Lecture 21:
Software Architectures

→ Architectural Styles

- Pipe and filter
- Object oriented:
  - Client-Server; Object Broker
- Event based
- Layered:
  - Designing Layered Architectures
- Repositories:
  - Blackboard, MVC
- Process control

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Analysis vs. Design

- Analysis
  - Asks "what is the problem?"
    - what happens in the current system?
    - what is required in the new system?
  - Results in a detailed understanding of:
    - Requirements
    - Domain Properties
  - Focuses on the way human activities are conducted
- Design
  - Investigates "how to build a solution"
    - How will the new system work?
    - How can we solve the problem that the analysis identified?
  - Results in a solution to the problem
    - A working system that satisfies the requirements
    - Hardware + Software + Peopleware
  - Focuses on building technical solutions
- Separate activities, but not necessarily sequential
  - …and attempting a design usually improves understanding of the problem

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Software Architecture

- A software architecture defines:
  - the components of the software system
  - how the components use each other's functionality and data
  - How control is managed between the components
- An example: client-server
  - Servers provide some kind of service; clients request and use services
  - applications are located with clients
    - E.g. running on PCs and workstations;
  - data storage is treated as a server
    - E.g. using a DBMS such as DB2, Ingres, Sybase or Oracle
    - Consistency checking is located with the server
  - Advantages:
    - Breaks the system into manageable components
    - Makes the control and data persistence mechanisms clearer
  - Variants:
    - Thick clients have their own services, thin ones get everything from servers
  - Note: Are we talking about logical (s/w) or physical (h/w) architecture?

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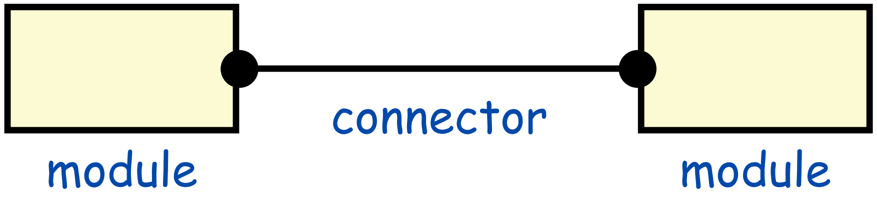
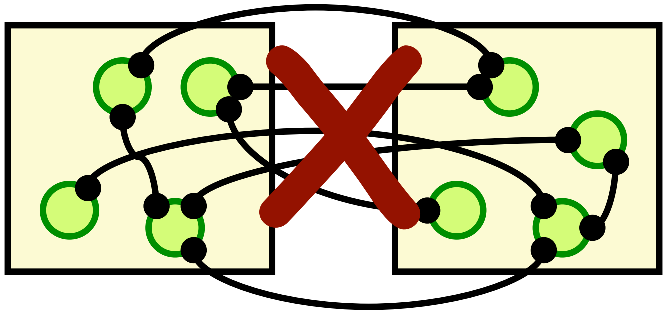
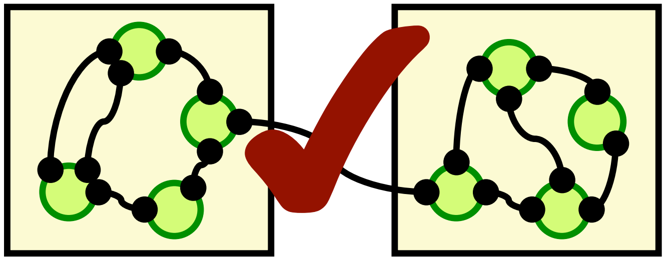
Coupling and Cohesion

- Architectural Building blocks:



- A good architecture:
  - Minimizes coupling between modules:
    - Goal: modules don't need to know much about one another to interact
    - Low coupling makes future change easier
  - Maximizes the cohesion of each module
    - Goal: the contents of each module are strongly inter-related
    - High cohesion makes a module easier to understand





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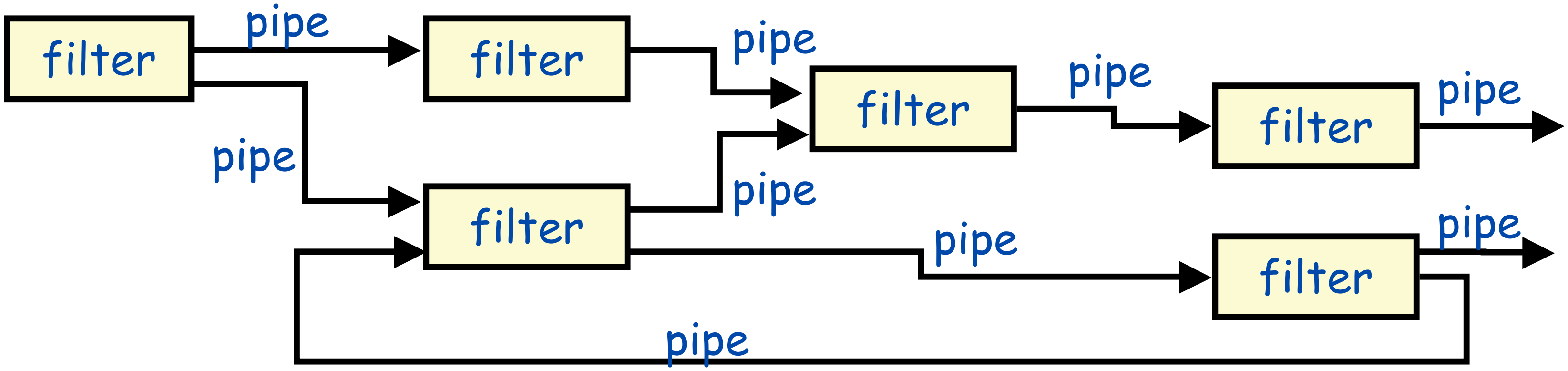
Pipe-and-filter

Source: *Adapted from Shaw & Garlan 1996, p21-2. See also van Vliet, 1999 Pp266-7 and p279*



