2IW80 Software specification and architecture

Structural specification: beyond class diagrams

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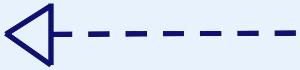
Where innovation starts

Before we start

- Match the pairs

1	Association	A	
2	Aggregation	B	
3	Composition	C	
4	Implementation	D	
5	Generalization	E	
6	Dependency	F	

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Before we start

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1E 2C 3F 4A 5D 6B

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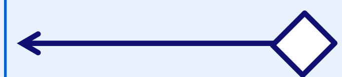
3	Composition	C	
4	Implementation	D	
5	Generalization	E	
6	Dependency	F	

Before we start

- A patient must be assigned to only one doctor, and a doctor can have one or more patients.

Determine x and y

This week sources

OMG Unified Modeling Language ™ (OMG UML)

Version 2.5

Slides by

David Meredith,
Aalborg University, DK

Marie-Elise Kontro,
Tampere University, FI

Site by

Kirill Fakhroutdinov
GE Healthcare, USA

Recall

Structural diagram is a diagram that identifies **modules, activities, or other entities** in a system or computer program and **shows how larger or more general entities break down into smaller**, more specific entities.

IEEE Standard Glossary of Software Engineering Terminology 610.12 1990

UML structure diagrams

Class diagram ✔

Object diagram

TODAY

Packages diagram

Component diagram

Deployment diagram

Composite structure diagram

Between specification and architecture

- **Packages diagram** and **deployment diagram**: the closest UML diagrams come to architecture
  - more about architecture: second half of the quartile

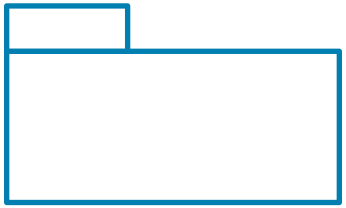
Packages diagram

- Represents the system at a **higher abstraction level**
  - Android SDK – 69 packages vs. 1231 classes
  - less prone to change, ergo better suited for evolution, than lower level representations

- NB: *Packages diagram* (UML standard) is frequently called *package diagram*

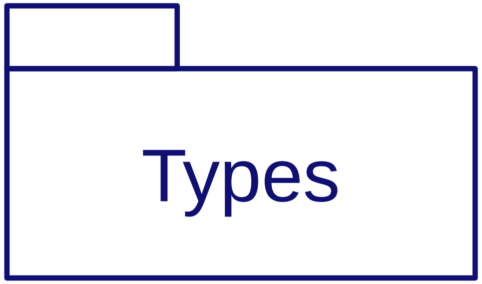
Packages diagram: Packages and Relations

- **Packages**
  - groups of “basic elements”, e.g., classes or use cases
  - namespaces, i.e., all members should have unique names
  - represented as file folders
  - can contain other packages, creating hierarchy

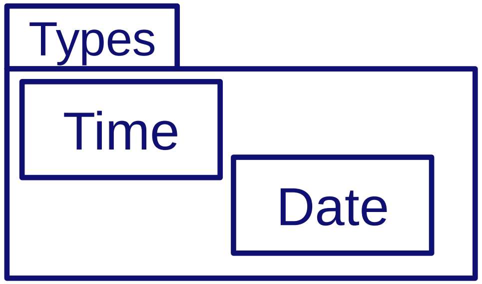


- **Relations**
  - dependencies, implementations, …
  - *imports* and *merges*

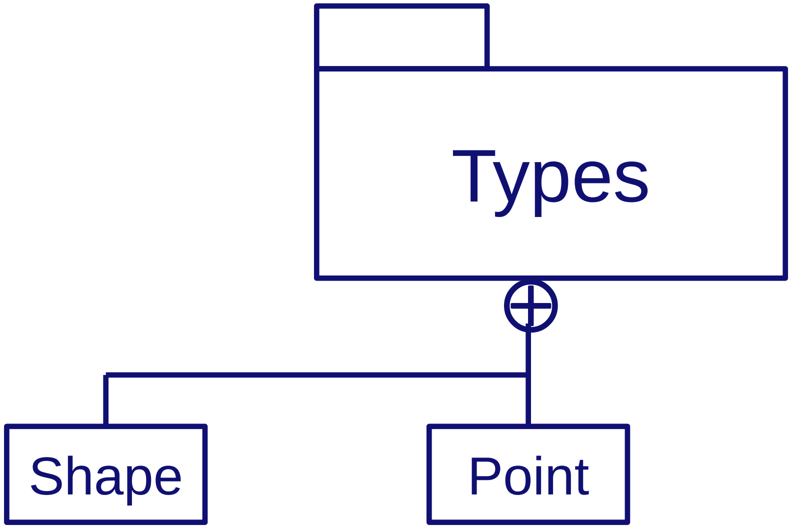
Package representations



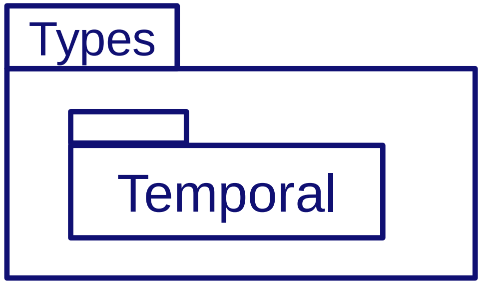
Package Types,
members not shown



Package Types, ***some*** members
within the borders of the package



Package Types, ***some*** members
shown using ⊕-notation



Nested packages

Relations

- Dependency
- Implementation
- Import / access
- Merge

Relations: Dependencies

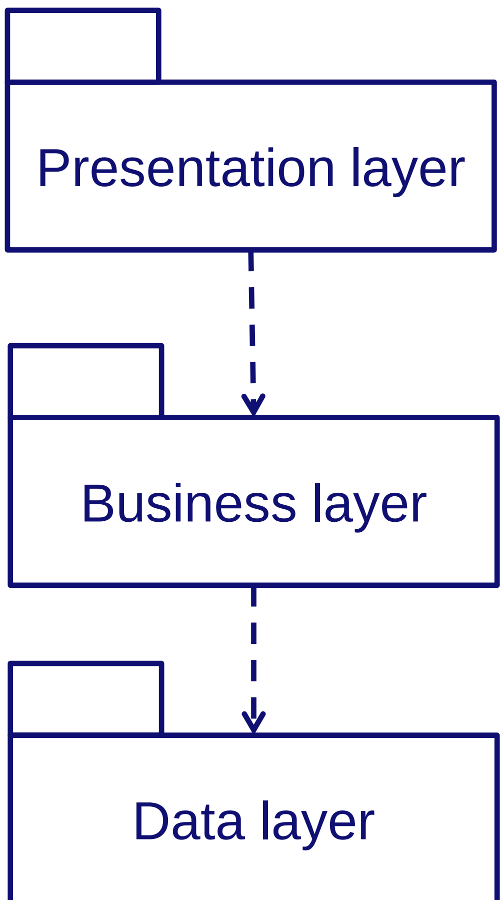
- Package A **depends** on package B if A contains a class which depends on a class in B
  - Summarise dependencies between classes

- Graphic representation:

or

Relations: Dependencies

- Package A **depends** on package B if A contains a class which depends on a class in B
  - Summarise dependencies between classes
- Typical 3-tier application (*sketch*):



UI, web-interface, services to other systems

Core calculations, operations, etc

Data storage (DB)

Relations: Dependencies

- Package A **depends** on package B if A contains a class which depends on a class in B
  - Summarise dependencies between classes

- Martin's **Acyclic Dependency Principle**

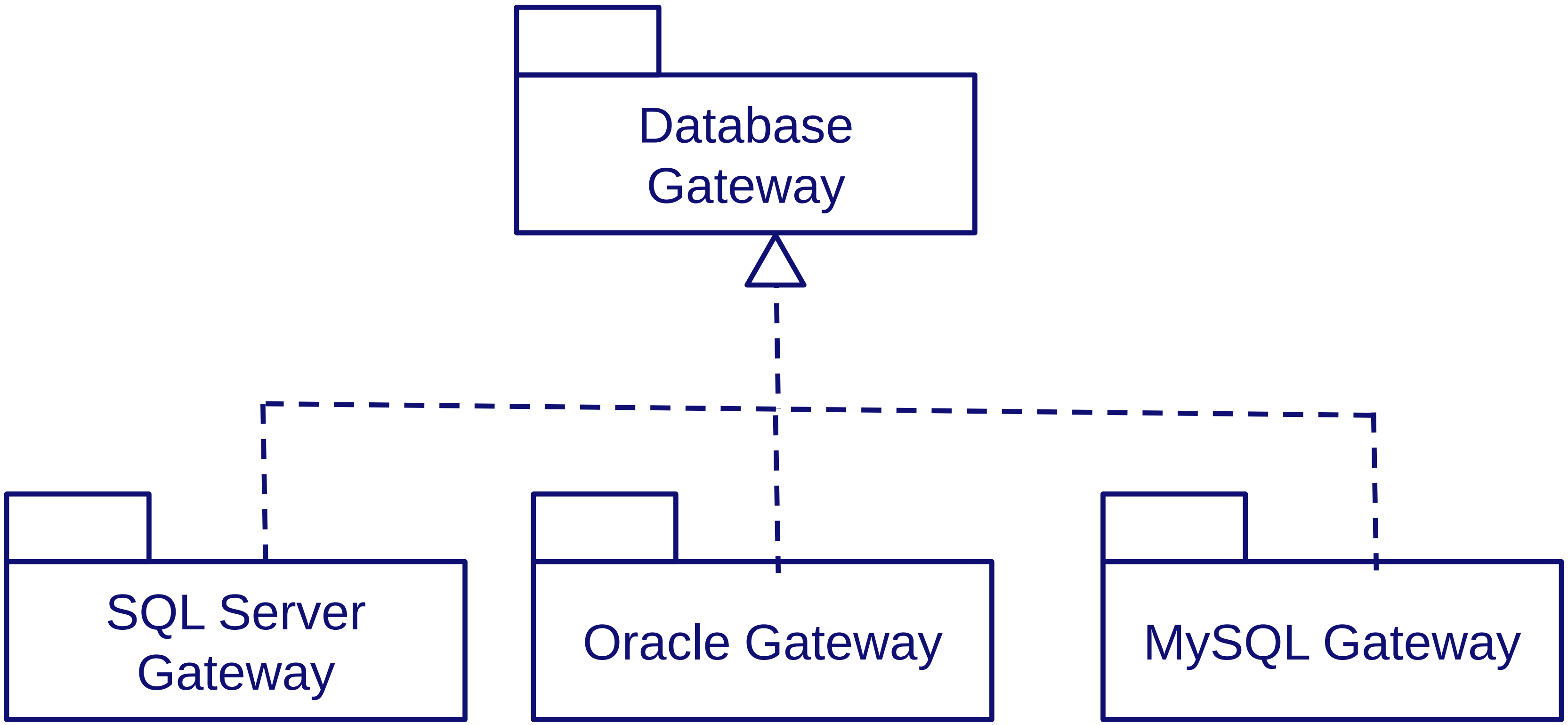
  there should be no cycles in the dependencies

- Fowler:

  If there are cycles in dependencies, these cycles should be localized, and, in particular, should not cross the tiers

