
Architectural Design

Software architecture

- The design process for identifying the sub-systems making up a system and the framework for sub-system control and communication is **architectural design**.
- The output of this design process is a description of the **software architecture**.

Advantages of explicit architecture

- Stakeholder communication
 - Architecture may be used as a focus of discussion by system stakeholders.
- System analysis
 - Means that analysis of whether the system can meet its non-functional requirements is possible.
- Large-scale reuse
 - The architecture may be reusable across a range of systems.

Architecture and system characteristics

- Performance
 - Localise critical operations and minimise communications. Use large rather than fine-grain components.
- Security
 - Use a layered architecture with critical assets in the inner layers.
- Safety
 - Localise safety-critical features in a small number of sub-systems.
- Availability
 - Include redundant components and mechanisms for fault tolerance.
- Maintainability
 - Use fine-grain, replaceable components.

Architectural conflicts

- Using large-grain components improves performance but reduces maintainability.
- Introducing redundant data improves availability but makes security more difficult.
- Localising safety-related features usually means more communication so degraded performance.

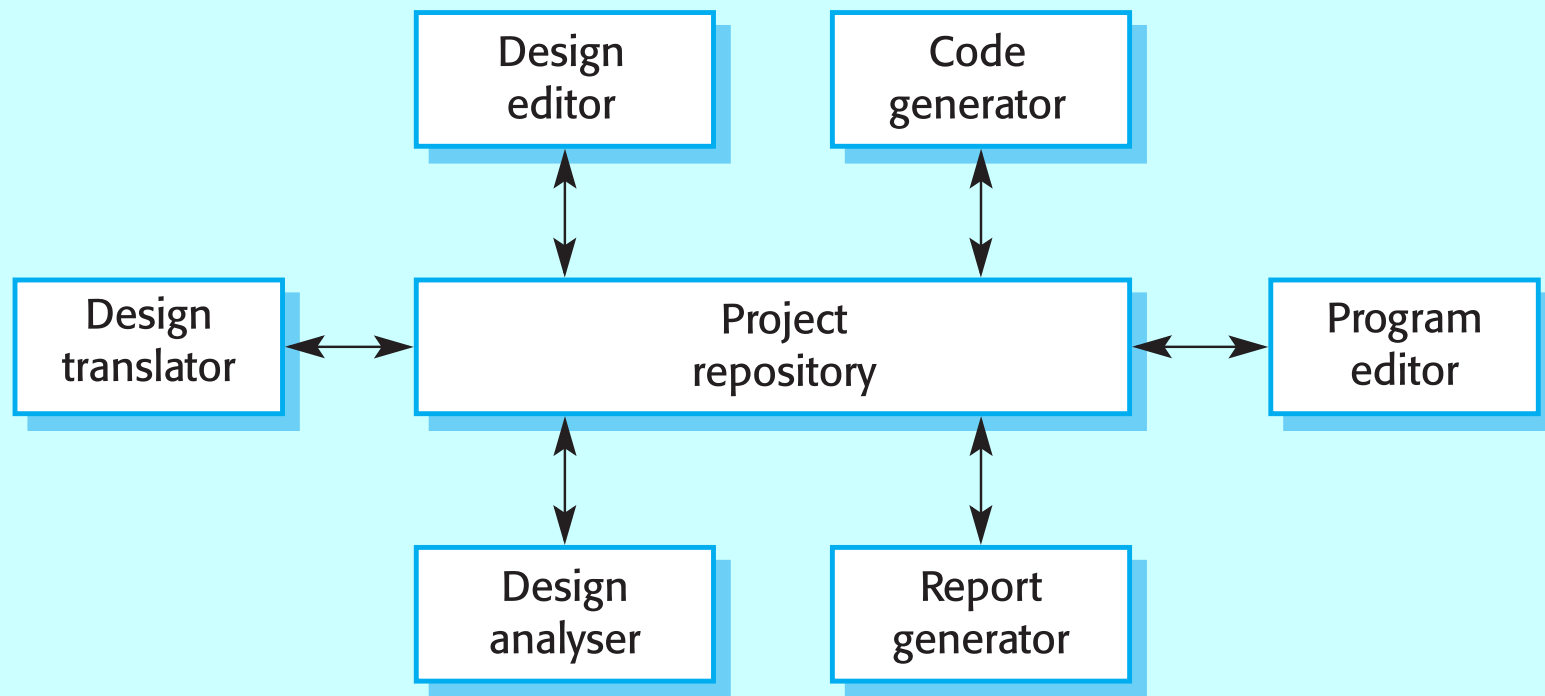
Architectural models

- Used to document an architectural design.
- Static structural model that shows the major system components.
- Dynamic process model that shows the process structure of the system.
- Interface model that defines sub-system interfaces.
- Relationships model such as a data-flow model that shows sub-system relationships.
- Distribution model that shows how sub-systems are distributed across computers.

The repository model

- Sub-systems must exchange data. This may be done in two ways:
 - Shared data is held in a central database or repository and may be accessed by all sub-systems;
 - Each sub-system maintains its own database and passes data explicitly to other sub-systems.
- When large amounts of data are to be shared, the repository model of sharing is most commonly used.

