Fundamental estimation questions

- How much effort is required to complete an activity?
- How much calendar time is needed to complete an activity?
- What is the total cost of an activity?
- Project estimation and scheduling and interleaved management activities

Software cost components

- Hardware and software costs
- Travel and training costs
- Effort costs (the dominant factor in most projects)
  - salaries of engineers involved in the project
  - Social and insurance costs
- Effort costs must take overheads into account
  - costs of building, heating, lighting
  - costs of networking and communications
  - costs of shared facilities (e.g library, staff restaurant, etc.)

Costing and pricing

- Estimates are made to discover the cost, to the developer, of producing a software system
- There is not a simple relationship between the development cost and the price charged to the customer
- Broader organisational, economic, political and business considerations influence the price charged

Software pricing factors

Factor	**Description**
Market opportunity	A development organisation may quote a low price because it wishes to move into a new segment of the software market. Accepting a low profit on one project may give the opportunity of more profit later. The experience gained may allow new products to be developed.
Cost estimate uncertainty	If an organisation is unsure of its cost estimate, it may increase its price by some contingency over and above its normal profit.
Contractual terms	A customer may be willing to allow the developer to retain ownership of the source code and reuse it in other projects. The price charged may then be less than if the software source code is handed over to the customer.
Requirements volatility	If the requirements are likely to change, an organisation may lower its price to win a contract. After the contract is awarded, high prices may be charged for changes to the requirements.
Financial health	Developers in financial difficulty may lower their price to gain a contract. It is better to make a small profit or break even than to go out of business.

Programmer productivity

- A measure of the rate at which individual engineers involved in software development produce software and associated documentation
- Not quality-oriented although quality assurance is a factor in productivity assessment
- Essentially, we want to measure useful functionality produced per time unit

Productivity measures

- Size related measures based on some output from the software process. This may be lines of delivered source code, object code instructions, etc.
- Function-related measures based on an estimate of the functionality of the delivered software. Function-points are the best known of this type of measure

Measurement problems

- Estimating the size of the measure
- Estimating the total number of programmer months which have elapsed
- Estimating contractor productivity (e.g. documentation team) and incorporating this estimate in overall estimate