Relations: Implementations

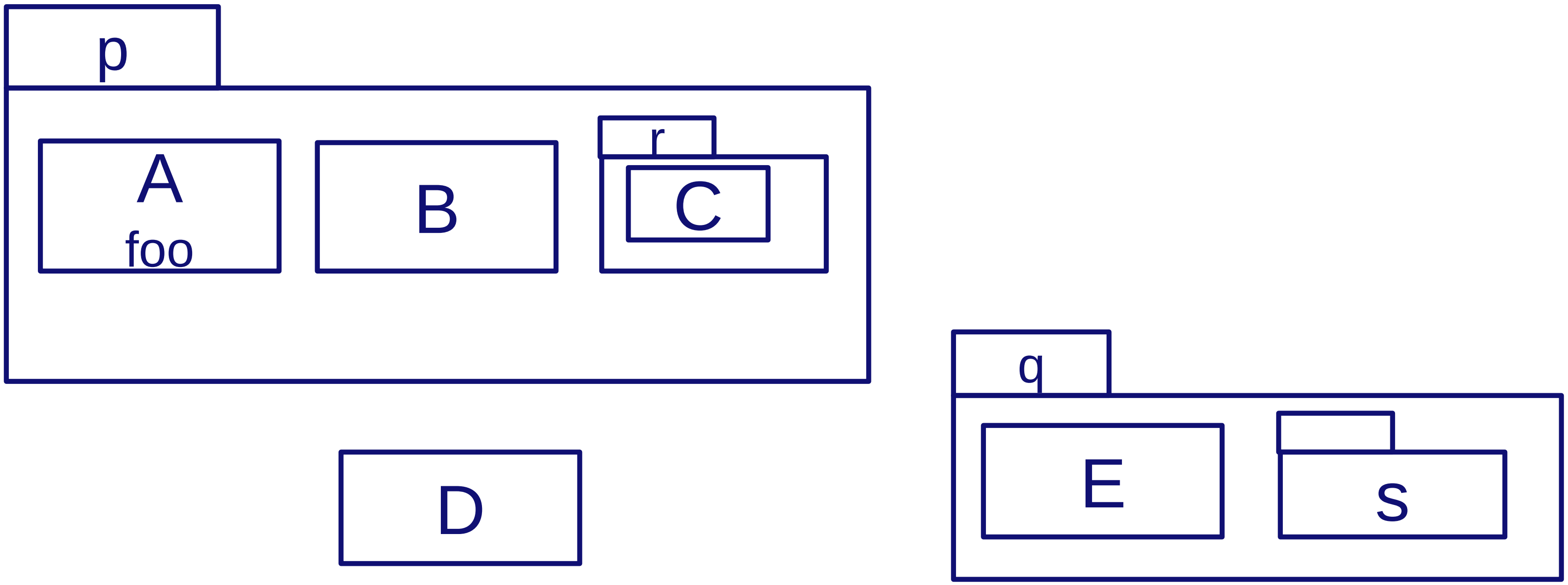
- Meaningful if multiple variants are present



Relations: Import / access

- To understand the **import / access** relation between packages
  - We need to know how **elements can reference each other**
  - What does an **element import / access** mean
  - How this notion can be generalized to **packages**

How elements can reference each other? (1)



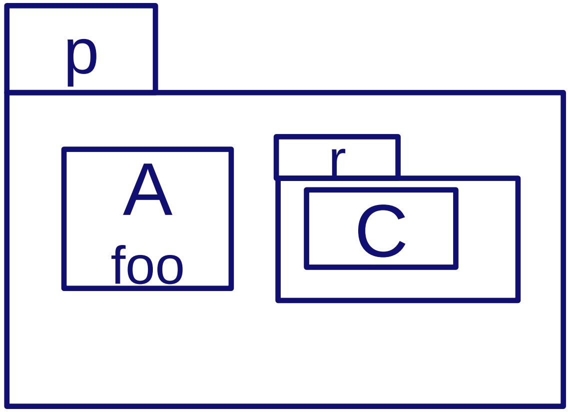
- Element can refer to other elements that are in its own package and in enclosing packages without using fully qualified names

Do you remember?

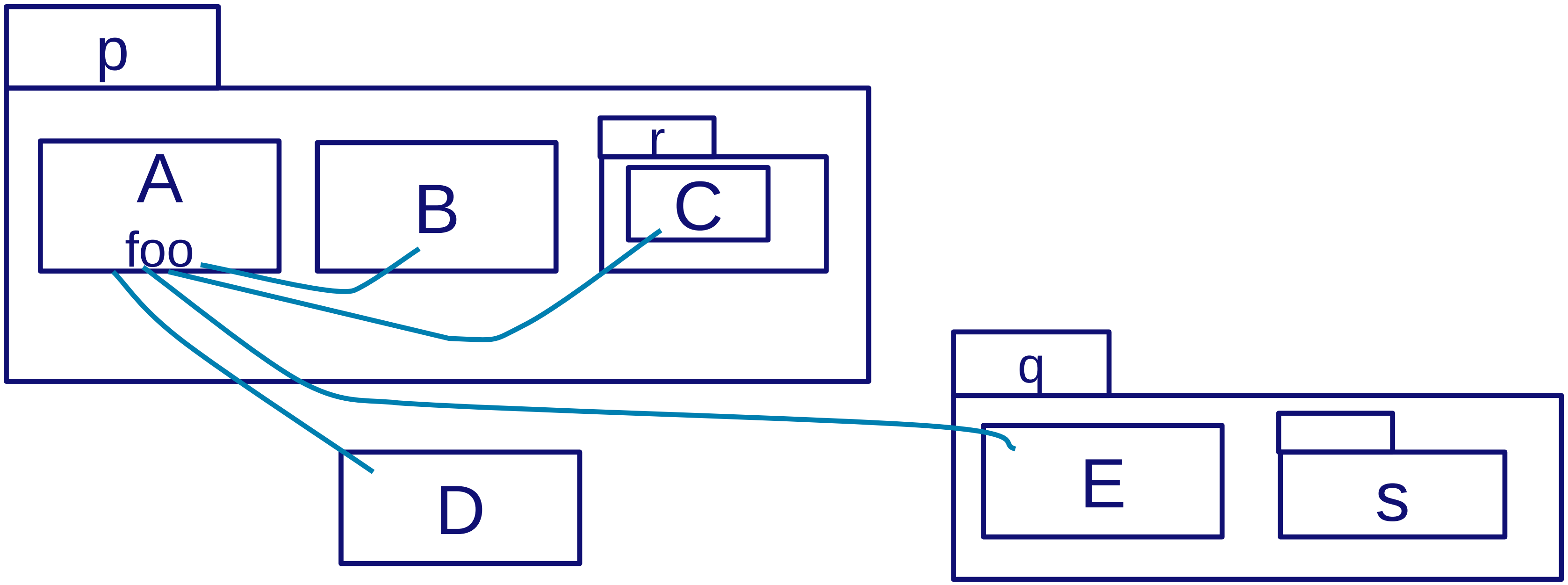
- **Fully qualified name**: a globally unique identifier of a package, class, attribute, method.

- **Fully qualified name** is composed of
  - **qualifier**: all names in the hierarchic sequence above the given element
  - the **name** of the given element itself

- Notation
  - UML, C++, Perl, Ruby **p::A::foo**, **p::r::C**
  - Java, C# **p.A.foo**, **p.r.C**



How elements can reference each other? (2)



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Element Import (1)

- Element import allows an element in another package to be referenced using its name without a qualifier
  - **<<import>>** imported element within importing package is public
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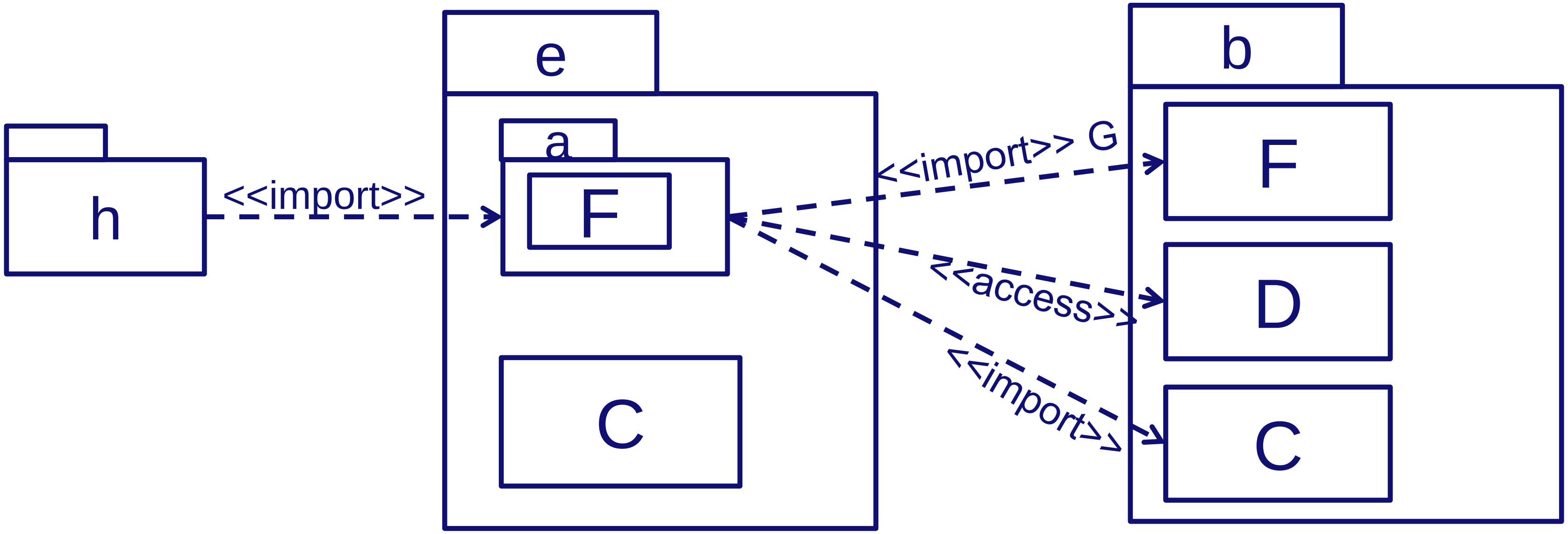

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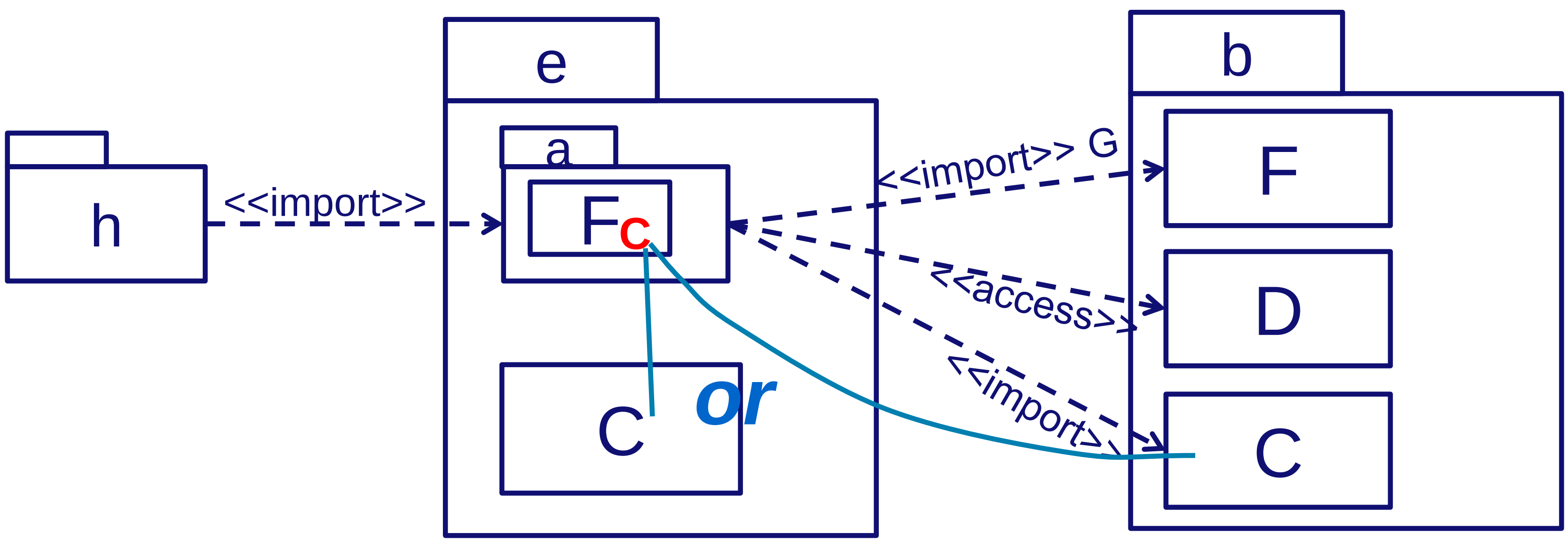

