Lecture 4: Showing the architecture

- → Coupling and Cohesion
- → UML Package Diagrams
- → Software Architectural Styles:
  - Layered Architectures
  - Pipe-and-filter
  - Object Oriented Architecture
  - Implicit Invocation
  - Repositories

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

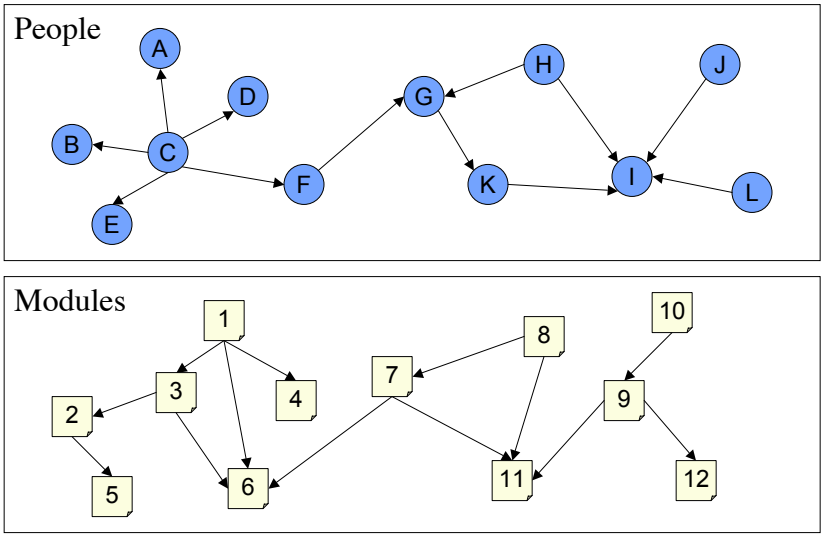
Goal: the contents of each module are strongly inter-related

High cohesion makes a module easier to understand

Conway's Law

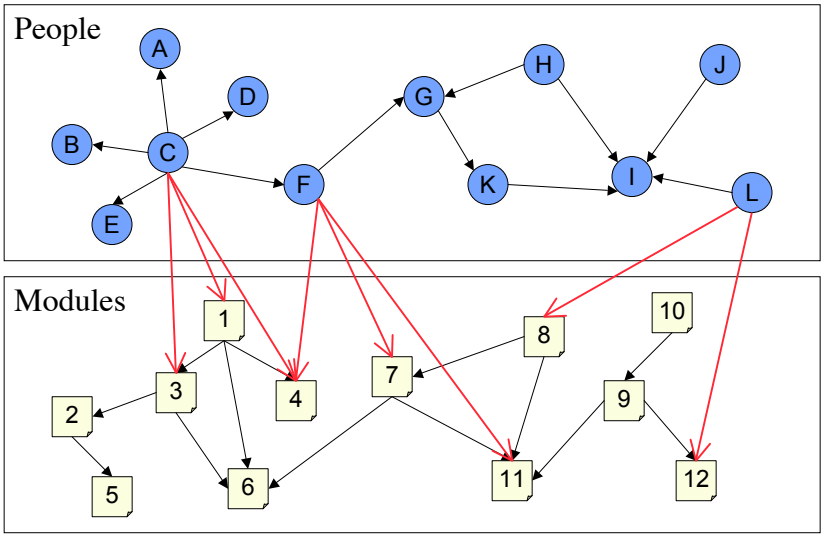
"The structure of a software system reflects the structure of the organisation that built it"

Socio-Technical Congruence



See: Valetto, et al., 2007.

Socio-Technical Congruence



See: Valetto, et al., 2007.

