Software Engineering:
A Practitioner's Approach, 6/e
Roger Pressman

Chapter 10
Architectural Design

Why Architecture?

The architecture is not the operational software. Rather, it is a representation that enables a software engineer to:

(1) analyze the effectiveness of the design in meeting its stated requirements,

(2) consider architectural alternatives at a stage when making design changes is still relatively easy, and

(3) reduce the risks associated with the construction of the software.

Why is Architecture Important?

- Representations of software architecture are an enabler for communication between all parties (stakeholders) interested in the development of a computer-based system.
- The architecture highlights early design decisions that will have a profound impact on all software engineering work that follows and, as important, on the ultimate success of the system as an operational entity.
- Architecture constitutes a relatively small, intellectually graspable model of how the system is structured and how its components work together.

Data Design

- At the architectural level …
  - Design of one or more databases to support the application architecture
  - Design of methods for 'mining' the content of multiple databases
    - navigate through existing databases in an attempt to extract appropriate business-level information
    - Design of a data warehouse - a large, independent database that has access to the data that are stored in databases that serve the set of applications required by a business

Data Design

- At the component level …
  - refine data objects and develop a set of data abstractions
  - implement data object attributes as one or more data structures
  - review data structures to ensure that appropriate relationships have been established
  - simplify data structures as required

Data Design—Component Level

1. The systematic analysis principles applied to function and behavior should also be applied to data.
2. All data structures and the operations to be performed on each should be identified.
3. A data dictionary should be established and used to define both data and program design.
4. Low level data design decisions should be deferred until late in the design process.
5. The representation of data structure should be known only to those modules that must make direct use of the data contained within the structure.
6. A library of useful data structures and the operations that may be applied to them should be developed.
7. A software design and programming language should support the specification and realization of abstract data types.

Architectural Styles

Each style describes a system category that encompasses:

(1) a set of components (e.g., a database, computational modules) that perform a function required by a system,

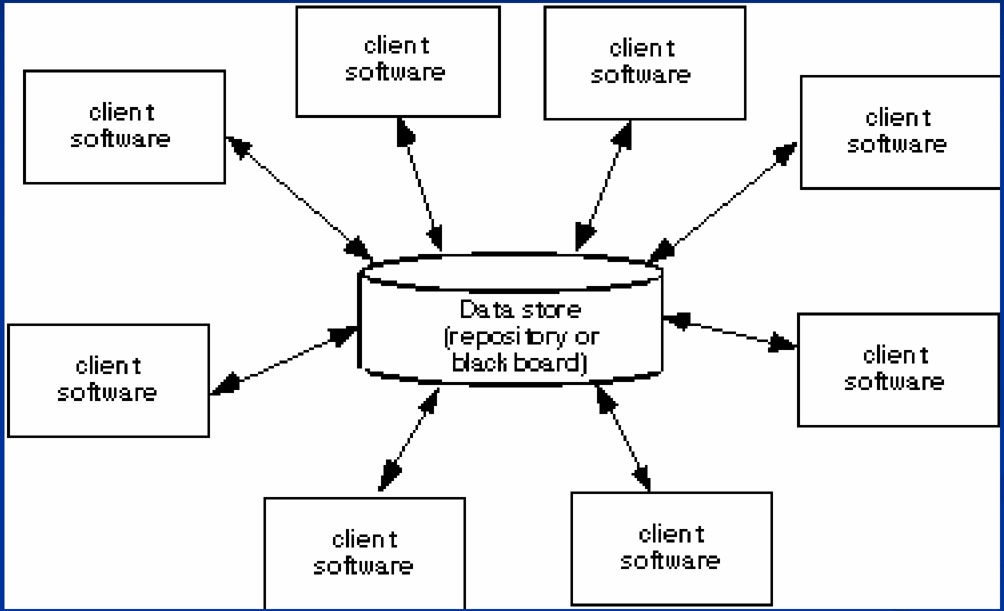
(2) a set of connectors that enable "communication, coordination and cooperation" among components,

(3) constraints that define how components can be integrated to form the system, and

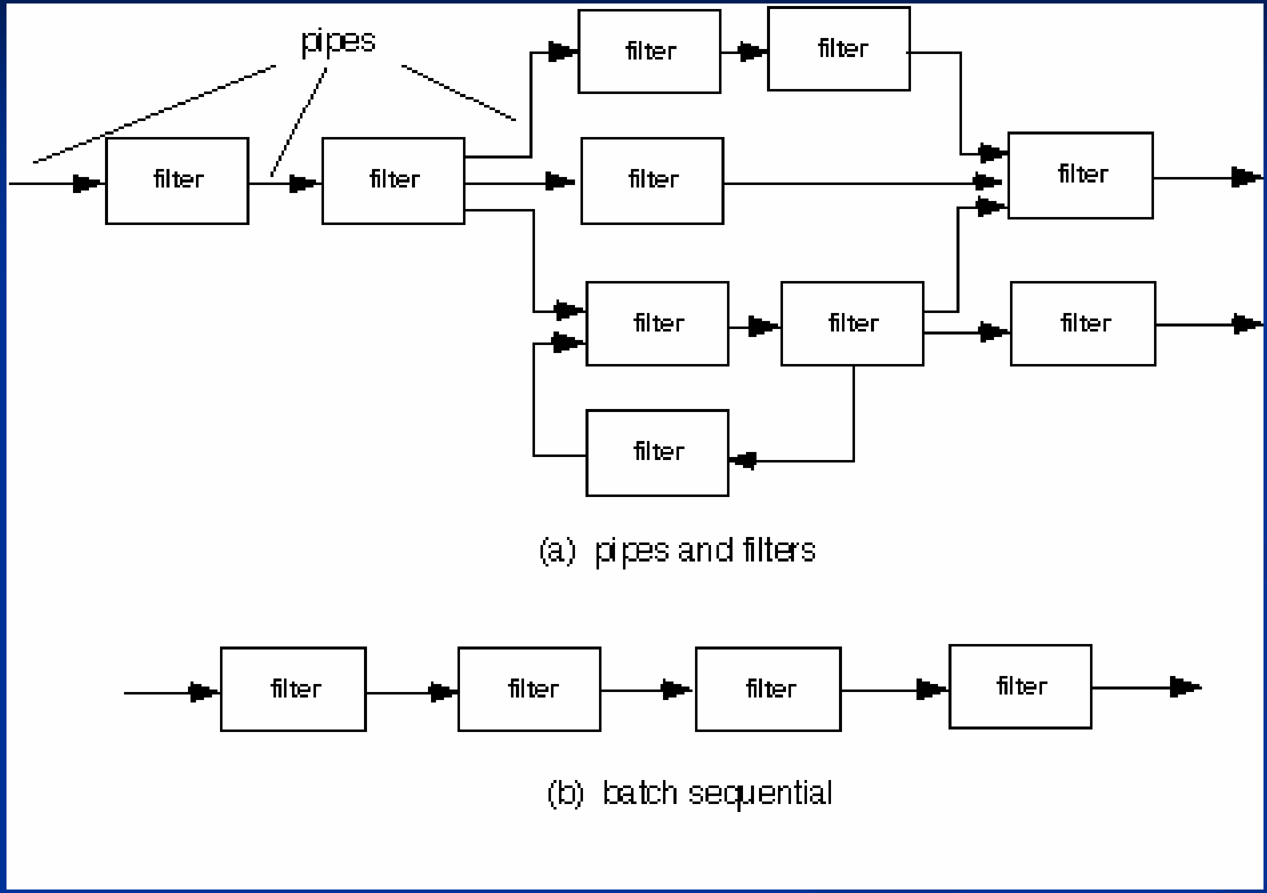
(4) semantic models that enable a designer to understand the overall properties of a system by analyzing the known properties of its constituent parts.

- Data-centered architectures
- Data flow architectures
- Call and return architectures
- Layered architectures
- Object-oriented architectures

