Chapter 23 – Project planning

Topics covered

- √ Project planning
- √ Software pricing
- √ Plan-driven development
- √ Project scheduling
- ✧ Agile planning
- ✧ Estimation techniques
- ✧ COCOMO cost modeling

Agile planning

Agile planning

- Agile methods of software development are **iterative** approaches where the software is developed and **delivered to customers in increments**.
- Unlike plan-driven approaches, **the functionality of these increments is not planned in advance** but is decided during the development.
  - The decision on what to include in an increment depends on **progress** and on the **customer's priorities**.
- The customer's priorities and requirements change so it makes sense to have a flexible plan that can accommodate these changes.

Agile planning stages

- **Release planning**, which looks ahead for several months and decides on the features that should be included in a release of a system.
- **Iteration planning**, which has a shorter term outlook, and focuses on planning the next increment of a system. This is typically 2-4 weeks of work for the team.

Approaches to agile planning

- Planning in **Scrum**
  - Covered in Chapter 3
- Based on managing a **project backlog** (things to be done) with daily reviews of progress and problems
- **The planning game**
  - Developed originally as part of Extreme Programming (XP)
  - Dependent on user stories as a measure of progress in the project

Story-based planning

- The planning game is based on user stories that reflect the features that should be included in the system.
- The project team read and discuss the stories and rank them in order of the amount of time they think it will take to implement the story.
- Stories are assigned ‘effort points’ reflecting their size and difficulty of implementation
- The number of **effort points** implemented per day is measured giving an estimate of the team’s ‘velocity’
- This allows the total effort required to implement the system to be estimated

The planning game

Release and iteration planning

- Release planning involves selecting and refining the stories that will reflect the features to be implemented in a release of a system and the order in which the stories should be implemented.
- Stories to be implemented in each iteration are chosen, with the number of stories reflecting the time to deliver an iteration (usually 2 or 3 weeks).
- The **team's velocity** is used to guide the choice of stories so that they can be delivered within an iteration.

Task allocation

- During the task planning stage, the developers break down stories into development tasks.
  - A development task should take 4–16 hours.
  - All of the tasks that must be completed to implement all of the stories in that iteration are listed.
  - The individual developers then sign up for the specific tasks that they will implement.
- Benefits of this approach:
  - The whole team gets an overview of the tasks to be completed in an iteration.
  - Developers have a sense of **ownership** in these tasks and this is likely to motivate them to complete the task.

Software delivery

- A software increment is always delivered at the end of each project iteration.
- If the features to be included in the increment cannot be completed in the time allowed, the scope of the work is reduced.
- The delivery schedule is never extended.

Agile planning difficulties

- Agile planning is **dependent on customer involvement and availability.**
- This can be difficult to arrange, as customer representatives sometimes have to prioritize other work and are not available for the planning game.
- Furthermore**, some customers** may be more familiar with **traditional project plans** and may find it difficult to engage in an agile planning process.