Software Architecture

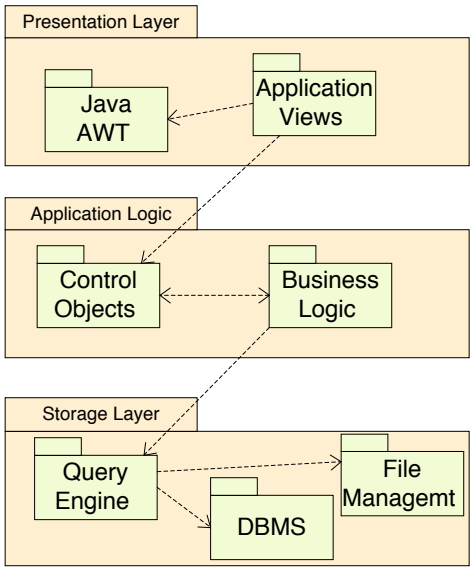
A software architecture defines:

- 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
- data storage is treated as a server

3-layer architecture



UML Packages

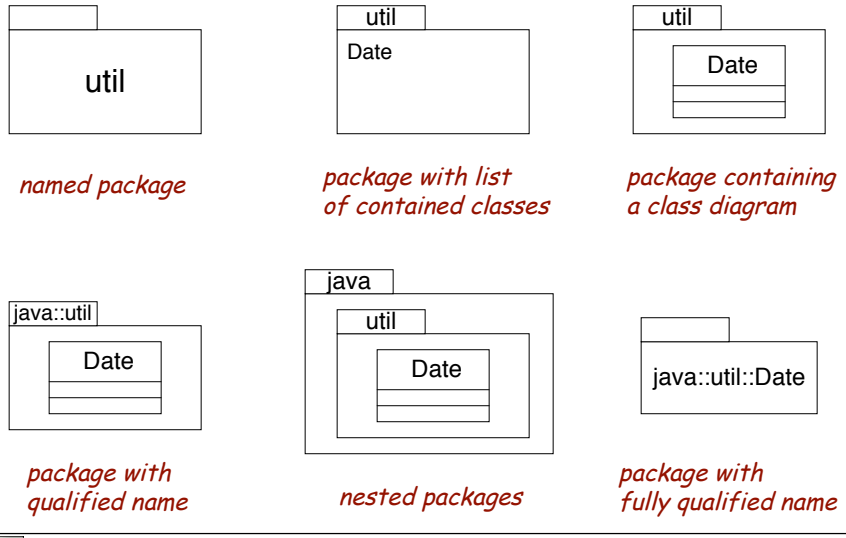
We need to represent our architectures

- UML elements can be grouped together in packages
- Elements of a package may be:
  - other packages (representing subsystems or modules);
  - classes;
  - models (e.g. use case models, interaction diagrams, statechart diagrams, etc)
- Each element of a UML model is owned by a single package

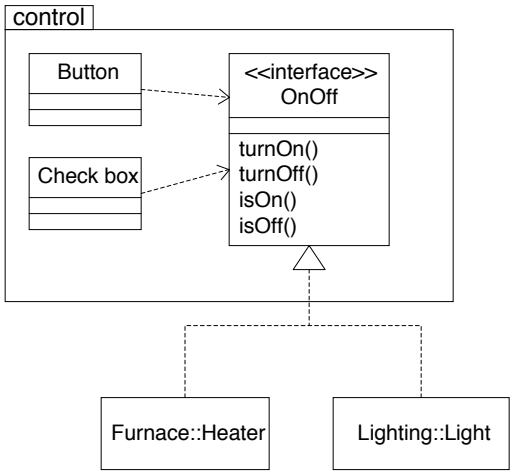
Criteria for decomposing a system into packages:

- **Ownership**
  - who is responsible for working on which diagrams
- **Application**
  - each problem has its own obvious partitions;
- **Clusters of classes with strong cohesion**
  - e.g., course, course description, instructor, student,…
- **Or use an architectural pattern to help find a suitable decomposition**

