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Module 626-1

ARCHITECTURE DU SYSTÈME D'INFORMATION ET DESIGN PATTERNS

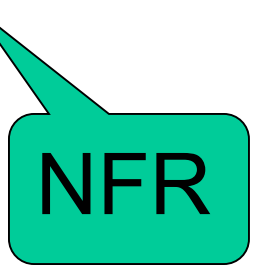
Dr. Stefan Behfar

session 1

Architecting systems

« **Architecting**…is helping determine the relative requirement priorities, acceptable performance, cost and schedule, taking into account such factors as technology risks, projected market size, likely competitors moves, economic trends, political regulatory requirements, project organization and the appropriate «illities» (availability, operability, manufacturability, survivability,…). »

[Rechtin E. – Systems Architecting. Prentice Hall, 1991]



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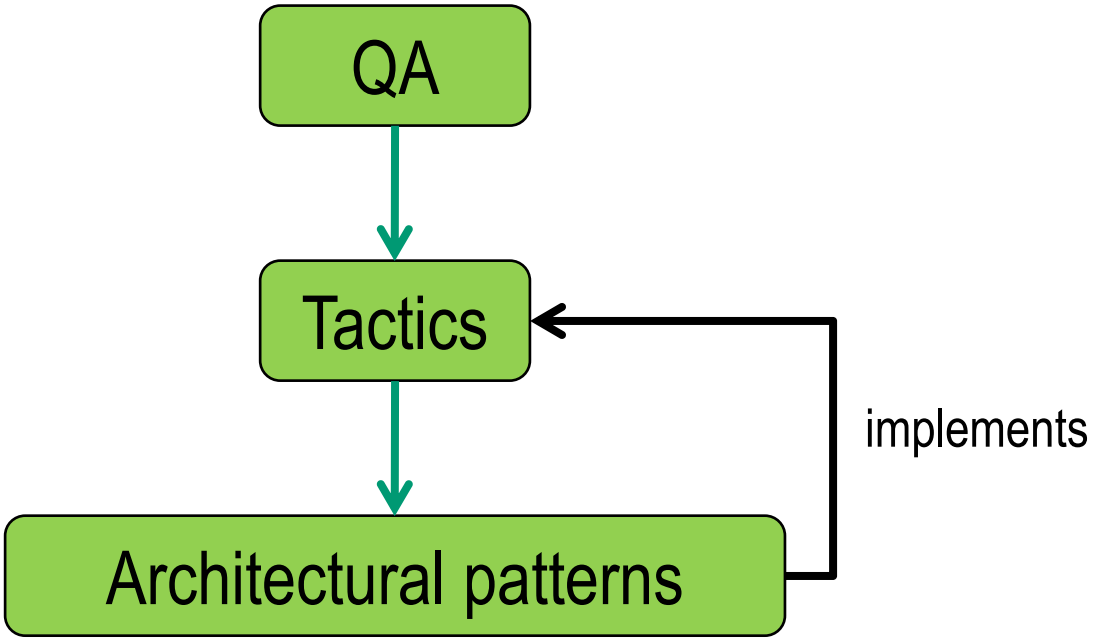
Designing the high level architecture



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Designing high level architecture based on NFR

2 concepts:

- Architectural tactic

  An architectural tactic is a design decision that helps achieve a specific quality-attribute response. Such a tactic must be motivated by a quality-attribute analysis model.

- Architectural pattern (architectural *style*)

  Architectural patterns express fundamental structural organization schemas for software systems. They provide a set of predefined subsystems, specify their responsibilities and include rules and guidelines for organizing the relationships between them.

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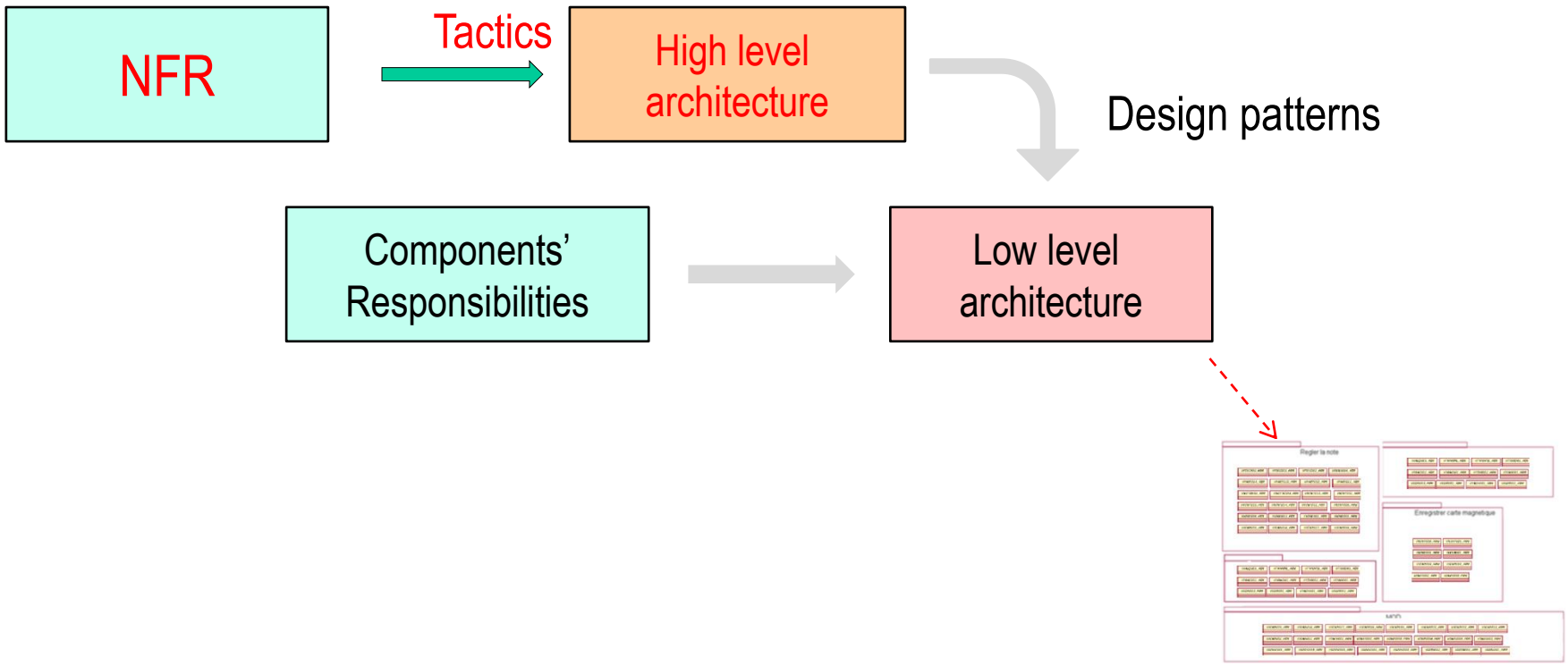
An overview: architecting steps



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QA: performance

- How long does it take for the system to respond to an event (latency) ?
  - Source of complication: the number of event sources and their arrival sequence.
- Source of performance problems
  - Availability of required resources

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Performance tactics

- Resource demand
  - Increase computational efficiency (better algorithms)
  - Reduce computational overhead (do not waste processor time)
  - Manage event rate (limit computational needs)
- Resource management
  - Introduce concurrency (threads)
  - Maintain multiples copies of either data or computation (cache)
- Resource arbitration
  - First-in first-out
  - Fixed priority scheduling

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Availability tactics

- Availability deals with system failures and their consequences.
  - A failure occurs when the system no longer delivers a service consistent with its specification.
  - A fault becomes a failure when it is observable by the user of the system.
    - Then, one way to avoid a failure is to detect and correct a fault before it becomes observable by the user.

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Availability tactics

- Fault detection
  - Ping / echo
  - Heartbeat
  - Exception
- Fault recovery
  - Voting
  - Active redundancy (hot restart) (mirroring)
  - Passive redundancy (backup)

to avoid failure

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Why is modifiability an issue ? Dependencies

Kind of dependencies between modules / components:

1. Syntax of function / signature
2. Semantics of function / methods
3. Sequence of calls
4. Name (identity) of an interface
5. Location of a component
6. Quality of service / data
7. Shared access to resources

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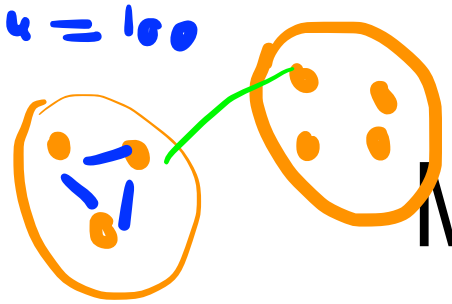

Modifiability tactics

- Localize modifications
  - Maintain semantic coherence (low coupling + high cohesion)
  - Anticipate expected change
  - Generalize the module (parameterization)
  - Limit possible options (extension points)
- Prevent ripple effect (limit dependencies)
  - Hide information
  - Maintain existing interface
  - Restrict communication paths
  - Use an intermediary

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- In this session, we will discuss
  - Design in the large system
  - Software architecture
  - Design principles
  - Architectural patterns
  - What do we model

Design in the Large

- Objects and methods
- Modules and components
- Large and complex systems
- Systems of systems

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Software Architecture

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

N. Taylor et al.

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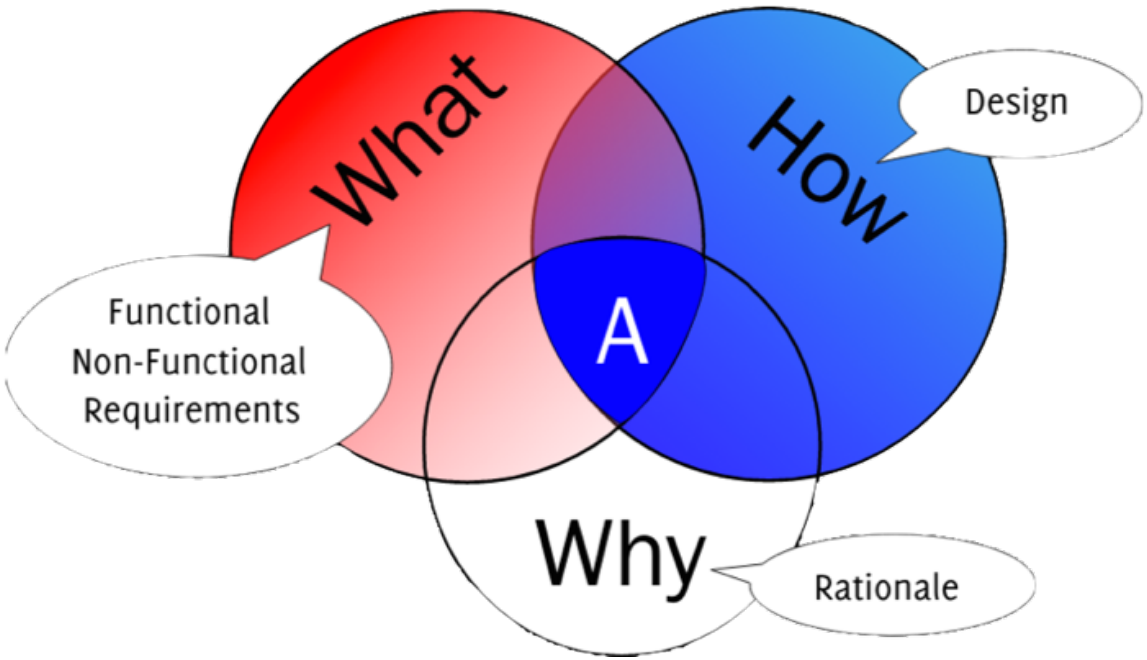
Abstraction



Manage complexity in the design

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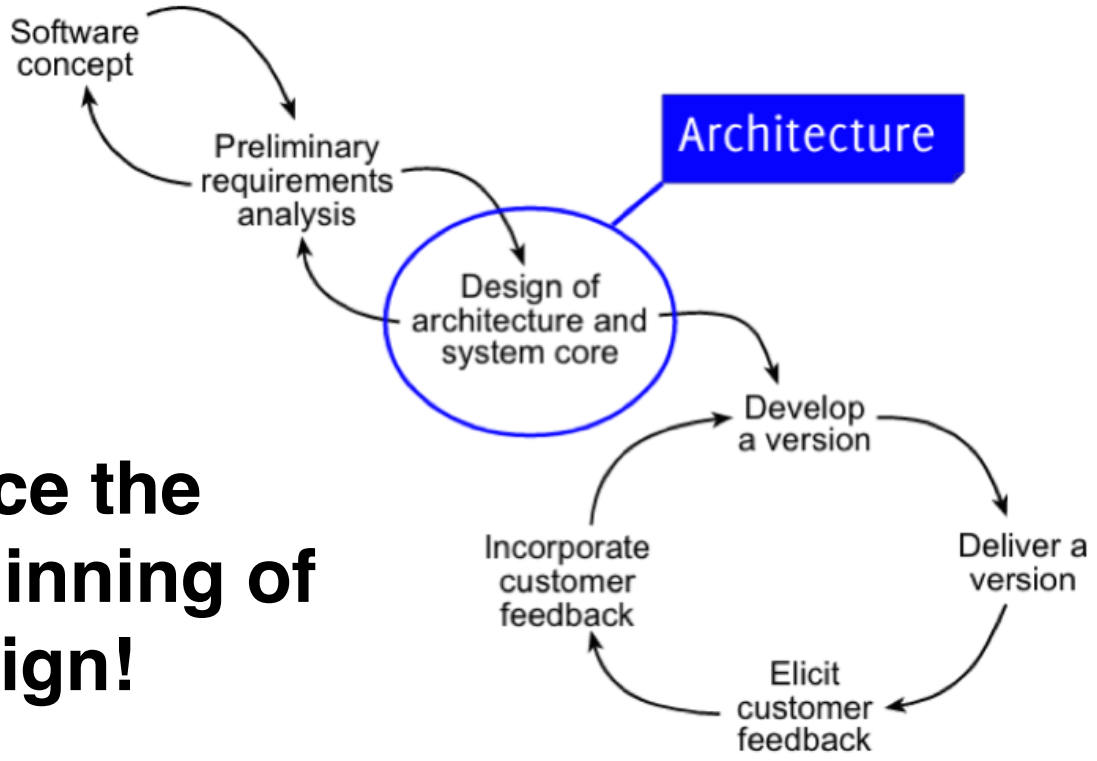
When Sw. Architecture Start ?



