CS 490 - Software Architecture and Design

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Outline

- **<u>What</u>** is software architecture?

- **<u>Why</u>** do we need software architecture?

- **<u>How</u>** do we design and model software architecture?

  - Fundamental principles

  - Architecture patterns and styles

What is software architecture?
(in traditional software engineering)

- *The top-level decomposition of a software system into major sub-systems together with a characterization of how these sub-systems interact is called software architecture.*

  - Software architecture is <u>top-level design</u> or <u>global design</u>!

  - Software architecture is <u>the result of the initial design process</u>.

What is software architecture? (in current research)

- *The software architecture of a program or computing system is the structure or structures of the system, which comprise software components, the externally visible properties of those components and the relationships among them.* - [Bass et al., 1998]

- *Software architecture = {Elements, Form, Rationale}* - [Dewayne Perry & Alex Wolf, 1992]

- This is the so-called *4C* model.

 - **C**omponent, **C**onnector, **C**onfiguration, **C**onstraint.

Components

- **<u>Component</u>** is an architectural entity that (1) encapsulates a subset of the system's functionality and/or data, (2) restricts access to that subset via an explicitly defined interface, and (3) has explicitly defined dependencies on its required execution context.

  - **Provided Interface** (2 above): operations/ services implemented within (*provided* by) the current component.

  - **Required Interface** (3 above): operations/ services that the component *requires* from the external for its implementation.

Connections

- **<u>Connection</u>** in an architectural model represents communication (e.g., function call, event broadcast) between two or more components.

  - Established from the required interface of one component (A) to the provided interface of another component (B). That is, B provides the services/operations required by A.