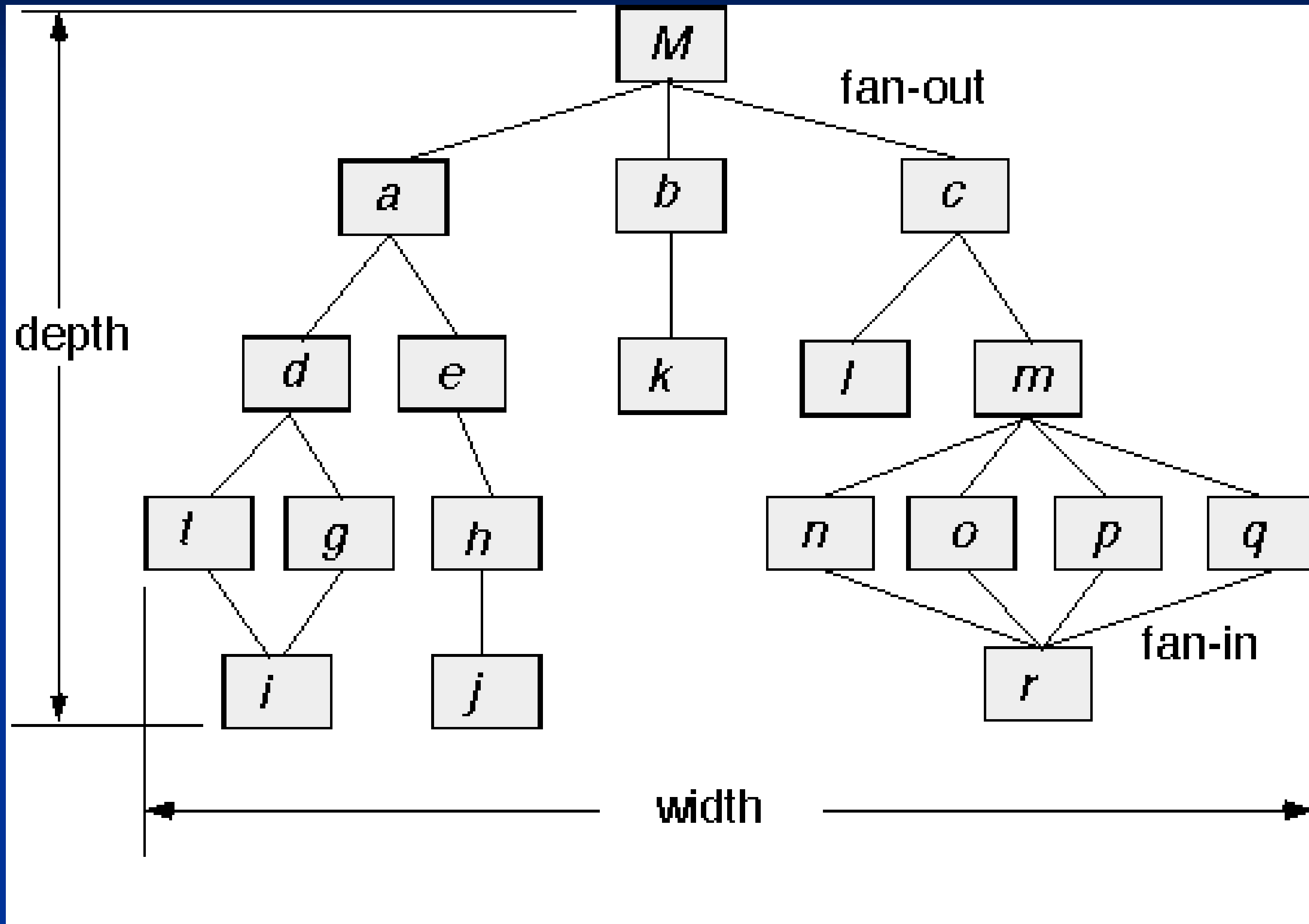
Data-Centered Architecture



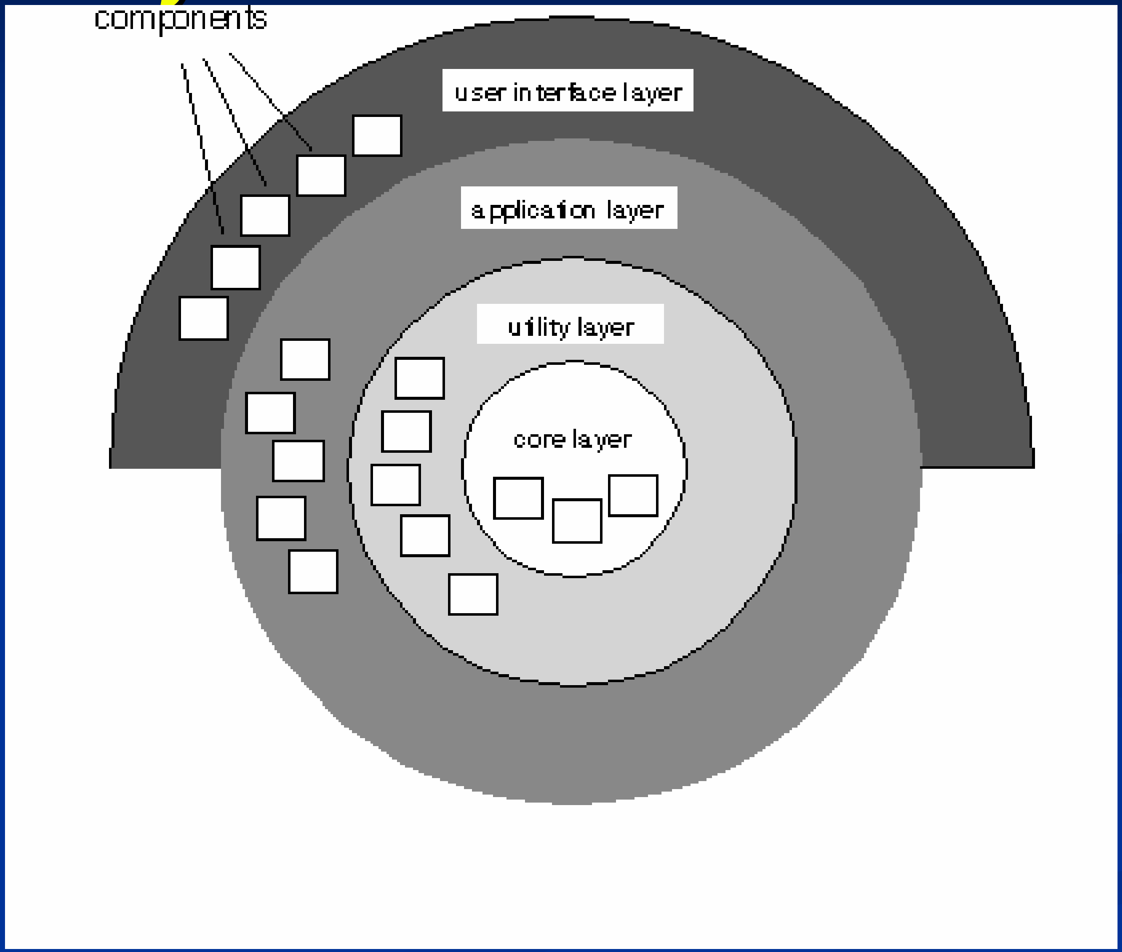
Data Flow Architecture



Call and Return Architecture



Layered Architecture



Object-Oriented Architecture

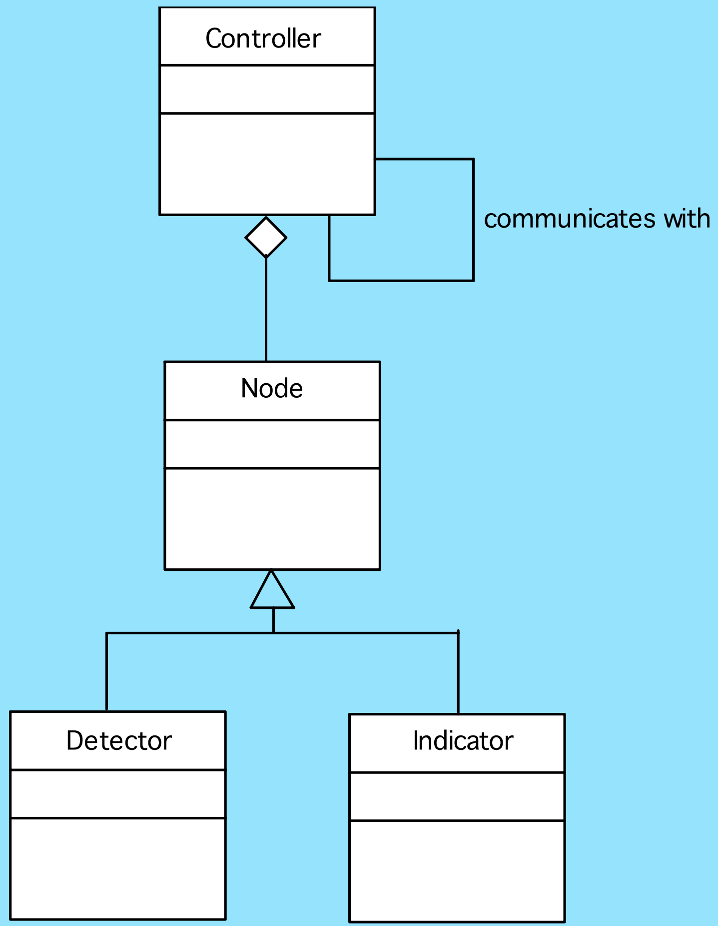


Figure 10.7 UML relationships for SafeHome security function archetypes (adapted from [BOS00])

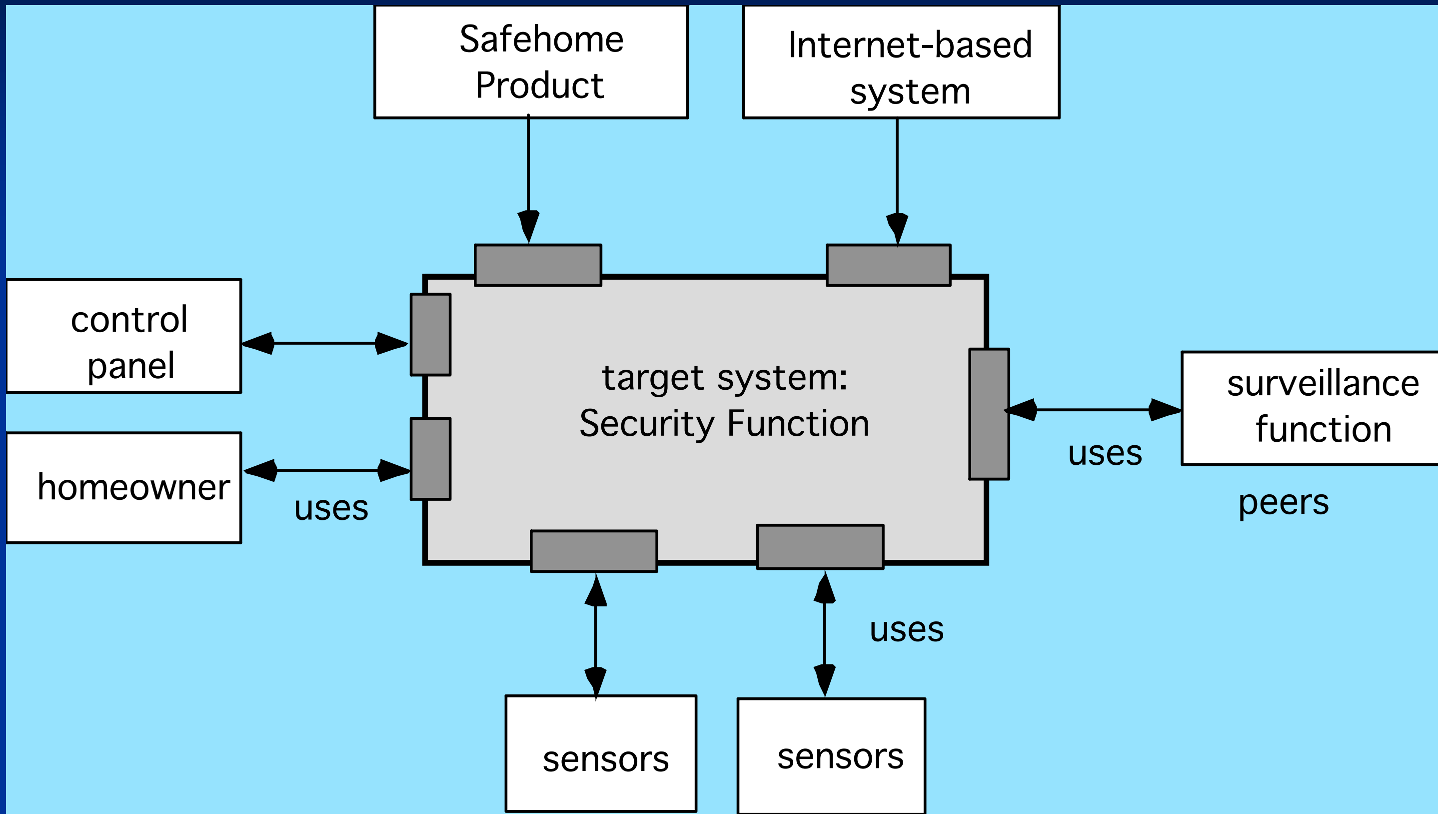
Architectural Patterns

- Concurrency—applications must handle multiple tasks in a manner that simulates parallelism
  - *operating system process management* pattern
  - *task scheduler* pattern
- Persistence—Data persists if it survives past the execution of the process that created it. Two patterns are common:
  - a *database management system* pattern that applies the storage and retrieval capability of a DBMS to the application architecture
  - an *application level persistence* pattern that builds persistence features into the application architecture
- Distribution— the manner in which systems or components within systems communicate with one another in a distributed environment
  - A *broker* acts as a 'middle-man' between the client component and a server component.

