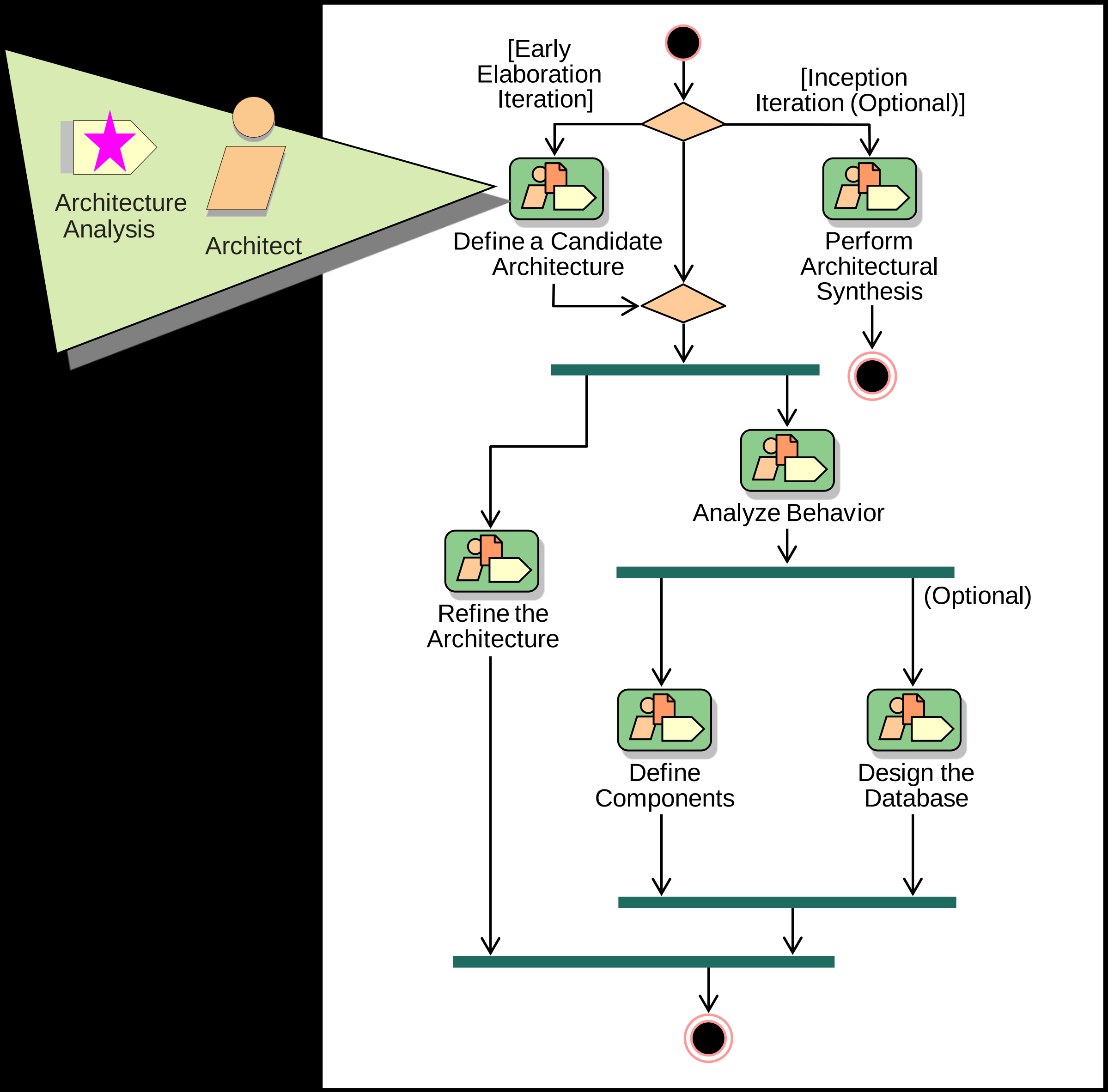
Object-Oriented Analysis and Design

Lecture 5: Architectural Analysis

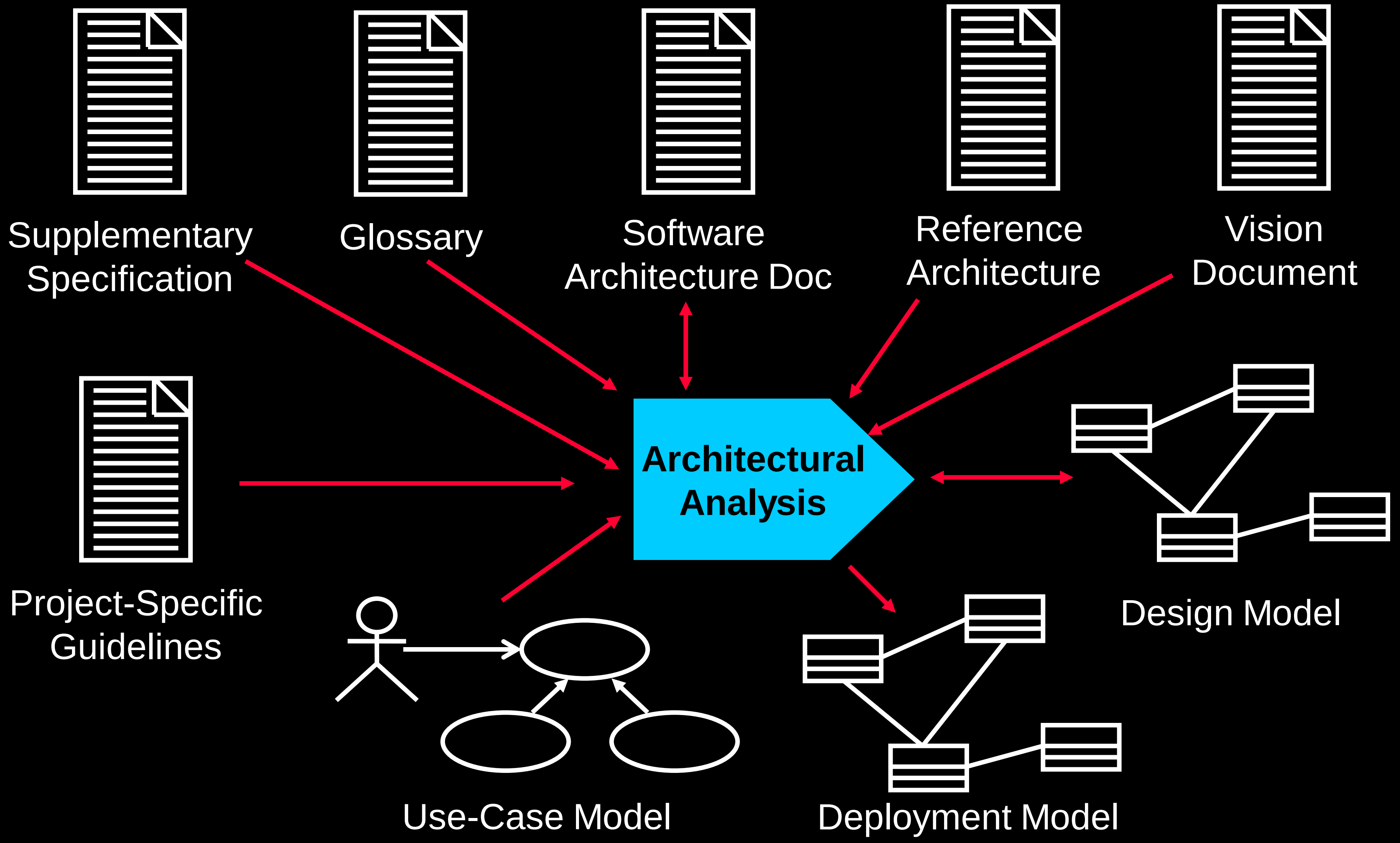
Objectives: Architectural Analysis

- Explain the purpose of Architectural Analysis and where it is performed in the lifecycle.
- Describe a representative architectural pattern and set of analysis mechanisms, and how they affect the architecture.
- Describe the rationale and considerations that support the architectural decisions.
- Show how to read and interpret the results of Architectural Analysis:
  - Architectural layers and their relationships
  - Key abstractions
  - Analysis mechanisms