Since the beginning of design!

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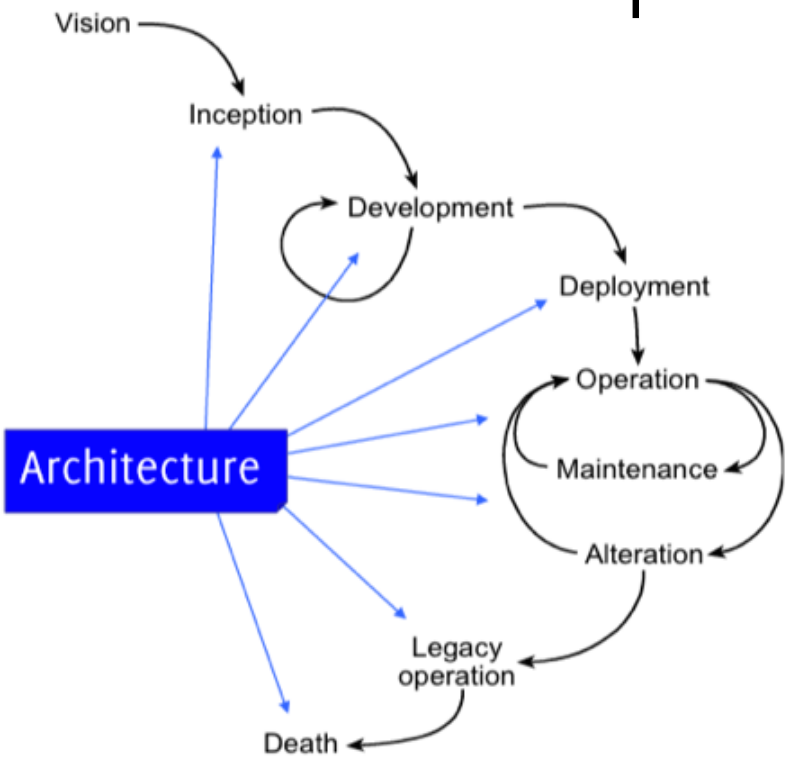
When Sw. Architecture Stop ?



Never!

Architecture is NOT a phase of development

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Software Architecture

- Blueprint for construction and evolution
  abstraction • principal design decisions
- Not only about design
  communicate • visualize • represent • quality
- Every application has one, which evolves
  descriptive • prescriptive • drift • erosion
- Not a phase of development

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What makes a “good” Architecture?

- No such things like perfect design and inherently good/bad architecture
- Fit to some purpose, and context-dependent
- Principles, guidelines and the use of collective experience (*method)*

Design principles - Arch. Patterns - Arch. Styles

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Design Principles

- Abstraction
- Encapsulation - Separation of Concerns
- Modularization
- KISS (*Keep it simple, stupid*)
- DRY (*Don't repeat yourself)*

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Architectural Patterns

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.

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Problem

- Complex processing with several levels of abstraction from input to output

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Model-View-Controller

The *Model-View-Controller* pattern is one of the best known and most common patterns in the architecture of *interactive* systems.

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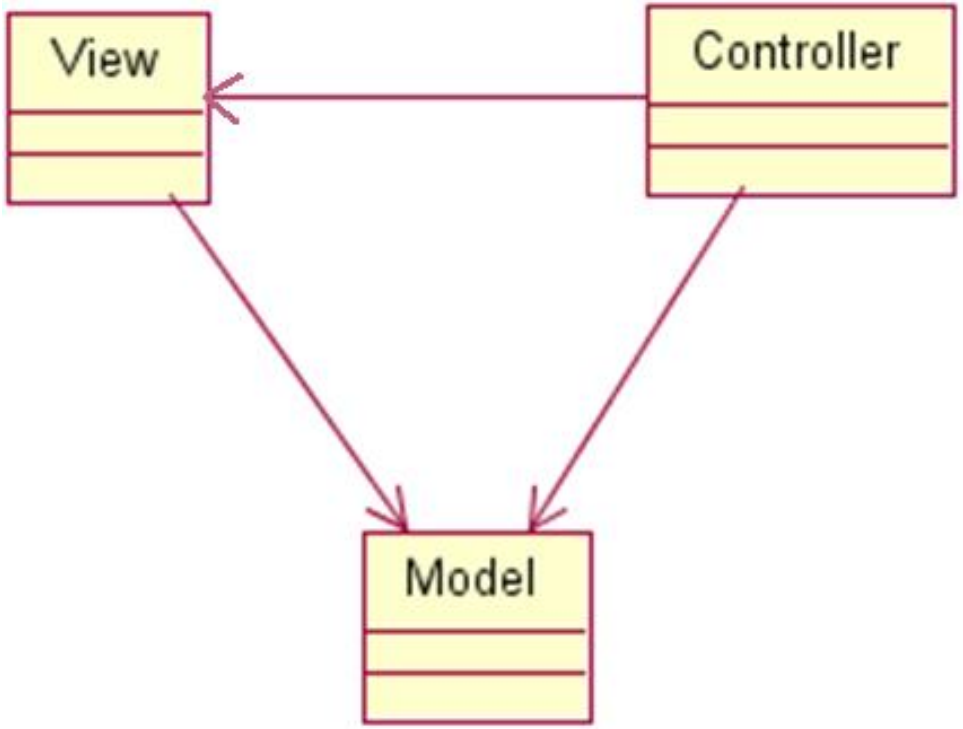
Model-View-Controller



Concept designed back in the 70's in Alan's Kay at Xerox. Implemented in Smalltalk 76, Smalltalk 78 then in the first commercial version: Smalltalk-80 by Adele Goldberg's group.

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Implemented tactics

Modifiability tactics:

- Anticipate expected change
- Separate concerns

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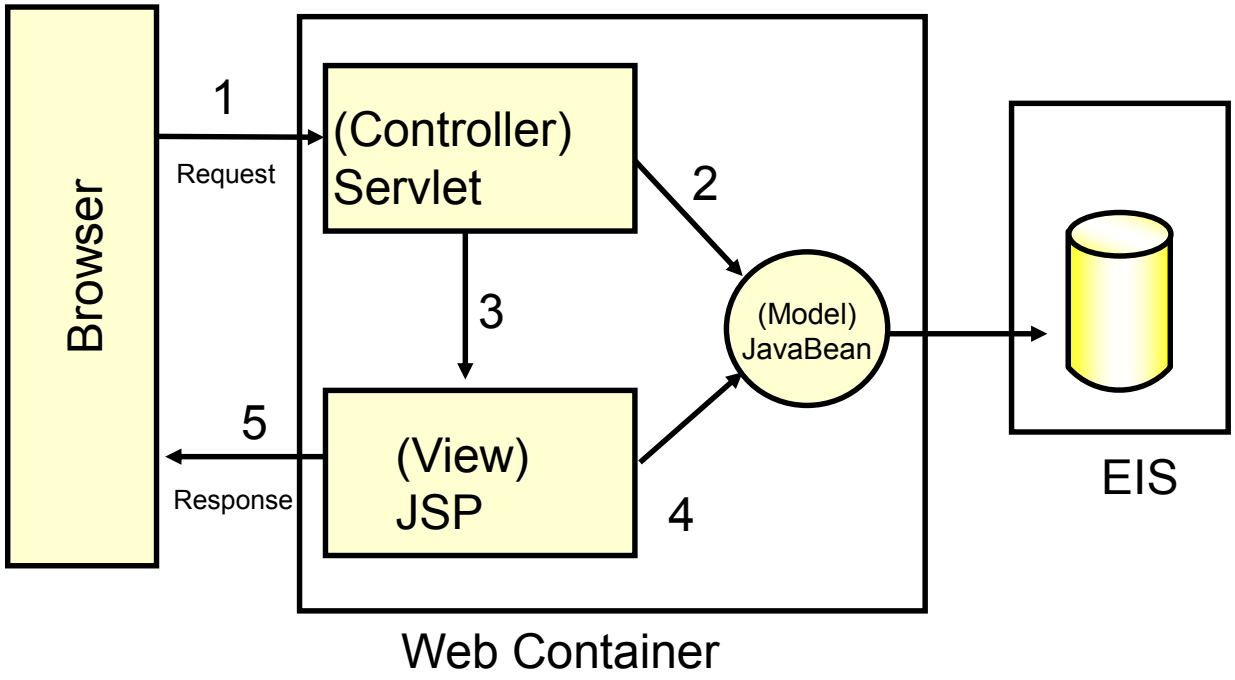
Exemple: good-old JSP / Servlet



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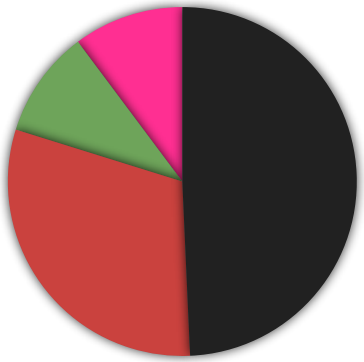
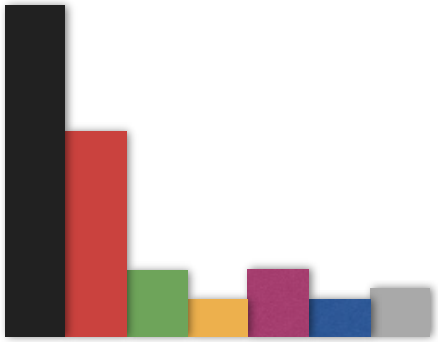
Example: Election Day

CDU/CSU	41,5 %
SPD	25,7 %
GRÜNE	8,4 %
FDP	4,8 %
LINKE	8,6 %
AfD	4,7 %
Sonstige	6,2 %

Bundestagswahl
22.09.2013





CDU/CSU	0,415
SPD	0,257
GRÜNE	0,084
FDP	0,048
LINKE	0,086
PIRATEN	0,047
Sonstige	0,062

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Problem

User interfaces are most frequently affected by changes.

- How can I represent the same information in different ways?
- How can I guarantee that changes in the dataset will be instantly reflected in all views?
- How can I change the user interface? (possibly at runtime)
- How can I support multiple user interfaces without changing the core of the application?

