Software Architecture

Martin Kellogg

Reading quiz: software architecture

Reading quiz: software architecture

Q1: Kästner's article used different maps of a city as a metaphor for different levels of abstraction. The maps were of which city?

A. Copenhagen
B. New York City
C. Pittsburgh
D. Tokyo

Q2: **TRUE** or **FALSE**: A weakness of architecture diagrams that the author of "How architecture diagrams enable better conversations" identified is that architecture diagrams are too hard to explain to new team members.

Reading quiz: software architecture

Q1: Kästner's article used different maps of a city as a metaphor for different levels of abstraction. The maps were of which city?

A. Copenhagen
B. New York City
C. Pittsburgh
D. Tokyo

Q2: **TRUE** or **FALSE**: A weakness of architecture diagrams that the author of "How architecture diagrams enable better conversations" identified is that architecture diagrams are too hard to explain to new team members.

Reading quiz: software architecture

Q1: Kästner's article used different maps of a city as a metaphor for different levels of abstraction. The maps were of which city?

A. Copenhagen
B. New York City
C. Pittsburgh
D. Tokyo

Q2: **TRUE** or **FALSE**: A ~~weakness~~ **benefit** of architecture diagrams that the author of "How architecture diagrams enable better conversations" identified is that architecture diagrams are ~~too hard~~ **useful for explaining the system** to new team members.

Software Architecture

Today's agenda:

- **Architecture vs Design**
- Architecture diagrams
- What makes an architecture good
- Architectural styles (with examples)

Software Architecture: motivation

Software Architecture: motivation

“There are two ways of constructing a software design:

Software Architecture: motivation

“There are two ways of constructing a software design:

- one way is to make it **so simple** that there are **obviously no deficiencies**

Software Architecture: motivation

"There are two ways of constructing a software design:

- one way is to make it **so simple** that there are **obviously no deficiencies**
- the other is to make it **so complicated** that there are **no obvious deficiencies**."

- Tony Hoare

Software Architecture: motivation

“There are two ways of constructing a software design:

- one way is to make it **so simple** that there are **obviously no deficiencies**
- the other is to make it so complicated that there are no obvious deficiencies.”

- Tony Hoare

Our goals: **separation of concerns** and **modularity**

“Architecture” vs “Design”

“Architecture” vs “Design”

Requirements

Source Code

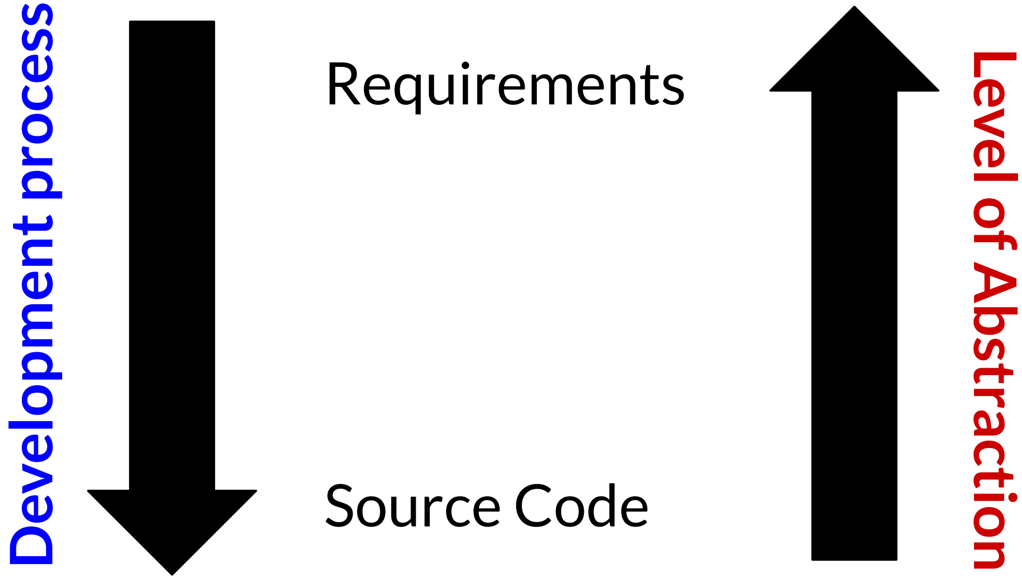
“Architecture” vs “Design”

Development process

Requirements

Source Code

“Architecture” vs “Design”



Levels of abstraction

- Recall that an **abstraction** ignores some details to present a simplified representation of reality

Levels of abstraction

- Recall that an **abstraction** ignores some details to present a simplified representation of reality
- Different ***levels of abstraction*** are characterized by the amount of details ignored

Levels of abstraction

- Recall that an **abstraction** ignores some details to present a simplified representation of reality
- Different ***levels of abstraction*** are characterized by the amount of details ignored
    - more abstract = ignore more details

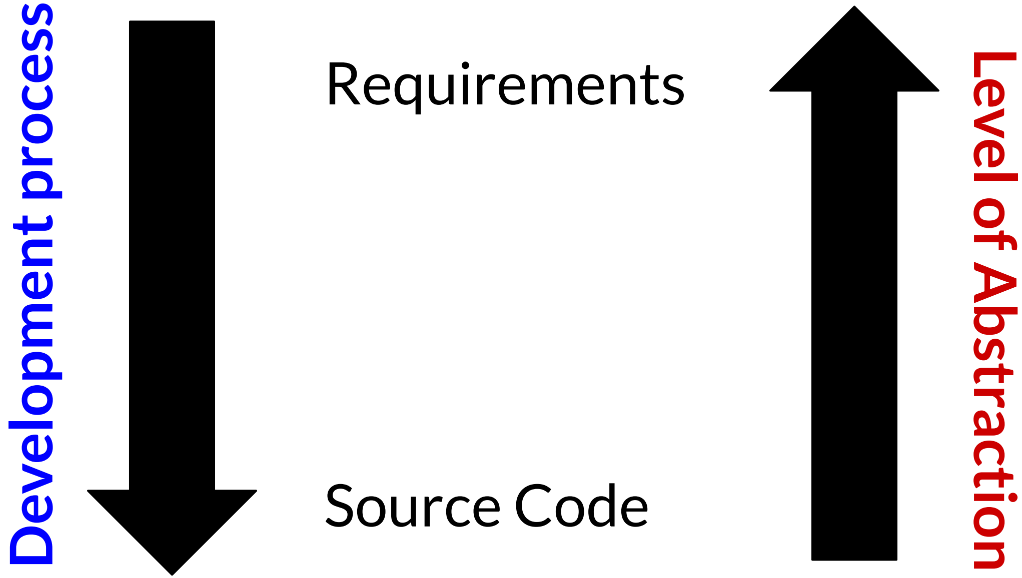
Levels of abstraction

- Recall that an **abstraction** ignores some details to present a simplified representation of reality
- Different ***levels of abstraction*** are characterized by the amount of details ignored
  - more abstract = ignore more details
  - which details to ignore depends on your **purpose** (analogy: what abstract values to choose in dataflow analysis?)

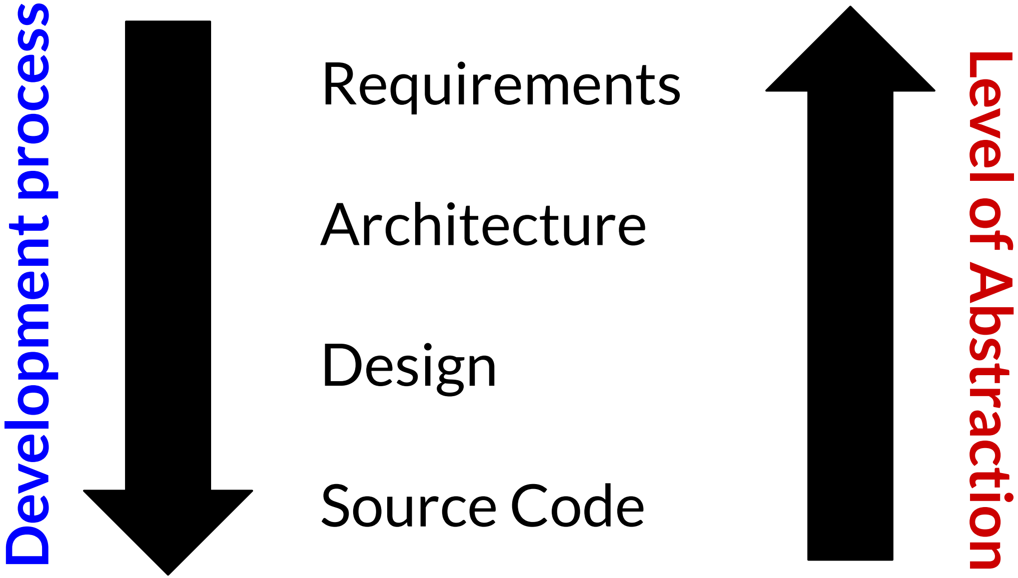
Levels of abstraction

- Recall that an **abstraction** ignores some details to present a simplified representation of reality
- Different ***levels of abstraction*** are characterized by the amount of details ignored
  - more abstract = ignore more details
  - which details to ignore depends on your **purpose** (analogy: what abstract values to choose in dataflow analysis?)
- **Implication**: requirements have fewer details than code. Architecture and design are somewhere in the middle. But **where**?

“Architecture” vs “Design”



“Architecture” vs “Design”



“Architecture” vs “Design”

Development process

Requirements

Architecture

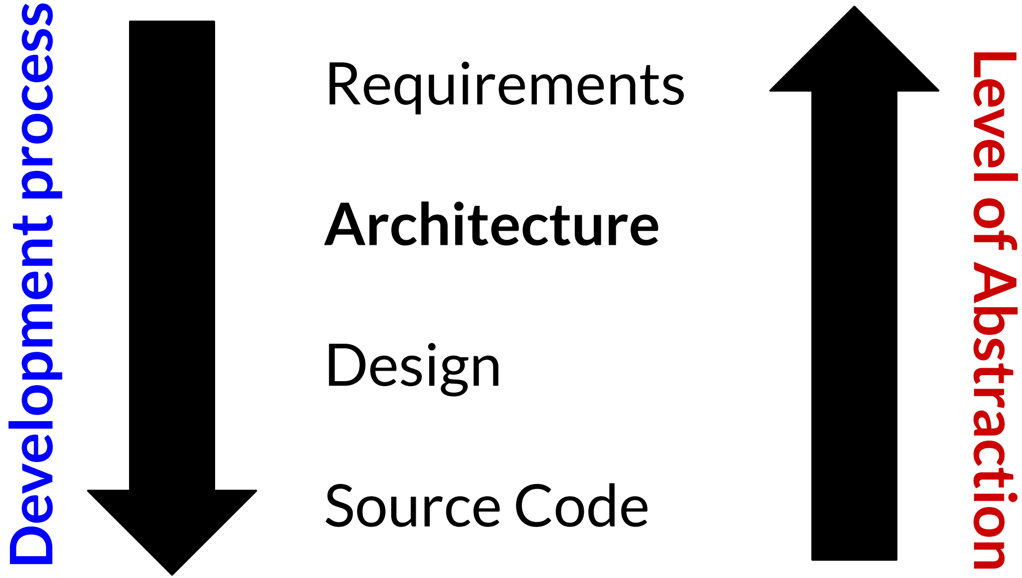
Design

Source Code

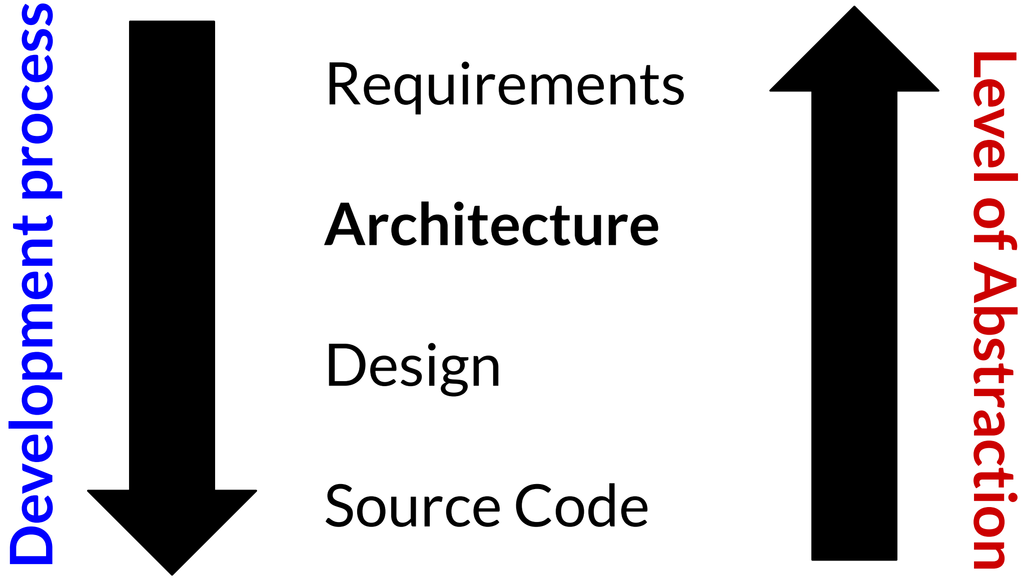
Level of Abstraction

Architecture and design are the “**glue**” between the **code** you actually write and what your software is **supposed to do**

