Basic Concepts

Software Architecture

What is Software Architecture?

- **Definition:**

  A software system's architecture is the set of *principal design decisions* about the system

- Software architecture is the blueprint for a software system's construction and evolution
- Design decisions encompass every facet of the system under development

  Structure

  Behavior

  Interaction

  Non-functional properties

What is "Principal"?

- "Principal" implies a degree of importance that grants a design decision "architectural status"

  It implies that not all design decisions are architectural

  That is, they do not necessarily impact a system's architecture

- How one defines "principal" will depend on what the stakeholders define as the system goals

Other Definitions of Software Architecture

- Perry and Wolf

  Software Architecture = { Elements, Form, Rationale }

  what *how* *why*

- Shaw and Garlan

  Software architecture [is a level of design that] involves

  - the description of elements from which systems are built,
  - interactions among those elements,
  - patterns that guide their composition, and
  - constraints on these patterns.

- Kruchten

  Software architecture deals with the design and implementation of the high-level structure of software.

  Architecture deals with abstraction, decomposition, composition, style, and *aesthetics*.

Temporal Aspect

- Design decisions are unmade over a system's lifetime

  Architecture has a temporal aspect
- At any given point in time the system has only one architecture
- A system's architecture will change over time

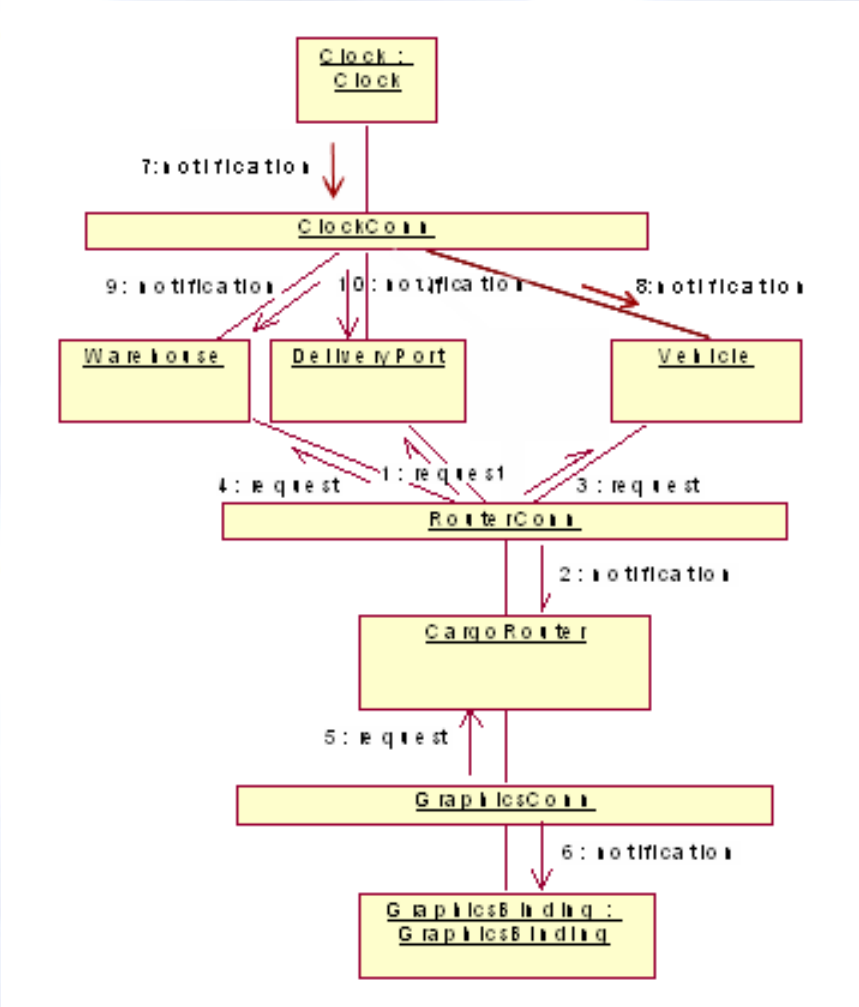
Prescriptive vs. Descriptive Architecture

- A system's *prescriptive architecture* captures the design decisions made prior to the system's construction