Architectural Analysis in Context


Architecture Analysis
Architect
[Early Elaboration Iteration]
[Inception Iteration (Optional)]
Define a Candidate Architecture
Perform Architectural Synthesis
Analyze Behavior
(Optional)
Refine the Architecture
Define Components
Design the Database

Architectural Analysis Overview



Supplementary Specification

Glossary

Software Architecture Doc

Reference Architecture

Vision Document

Architectural Analysis

Project-Specific Guidelines

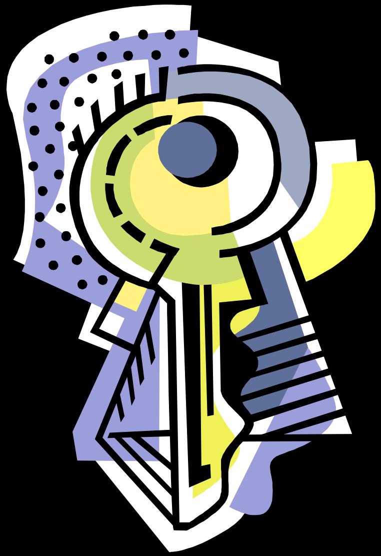
Design Model

Use-Case Model

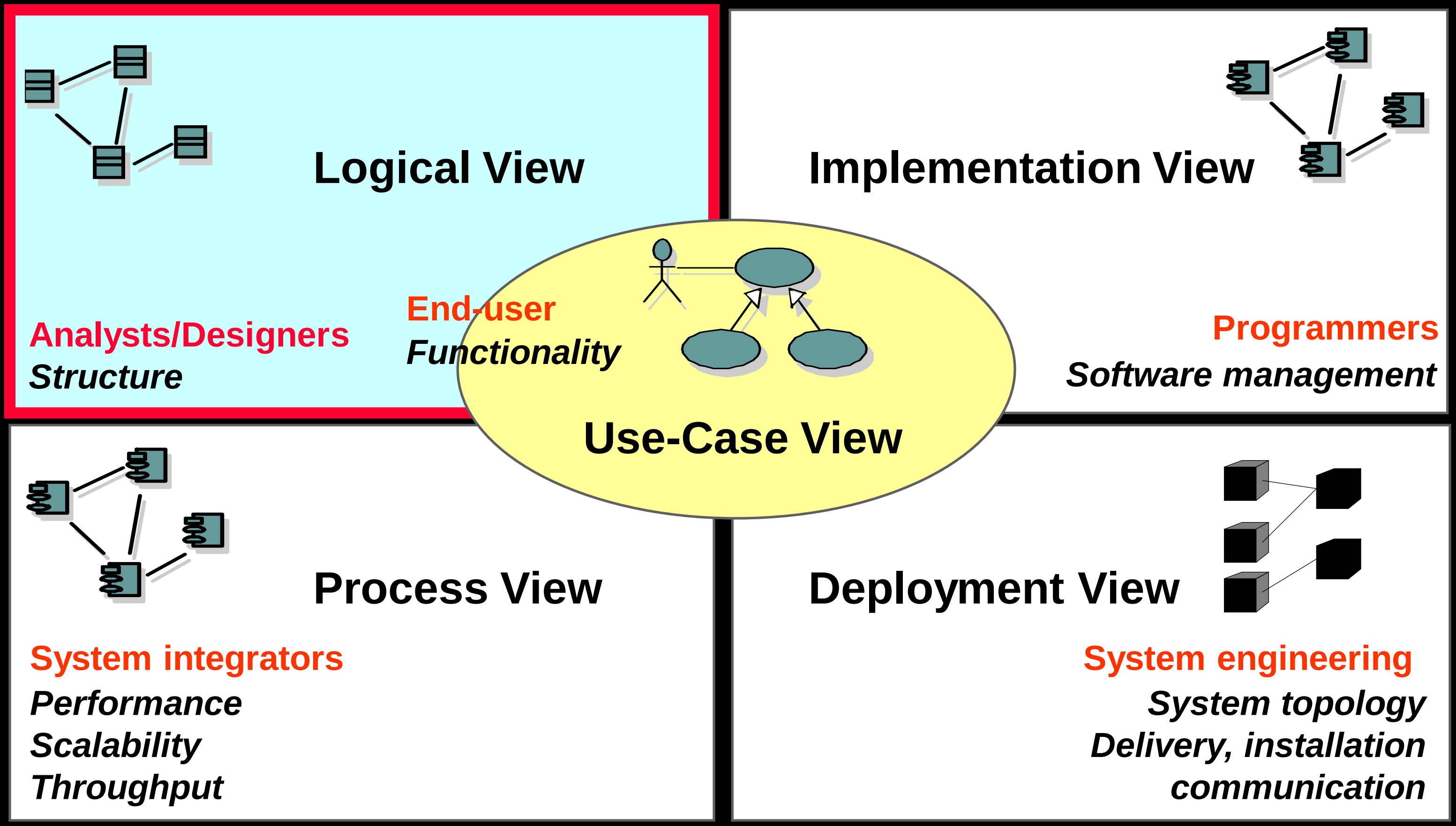
Deployment Model

Architectural Analysis Steps

- ★ Key Concepts
- Define the High-Level Organization of Subsystems
- Identify Analysis mechanisms
- Identify Key Abstractions
- Create Use-Case Realizations
- Checkpoints



Review: What Is Architecture: The “4+1 View” Model



Logical View

Analysts/Designers

Structure

Implementation View

Programmers

Software management

End-user

Functionality

Use-Case View

Process View

System integrators

Performance

Scalability

Throughput

Deployment View

System engineering

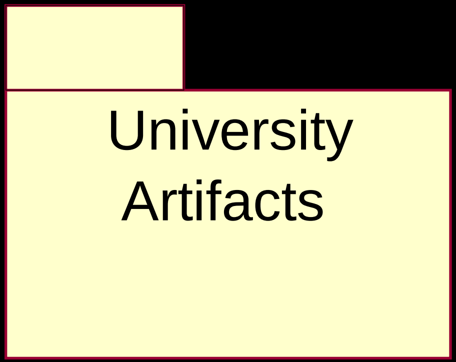
System topology

Delivery, installation

communication

Review: What Is a Package?

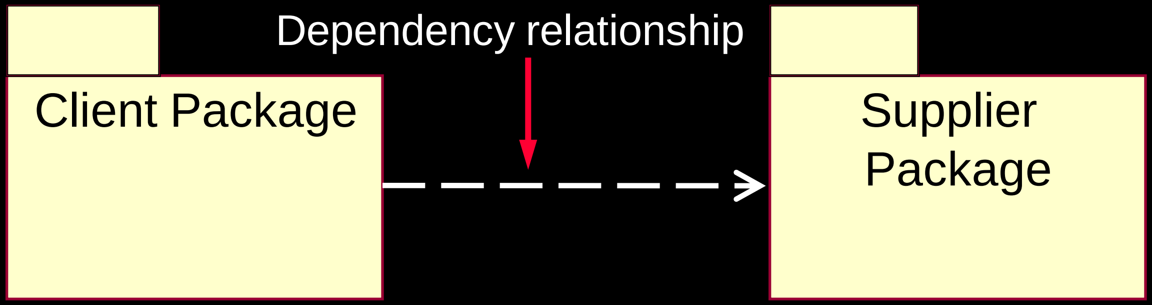
- A package is a general-purpose mechanism for organizing elements into groups.
- It is a model element that can contain other model elements.