CASE toolset architecture



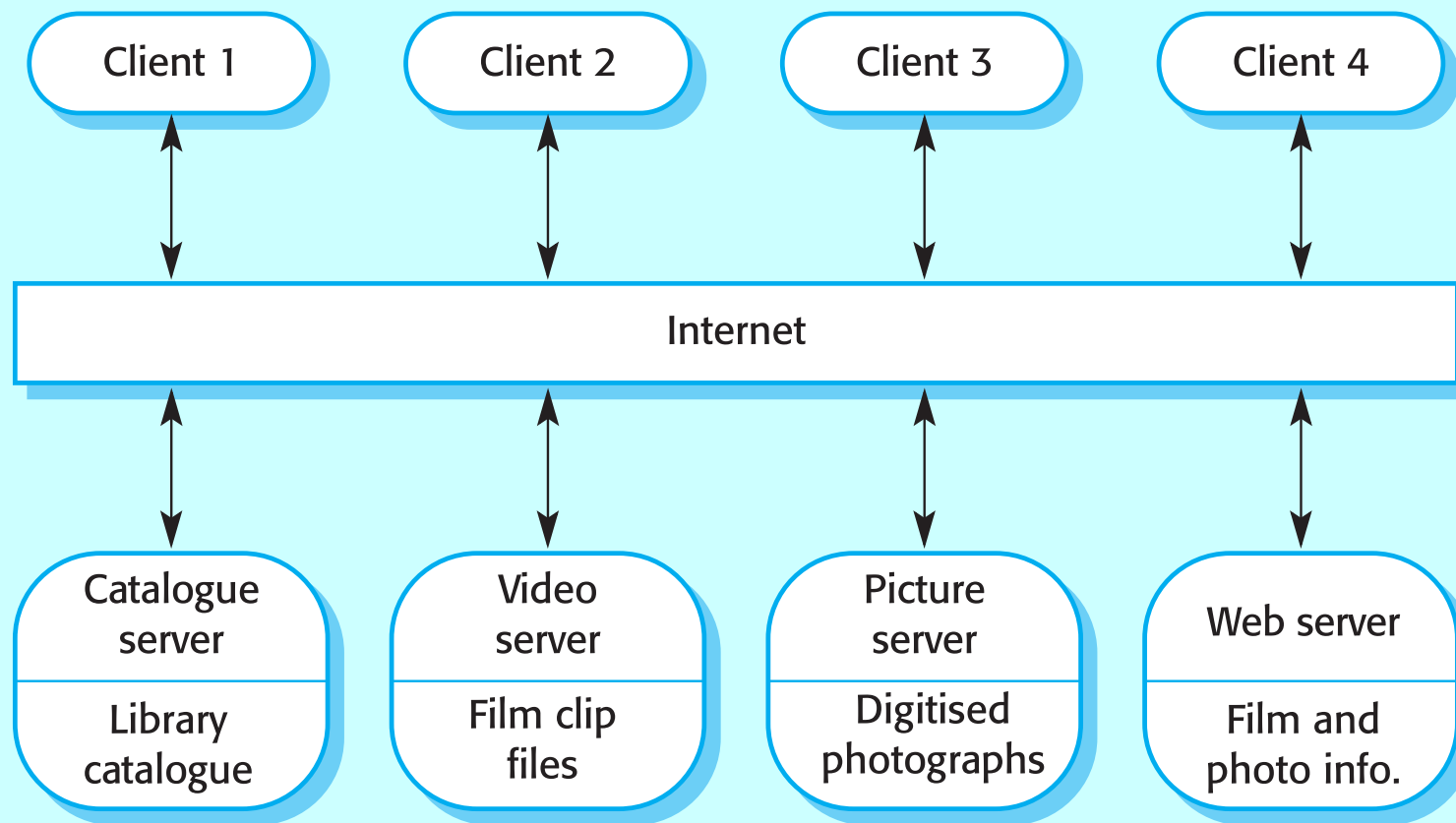
Repository model characteristics

- Advantages
 - Efficient way to share large amounts of data;
 - Sub-systems need not be concerned with how data is produced Centralised management e.g. backup, security, etc.
 - Sharing model is published as the repository schema.
- Disadvantages
 - Sub-systems must agree on a repository data model. Inevitably a compromise;
 - Data evolution is difficult and expensive;
 - No scope for specific management policies;
 - Difficult to distribute efficiently.

Client-server model

- Distributed system model which shows how data and processing is distributed across a range of components.
- Set of stand-alone servers which provide specific services such as printing, data management, etc.
- Set of clients which call on these services.
- Network which allows clients to access servers.

Film and picture library



Client-server characteristics

- Advantages
 - Distribution of data is straightforward;
 - Makes effective use of networked systems. May require cheaper hardware;
 - Easy to add new servers or upgrade existing servers.
- Disadvantages
 - No shared data model so sub-systems use different data organisation. Data interchange may be inefficient;
 - Redundant management in each server;
 - No central register of names and services - it may be hard to find out what servers and services are available.

Abstract machine (layered) model

- Used to model the interfacing of sub-systems.
- Organises the system into a set of layers (or abstract machines) each of which provide a set of services.
- Supports the incremental development of sub-systems in different layers. When a layer interface changes, only the adjacent layer is affected.
- However, often artificial to structure systems in this way.