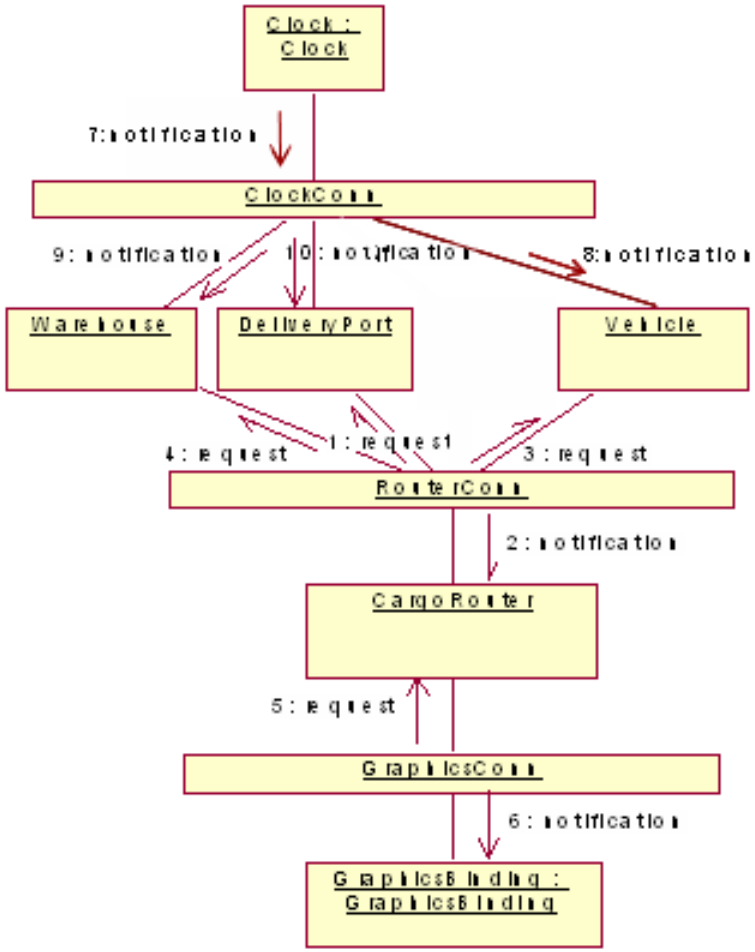
  It is the *as-conceived* or *as-intended* architecture
- A system's *descriptive architecture* describes how the system has been built

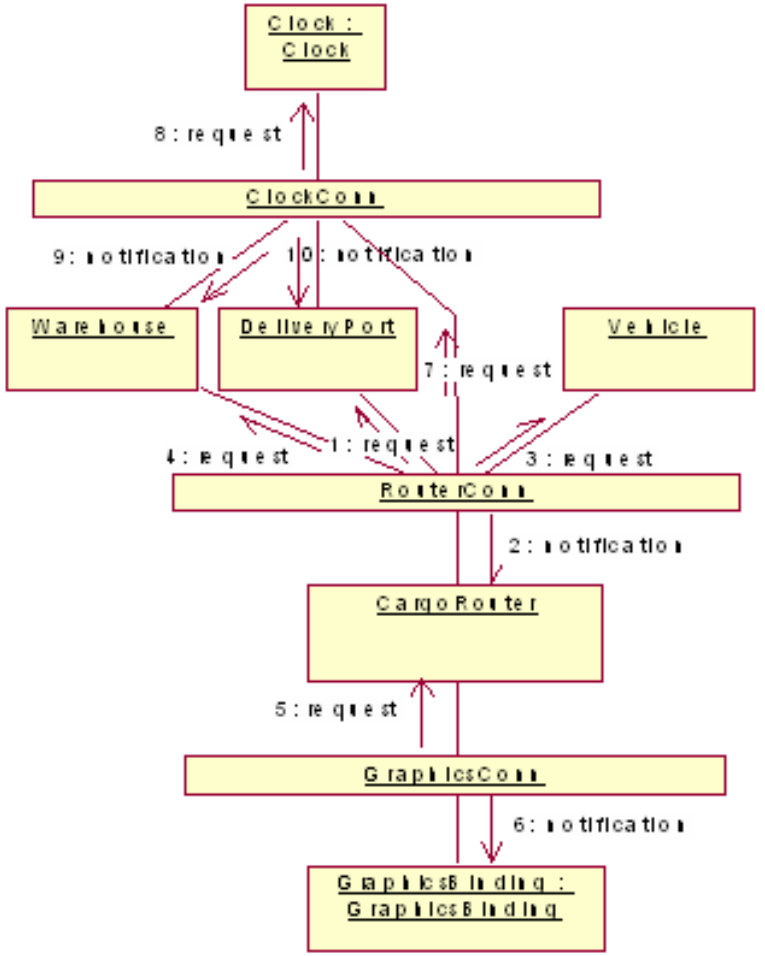
  It is the *as-implemented* or *as-realized* architecture

