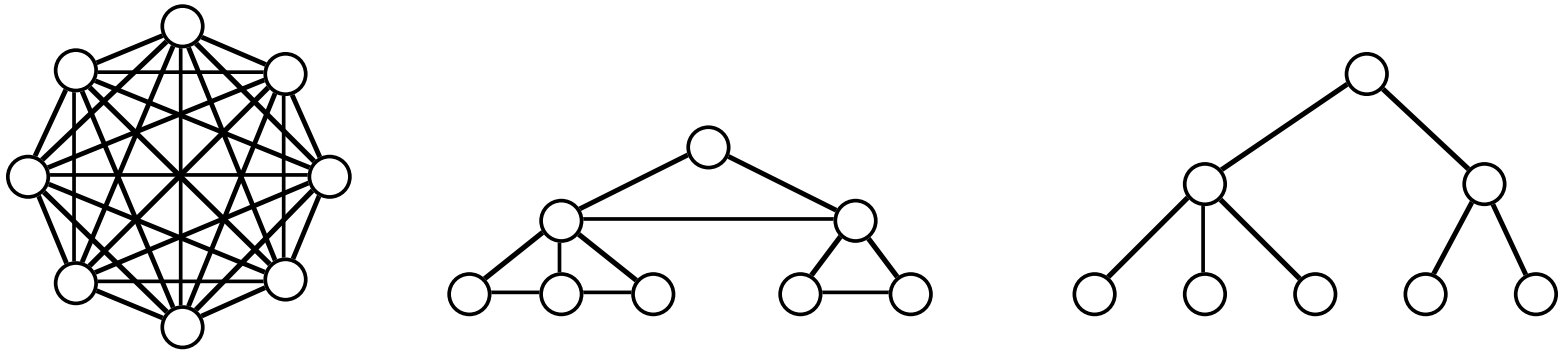
Principle 7: Revise and refine estimates as work progresses

- As you add detail.
- As the requirements change.
- As the risk management process uncovers problems.

11.4 Building Software Engineering Teams

Software engineering is a human process.

- Choosing appropriate people for a team, and assigning roles and responsibilities to the team members, is therefore an important project management skill
- Software engineering teams can be organized in many different ways



a) Egoless b) Chief programmer c) Strict hierarchy

Software Engineering Teams

Egoless team:

- In such a team everybody is equal, and the team works together to achieve a common goal.
- Decisions are made by consensus.
- Most suited to difficult projects with many technical challenges.

Software Engineering Teams

Hierarchical manager-subordinate structure:

- Each individual reports to a manager and is responsible for performing the tasks delegated by that manager.
- Suitable for large projects with a strict schedule where everybody is well-trained and has a well-defined role.
- However, since everybody is only responsible for their own work, problems may go unnoticed.

Software Engineering Teams

Chief programmer team:

- Midway between egoless and hierarchical.
- The chief programmer leads and guides the project.
- He or she consults with, and relies on, individual specialists.

Choosing an Effective Size for a Team

- For a given estimated development effort, in person months, there is an optimal team size.
  - —Doubling the size of a team will not halve the development time.
- Subsystems and teams should be sized such that the total amount of required knowledge and exchange of information is reduced.
- For a given project or project iteration, the number of people on a team will not be constant.
- You can not generally add people if you get behind schedule, in the hope of catching up.

Skills Needed on a Team

- Architect
- Project manager
- Configuration management and build specialist
- User interface specialist
- Technology specialist
- Hardware and third-party software specialist
- User documentation specialist
- Tester