Version management system

Configuration management system layer

Object management system layer

Database system layer

Operating system layer

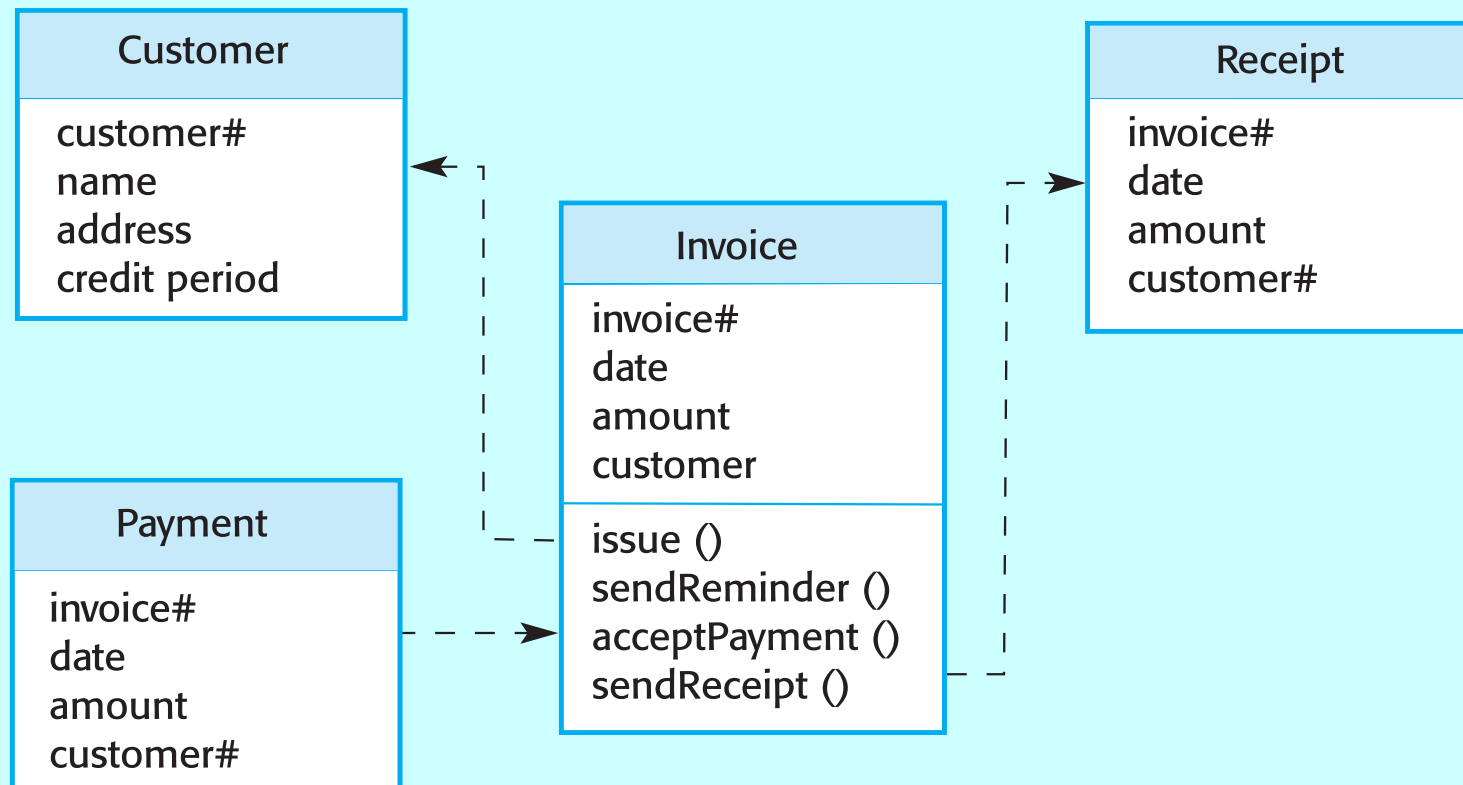
Modular decomposition

- Another structural level where sub-systems are decomposed into modules.
- Two modular decomposition models covered
 - An object model where the system is decomposed into interacting object;
 - A pipeline or data-flow model where the system is decomposed into functional modules which transform inputs to outputs.
- If possible, decisions about concurrency should be delayed until modules are implemented.

Object models

- Structure the system into a set of loosely coupled objects with well-defined interfaces.
- Object-oriented decomposition is concerned with identifying object classes, their attributes and operations.
- When implemented, objects are created from these classes and some control model used to coordinate object operations.