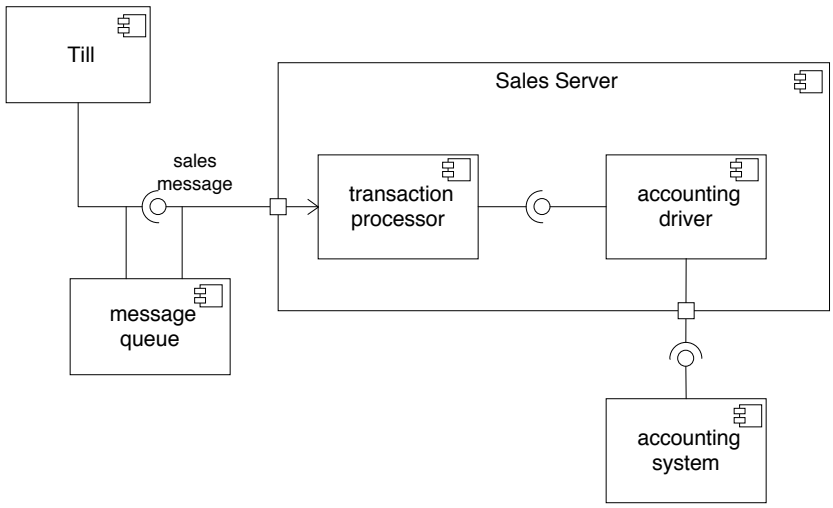
Package notation



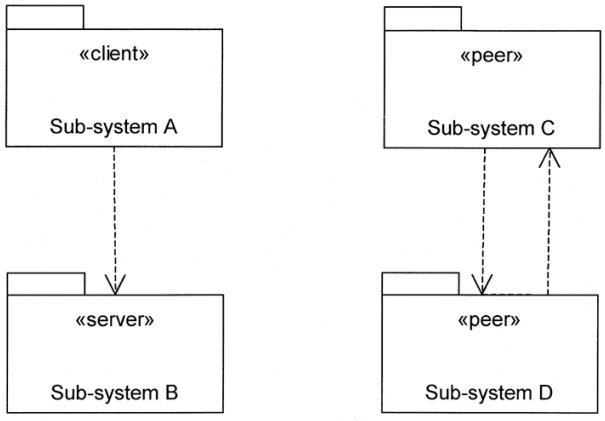
Towards component-based design



Or use Component Diagrams…



Dependency cycles…

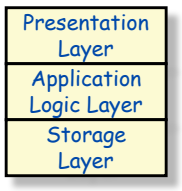


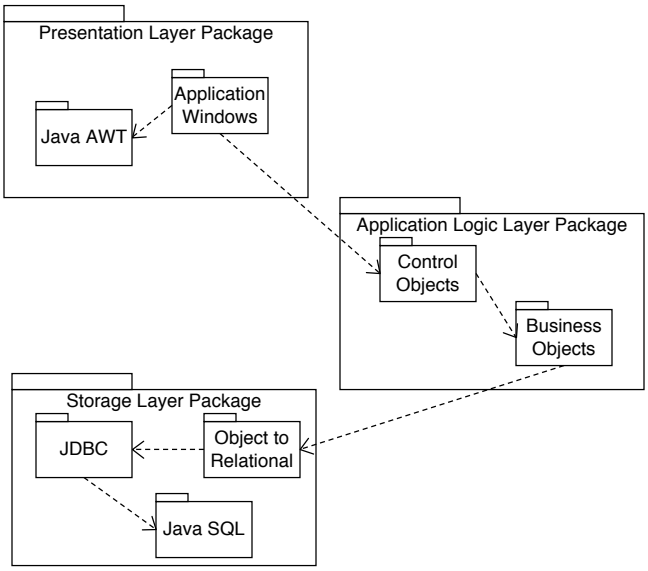
The server sub-system does not depend on the client sub-system and is not affected by changes to the client's interface.

Each peer sub-system depends on the other and each is affected by changes in the other's interface.