- A package can be used
  - To organize the model under development.
  - As a unit of configuration management.

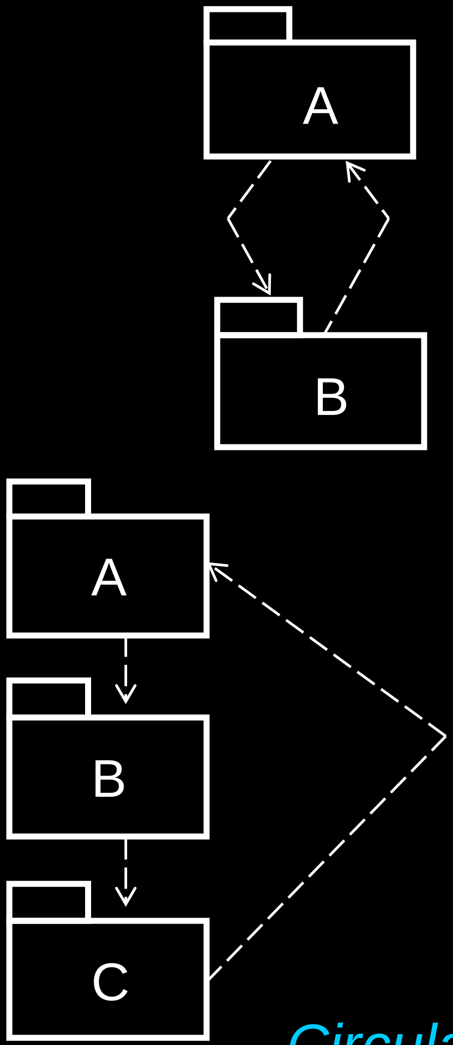
Package Relationships: Dependency

- Packages can be related to one another using a dependency relationship.

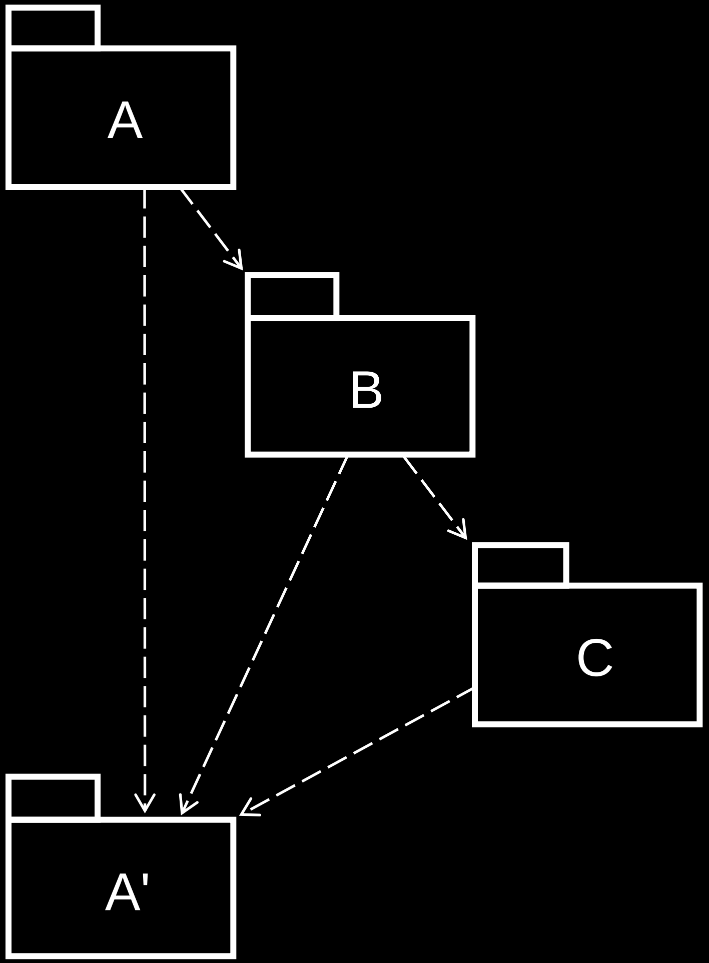


- Dependency Implications
  - Changes to the Supplier package may affect the Client package.
  - The Client package cannot be reused independently because it depends on the Supplier package.

Avoiding Circular Dependencies



Hierarchy should be acyclic



Circular dependencies make it impossible to reuse one package without the other.

Architectural Analysis Steps

- Key Concepts
- ★ Define the High-Level Organization of Subsystems
- Identify Analysis mechanisms
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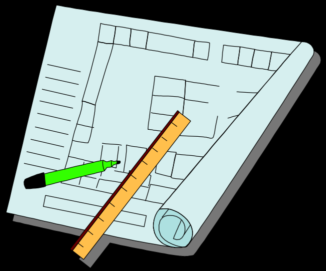
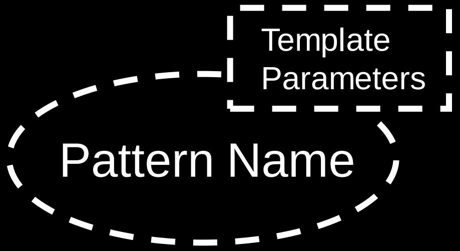
Patterns and Frameworks

- Pattern
  - Provides a common solution to a common problem in a context
- Analysis/Design pattern
  - Provides a solution to a narrowly-scoped technical problem
  - Provides a fragment of a solution, or a piece of the puzzle
- Framework
  - Defines the general approach to solving the problem
  - Provides a skeletal solution, whose details may be Analysis/Design patterns

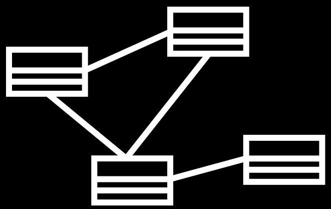


What Is a Design Pattern?

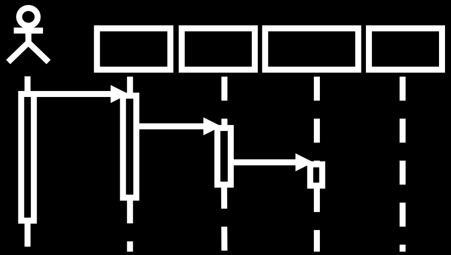
- A design pattern is a solution to a common design problem.
  - Describes a common design problem
  - Describes the solution to the problem
  - Discusses the results and trade-offs of applying the pattern
- Design patterns provide the capability to reuse successful designs.