Invoice processing system



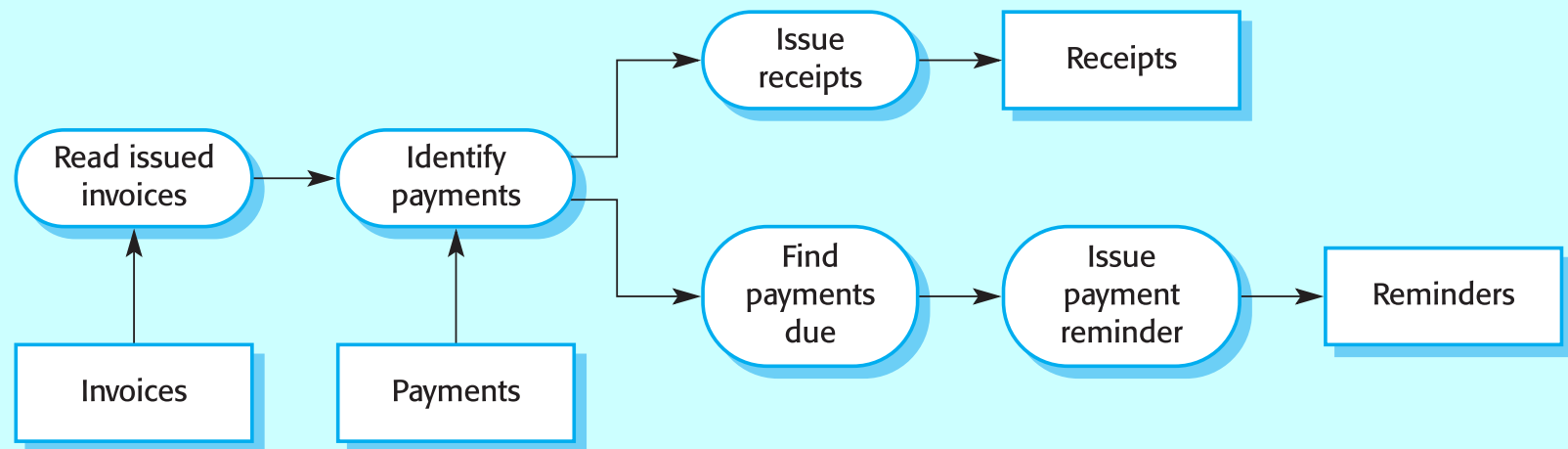
Object model advantages

- Objects are loosely coupled so their implementation can be modified without affecting other objects.
- The objects may reflect real-world entities.
- OO implementation languages are widely used.
- However, object interface changes may cause problems and complex entities may be hard to represent as objects.

Function-oriented pipelining

- Functional transformations process their inputs to produce outputs.
- May be referred to as a pipe and filter model (as in UNIX shell).
- Variants of this approach are very common. When transformations are sequential, this is a batch sequential model which is extensively used in data processing systems.
- Not really suitable for interactive systems.

Invoice processing system



Pipeline model advantages

- Supports transformation reuse.
- Intuitive organisation for stakeholder communication.
- Easy to add new transformations.
- Relatively simple to implement as either a concurrent or sequential system.
- However, requires a common format for data transfer along the pipeline and difficult to support event-based interaction.