- **Examples:**
  - UNIX shell commands
  - Compilers:
    - Lexical Analysis -> parsing -> semantic analysis -> code generation
  - Signal Processing
- **Interesting properties:**
  - filters don't need to know anything about what they are connected to
  - filters can be implemented in parallel
  - behaviour of the system is the composition of behaviour of the filters
    - specialized analysis such as throughput and deadlock analysis is possible

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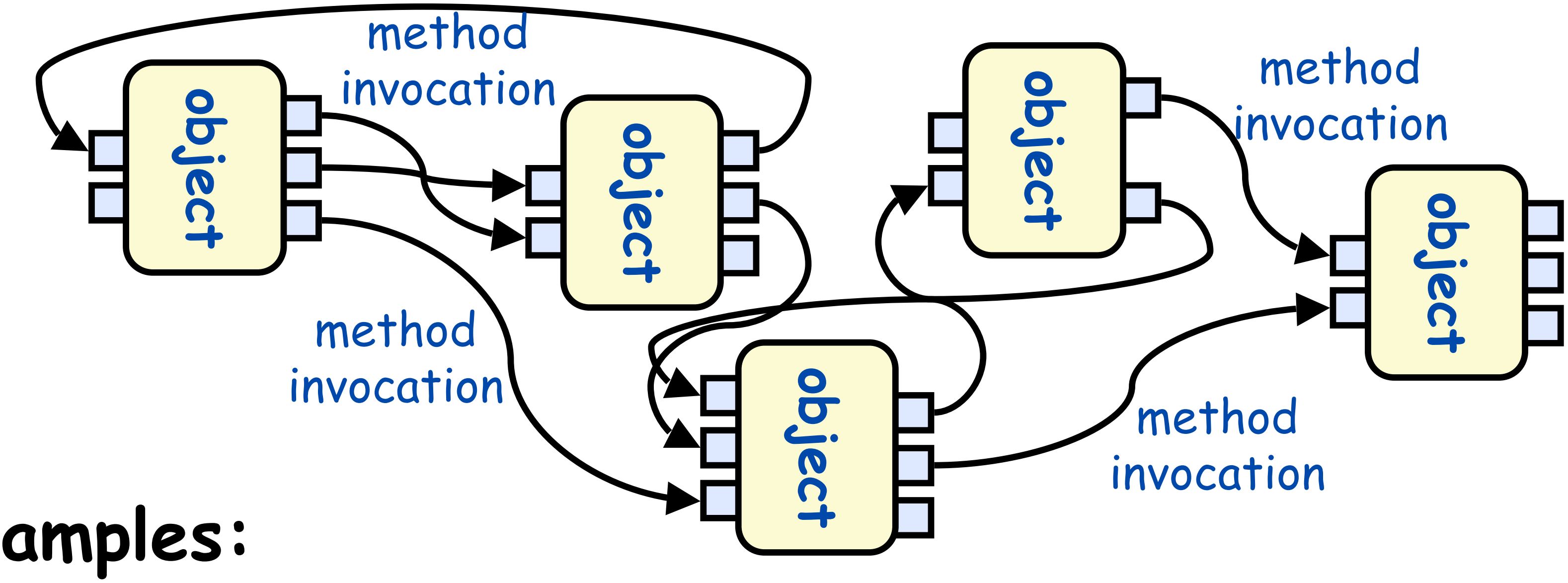
Object Oriented Architectures

Source: *Adapted from Shaw & Garlan 1996, p22-3.*



→ **Examples:**

↳ abstract data types

→ **Interesting properties**

↳ data hiding (internal data representations are not visible to clients)

↳ can decompose problems into sets of interacting agents

↳ can be multi-threaded or single thread

→ **Disadvantages**

↳ objects must know the identity of objects they wish to interact with

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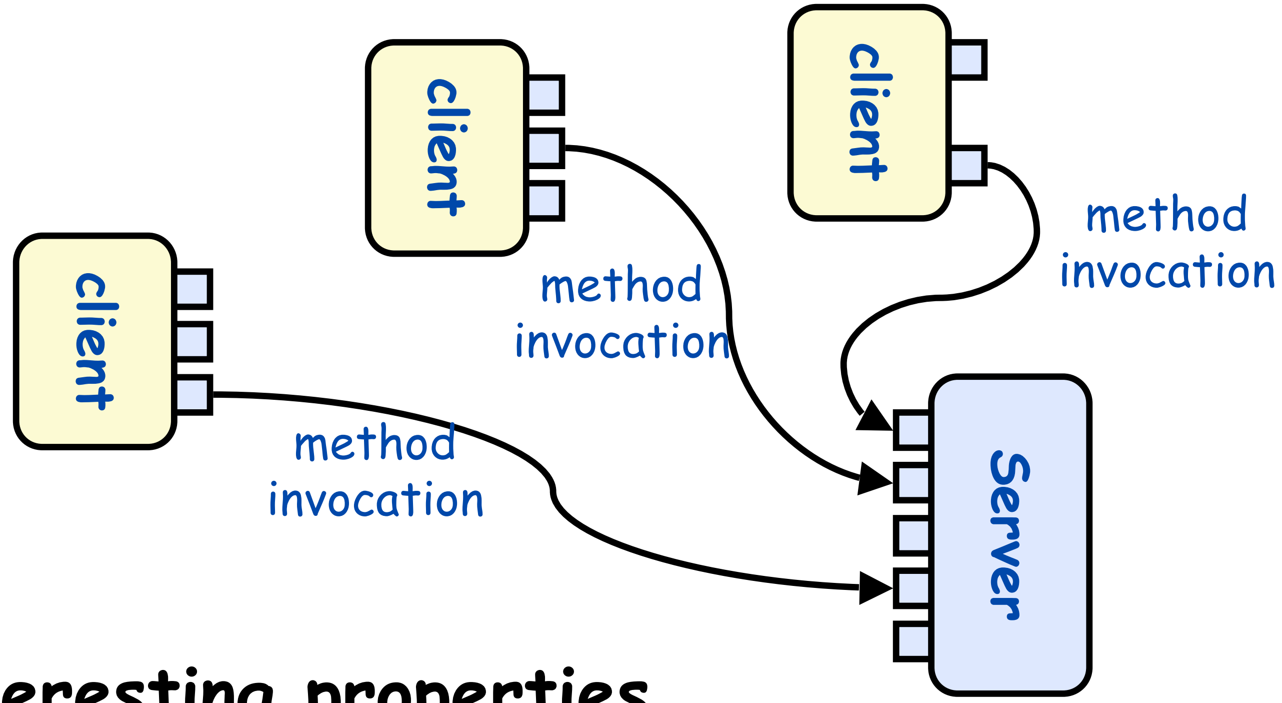
Variant 1: Client Server