“Architecture” vs “Design”



“Architecture” vs “Design”



Definition: “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”

[L. Bass, P. Clements and R. Kazman. Software Architecture in Practice. Addison Wesley, 1999, ISBN 0- 201-19930-0.]

"Architecture" vs "Design"

Architecture = **high-level view** of the system

Development process

Requirements

Architecture

Design

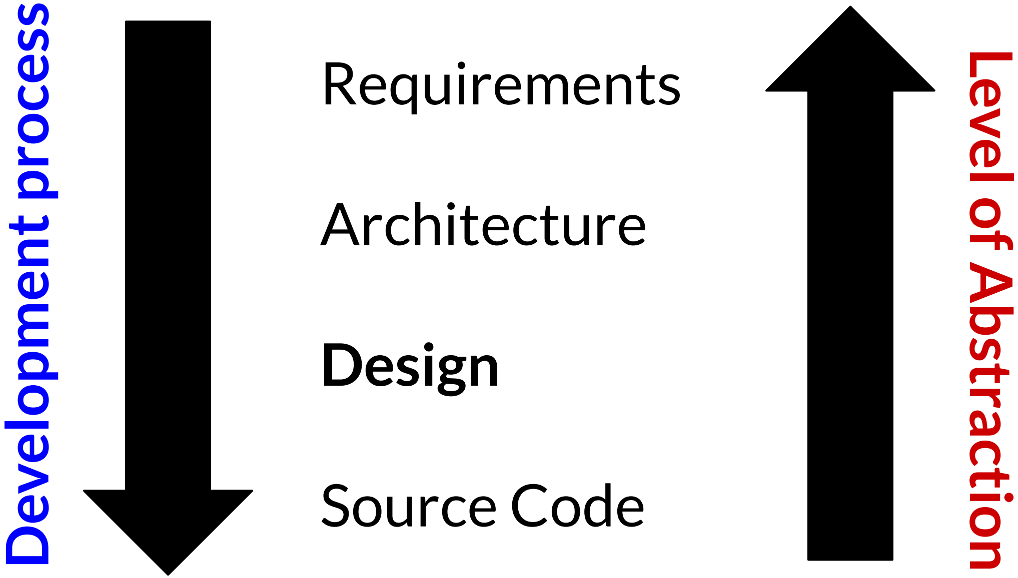
Source Code

Level of Abstraction

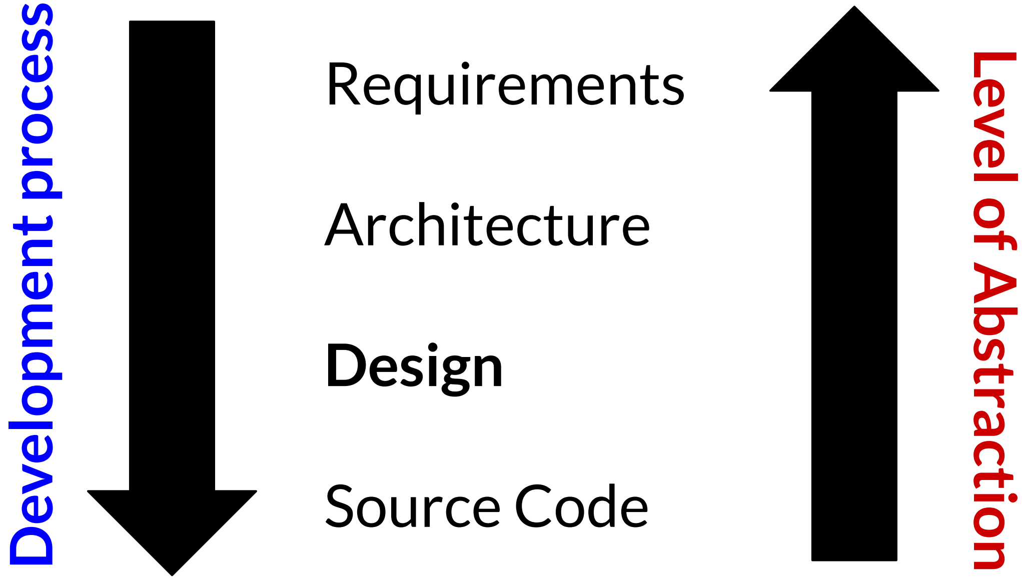
Definition: "the ***software architecture*** of a program or computing system is the structure or structures of the system, which comprise software components, the externally visible properties of those components, and the relationships among them"

[L. Bass, P. Clements and R. Kazman. Software Architecture in Practice. Addison Wesley, 1999, ISBN 0- 201-19930-0.]

“Architecture” vs “Design”

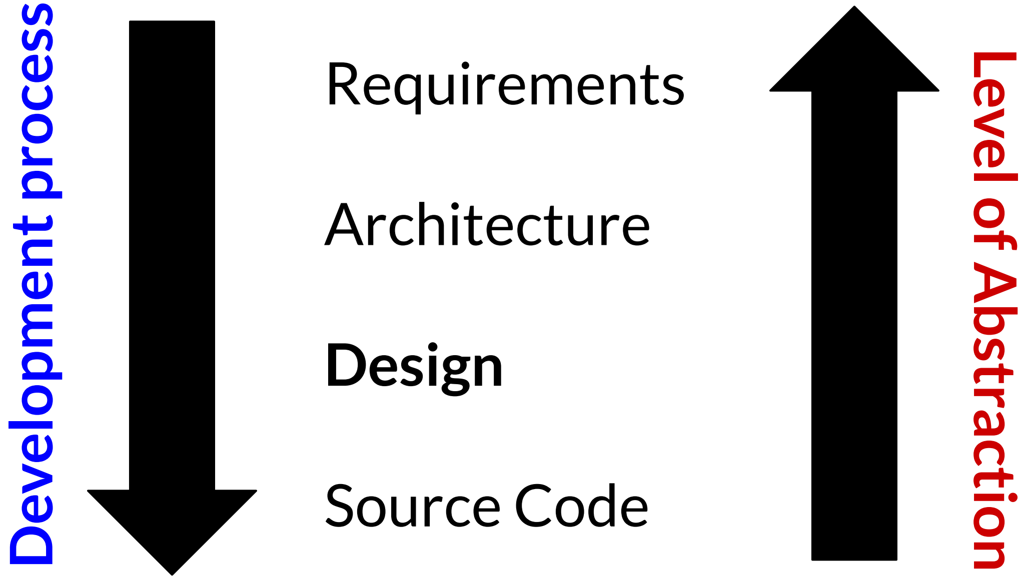


“Architecture” vs “Design”



Definition: ***software design*** is the structure or organization of a particular component of your system

“Architecture” vs “Design”



Definition: ***software design*** is the structure or organization of a particular component of your system

- the phrase “software design” often refers to the **process** of producing a software design

“Architecture” vs “Design”

Development process

Requirements

Architecture

Design

Source Code

Level of Abstraction

Definition: ***software design*** is the structure or organization of a particular component of your system

- the phrase “software design” often refers to the **process** of producing a software design
- both “design” and “architecture” are **flexible** terms, used differently by different people

“Architecture” vs “Design”: summary

- Architecture (what is developed?)
  - High-level view of the overall system:
    - What components do exist?
    - What are the protocols between components?
    - What type of storage etc.?
- Design (how are the components developed?)
  - Considers individual components:
    - Data representation
    - Interfaces, Class hierarchy
    - …

“Architecture” vs “Design”: analogy: offices

“Architecture”

[UW Gates Center, LMN]

“Design”

[Office design, New York Times]

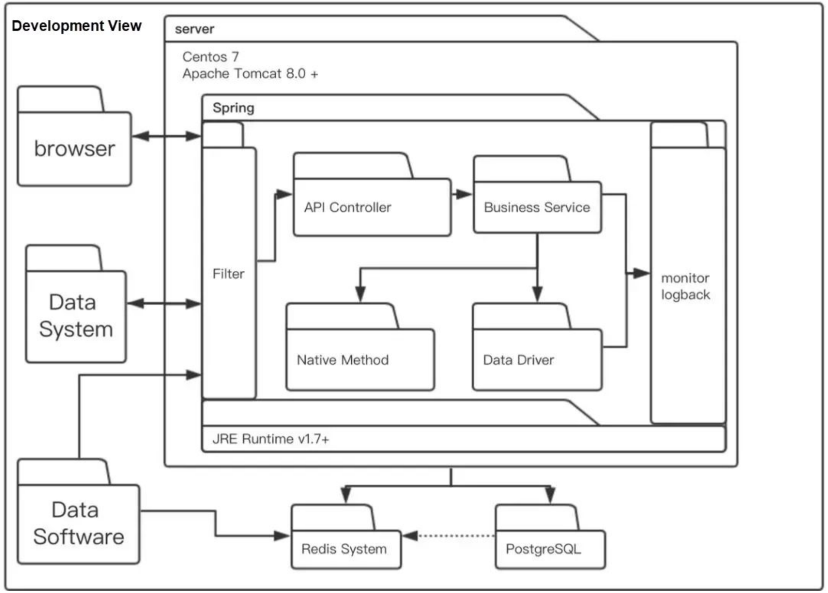
Software Architecture

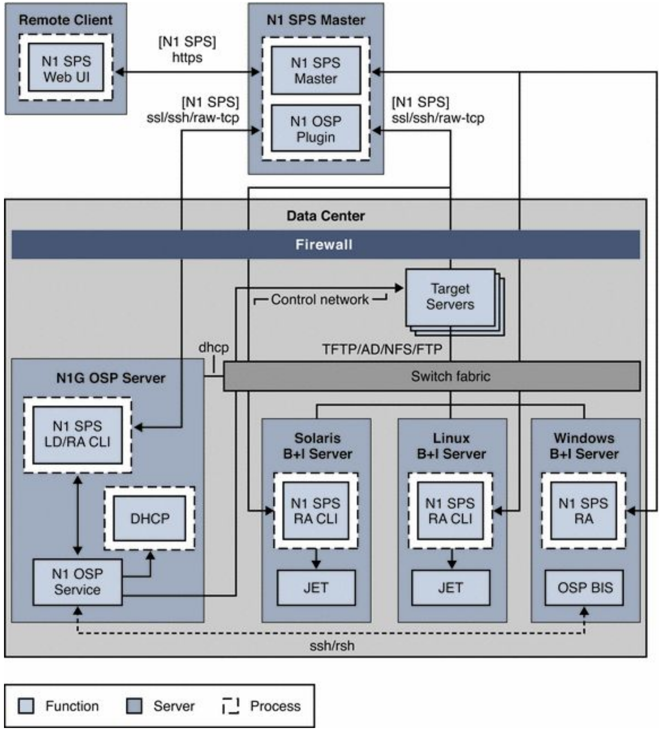
Today's agenda:

- Architecture vs Design
- **Architecture diagrams**
- What makes an architecture good
- Architectural styles (with examples)

Architecture: diagrams

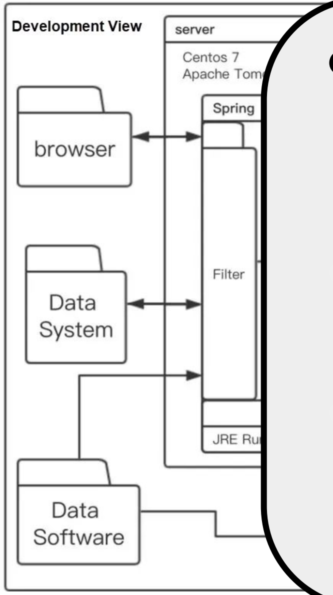
Architecture: diagrams



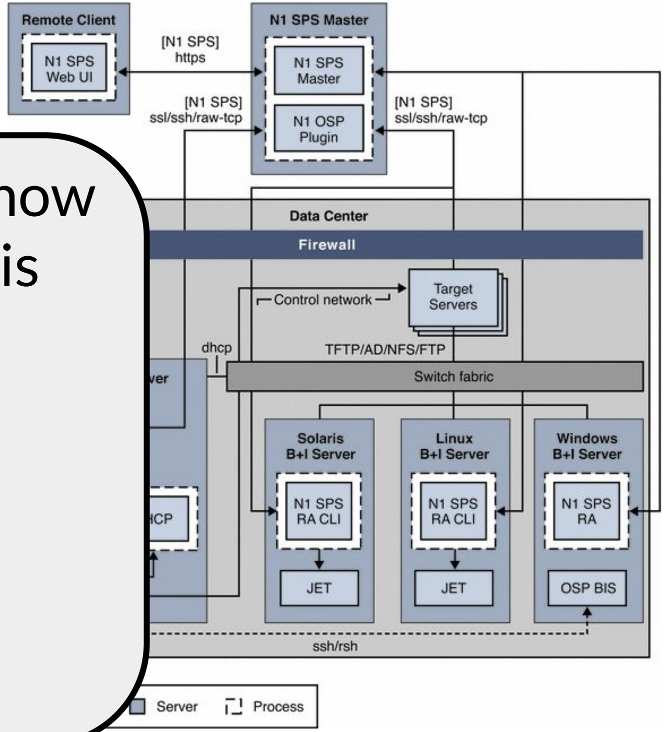


[https://www.alibabacloud.com/blog/how-to-create-an-effective-technical-architectural-diagram_596100]
[https://docs.oracle.com/cd/E19118-01/n1.sprovsys52/819-6519/images/osp-arch-diagram.gif]

Architecture: diagrams

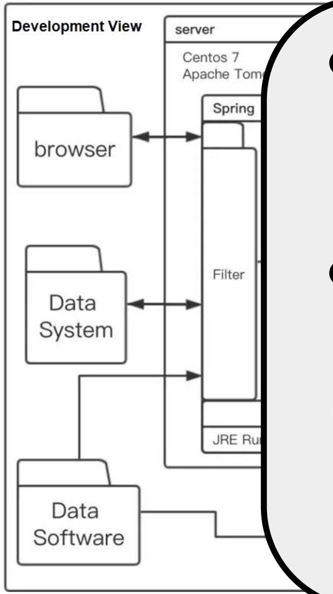


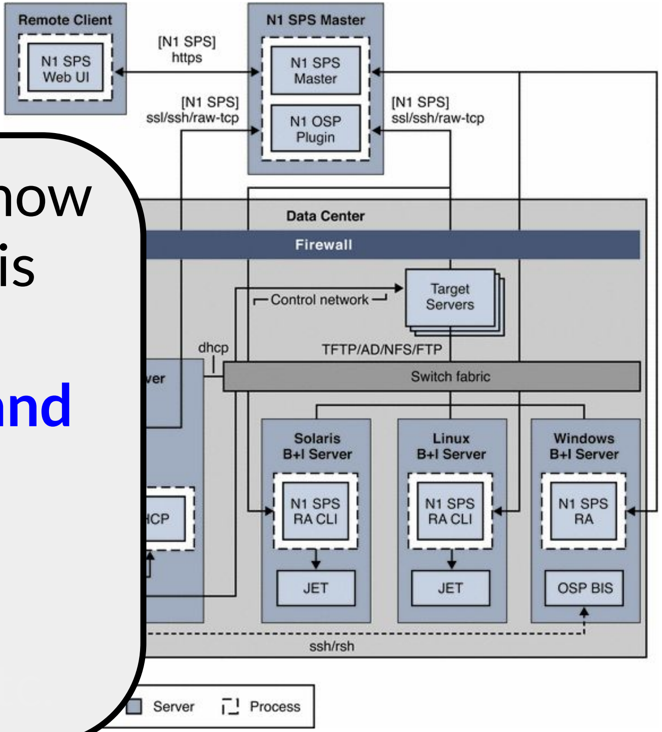
- The traditional way to show a software architecture is via a **diagram**.



[https://www.alibabacloud.com/blog/how-to-create-an-effective-technical-architectural-diagram_596100]
[https://docs.oracle.com/cd/E19118-01/n1.sprovsys52/819-6519/images/osp-arch-diagram.gif]

Architecture: diagrams

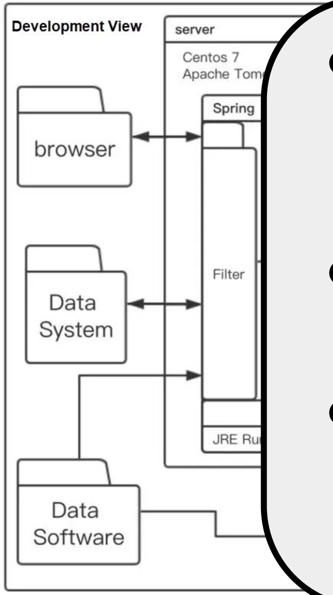


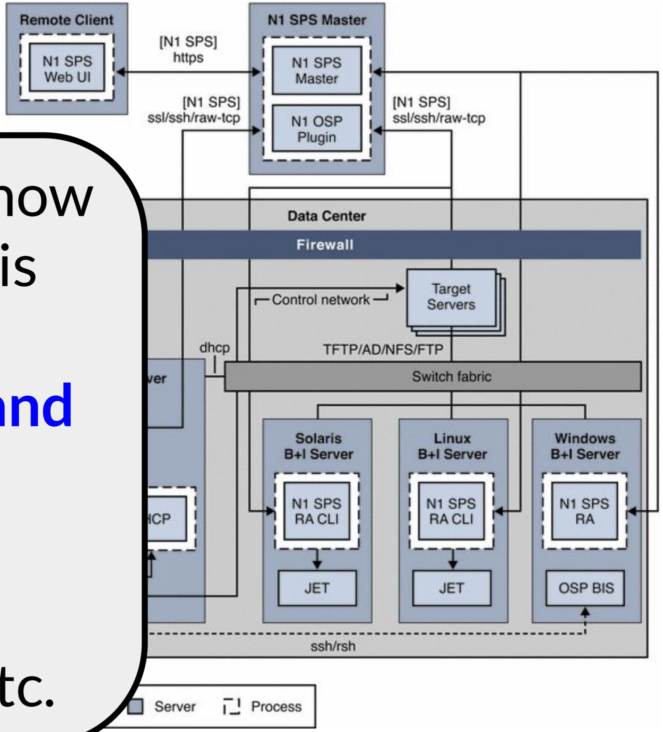


- The traditional way to show a software architecture is via a **diagram**.
- Diagrams are **common and helpful**.

[https://www.alibabacloud.com/blog/how-to-create-an-effective-technical-architectural-diagram_596100]
[https://docs.oracle.com/cd/E19118-01/n1.sprovsys52/819-6519/images/osp-arch-diagram.gif]

Architecture: diagrams





- The traditional way to show a software architecture is via a **diagram**.
- Diagrams are **common and helpful**.
- But, what does a box represent? an arrow? a layer? adjacent boxes? etc.

[https://www.alibabacloud.com/blog/how-to-create-an-effective-technical-architectural-diagram_596100]
[https://docs.oracle.com/cd/E19118-01/n1.sprovsys52/819-6519/images/osp-arch-diagram.gif]

Architecture: components and connectors

Architecture: components and connectors

Definition: ***Components*** define the basic computations comprising the system and their behaviors

- e.g., abstract data types, filters, etc.

Architecture: components and connectors

Definition: ***Components*** define the basic computations comprising the system and their behaviors

- e.g., abstract data types, filters, etc.

Definition: ***Connectors*** define the interconnections between components

- e.g., procedure calls, event announcements, asynchronous message sends, etc.

Architecture: components and connectors

Definition: ***Components*** define the basic computations comprising the system and their behaviors

- e.g., abstract data types, filters,

Definition: ***Connectors*** define the i

components

- e.g., procedure calls, event announcements, asynchronous message sends, etc.

Note: the line between them may be **fuzzy**. For example, a connector might (de)serialize data, but can it perform other, richer computations?

Aside: UML diagrams

- You might have heard the terms “components” and “connectors” before in the context of a **UML diagram**

Aside: UML diagrams

- You might have heard the terms “components” and “connectors” before in the context of a **UML diagram**
- UML diagrams are just one of many **modeling languages** that you can use to visualize an architecture or design

Aside: UML diagrams

- You might have heard the terms "components" and "connectors" before in the context of a **UML diagram**
- UML diagrams are just one of many **modeling languages** that you can use to visualize an architecture or design
  - UML is relatively popular, but I don't see much value in making you memorize it

Aside: UML diagrams

- You might have heard the terms "components" and "connectors" before in the context of a **UML diagram**
- UML diagrams are just one of many **modeling languages** that you can use to visualize an architecture or design
    - UML is relatively popular, but I don't see much value in making you memorize it
    - so, it's not going to be the topic of this lecture

Aside: UML diagrams

- You might have heard the terms "components" and "connectors" before in the context of a **UML diagram**
- UML diagrams are just one of many **modeling languages** that you can use to visualize an architecture or design
  - UML is relatively popular, but I don't see much value in making you memorize it
  - so, it's not going to be the topic of this lecture
  - if and when you do encounter UML, look up the symbols and map them back to the **concepts** we're discussing today

Software Architecture

Today's agenda:

- Architecture vs Design
- Architecture diagrams
- **What makes an architecture good**
- Architectural styles (with examples)

Properties of a good architecture

Properties of a good architecture

- Satisfies functional and performance requirements
- Manages complexity
- Accommodates future change
- Is concerned with reliability, safety, understandability, compatibility, robustness, etc.
    - but, the emphasis on these may more larger or smaller depending on the domain

Properties of a good architecture

A good architecture helps with all (or at least many) of the following:

Properties of a good architecture

A good architecture helps with all (or at least many) of the following:

- **System understanding**: interactions between modules

Properties of a good architecture

A good architecture helps with all (or at least many) of the following:

- **System understanding**: interactions between modules
- **Reuse**: high-level view shows opportunity for reuse

Properties of a good architecture

A good architecture helps with all (or at least many) of the following:

- **System understanding**: interactions between modules
- **Reuse**: high-level view shows opportunity for reuse
- **Construction**: breaks development down into work items and provides a path from requirements to code

Properties of a good architecture

A good architecture helps with all (or at least many) of the following:

- **System understanding**: interactions between modules
- **Reuse**: high-level view shows opportunity for reuse
- **Construction**: breaks development down into work items and provides a path from requirements to code
- **Evolution**: high-level view shows evolution path

Properties of a good architecture

A good architecture helps with all (or at least many) of the following:

- **System understanding**: interactions between modules
- **Reuse**: high-level view shows opportunity for reuse
- **Construction**: breaks development down into work items and provides a path from requirements to code
- **Evolution**: high-level view shows evolution path
- **Management**: helps understand work items and track progress

Properties of a good architecture

A good architecture helps with all (or at least many) of the following:

- **System understanding**: interactions between modules
- **Reuse**: high-level view shows opportunity for reuse
- **Construction**: breaks development down into work items and provides a path from requirements to code
- **Evolution**: high-level view shows evolution path
- **Management**: helps understand work items and track progress
- **Communication**: provides vocabulary; a picture says 1000 words

Properties of a good architecture: modularity

Properties of a good architecture: modularity

Definition: ***modularity*** is the degree to which a system's components may be separated and recombined, often with the benefit of flexibility and variety in use

Properties of a good architecture: modularity

Definition: ***modularity*** is the degree to which a system's components may be separated and recombined, often with the benefit of flexibility and variety in use

- modularity is **the key** to good architecture
    - use of abstraction leads to modularity
    - choice of abstractions is extremely important!

Properties of a good architecture: modularity

Definition: ***modularity*** is the degree to which a system's components may be separated and recombined, often with the benefit of flexibility and variety in use

- modularity is **the key** to good architecture
  - use of abstraction leads to modularity
  - choice of abstractions is extremely important!
- to achieve modularity, you need:

Properties of a good architecture: modularity

Definition: ***modularity*** is the degree to which a system's components may be separated and recombined, often with the benefit of flexibility and variety in use

- modularity is **the key** to good architecture
  - use of abstraction leads to modularity
  - choice of abstractions is extremely important!
- to achieve modularity, you need:
  - strong **cohesion** within a component
  - loose **coupling** between components

Properties of a good architecture: modularity

Definition: ***modularity*** is the degree to which a system's components may be separated and recombined, often with the benefit of flexibility and variety in use

- modularity is **the key** to good architecture
  - use of abstraction leads to modularity
  - choice of abstractions is extremely important!
- to achieve modularity, you need:
  - strong **cohesion** within a component
  - loose **coupling** between components
  - and these properties should be true at each level

Properties of a good architecture: modularity

Definition: *modularity* is the degree to which a system's components may be separated and recombined, flexibility and variety in use

- modularity is **the key** to good a
  - use of abstraction leads to
  - choice of abstractions is ex
- to achieve modularity, you nee
  - strong **cohesion** within a co
  - loose **coupling** between components
  - and these properties should be true at each level

Modularity also enables **decomposition**, which:

- decreases size of tasks
- supports independent testing and analysis
- enables separate work assignments
- eases understanding

Modularity: cohesion

Definition: ***cohesion*** is how closely the operations in a module are related

Modularity: cohesion

Definition: ***cohesion*** is how closely the operations in a module are related

- Scale is usually "**strong**" vs "**weak**"

Modularity: cohesion

Definition: *cohesion* is how closely the operations in a module are related

- Scale is usually "**strong**" vs "**weak**"
- Tight relationships **improve clarity and understanding**

Modularity: cohesion

Definition: ***cohesion*** is how closely the operations in a module are related

- Scale is usually "**strong**" vs "**weak**"
- Tight relationships **improve clarity and understanding**
- A class with good abstraction usually has strong internal cohesion

Modularity: cohesion

Definition: ***cohesion*** is how closely the operations in a module are related

- Scale is usually "**strong**" vs "**weak**"
- Tight relationships **improve clarity and understanding**
- A class with good abstraction usually has strong internal cohesion
- **Avoid** classes that have multiple, independent jobs

Modularity: cohesion

Definition: ***cohesion*** is how closely the operations in a module are related

- Scale is usually "**strong**" vs "**weak**"
- Tight relationships **improve clarity and understanding**
- A class with good abstraction usually has strong internal cohesion
- **Avoid** classes that have multiple, independent jobs
    - and especially avoid "**god**" classes that control the entire application!
    - such classes almost always have weak cohesion

Modularity: cohesion: strong or weak?

```
class Employee {
    public:
    …
    FullName GetName() const;
    Address GetAddress() const;
    PhoneNumber GetWorkPhone() const;
    …
    bool IsJobClassificationValid(JobClassification jobClass);
    bool IsZipCodeValid (Address address);
    bool IsPhoneNumberValid (PhoneNumber phoneNumber);
    …
    SqlQuery GetQueryToCreateNewEmployee() const;
    SqlQuery GetQueryToModifyEmployee() const;
    SqlQuery GetQueryToRetrieveEmployee() const;
    …
}
```

Modularity: cohesion: strong or weak?

```
class Employee {
    public:
    …
    FullName GetName() const;
    Address GetAddress() const;
    PhoneNumber GetWorkPhone() const;
    …
    bool IsJobClassificationValid(JobClassification jobClass);
    bool IsZipCodeValid (Address address);
    bool IsPhoneNumberValid (PhoneNumber phoneNumber);
    …
    SqlQuery GetQueryToCreateNewEmployee() const;
    SqlQuery GetQueryToModifyEmployee() const;
    SqlQuery GetQueryToRetrieveEmployee() const;
    …
}
```

No problem for cohesion here

Modularity: cohesion: strong or weak?

```
class Employee {
    public:
    …
    FullName GetName() const;
    Address GetAddress() const;
    PhoneNumber GetWorkPhone() const;
    …
    bool IsJobClassificationValid(JobClassification jobClass);
    bool IsZipCodeValid (Address address);
    bool IsPhoneNumberValid (PhoneNumber phoneNumber);
    …
    SqlQuery GetQueryToCreateNewEmployee() const;
    SqlQuery GetQueryToModifyEmployee() const;
    SqlQuery GetQueryToRetrieveEmployee() const;
    …
}
```

Probably a cohesion problem here (what does "valid" mean? is it a property of being an Employee?)

Modularity: cohesion: strong or weak?

```
class Employee {
    public:
    …
    FullName GetName() const;
    Address GetAddress() const;
    PhoneNumber GetWorkPhone() const;
    …
    bool IsJobClassificationValid(JobClassification jobClass);
    bool IsZipCodeValid (Address address);
    bool IsPhoneNumberValid (PhoneNumber phoneNumber);
    …
    SqlQuery GetQueryToCreateNewEmployee() const;
    SqlQuery GetQueryToModifyEmployee() const;
    SqlQuery GetQueryToRetrieveEmployee() const;
    …
}
```

Definitely a cohesion problem here! (SQL query generation != model of employee)

Modularity: coupling

Definition: the ***coupling*** of a software project is the kind and quantity of interconnections among its modules

Modularity: coupling

Definition: the ***coupling*** of a software project is the kind and quantity of interconnections among its modules

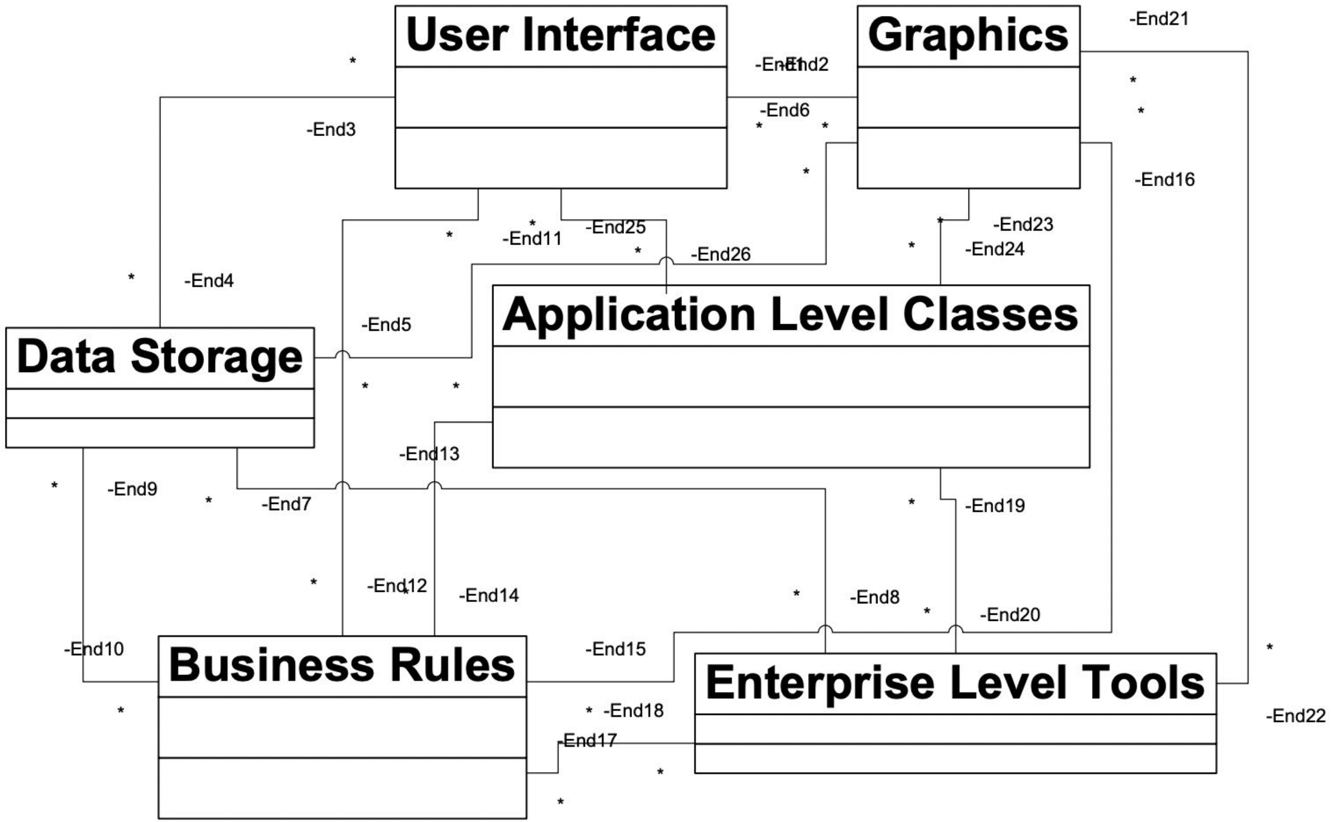
- scale: “loose” vs “tight”