An example of software architecture
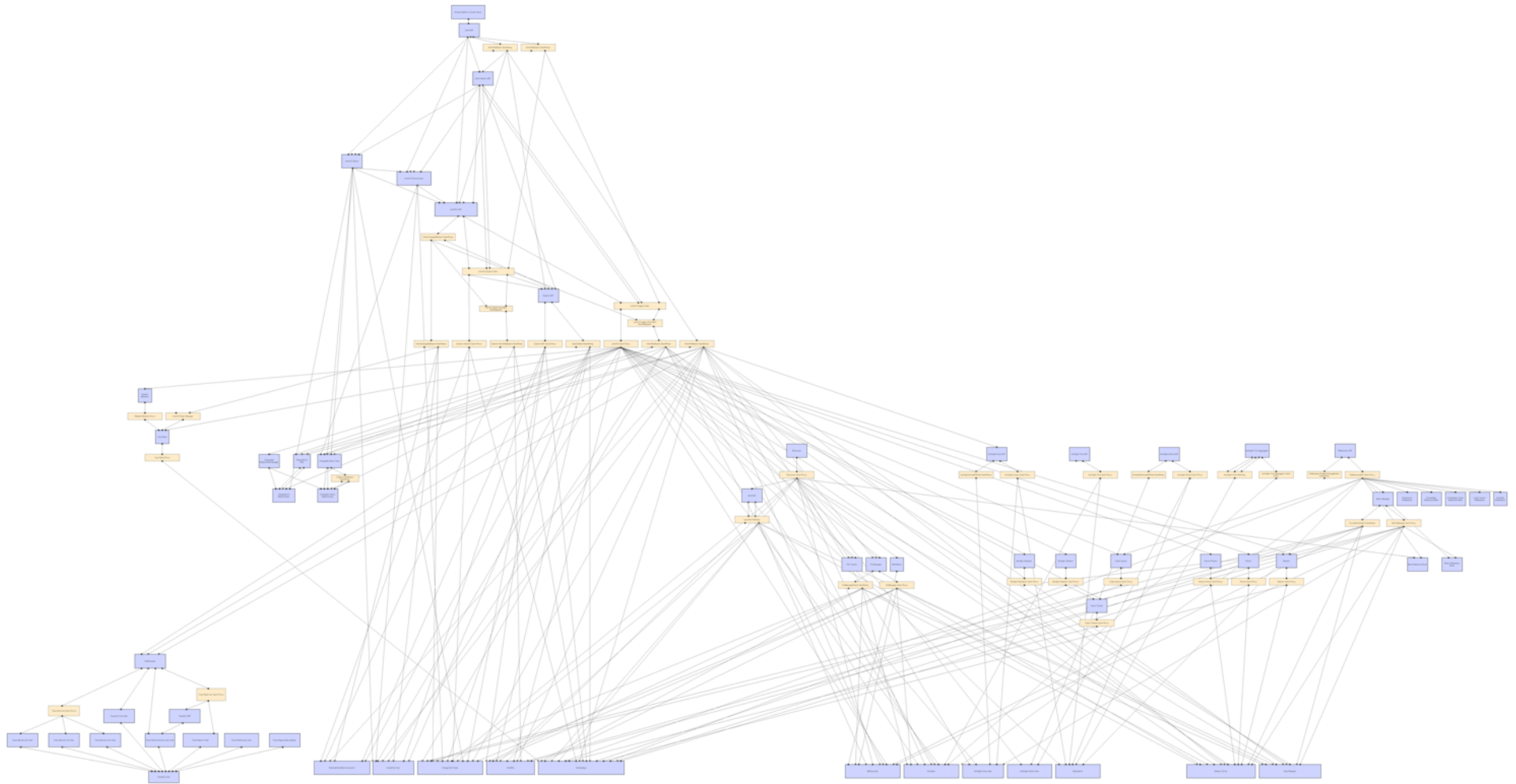
A less complicated example
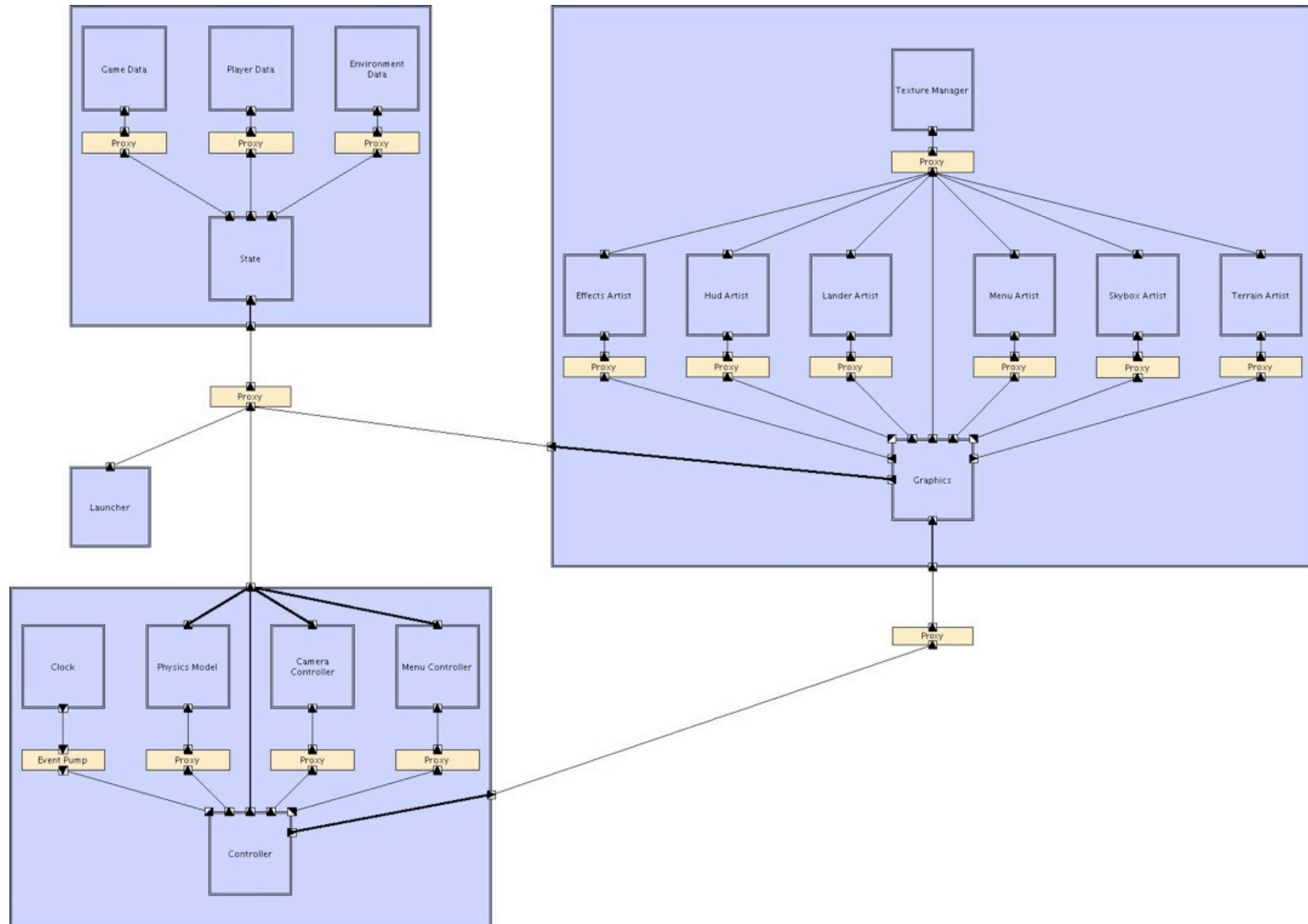
Another example

```xml
<xArch>
  <archStructure id="tvset">
    <description>TV Set</description>
    <component id="tuner">
      <description>
        TV Tuner Component
      </description>
      <interface id="tuner.channel">
        <description>
          ChangeChannel Interface
          (in)
        </description>
        <direction>in</direction>
      </interface>
    </component>
    <component id="ir">
      <description>
        Infrared Receiver Component
      </description>
      <interface id="ir.channel">
        <description>
          ChangeChannel Interface
          (out)
        </description>
        <direction>out</direction>
      </interface>
    </component>
    <connector id="tvconn">
      <description>
        TV Connector
      </description>
      <interface id="tvconn.in">
        <description>