Architectural Patterns

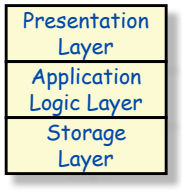
E.g. 3 layer architecture:

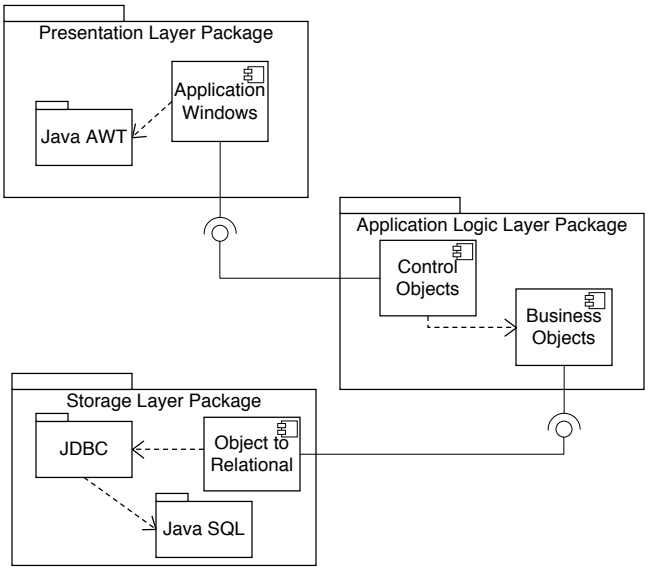




Or to show the interfaces…

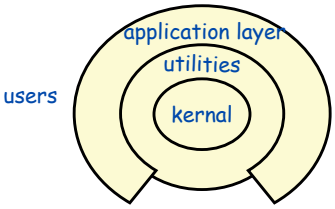
E.g. 3 layer architecture:





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

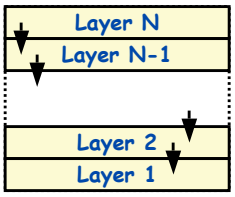
Disadvantages

- May not be able to identify (clean) layers

Open vs. Closed Layered Architecture

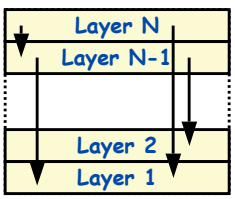
closed architecture

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



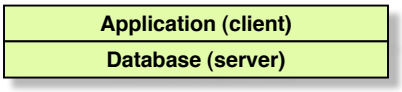
open architecture

- 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

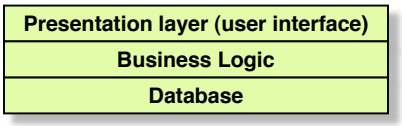


How many layers?

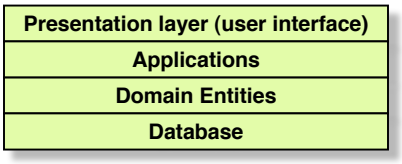
2-layers:
- application layer
- database layer
- e.g. simple client-server model



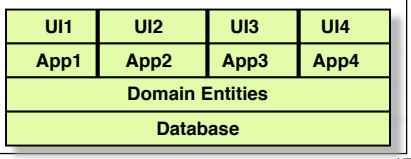
3-layers:
- separate out the business logic
  - helps to make both user interface and database layers modifiable



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

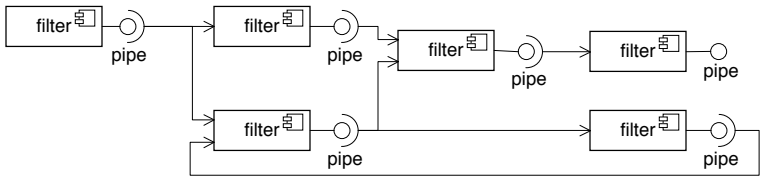


Partitioned 4-layers
- identify separate applications



Pipe-and-filter

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

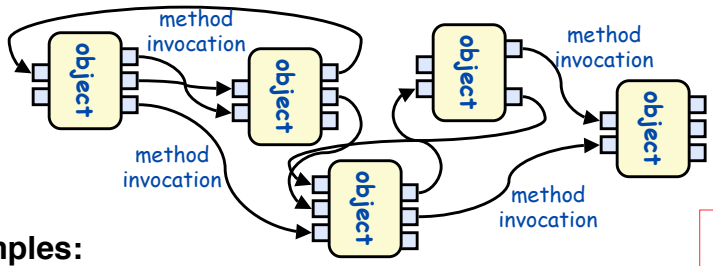


Examples:
- UNIX shell commands
- Compilers:
  - Lexical Analysis -> parsing -> semantic analysis -> code generation
- Signal Processing

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.



