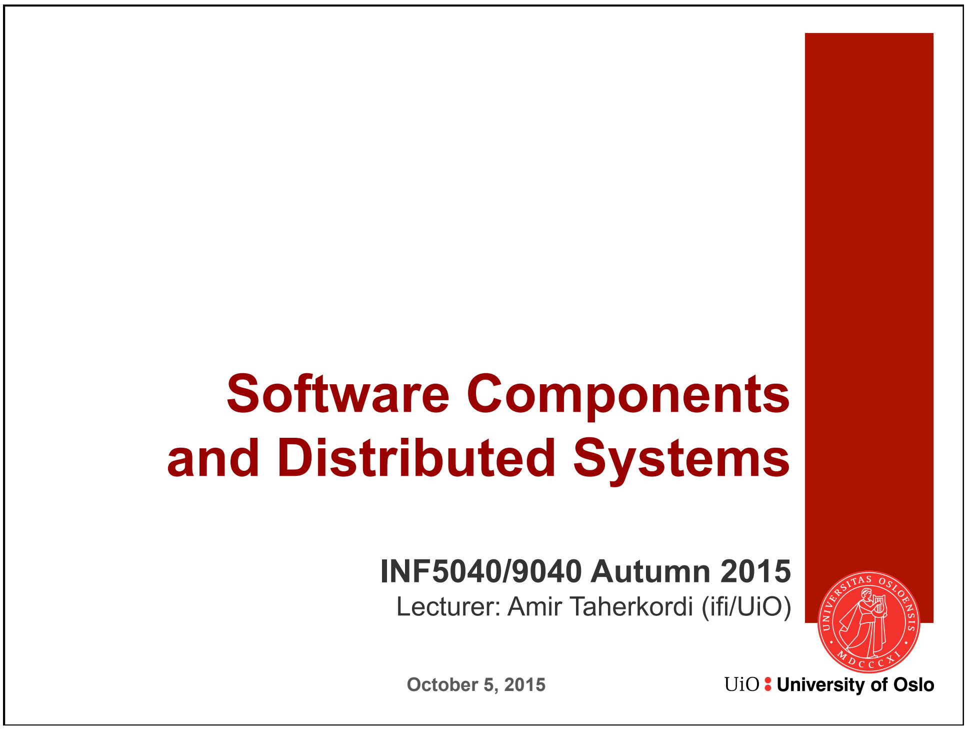

Software Components and Distributed Systems

INF5040/9040 Autumn 2015

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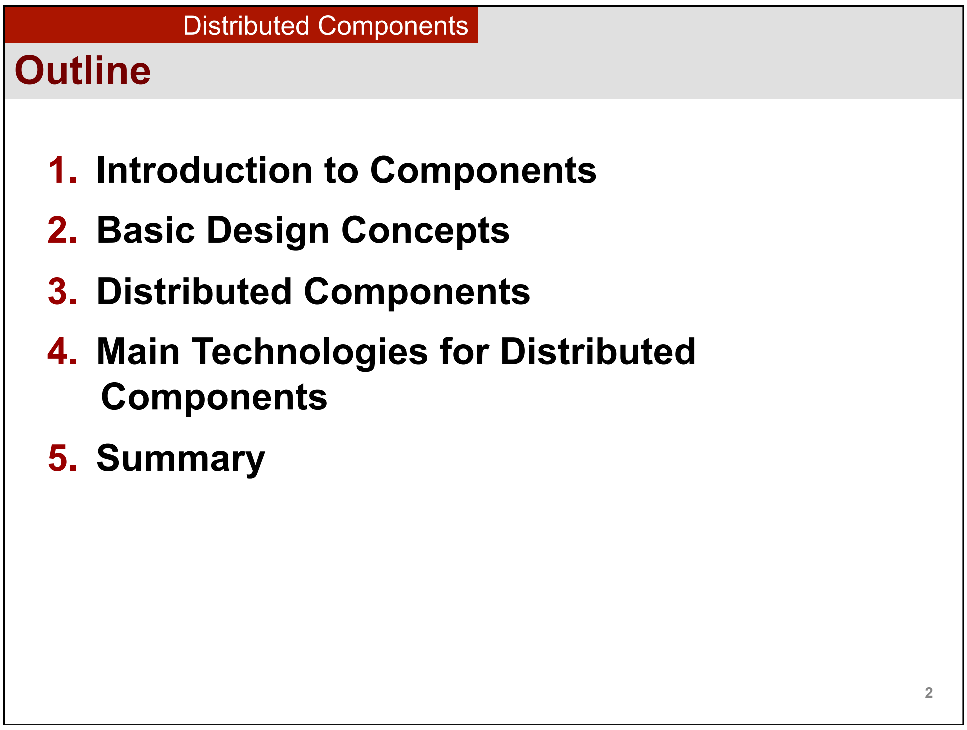
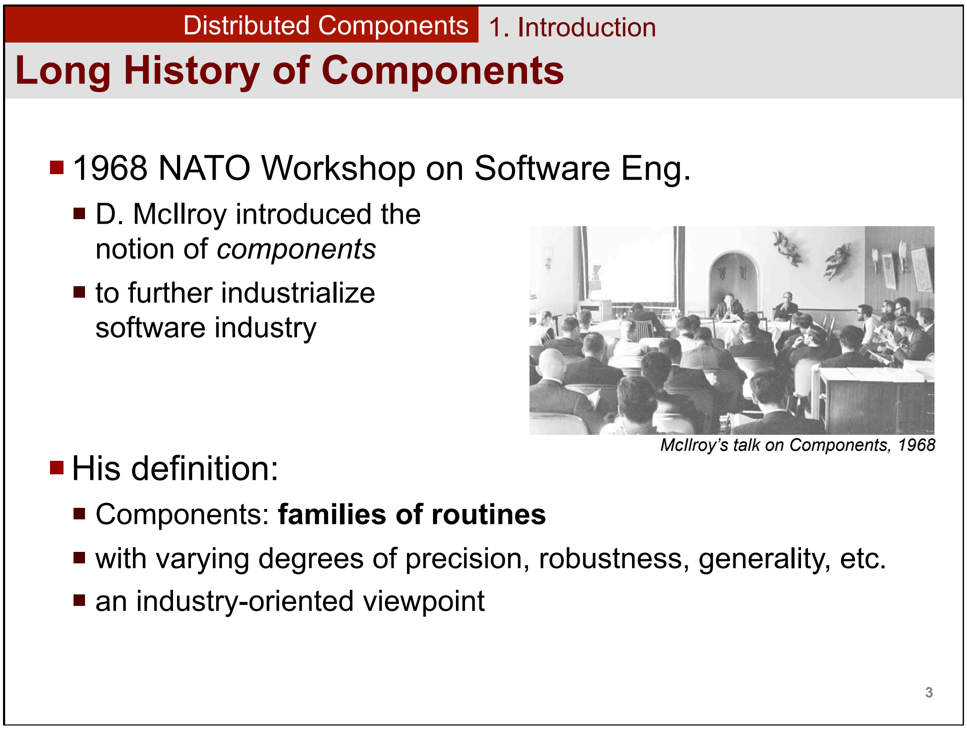