- Interesting properties
  - Is a special case of the previous pattern object oriented architecture
  - Clients do not need to know about one another
- Disadvantages
  - Client objects must know the identity of the server

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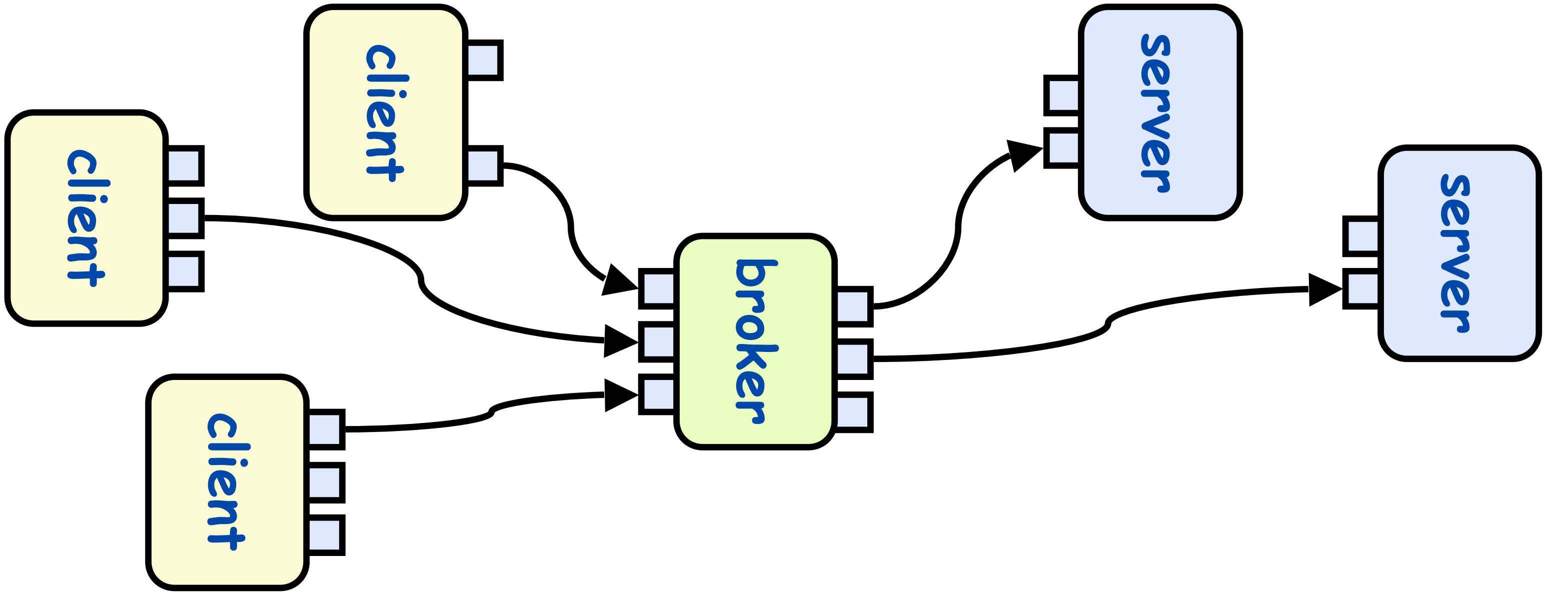
Variant 2: Object Brokers



→ Interesting properties

- ↳ Adds a broker between the clients and servers
- ↳ Clients no longer need to know which server they are using
- ↳ Can have many brokers, many servers.

→ Disadvantages

- ↳ Broker can become a bottleneck
- ↳ Degraded performance

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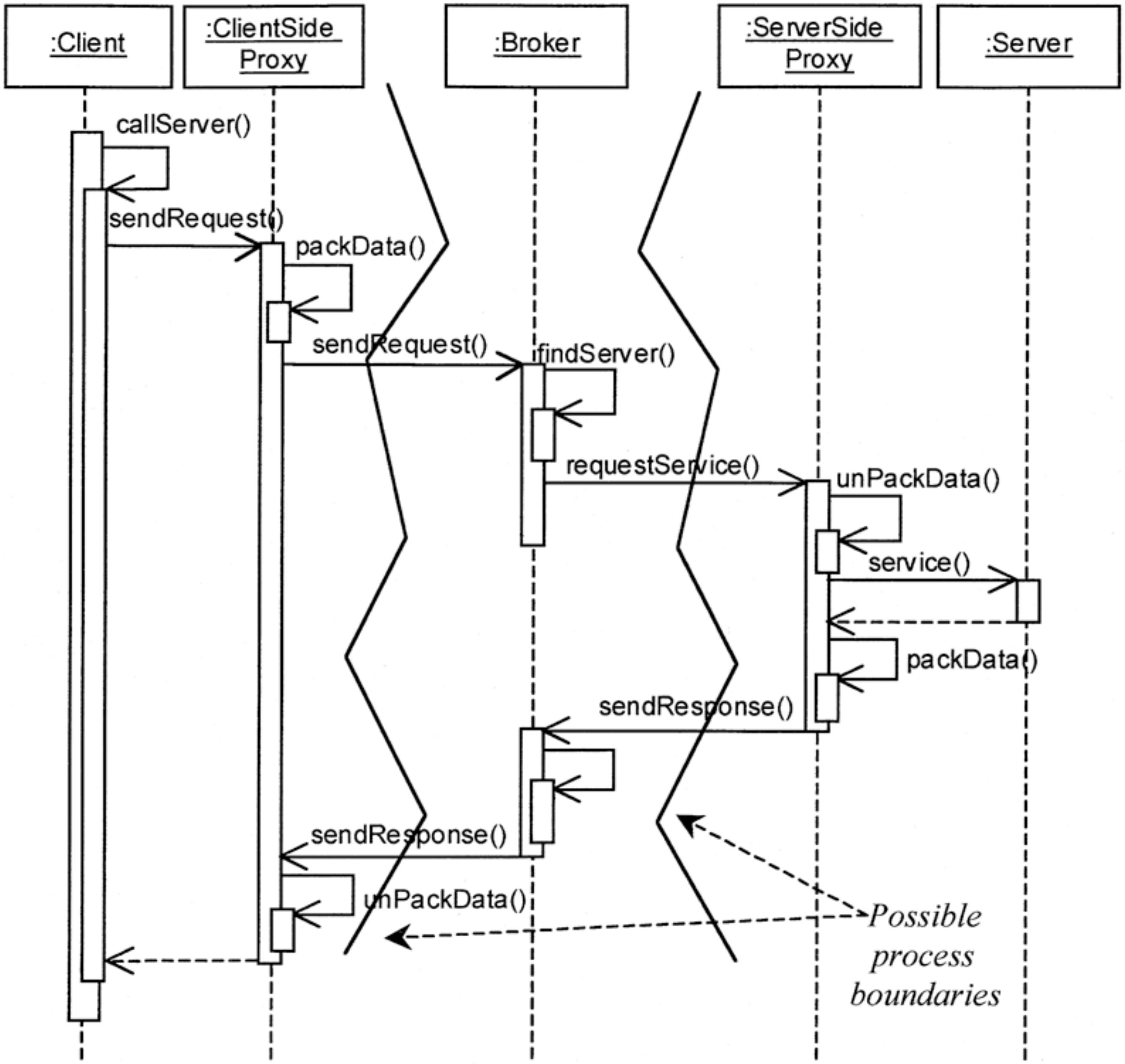
Broker Architecture Example