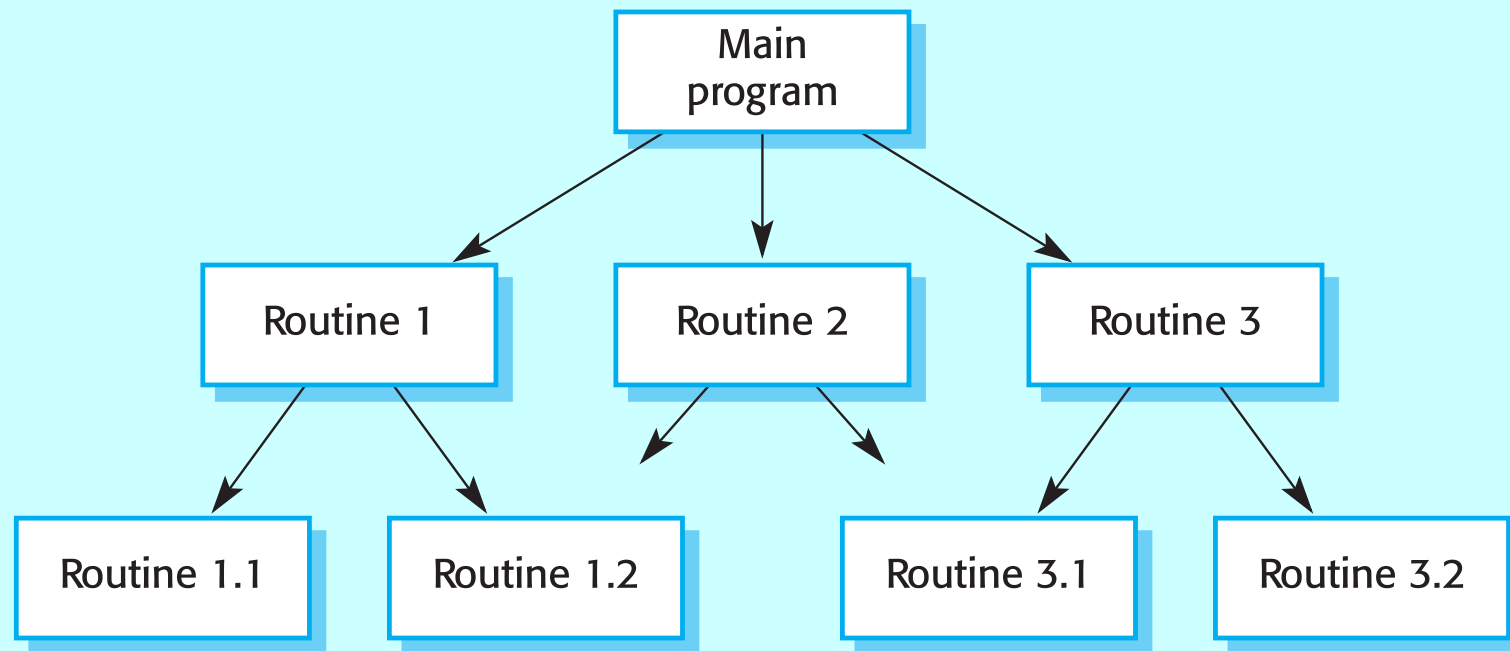
Control styles

- Are concerned with the control flow between sub-systems. Distinct from the system decomposition model.
- Centralised control
 - One sub-system has overall responsibility for control and starts and stops other sub-systems.
- Event-based control
 - Each sub-system can respond to externally generated events from other sub-systems or the system's environment.