As-Designed vs. As-Implemented Architecture



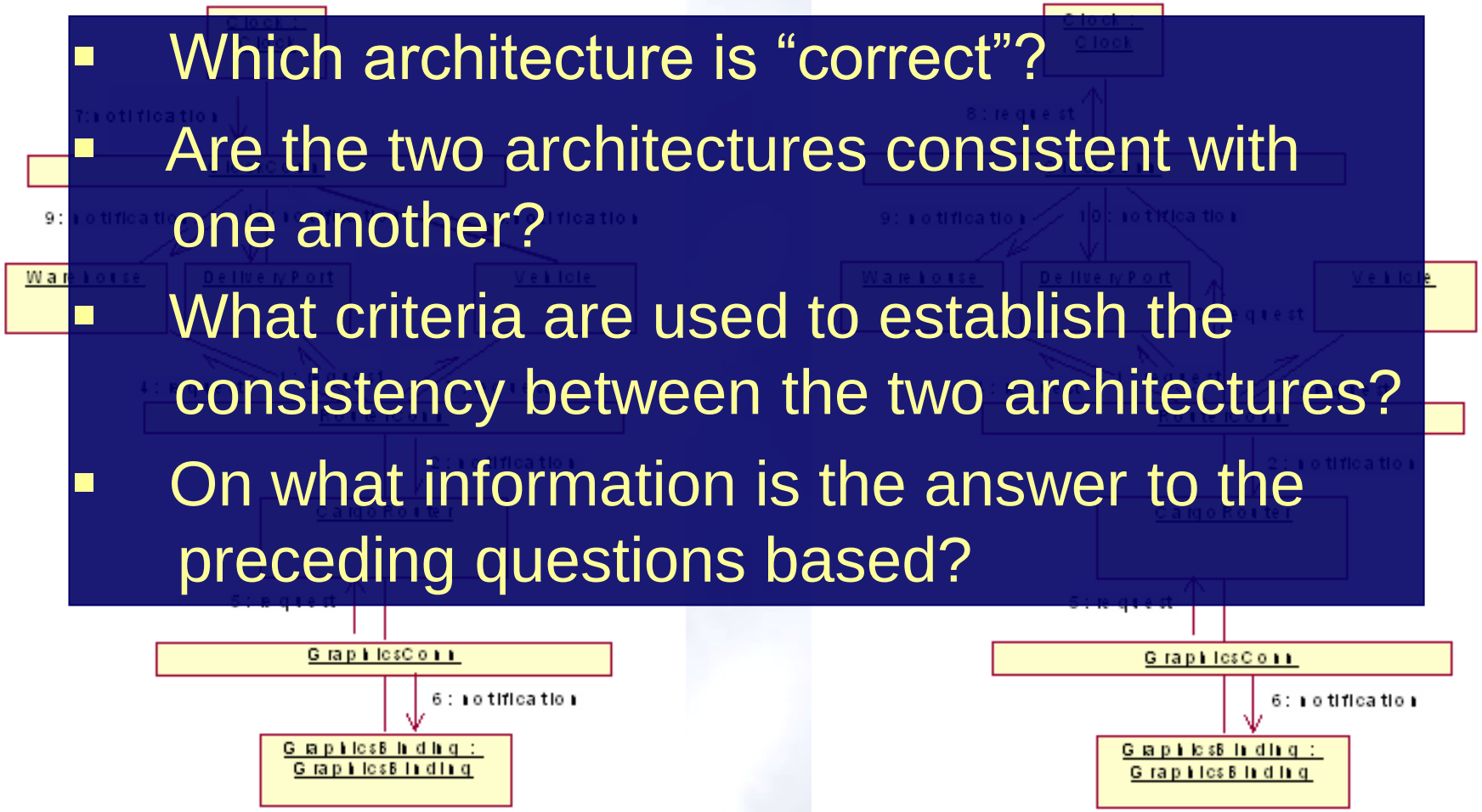
As-Designed vs. As-Implemented Architecture





As-Designed vs. As-Implemented Architecture

- Which architecture is “correct”?
- Are the two architectures consistent with one another?
- What criteria are used to establish the consistency between the two architectures?
- On what information is the answer to the preceding questions based?