Architectural Design

- The software must be placed into context
  - the design should define the external entities (other systems, devices, people) that the software interacts with and the nature of the interaction
- A set of architectural archetypes should be identified
  - An *archetype* is an abstraction (similar to a class) that represents one element of system behavior
- The designer specifies the structure of the system by defining and refining software components that implement each archetype

Architectural Context



Archetypes

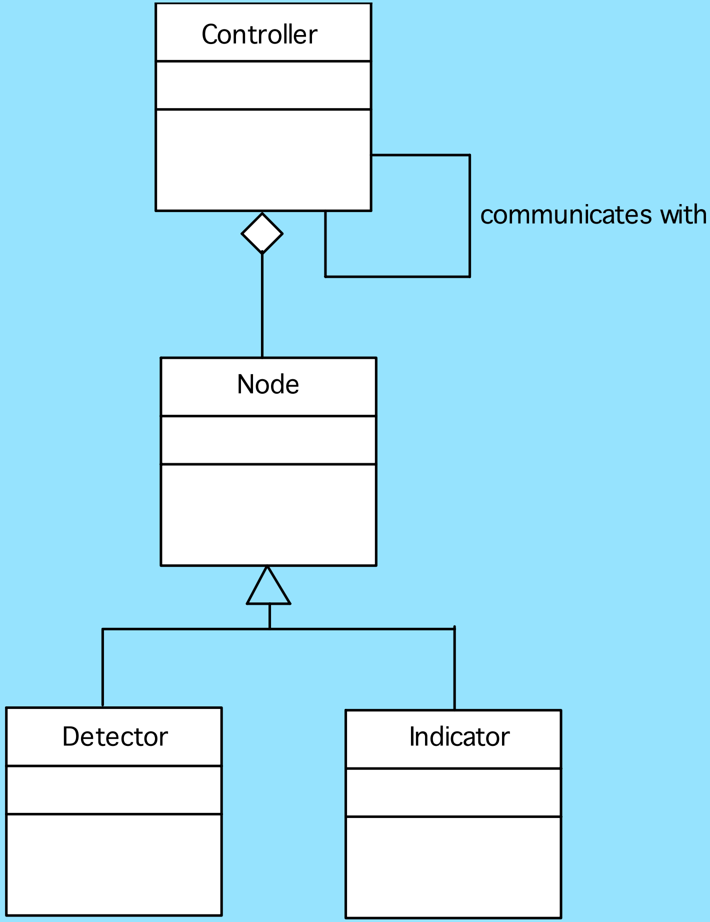
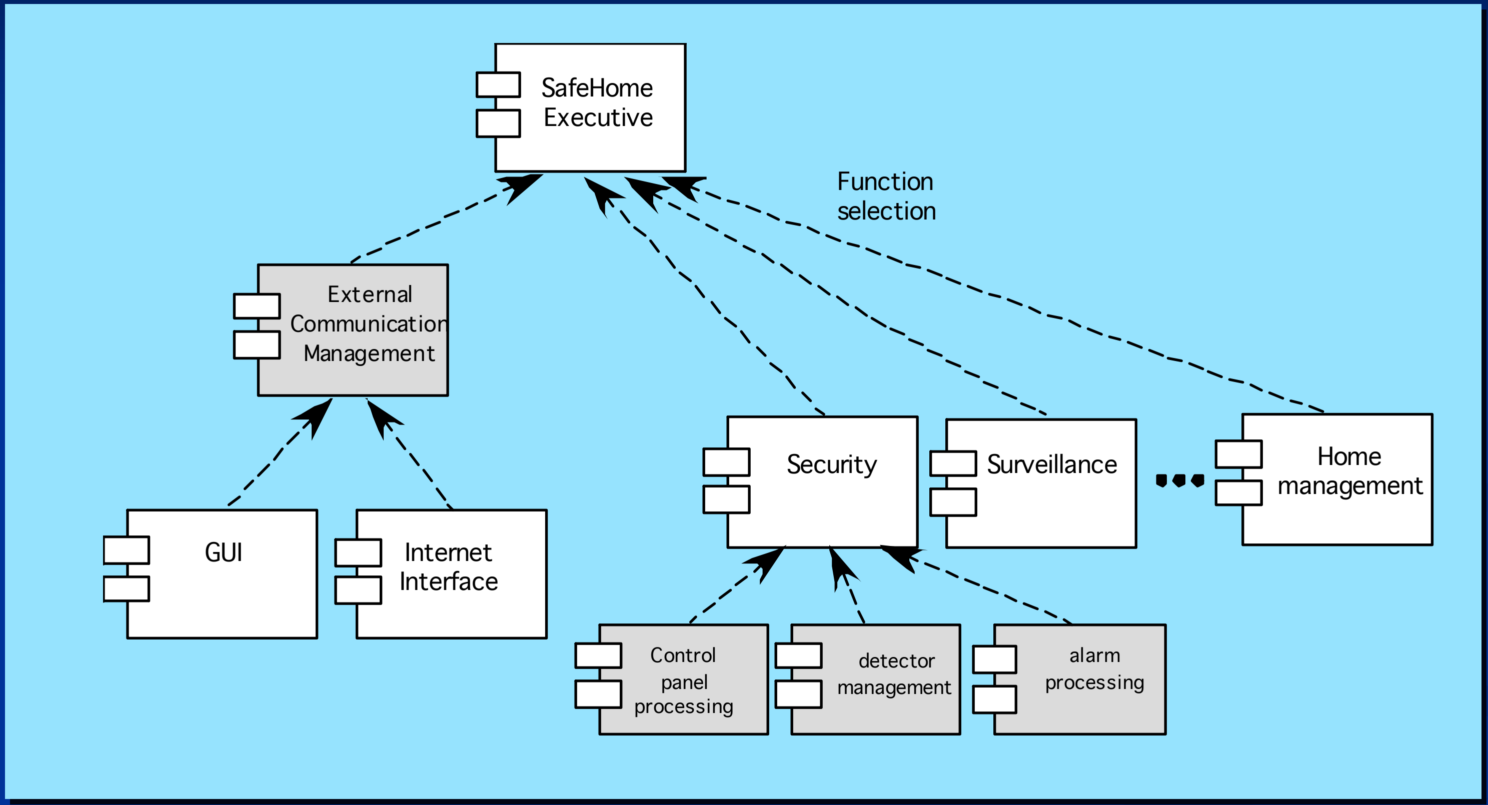
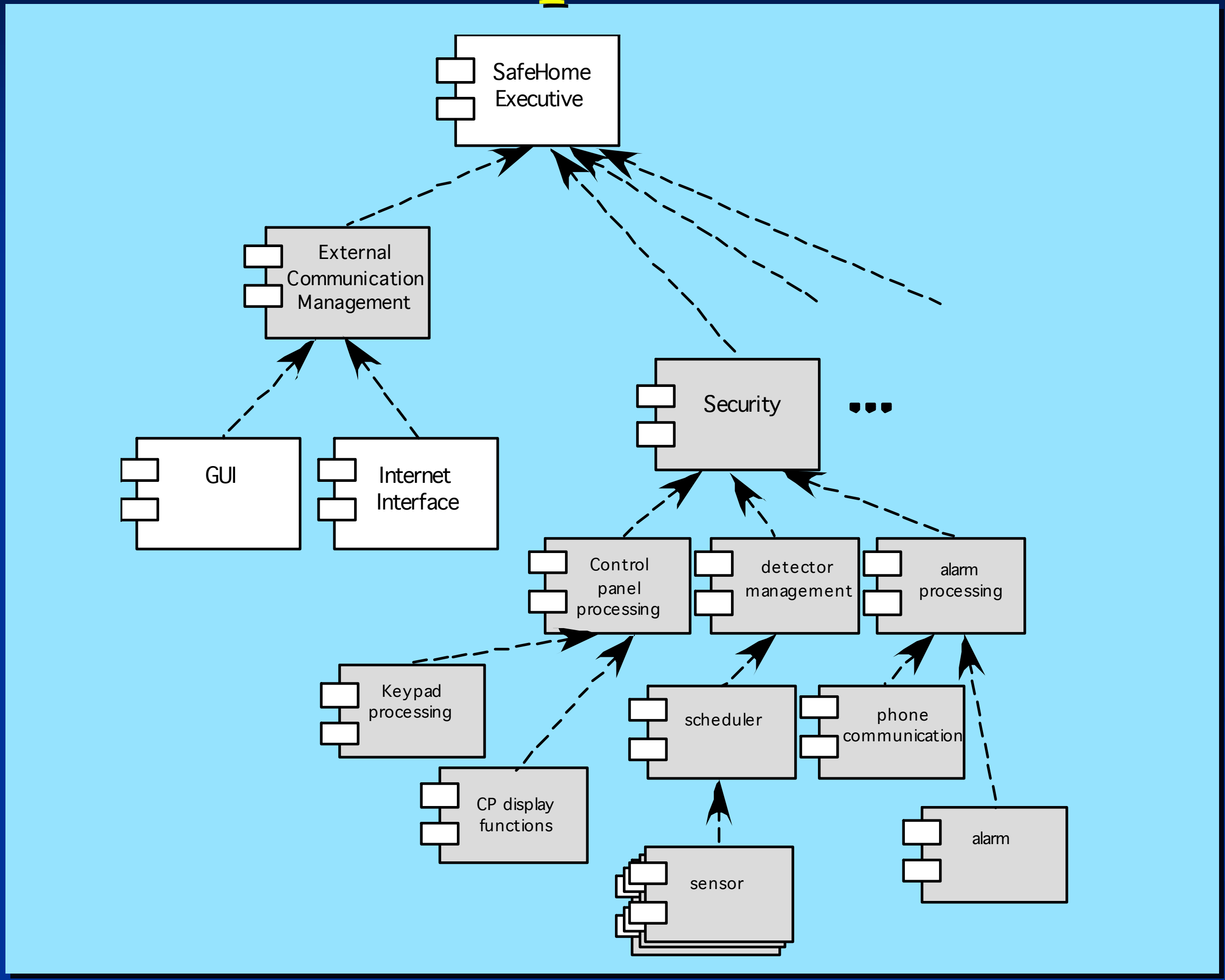


Figure 10.7 UML relationships for SafeHome security function archetypes (adapted from [BOS00])

Component Structure



Refined Component Structure



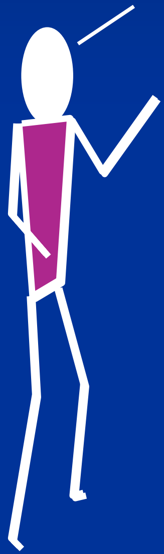
Analyzing Architectural Design

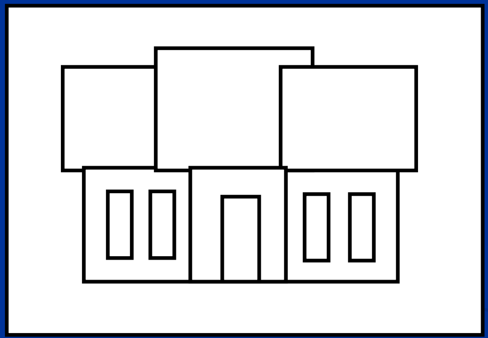
1. Collect scenarios.
2. Elicit requirements, constraints, and environment description.
3. Describe the architectural styles/patterns that have been chosen to address the scenarios and requirements:
   - module view
   - process view
   - data flow view
4. Evaluate quality attributes by considered each attribute in isolation.
5. Identify the sensitivity of quality attributes to various architectural attributes for a specific architectural style.
6. Critique candidate architectures (developed in step 3) using the sensitivity analysis conducted in step 5.