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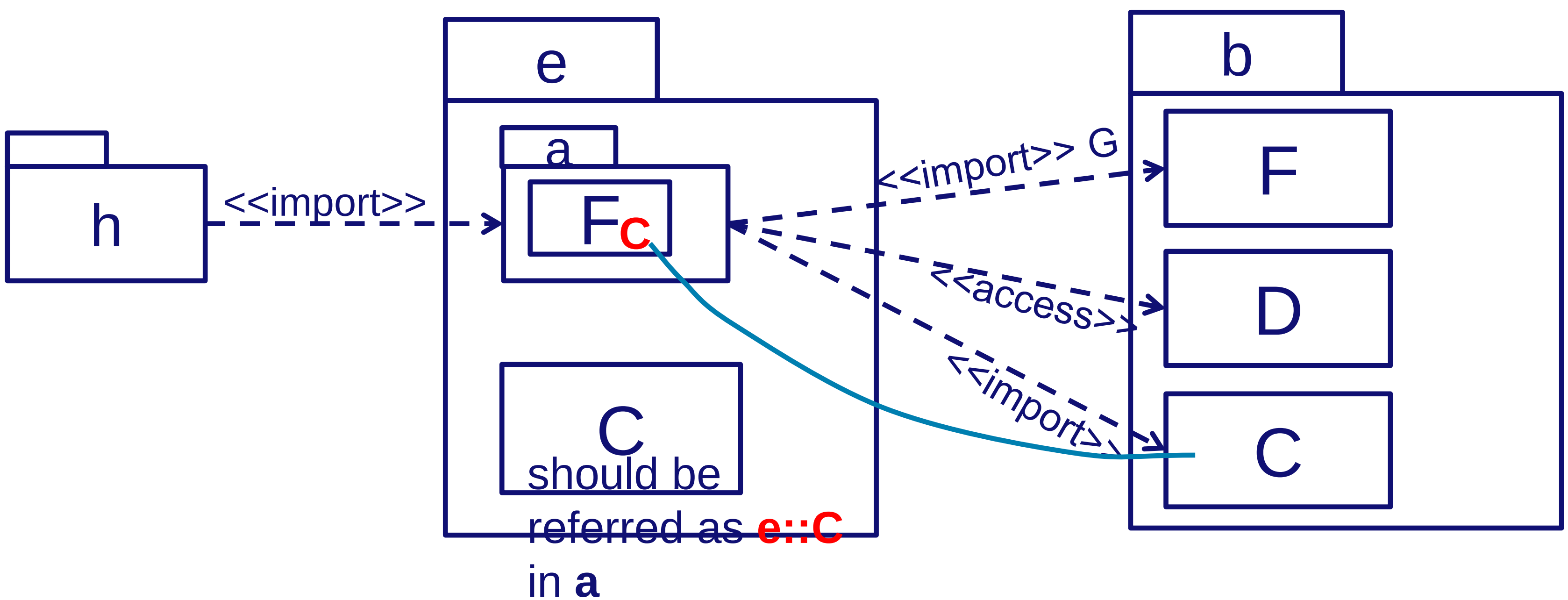

Element Import (5)

- Element import allows an element in another package to be referenced us
  - **<<import>>** impo s public
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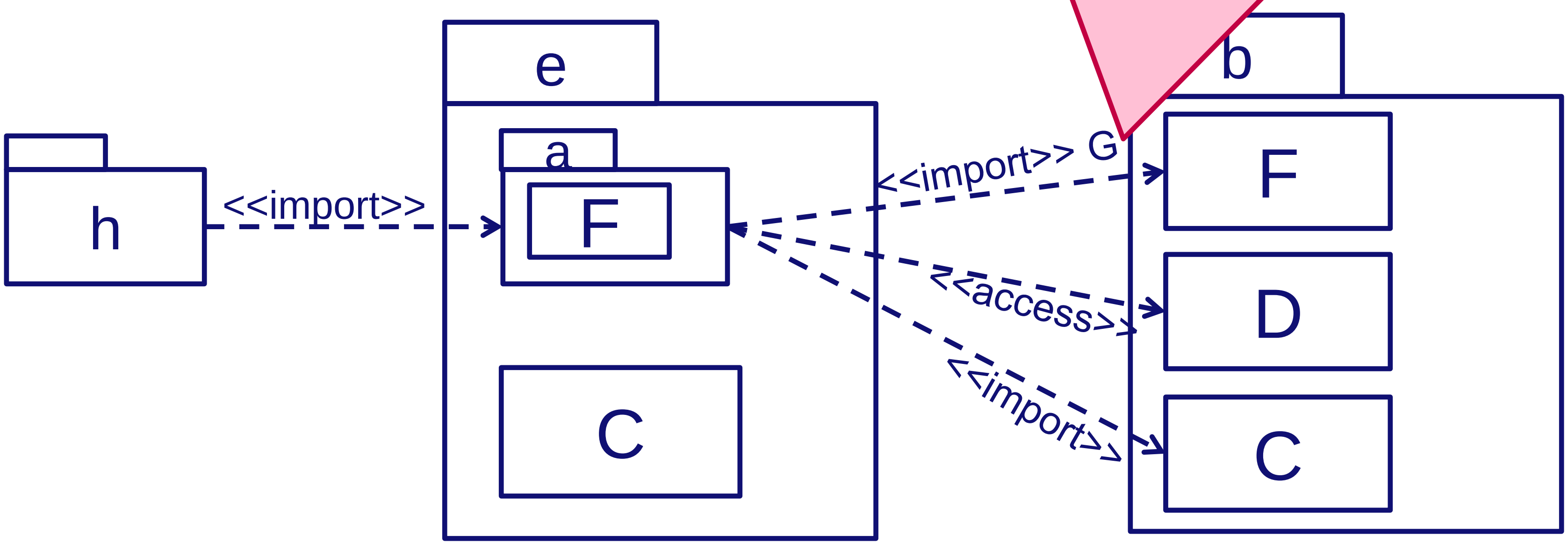
F cannot be imported to a since there is already an **F** in **a**. Hence, we need to rename **b::F** to **G** in **a**.



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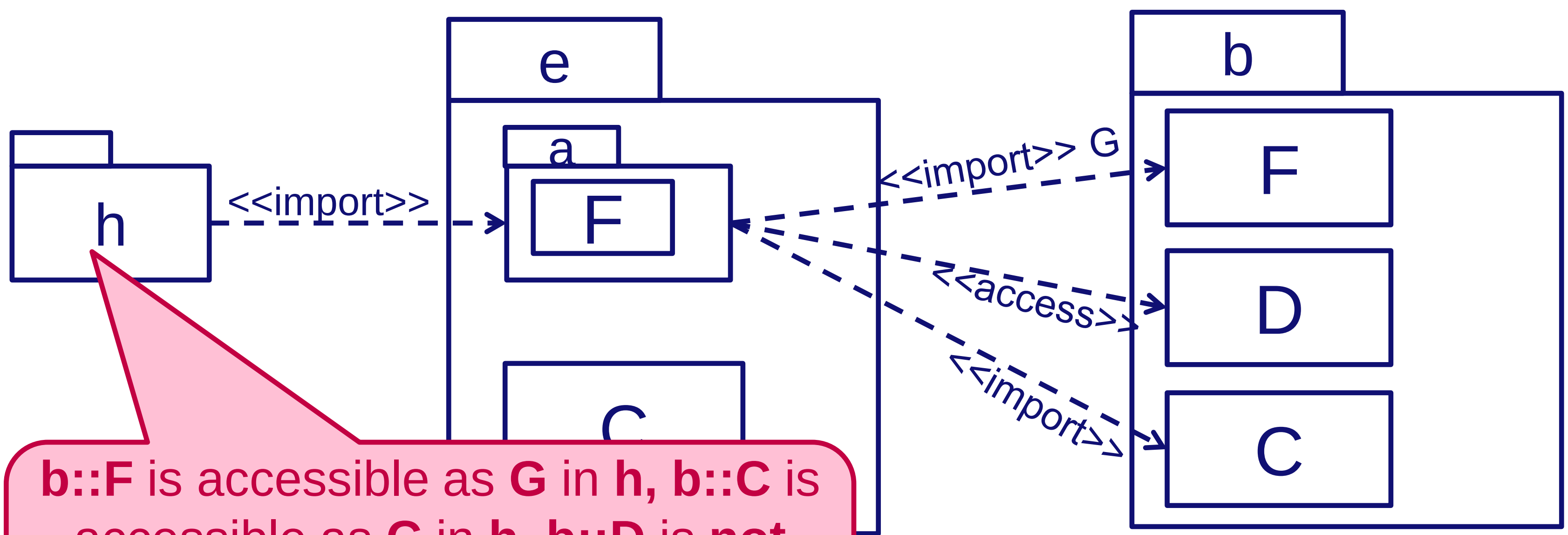

b::F is accessible as **G** in **h, b::C** is accessible as **C** in **h**, **b::D** is **not** accessible in **h** (private visibility of **b::D** in **a** due to **<<access>>**).

Package import (1)

- A **package import** identifies a package whose members are to be imported
  - Conceptually equivalent to having an element import to each individual member of the imported package
  - **<<import>>** if package import is public
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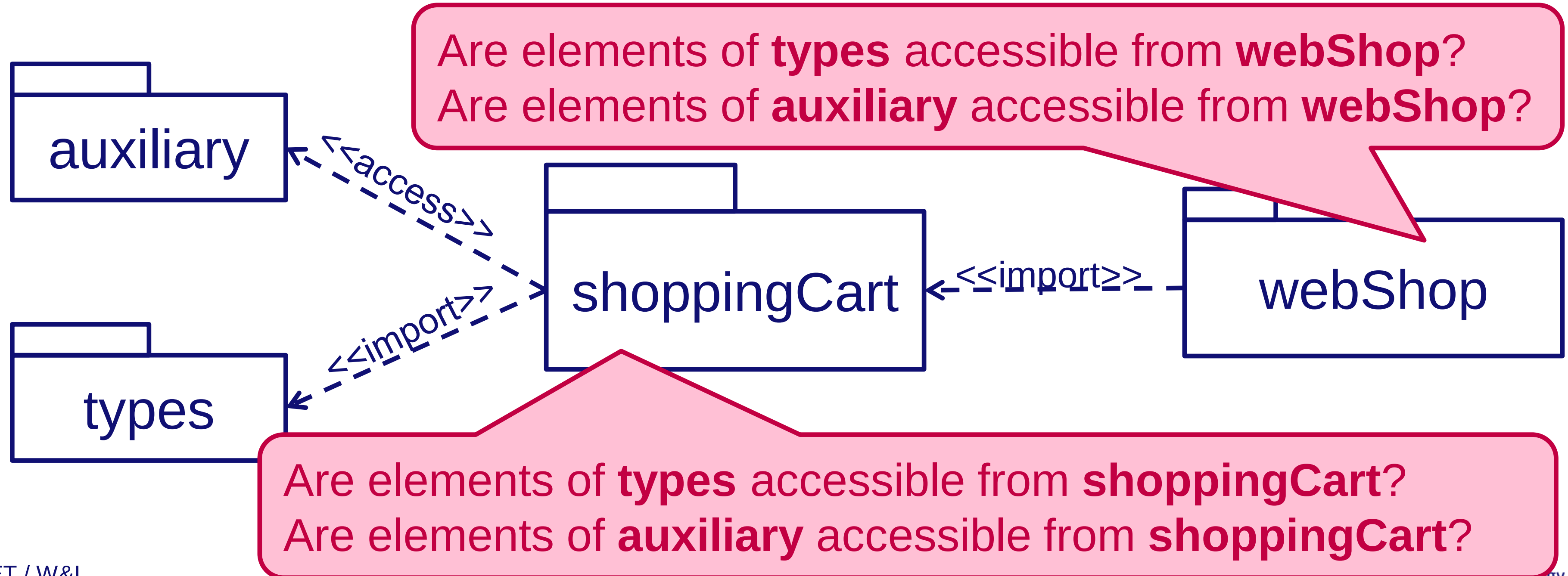