Agile planning applicability

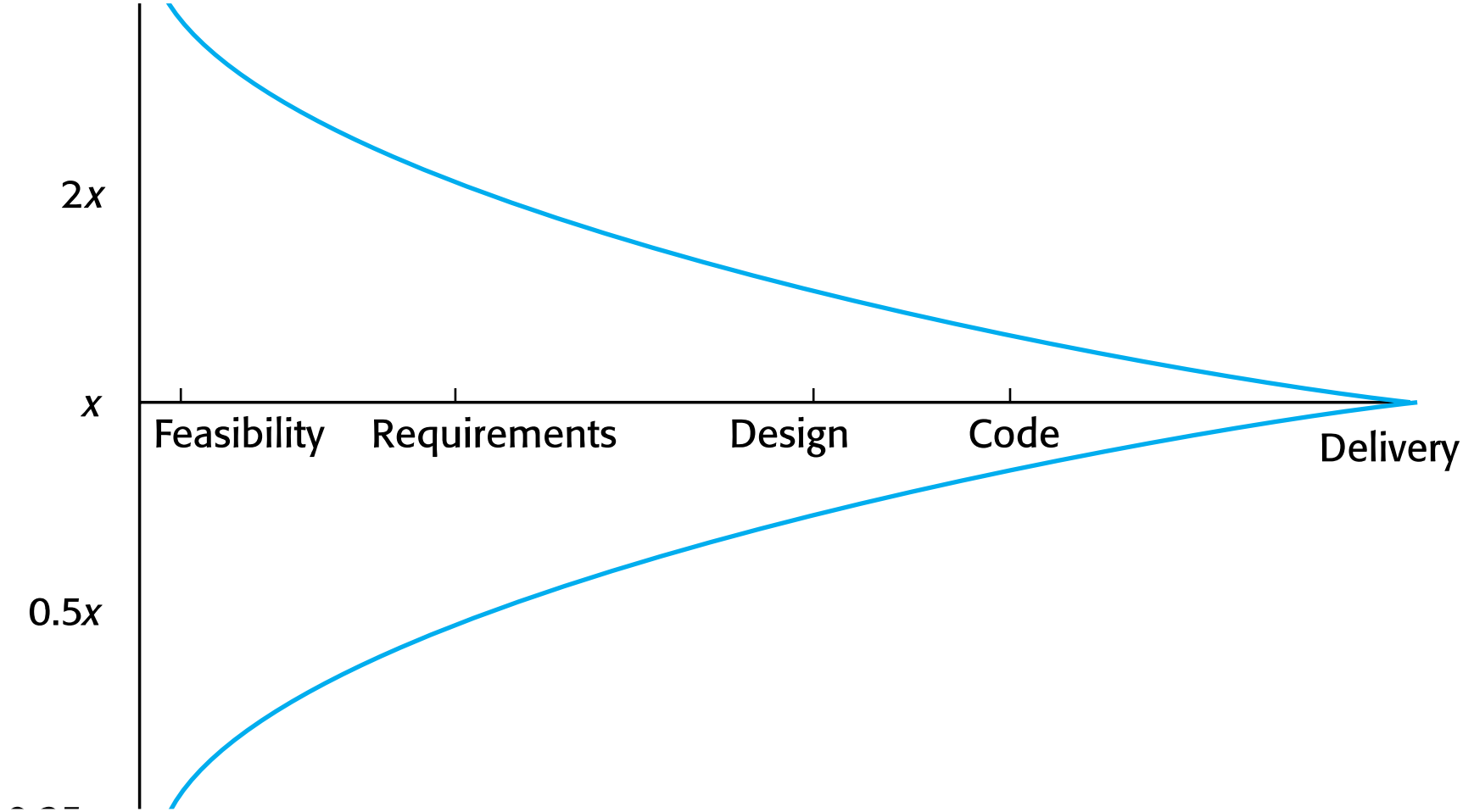
- Agile planning works well with **small**, **stable development teams** that can get together and discuss the stories to be implemented.
- However, where teams are large and/or geographically distributed, or when team membership changes frequently, **it is practically impossible for everyone to be involved in the collaborative** planning that is essential for agile project management.

Estimation techniques

Estimation techniques

- Organizations need to make software effort and cost estimates. There are two types of technique that can be used to do this:
  - ***Experience-based techniques*** The estimate of future effort requirements is based on the manager's experience of past projects and the application domain. Essentially, the manager makes an informed judgment of what the effort requirements are likely to be.
  - ***Algorithmic cost modeling*** In this approach, a formulaic approach is used to compute the project effort based on estimates of product attributes, such as size, and process characteristics, such as experience of staff involved.

Estimate uncertainty



Experience-based approaches

- Experience-based techniques rely on judgments based on experience of past projects and the effort expended in these projects on software development activities.
- Typically, you identify the deliverables to be produced in a project and the different software components or systems that are to be developed.
- You document these in a spreadsheet, estimate them individually and compute the total effort required.
- It usually helps to get a group of people involved in the effort estimation and to ask each member of the group to explain their estimate.

Problem with experience-based approaches

- The **difficulty** with experience-based techniques is that a **new software project may not have much in common with previous projects.**
- **Software development changes very quickly** and a project will often use unfamiliar techniques such as web services, application system configuration or HTML5.
- If you have not worked with these techniques, your previous experience may not help you to estimate the effort required, making it more difficult to produce accurate costs and schedule estimates.