An Architectural Design Method

customer requirements

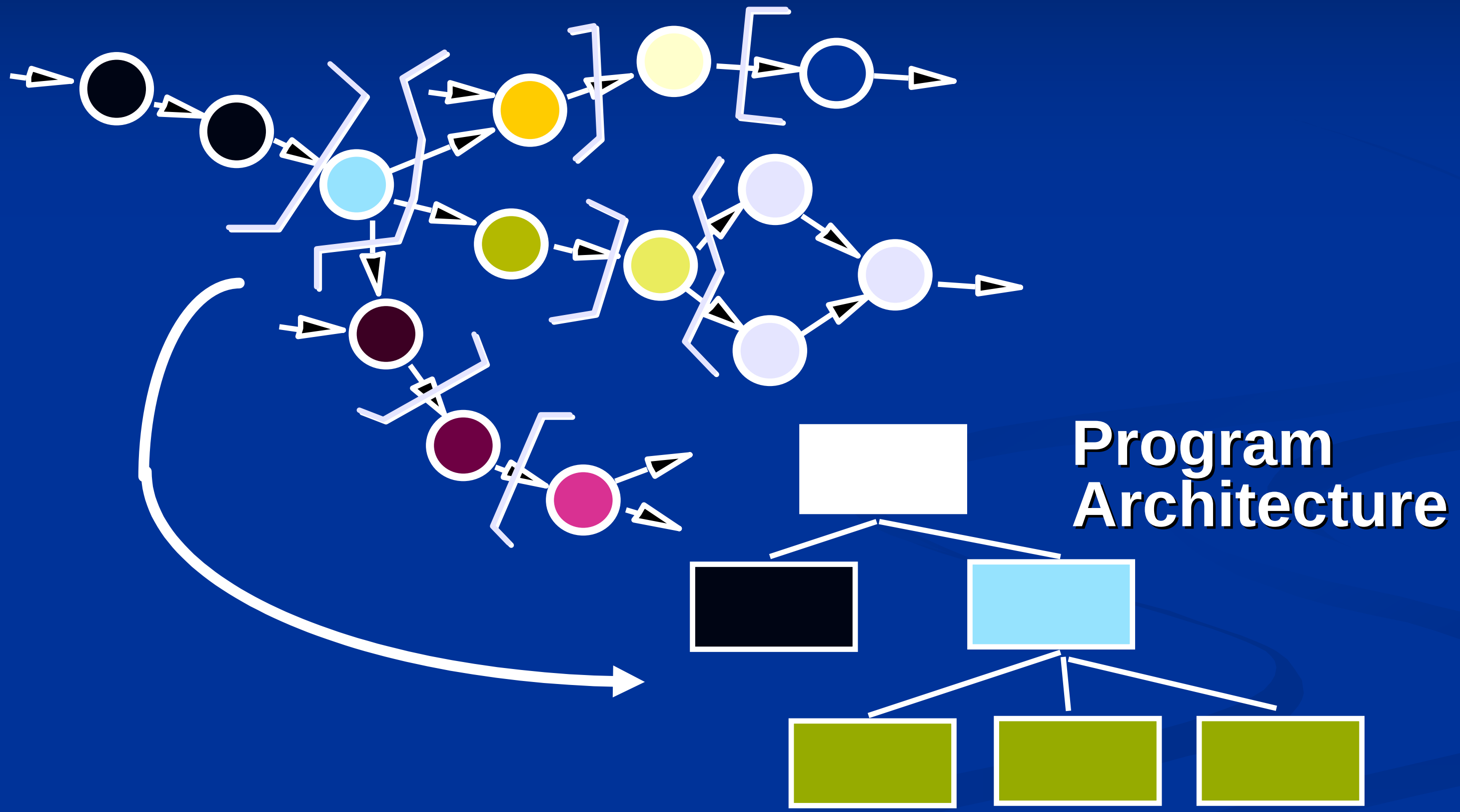
"four bedrooms, three baths,
lots of glass ..."





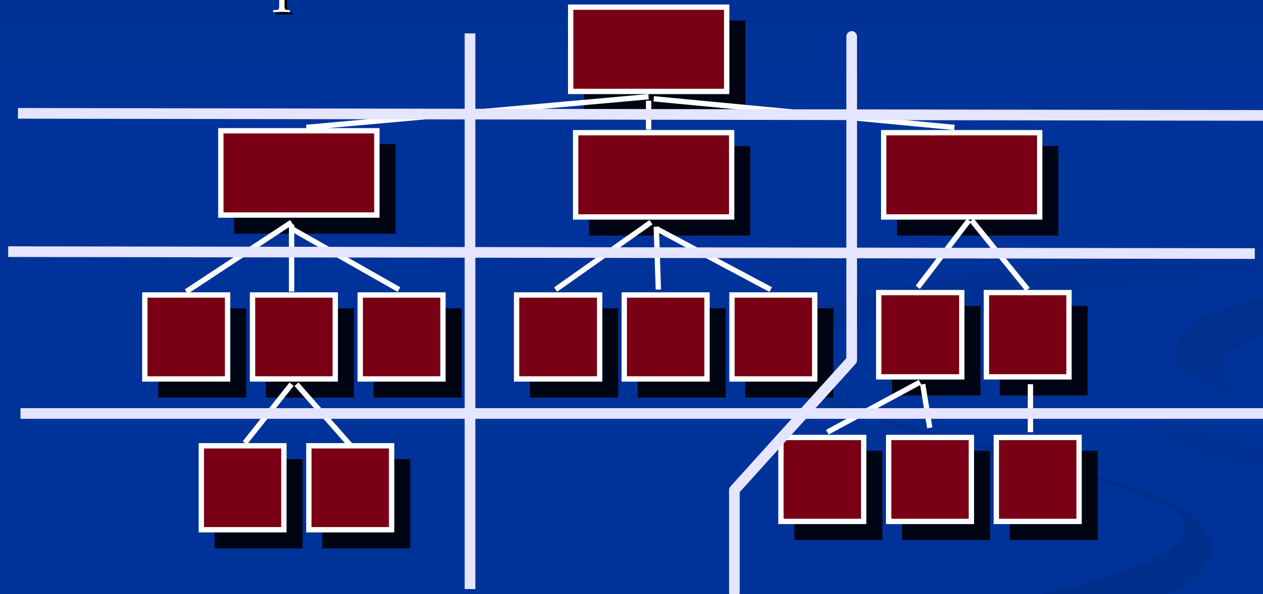
architectural design

Deriving Program Architecture



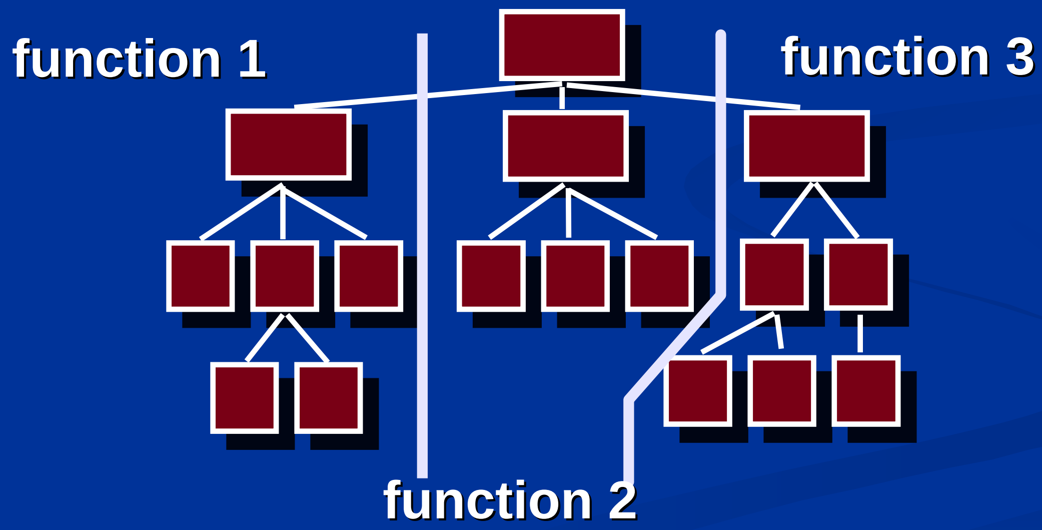
Partitioning the Architecture

- "horizontal" and "vertical" partitioning are required



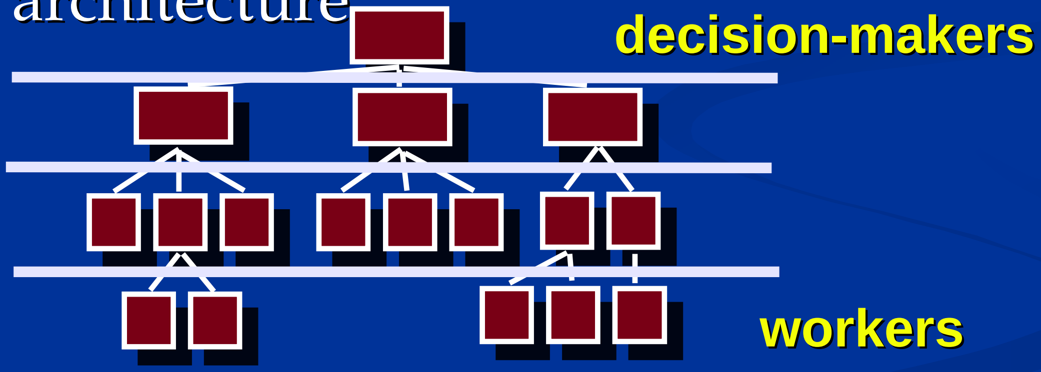
Horizontal Partitioning

- define separate branches of the module hierarchy for each major function
- use control modules to coordinate communication between functions



Vertical Partitioning: Factoring

- design so that decision making and work are stratified
- decision making modules should reside at the top of the architecture



