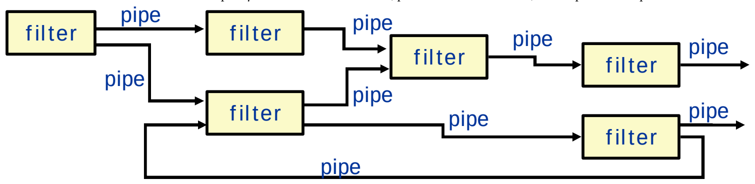
Lecture 13: Software Architectures

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

Pipe-and-filter

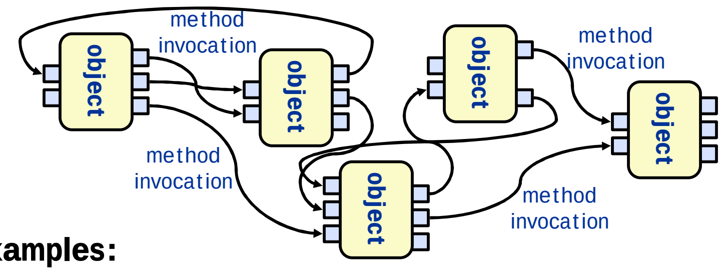
Source: *Adapted from Shaw & Garlan 1996, p21-2. See also van Vliet, 1999 Pp266-7 and p279*



- 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

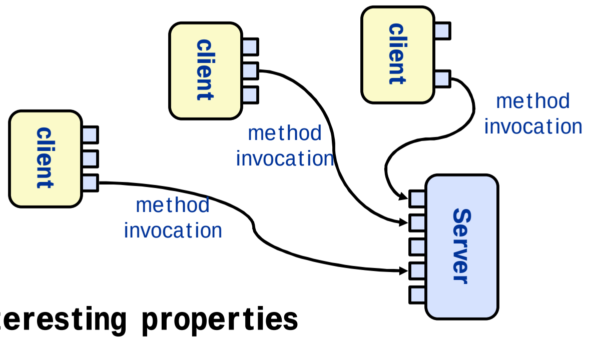
Object Oriented Architectures

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



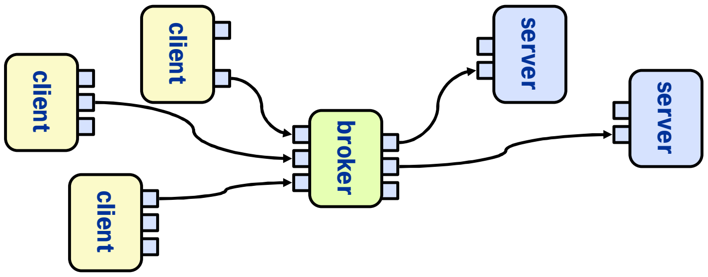
- **Examples:**
  - abstract data types
- **Interesting properties**
  - data hiding (internal data representations are not visible to clients)
  - can decompose problems into sets of interacting agents
  - can be multi-threaded or single thread
- **Disadvantages**
  - objects must know the identity of objects they wish to interact with

Variant 1: Client Server



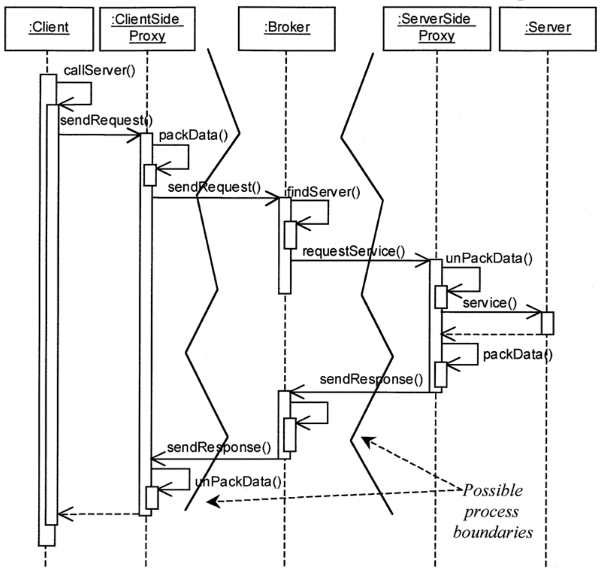
- **Interesting properties**
  - Is a special case of the previous pattern object oriented architecture
  - Clients do not need to know about one another
- **Disadvantages**
  - Client objects must know the identity of the server