Modularity: coupling

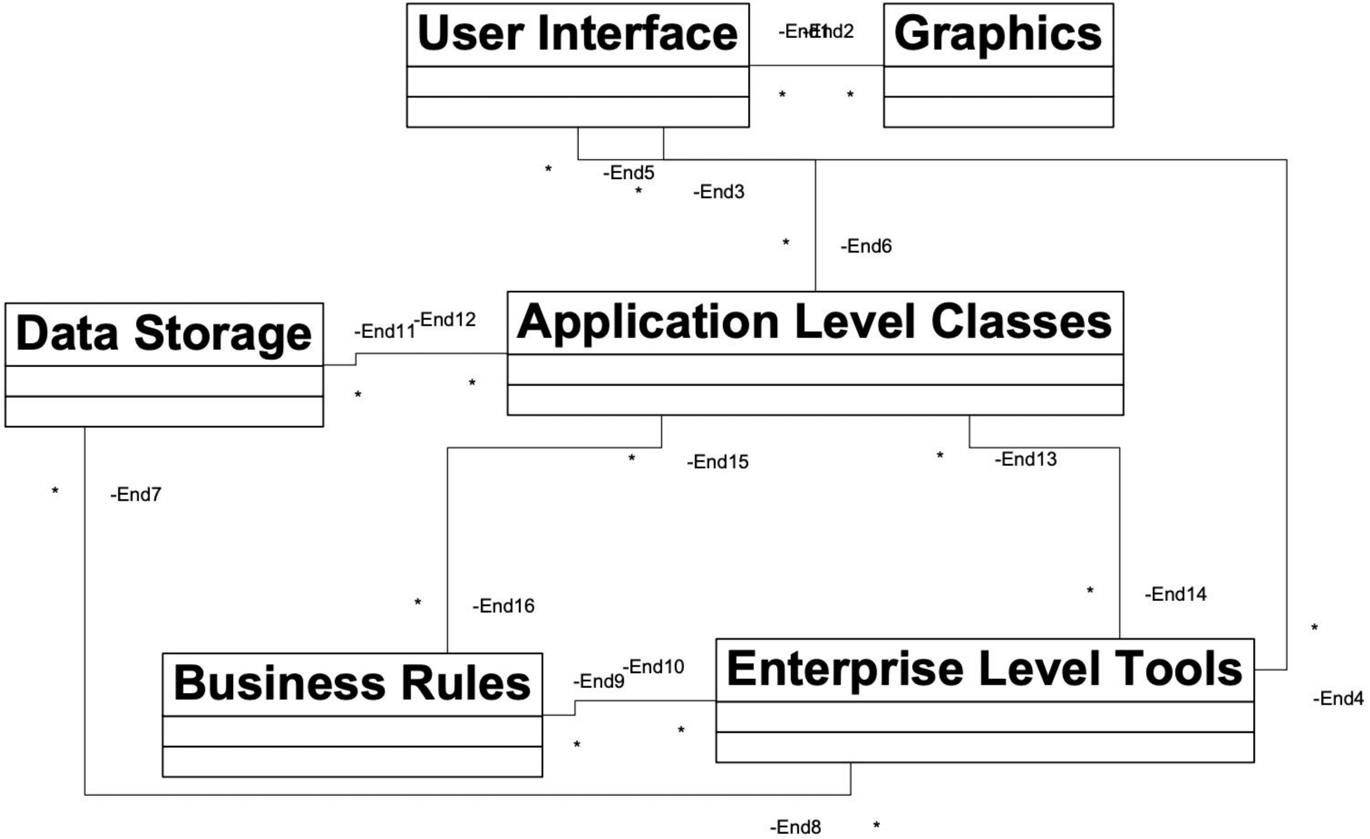
Definition: the ***coupling*** of a software project is the kind and quantity of interconnections among its modules

- scale: “loose” vs “tight”
- modules that are **loosely coupled** (or uncoupled) are **better** than those that are tightly coupled
  - the more tightly coupled two modules are, the harder it is to work with them separately

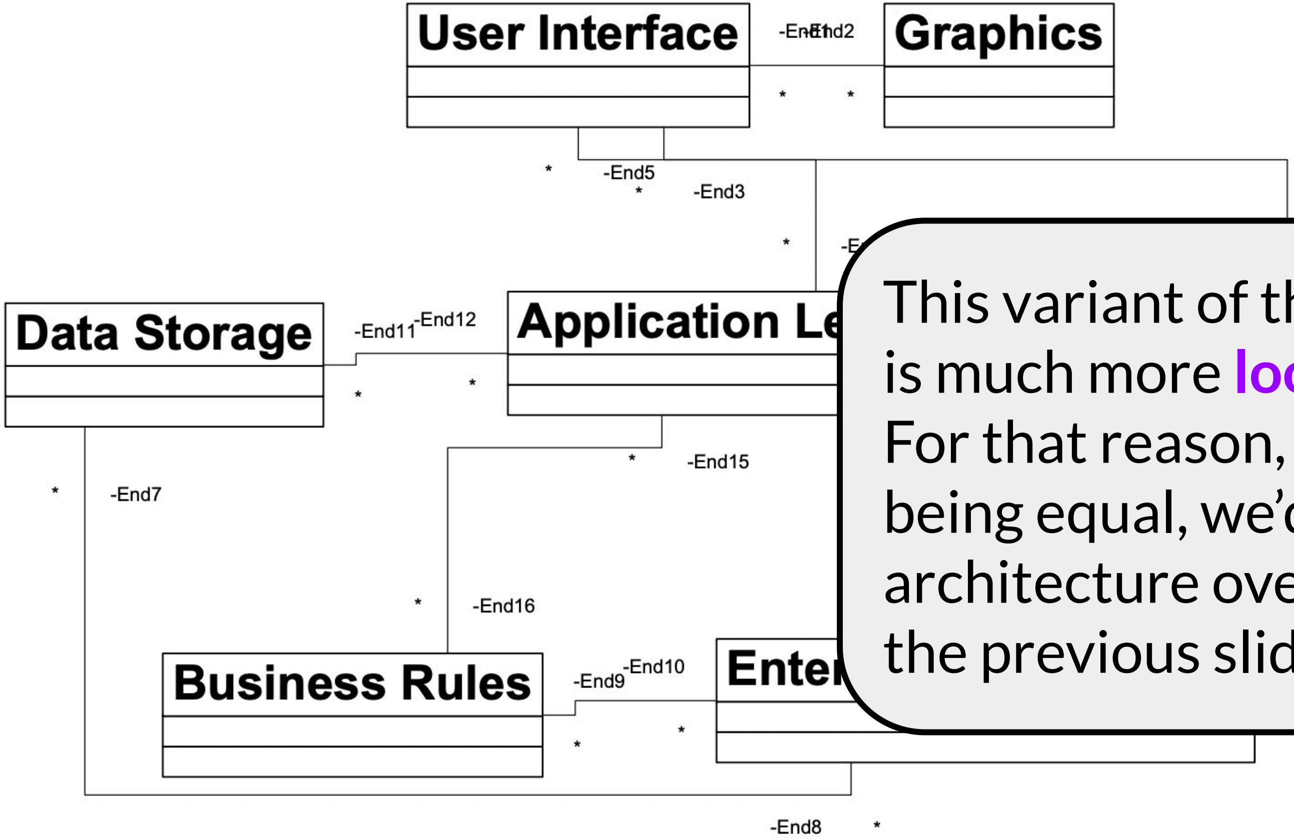
Modularity: coupling: loose or tight?



Modularity: coupling: loose or tight?



Modularity: coupling: loose or tight?



This variant of the architecture is much more **loosely coupled**. For that reason, all other things being equal, we'd prefer this architecture over the one on the previous slide.

Modularity: implementation

- How do you actually achieve modularity?

Modularity: implementation

- How do you actually achieve modularity?
    - Implementation techniques: information hiding, interfaces

Modularity: implementation

- How do you actually achieve modularity?
  - Implementation techniques: information hiding, **interfaces**

Modularity: implementation

- How do you actually achieve modularity?
  - Implementation techniques: information hiding, **interfaces**

public interface: data and behavior of the object that can be seen and executed externally by "client" code

Modularity: implementation

- How do you actually achieve modularity?
  - Implementation techniques: information hiding, **interfaces**

public interface: data and behavior of the object that can be seen and executed externally by "client" code
private implementation: internal data and methods in the object, used to help implement the public interface, but cannot be directly accessed

Modularity: implementation

- How do you actually achieve modularity?
  - Implementation techniques: information hiding, **interfaces**

public interface: data and behavior of the object that can be seen and executed externally by "client" code
private implementation: internal data and methods in the object, used to help implement the public interface, but cannot be directly accessed
client: code that uses your class/subsystem

Modularity: implementation

- How do you actually achieve modularity?
    - Implementation techniq

public interface: data and beha
and executed externally by "clie
private implementation: intern
used to help implement the pub
accessed
client: code that uses your class/subsystem

Example: a radio

Modularity: implementation

- How do you actually achieve modularity?
  - Implementation techniq

public interface: data and beha
and executed externally by "clie
private implementation: intern
used to help implement the pub
accessed
client: code that uses your class/subsystem

Example: a radio

- public interface is the speaker, volume buttons, station dial

Modularity: implementation

- How do you actually achieve modularity?
  - Implementation techniq

public interface: data and beha
and executed externally by "clie
private implementation: intern
used to help implement the pub
accessed
client: code that uses your class/subsystem

Example: a radio

- public interface is the speaker, volume buttons, station dial
- private implementation is the guts of the radio: the transistors, capacitors, voltage readings, frequencies, etc. that a user should not see

Software Architecture

Today's agenda:

- Architecture vs Design
- Architecture diagrams
- What makes an architecture good
- **Architectural styles (with examples)**

Architecture: styles

Architecture: styles

Definition: an ***architectural style*** is a class of architectures sharing common features

Architecture: styles

Definition: an ***architectural style*** is a class of architectures sharing common features

An architectural style defines:

Architecture: styles

Definition: an ***architectural style*** is a class of architectures sharing common features

An architectural style defines:

- the **vocabulary** of components and connectors

Architecture: styles

Definition: an ***architectural style*** is a class of architectures sharing common features

An architectural style defines:

- the **vocabulary** of components and connectors
- **constraints** on the elements and their combination

Architecture: styles

Definition: an ***architectural style*** is a class of architectures sharing common features

An architectural style defines:

- the **vocabulary** of components and connectors
- **constraints** on the elements and their combination
  - topological constraints (no cycles, etc.)
  - execution constraints (timing, etc.)

Architecture: styles

Definition: an ***architectural style*** is a class of architectures sharing common features

An architectural style defines

- the **vocabulary** of compo
- **constraints** on the eleme
  - topological constrain
  - execution constraints

By choosing a style, one gets all the **known properties** of that style (for any architecture in that style)

- for example: performance, lack of deadlock, ease of making particular classes of changes, etc.