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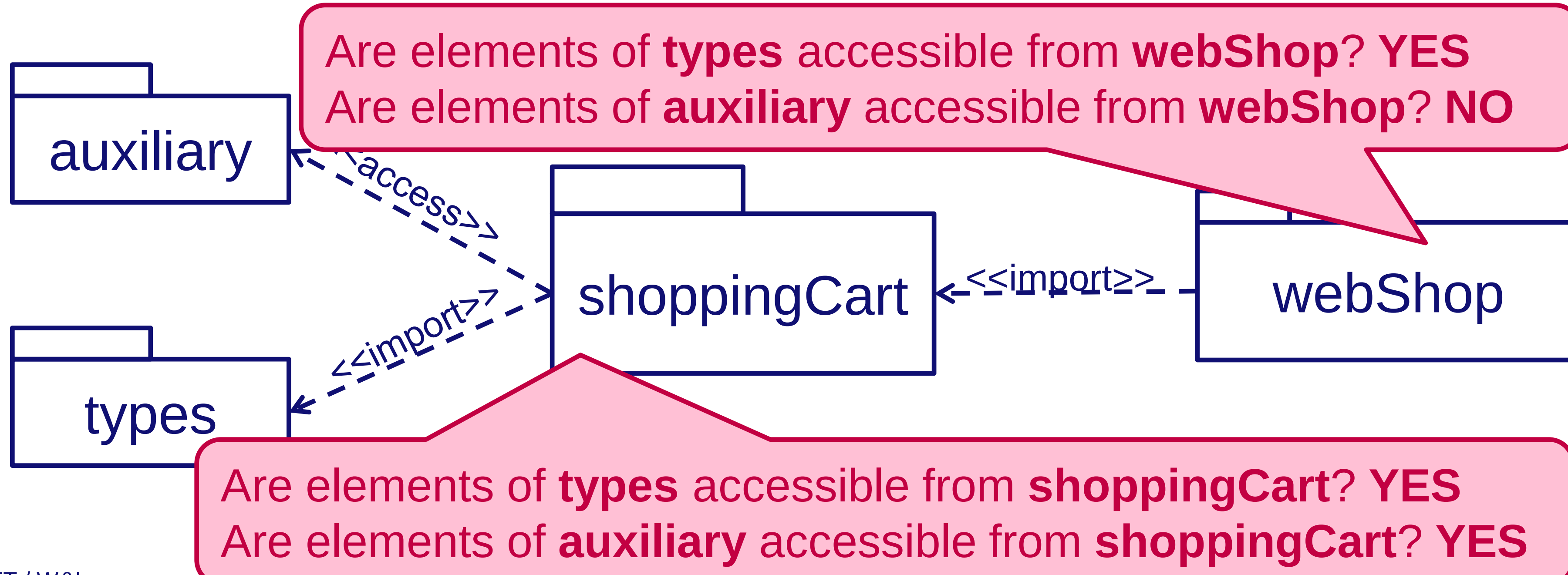

Relations: Recap

- ✓ Dependency
- ✓ Implementation
- ✓ Import / access
- Merge

Package merge

- A **package merge** indicates that the contents of the two packages are to be combined.
  - A (merged package) is merged into B (receiving package) that becomes B' (resulting package)

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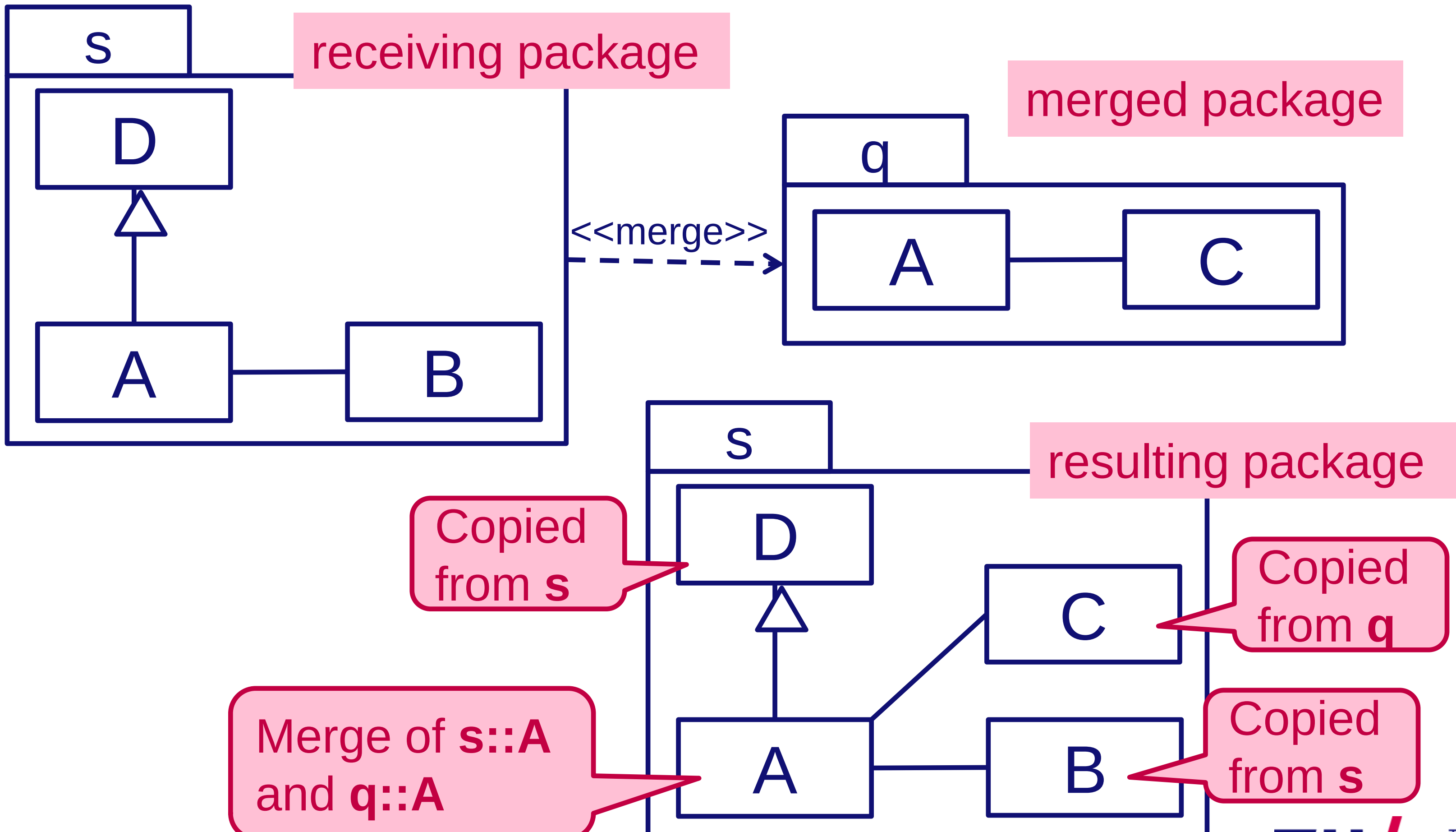
- Merge is **possible** only if
  - There is no cycle on “merge” dependencies
  - Receiving package does not contain the merged package
  - Receiving package is not contained in the merged package
  - Receiving element cannot have references to the merged element
  - Matching typed elements should have the same type (class) or a common supertype (superclass)

Merge rules

UML 2.5 Beta 2, pp. 252-262
http://www.omg.org/spec/UML/2.5/Beta2/



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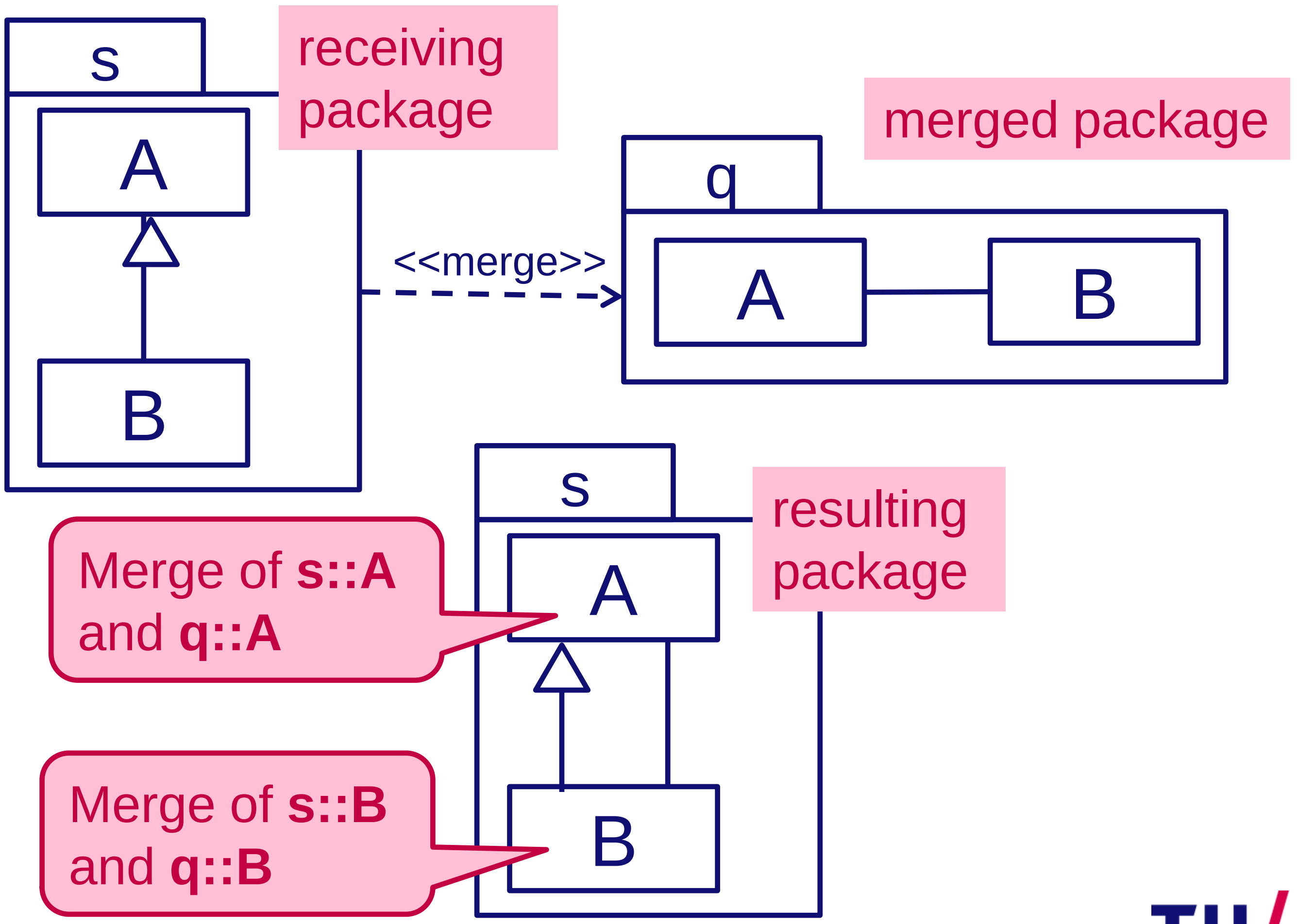
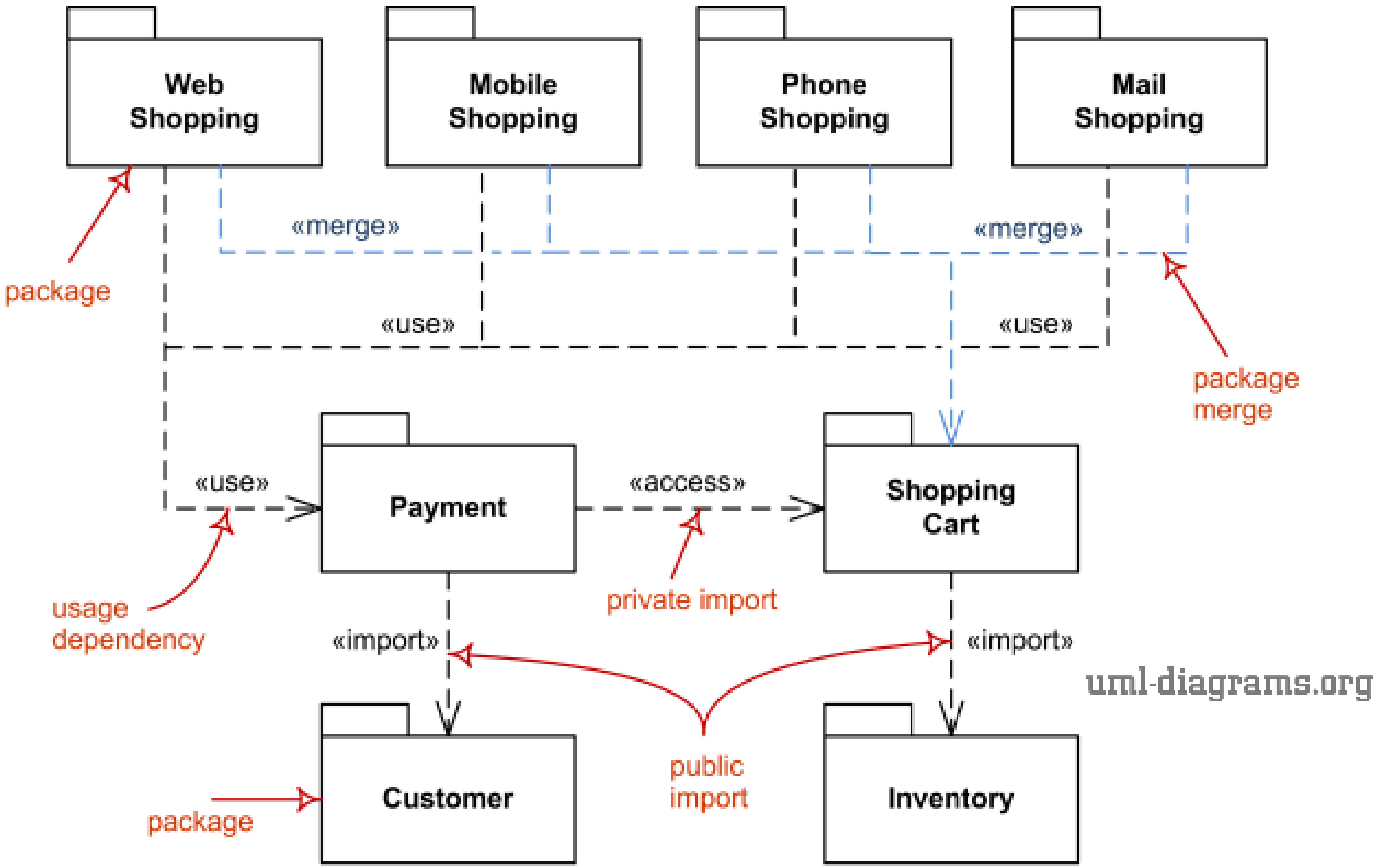