Parameterized Collaboration



Structural Aspect

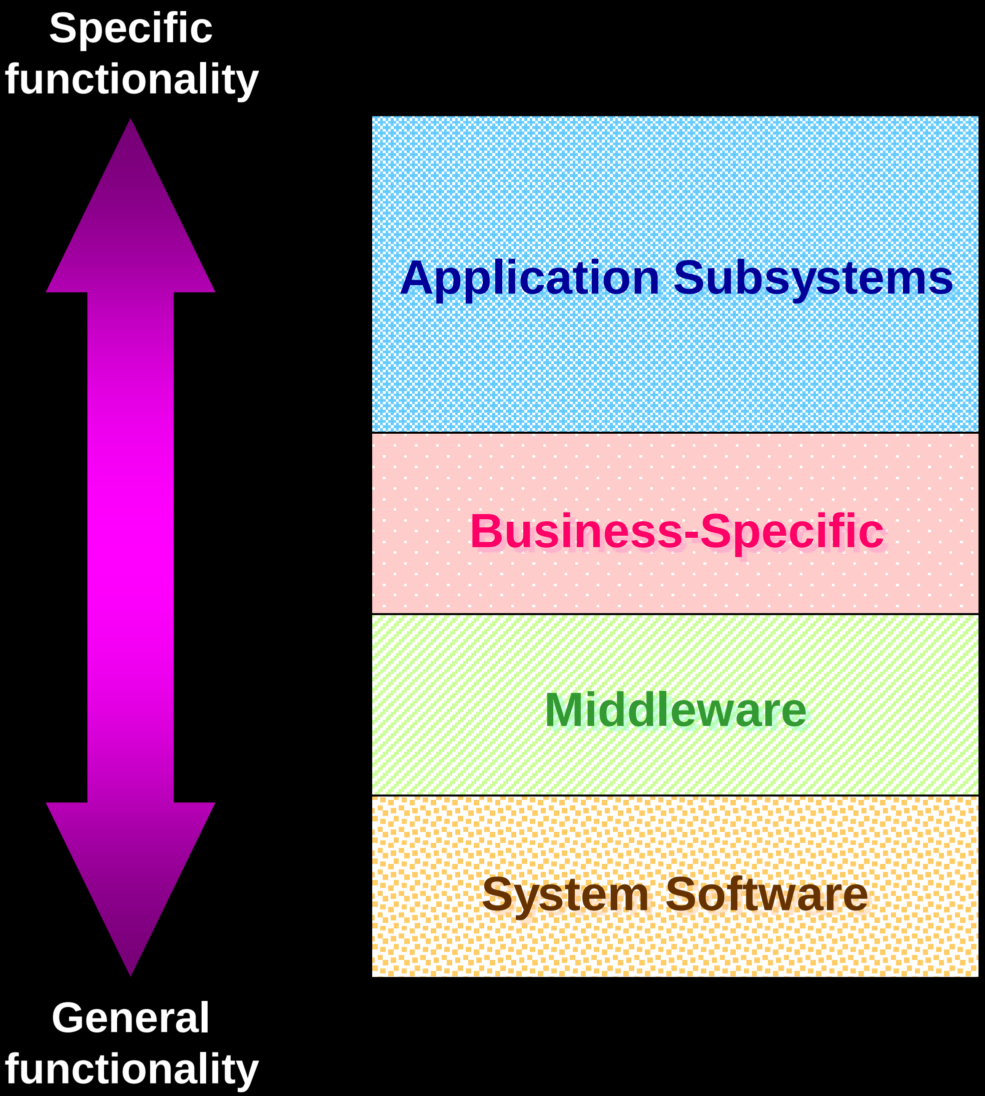


Behavioral Aspect

What Is an Architectural Pattern?

- An architectural pattern expresses a fundamental structural organization schema for software systems. It provides a set of predefined subsystems, specifies their responsibilities, and includes rules and guidelines for organizing the relationships between them – *Buschman et al, “Pattern-Oriented Software Architecture — A System of Patterns”*
  - Layers
  - Model-view-controller (M-V-C)
  - Pipes and filters
  - Blackboard

Typical Layering Approach



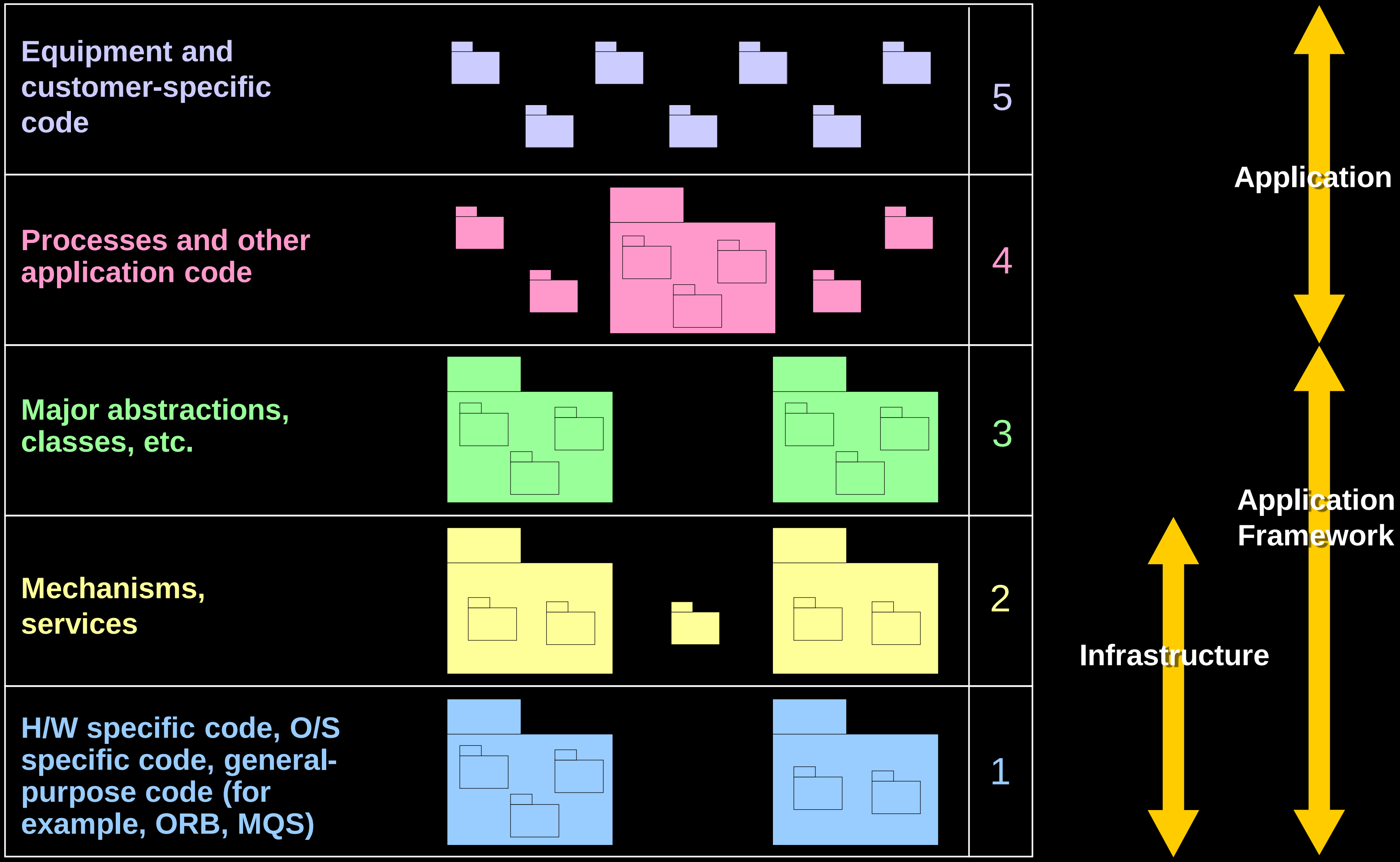
Distinct application subsystems that make up an application — contains the value adding software developed by the organization.

Business specific — contains a number of reusable subsystems specific to the type of business.

Middleware — offers subsystems for utility classes and platform-independent services for distributed object computing in heterogeneous environments and so on.

System software — contains the software for the actual infrastructure such as operating systems, interfaces to specific hardware, device drivers, and so on.