Architectural Evolution

- When a system evolves, ideally its prescriptive architecture is modified first
- In practice, the system – and thus its descriptive architecture – is often directly modified
- This happens because of
  - Developer sloppiness
  - Perception of short deadlines which prevent thinking through and documenting
  - Lack of documented prescriptive architecture
  - Need or desire for code optimizations
  - Inadequate techniques or tool support

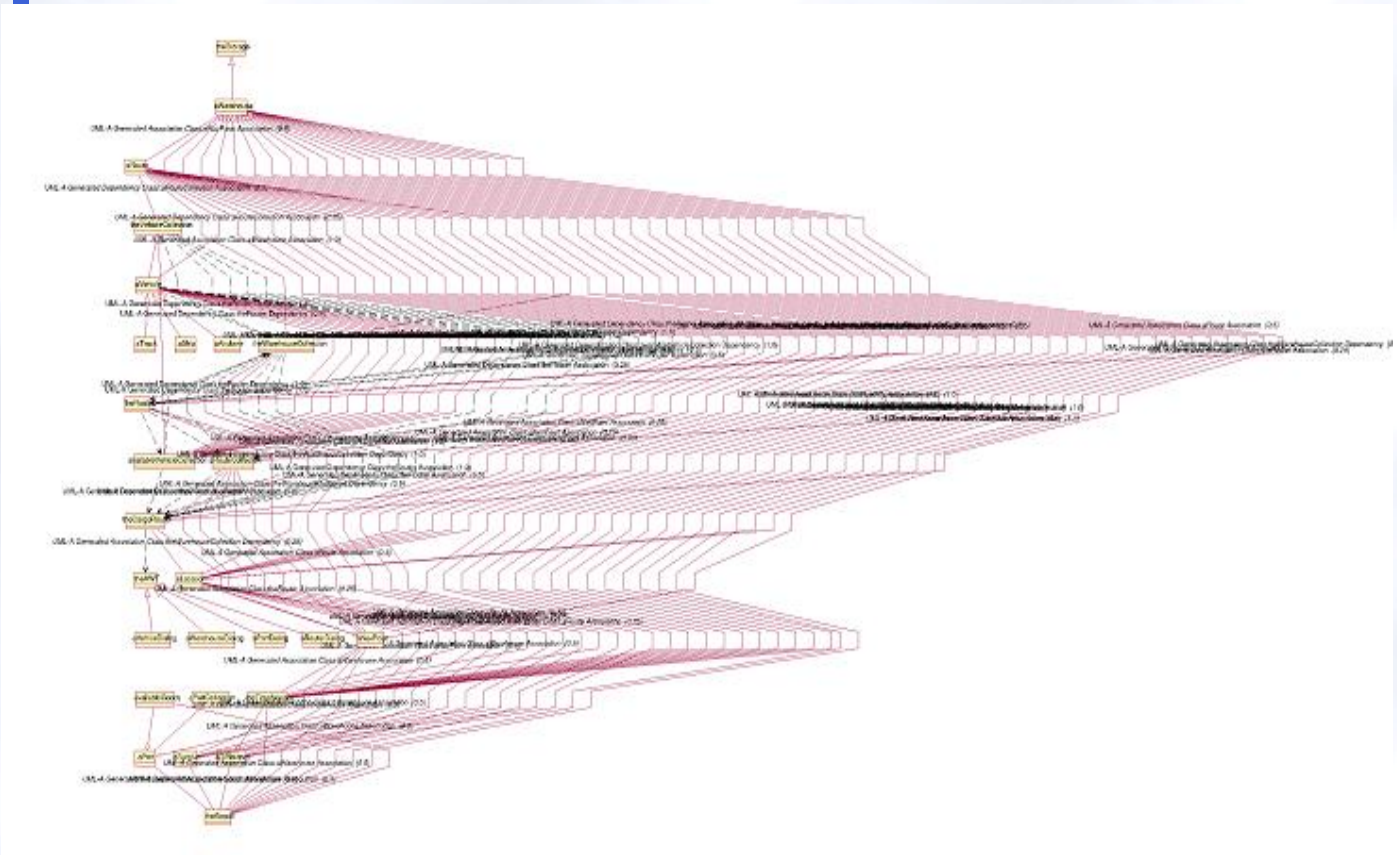
Architectural Degradation

- Two related concepts
  - Architectural drift
  - Architectural erosion
- *Architectural drift* is introduction of principal design decisions into a system's descriptive architecture that
  - are not included in, encompassed by, or implied by the prescriptive architecture
  - but which do not violate any of the prescriptive architecture's design decisions
- *Architectural erosion* is the introduction of architectural design decisions into a system's descriptive architecture that violate its prescriptive architecture