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Solution

The *Model-View-Controller* pattern splits the application into three parts:

- The *model* is responsible for processing,
- The *view* takes care of output,
- The *controller* concerns itself with input

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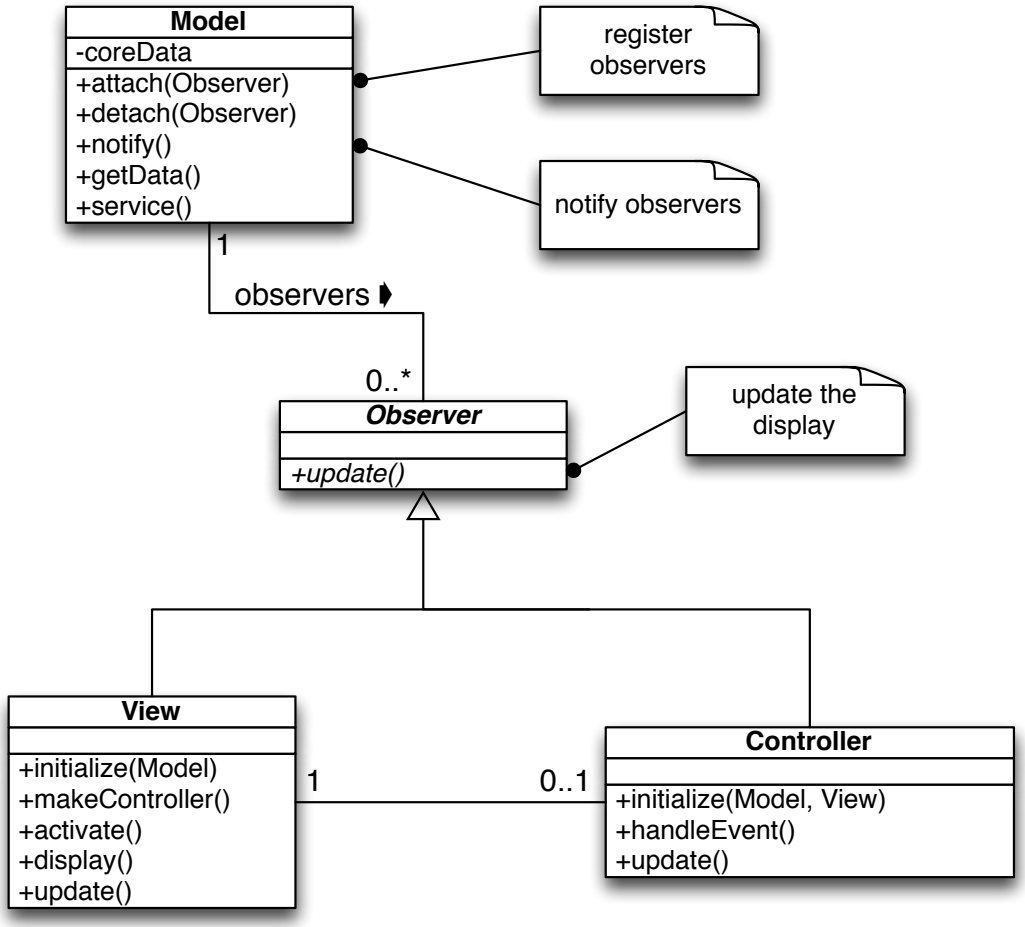
Structure



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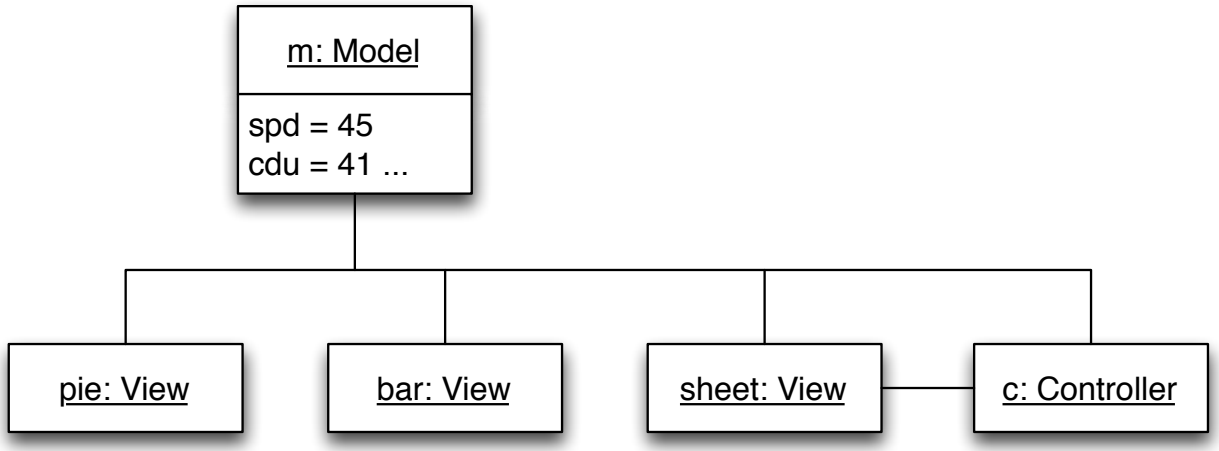
Structure (2)

Each model can *register* multiple *observers* (= views and controllers).



As soon as the model changes, all registered observers are *notified*, and they update themselves accordingly.

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Participants

The **model** encapsulates core data and functionality; it is independent of any concrete output representation, or input behavior.

Model	*collaboration with*
responsible for	View , Controller
•Core functionality	
•Registering dependent views and controls	
•Notifying registered components on data changes	

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Participants (2)

The **view** displays information to the user. A model can have multiple views.

View	*collaboration with*
responsible for • Showing information to the user • Possibly creating the appropriate Control • Reading data from Model	Controller, Model

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Participants (3)

The controller processes input and invokes the appropriate services of the view or the model; every controller is assigned to a single view; a model can have multiple controllers.

Controller	*collaboration with*
responsible for • Accepting user input • Matching inputs to service invocations (displaying services of the View, or services of the Model)	View, Model

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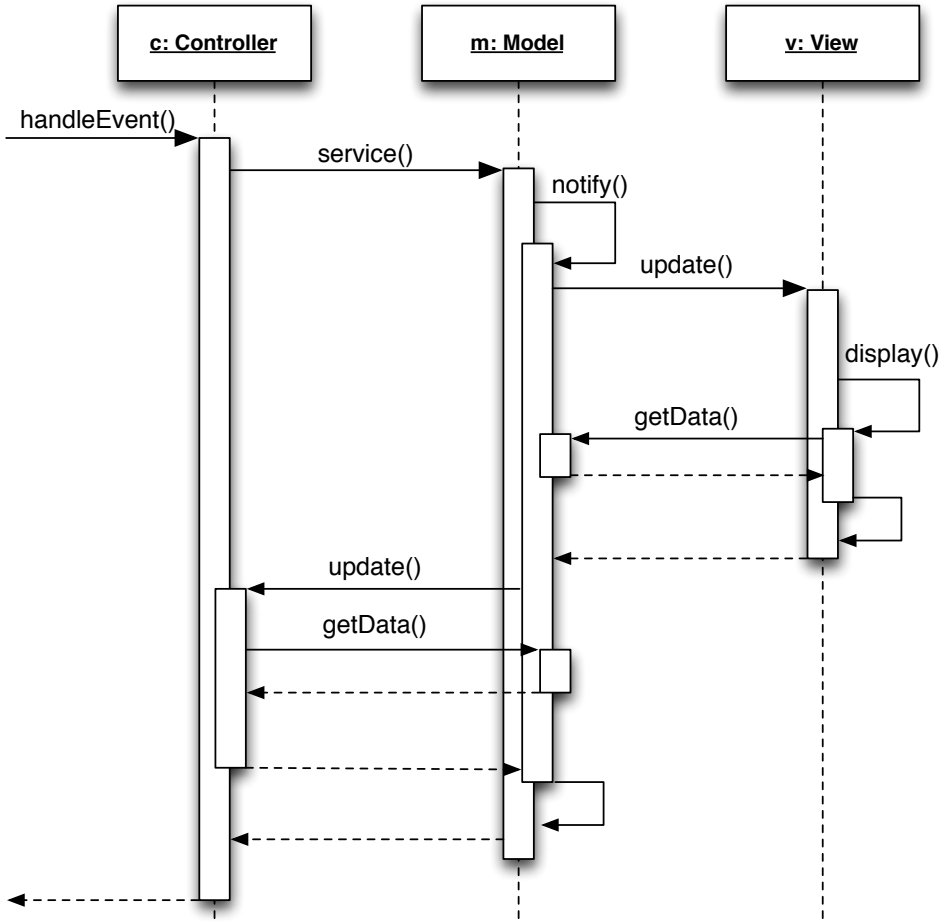
Dynamic behavior



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Consequences of the Model-View-Controller Pattern

Benefits

- multiple views of the same system
- synchronous views
- attachable views and controllers

Drawbacks

- increased complexity
- strong coupling between Model and View
- Strong coupling between Model and Controllers (can be avoided by means of the command pattern)

Known applications: GUI libraries, Smalltalk, Microsoft Foundation Classes

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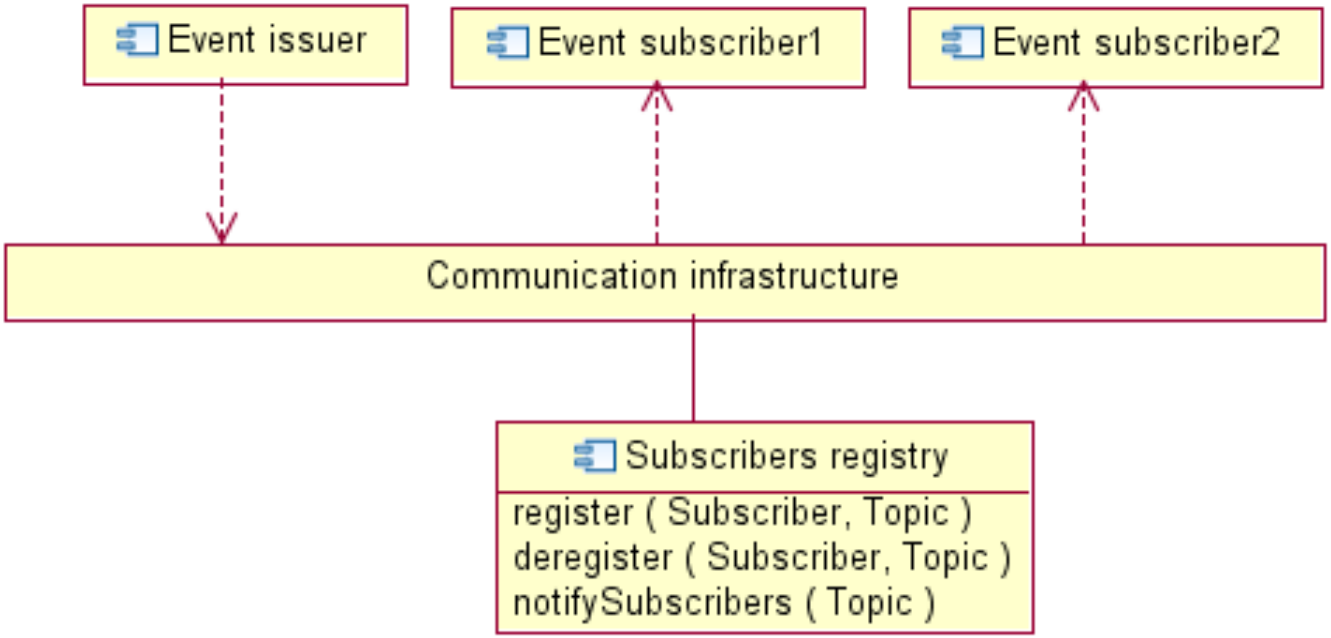
Publish-subscribe



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Implemented tactics

Modifiability tactics

- Restrict communication paths
- Use an intermediary
- Standardize collaboration

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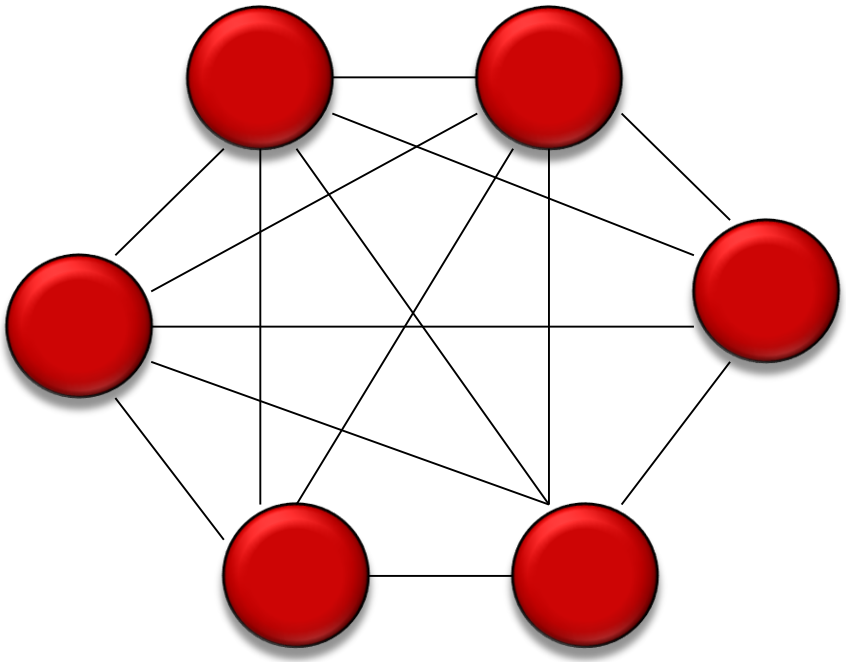
Problem: point to point communication among components