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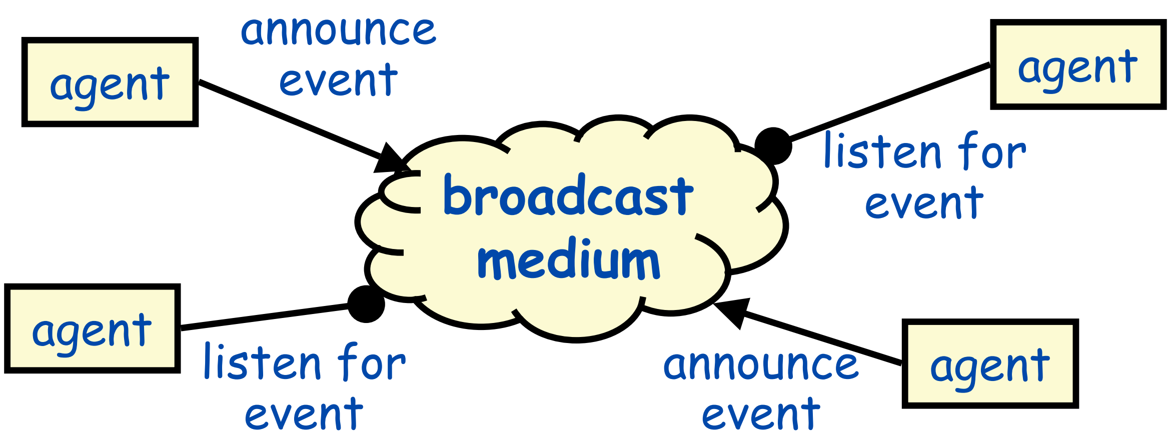
Event based (implicit invocation)

Source: *Adapted from Shaw & Garlan 1996, p23-4. See also van Vliet, 1999 Pp264-5 and p278*



→ Examples

- debugging systems (listen for particular breakpoints)
- database management systems (for data integrity checking)
- graphical user interfaces

→ Interesting properties

- announcers of events don't need to know who will handle the event
- Supports re-use, and evolution of systems (add new agents easily)

→ Disadvantages

- Components have no control over ordering of computations

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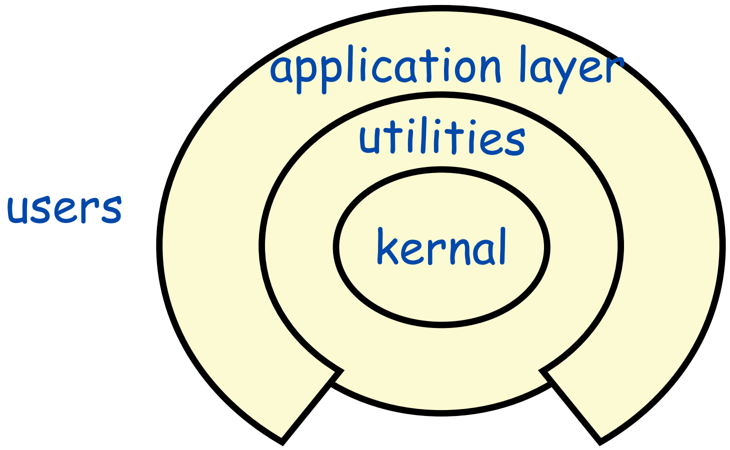
Layered Systems

Source: *Adapted from Shaw & Garlan 1996, p25. See also van Vliet, 1999, p281.*



→ Examples

- Operating Systems
- communication protocols

→ Interesting properties

- Support increasing levels of abstraction during design
- Support enhancement (add functionality) and re-use
- can define standard layer interfaces