Algorithmic cost modelling

- Cost is estimated as a **mathematical** function of **product**, **project** and **process attributes** whose values are estimated by project managers:

$$\text{Effort} = A \times \text{Size}^{B} \times M$$

  - A is an organisation-dependent constant, B reflects the disproportionate effort for large projects and M is a multiplier reflecting product, process and people attributes.
- The most commonly used product attribute for cost estimation is **code size**.
- Most models are similar but they use different values for A, B and M.

Estimation accuracy

- The size of a software system can only be known accurately when it is finished.
- Several factors influence the final size
  - Use of reused systems and components;
  - Programming language;
  - Distribution of system.
- As the development process progresses then the size estimate becomes more accurate.
- The estimates of the factors contributing to B and M are **subjective and vary according to the judgment of the estimator.**

Effectiveness of algorithmic models

- Algorithmic cost models are a **systematic way** to estimate the effort required to develop a system. However, these models are complex and difficult to use.
- There are many attributes and considerable scope for uncertainty in estimating their values.
- This complexity means that the practical application of **algorithmic cost modeling has been limited to a relatively small number of large companies**, mostly working in defense and aerospace systems engineering.

COCOMO cost modeling

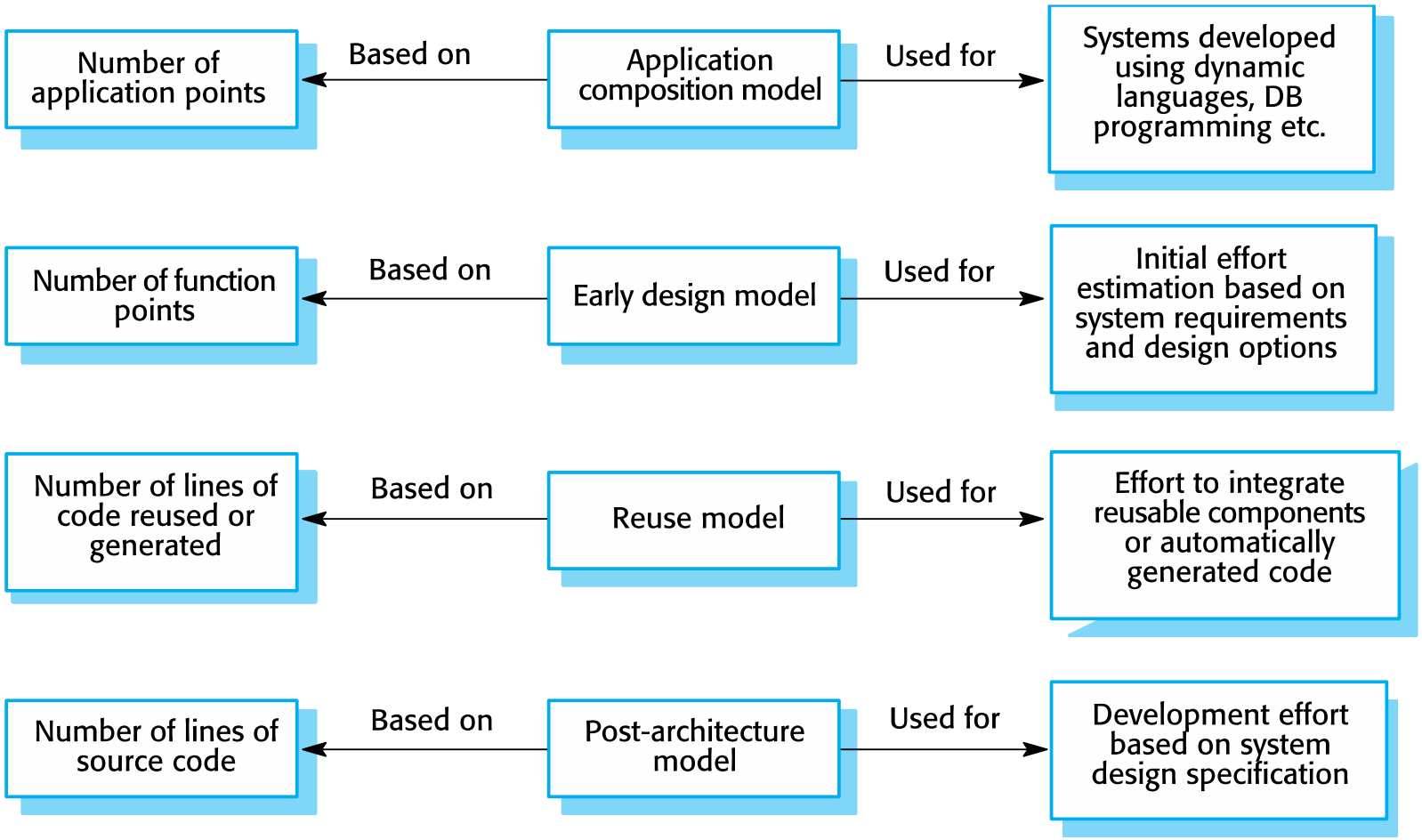
COCOMO cost modeling

- An **empirical** model based on project experience.
- Well-documented, '**independent**' model which is not tied to a specific software vendor.
- Long history from initial version published in 1981 (COCOMO-81) through various instantiations to COCOMO 2.
- COCOMO 2 takes into account different approaches to software development, reuse, etc.

COCOMO 2 models

- COCOMO 2 incorporates a range of **sub-models** that produce increasingly detailed software estimates.
- The sub-models in COCOMO 2 are:
  - Application composition model. Used when software is composed from existing parts.
  - Early design model. Used when requirements are available but design has not yet started.
  - Reuse model. Used to compute the effort of integrating reusable components.
  - Post-architecture model. Used once the system architecture has been designed and more information about the system is available.

COCOMO estimation models



Application composition model

- Supports prototyping projects and projects where there is extensive reuse.
- Based on standard estimates of developer productivity in application (object) points/month.
- Takes software tool use into account.
- Formula is
  - PM = (NAP ∗ (1 - %reuse/100)) / PROD