Variant 2: Object Brokers



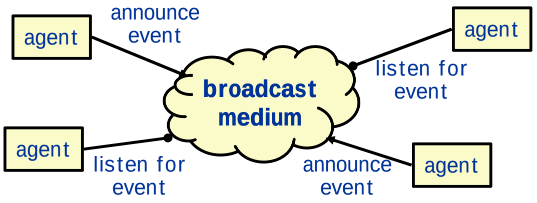
- Interesting properties
  - Adds a broker between the clients and servers
  - Clients no longer need to know which server they are using
  - Can have many brokers, many servers.
- Disadvantages
  - Broker can become a bottleneck
  - Degraded performance

Broker Architecture Example



Event based (implicit invocation)

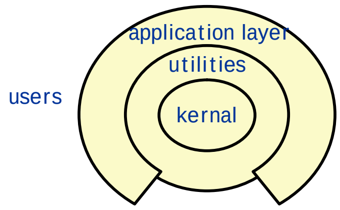
Source: *Adapted from Shaw & Garlan 1996, p23-4. See also van Vliet, 1999 Pp264-5 and p278*



- **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

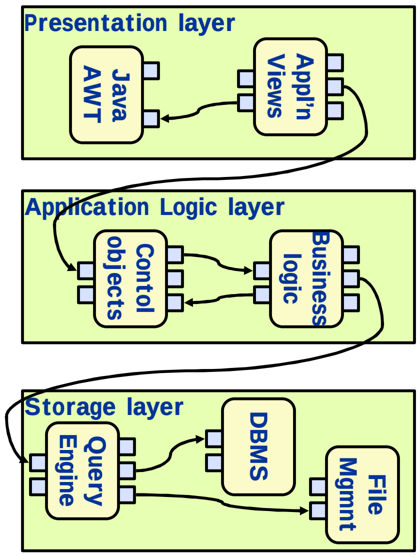
Layered Systems

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



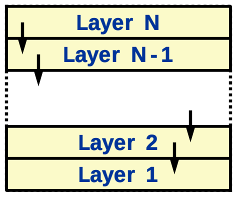
- **Examples**
  - Operating Systems
  - communication protocols
- **Interesting properties**
  - Support increasing levels of abstraction during design
  - Support enhancement (add functionality) and re-use
  - can define standard layer interfaces
- **Disadvantages**
  - May not be able to identify (clean) layers

Variant: 3-layer data access

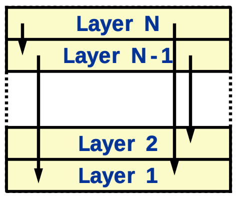


Open vs. Closed Layered Architecture

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

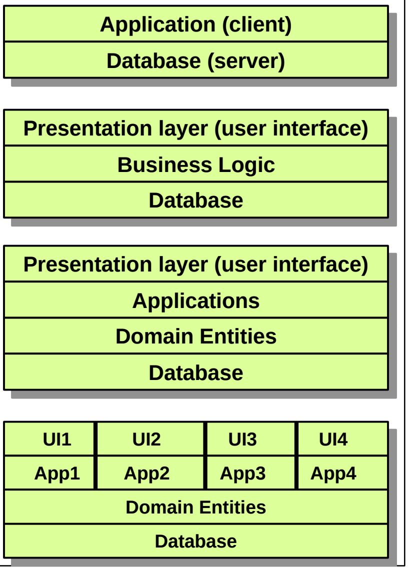


- open architecture
  - a layer can use services from any lower layer.
  - More compact code, as the services of lower layers can be accessed directly
  - Breaks the encapsulation of layers, so increase dependencies between layers



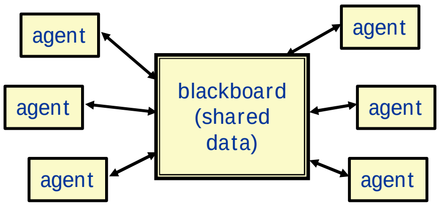
How many layers?