Summary: UML package diagrams



http://www.uml-diagrams.org/package-diagrams-overview.html

How do we organize classes/use-cases in packages?

- **General**: try to give packages meaningful names

- Two special cases:
  - **Class package diagrams**
    - “basic elements” are class diagrams
    - The most popular special case
  - **Use-case package diagrams**
    - “basic elements” are use-case diagrams
    - Useful for larger projects to organize requirements

Class Package Diagrams

- **Heuristics** to organize classes into packages:
  - Classes of a framework belong in the same package.
  - Classes in the same inheritance hierarchy typically belong in the same package.
  - Classes related to one another via aggregation or composition often belong in the same package.
  - Classes that collaborate with each other a lot often belong in the same package.

How would you organize into 2 packages?

- Car, Cylinder, Driver, Driving License, Engine, Person, Wheel

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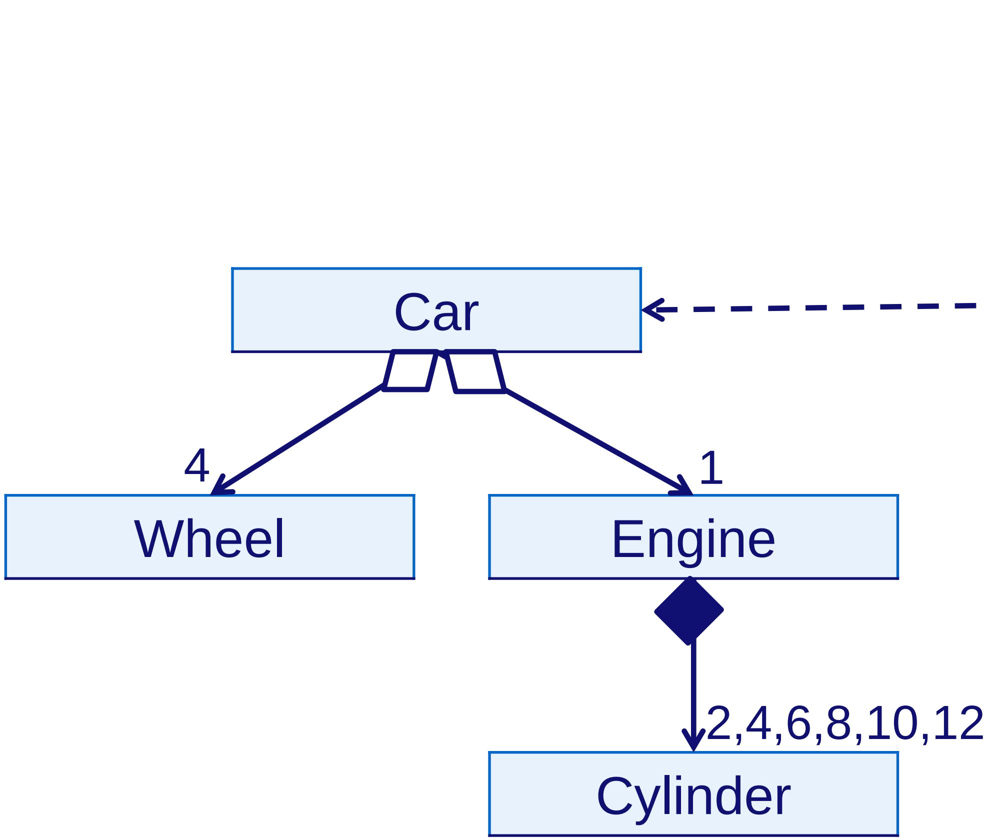

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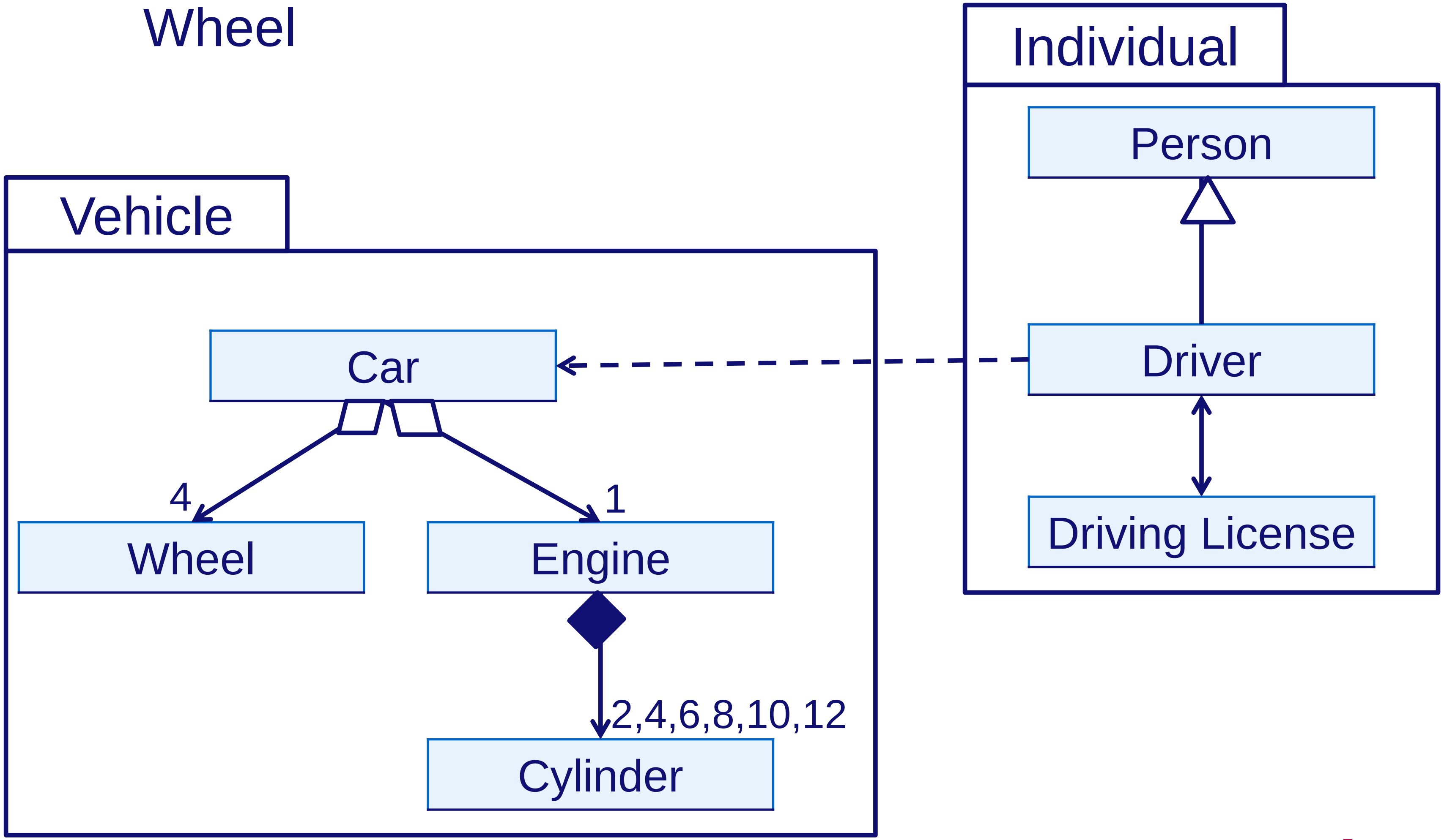