Architectural Pattern: Layers



Equipment and customer-specific code	5
Processes and other application code	4
Major abstractions, classes, etc.	3
Mechanisms, services	2
H/W specific code, O/S specific code, general-purpose code (for example, ORB, MQS)	1

Application

Application Framework

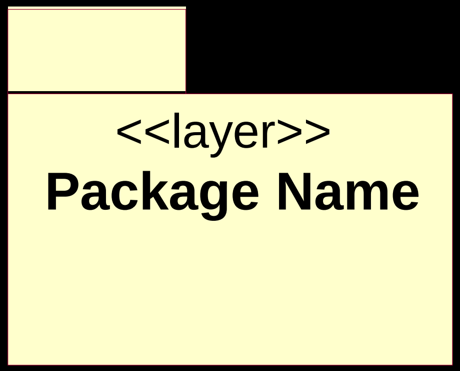
Infrastructure

Layering Considerations

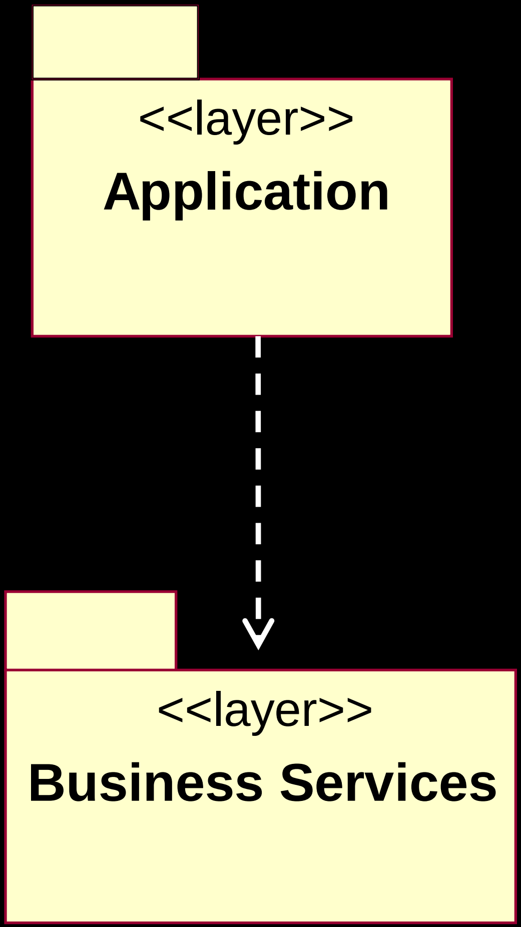
- Level of abstraction
  - Group elements at the same level of abstraction
- Separation of concerns
  - Group like things together
  - Separate disparate things
  - Application vs. domain model elements
- Resiliency
  - Loose coupling
  - Concentrate on encapsulating change
  - User interface, business rules, and retained data tend to have a high potential for change

Modeling Architectural Layers

- Architectural layers can be modeled using stereotyped packages.
- <<layer>> stereotype



Example: High-Level Organization of the Model



Architectural Analysis Steps

- Key Concepts
- Define the High-Level Organization of Subsystems
- ★ Identify Analysis mechanisms
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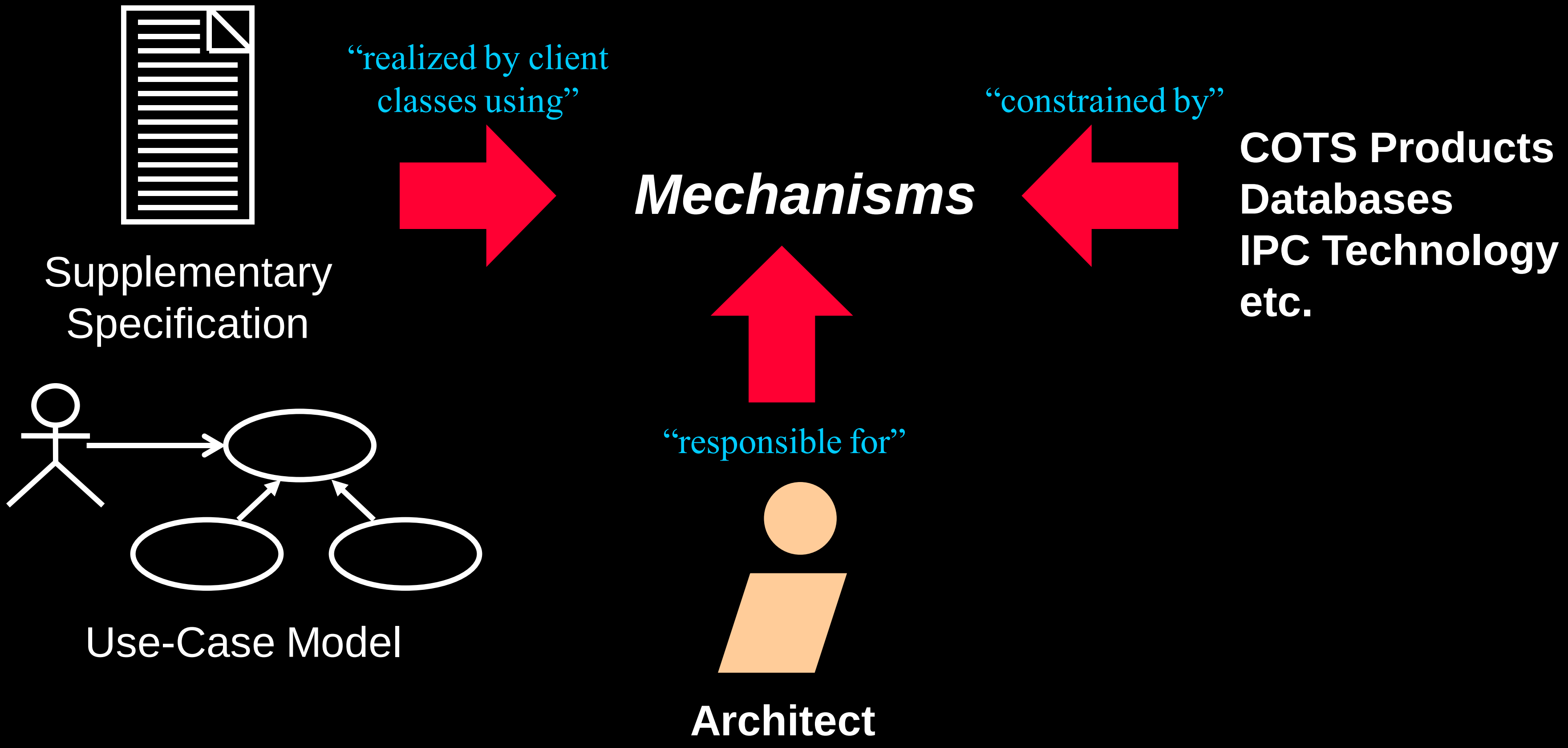
What Are Architectural Mechanisms?

Required Functionality

Implementation Environment



Supplementary Specification

Use-Case Model

"realized by client classes using"

Mechanisms

"constrained by"

COTS Products
Databases
IPC Technology
etc.

"responsible for"

Architect

Architectural Mechanisms: Three Categories

- Architectural Mechanism Categories
  - Analysis mechanisms (conceptual)
  - Design mechanisms (concrete)
  - Implementation mechanisms (actual)

Why Use Analysis Mechanisms?

Oh no! I found a group of classes that has persistent data. How am I supposed to design these things if I don't even know what database we are going to be using?

That is why we have a persistence analysis mechanism. We don't know enough yet, so we can bookmark it and come back to it later.

Analysis mechanisms are used during analysis to reduce the complexity of analysis and to improve its consistency by providing designers with a shorthand representation for complex behavior.