Distributed Components

Outline

1. Introduction to Components
2. Basic Design Concepts
3. Distributed Components
4. Main Technologies for Distributed Components
5. Summary

2



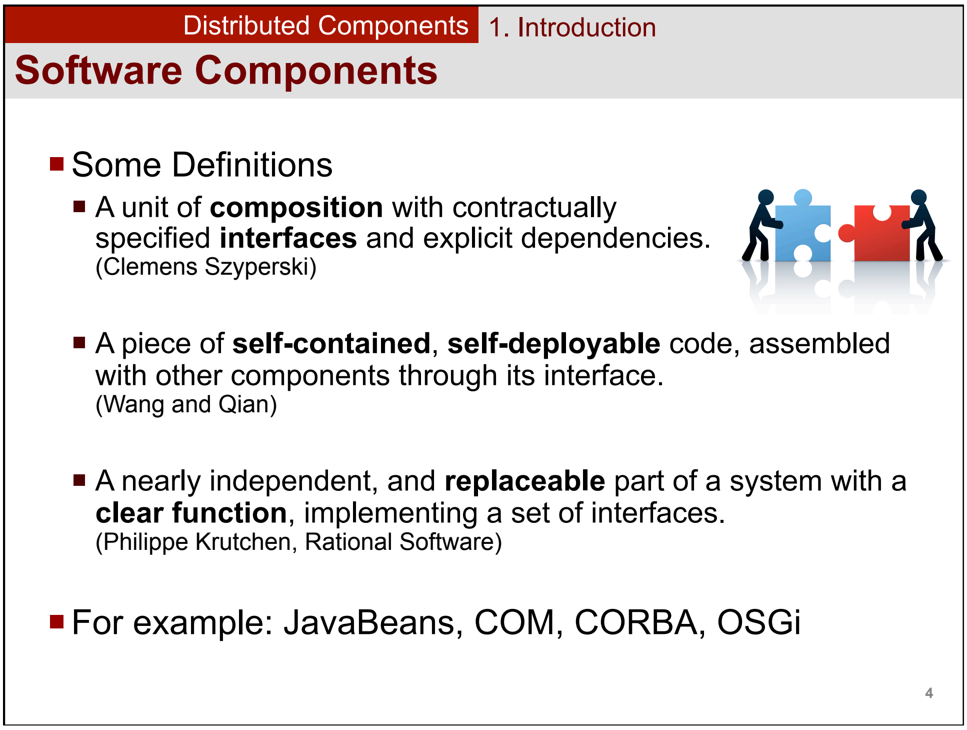
Distributed Components 1. Introduction

Long History of Components

- 1968 NATO Workshop on Software Eng.
  - D. McIlroy introduced the notion of *components*
  - to further industrialize software industry

McIlroy's talk on Components, 1968

- His definition:
  - Components: **families of routines**
  - with varying degrees of precision, robustness, generality, etc.
  - an industry-oriented viewpoint



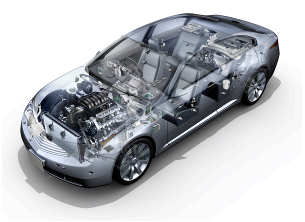
Distributed Components 1. Introduction

Software Components

- Some Definitions
  - A unit of **composition** with contractually specified **interfaces** and explicit dependencies.
    (Clemens Szyperski)
  - A piece of **self-contained**, **self-deployable** code, assembled with other components through its interface.
    (Wang and Qian)
  - A nearly independent, and **replaceable** part of a system with a **clear function**, implementing a set of interfaces.
    (Philippe Krutchen, Rational Software)
- For example: JavaBeans, COM, CORBA, OSGi

Distributed Components 1. Introduction

Why Components?

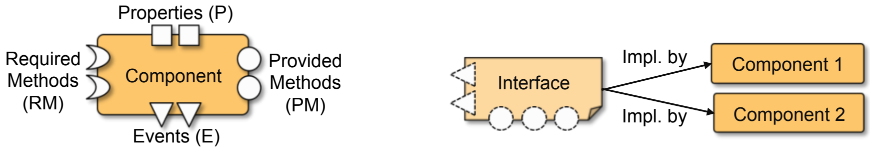


- A natural way for building systems, e.g., automotive industry
- Industrialized viewpoint to software production?
- Avoid handmade software products
- Main goals:
  - *Conquering Complexity*: increase in software size
  - *Managing Change*
  - *Software Reuse*: black-box, gray-box and white-box reuse

Distributed Components

Three Basic Design Concepts

I. Component Model



C = (P, PM, RM, E)

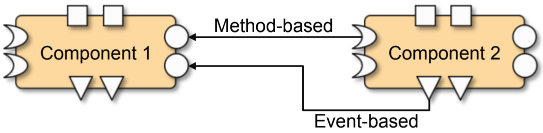
I = (PM, E)

- Binding of provided and required interfaces
  - Reflects direction of method calls (Not the direction of data flow)
  - Required interface
    - A set of method calls a component potentially may issue
- Support for distribution?
  - When the binding can be made across address spaces and computers

Three Basic Design Concepts – cont’d

II. Connection Models and Composition

- **Integrate** components to generate a **new component** with pre-defined composition operators.
- **Composition** is the fundamental method for construction, extension and reuse of components
- In contrast to inheritance in object-oriented models
- Main connectors:
  - Method-based: composition of components
  - Event-based



III. Deployment Models

- the process and activities for component **installation** and any necessary **configuration**.
- E.g., EJB produces a XML-based deployment descriptor

Designing a Component Platform

- The underlying foundation to **construct**, **assemble**, **deploy** and **manage** components.
- Defines rules for **deployment**, **composition** and **activation** of components.
- To deliver and deploy components: a standardized archive format that **packages component** code and meta-data
- Embraces three design concepts:
  - component model, connection model, and deployment model
- designed as a set of **contractually specified interfaces**
- **Contracts** agreed between components and a component platform

Designing a Component Platform – cont'd

- **Contracts** as the key design element
- What is a contract?
  - Set of **provided** interfaces: Some may be required by the component platform
  - Set of **required** interfaces: must be offered by other components available on the platform
  - Pre and post conditions/invariants
  - Extra-functional requirements: transactions, security, performance, ...
- Functions defined both syntactically and semantically
  - int add(int a, int b)
  - pre: a + b <= Integer.MAXINT
  - post: result' = a + b
- **Extra-functional** requirements
  - Guarantees: Response within 10 ms
  - Conditions: Needs 1000 CPU-cycles
  - Transaction requirements: e.g, create new transaction when component is invoked, serializable, ...

