Software components and distributed systems

INF 5040 autumn 2007

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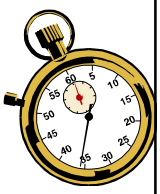
Literature

- G. T. Heineman, W.T. Councill, "Component-based Software Engneering" - Putting the Pieces Together, Addison Wesley 2001, ch 1 and 3
  - copies available at http://heim.ifi.uio.no/~frank/inf5040/CBSE/
- Recommended
  - Szyperski, C., Gruntz, D., Murer, S., "Component Software – Beyond Object-Oriented Programming", *Second Edition*, Addison Wesley/ACM Press, 2002

A history of middleware

- First generation middleware
  - Exclusively based on *client-server model*
  - Examples include Open Group's DCE
- Second generation middleware
  - Based on *distributed object technology*
  - Examples include CORBA and Java RMI
- Third generation middleware?
  - Based on (emerging) *component technology*

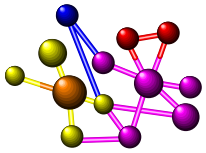


The emergence of component technologies

- What is a component [Szyperski]?

" a unit of *composition* with *contractually specified interfaces* and explicit *context dependencies* only"

"in this context, a component can be *deployed independently* and is subject to *third-party composition*"



Software component according to Heineman et al

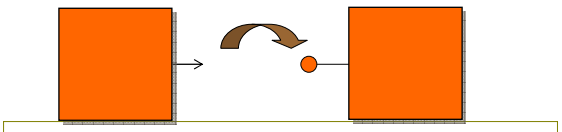
- *Software component*: Software element that conforms to a component model and can be independently deployed and composed without modification according to a composition standard
- *Component model*: defines specific interaction and composition standards
- *Component model implementation*: dedicated set of executable software elements required to support the execution of components that conform to the model
- *Software component infrastructure:* a set of interacting software components designed to ensure that a a software system constructed using those components and interfaces will satisfy clearly defined performance specifications

Rationale for components

- Time to marked
  - Improved productivity/ reduced complexity
  - Focus on reuse
- Programming by assembly rather than by engineering
  - Reduced requirements to knowledge
- Most important advantage: development of server side?
  - (cf. EJB/JEE or CORBA Component Model - later)

Composition

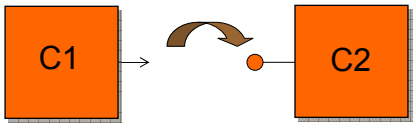
- Components and composition
  - Composition is the fundamental method for construction, extension and reuse of component-based software development
  - In contrast to (implementation) inheritance in object-oriented approaches

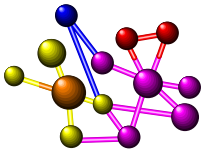


"Components are made for composition"

Connection-oriented programming

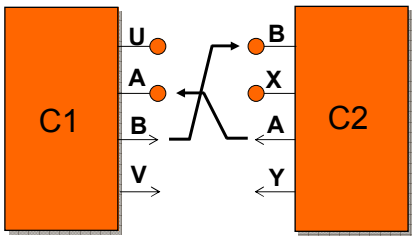
- Composition of pre-manufactured components
- Binding of incoming and outgoing interfaces
  - provided/required interfaces
  - Reflects direction of method calls
    - Not the direction of data flow
  - Outgoing interface
    - The method calls a component potentially may issue
  - Support for distribution?
    - When the binding can be made across address spaces and computers