Sample Analysis Mechanisms

- Persistency
- Communication (IPC and RPC)
- Message routing
- Distribution
- Transaction management
- Process control and synchronization (resource contention)
- Information exchange, format conversion
- Security
- Error detection / handling / reporting
- Redundancy
- Legacy Interface

Examples of Analysis Mechanism Characteristics

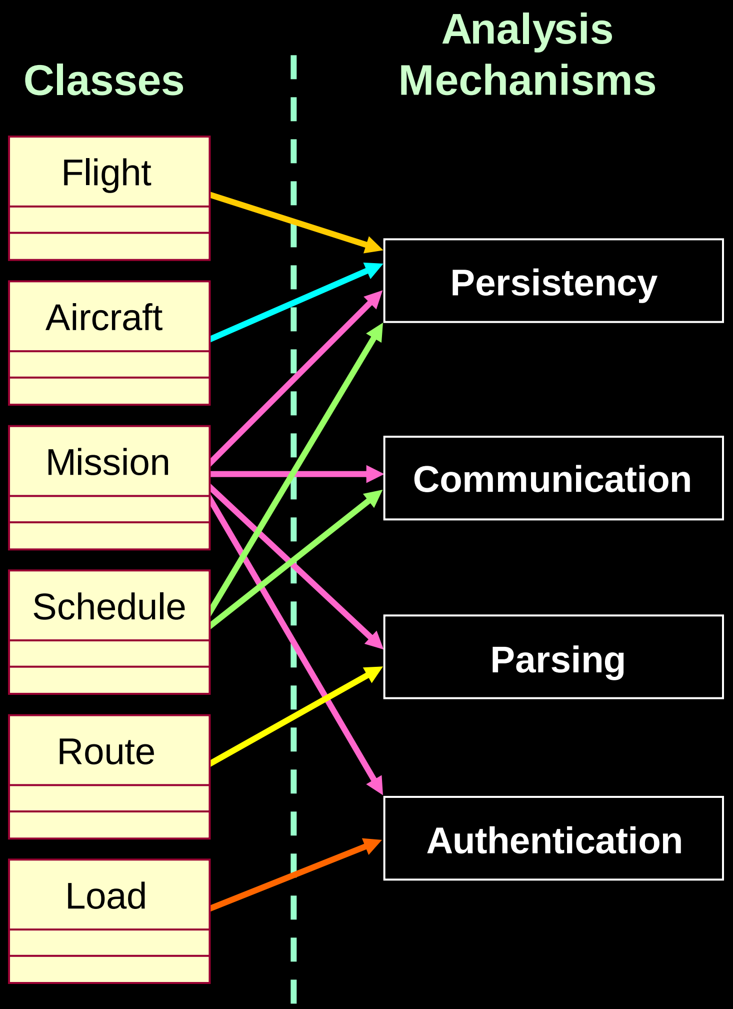
- Persistency mechanism
  - Granularity
  - Volume
  - Duration
  - Access mechanism
  - Access frequency (creation/deletion, update, read)
  - Reliability
- Inter-process Communication mechanism
  - Latency
  - Synchronicity
  - Message size
  - Protocol

Example of Analysis Mechanism Characteristics (cont.)

- Legacy interface mechanism
  - Latency
  - Duration
  - Access mechanism
  - Access frequency
- Security mechanism
  - Data granularity
  - User granularity
  - Security rules
  - Privilege types
- Others

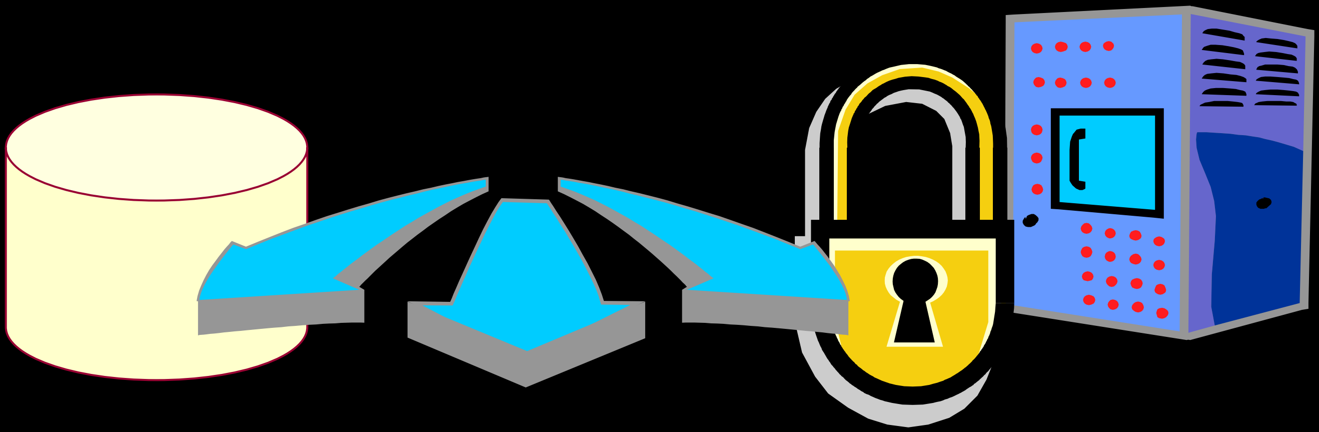
Describing Analysis Mechanisms

- Collect all analysis mechanisms in a list
- Draw a map of classes to analysis mechanisms
- Identify characteristics of analysis mechanisms
- Model using collaborations



Example: Course Registration Analysis Mechanisms

- Persistence
- Distribution
- Security
- Legacy Interface



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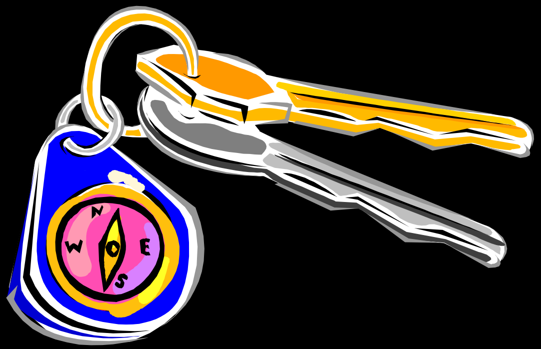
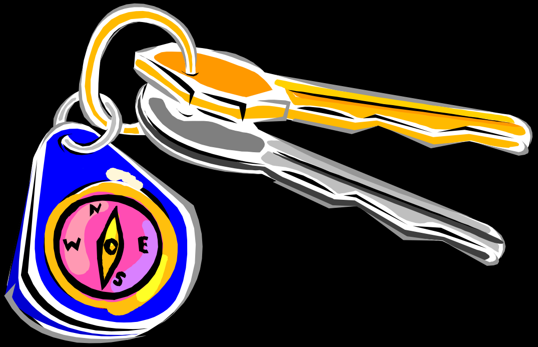


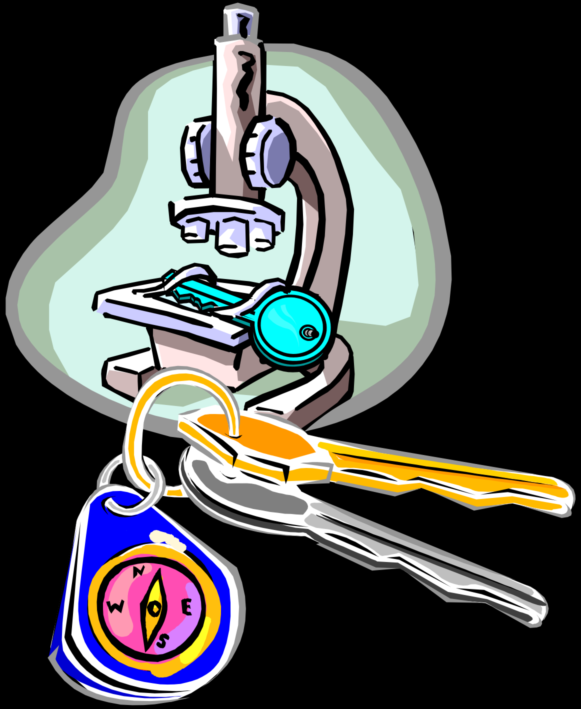
What Are Key Abstractions?