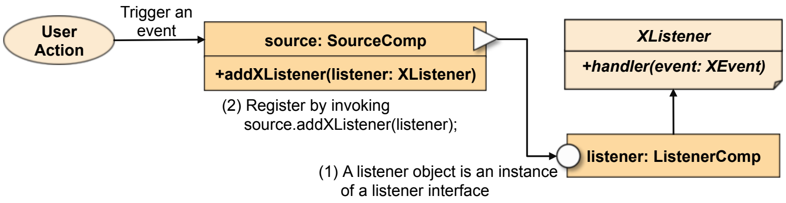
Components vs. Objects

- Objects
  - one mission: **encapsulation** for reusability
  - reusable class libraries, e.g., Foundation Classes for Java or C++
- Objects for reuse in the large?
  - fine-grained classes with **complex relationships** and dependencies
  - Difficult to take classes out of the lib and reuse

Object-Oriented	Component-based
classes and object	components
data types and hierarchies	interfaces and composition
implementation technology	packaging & distribution technology
tightly coupled: low-level reuse	loosely coupled: high-level reuse
limited sets of supported services: security, transactions, …	more support for high-level services: security and transactions, …

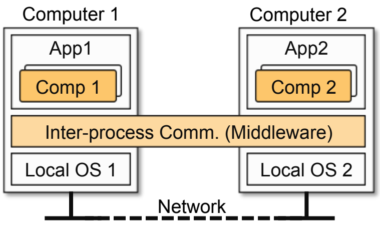
An Example: JavaBeans

- Java-based Component model
- A JavaBean component: **Properties**, **Methods**, **Events**, Customization, and Persistence.
- Requirements for developing beans:
  - implementing the `Serializable` interface to store/retrieve a bean
  - Properties: exposed through the “ set” and “ get” methods
  - Events: exposed through public “add” and “remove” methods
- Example: JavaBean Events


User Action
Trigger an event
source: SourceComp
+addXListener(listener: XListener)
(2) Register by invoking source.addXListener(listener);
XListener
+handler(event: XEvent)
listener: ListenerComp
(1) A listener object is an instance of a listener interface

Distributed Components

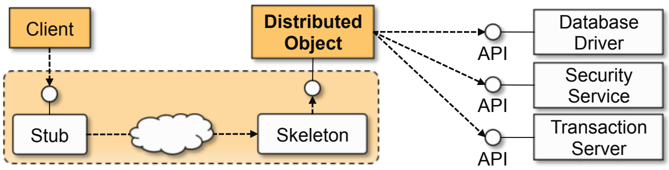
- Advantages of distribution
  - Load sharing
  - Increased availability
  - Heterogeneity
  - Replication
  - …
- Distributed components
  - characteristics of components + functionality of middleware systems
  - inter-process communication across machine boundaries



- An evolution of **distributed objects**

Revisit Distributed Objects

- Objects that
  - reside in separate address spaces
  - their methods are remotely accessible: client & server objects
- Distributed object middleware
  - Infrastructure for access to remote objects transparently
  - based on the Remote Procedure Call (RPC)

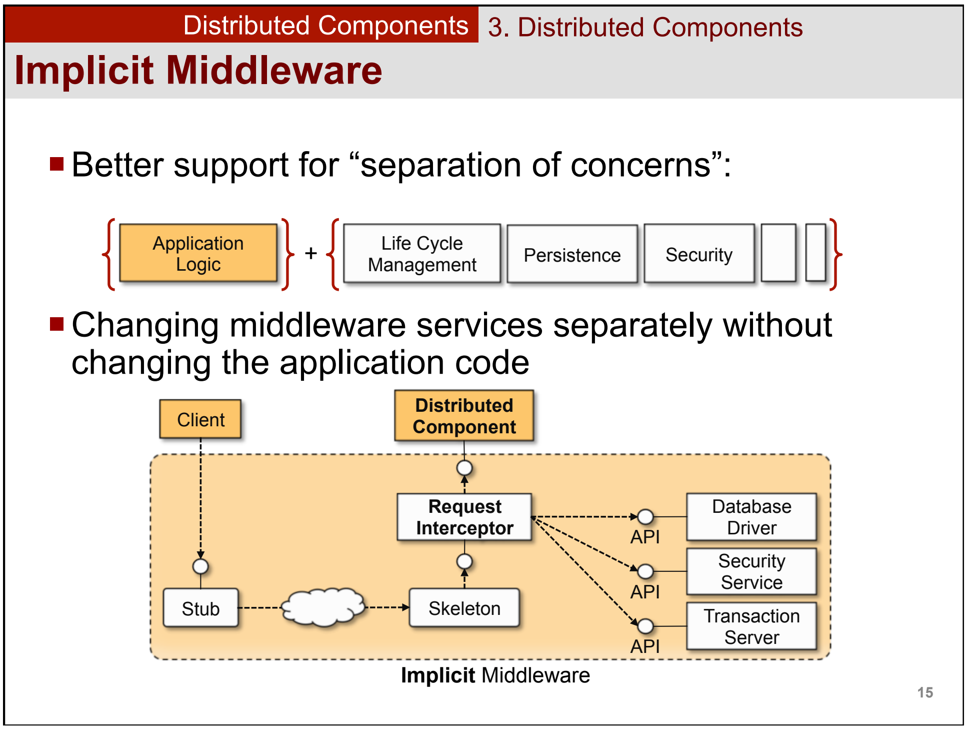


Explicit Middleware

  - Application logic entangled with logic for life cycle management, transactions, security, persistence, etc.
- Object developer
  - particular implementations of services for particular settings

Issues with Object-Oriented Middleware

- Implicit dependencies
  - It is not clear what dependencies an object have on other objects
- Interaction with the middleware
  - Many low-level details
- Lack of separation of distributed concerns
  - Security, transactions, coordination, etc.
- No support for deployment
- For example in CORBA and Java-RMI
  - **How to deploy** the components of my application?
  - Which **services** will be **available** on a given host?
  - Who **activates** my objects?
  - Who manages the **life-cycle of my objects**?