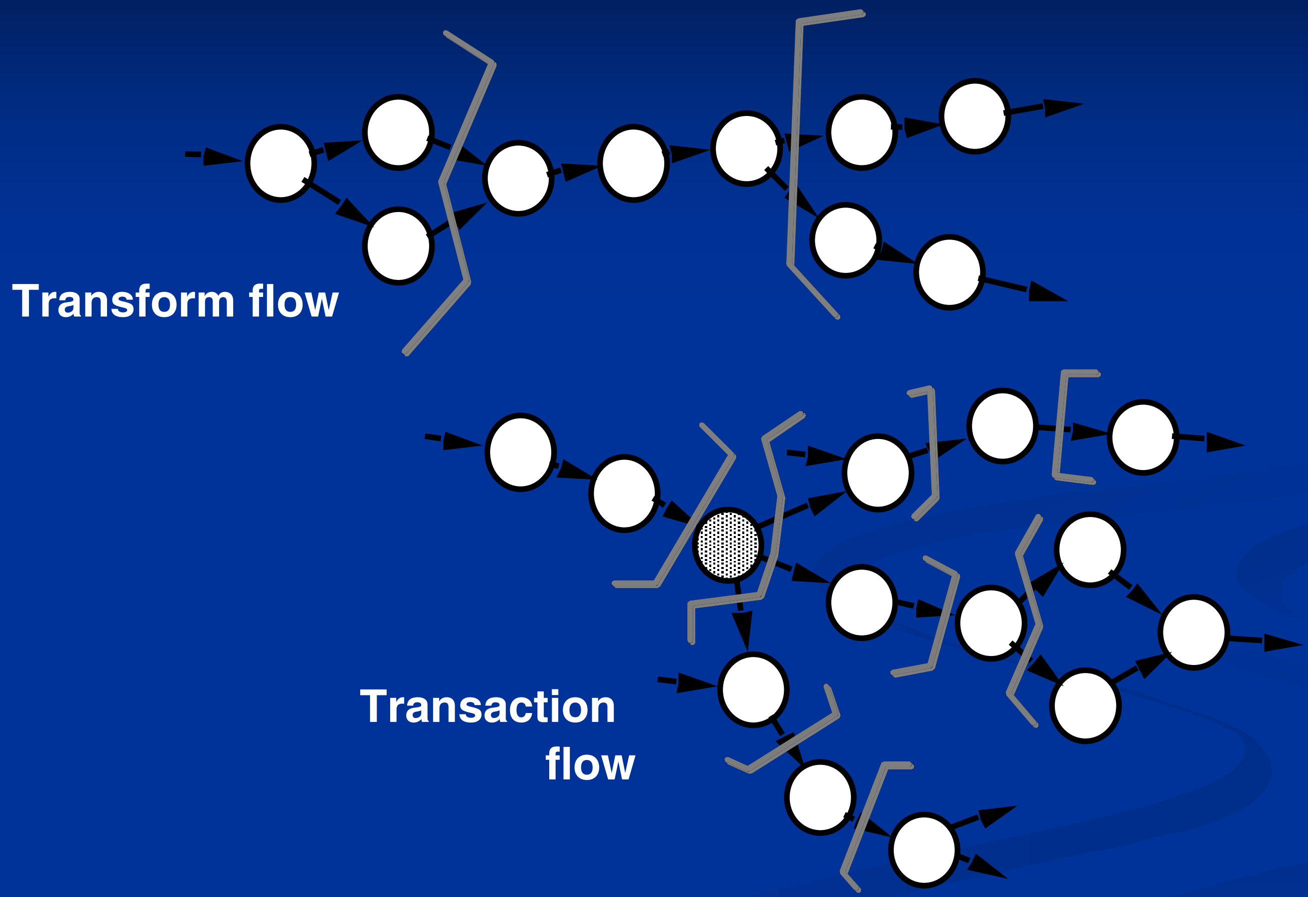
Why Partitioned Architecture?

- results in software that is easier to test
- leads to software that is easier to maintain
- results in propagation of fewer side effects
- results in software that is easier to extend

Structured Design

- objective: to derive a program architecture that is partitioned
- approach:
  - the Data Flow Diagram (DFD) is mapped into a program architecture
  - the Process Specification (PSPEC) and State Transition Diagram (STD) are used to indicate the content of each module
- notation: structure chart

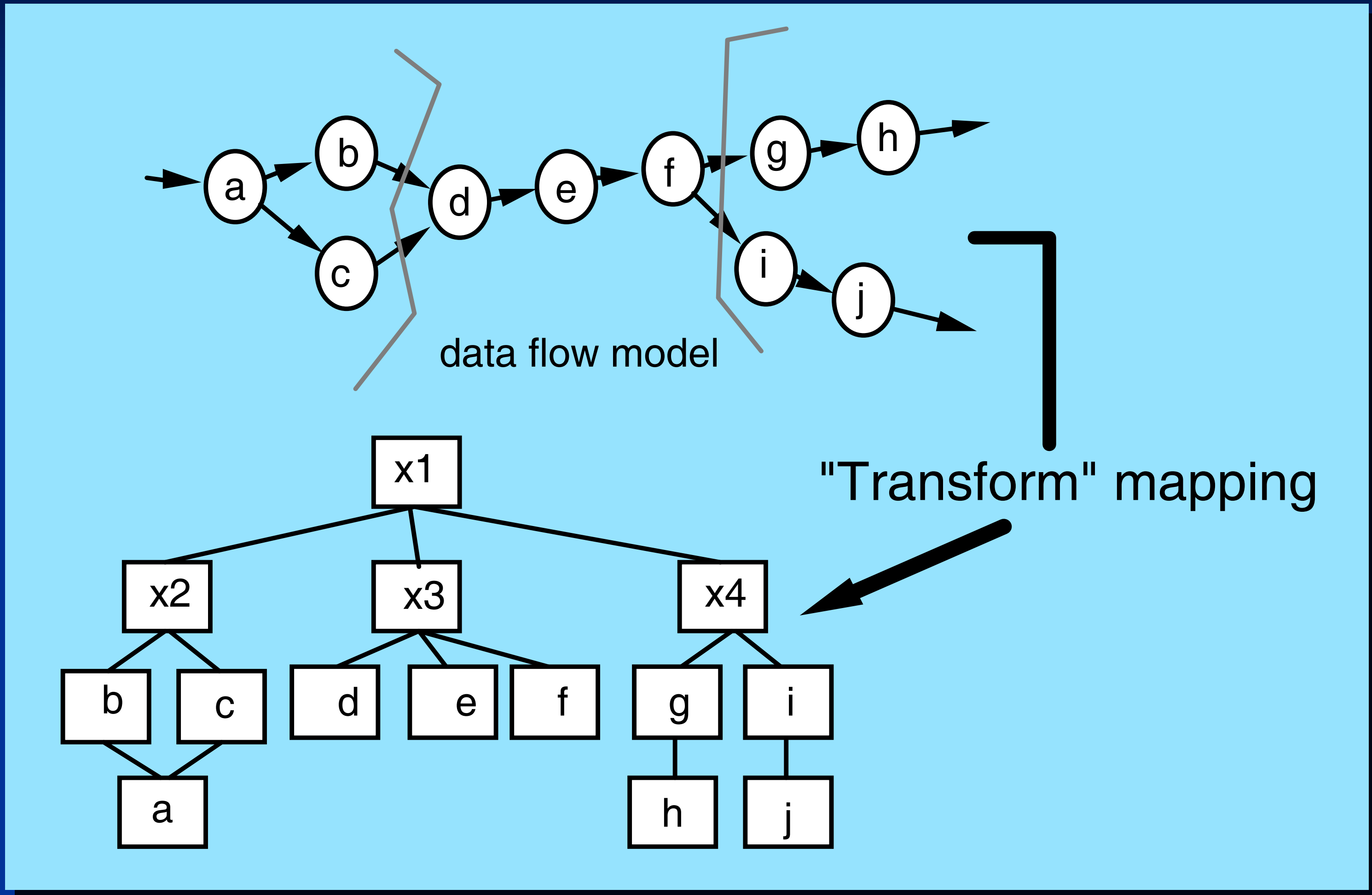
Flow Characteristics



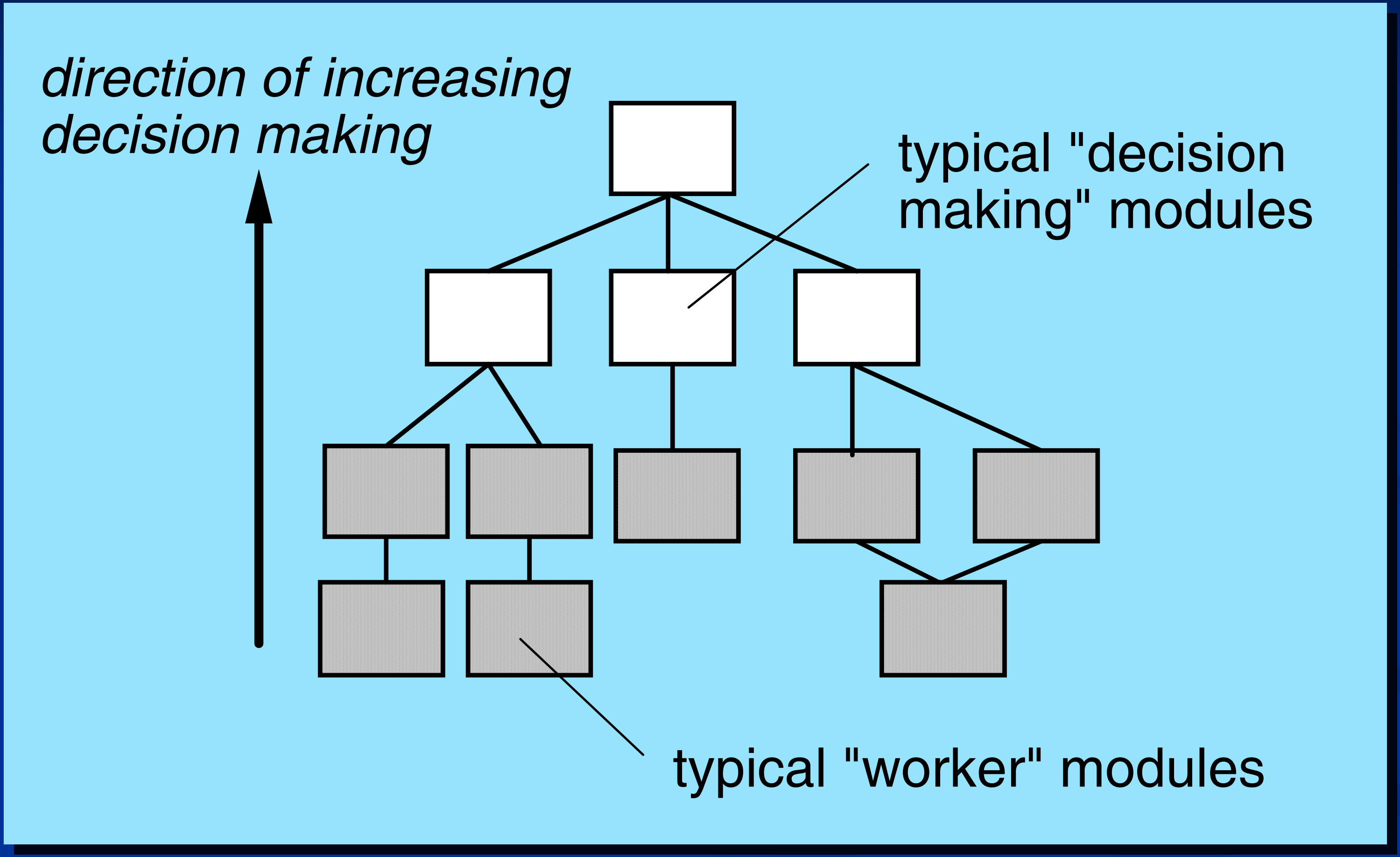
General Mapping Approach

- isolate incoming and outgoing flow boundaries; for transaction flows, isolate the transaction center
- working from the boundary outward, map DFD transforms into corresponding modules
- add control modules as required
- refine the resultant program structure using effective modularity concepts