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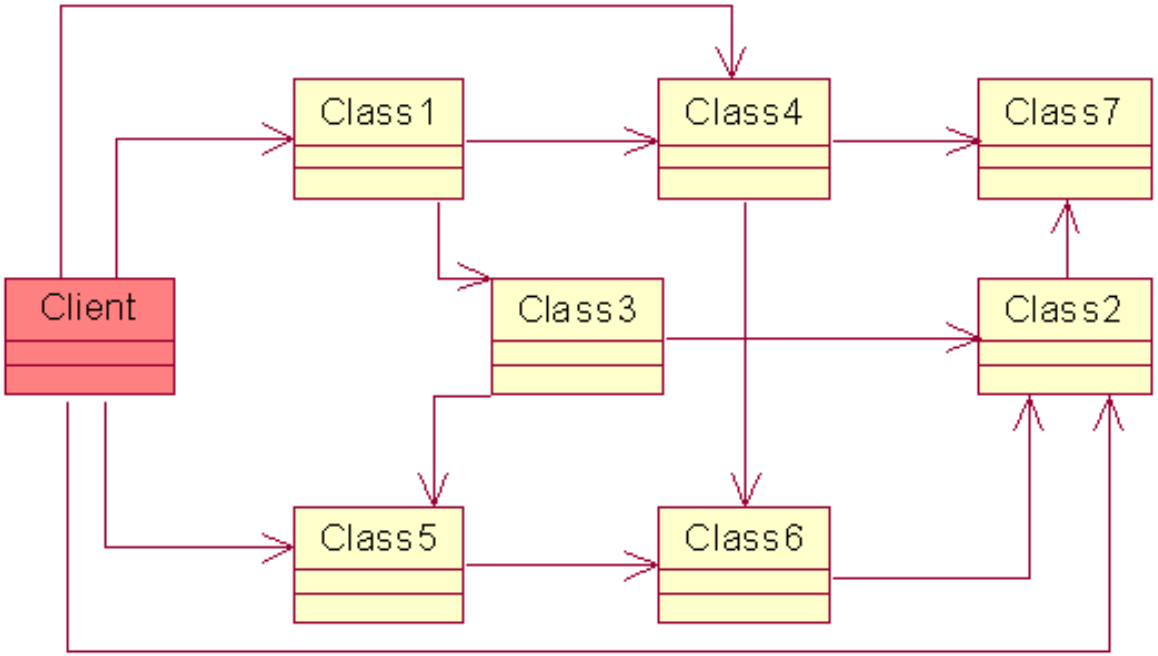
Problem: too many communications paths



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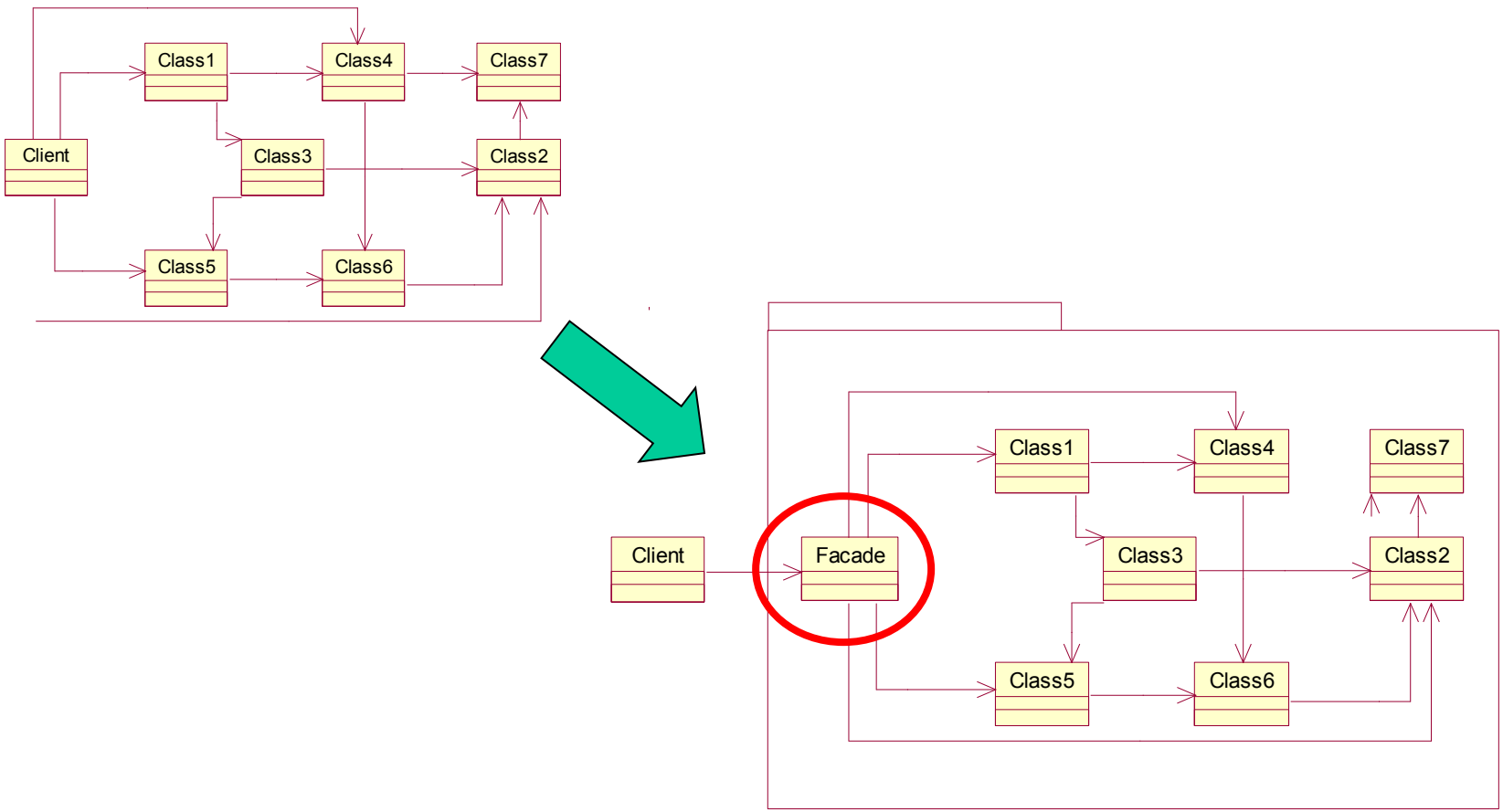
Facade



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Implemented tactics

Modifiability tactics

- Hide information
- Restrict communication paths
- Use an intermediary

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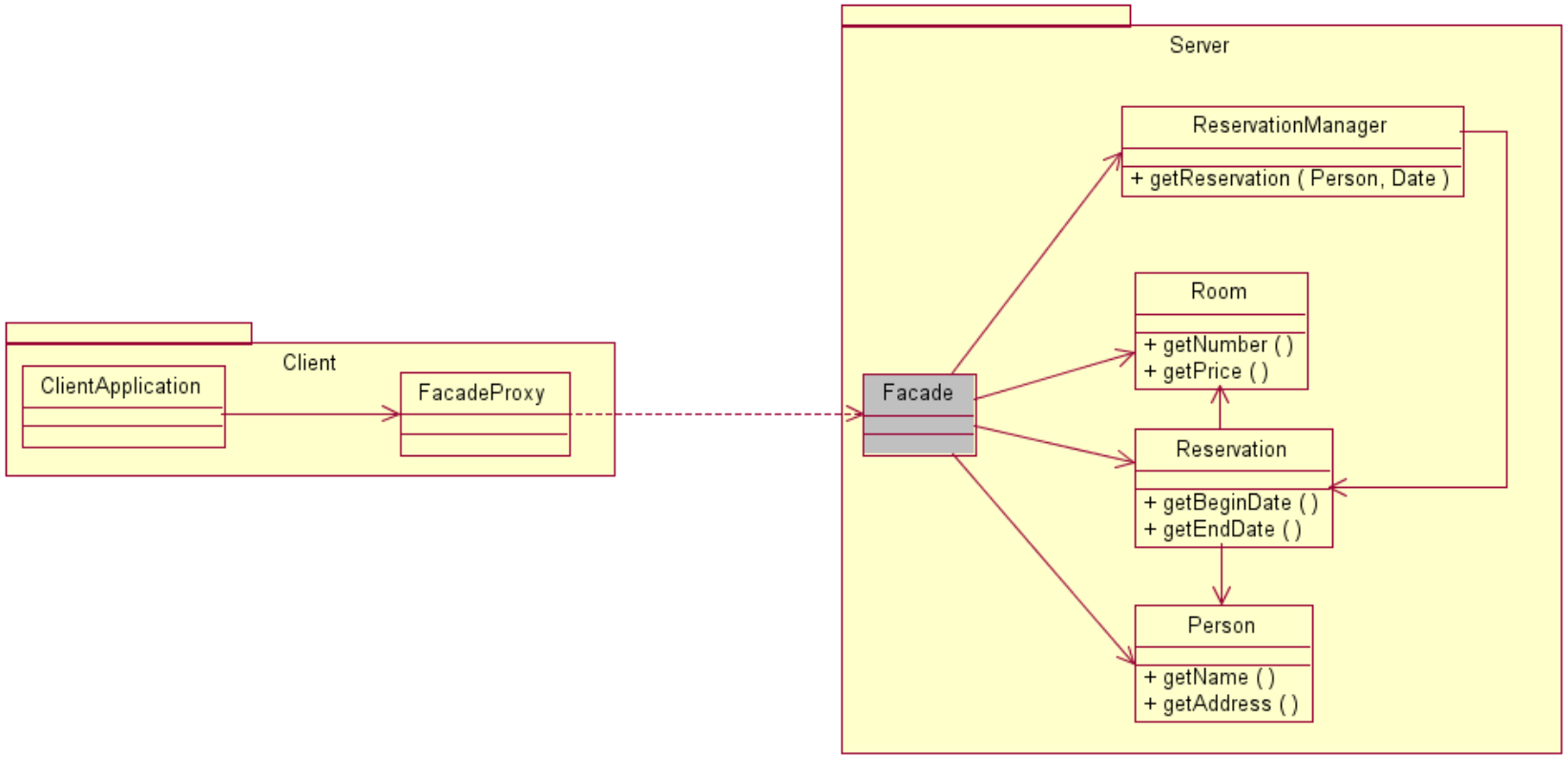
New architecture: façade & proxy



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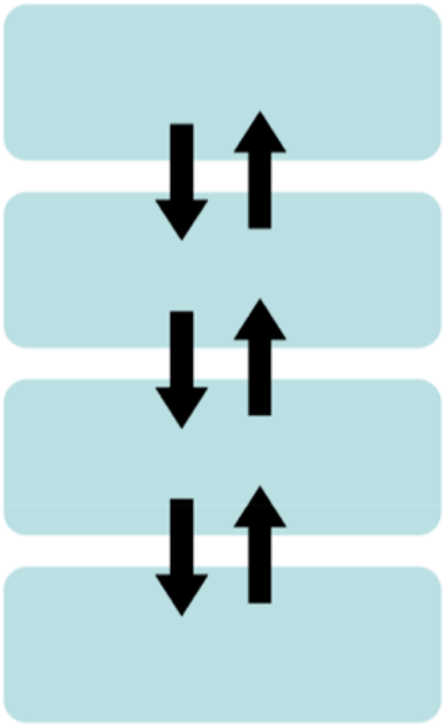
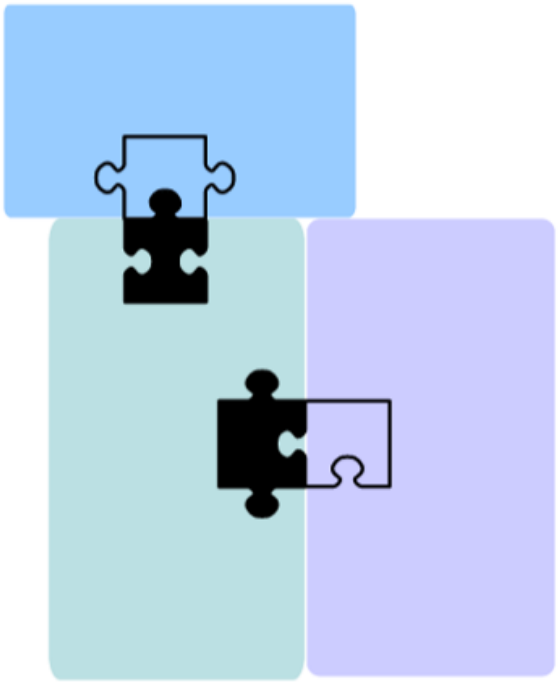
Layered