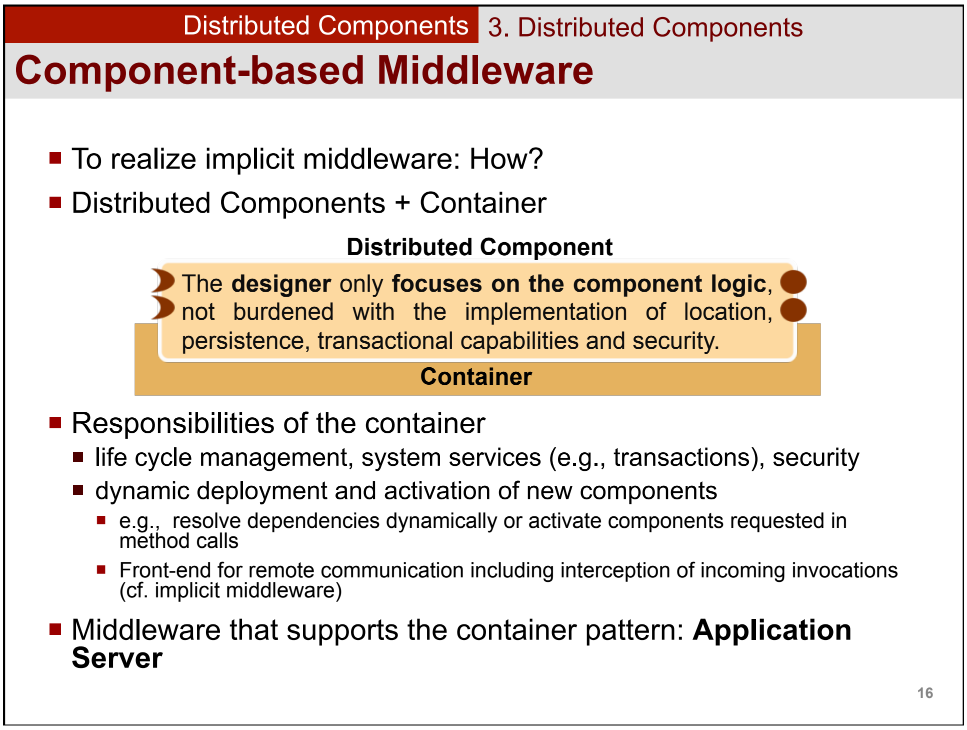


Implicit Middleware

- Better support for “separation of concerns”:

- Changing middleware services separately without changing the application code

Implicit Middleware



Component-based Middleware

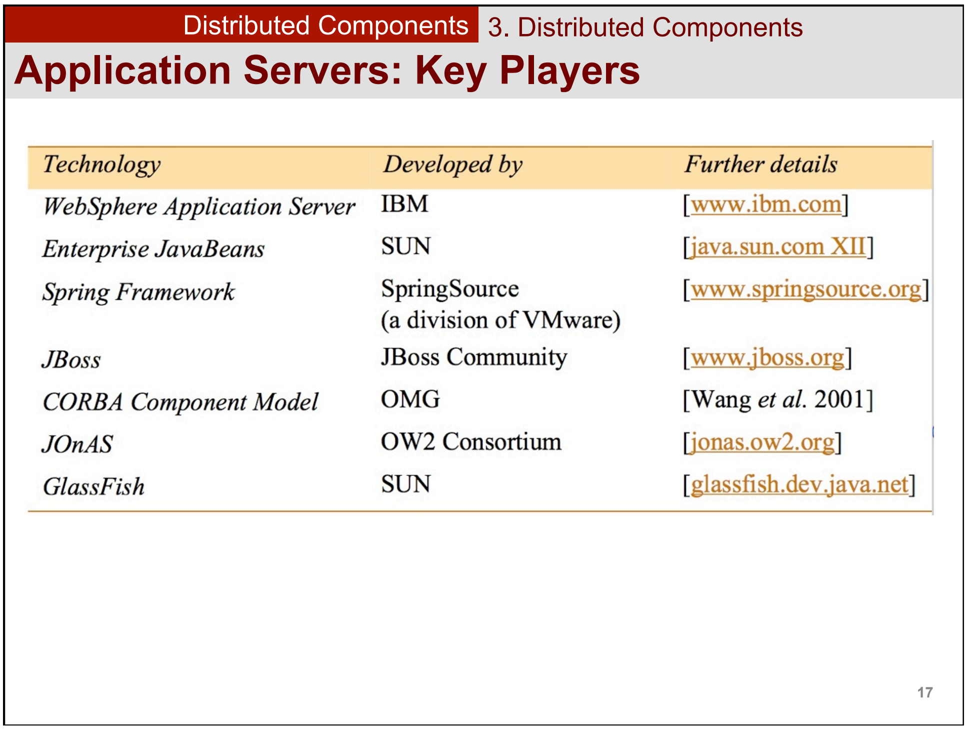
- To realize implicit middleware: How?
- Distributed Components + Container

Distributed Component

The **designer** only **focuses on the component logic**, not burdened with the implementation of location, persistence, transactional capabilities and security.