Transform Mapping

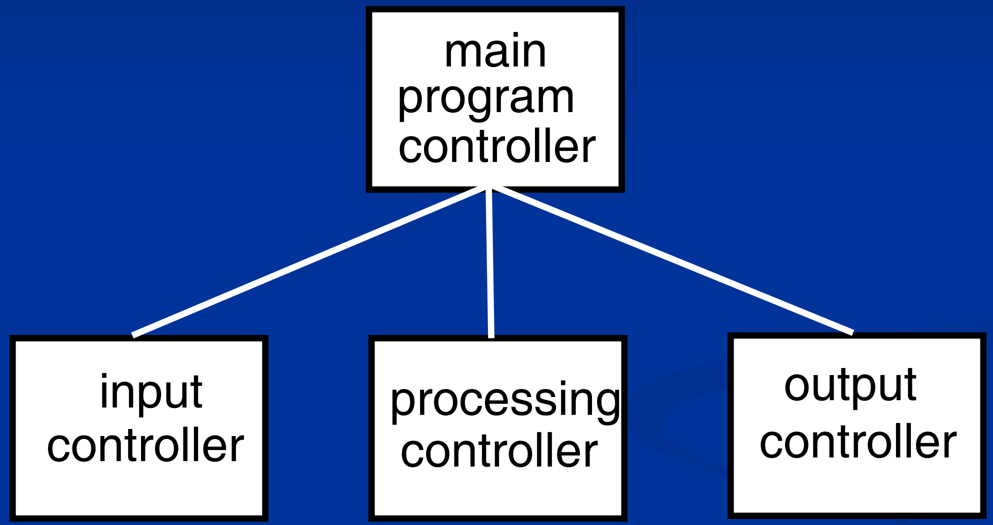


Factoring

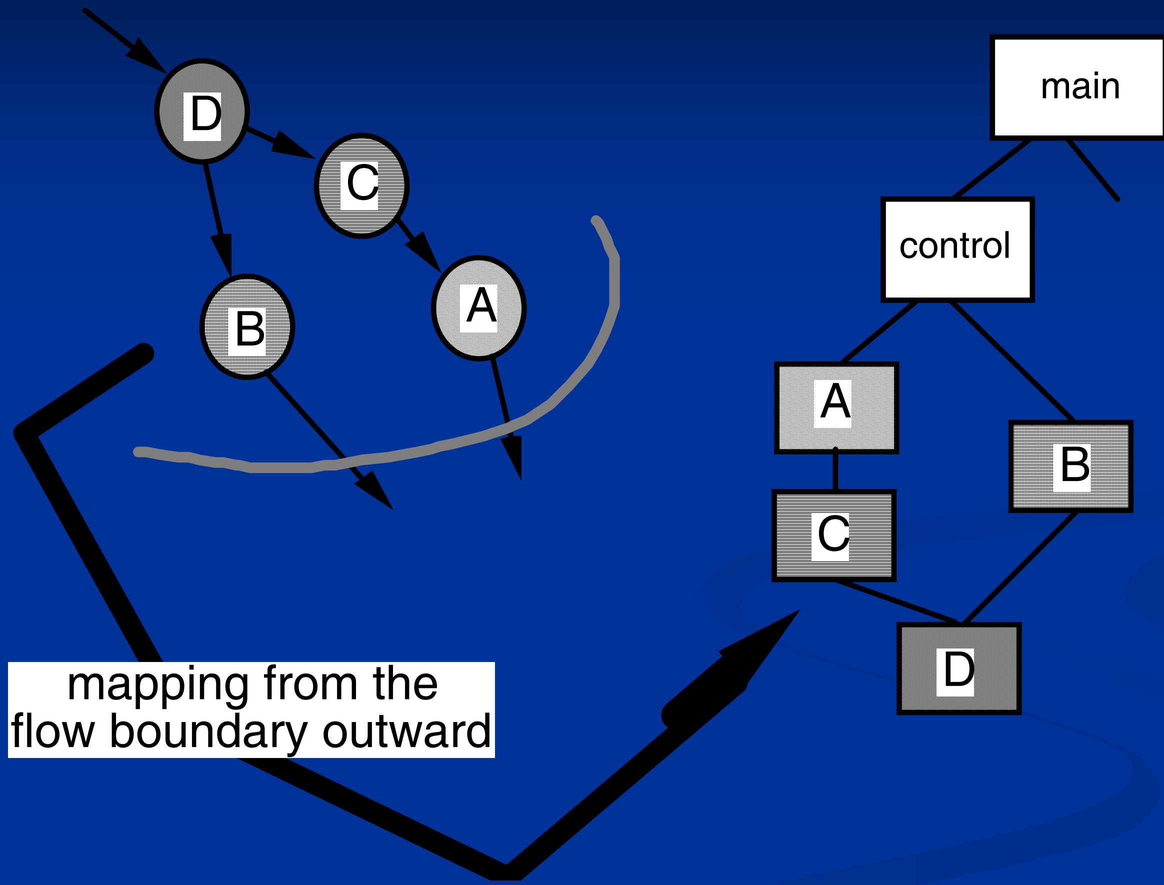


direction of increasing
decision making
typical "decision
making" modules
typical "worker" modules