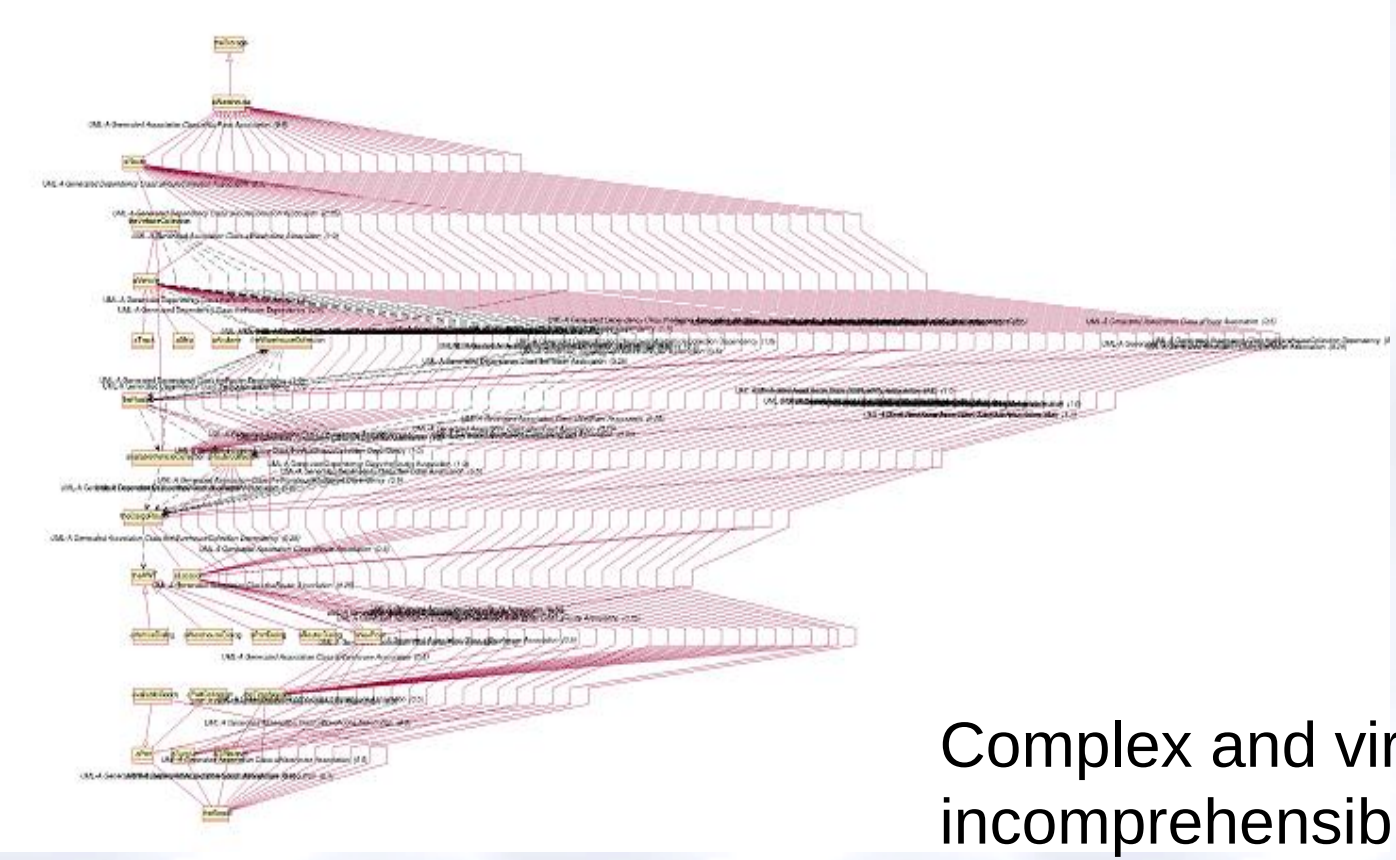
Architectural Recovery

- If architectural degradation is allowed to occur, one will be forced to *recover* the system's architecture sooner or later
- *Architectural recovery* is the process of determining a software system's architecture from its implementation-level artifacts
- Implementation-level artifacts can be
  - Source code
  - Executable files
  - Java .class files