- A key abstraction is a concept, normally uncovered in Requirements, that the system must be able to handle
- Sources for key abstractions
  - Domain knowledge
  - Requirements
  - Glossary
  - Domain Model, or the Business Model (if one exists)

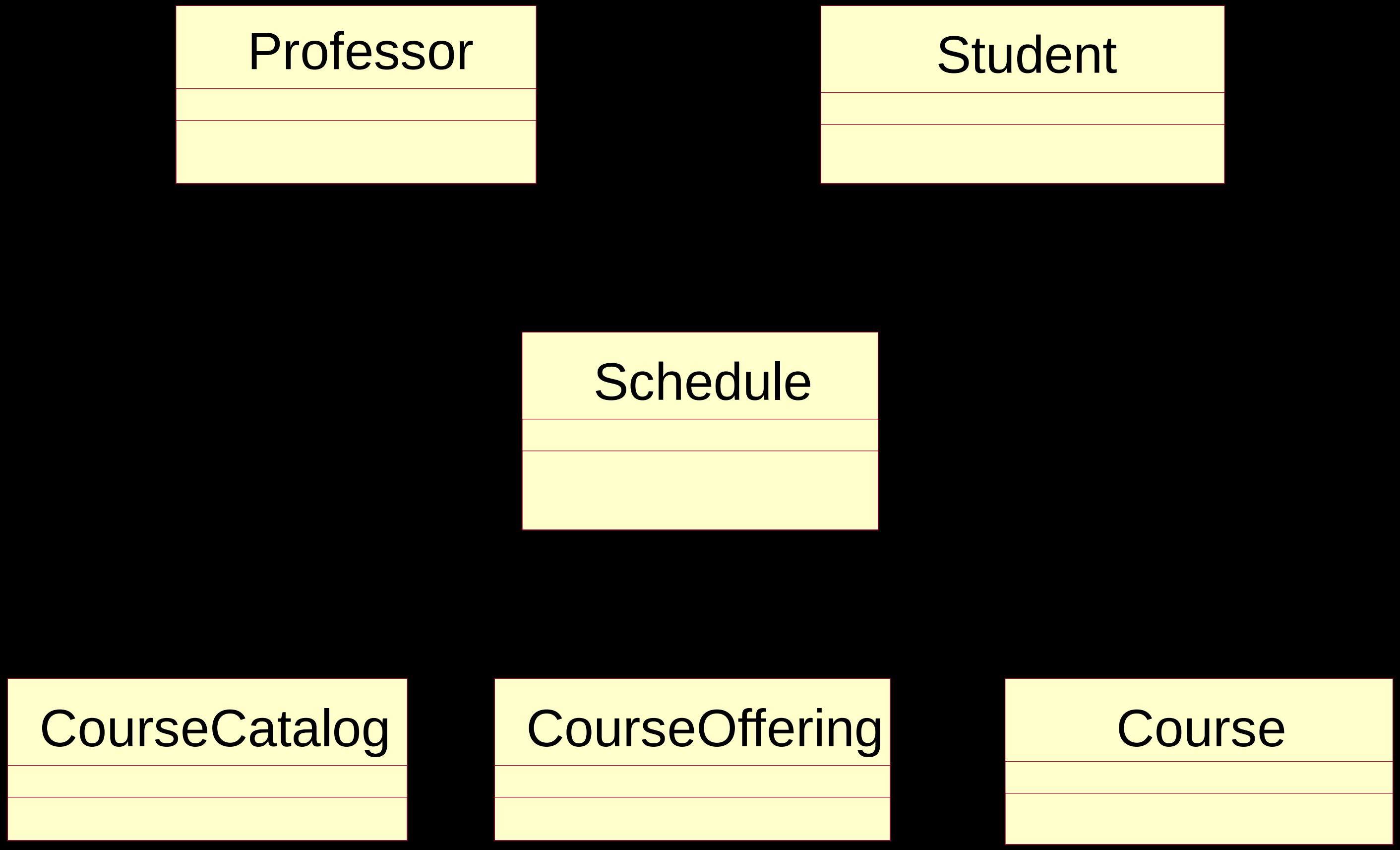


Defining Key Abstractions

- Define analysis class relationships
- Model analysis classes and relationships on class diagrams
  - Include brief description of analysis class
- Map analysis classes to necessary analysis mechanisms