Plug-in



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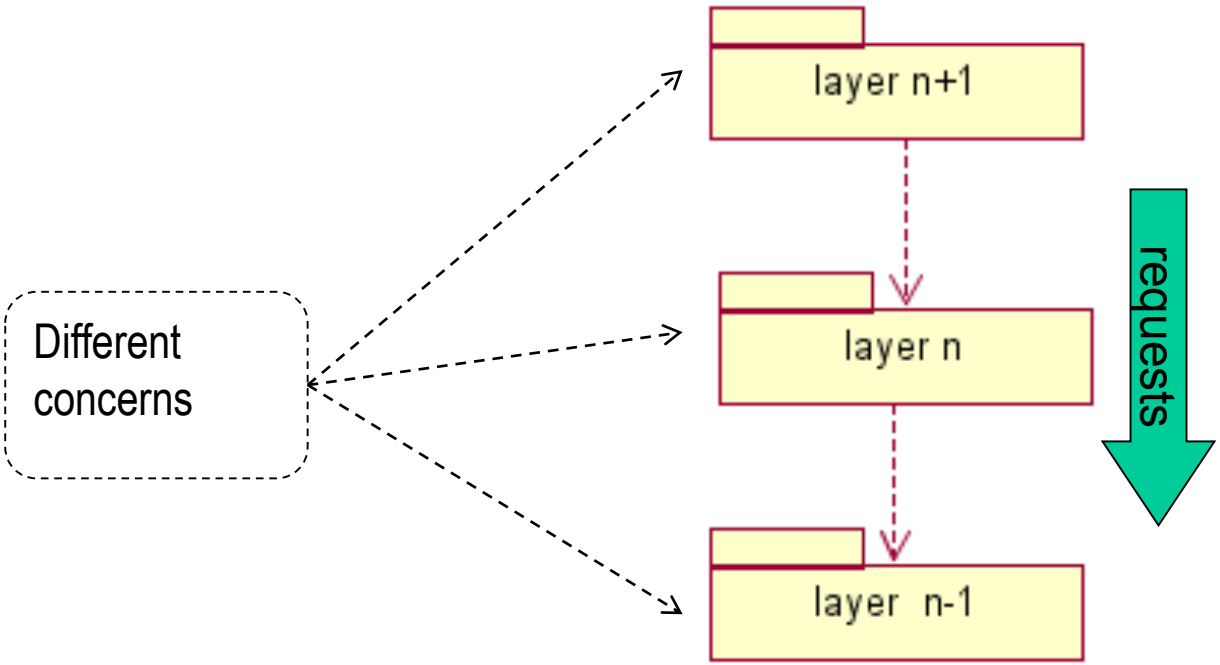
Layers



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Choosing the layers

- Define the abstraction criterion (concern) each layer provides (targets)
  - Potential changes
  - Reusability opportunities
  - Category of responsibilities
- Choose the number of layers
  - Abstraction levels / number of categories
  - Keep the number of layer small
    - Avoid the performance overhead
- Specify the interface for each layer
  - Each layer should represent a black box for the layer above

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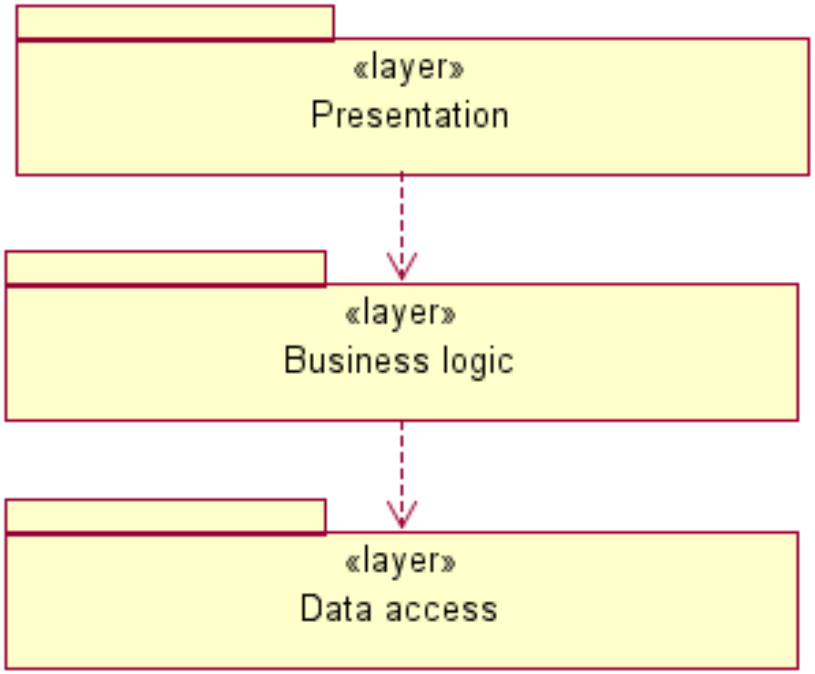
Change in one of the concerns: display, data access

Responsibility-based structure



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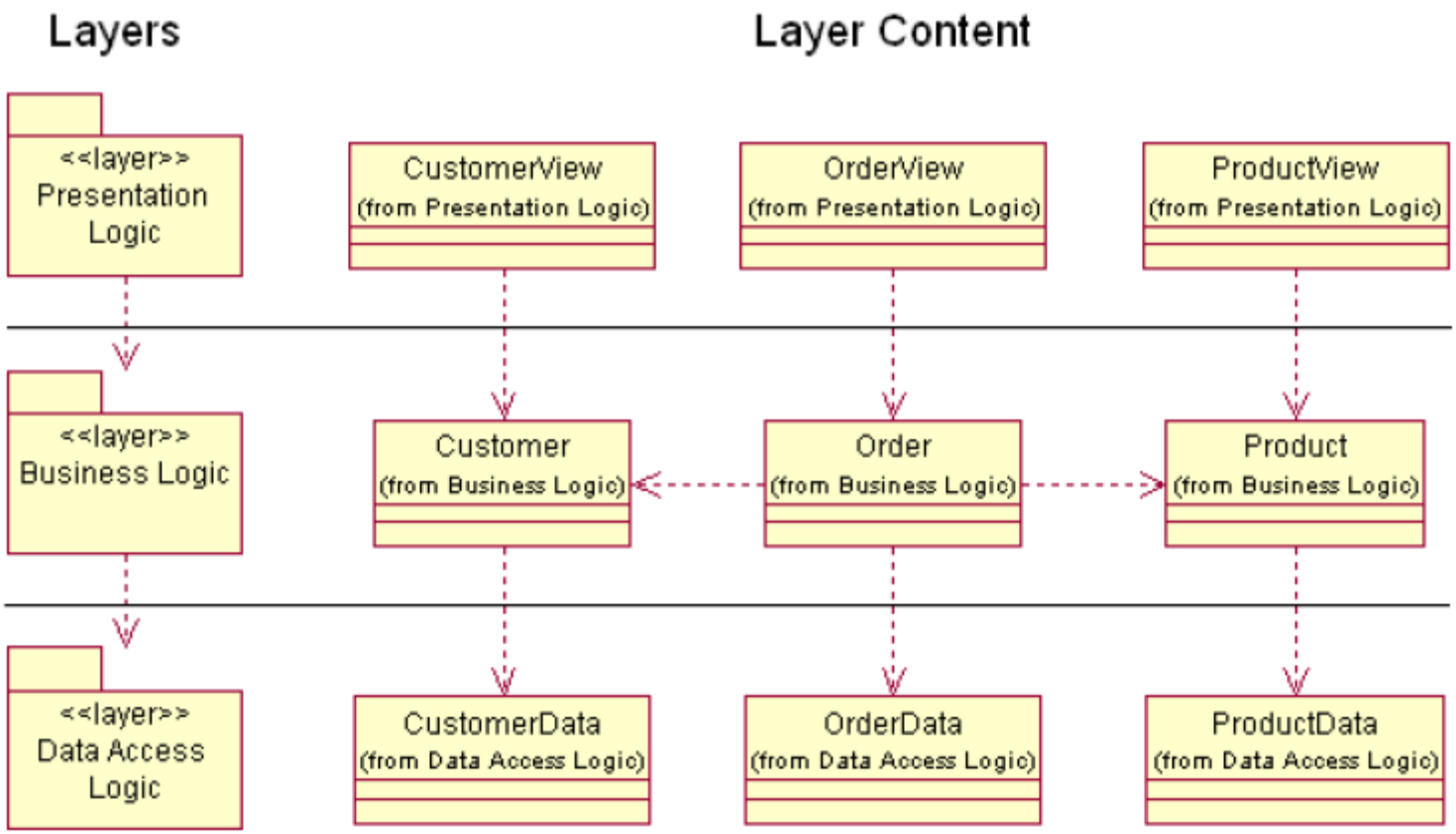
Exemple



[Source: Peter Eeles - Layering Strategies, Rational Software White Paper TP 199, 08/01, 2002]

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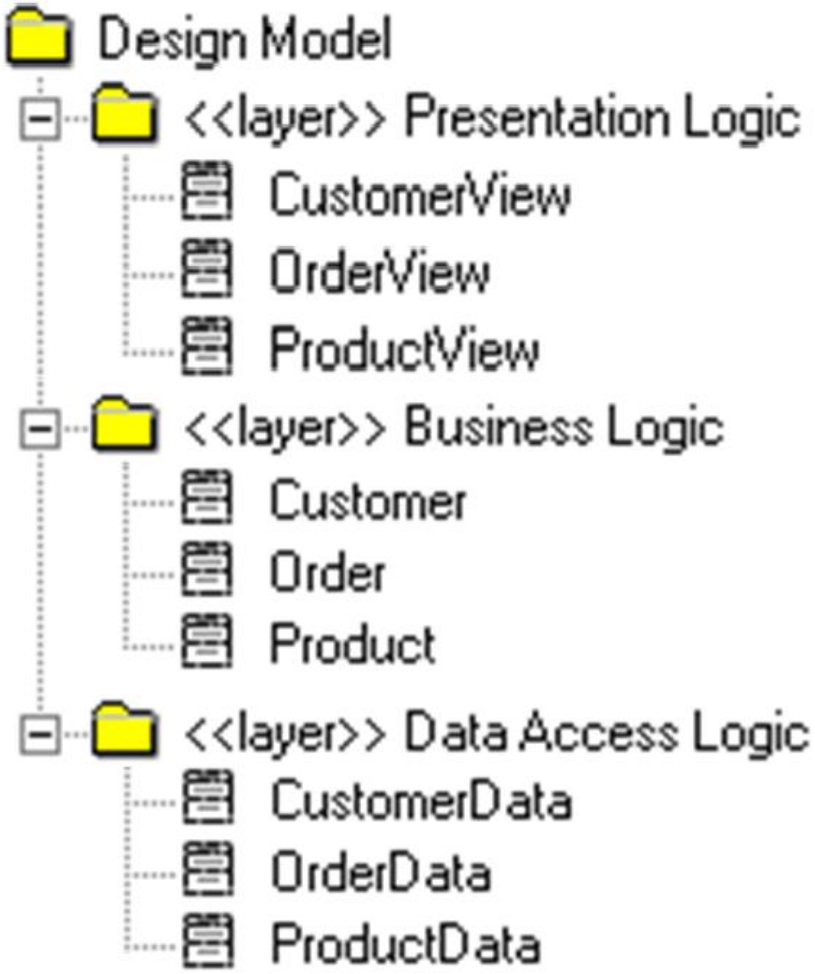
Representation of the example as Java packages / folders



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What do we model ?

- The system-to-be (Design model)
  - *Static architecture*
  - *Dynamic architecture*
- Quality attributes and non-functional properties
- The problem (Domain model)
- The environment (System context and stakeholders)
- The design process

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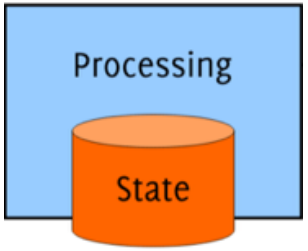
Software Components

Reusable unit of composition

Can be composed into larger systems

Locus of computation



State in a system

Application-specific — Infrastructure

Media Player *Web Server*

Math Library *Database*

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Components

- Encapsulate state and functionality
- Coarse-grained
- Black box architecture elements
- Structure of architecture

Objects

- Encapsulate state and functionality
- Fine-grained
- Can “move” across components
- Identifiable unit of instantiation

Modules

- Rarely exist at run time
- May require other modules to compile
- Package the code