→ Disadvantages

- May not be able to identify (clean) layers

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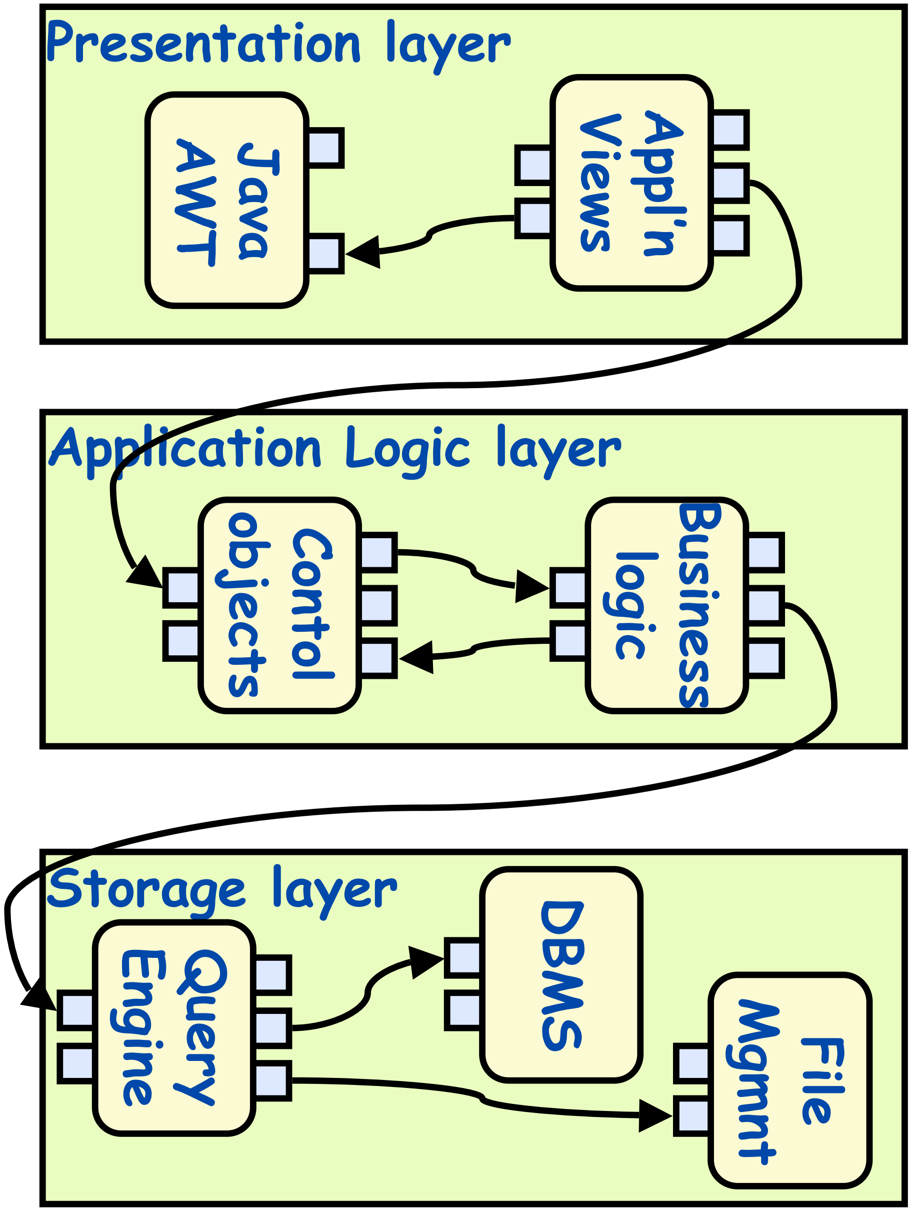
Variant: 3-layer data access



Presentation layer

Java AWT

Appl'n Views

Application Logic layer

Contol objects

Business logic

Storage layer

Query Engine

DBMS

File Mgmnt

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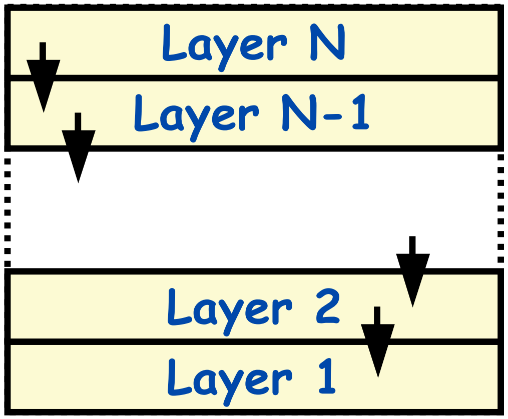
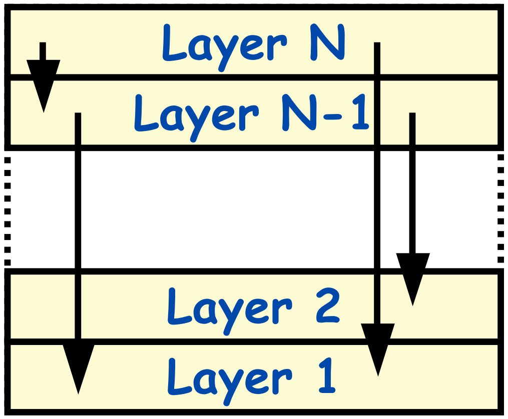
Open vs. Closed Layered Architecture

- → closed architecture
  - ↳ each layer only uses services of the layer immediately below;
  - ↳ Minimizes dependencies between layers and reduces the impact of a change.



- → open architecture
  - ↳ a layer can use services from any lower layer.
  - ↳ More compact code, as the services of lower layers can be accessed directly
  - ↳ Breaks the encapsulation of layers, so increase dependencies between layers