  - PM is the effort in person-months, NAP is the number of application points and PROD is the productivity.

Application-point productivity

Developer's experience and capability	Very low	Low	Nominal	High	Very high
ICASE maturity and capability	Very low	Low	Nominal	High	Very high
PROD (NAP/month)	4	7	13	25	50

Figure 23.11 shows the levels of application-point productivity suggested by the COCOMO model developers.

Early design model

- Estimates can be made after the requirements have been agreed.
- Based on a standard formula for algorithmic models
- $PM = A * Size^{B} * M$ where
  - M = PERS * RCPX * RUSE * PDIF * PREX * FCIL * SCED;
  - A = 2.94 in initial calibration,
  - Size in KLOC,
  - B varies from 1.1 to 1.24 depending on novelty of the project, development flexibility, risk management approaches and the process maturity.

Multipliers

- Multipliers reflect the capability of the developers, the non-functional requirements, the familiarity with the development platform, etc.
  - RCPX - product reliability and complexity;
  - RUSE - the reuse required;
  - PDIF - platform difficulty;
  - PREX - personnel experience;
  - PERS - personnel capability;
  - SCED - required schedule;
  - FCIL - the team support facilities.

The reuse model

- Takes into account black-box code that is reused without change and code that has to be adapted to integrate it with new code.
- There are two versions:
  - Black-box reuse where code is not modified. **(An effort estimate (PM) is computed).**
  - White-box reuse where code is modified. **(A size estimate equivalent to the number of lines of new source code is computed).** This then adjusts the size estimate for new code.

Reuse model estimates 1

- For generated code:
- PM = (ASLOC * AT/100)/ATPROD
  - ASLOC is the number of lines of generated code
  - AT is the percentage of code automatically generated.
  - ATPROD is the productivity of engineers in integrating this code.

Reuse model estimates 2

Three factors contribute to the effort involved in reusing white-box code components:

1. The effort involved in assessing whether or not a component could be reused in a system that is being developed.
2. The effort required to understand the code that is being reused.
3. The effort required to modify the reused code to adapt it and integrate it with the system being developed.

Reuse model estimates 2

✧ When code has to be understood and integrated

ESLOC = (ASLOC × (1-AT/100) × AAM)

ESLOC: the equivalent number of lines of new source code.

ASLOC: an estimate of the number of lines of code in the reused components that have to be changed.

AT: the percentage of reused code that can be modified automatically.

AAM: an Adaptation Adjustment Multiplier that reflects the additional effort required to reuse components.