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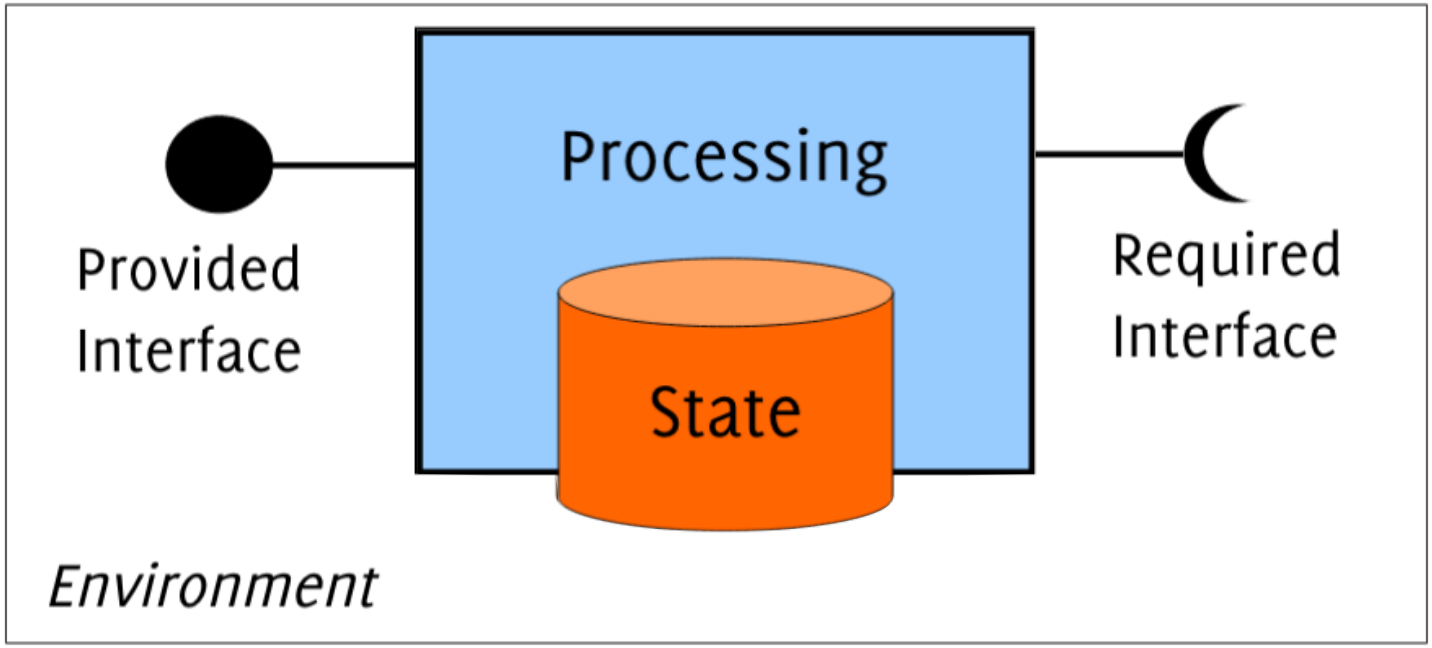
Component Interfaces



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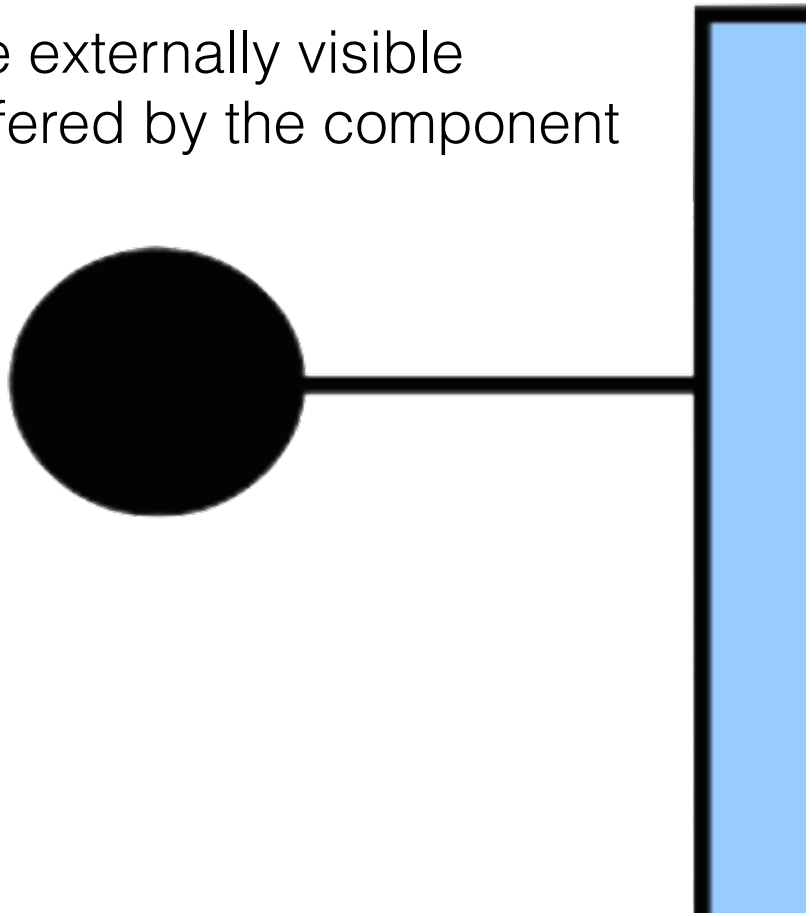
Provided Interfaces

- Specify and document the externally visible features (or public API) offered by the component
  - *Data types and model*
  - *Operations*
  - *Properties*
  - *Events and call-backs*



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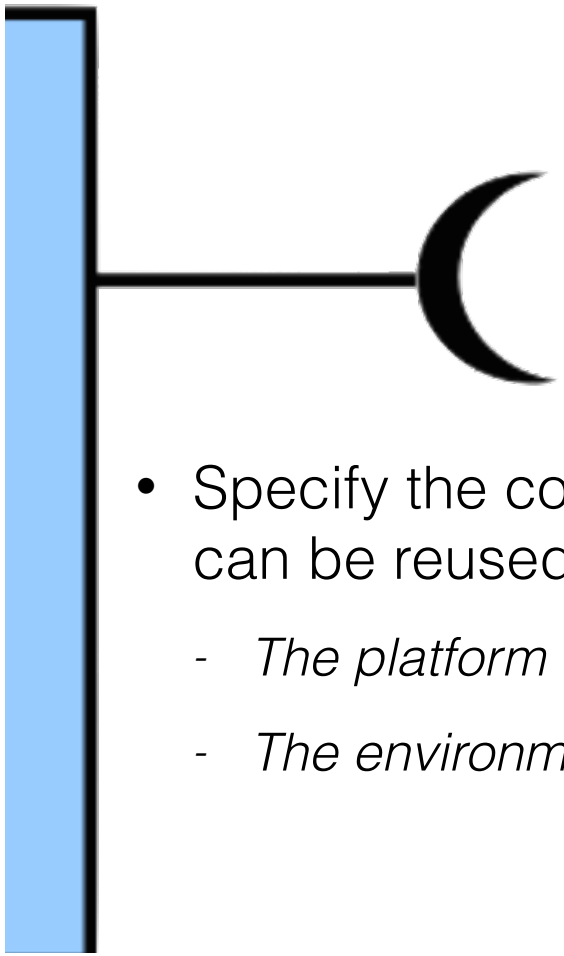
Required Interface



- Specify the conditions upon which a component can be reused
  - *The platform is compatible*
  - *The environment is setup correctly*

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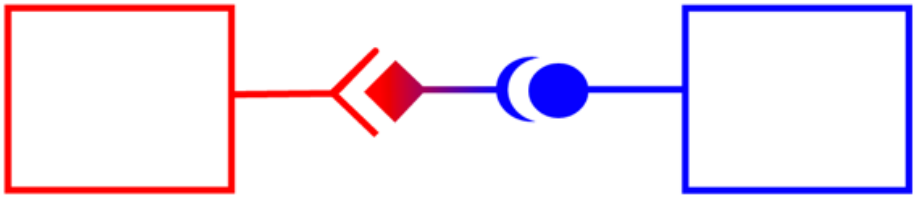
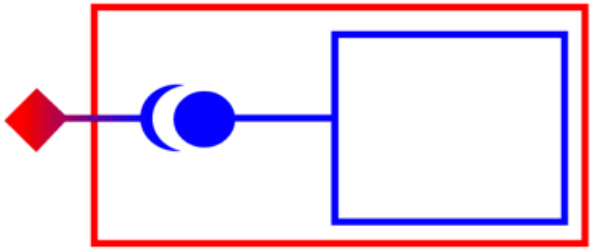
Compatible Interfaces

Component interfaces must match perfectly to be connected



Adapter



Wrapper

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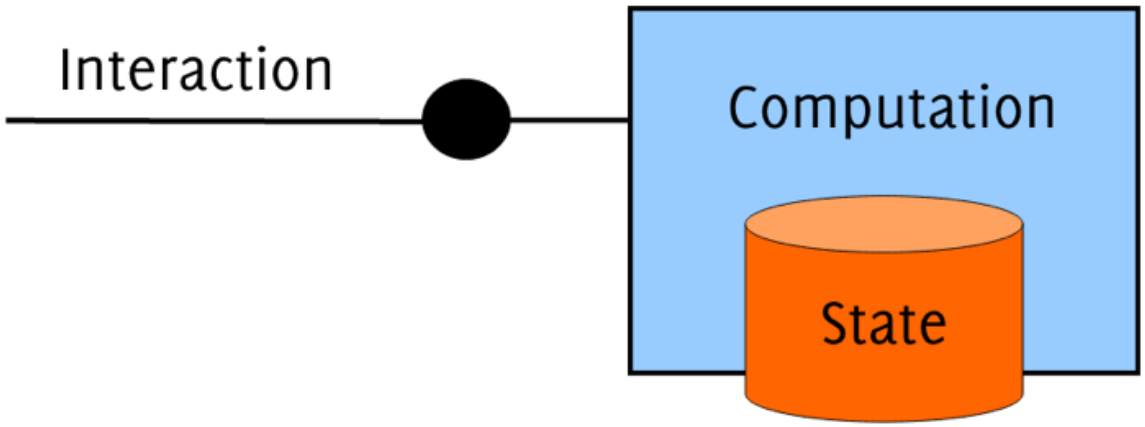
Software Connectors



Model static and dynamic aspects of the **interaction** between component interfaces

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Connector Roles

- Communication

  deliver data and transfer of control, support different communication mechanisms, quality of the delivery

- Coordination

  control the delivery of data, separate control from computation

- Conversion

  enable interaction of mismatched components

- Facilitation

  mediate the interaction among components, govern access to shared information, provide synchronization

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Connectors, not Components!

Connectors are not usually directly visible in the code, which is not true for components

Connectors are mostly application-independent, while components can be both application-dependent or not

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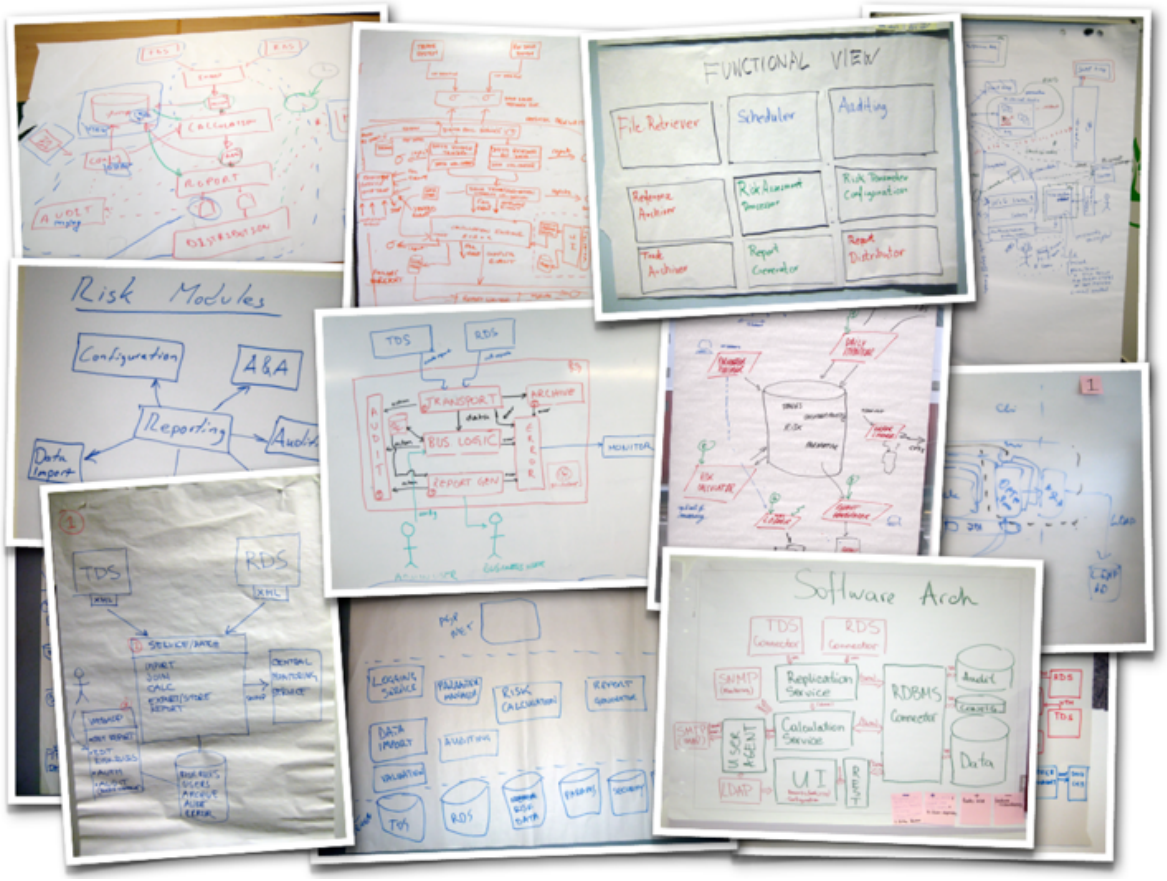
Views and Viewpoints



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How many views?