11.5 Project Scheduling and Tracking

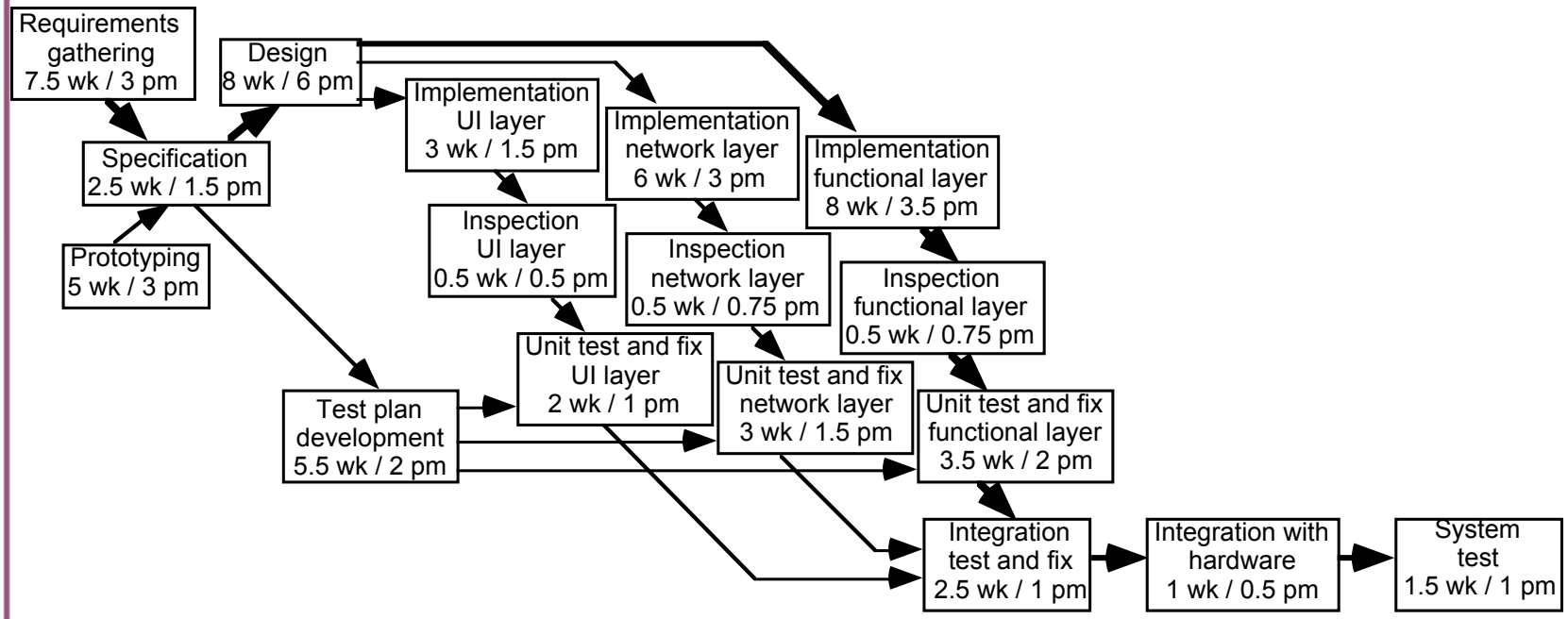
- *Scheduling* is the process of deciding:
  - —In what sequence a set of activities will be performed.
  - —When they should start and be completed.
- *Tracking* is the process of determining how well you are sticking to the cost estimate and schedule.

PERT Charts

A PERT chart shows the sequence in which tasks must be completed.

- In each node of a PERT chart, you typically show the elapsed time and effort estimates.
- The *critical path* indicates the minimum time in which it is possible to complete the project.