Architecture: styles: pipe and filter

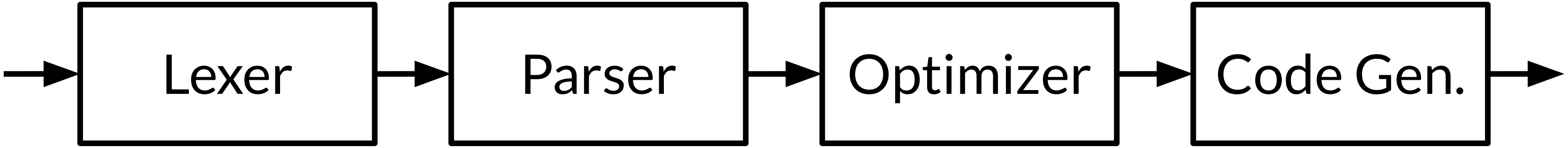
Architecture: styles: pipe and filter

Definition: a ***pipe-and-filter architecture*** consists of a series of discrete stages (***filters***) connected end to end (by ***pipes***)

Architecture: styles: pipe and filter

Definition: a ***pipe-and-filter architecture*** consists of a series of discrete stages (***filters***) connected end to end (by ***pipes***)

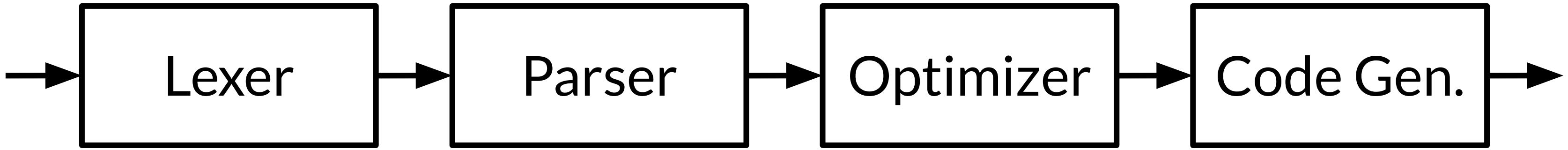
- e.g., a compiler:



Architecture: styles: pipe and filter

Definition: a *pipe-and-filter architecture* consists of a series of discrete stages (***filters***) connected end to end (by ***pipes***)

- e.g., a compiler:

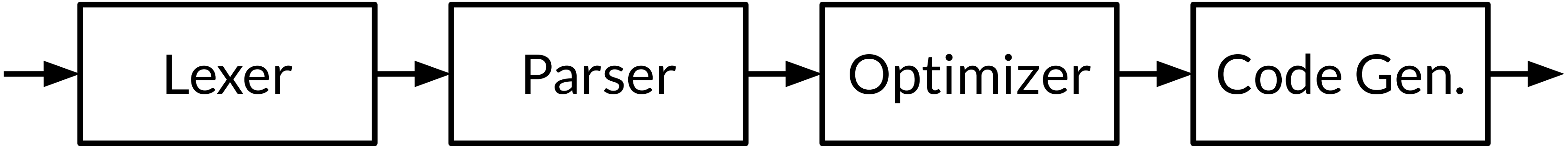


- Constraints:

Architecture: styles: pipe and filter

Definition: a *pipe-and-filter architecture* consists of a series of discrete stages (*filters*) connected end to end (by *pipes*)

- e.g., a compiler:

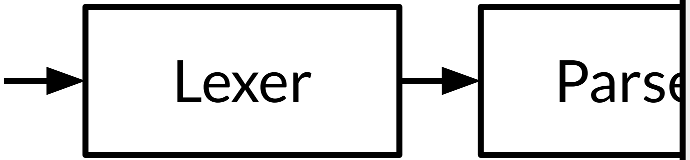


- Constraints:
  - pipes must compute local transformations
  - filters must not share state with other filters
  - there must be no cycles

Architecture: styles: pipe and filter

Definition: a ***pipe-and-filter architecture*** consists of a series of discrete stages (***filters***) conne

- e.g., a compiler:



If these constraints are violated, it's not a pipe-and-filter architecture anymore!

- you can't necessarily tell this from a picture, either

- Constraints:
  - pipes must compute local transformations
  - filters must not share state with other filters
  - there must be no cycles

Architecture vs. reality

Architecture vs. reality

- Remember, the architecture is an **abstraction** of the real system

Architecture vs. reality

- Remember, the architecture is an **abstraction** of the real system
  - The code is often less clean than the architecture, with many more little details

Architecture vs. reality

- Remember, the architecture is an **abstraction** of the real system
  - The code is often less clean than the architecture, with many more little details
- The architecture is still useful (as long as the little details don't **contradict** it):

Architecture vs. reality

- Remember, the architecture is an **abstraction** of the real system
  - The code is often less clean than the architecture, with many more little details
- The architecture is still useful (as long as the little details don't **contradict** it):
  - enables easy **communication** among team members

Architecture vs. reality

- Remember, the architecture is an **abstraction** of the real system
  - The code is often less clean than the architecture, with many more little details
- The architecture is still useful (as long as the little details don't **contradict** it):
  - enables easy **communication** among team members
  - selected **deviations** can be explained more concisely and with clearer reasoning

Architecture vs. reality: interfaces

- When looking at an architecture, small details do matter a lot at the **interface** between components

Architecture vs. reality: interfaces

- When looking at an architecture, small details do matter a lot at the **interface** between components
  - e.g., NASA lost a $125 million Mars orbiter because one engineering team used metric units while another used Imperial units

Architecture vs. reality: interfaces

- When looking at an architecture, small details do matter a lot at the **interface** between components
  - e.g., NASA lost a $125 million Mars orbiter because one engineering team used metric units while another used Imperial units
- Architecture should warn about **incompatibility between components**, which can be caused by (among other things):
  - mismatched interfaces
  - mismatched operating assumptions (e.g., one component assumes Windows, the other assumes Linux)

Architecture: styles: other examples

Examples of architectural styles:

- pipe-and-filter
- client-server
- model-view-controller
- microservices

Architecture: styles: other examples

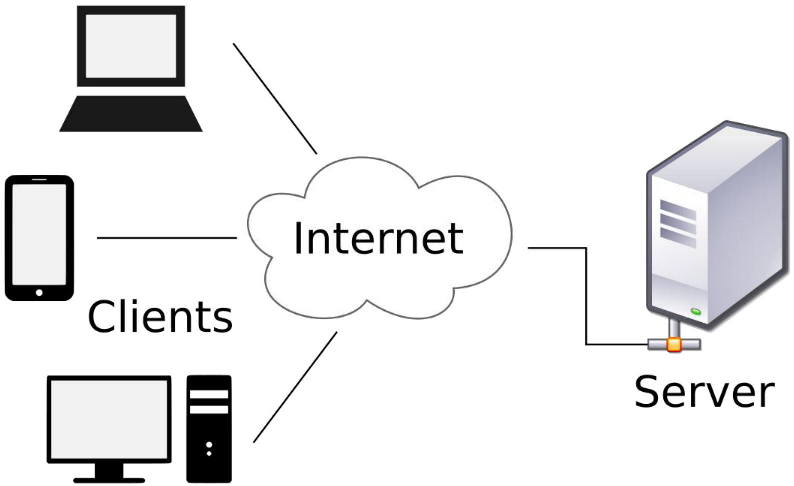
Examples of architectural styles:

- pipe-and-filter
- **client-server**
- model-view-controller
- microservices

Architecture: styles: client-server

Architecture: styles: client-server

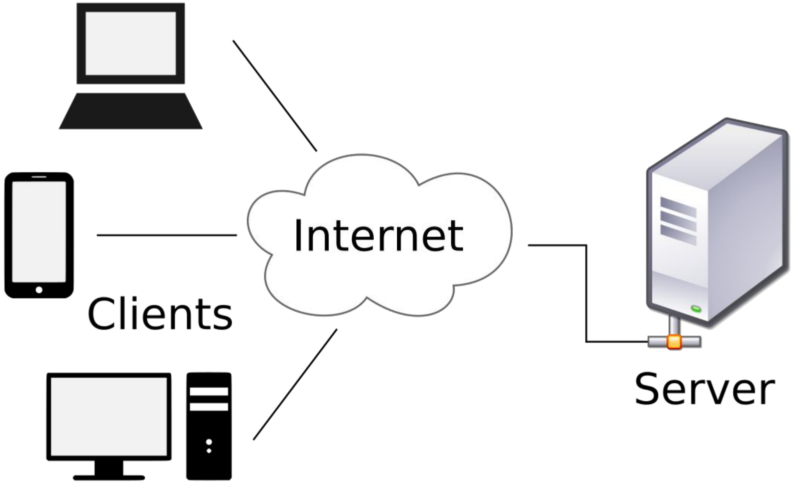
Definition: a *client-server architecture* partitions tasks or workloads between the providers of a resource or service (*servers*) and service requesters (*clients*) [Wikipedia]



Architecture: styles: client-server

Definition: a ***client-server architecture*** partitions tasks or workloads between the providers of a resource or service (***servers***) and service requesters (***clients***) [Wikipedia]

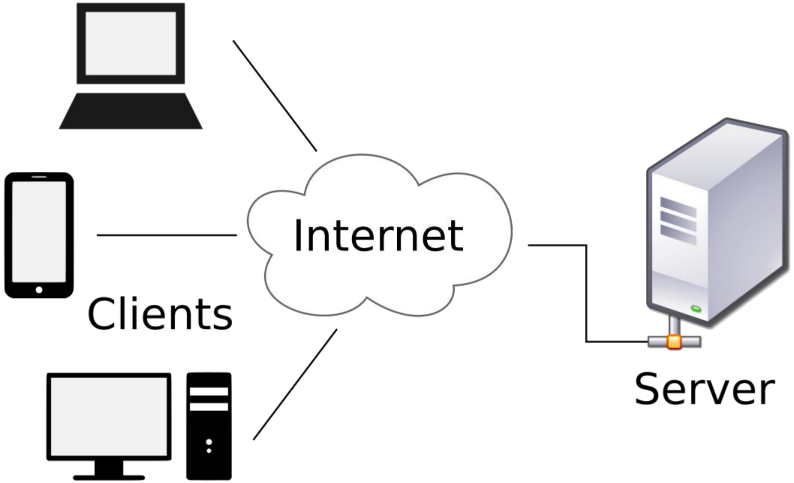
- network doesn't have to be the internet (client and server can even be on the same machine!)



Architecture: styles: client-server

Definition: a *client-server architecture* partitions tasks or workloads between the providers of a resource or service (***servers***) and service requesters (***clients***) [Wikipedia]

- network doesn't have to be the internet (client and server can even be on the same machine!)
- example of decomposition: server has its **own architecture** internally, but we don't see it



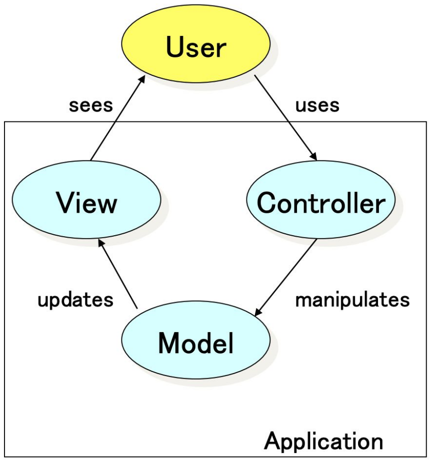
Architecture: styles: model-view-controller

Architecture: styles: model-view-controller

Definition: a ***model-view-controller architecture*** splits the project into three parts:

Architecture: styles: model-view-controller

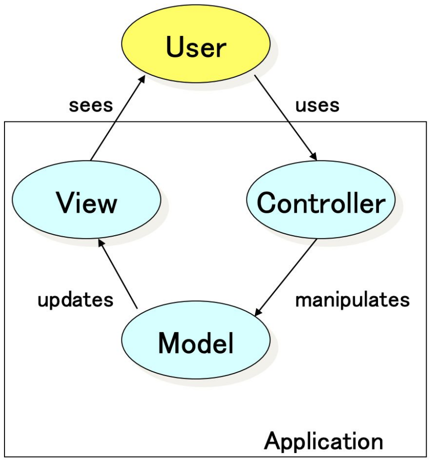
Definition: a ***model-view-controller architecture*** splits the project into three parts:



Architecture: styles: model-view-controller

Definition: a ***model-view-controller architecture*** splits the project into three parts:

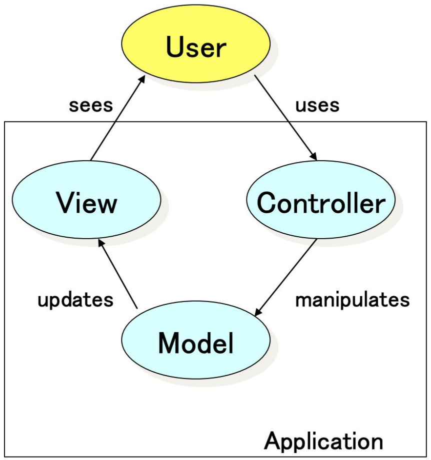
- a single ***model***, which is the application's dynamic data structure, independent of the user interface