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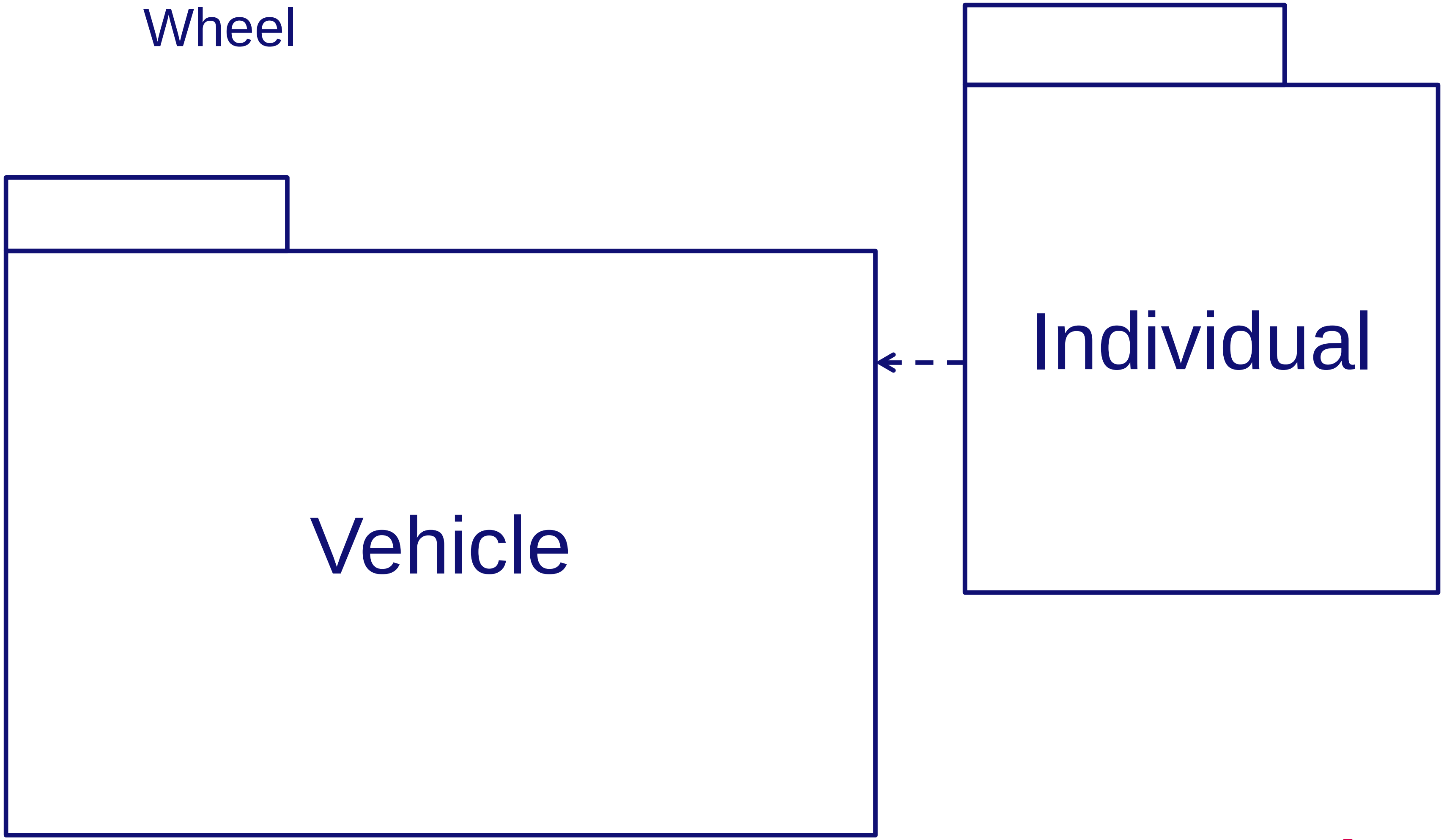
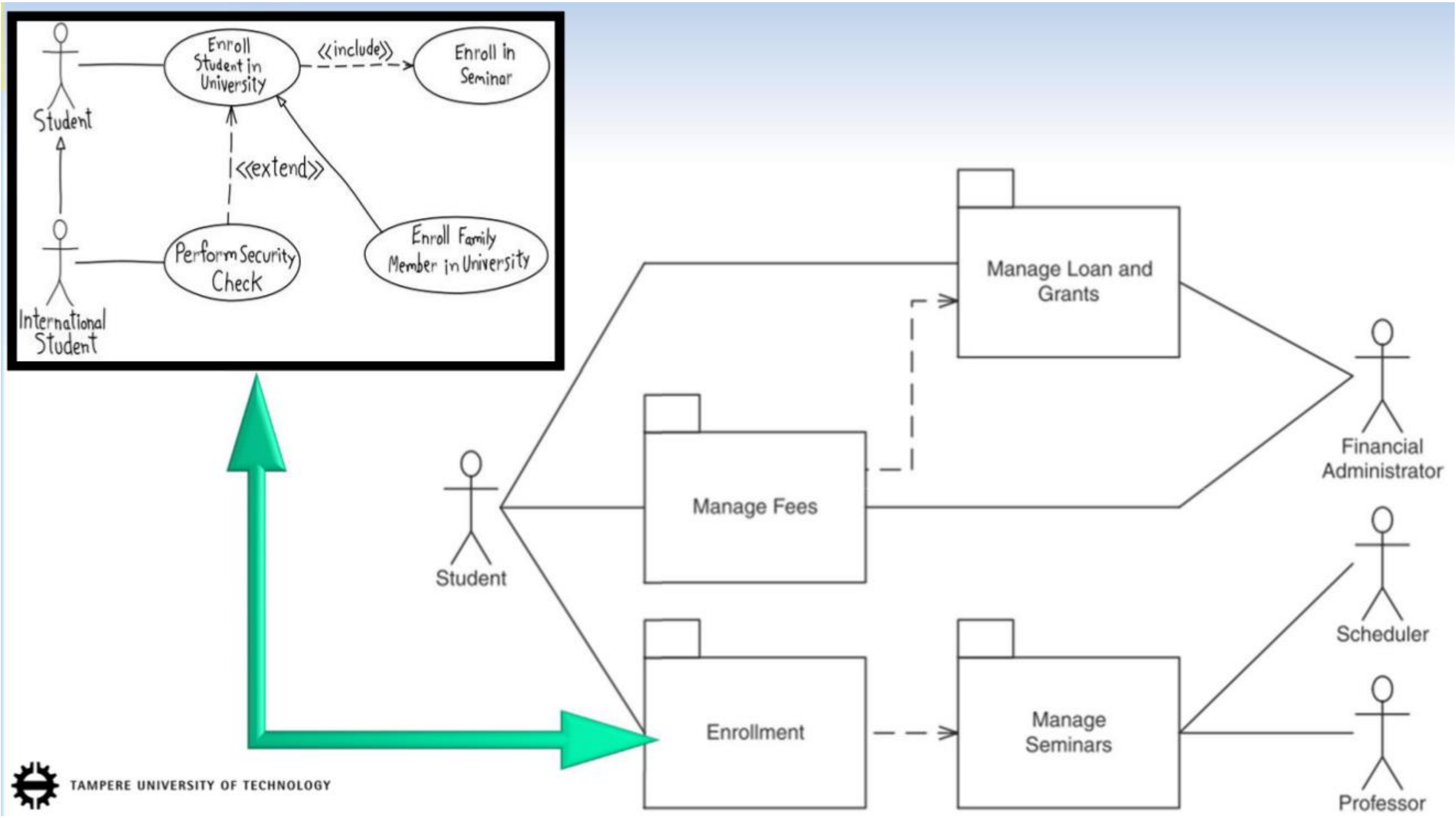


Use-Case Package Diagrams

- **Heuristics** to organize use cases into packages:
  - Keep **associated** use cases together: included, extending and inheriting use cases belong in the same package.
  - Group use cases on the basis of the needs of the main actors.

Use-Case Package Diagram Example



http://www.students.tut.fi/~kontrom/files/Lecture6.pdf

UML structure diagrams

Class diagram

Object diagram

Packages diagram

TODAY

Component diagram

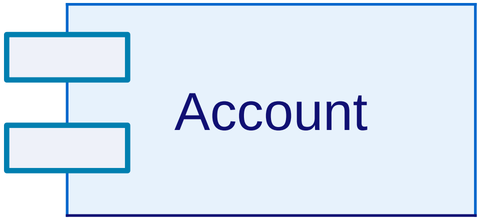
Deployment diagram

Composite structure diagram

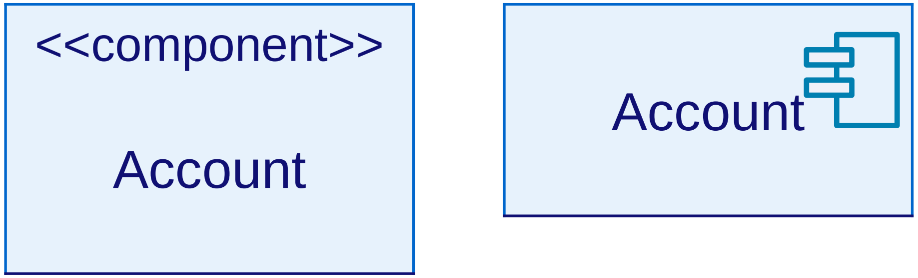
Component diagrams

- **Component**: a modular unit with well-defined interfaces that is replaceable within its environment (UML Superstructure Specification, v.2.0, Chapter 8)
  - fosters reuse
  - stresses interfaces

- Graphical representation: **special kind of class**



UML 1



UML 2

Component diagrams

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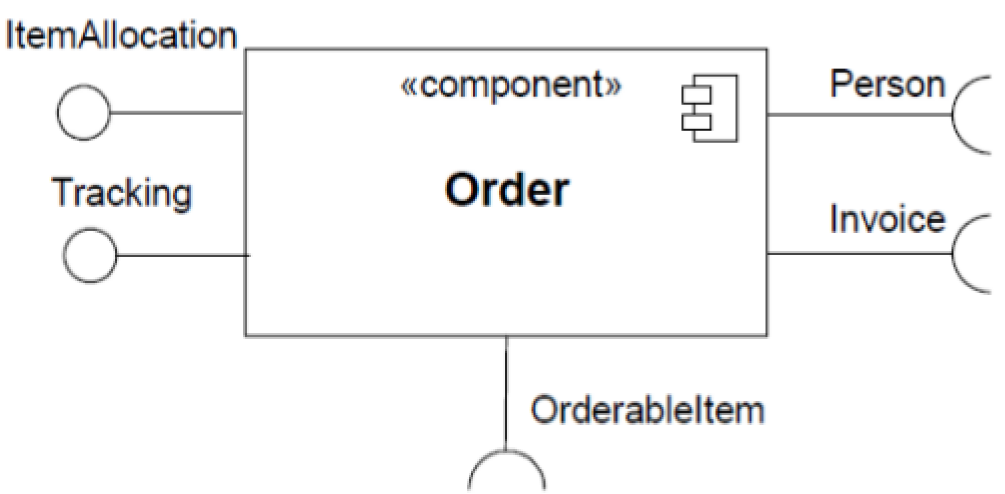
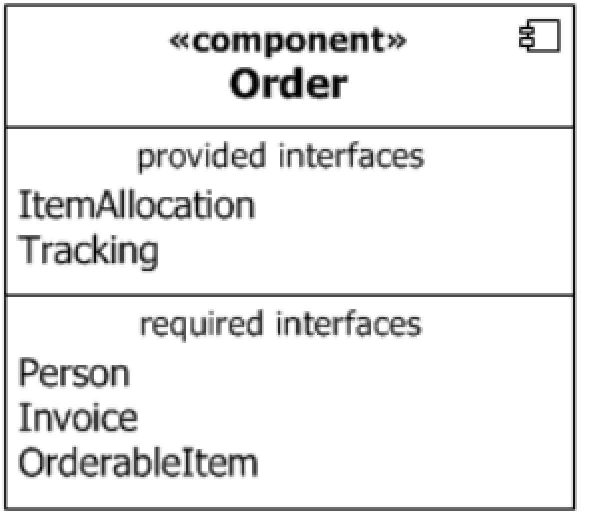
- Two views: black-box and white-box
  - **Black-box** view: interfaces provided and required only