Example of a PERT Chart

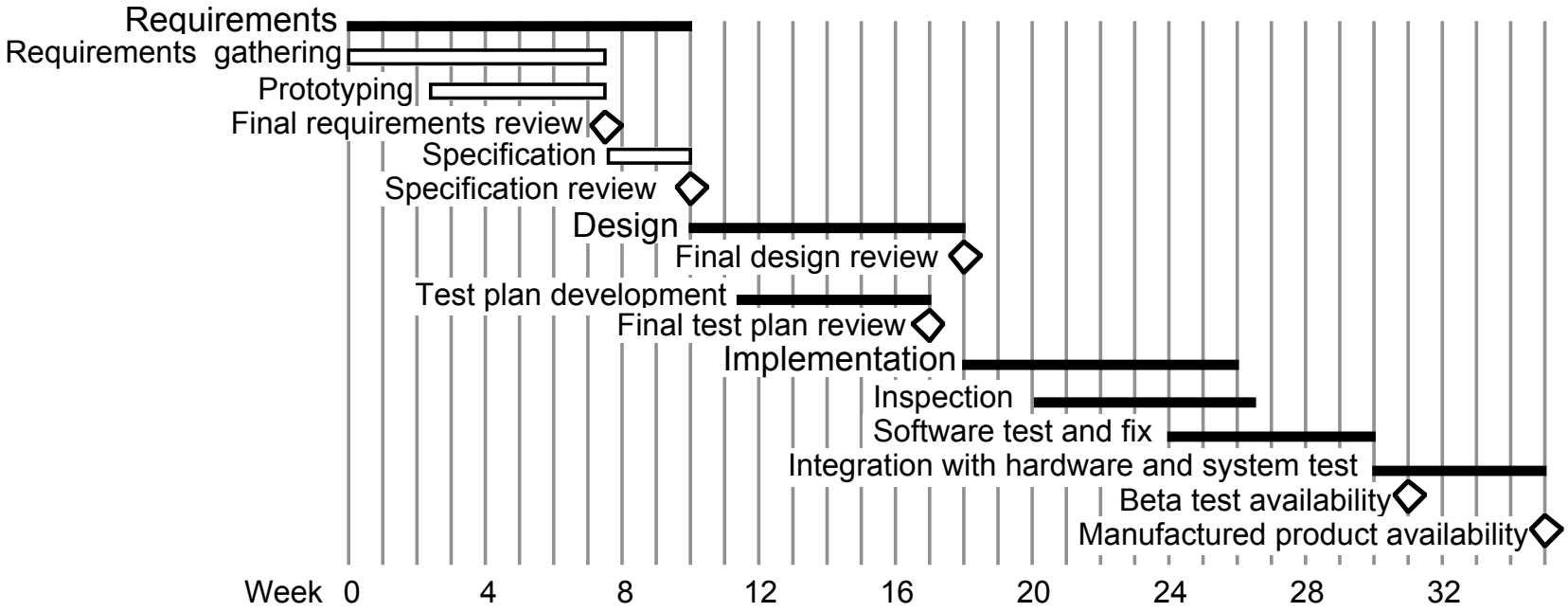


Gantt Charts

A Gantt chart is used to graphically present the start and end dates of each software engineering task

- One axis shows time.
- The other axis shows the activities that will be performed.
- The black bars are the top-level tasks.
- The white bars are subtasks
- The diamonds are *milestones:*
  - —Important deadline dates, at which specific events may occur

