XVIII.1 Software Architectures

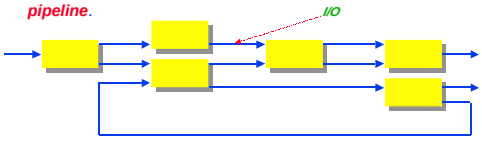
Software Architectures
Subsystems, Modules and Connectors
Pipes and Filters, Object-Oriented, Layered,
Event-Driven, Repository-Based Architectures
Client Server Architectures
Web-Based Software Architectures
Examples

Architectural Styles

- It is useful to classify software architectures into classes of ***architectural styles***.
- For example, the client-server architecture discussed earlier is an architectural style.
- The styles we'll discuss below are as follows:
  - ✓ Pipes and filters;
  - ✓ Object-Orientation;
  - ✓ Event-Based
  - ✓ Layered;
  - ✓ Repository-Based;
  - ✓ Client-Server;
  - ✓ Three-Tier;
  - ✓ ...more...

Pipes and Filters

- Each component has ***inputs*** and ***outputs***. A component reads streams of data on its inputs and produces data on its outputs, continuously as data are coming in.
- Components compute by performing local transformations on their inputs to produce their outputs and are termed ***filters***. The connectors of components transmit the outputs of one component to the inputs of another and are termed ***pipes***.
- Unix supports a linear pipe and filter architecture called ***pipeline***.



Pipes and Filters: Strengths and Weaknesses

Strengths

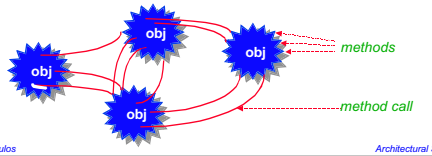
- Makes it easy to understand overall function of the system as a composition of filter functions
- Encourages reuse of filters
- Facilitates maintenance
- Facilitates deadlock and throughput analysis

Weaknesses

- Often leads to batch-type processing
- Not good for interactive applications where you often want to do incremental computations, e.g., incremental display updates
- Can't coordinate stream inputs
- Data transmission critical for system performance

Data Abstraction and Object-Orientation

- Data structures and their associated operations are ***encapsulated*** in an ***abstract data type*** (ADT) or ***object***. The components of a system are instances of an ADT and they interact through procedure (or ***method***) calls
- An object is responsible for preserving the integrity of its data structures and also these data structures are hidden from other objects.
- Objects may operate concurrently or not



Data Abstraction: Strengths and Weaknesses

Strengths

- Possible to change implementation of an object without affecting its clients
- Encourages decomposition of a problem into a number of interacting components/agents
- Encourages software reuse

Weaknesses

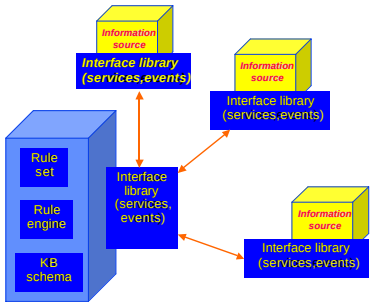
- For an object to interact with another, it must know its identity (not so for pipe&filter architectures)
- When the methods of an object change, so must all other objects that use this object

Client-Server Architecture a special case of the Data Abstraction Architecture

Event-Based Architectures

- Instead of invoking a procedure directly, a component can ***announce*** one or more ***events*** (such as arrival of data or execution of an operation)
  - ***On*** <event> ***if*** <condition> ***then*** <action>
  - ***On*** arrive(D) ***if*** D < a or D ≥ b ***then*** print("out of bounds")
- Such procedures are also called triggers, actors or event-condition-action (ECA) rules
- An advantage of event-based invocation is that it encourages reuse; a component can be introduced in a system simply by registering it for the events of that system
- A drawback is that sometimes event-based systems become quite unpredictable and hard to control.

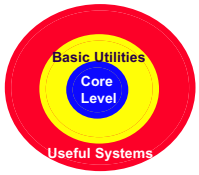
Event-Based Architecture for Data Integration



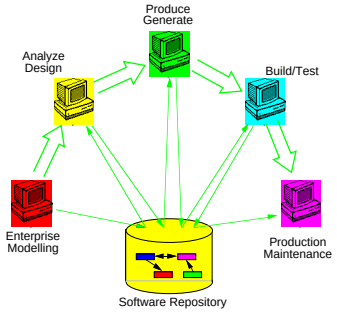
[Gal97]

Layered Systems

- A layered system is organized hierarchically, each layer serving the layer above. In some systems, inner layers are hidden in all but the adjacent outer layer.
- Best examples of layered software systems are layered communication protocols.
- Layered systems support design based on increasing levels of abstraction. However, not all systems can be structured in a layered fashion.



Repository-Based Architectures



Repository-Based Architectures

- A repository architecture consists of a central data structure (often a database) and a collection of independent components which operate on the central data structure
- Examples of repository architectures include ***blackboard architectures***, where a blackboard serves as communication centre for a collection of knowledge sources, and database systems serving several applications
- Repositories are very important for data integration, are being introduced in a variety of applications, including software development, CAD etc.

Other Architectural Styles

- ***Table-Driven Interpreters*** -- each interpreter offers a "virtual machine" to high layers of interpreters; special case of the layered architecture
- ***Distributed Processes*** -- program consists of distributed components organized into a static or dynamic configuration; this is a special case of the object-oriented architecture
- ***Main Program/Subroutine*** -- FORTRAN-style architecture
- ***State-Transition Architecture*** -- system structured in terms of states, state transitions; useful architecture for real-time systems.

Additional Reading

[Architectures] http://www.pithecanthropus.com/~awg/browsing_library.html
[Bass98] Bass, L., Clements, P., Katzman, R., *Software Architecture in Practice*, Addison Wesley, 1998.
[Gal97] Gal, A. and Mylopoulos, J. "The CoopWARE Demo", http://www.cs.toronto.edu/~coopware, 1997.
[Garlan93] Garlan D. and Shaw, M., "An Introduction to Software Architectures", in *Advances in Software Engineering and Knowledge Engineering*, volume I, World Scientific, 1993.
[Umar97] Umar, A., *Application Reengineering*, Prentice Hall, 1997.