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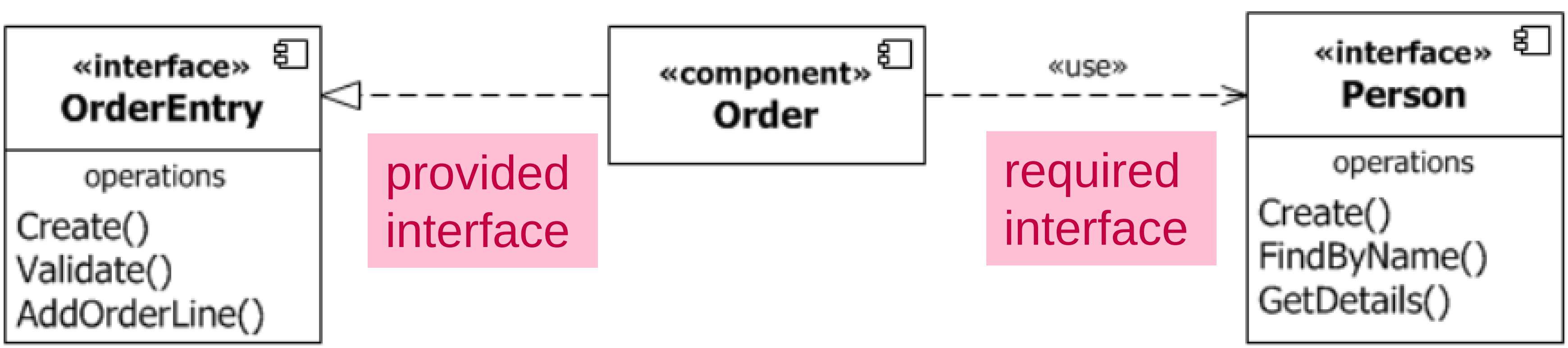

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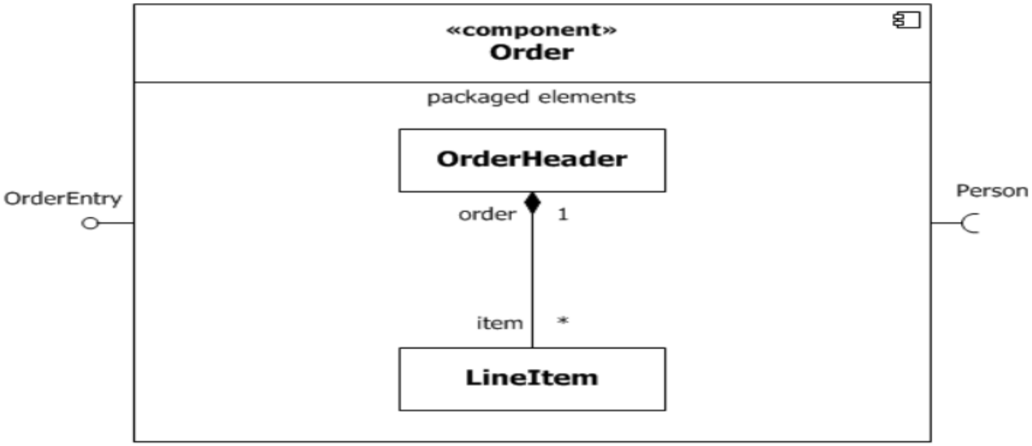

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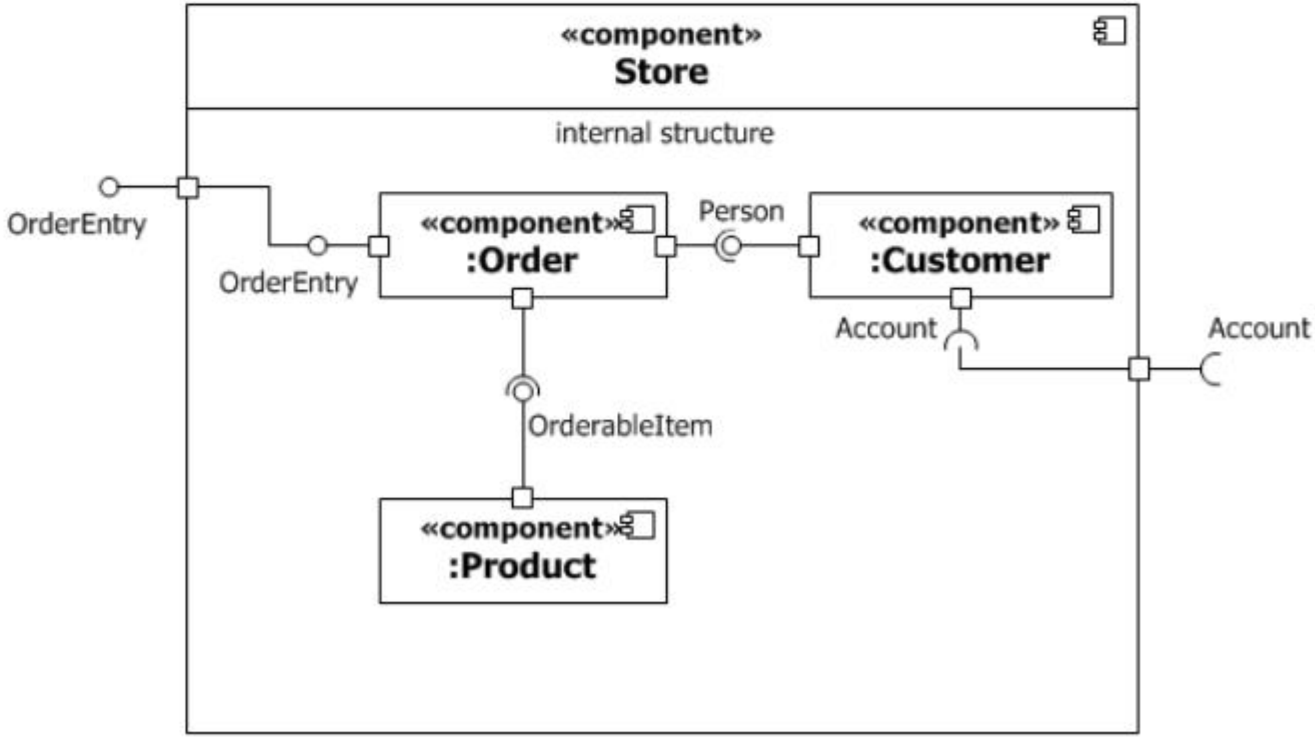
Nested components

- Components can be **contained** in other components
- Interfaces can then be **delegated** through **ports**



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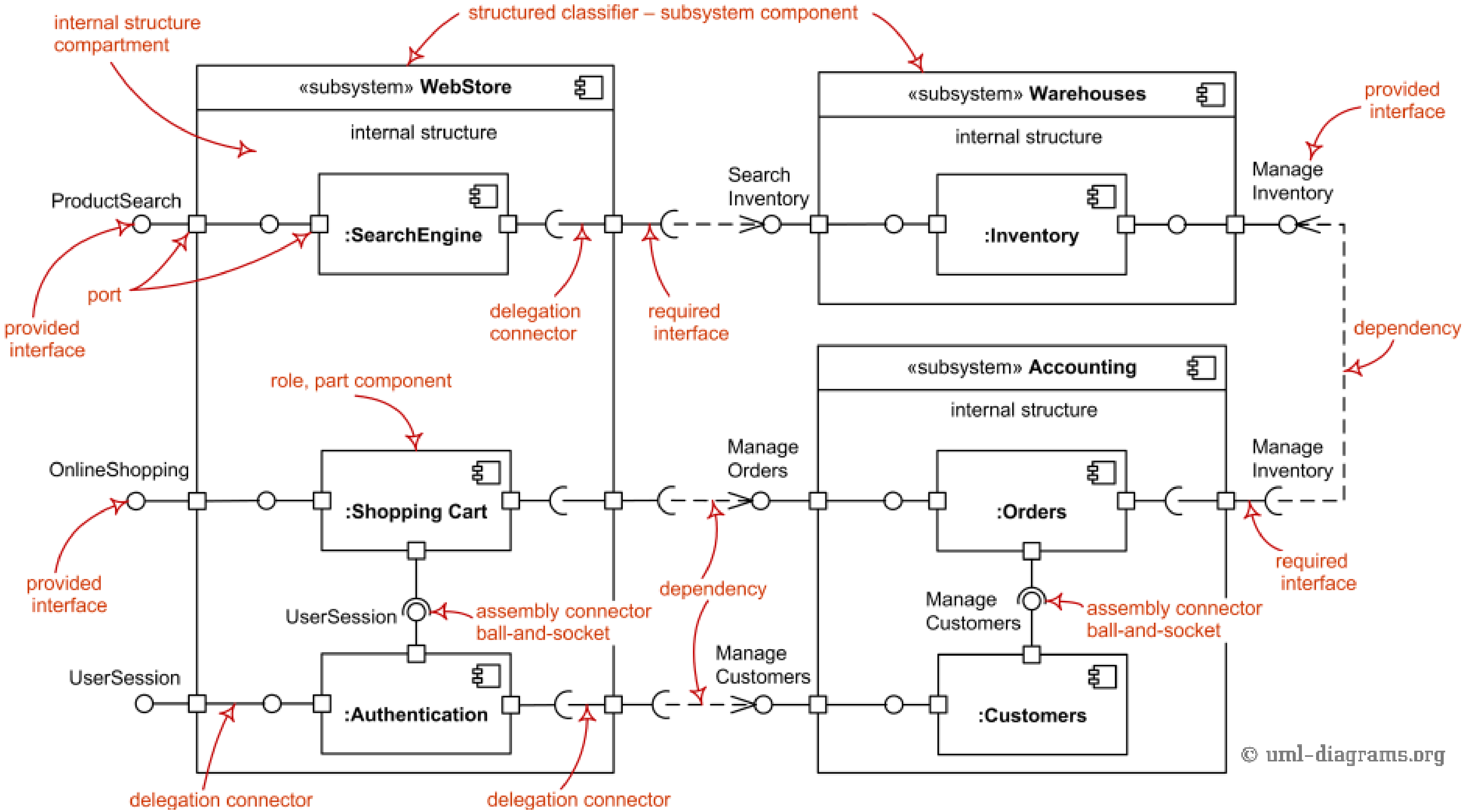
Summary: UML component diagrams



http://www.uml-diagrams.org/component-diagrams.html

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Deployment

- **Deployment**: relationship between logical and/or physical elements of systems (**Nodes**) and information technology assets assigned to them (**Artefacts**).

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  - **devices**: application server, client workstation, …
  - **execution environments**: DB system, J2EE container, …
  - Graphical representation: **box**

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- **Nodes**
  - **devices**: application server, client workstation, …
  - **execution environments**: DB system, J2EE container, …
  - Graphical representation: **box**
- Nodes can be **physically connected** (e.g., via cables or wireless)
  - UML-parlance: CommunicationPath
  - Graphical representation: as an association

Deployment

- **Deployment**: relationship between logical and/or physical elements of systems (**Nodes**) and information technology assets assigned to them (**Artefacts**).