- 5 by Taylor et al.: Logical, Physical, Deployment, Concurrency, Behavioral
- 3 by Bass et al.: Component & Connector, Module View, Behavior
- 4+1 by Kruchten: Logical, Physical, Process, Development, and Scenarios

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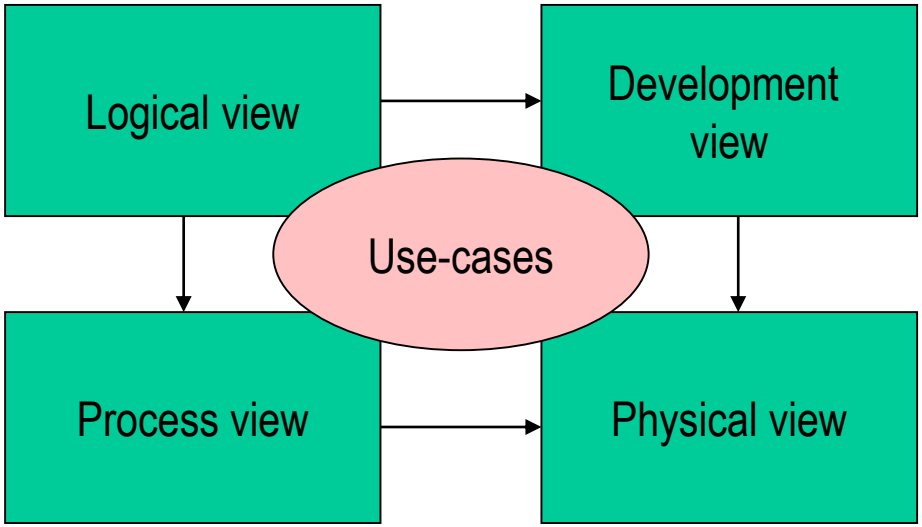
Historical model: Kruchten's 4+1 views (RUP)



[Source: Kruchten Ph.- The 4+1 View Model of Architecture. IEEE Software 12(6), Nov. 1995]

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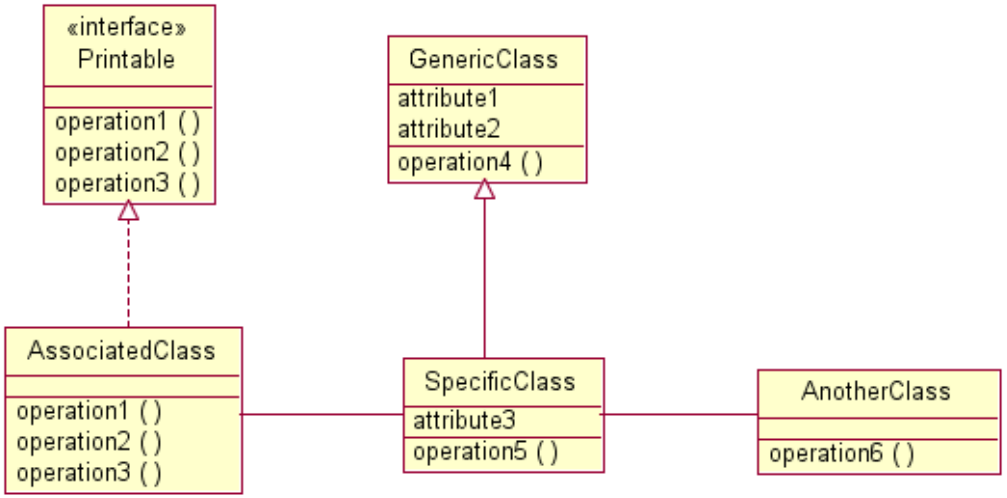
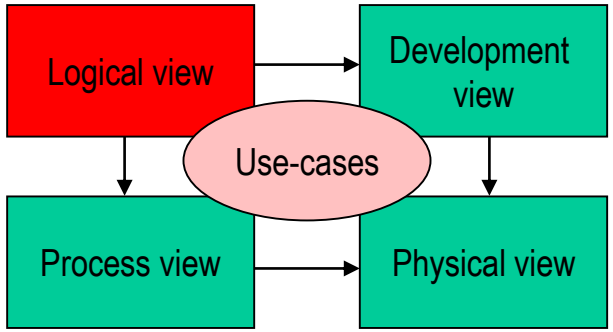
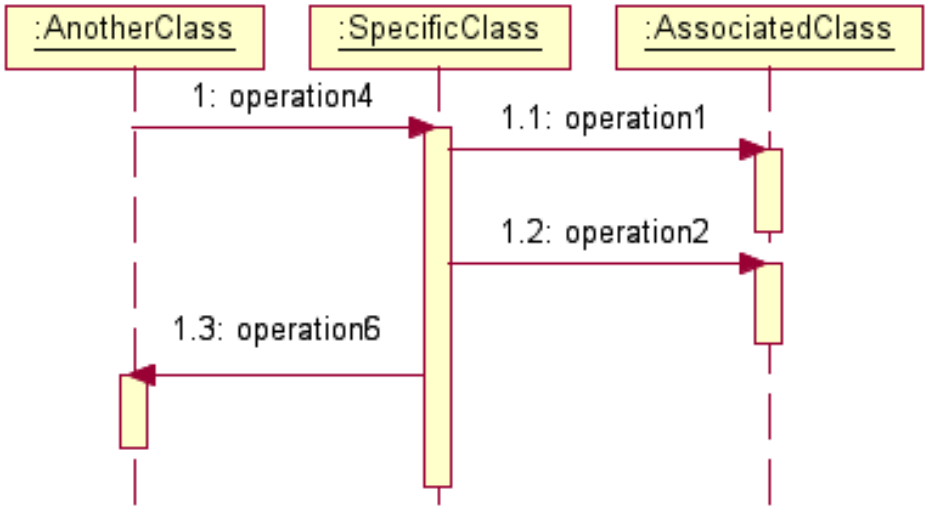
Logical view

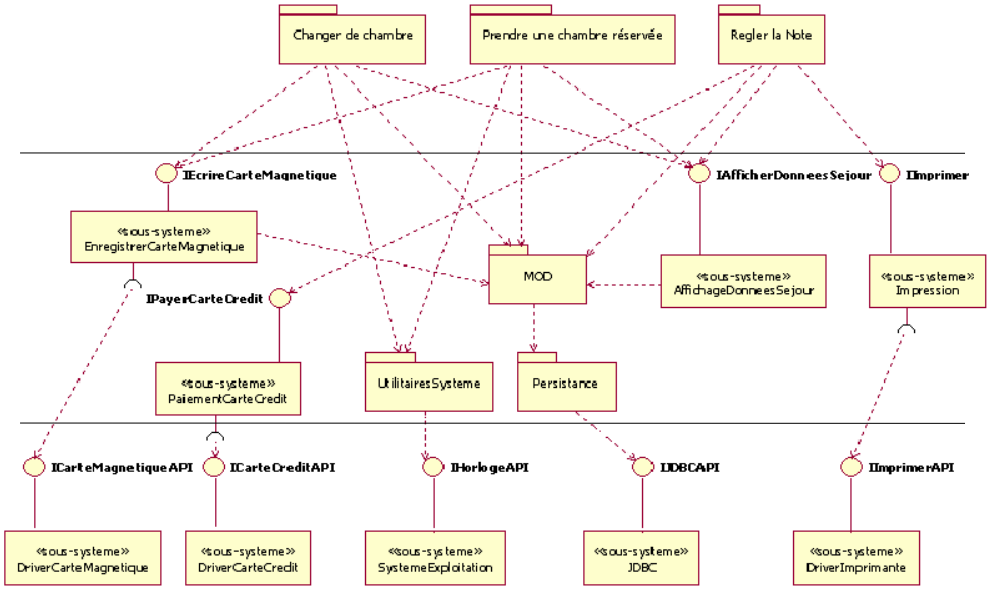


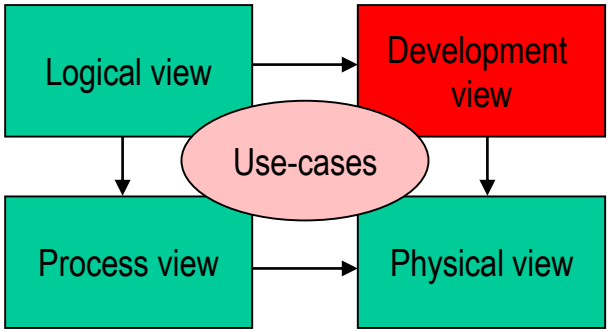


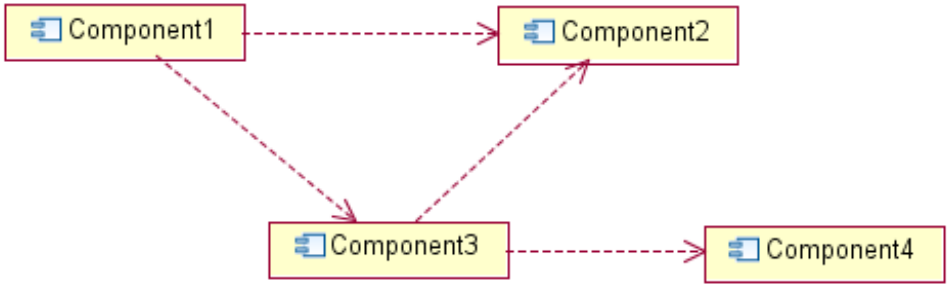


Classes, sequence diagrams, state diagrams, activity diagrams…

Development view







Components, packages, layers, subsystems.

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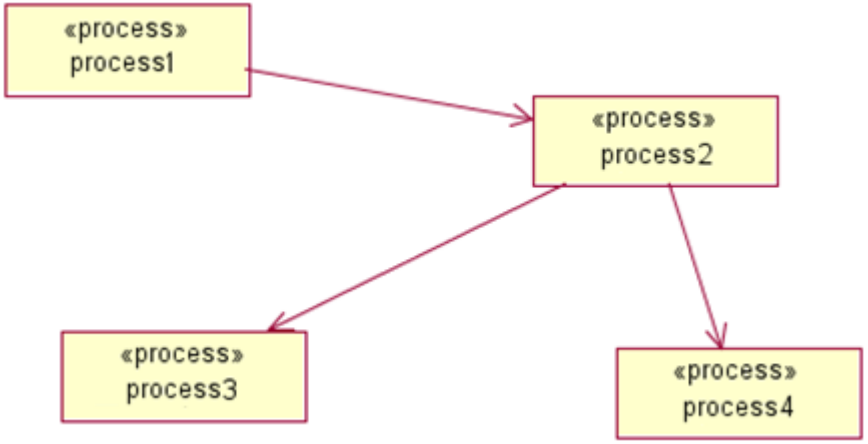
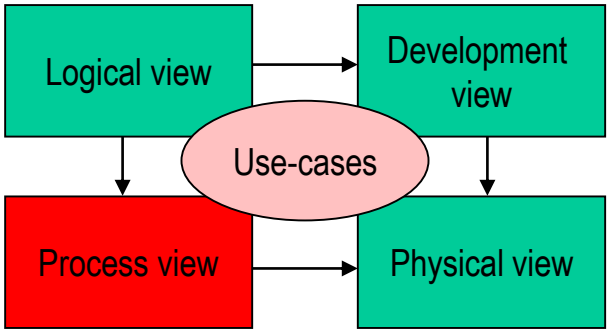
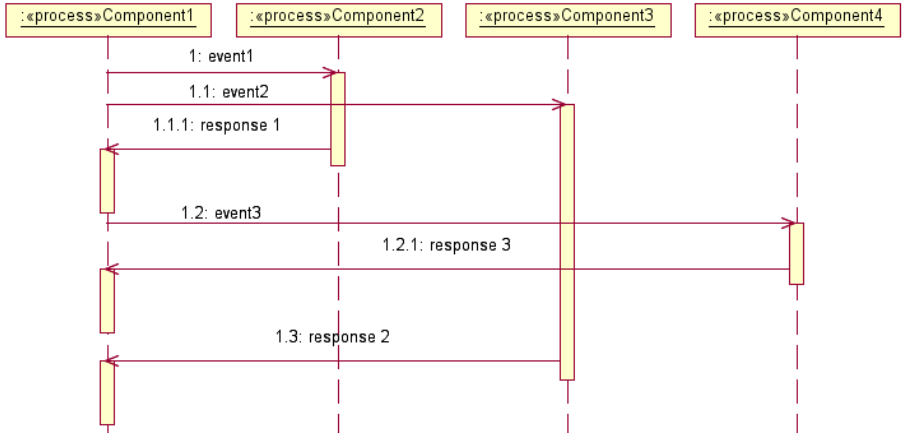
Process view