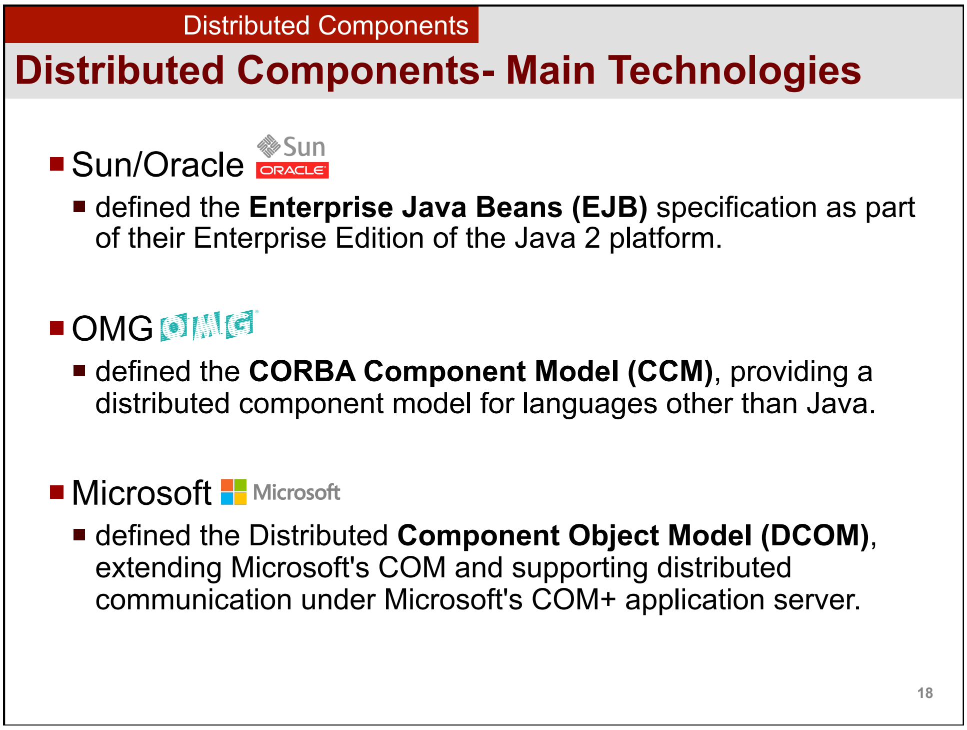
Container

- Responsibilities of the container
  - life cycle management, system services (e.g., transactions), security
  - dynamic deployment and activation of new components
    - e.g., resolve dependencies dynamically or activate components requested in method calls
    - Front-end for remote communication including interception of incoming invocations (cf. implicit middleware)
- Middleware that supports the container pattern: **Application Server**



Application Servers: Key Players

Technology	*Developed by*	*Further details*
WebSphere Application Server	IBM	[www.ibm.com]
Enterprise JavaBeans	SUN	[java.sun.com XII]
Spring Framework	SpringSource (a division of VMware)	[www.springsource.org]
JBoss	JBoss Community	[www.jboss.org]
CORBA Component Model	OMG	[Wang *et al.* 2001]
JOnAS	OW2 Consortium	[jonas.ow2.org]
GlassFish	SUN	[glassfish.dev.java.net]

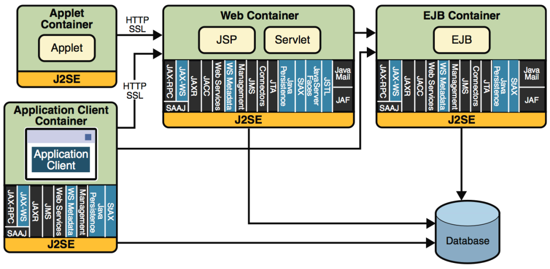


Distributed Components- Main Technologies

- Sun/Oracle
  - defined the **Enterprise Java Beans (EJB)** specification as part of their Enterprise Edition of the Java 2 platform.
- OMG
  - defined the **CORBA Component Model (CCM)**, providing a distributed component model for languages other than Java.
- Microsoft
  - defined the Distributed **Component Object Model (DCOM)**, extending Microsoft's COM and supporting distributed communication under Microsoft's COM+ application server.

Enterprise JavaBeans

- A server-side component model
- Three-tier architecture



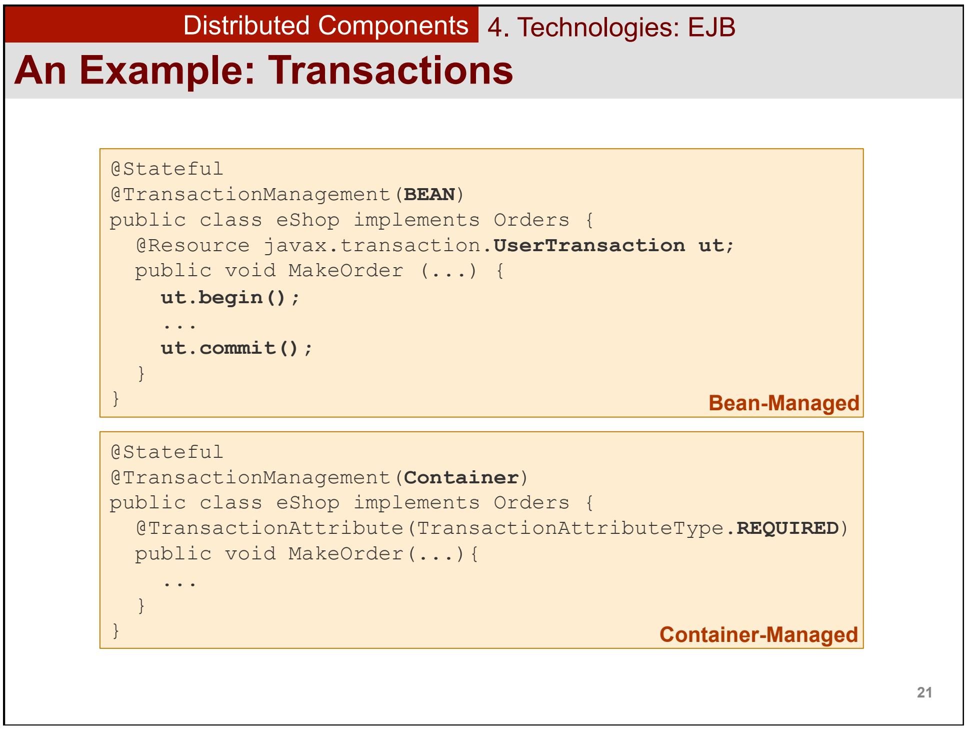
- **Beans** in EJB: to capture business **logic**
- EJB **container**: supporting key distribution services: transactions, security and lifecycle
  - **container-managed**: injecting calls to the associated services
  - **bean-managed**: developer takes more control over these services

EJB Component Model

- Bean: a component offering business interfaces (remote and local)
  - Session beans: stateless and stateful
  - Message-driven beans: listener-style interface
- Bean implementation
  - Plain Old Java Object (POJO) with annotations, e.g.:

```
@Stateful public class eShop implements Orders {...}
@Remote public interface Orders {...}
```