Architecture: styles: model-view-controller

Definition: a ***model-view-controller architecture*** splits the project into three parts:

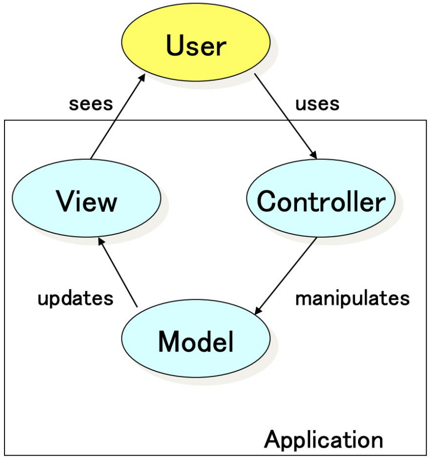
- a single ***model***, which is the application's dynamic data structure, independent of the user interface
- one or more ***views***, which are representations of information (e.g., charts, tables, or UIs)



Architecture: styles: model-view-controller

Definition: a ***model-view-controller architecture*** splits the project into three parts:

- a single ***model***, which is the application's dynamic data structure, independent of the user interface
- one or more ***views***, which are representations of information (e.g., charts, tables, or UIs)
- one or more ***controllers***, which accept input and convert it to commands for the model or view



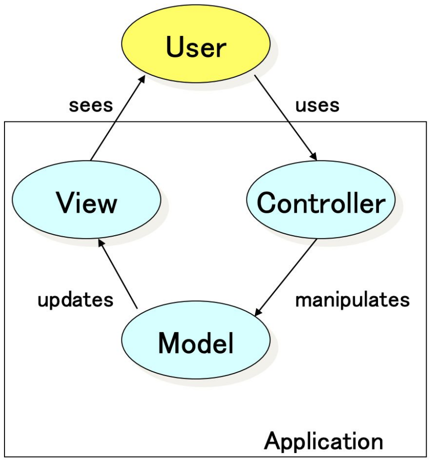
Architecture: styles: model-view-controller

Definition: a ***model-view-controller architecture*** splits the project into three parts:

- a single ***model***, which is the application's dynamic data structure, independent of the user interface
- one or mor… which are representations … of inform…
- one or m… d … convert i…

Key advantage of MVC:

separates data representation (Model), visualization/user interface (View), and client interaction (Controller)

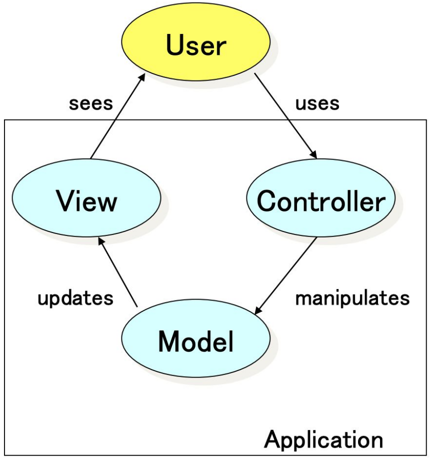


Architecture: styles: model-view-controller

Definition: a ***model-view-controller architecture*** splits the project into three parts:

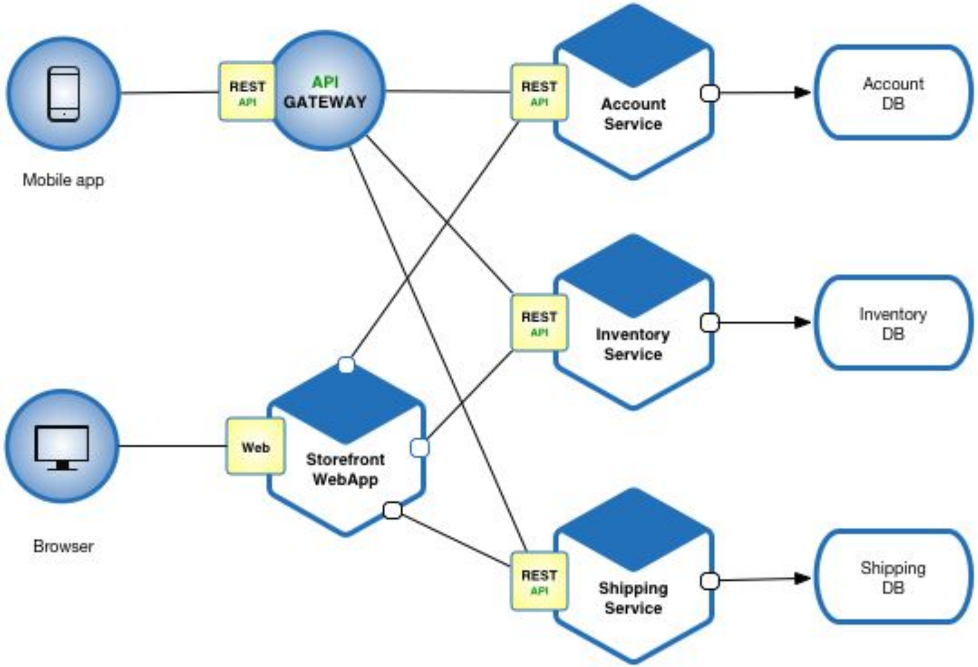
- a single ***model***, which is the application's dynamic data structure, independent of the user interface
- one or mor
  of inform
- one or m
  convert i

Key advantage of MVC: **separates** data representation (Model), visualization/user interface (View), and client interaction (Controller)



Architecture: styles: microservices

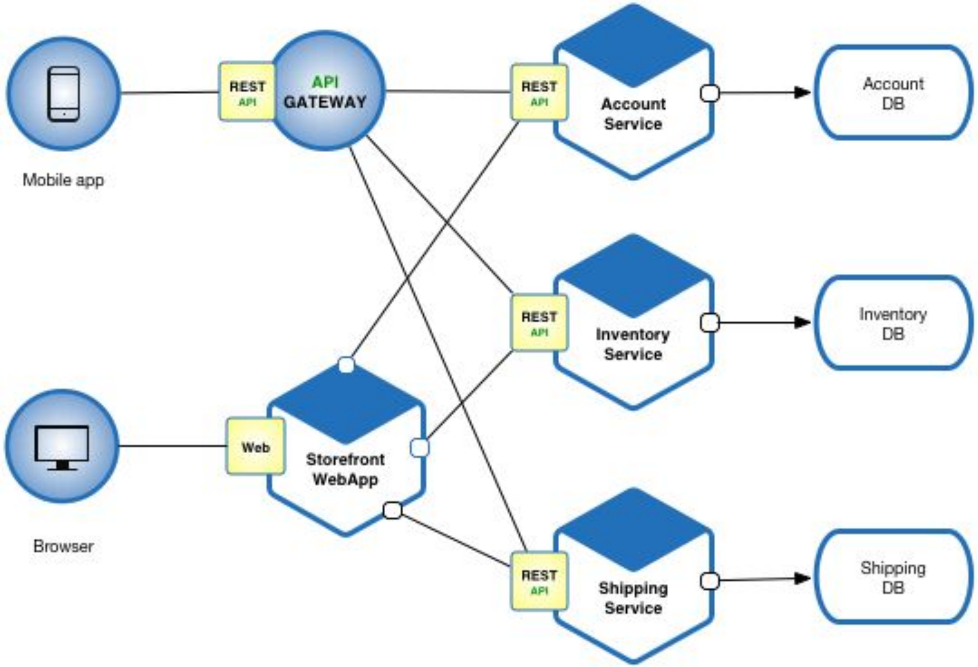
Architecture: styles: microservices



[https://microservices.io/]

Architecture: styles: microservices

Definition: a *microservice architecture* structures an application as a collection of **services** that are:

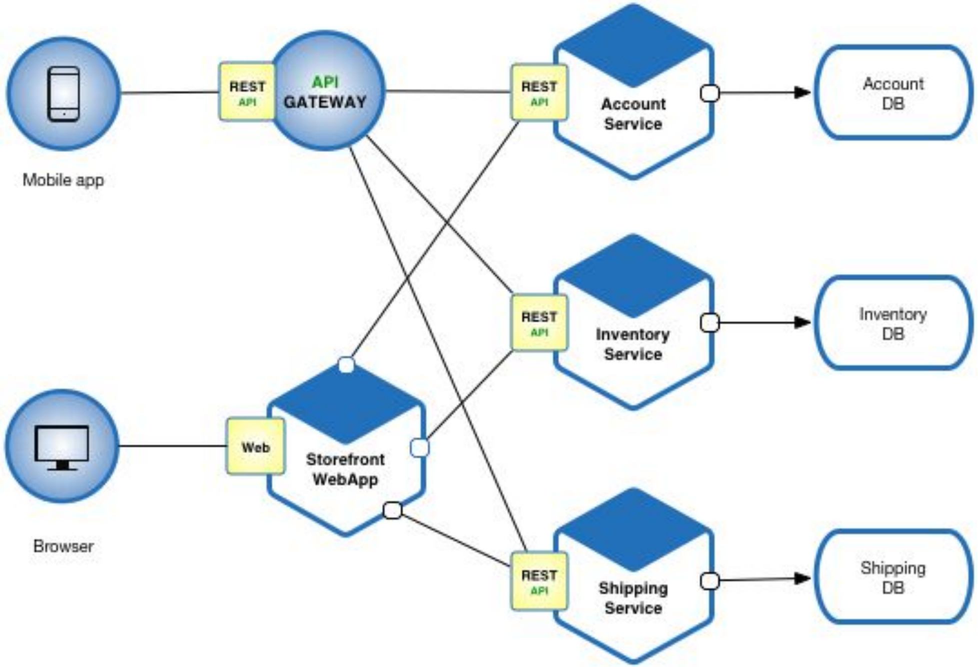


[https://microservices.io/]

Architecture: styles: microservices

Definition: a *microservice architecture* structures an application as a collection of **services** that are:

- Independently deployable

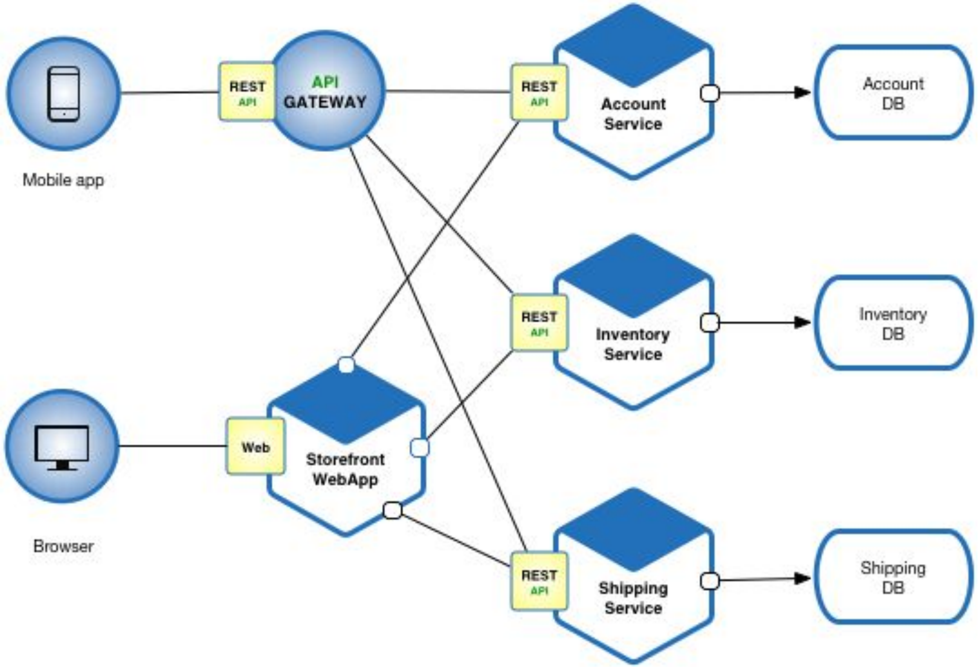


[https://microservices.io/]