Implementation-Level View of an Application



Implementation-Level View of an Application



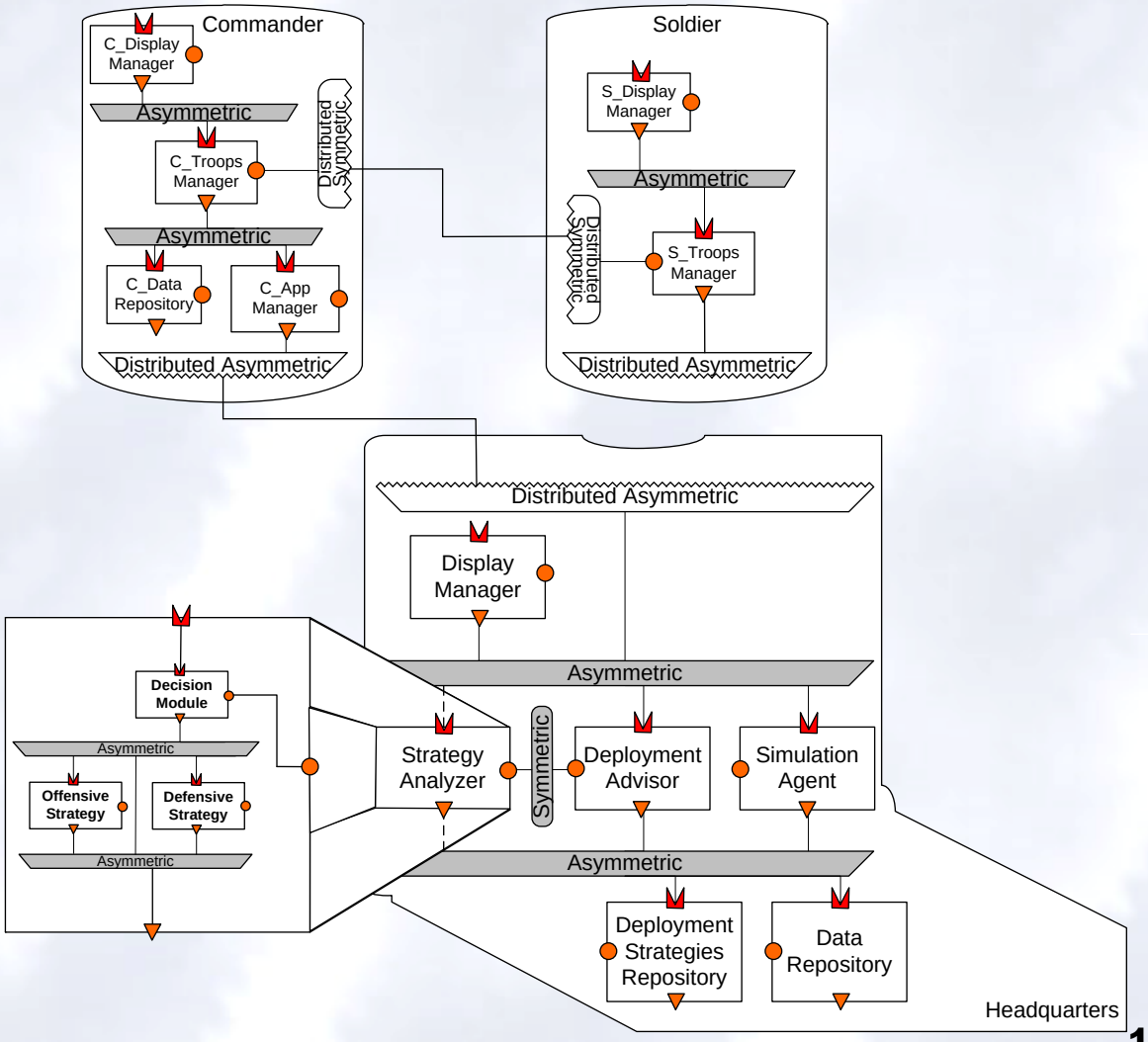
Complex and virtually incomprehensible!

Deployment

- A software system cannot fulfill its purpose until it is *deployed*
  - Executable modules are physically placed on the hardware devices on which they are supposed to run
- The deployment view of an architecture can be critical in assessing whether the system will be able to satisfy its requirements
- Possible assessment dimensions
  - Available memory
  - Power consumption
  - Required network bandwidth

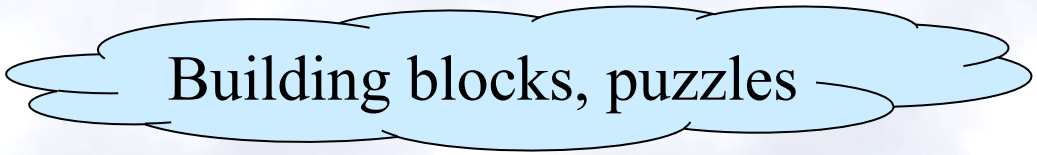
A System's Deployment Architectural Perspective

1-N
N-1



Software Architecture's Elements

- A software system's architecture typically is not (and should not be) a uniform monolith
- A software system's architecture should be a composition and interplay of different elements
  - Processing
  - Data, also referred as information or state
  - Interaction



Components

- Elements that encapsulate processing and data in a system's architecture are referred to as *software components*
- **Definition**