  - A significant number of annotations for container services



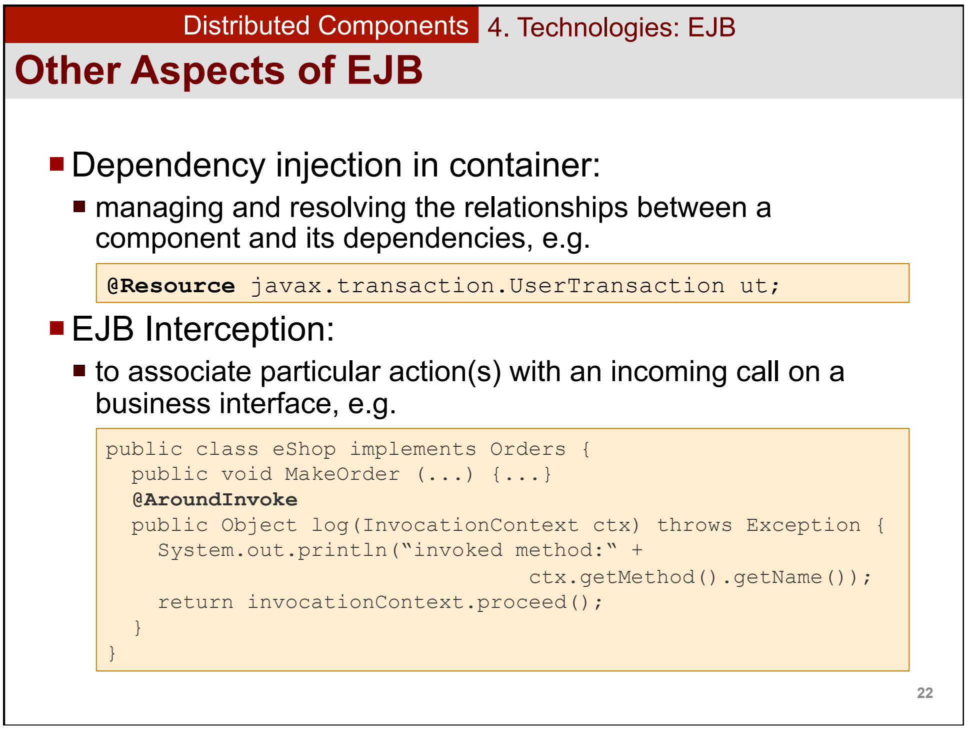
An Example: Transactions

```
@Stateful
@TransactionManagement(BEAN)
public class eShop implements Orders {
  @Resource javax.transaction.UserTransaction ut;
  public void MakeOrder (...) {
    ut.begin();
    ...
    ut.commit();
  }
}
```

Bean-Managed

```
@Stateful
@TransactionManagement(Container)
public class eShop implements Orders {
  @TransactionAttribute(TransactionAttributeType.REQUIRED)
  public void MakeOrder(...){
    ...
  }
}
```

Container-Managed



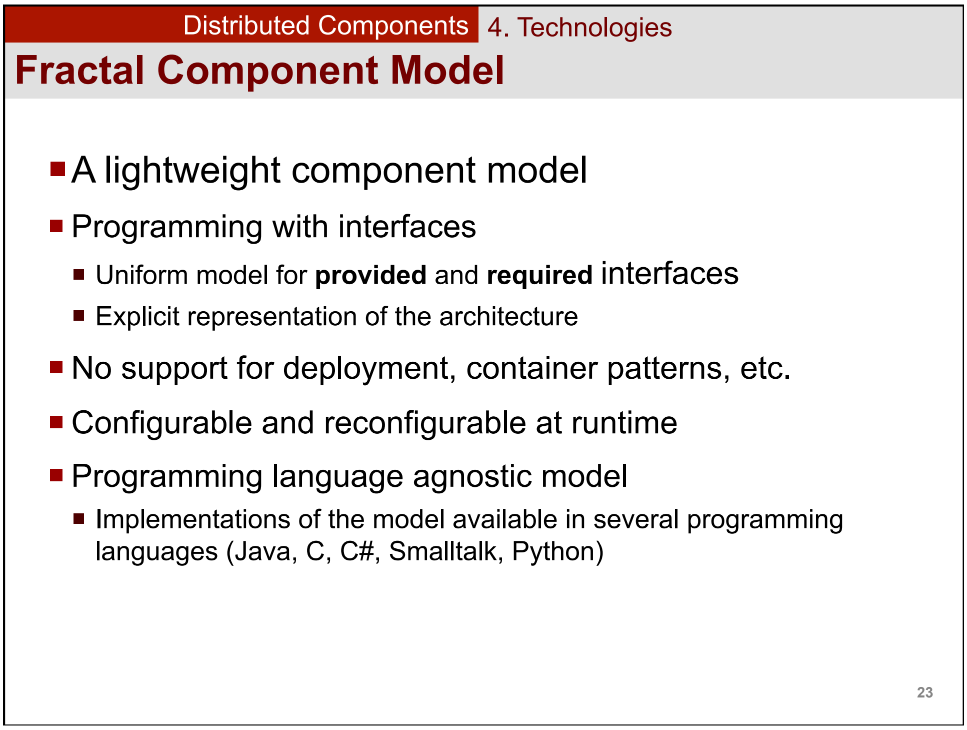
Other Aspects of EJB

- Dependency injection in container:
  - managing and resolving the relationships between a component and its dependencies, e.g.

```
@Resource javax.transaction.UserTransaction ut;
```