Example: Key Abstractions



Architectural Analysis Steps

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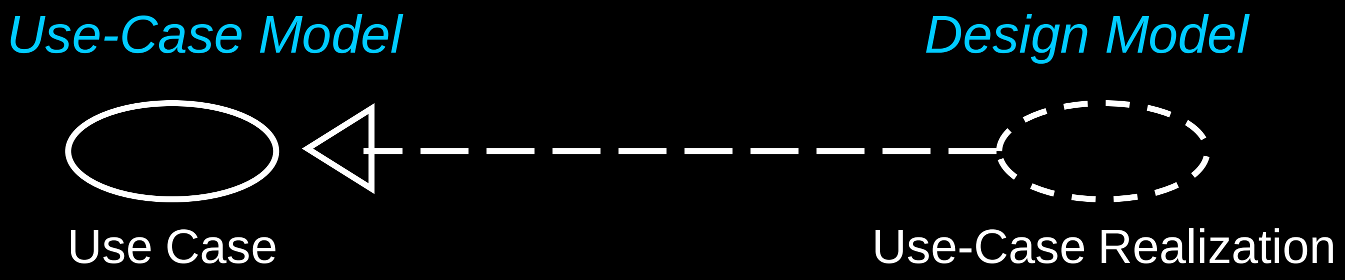
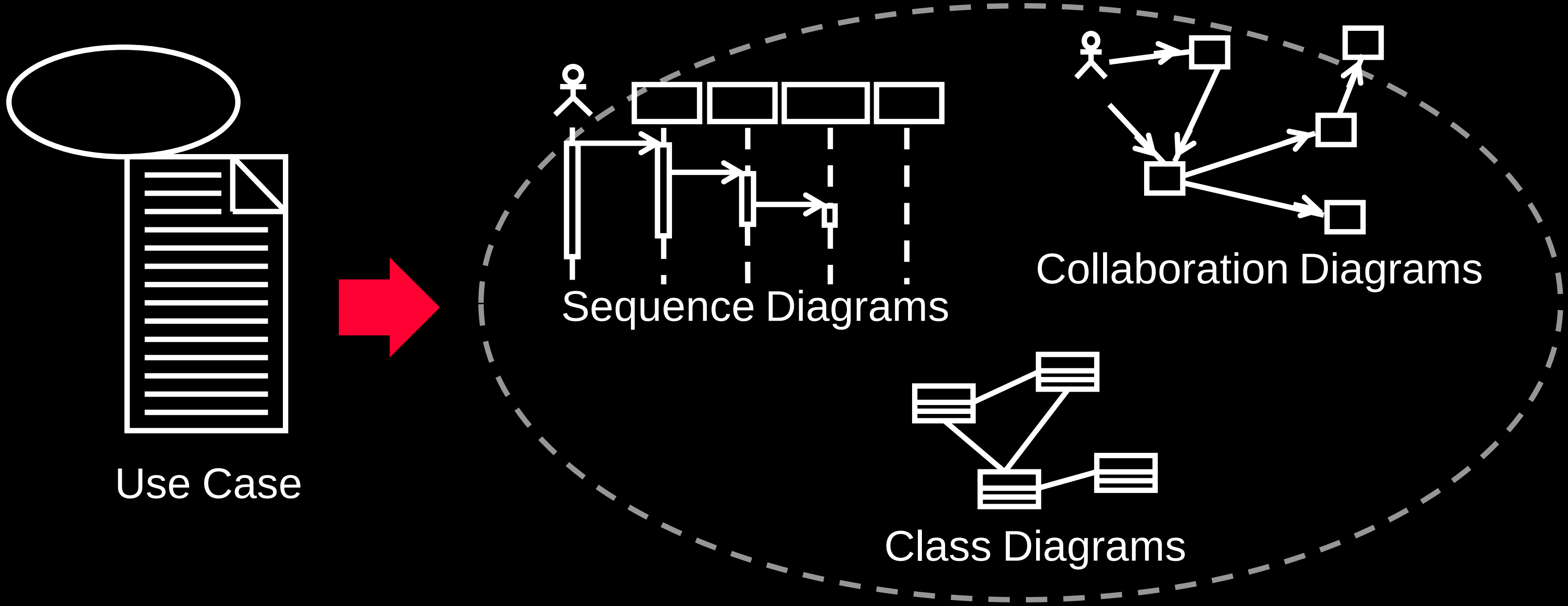
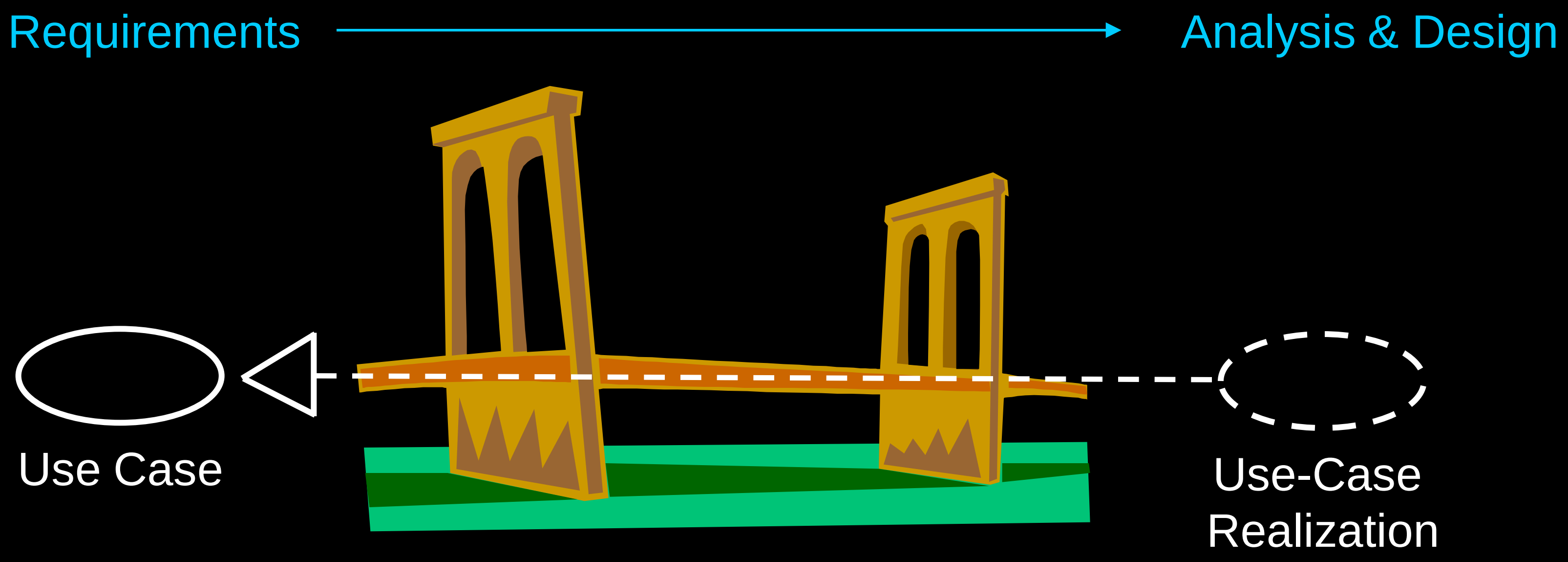
Review: What is a Use-Case Realization?





The Value of Use-Case Realizations

- Provides traceability from Analysis and Design back to Requirements
- The Architect creates the Use-Case Realization



Requirements → Analysis & Design

Use Case

Use-Case Realization

Architectural Analysis Steps

- Key Concepts
- Define the High-Level Organization of Subsystems
- Identify Analysis mechanisms
- Identify Key Abstractions
- Create Use-Case Realizations
- ★ Checkpoints

Checkpoints

- General
  - Is the package partitioning and layering done in a logically consistent way?
  - Have the necessary analysis mechanisms been identified?
- Packages
  - Have we provided a comprehensive picture of the services of the packages in upper-level layers?

(continued)

Checkpoints (cont.)

- Classes
  - Have the key entity classes and their relationships been identified and accurately modeled?
  - Does the name of each class clearly reflect the role it plays?
  - Are the key abstractions/classes and their relationships consistent with the Business Model, Domain Model, Requirements, Glossary, etc.?

Review: Architectural Analysis

- What is the purpose of Architectural Analysis?
- What is a package?
- What are analysis mechanisms? Give examples.
- What key abstractions are identified during Architectural Analysis? Why are they identified here?
- What is a layered architecture? Give examples of typical layers.

Exercise: Architectural Analysis

- Given the following:
  - Some results from the Requirements discipline:
    - Problem statement
    - Use-Case Model main diagram
    - Glossary
  - Some architectural decisions:
    - (textually) The upper-level architectural layers and their dependencies

(continued)

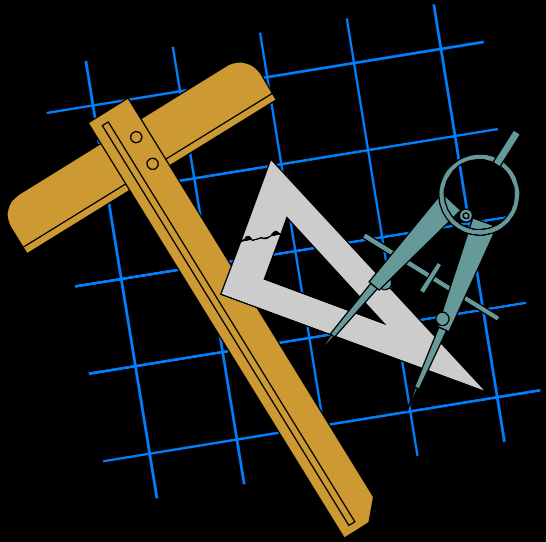
Exercise: Architectural Analysis (cont.)

- Identify the following:
  - The key abstractions

(continued)

Exercise: Architectural Analysis (cont.)

- Produce the following:
  - Class diagram containing the key abstractions
  - Class diagram containing the upper-level architectural layers and their dependencies



Exercise: Review

- Compare your key abstractions with the rest of the class
  - Have the key concepts been identified?
  - Does the name of each class reflect the role it plays?
- Compare your class diagram showing the upper-level layers
  - Do the package relationships support the Payroll System architecture?