  A *software component* is an architectural entity that
  - encapsulates a subset of the system's functionality and/or data
  - restricts access to that subset via an explicitly defined interface
  - has explicitly defined dependencies on its required execution context
- Components typically provide application-specific services

Connectors

- In complex systems *interaction* may become more important and challenging than the functionality of the individual components
- **Definition**

  A *software connector* is an architectural building block tasked with effecting and regulating interactions among components
- In many software systems connectors are usually simple procedure calls or shared data accesses

  Much more sophisticated and complex connectors are possible!
- Connectors typically provide application-independent interaction facilities

Examples of Connectors

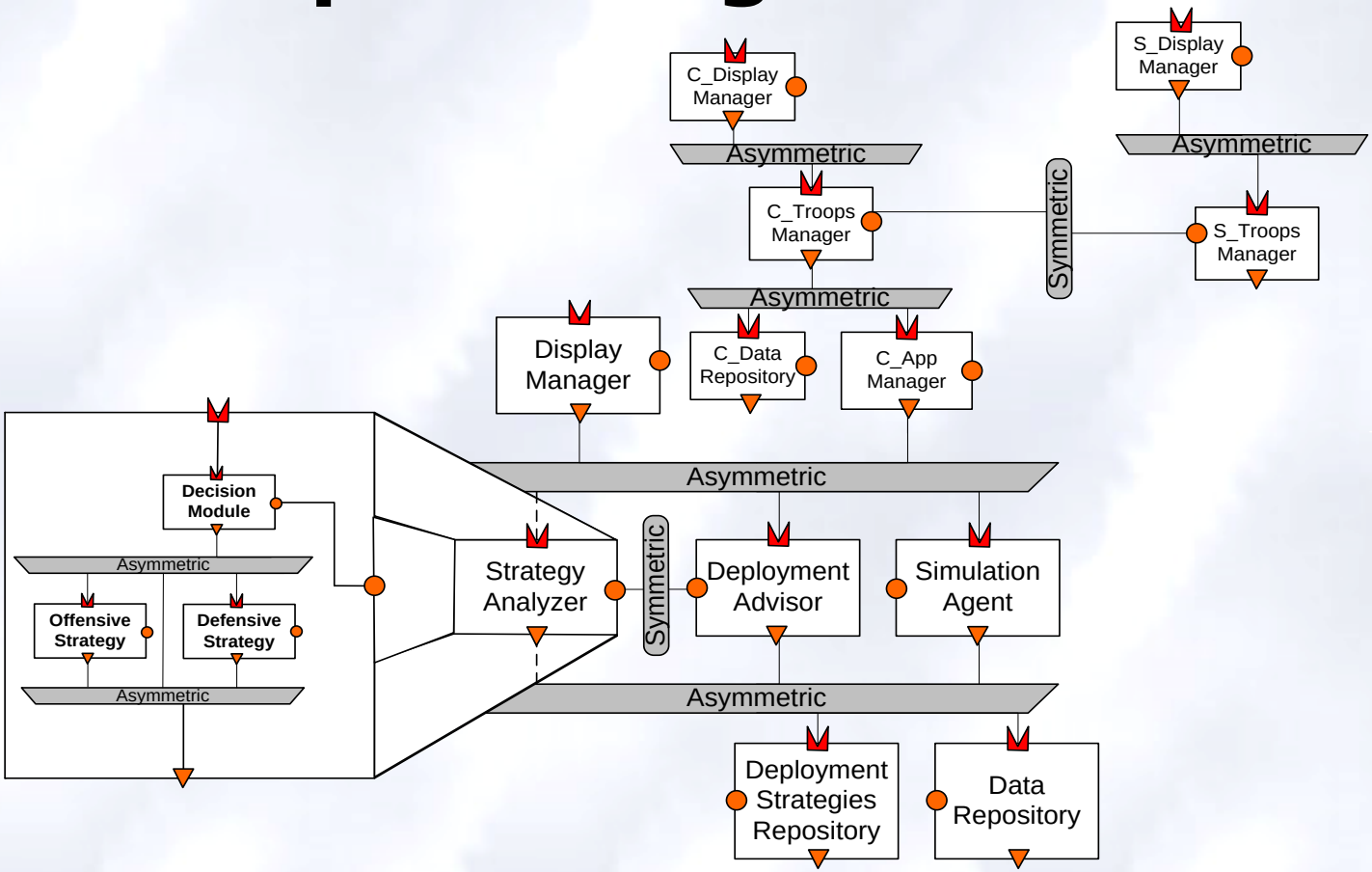
- Procedure call connectors
- Shared memory connectors
- Message passing connectors
- Streaming connectors
- Distribution connectors
- Wrapper/adaptor connectors