          ChangeChannel Interface
          (in)
        </description>
        <direction>in</direction>
      </interface>
      <interface id="tvconn.out">
        <description>
          ChangeChannel Interface
          (out)
        </description>
        <direction>out</direction>
      </interface>
    </connector>
    <link id="link1">
      <description>
        Tuner to Connector
      </description>
      <point>
        <anchor
          href="#tuner.channel"/>
      </point>
      <point>
        <anchor
          href="#tvconn.out"/>
      </point>
    </link>
    <link id="link2">
      <description>
        Connector to IR
      </description>
      <point>
        <anchor href="#tvconn.in"/>
      </point>
      <point>
        <anchor
          href="#ir.channel"/>
      </point>
    </link>
  </archStructure>
</xArch>
```
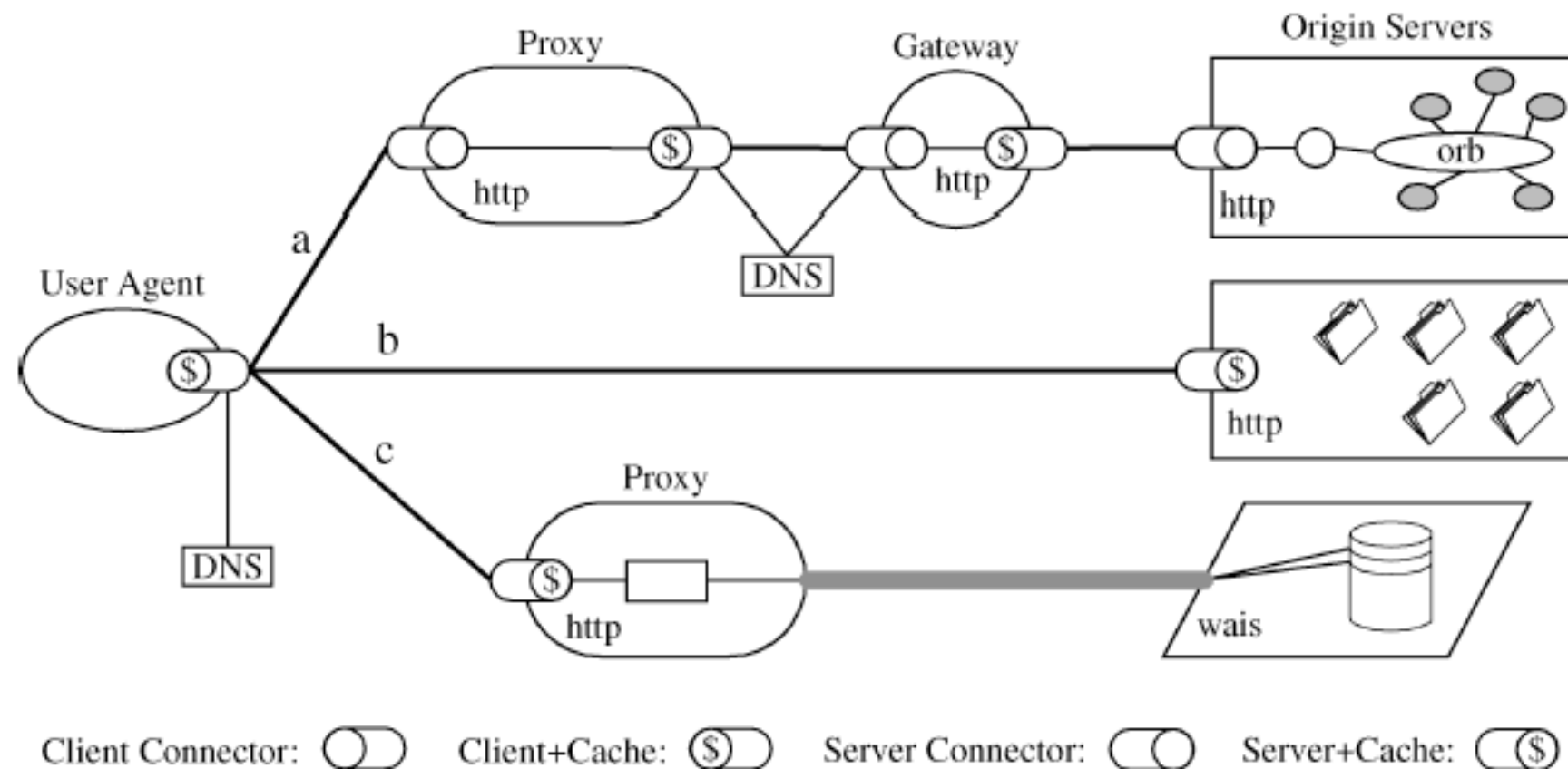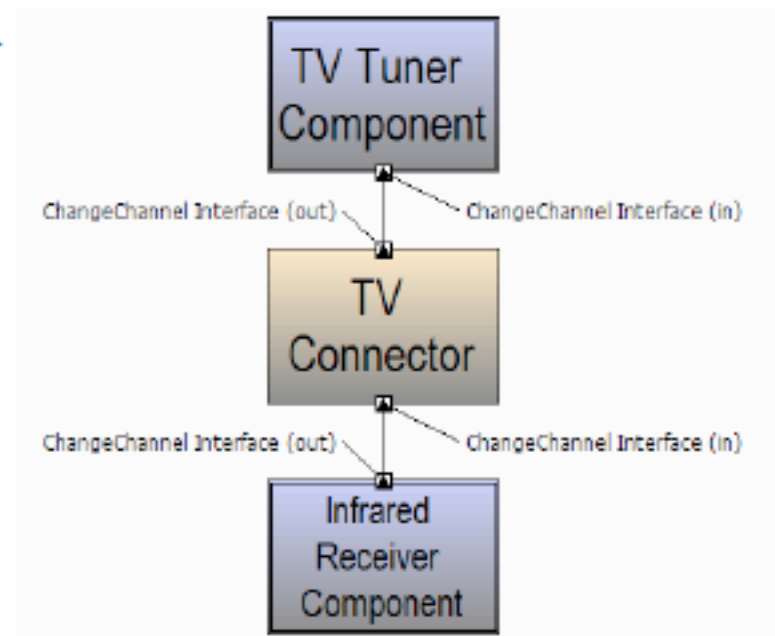
Why do we need software architecture? (architecture in context)