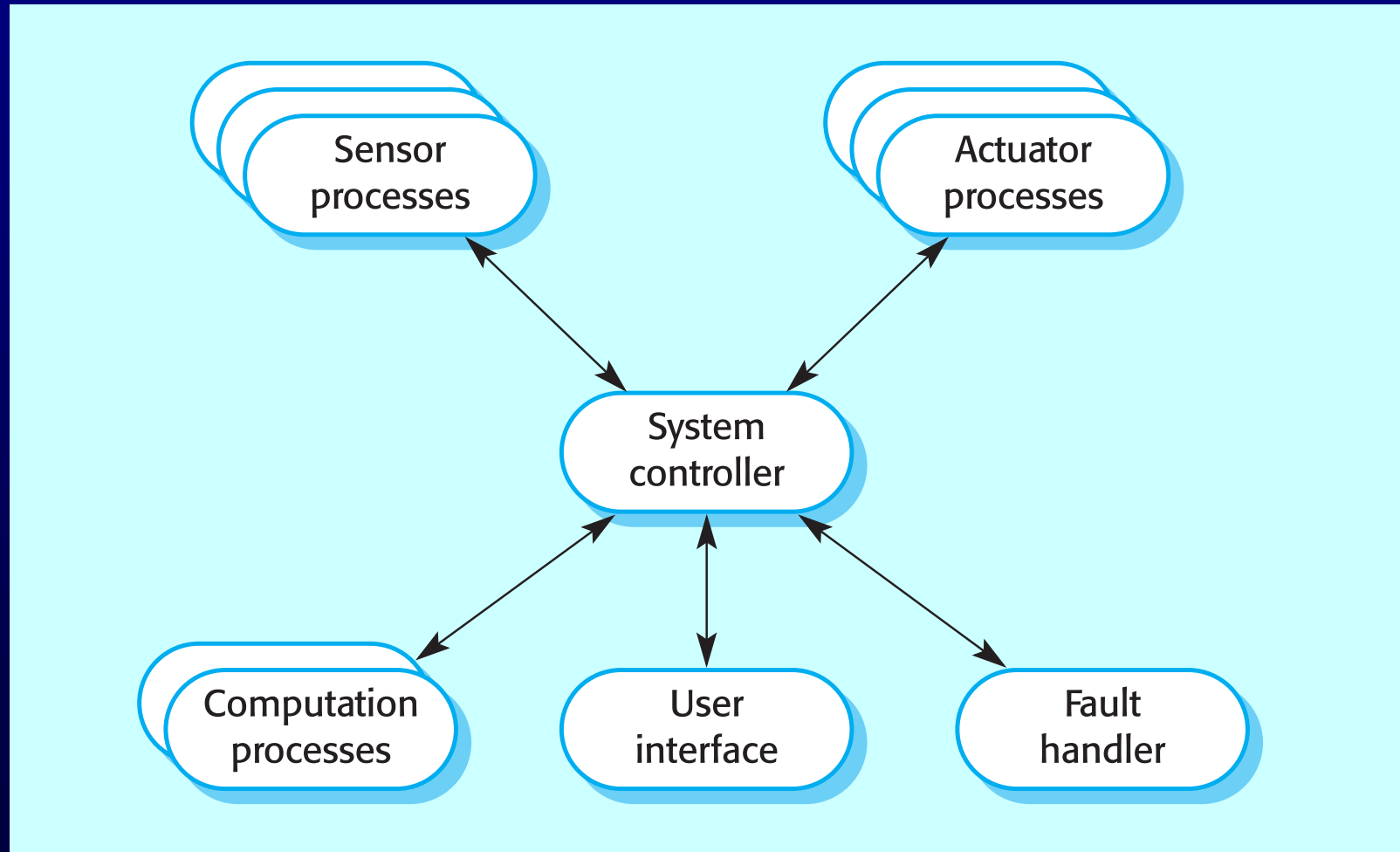
Centralised control

- A control sub-system takes responsibility for managing the execution of other sub-systems.
- Call-return model
 - Top-down subroutine model where control starts at the top of a subroutine hierarchy and moves downwards. Applicable to sequential systems.
- Manager model
 - Applicable to concurrent systems. One system component controls the stopping, starting and coordination of other system processes. Can be implemented in sequential systems as a case statement.

Call-return model



Real-time system control



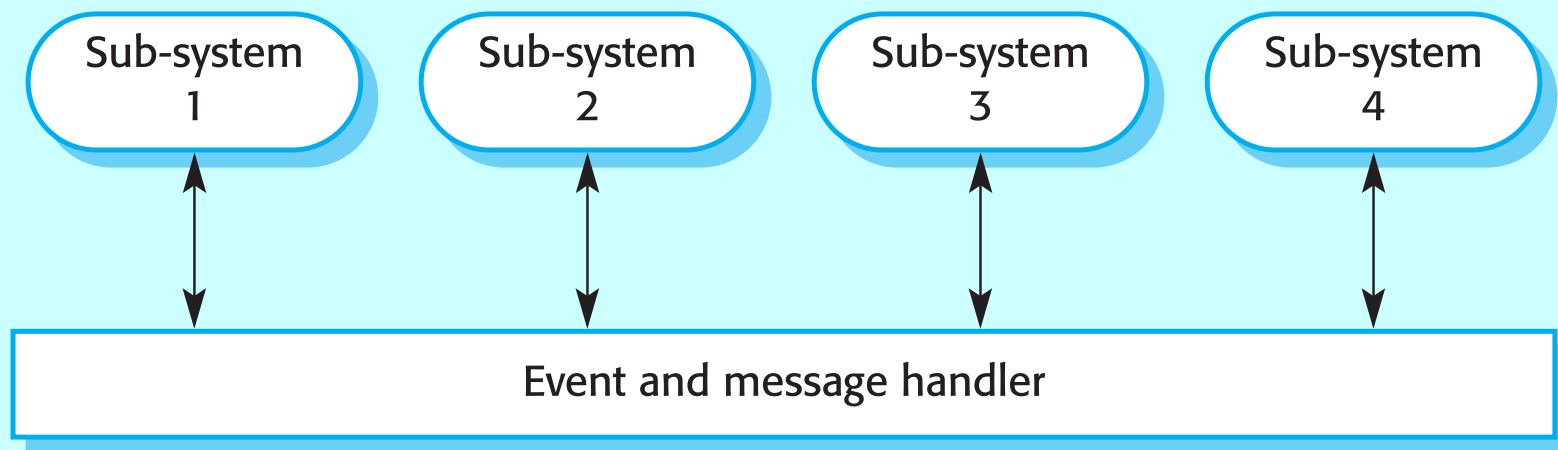
Event-driven systems

- Driven by externally generated events where the timing of the event is outwith the control of the sub-systems which process the event.
- Two principal event-driven models
 - Broadcast models. An event is broadcast to all sub-systems. Any sub-system which can handle the event may do so;
 - Interrupt-driven models. Used in real-time systems where interrupts are detected by an interrupt handler and passed to some other component for processing.
- Other event driven models include spreadsheets and production systems.

Broadcast model

- Effective in integrating sub-systems on different computers in a network.
- Sub-systems register an interest in specific events. When these occur, control is transferred to the sub-system which can handle the event.
- Control policy is not embedded in the event and message handler. Sub-systems decide on events of interest to them.
- However, sub-systems don't know if or when an event will be handled.