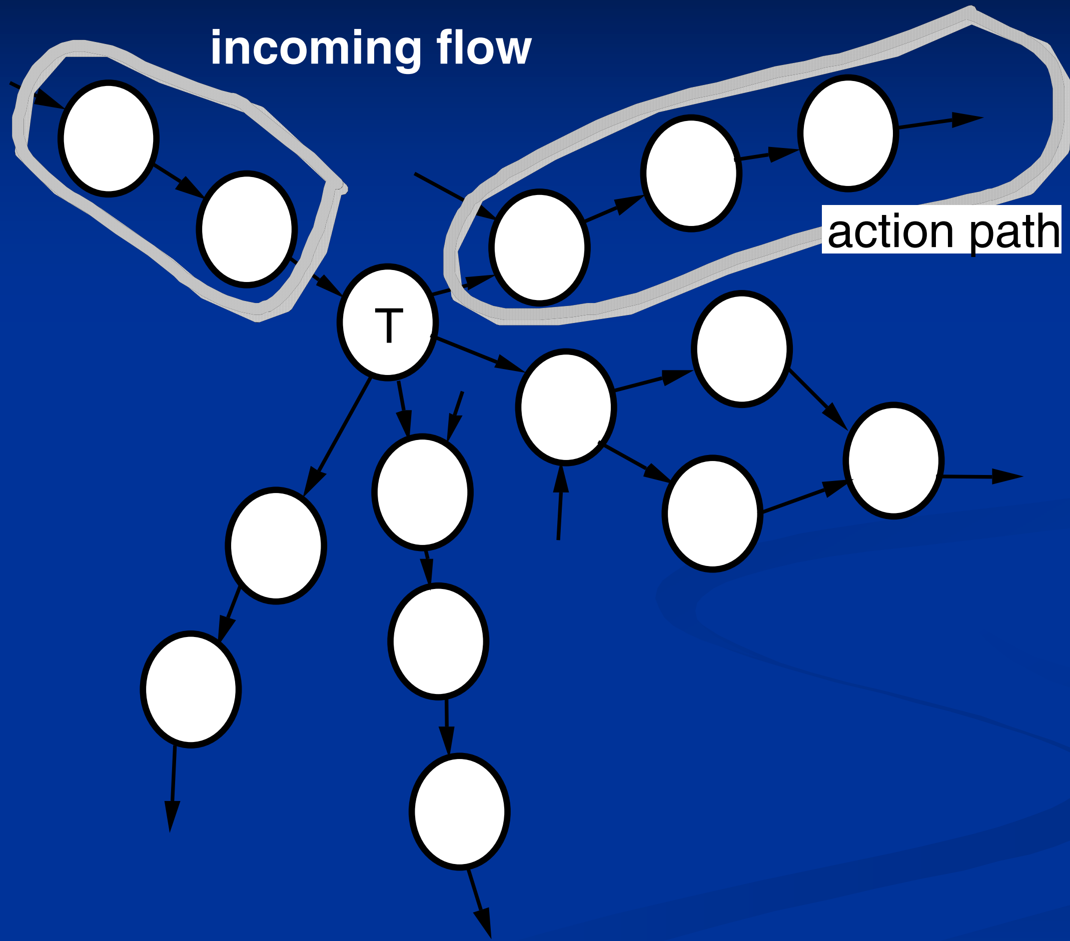
First Level Factoring



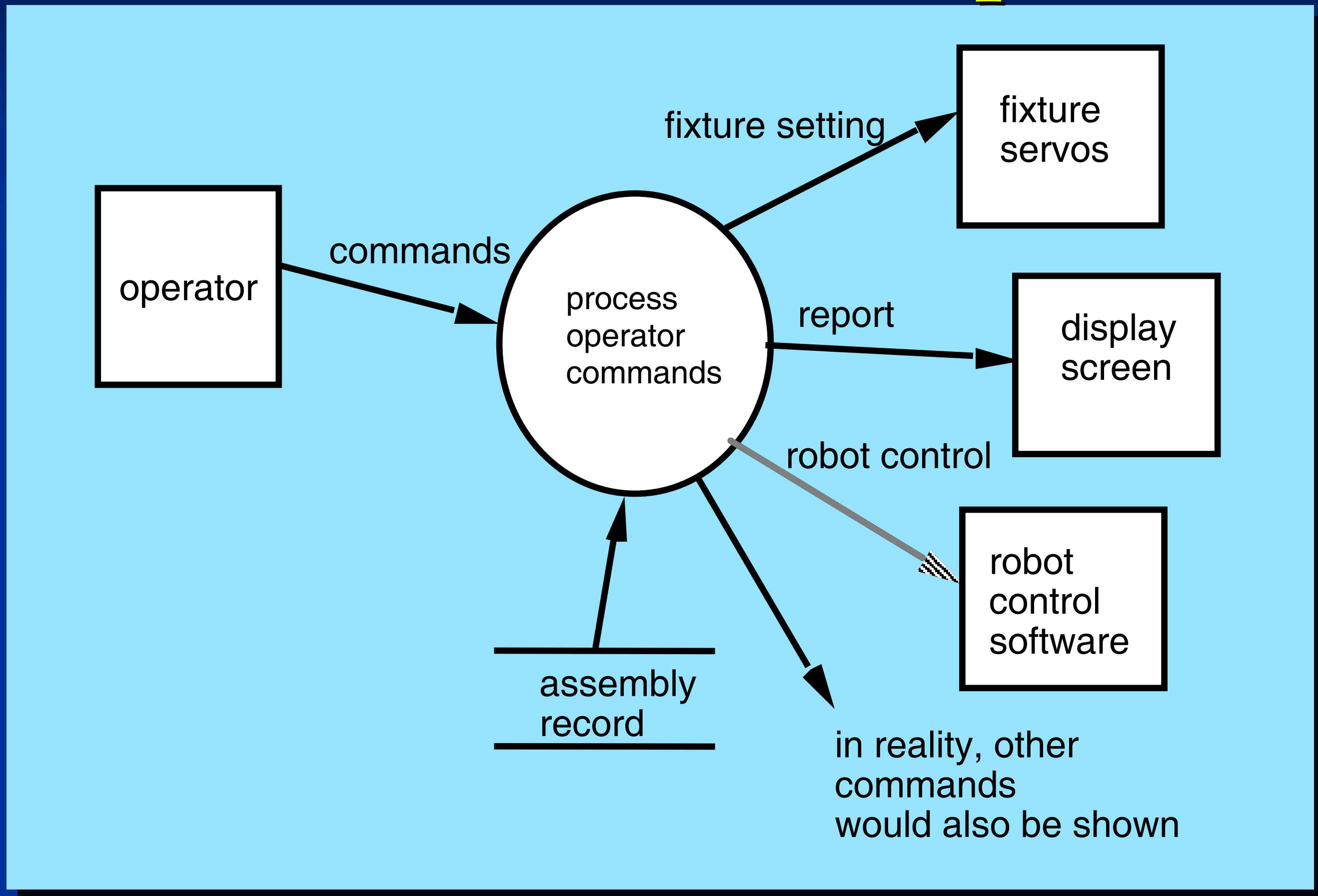
Second Level Mapping



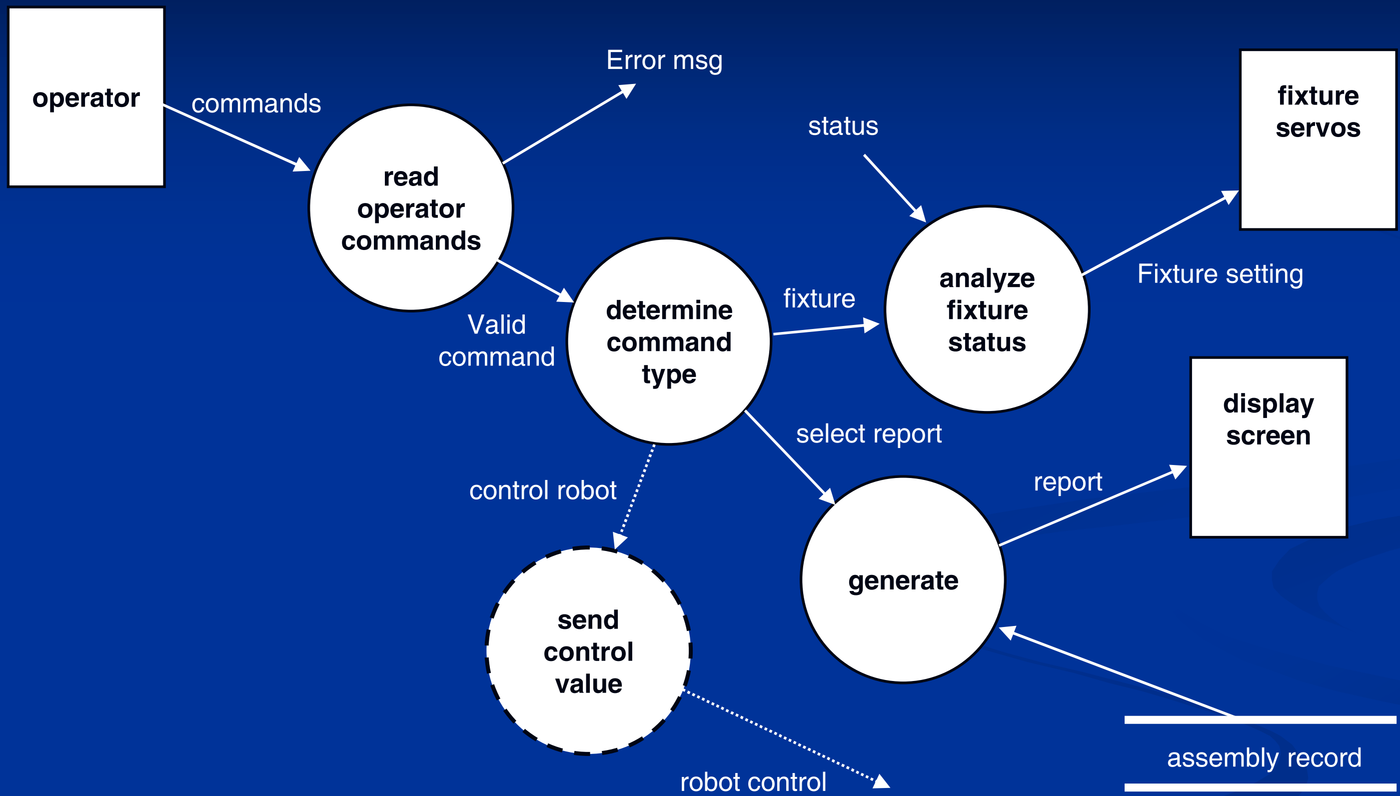
Transaction Flow



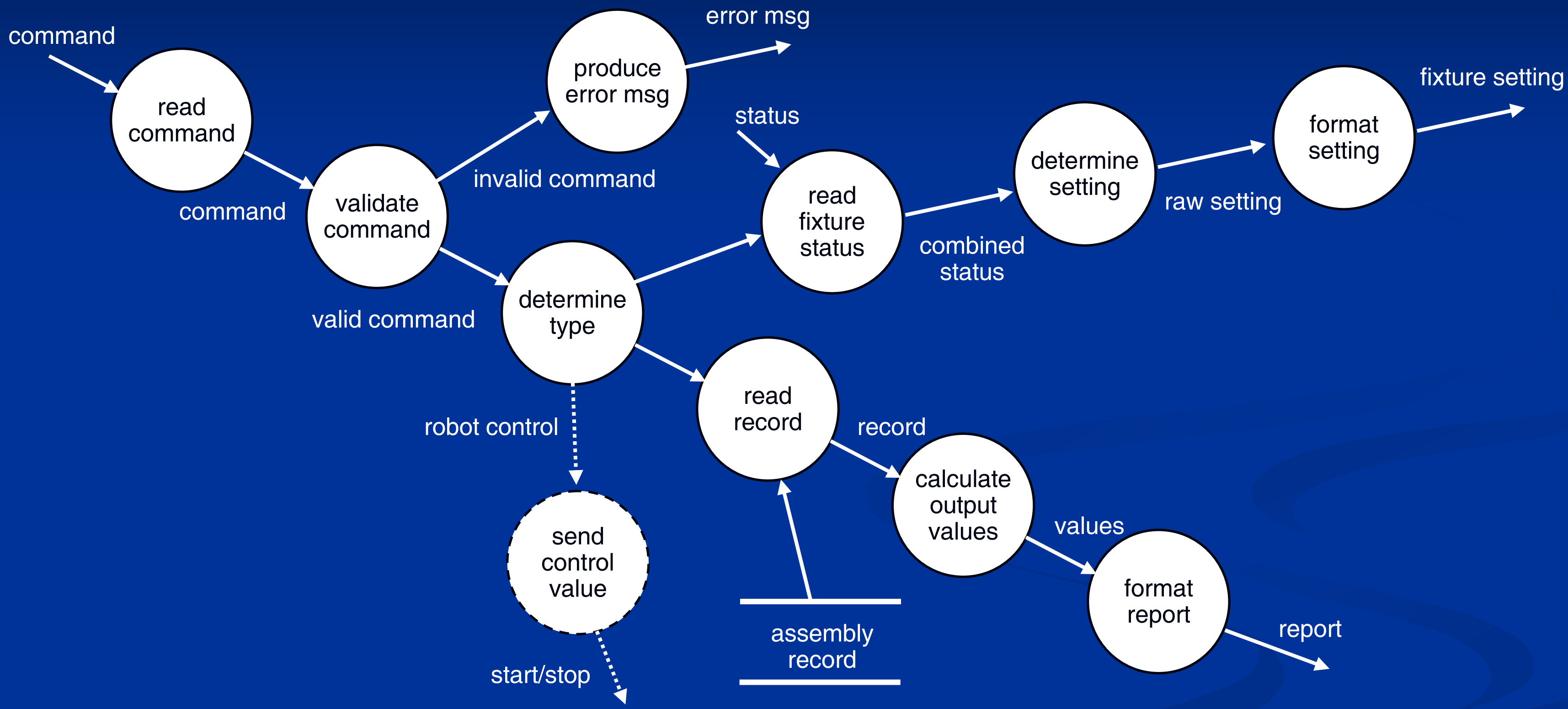
Transaction Example



Level 1 Data Flow Diagram



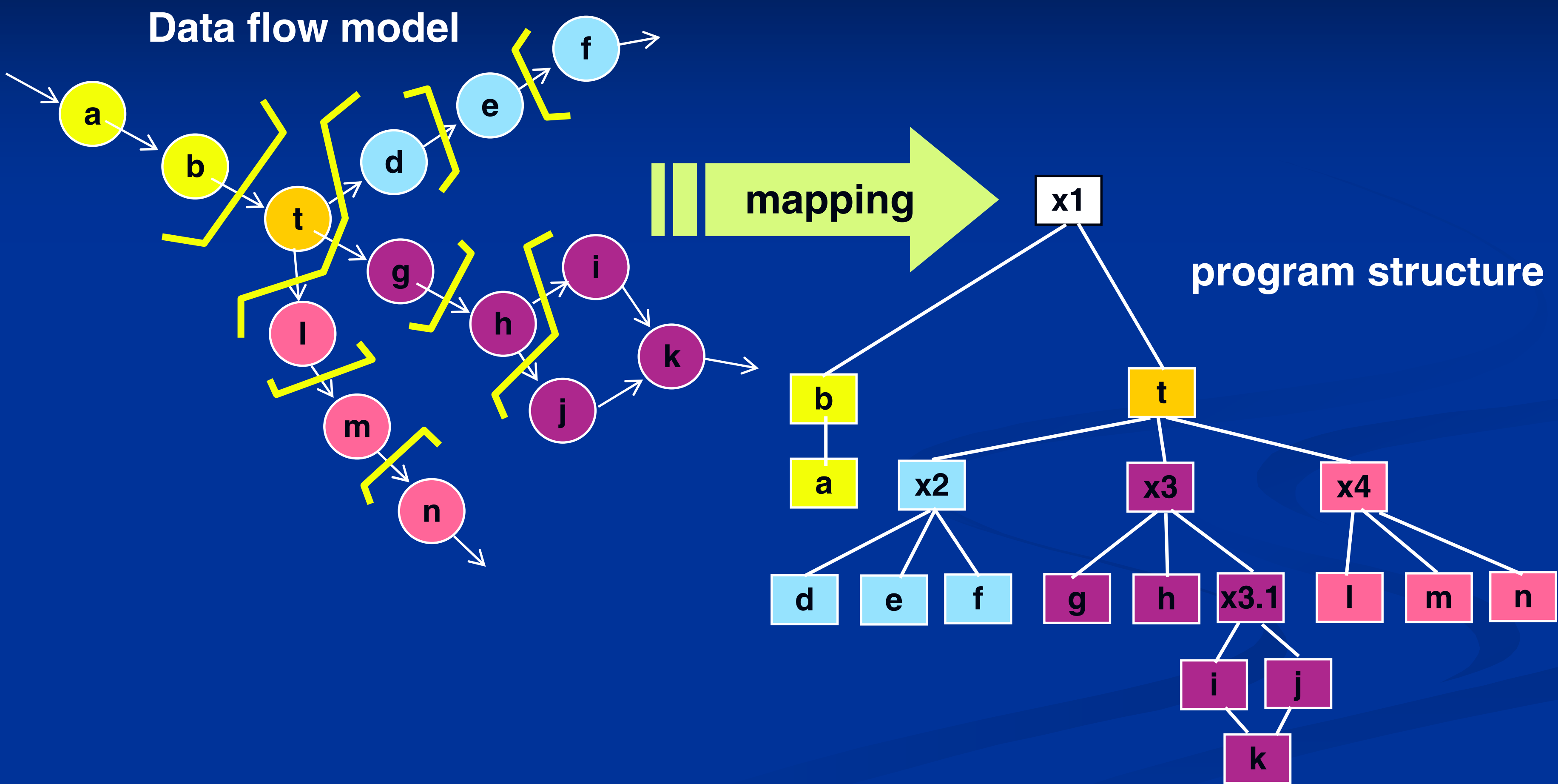
Level 2 Data Flow Diagram



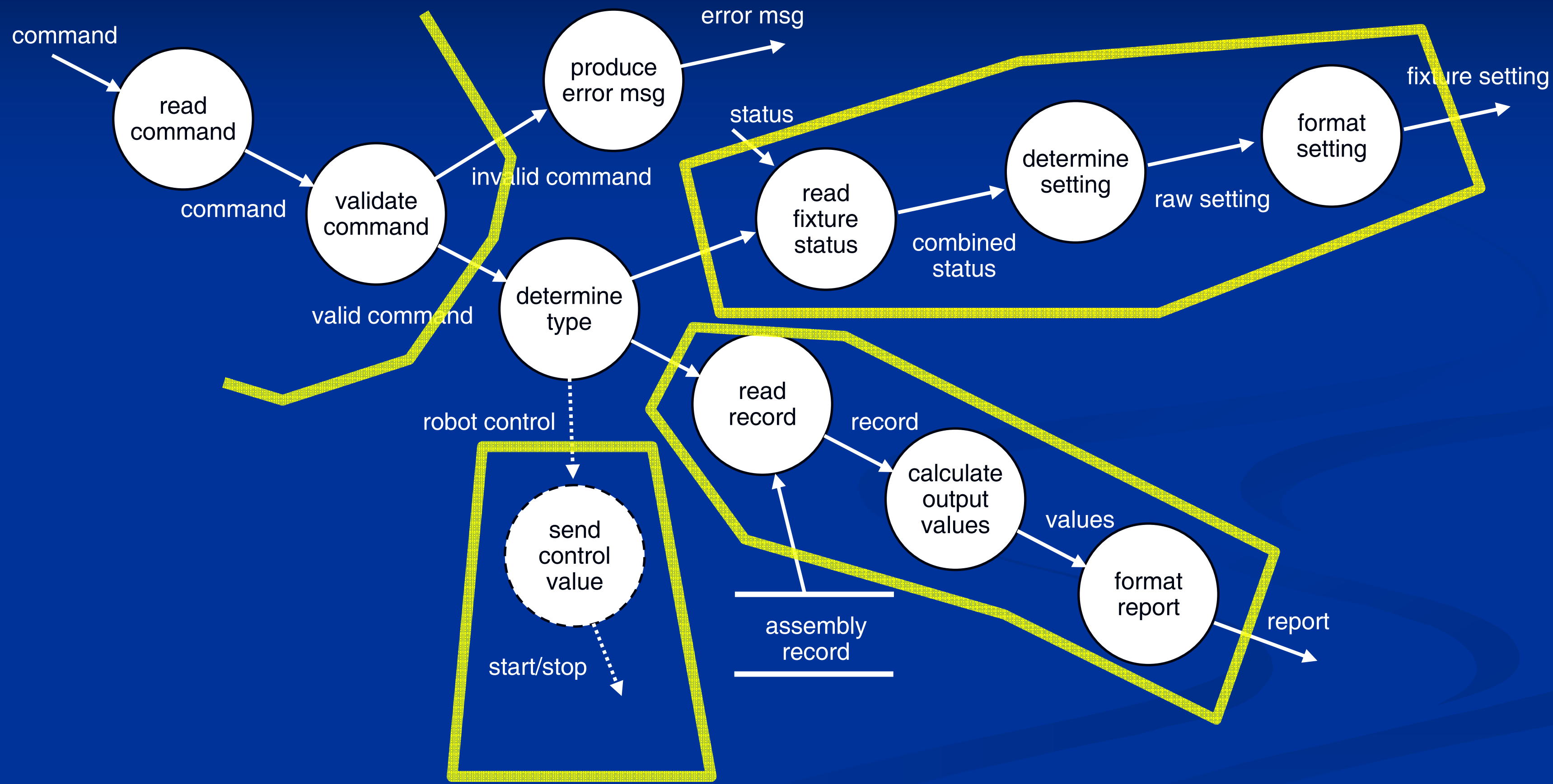