- Requirements

  - Existing architectures provide vocabulary for requirements.

- Design

  - Software architecture is the outcome of software design.

- Implementation

  - High-level reuse

- Testing

  - Early system analysis

- Maintenance

  - Open architecture

How do we design architecture?

- Creativity

  - This requires extensive experience, broad training, ...

- Principles, process, and methods

  - Goals, activities, and principles

  - Design methods: object-oriented design, functional design, and quality-driven design

- Reuse

  - Horizontal reuse: architecture patterns and styles

  - Vertical reuse: product-line architectures

Activities of Architecture Design

- Analyzing and refining requirements

- **Decomposing** the system into components

- Selecting protocols for communication, synchronization, and data access

- Developing global structures

- Designing component internal structures

- Selecting among design alternatives (often needs to consider non-functional properties)

- Dealing with deployment issues

- Making stakeholder related decisions

Goals (Considerations) of Architecture Design

Conceptual Integrity

The fact that a software product presents to each of its users <u>a coherent mental model</u> of the application, of strategies for doing the application, and of the user-interface tactics to be used in specifying actions and parameters. The conceptual integrity of the product is the most important fact in ease of use. - [Fred Brooks]

Conceptual integrity implies that the similar or same design decisions are made to solve a collection of similar problems for the same goal.

Design Principles

- **Abstraction**: we concentrate on the essential features and ignore, abstract from, details that are not relevant at the level we are currently working.

- **Modularity**: the degree (cohesion, coupling) to which a system is partitioned into components (or modules).

  - Cohesion: a measure of the mutual affinity of the elements of a component. E.g. functional cohesion, data cohesion.

  - Coupling: a measure of the strength of the inter-component connections. E.g. control coupling, data coupling.

  - High-cohesion and loose-coupling are generally preferred.

Design Principles, cont.

- **Information hiding** (i.e., encapsulation): one begins with a list of difficult design decisions or design decisions which are likely to change. Every module (component) is designed to hide such a decision from all others. Its interface or definition was chosen to reveal as little as possible about its inner workings. [Parnas]

Reference

- Richard N. Taylor, Nenad Medvidovic, and Eric M. Dashofy. Software Architecture: Foundations, Theory, and Practice. John Wiley and Sons. ISBN-10: 0470167742; ISBN-13: 978-0470167748. 2010.