- **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



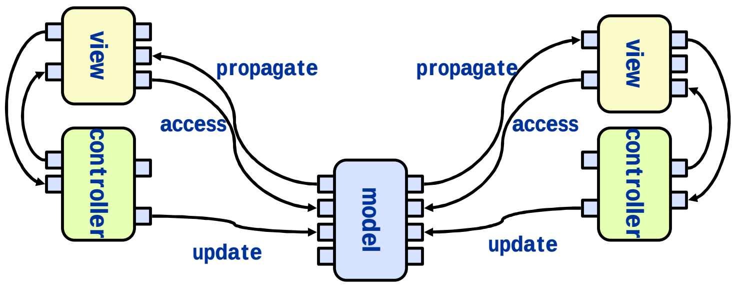
Repositories

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

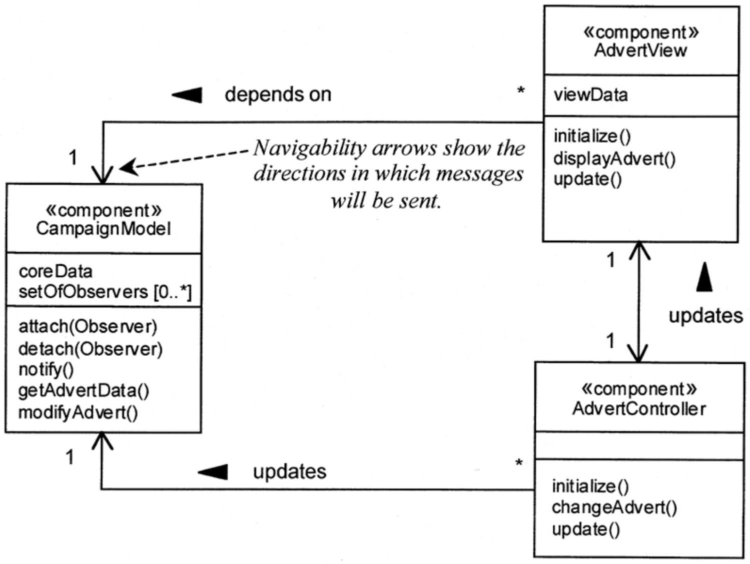
Variant: Model-View-Controller



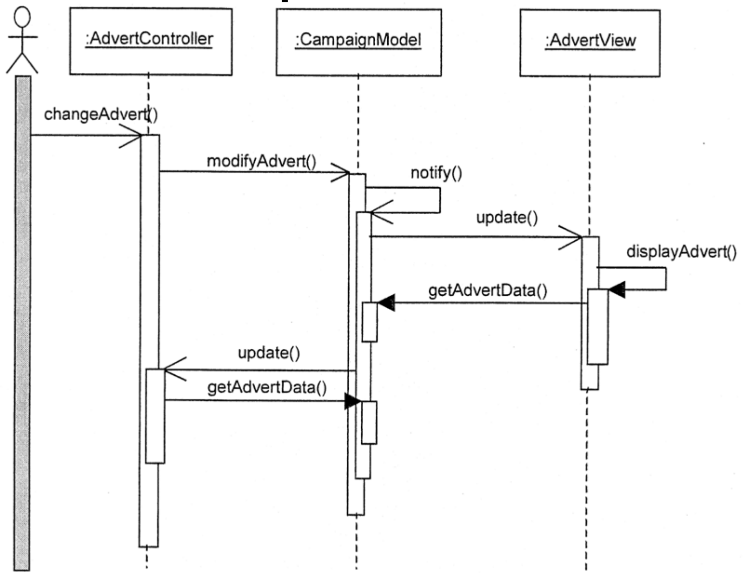
➲ **Properties**

- 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

Model View Controller Example

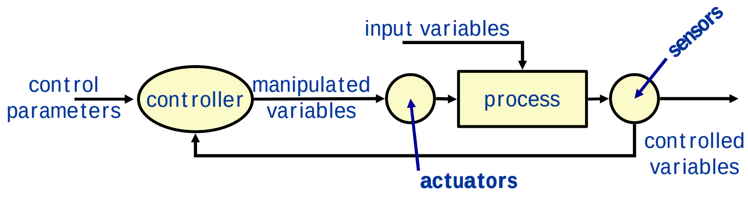


MVC Component Interaction



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