This is not UML!

Examples:

- abstract data types

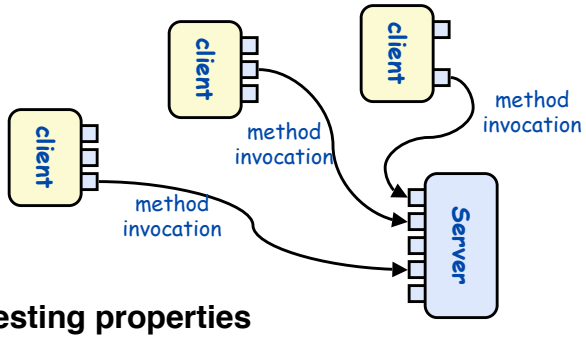
Interesting properties

- 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



This is not UML!

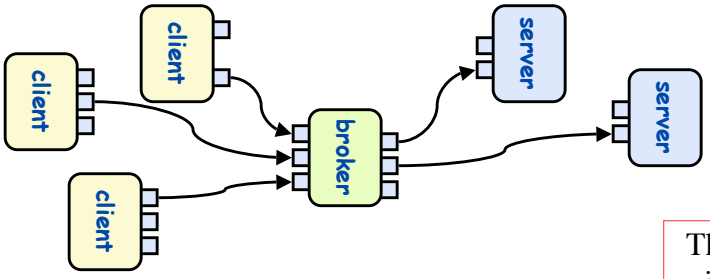
Interesting properties

- 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



This is not UML!

Interesting properties

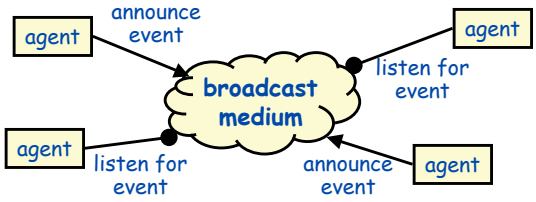
- Adds a broker between the clients and servers
- Clients no longer need to know which server they are using
- Can have many brokers, many servers.

Disadvantages

- Broker can become a bottleneck
- Degraded performance

Event based (implicit invocation)

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



This is not UML!

Examples

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

Interesting properties

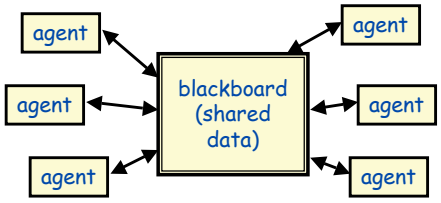
- announcers of events don't need to know who will handle the event
- Supports re-use, and evolution of systems (add new agents easily)

Disadvantages

- Components have no control over ordering of computations

Repositories

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



Examples

- databases
- blackboard expert systems
- programming environments

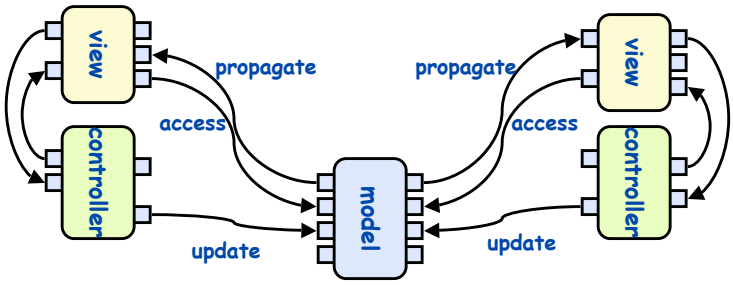
Interesting properties

- 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