Example of a Gantt Chart



Earned Value

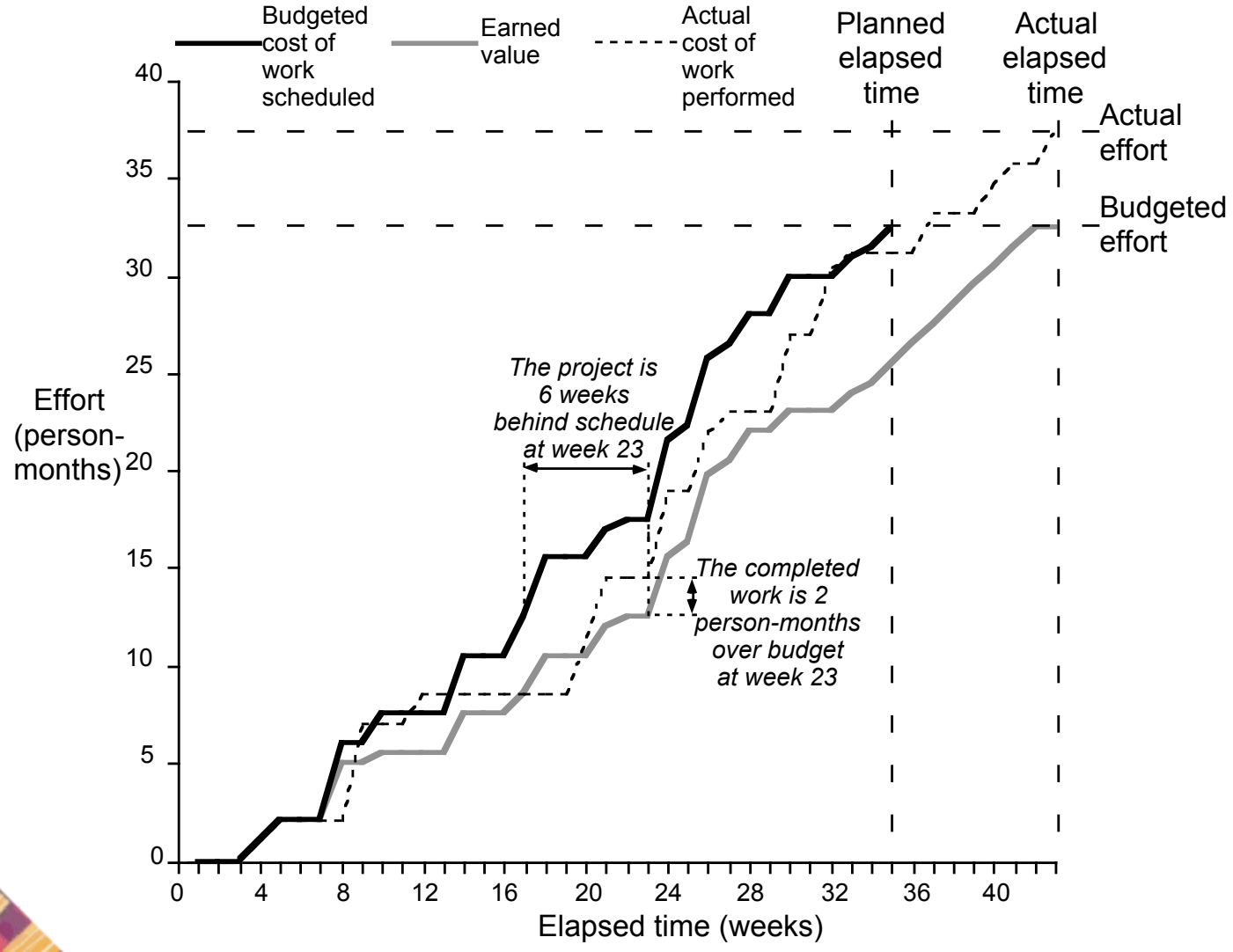
- *Earned value* is the amount of work completed, measured according to the *budgeted* effort that the work was supposed to consume.
- It is also called the *budgeted cost of work performed*.
- As each task is completed, the number of person-months originally planned for that task is added to the earned value of the project.

Earned Value Charts

An earned value chart has three curves:

- The budgeted cost of the work scheduled.
- The earned value.
- The actual cost of the work performed so far.

Example of an Earned Value Chart



11.6 Contents of a Project Plan

A. **Purpose**
B. **Background information**
C. **Processes to be used**
D. **Subsystems and planned releases**
E. **Risks and challenges**
F. **Tasks**
G. **Cost estimates**
H. **Team**
I. **Schedule and milestones**

11.7 Difficulties and Risks in Project Management

- **Accurately estimating costs is a constant challenge**
  - —*Follow the cost estimation guidelines.*
- **It is very difficult to measure progress and meet deadlines**
  - —*Improve your cost estimation skills so as to account for the kinds of problems that may occur.*
  - —*Develop a closer relationship with other members of the team.*
  - —*Be realistic in initial requirements gathering, and follow an iterative approach.*
  - —*Use earned value charts to monitor progress.*

Difficulties and Risks in Project Management

- **It is difficult to deal with lack of human resources or technology needed to successfully run a project**
  - —*When determining the requirements and the project plan, take into consideration the resources available.*
  - —*If you cannot find skilled people or suitable technology then you must limit the scope of your project.*

Difficulties and Risks in Project Management

- **Communicating effectively in a large project is hard**
  - —*Take courses in communication, both written and oral.*
  - —*Learn how to run effective meetings.*
  - —*Review what information everybody should have, and make sure they have it.*
  - —*Make sure that project information is readily available.*
  - —*Use 'groupware' technology to help people exchange the information they need to know*

Difficulties and Risks in Project Management

- **It is hard to obtain agreement and commitment from others**
  - —*Take courses in negotiating skills and leadership.*
  - —*Ensure that everybody understands*
    - *The position of everybody else.*
    - *The costs and benefits of each alternative.*
    - *The rationale behind any compromises.*
  - —*Ensure that everybody's proposed responsibility is clearly expressed.*
  - —*Listen to everybody's opinion, but take assertive action, when needed, to ensure progress occurs.*