Configurations

- Components and connectors are composed in a specific way in a given system's architecture to accomplish that system's objective
- **Definition**

  An *architectural configuration*, or topology, is a set of specific associations between the components and connectors of a software system's architecture

An Example Configuration



Architectural Styles

- Certain design choices regularly result in solutions with superior properties

  Compared to other possible alternatives, solutions such as this are more elegant, effective, efficient, dependable, evolvable, scalable, and so on

- **Definition**

  An *architectural style* is a named collection of architectural design decisions that

  - are applicable in a **given development context**
  - constrain architectural design decisions that are specific to a particular system within that **contex**t
  - elicit beneficial qualities in each resulting system

Architectural Patterns

- **Definition**

  An *architectural pattern* is a set of architectural design decisions that are applicable to a **recurring design problem**, and parameterized to account for different software development contexts in which that problem appears

- A widely used pattern in modern distributed systems is the *three-tiered system* pattern

  Science

  Banking

  E-commerce

  Reservation systems

Three-Tiered Pattern

- Front Tier

  Contains the user interface functionality to access the system's services
- Middle Tier

  Contains the application's major functionality
- Back Tier

  Contains the application's data access and storage functionality

Architectural Styles vs. Patterns

- General vs. specific

Eg. GUI-intensive, distributed

- context vs. problem

- Strategic vs. tactical

- Abstraction

Styles are too abstract to yield concrete design decisions

Patterns are parameterized architectural fragments=> a piece of design decisions.

Architectural Models, Views, and Visualizations

- Architecture Model

  An artifact documenting some or all of the architectural design decisions about a system

- Architecture Visualization

  A way of depicting some or all of the architectural design decisions about a system to a stakeholder

- Architecture View

  A subset of related architectural design decisions

Architectural Models, Views, and Visualizations

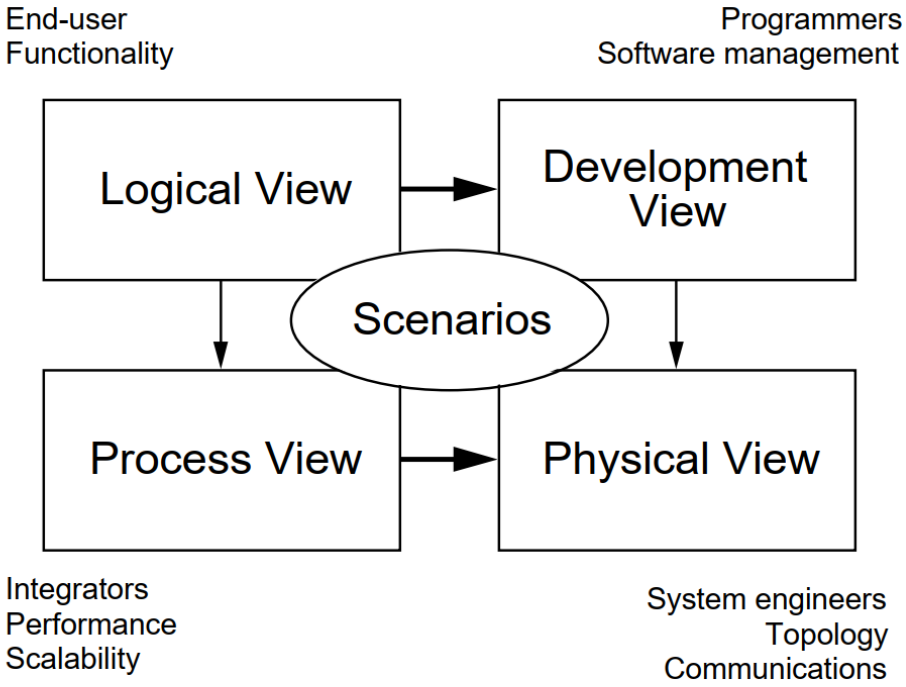


Figure 1 — The "4+1" view model

Paper published in IEEE Software 12 (6)
November 1995, pp. 42-50

Architectural Blueprints—The "4+1" View Model of Software Architecture

Philippe Kruchten
Rational Software Corp.

Architectural Processes

- Architectural design
- Architecture modeling and visualization
- Architecture-driven system analysis
- Architecture-driven system implementation
- Architecture-driven system deployment, runtime redeployment, and mobility
- Architecture-based design for non-functional properties, including security and trust
- architectural adaptation

Stakeholders in a System's Architecture

- Architects
- Developers
- Testers
- Managers
- Customers
- Users
- Vendors