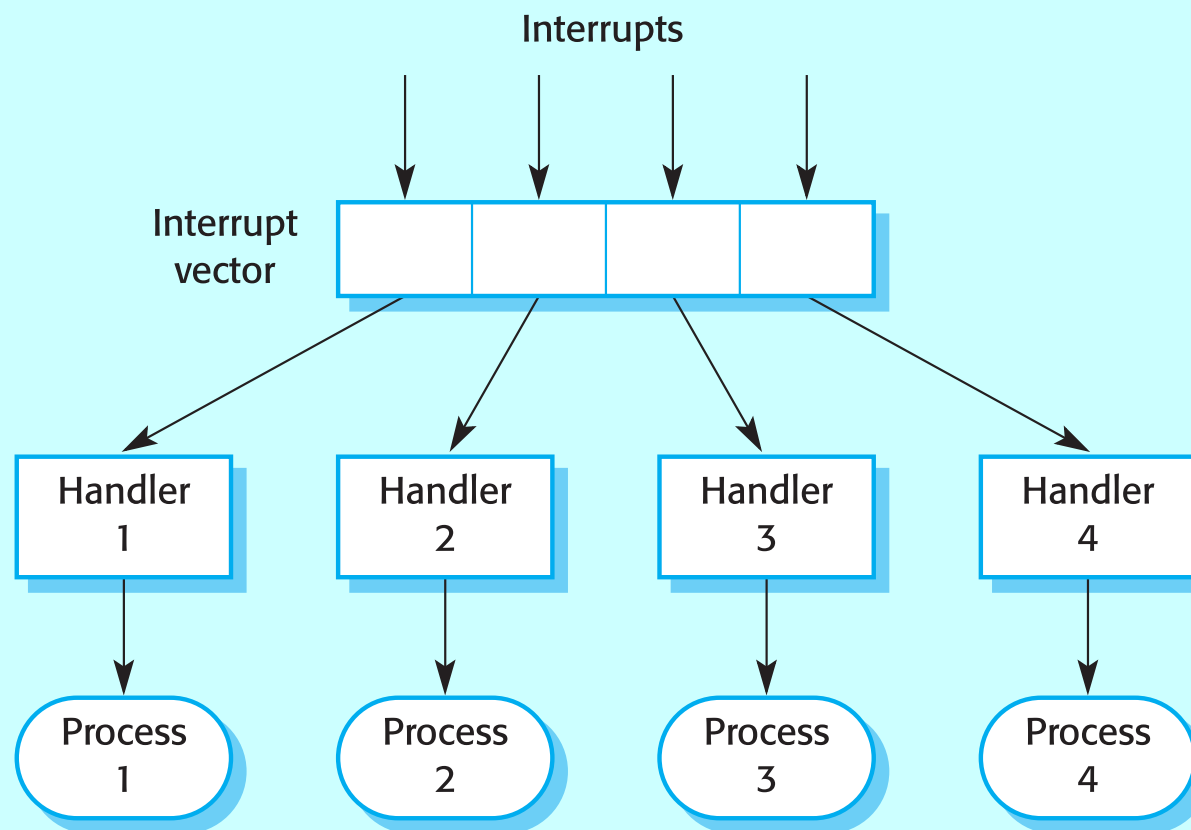
Selective broadcasting



Interrupt-driven systems

- Used in real-time systems where fast response to an event is essential.
- There are known interrupt types with a handler defined for each type.
- Each type is associated with a memory location and a hardware switch causes transfer to its handler.
- Allows fast response but complex to program and difficult to validate.

Interrupt-driven control



Reference architectures

- Architectural models may be specific to some application domain.
- Two types of domain-specific model
 - Generic models which are abstractions from a number of real systems and which encapsulate the principal characteristics of these systems. Covered in Chapter 13.
 - Reference models which are more abstract, idealised model. Provide a means of information about that class of system and of comparing different architectures.
- Generic models are usually bottom-up models; Reference models are top-down models.

Reference architectures

- Reference models are derived from a study of the application domain rather than from existing systems.
- May be used as a basis for system implementation or to compare different systems. It acts as a standard against which systems can be evaluated.
- OSI model is a layered model for communication systems.

OSI reference model