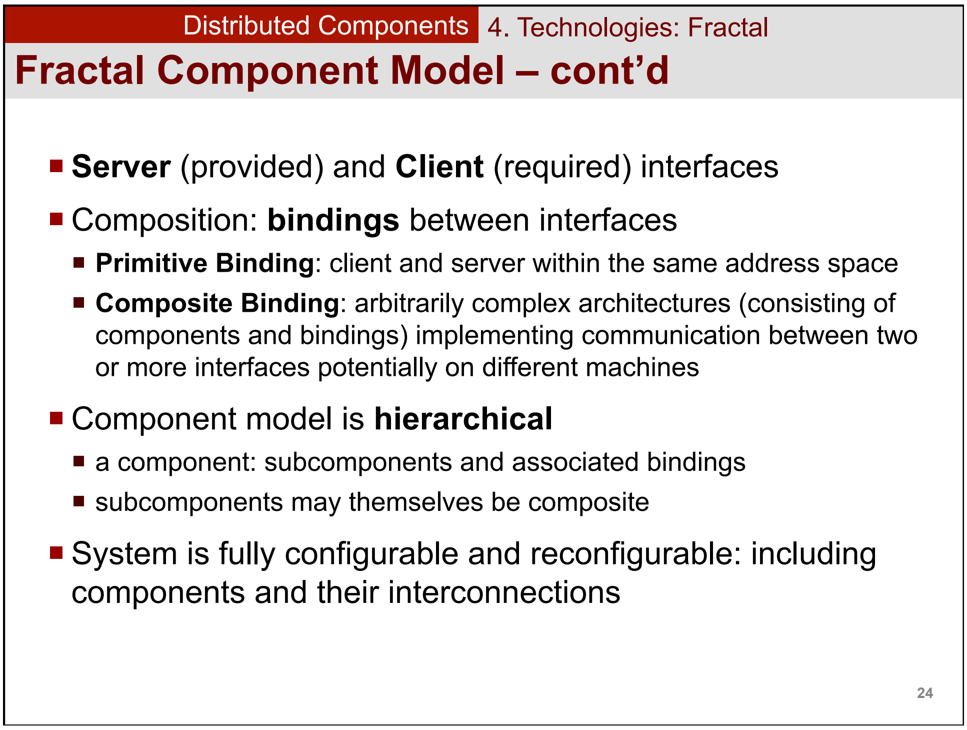
- EJB Interception:
  - to associate particular action(s) with an incoming call on a business interface, e.g.

```
public class eShop implements Orders {
  public void MakeOrder (...) {...}
  @AroundInvoke
  public Object log(InvocationContext ctx) throws Exception {
    System.out.println(“invoked method:” +
                                    ctx.getMethod().getName());
    return invocationContext.proceed();
  }
}
```



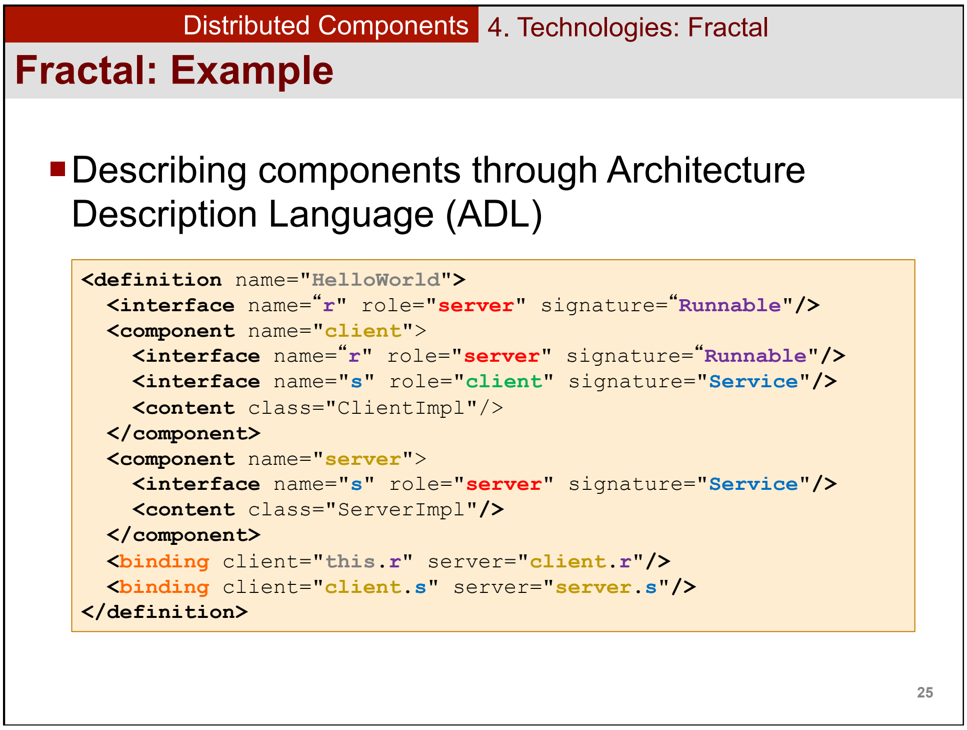
Fractal Component Model

- A lightweight component model
- Programming with interfaces
  - Uniform model for **provided** and **required** interfaces
  - Explicit representation of the architecture
- No support for deployment, container patterns, etc.
- Configurable and reconfigurable at runtime
- Programming language agnostic model
  - Implementations of the model available in several programming languages (Java, C, C#, Smalltalk, Python)



Fractal Component Model – cont’d

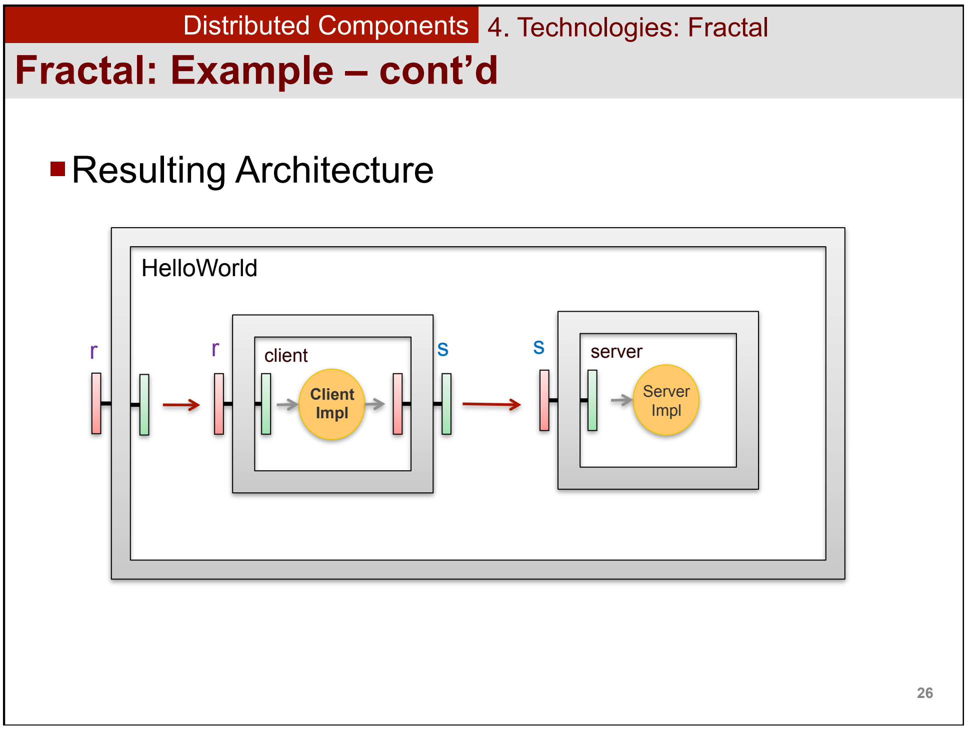
- **Server** (provided) and **Client** (required) interfaces
- Composition: **bindings** between interfaces
  - **Primitive Binding**: client and server within the same address space
  - **Composite Binding**: arbitrarily complex architectures (consisting of components and bindings) implementing communication between two or more interfaces potentially on different machines
- Component model is **hierarchical**
  - a component: subcomponents and associated bindings
  - subcomponents may themselves be composite
- System is fully configurable and reconfigurable: including components and their interconnections