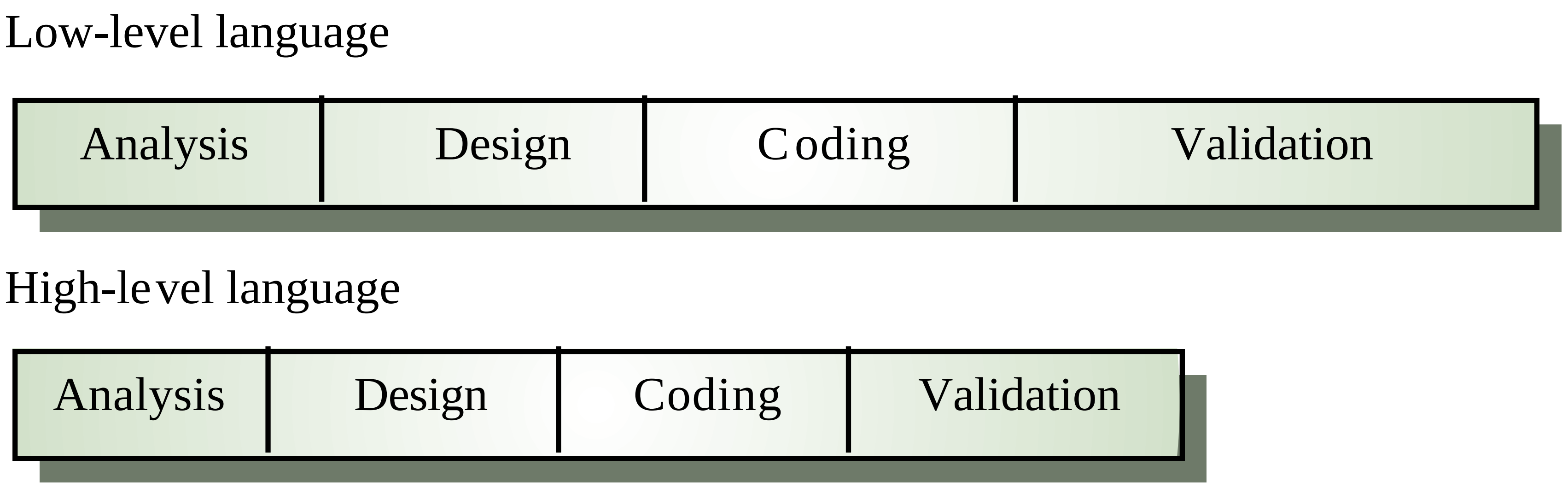
Lines of code

- What's a line of code?
  - The measure was first proposed when programs were typed on cards with one line per card
  - How does this correspond to statements as in Java which can span several lines or where there can be several statements on one line
- What programs should be counted as part of the system?
- Assumes linear relationship between system size and volume of documentation

Productivity comparisons

- The lower level the language, the more productive the programmer
  - The same functionality takes more code to implement in a lower-level language than in a high-level language
- The more verbose the programmer, the higher the productivity
  - Measures of productivity based on lines of code suggest that programmers who write verbose code are more productive than programmers who write compact code

High and low level languages



System development times

	Analysis	Design	Coding	Testing	Documentation
Assembly code	3 weeks	5 weeks	8 weeks	10 weeks	2 weeks
High-level language	3 weeks	5 weeks	8 weeks	6 weeks	2 weeks

	Size	Effort	Productivity
Assembly code	5000 lines	28 weeks	714 lines/month
High-level language	1500 lines	20 weeks	300 lines/month

Function points

- Based on a combination of program characteristics
  - external inputs and outputs
  - user interactions
  - external interfaces
  - files used by the system
- A weight is associated with each of these
- The function point count is computed by multiplying each raw count by the weight and summing all values

Function points

- Function point count modified by complexity of the project
- FPs can be used to estimate LOC depending on the average number of LOC per FP for a given language
  - LOC = AVC * number of function points
  - AVC is a language-dependent factor varying from 200-300 for assemble language to 2-40 for a 4GL
- FPs are very subjective. They depend on the estimator.
  - Automatic function-point counting is impossible

Object points

- Object points are an alternative function-related measure to function points when 4Gls or similar languages are used for development
- Object points are NOT the same as object classes
- The number of object points in a program is a weighted estimate of
  - The number of separate screens that are displayed
  - The number of reports that are produced by the system
  - The number of 3GL modules that must be developed to supplement the 4GL code

Object point estimation

- Object points are easier to estimate from a specification than function points as they are simply concerned with screens, reports and 3GL modules
- They can therefore be estimated at an early point in the development process. At this stage, it is very difficult to estimate the number of lines of code in a system

Productivity estimates

- Real-time embedded systems, 40-160 LOC/P-month
- Systems programs , 150-400 LOC/P-month
- Commercial applications, 200-800 LOC/P-month
- In object points, productivity has been measured between 4 and 50 object points/month depending on tool support and developer capability

Factors affecting productivity

Factor	**Description**
Application domain experience	Knowledge of the application domain is essential for effective software development. Engineers whoalready understand a domain are likely to be the most productive.
Process quality	The development process used can have a significant effect on productivity. This is covered in Chapter 31.
Project size	The larger a project, the more time required for team communications. Less time is available for development so individual productivity is reduced.
Technology support	Good support technology such as CASE tools, supportive configuration management systems, etc. can improve productivity.
Working environment	As discussed in Chapter 28, a quiet working environment with private work areas contributes to improved productivity.

Quality and productivity

- All metrics based on volume/unit time are flawed because they do not take quality into account
- Productivity may generally be increased at the cost of quality
- It is not clear how productivity/quality metrics are related
- If change is constant then an approach based on counting lines of code is not meaningful