Post-architecture level

- ✧ Uses the same formula as the early design model but with 17 rather than 7 associated multipliers.
- ✧ The code size is estimated as:
  - Number of lines of new code to be developed;
  - Estimate of equivalent number of lines of new code computed using the reuse model;
  - An estimate of the number of lines of code that have to be modified according to requirements changes.

Scale factors used in the exponent computation in the post-architecture model

Scale factor	Explanation
Architecture/risk resolution	Reflects the extent of risk analysis carried out. Very low means little analysis; extra-high means a complete and thorough risk analysis.
Development flexibility	Reflects the degree of flexibility in the development process. Very low means a prescribed process is used; extra-high means that the client sets only general goals.
Precedentedness	Reflects the previous experience of the organization with this type of project. Very low means no previous experience; extra-high means that the organization is completely familiar with this application domain.
Process maturity	Reflects the process maturity of the organization. The computation of this value depends on the CMM Maturity Questionnaire, but an estimate can be achieved by subtracting the CMM process maturity level from 5.
Team cohesion	Reflects how well the development team knows each other and work together. Very low means very difficult interactions; extra-high means an integrated and effective team with no communication problems.

Multipliers

- ✧ Product attributes
  - Concerned with required characteristics of the software product being developed.
- ✧ Computer attributes
  - Constraints imposed on the software by the hardware platform.
- ✧ Personnel attributes
  - Multipliers that take the experience and capabilities of the people working on the project into account.
- ✧ Project attributes
  - Concerned with the particular characteristics of the software development project.

The effect of cost drivers on effort estimates

Exponent value	**1.17**
System size (including factors for reuse and requirements volatility)	128,000 LOC
Initial COCOMO estimate without cost drivers	**730 person-months**
Reliability	Very high, multiplier = 1.39
Complexity	Very high, multiplier = 1.3
Memory constraint	High, multiplier = 1.21
Tool use	Low, multiplier = 1.12
Schedule	Accelerated, multiplier = 1.29
Adjusted COCOMO estimate	**2,306 person-months**

The effect of cost drivers on effort estimates

Exponent value	**1.17**
Reliability	Very low, multiplier = 0.75
Complexity	Very low, multiplier = 0.75
Memory constraint	None, multiplier = 1
Tool use	Very high, multiplier = 0.72
Schedule	Normal, multiplier = 1
Adjusted COCOMO estimate	**295 person-months**

Project duration and staffing

- As well as effort estimation, managers must estimate the calendar time required to complete a project and when staff will be required.
- Calendar time can be estimated using a COCOMO 2 formula
  - **$TDEV = 3 * (PM)^{(0.33+0.2*(B-1.01))}$**
  - PM is the effort computation and B is the exponent computed as discussed above (B is 1 for the early prototyping model). This computation predicts the nominal schedule for the project.
- The time required is independent of the number of people working on the project.

Staffing requirements

- Staff required can't be computed by diving the **development time** by the required schedule.
- The number of people working on a project **varies depending on the phase of the project.**
- The more people who work on the project, the more total effort is usually required.
- **A very rapid build-up of people** often correlates with schedule slippage.

Key points

- The price charged for a system does not just depend on its estimated development costs and the profit required by the development company. Organizational factors may mean that the price is increased to compensate for increased risk or decreased to gain competitive advantage.
- Software is often priced to gain a contract and the functionality of the system is then adjusted to meet the estimated price.
- Plan-driven development is organized around a complete project plan that defines the project activities, the planned effort, the activity schedule and who is responsible for each activity.

Key points

- Project scheduling involves the creation of various graphical representations of part of the project plan. Bar charts, which show the activity duration and staffing timelines, are the most commonly used schedule representations.
- **A project milestone** is a predictable outcome of an activity or set of activities. At each milestone, a formal report of progress should be presented to management**. A deliverable** is a work product that is delivered to the project customer.
- The agile planning game involves the whole team in project planning. The plan is developed incrementally and, if problems arise, it is adjusted so that software functionality is reduced instead of delaying the delivery of an increment.

Key points

- Estimation techniques for software may be experience-based, where managers judge the effort required, or algorithmic, where the effort required is computed from other estimated project parameters.
- The COCOMO II costing model is a mature algorithmic cost model that takes project, product, hardware and personnel attributes into account when formulating a cost estimate.