Fractal: Example

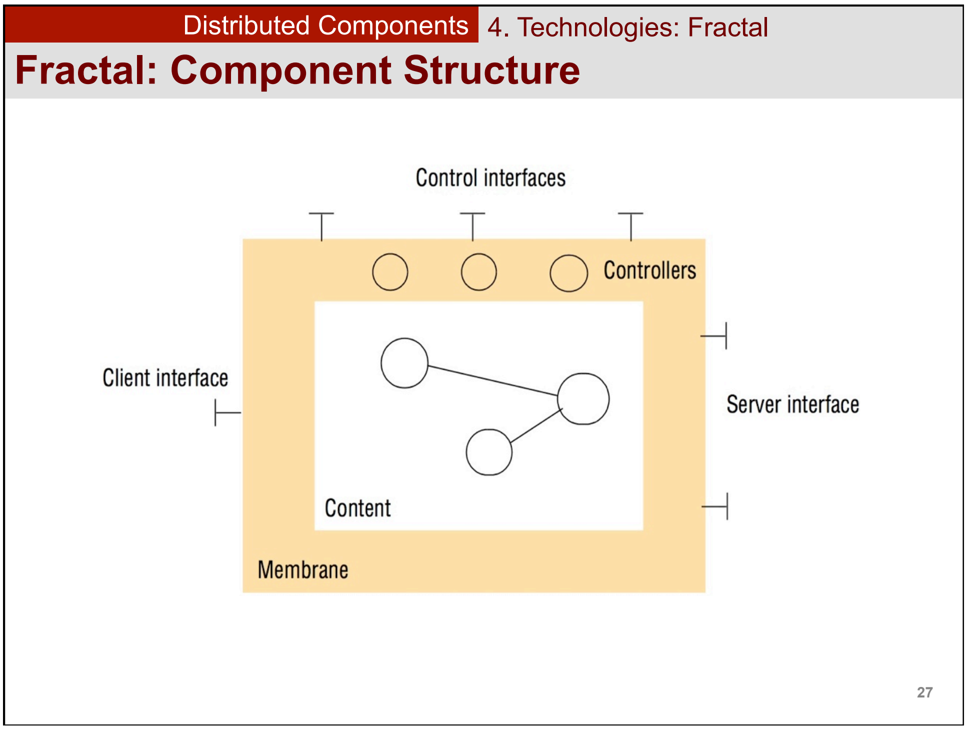
- Describing components through Architecture Description Language (ADL)

```
<definition name="HelloWorld">
  <interface name=“r" role="server" signature=“Runnable"/>
  <component name="client">
    <interface name=“r" role="server" signature=“Runnable"/>
    <interface name="s" role="client" signature="Service"/>
    <content class="ClientImpl"/>
  </component>
  <component name="server">
    <interface name="s" role="server" signature="Service"/>
    <content class="ServerImpl"/>
  </component>
  <binding client="this.r" server="client.r"/>
  <binding client="client.s" server="server.s"/>
</definition>
```



Fractal: Example – cont’d

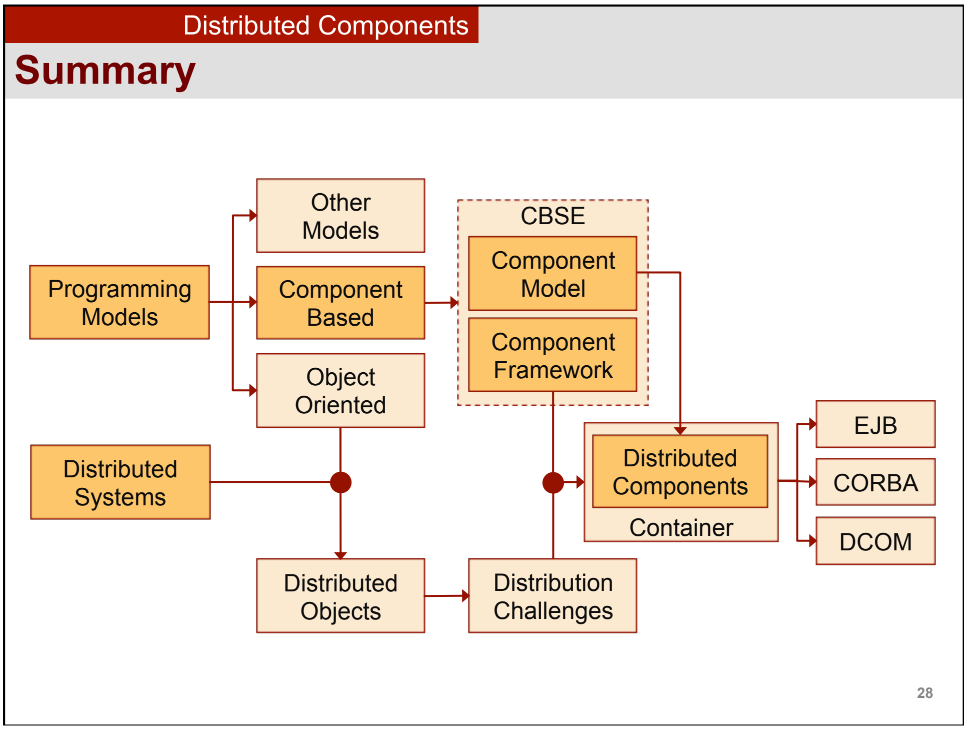
- Resulting Architecture



Distributed Components 4. Technologies: Fractal

Fractal: Component Structure

27



Distributed Components

Summary

28