Architecture: styles: microservices

Definition: a *microservice architecture* structures an application as a collection of **services** that are:

- Independently deployable
- Loosely coupled

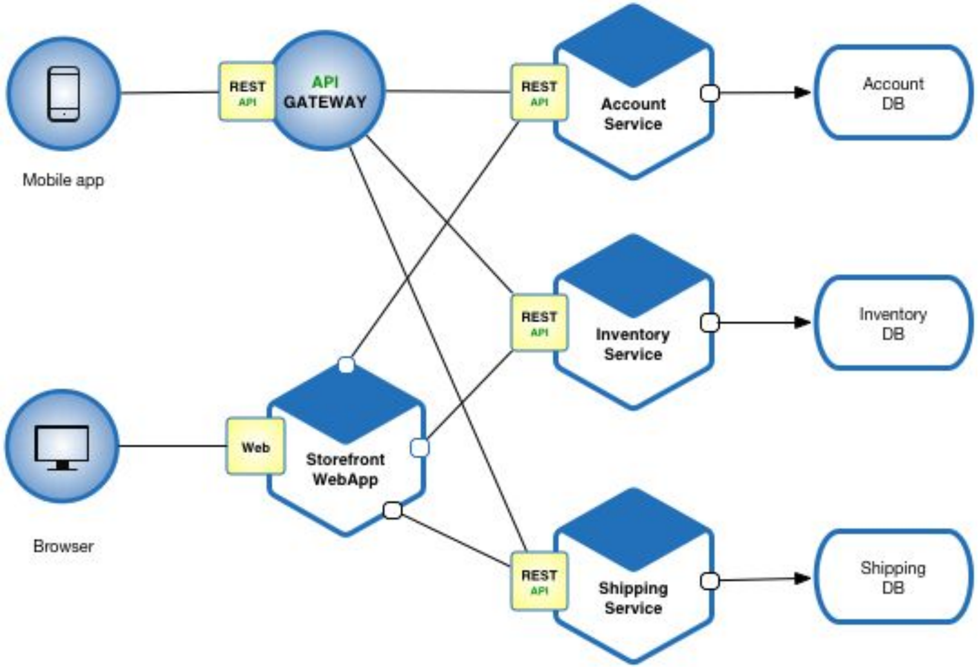


[https://microservices.io/]

Architecture: styles: microservices

Definition: a ***microservice architecture*** structures an application as a collection of **services** that are:

- Independently deployable
- Loosely coupled
- Organized around business capabilities

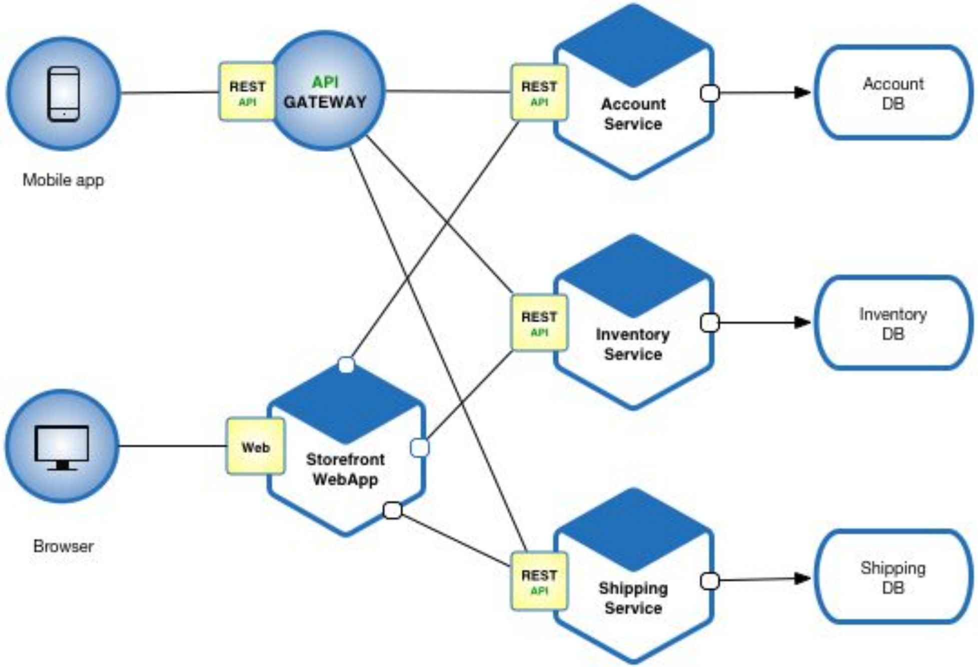


[https://microservices.io/]

Architecture: styles: microservices

Definition: a *microservice architecture* structures an application as a collection of services that are:

- Independently deployable
- Loosely coupled
- Organized around business capabilities
- Owned by a small team

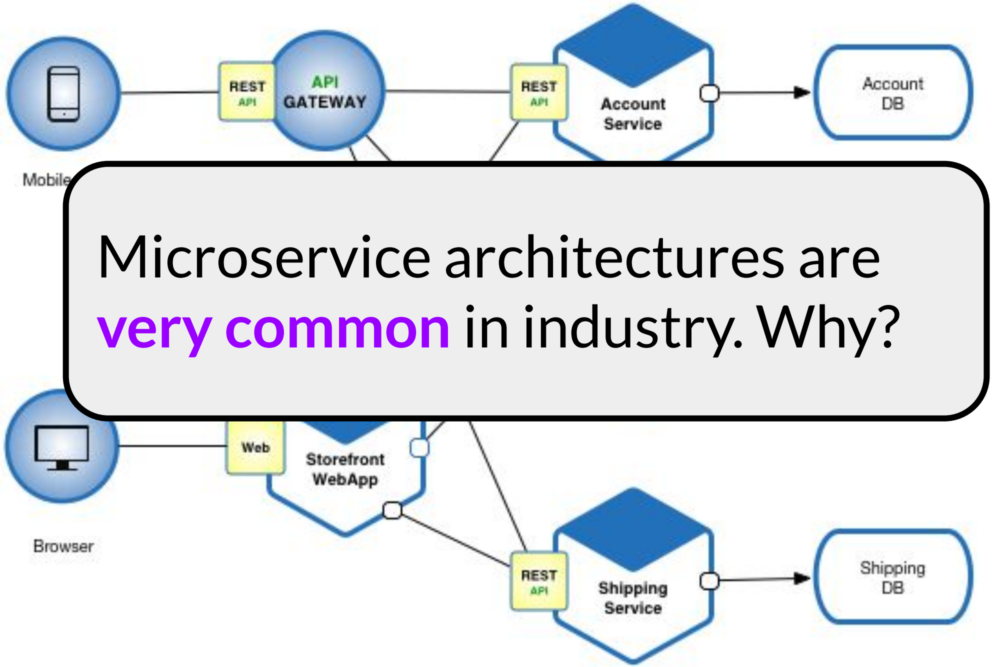


[https://microservices.io/]

Architecture: styles: microservices

Definition: a *microservice architecture* structures an application as a collection of services that are:

- Independently deployable
- Loosely coupled
- Organized around business capabilities
- Owned by a small team



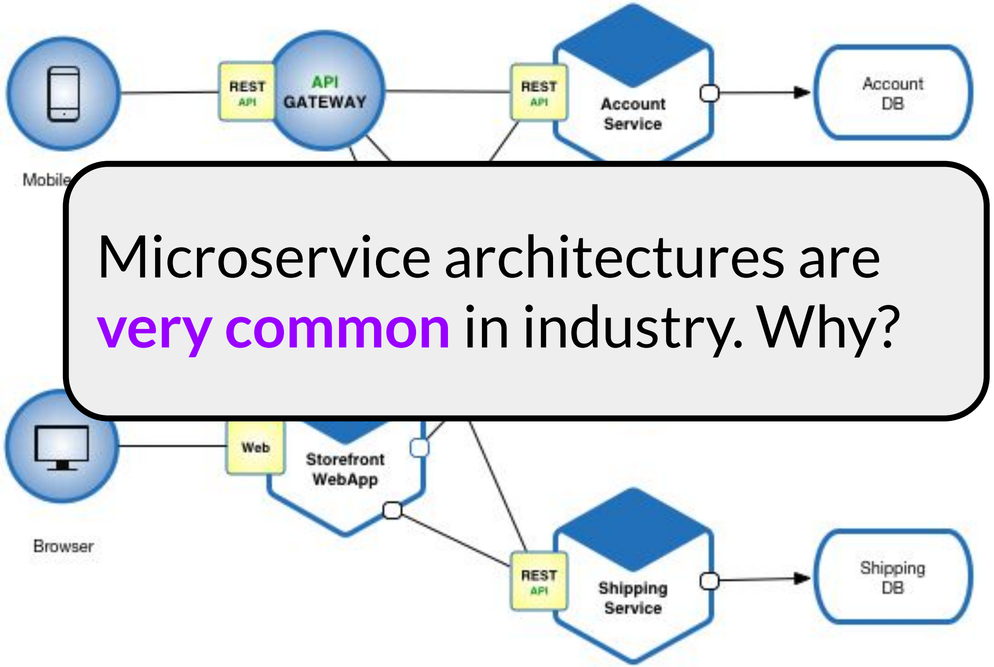
Microservice architectures are **very common** in industry. Why?

[https://microservices.io/]

Architecture: styles: microservices

Definition: a *microservice architecture* structures an application as a collection of **services** that are:

- Independently deployable
- Loosely coupled
- Organized around business capabilities
- **Owned by a small team (makes management easy)**



Microservice architectures are **very common** in industry. Why?

[https://microservices.io/]

Architecture: styles: others

- This has been a whirlwind tour of a series of **examples** of common architectural styles

Architecture: styles: others

- This has been a whirlwind tour of a series of **examples** of common architectural styles
    - There are **many others**!

Architecture: styles: others

- This has been a whirlwind tour of a series of **examples** of common architectural styles
  - There are **many others**!
- **Key skill**: understand what an architecture diagram is and is not communicating

Architecture: styles: others

- This has been a whirlwind tour of a series of **examples** of common architectural styles
  - There are **many others**!
- **Key skill**: understand what an architecture diagram is and is not communicating
  - does communicate overall structure of the system

Architecture: styles: others

- This has been a whirlwind tour of a series of **examples** of common architectural styles
  - There are **many others**!
- **Key skill**: understand what an architecture diagram is and is not communicating
  - does communicate overall structure of the system
  - does communicate how components are related

Architecture: styles: others

- This has been a whirlwind tour of a series of **examples** of common architectural styles
    - There are **many others**!
- **Key skill**: understand what an architecture diagram is and is not communicating
    - does communicate overall structure of the system
    - does communicate how components are related
    - does not communicate internal structure of components
        - definitely does not tell you how to implement them!

Takeaways: architecture

- An architecture is a high-level view of a software system
- Good architectures communicate how the pieces of the system (the components) fit together
- Many architectural styles exist, and you should have a passing familiarity with several
  - common interview question: “on the whiteboard, design a [insert architectural style here] system to do X”
- Architectural styles are a guide, but are not prescriptive
  - real systems usually deviate from their “whiteboard architecture”, but deviations can be explained