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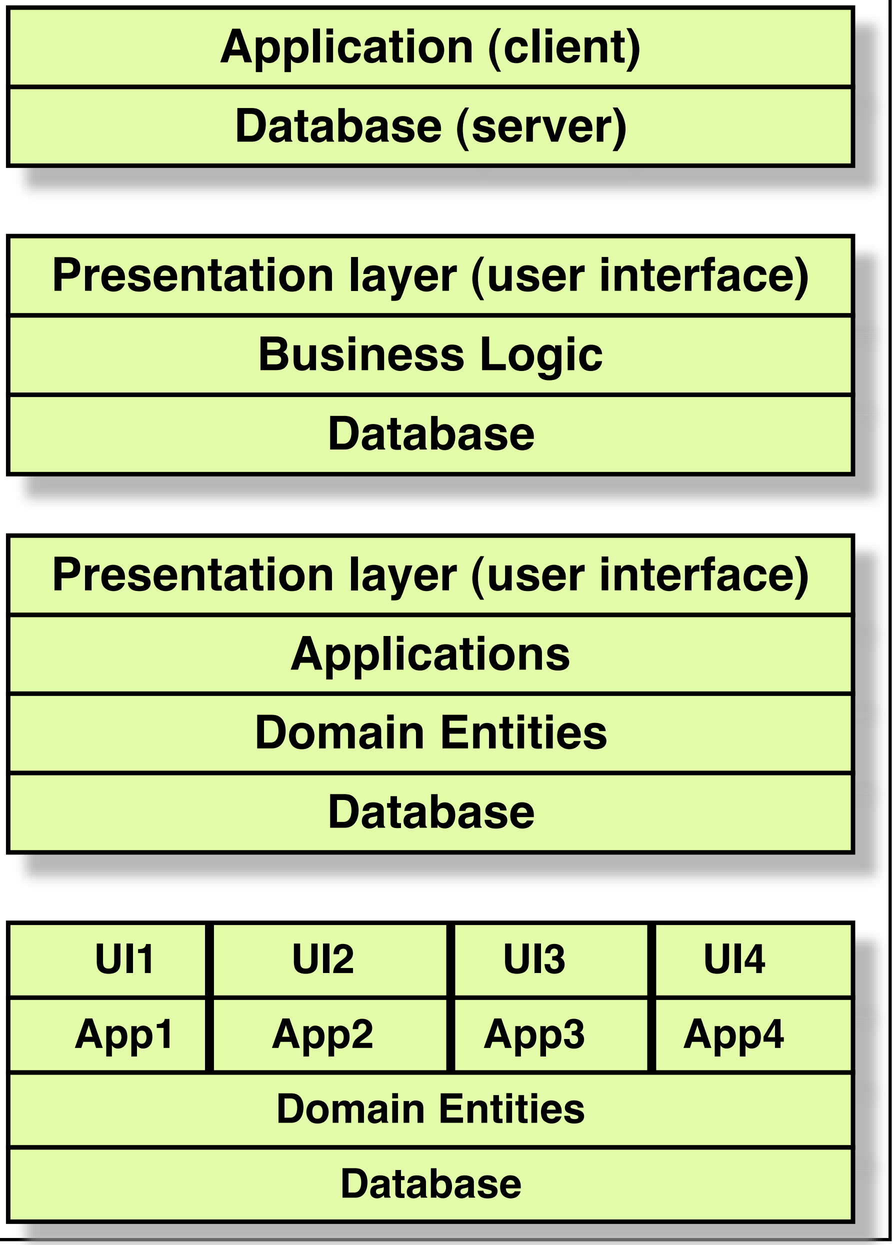
How many layers?

- → 2-layers:
  - ↳ application layer
  - ↳ database layer
  - ↳ e.g. simple client-server model
- → 3-layers:
  - ↳ separate out the business logic
    - ➢helps to make both user interface and database layers modifiable
- → 4-layers:
  - ↳ Separates applications from the domain entities that they use:
    - ➢boundary classes in presentation layer
    - ➢control classes in application layer
    - ➢entity classes in domain layer
- → Partitioned 4-layers
  - ↳ identify separate applications



Application (client)

Database (server)

Presentation layer (user interface)

Business Logic

Database

Presentation layer (user interface)

Applications

Domain Entities

Database

UI1	UI2	UI3	UI4
App1	App2	App3	App4
Domain Entities			
Database			

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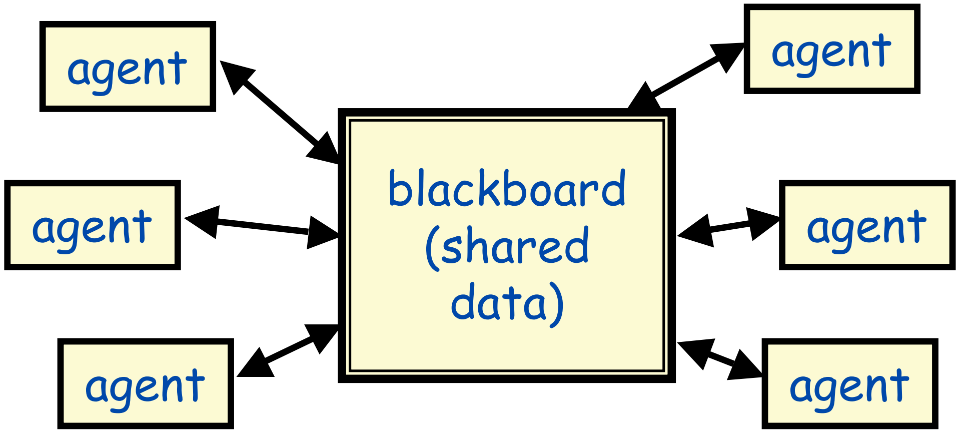
Repositories

Source: *Adapted from Shaw & Garlan 1996, p26-7. See also van Vliet, 1999, p280*



→ Examples

- databases
- blackboard expert systems
- programming environments

→ Interesting properties

- can choose where the locus of control is (agents, blackboard, both)
- reduce the need to duplicate complex data