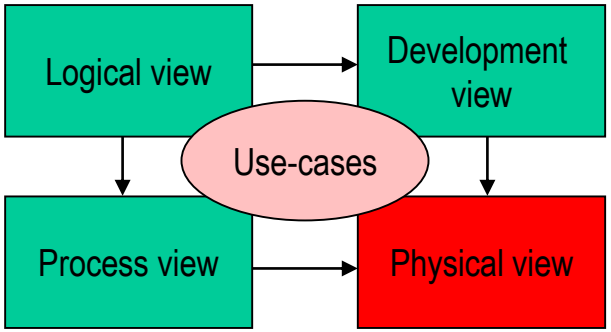


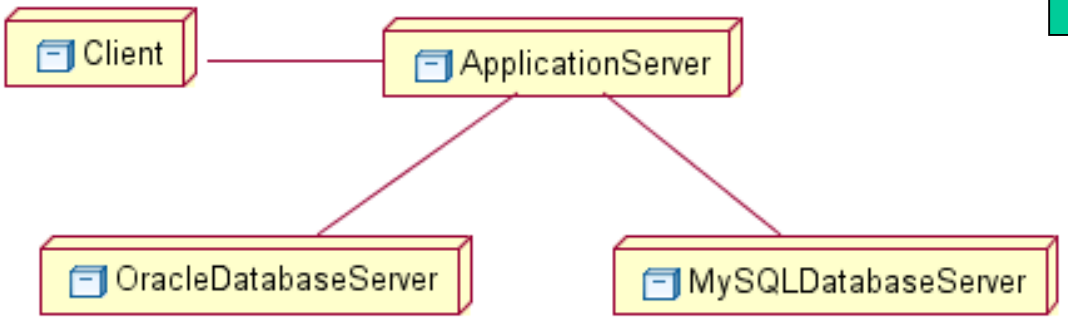




Process, communications, synchronisations, …

Physical view





Physical files, machines, communication channels, protocols,…

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Use Case Scenarios

- Unify and link the elements of the other 4 views
- Scenarios help to ensure that the architectural model is complete with respect to requirements
- The architecture can be broken down according to the scenarios and illustrated using the other 4 views

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Music Player Scenarios

- Browse for new songs
- Pay to hear the entire song
- Download the purchased song on the phone
- Play the song

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Logical View

- Decompose the system structure into software components and connectors
- Map functionality (use cases) onto the components
    - **Concern**: Functionality
    - **Target Audience**: Developers and Users

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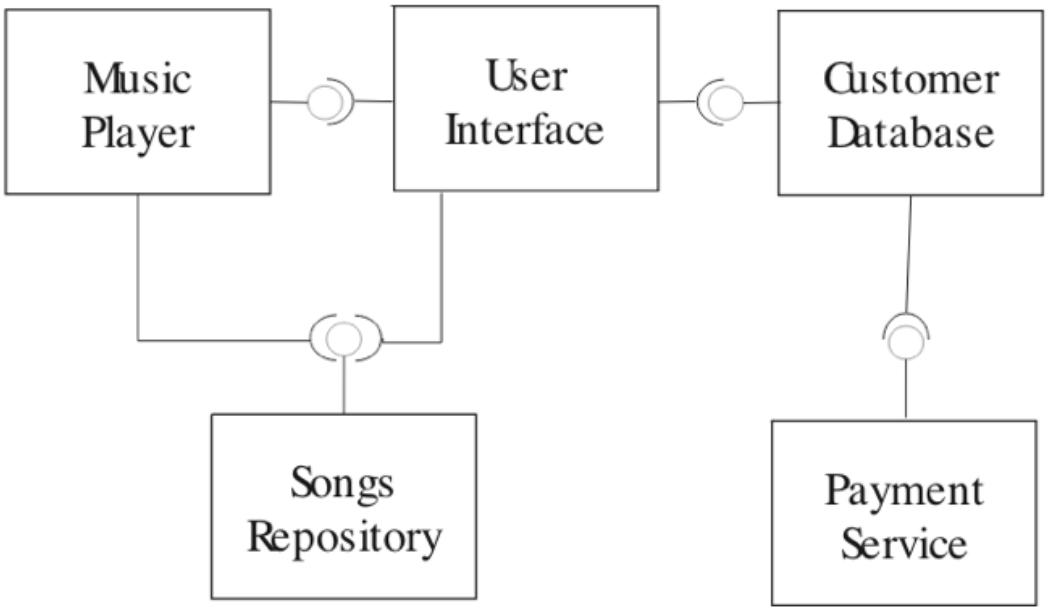

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Process View

- Model the dynamic aspects of the architecture and the behavior its parts
  - *active components*
  - *concurrent threads*

- Describe how processes/threads communicate
  - *RPC*
  - *Message bus*

    - **Concern**: Functionality, Performance

    - **Target Audience**: Developers

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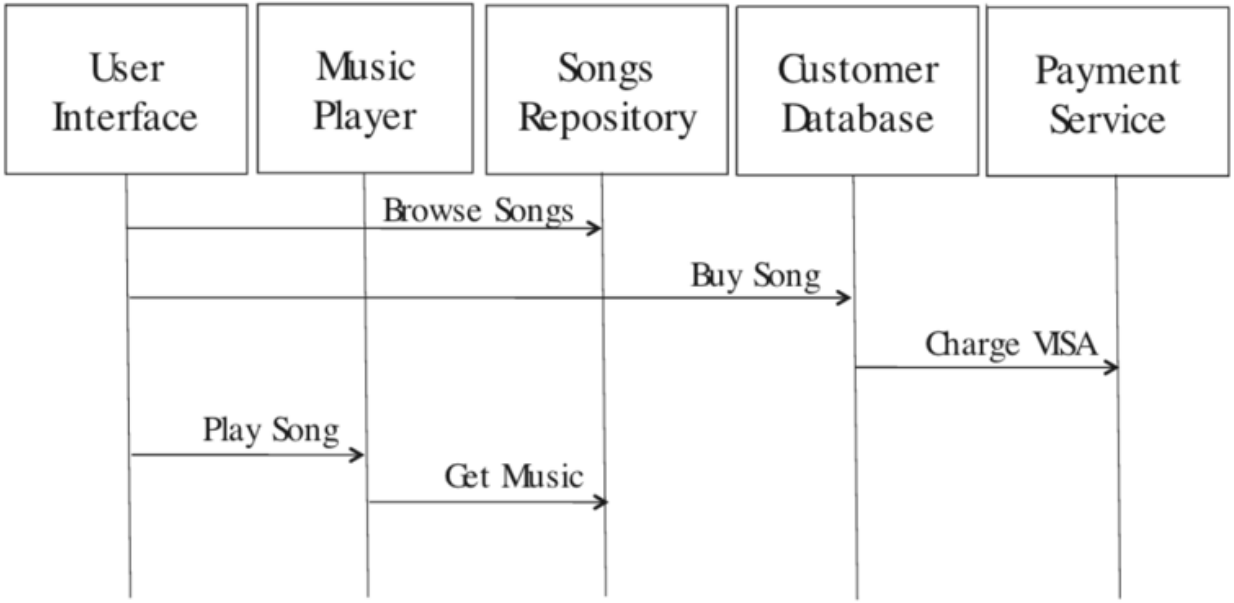

Use Cases: Browse, Pay and Play For Songs

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Development View

- Static organization of the software code artifacts
  - *packages*
  - *modules*
  - *binaries*

- Mapping between the elements in the logical view and the code artifacts

    - **Concern**: Reuse, Portability, Build

    - **Target Audience**: Developers

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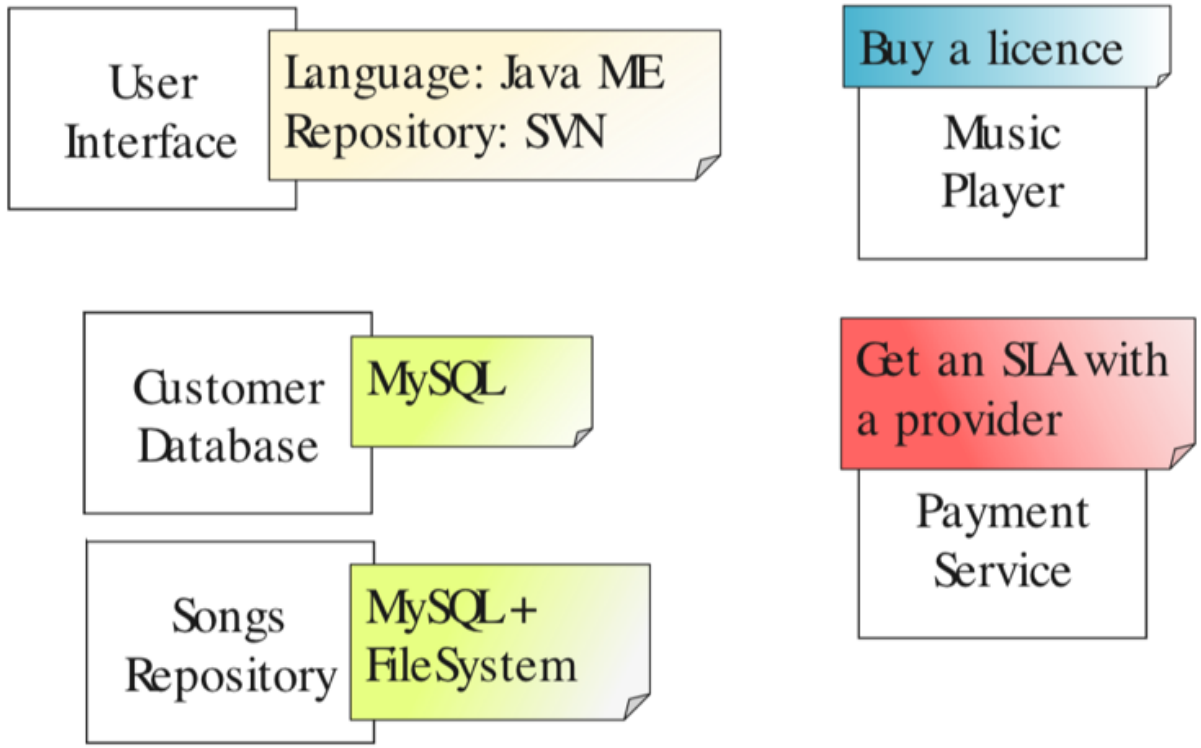

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Physical View

- Hardware environment where the software will be deployed
  - *hosts*
  - *networks*
  - *storage*

- Mapping between logical and physical entities

  - **Concern**: Quality attributes

  - **Target Audience**: Operations

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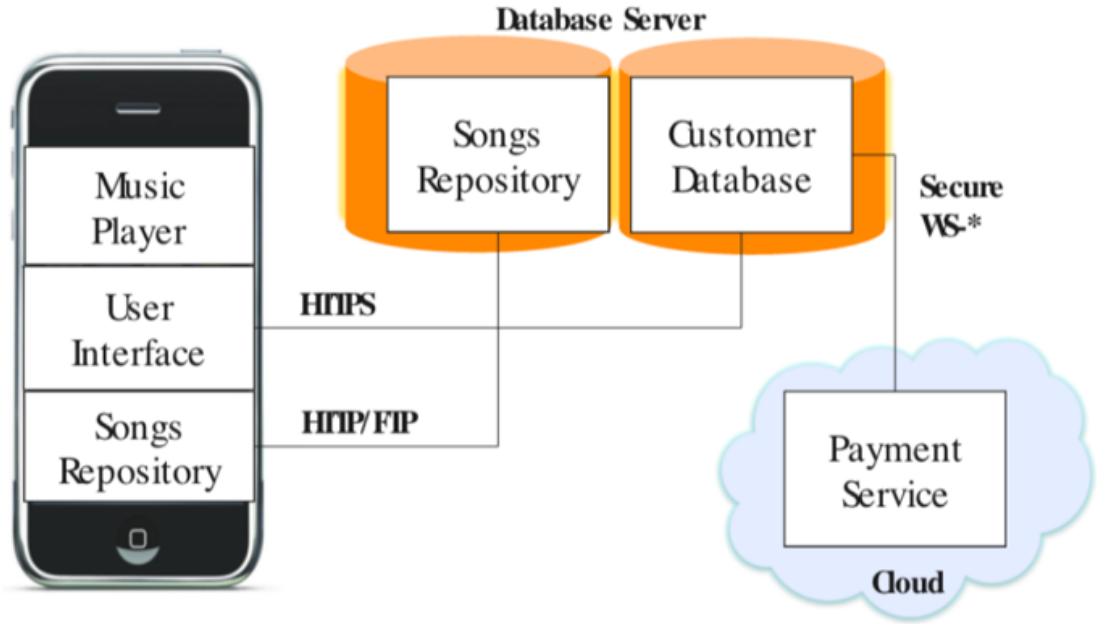

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Reuse and Libraries

Is it possible to reuse existing classes?

Possibly adapter classes are needed.

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