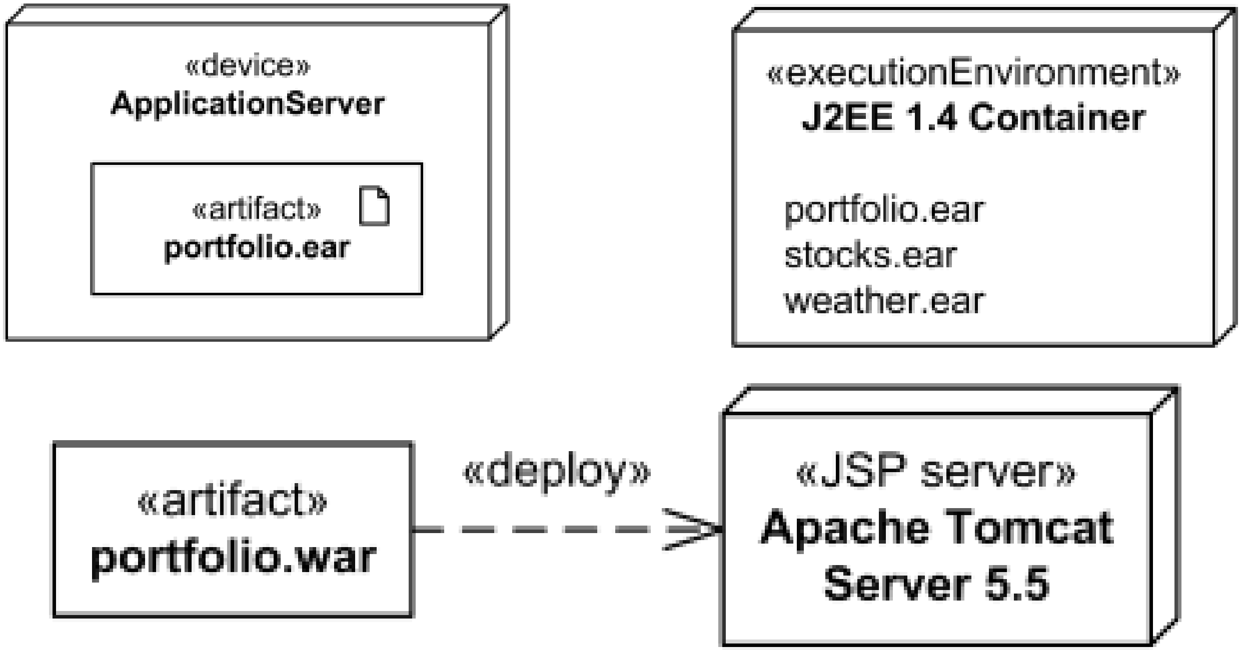
- **Artefacts**: information items produced during software development or when operating the system
  - model files, source files, scripts, executable files, database tables, word-processing documents, mail messages, …
  - Graphical representation: “class-like”

- Relations: dependencies

Deployment

- **Deployment**: relationship between logical and/or physical elements of systems (**Nodes**) and information technology assets assigned to them (**Artefacts**).

- Deployment: three equally valid representations



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Deployment: missing piece

- How do we know where a given use case, class, component, or package is deployed?
  - Use case / class / component / packages diagrams do not discuss deployment
  - Deployment diagrams do not discuss use cases / classes / components / packages but only artifacts

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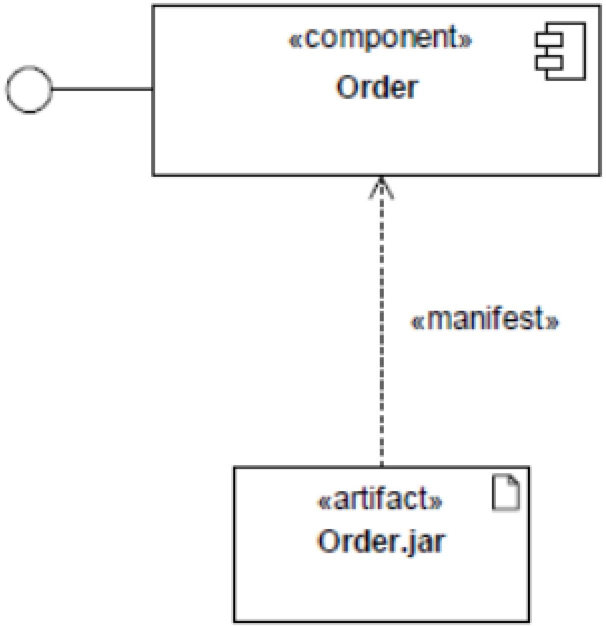
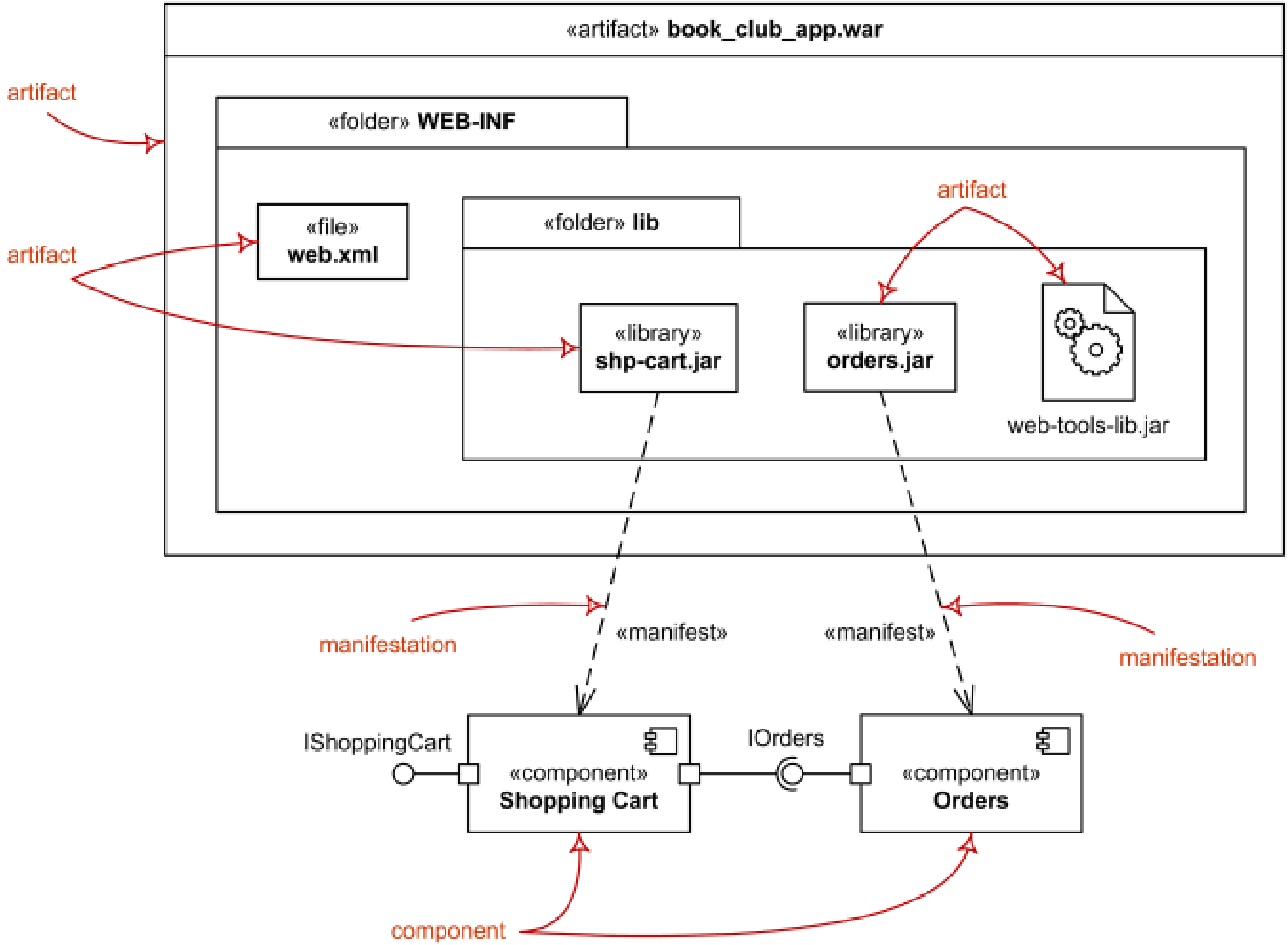
- **Manifestation** maps artifacts to use cases / classes / components / packages



Summary: deployment diagrams



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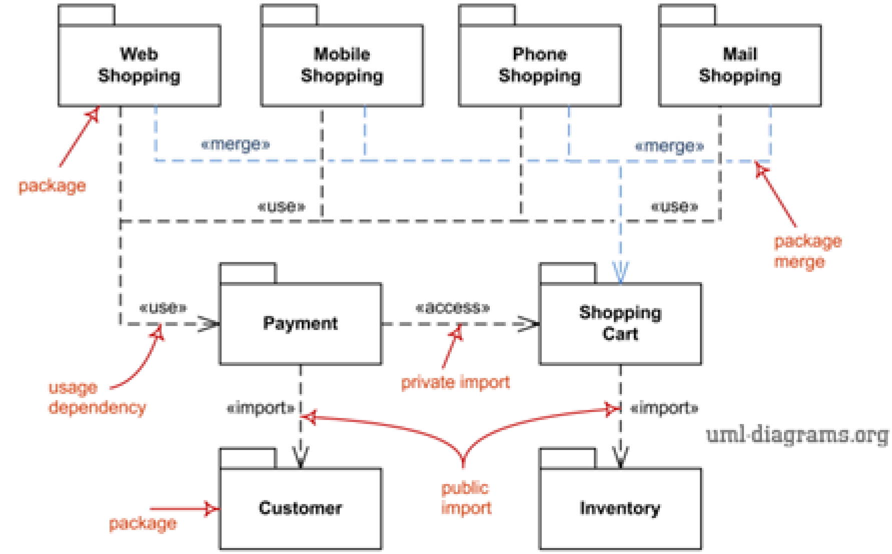

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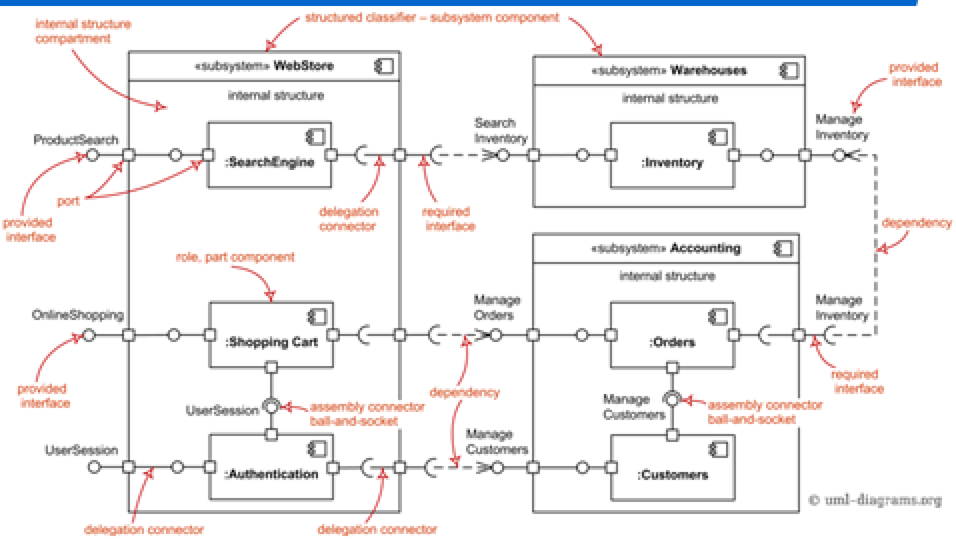

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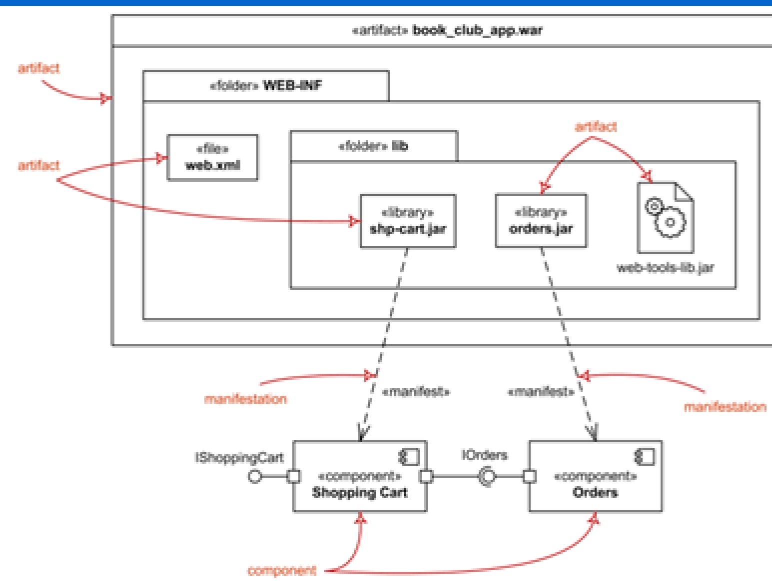

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