→ Disadvantages

- blackboard becomes a bottleneck

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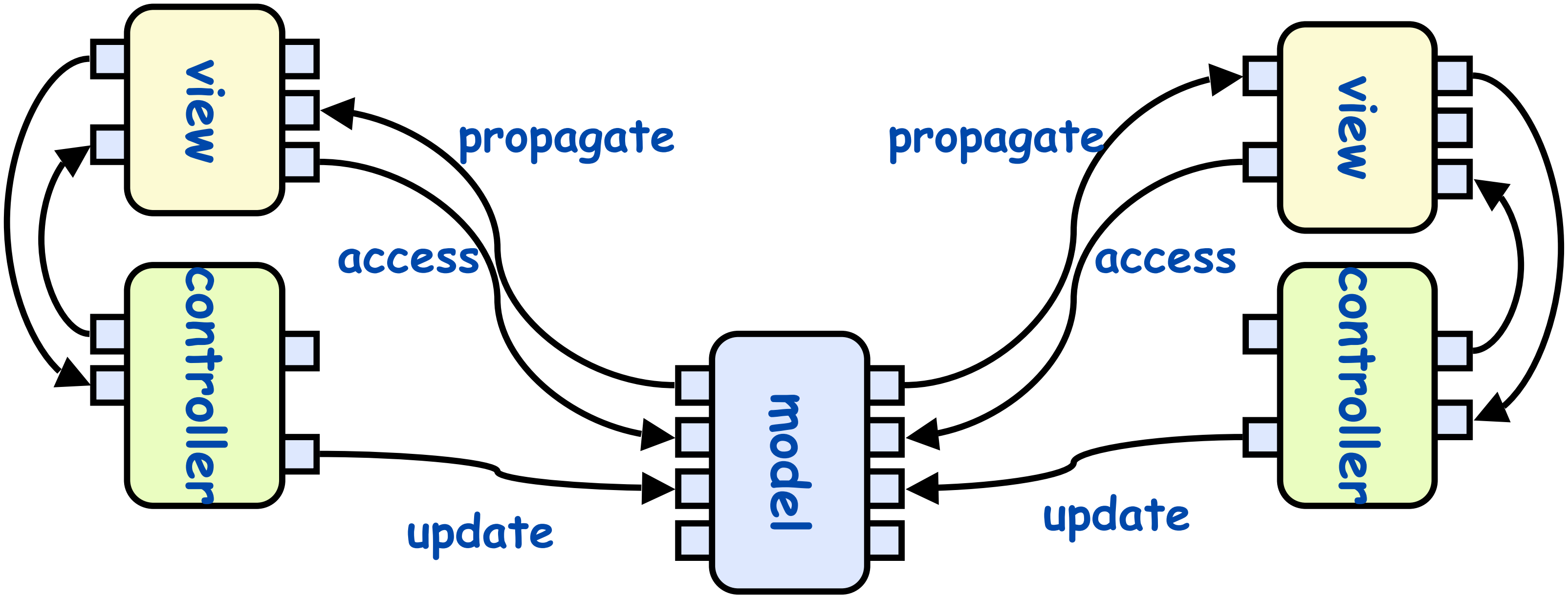
Variant: Model-View-Controller



→ Properties

- ↳ One central model, many views (viewers)
- ↳ Each view has an associated controller
- ↳ The controller handles updates from the user of the view
- ↳ Changes to the model are propagated to all the views

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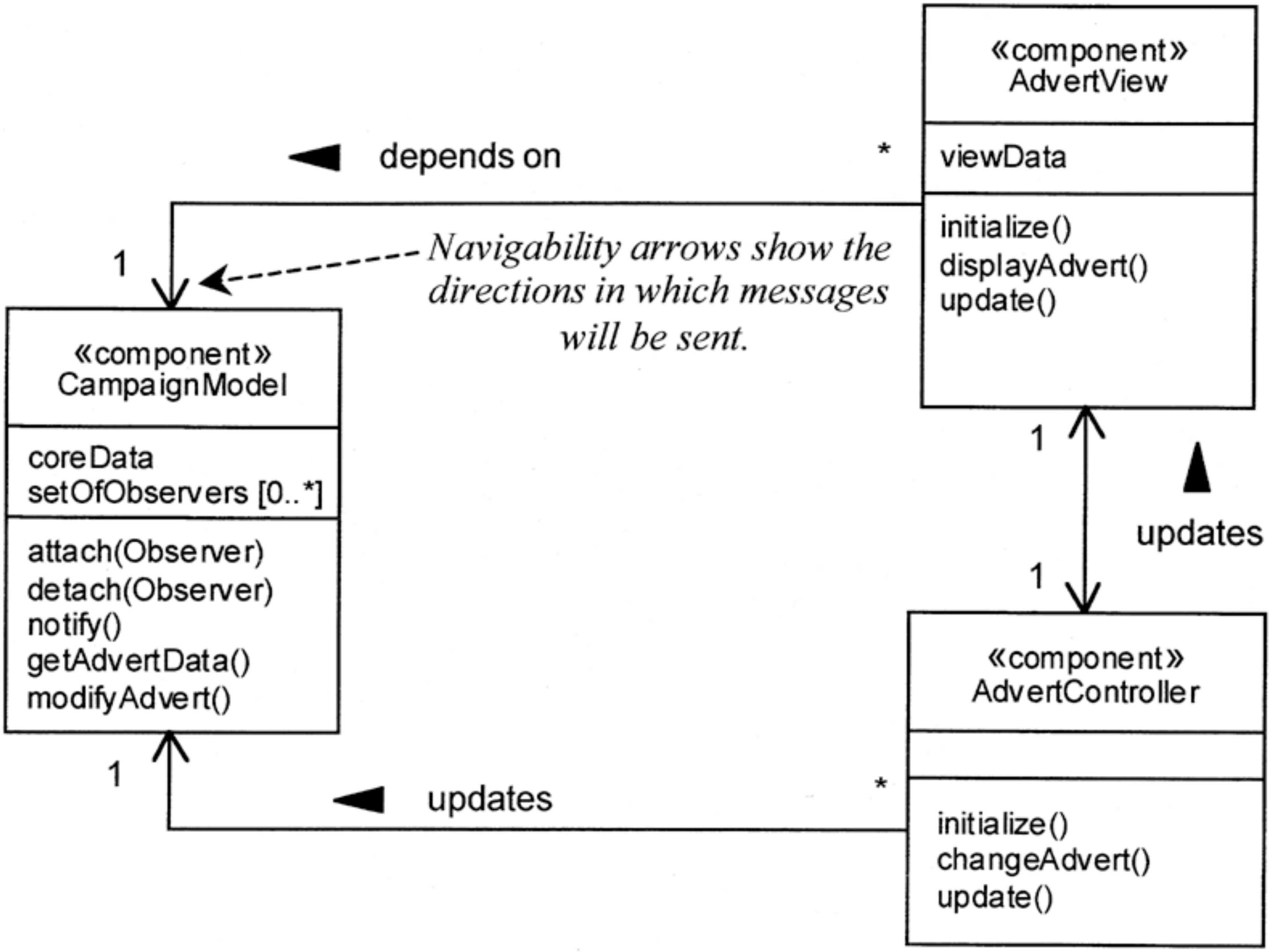
Model View Controller Example