Transaction Mapping Principles

- isolate the incoming flow path
- define each of the action paths by looking for the "spokes of the wheel"
- assess the flow on each action path
- define the dispatch and control structure
- map each action path flow individually

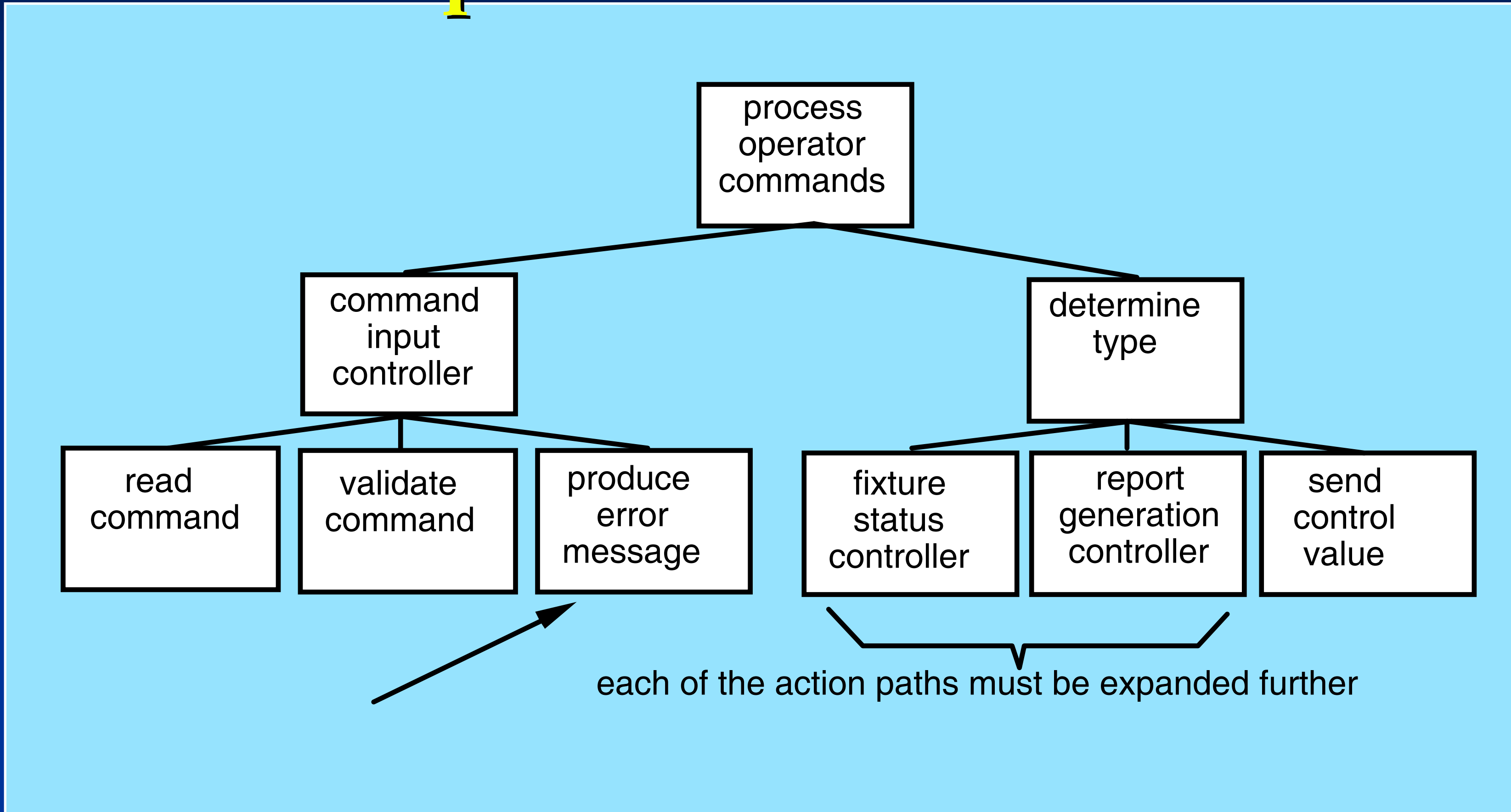
Transaction Mapping



Isolate Flow Paths



Map the Flow Model



Refining the Structure Chart