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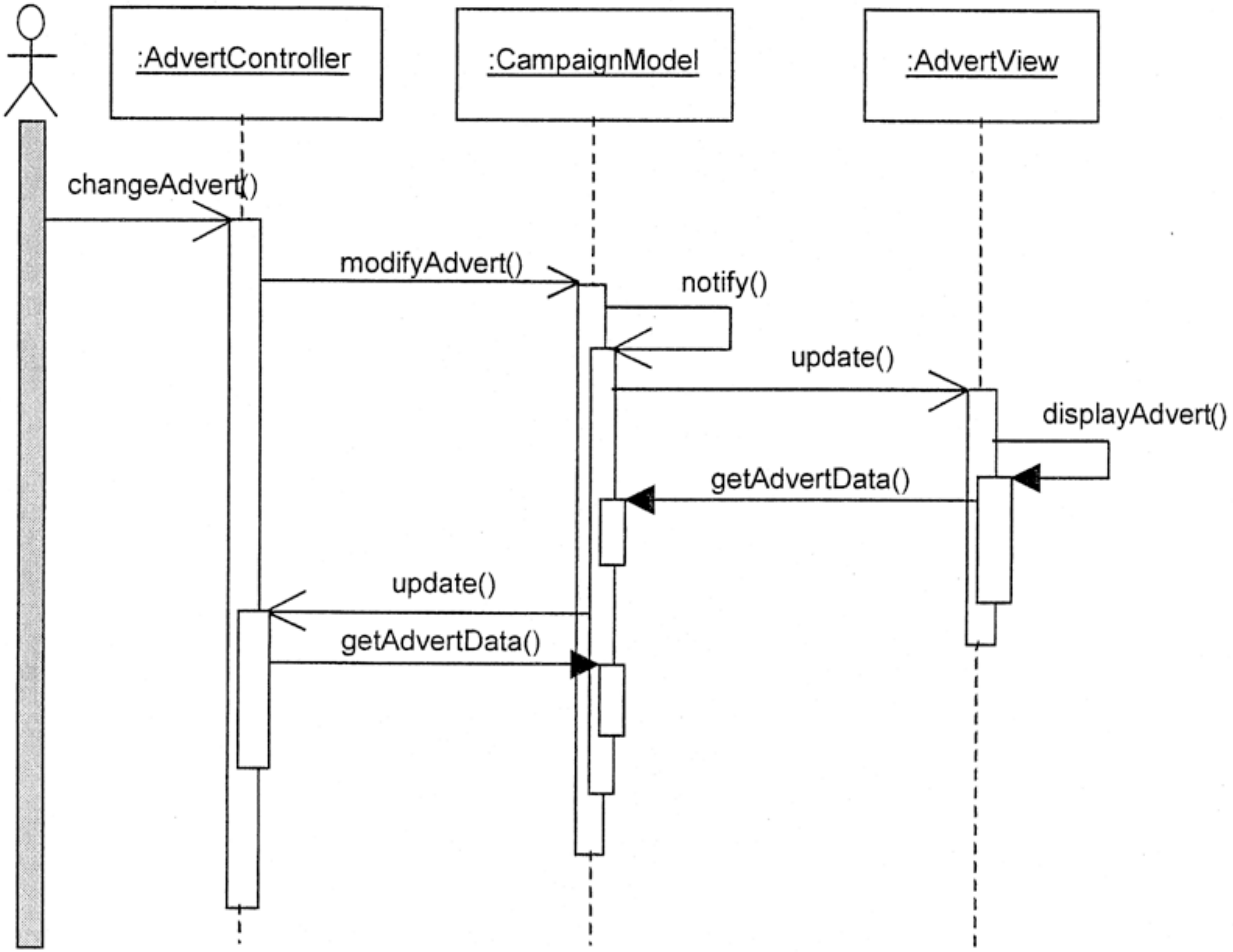
MVC Component Interaction



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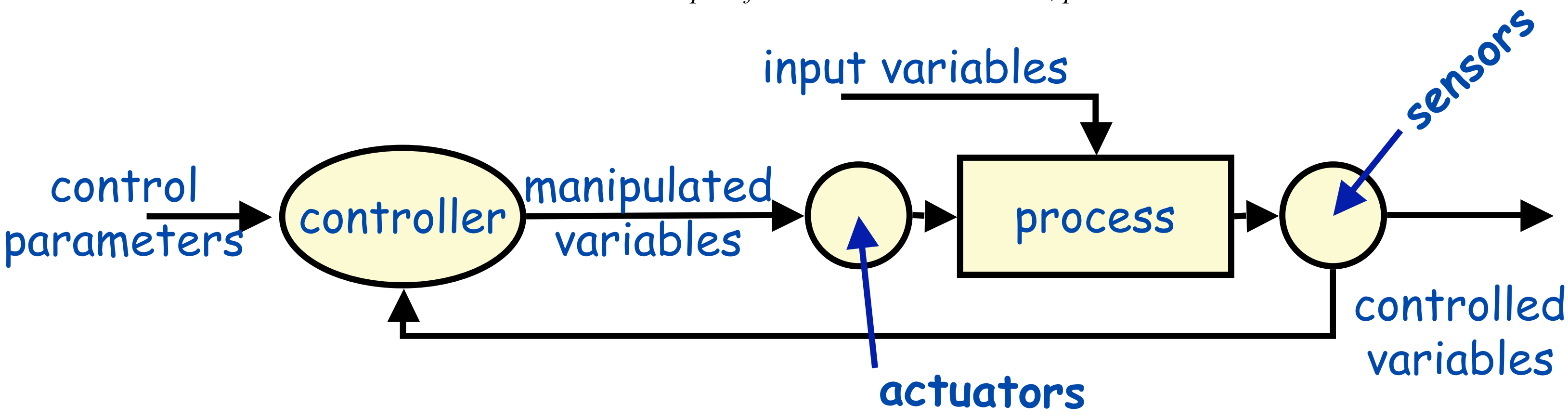
Process Control

Source: *Adapted from Shaw & Garlan 1996, p27-31.*



→ Examples

- ↳ aircraft/spacecraft flight control systems
- ↳ controllers for industrial production lines, power stations, etc.
- ↳ chemical engineering

→ Interesting properties

- ↳ separates control policy from the controlled process
- ↳ handles real-time, reactive computations

→ Disadvantages

- ↳ Difficult to specify the timing characteristics and response to disturbances

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