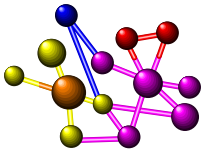




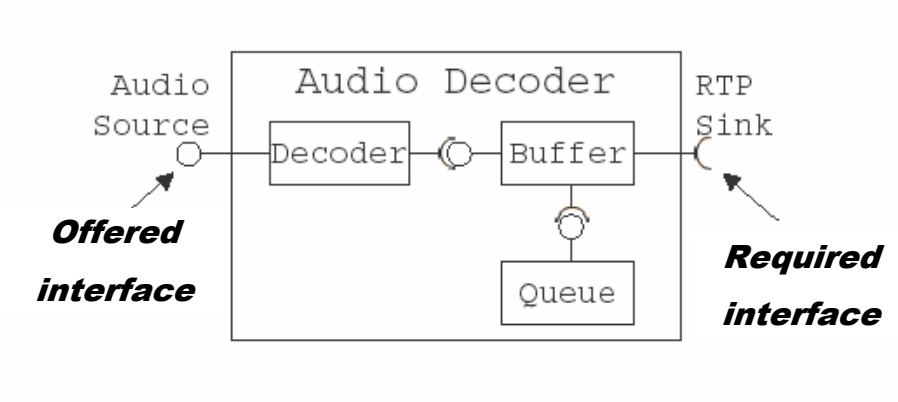
Third party composition

- The composition can be done by a third party
- Example
  - Connections, outgoing and ingoing interfaces
  - Connects "matching" interfaces
  - Can be done during run time by a third party
    - Can typically be realized by setting an appropriate attribute of the component with the outgoing interface (for C1, methods: setB, setV)





Composition: Reuse and assembly of components



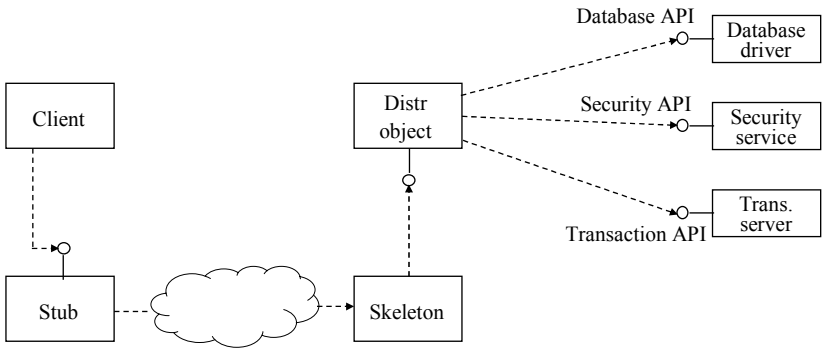
Background for Java og CORBA component models

- Known problems with 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?

=> We need a standard development, deployment and runtime environment for distributed objects (CORBA, Java)

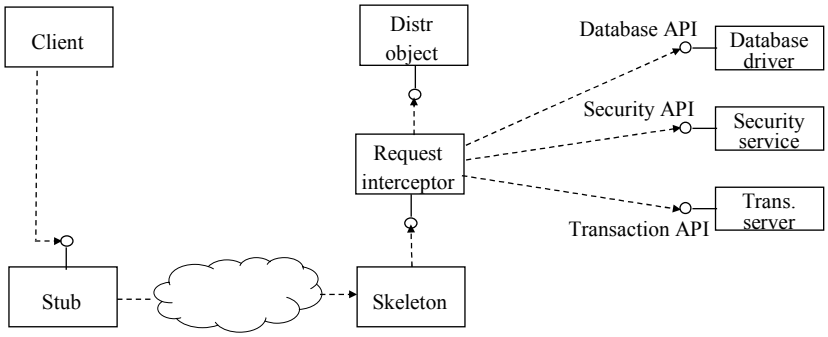
Explicit middleware: lack of "separation of concerns"

- Programs directly towards a middleware API
- Application logic entangled with logic for life cycle management, transactions, security, persistence, etc.



Implicit middleware: better support for “separation of concerns”

- Logic for life cycle management, transactions, security, persistence, etc. managed by the middleware
- Requirements for middleware services declared separately and can later be changed without changing the application code
- Middleware can be changed without changing the application code



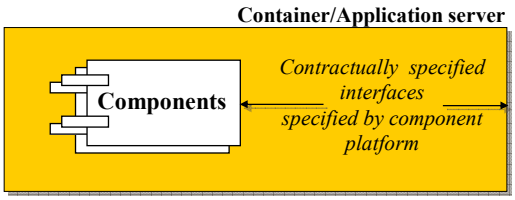
Component platform

- A standard development, deployment and runtime environment can be designed as a set of contractually specified interfaces
- Contracts agreed between components and a component platform
- Component platform defines the rules for deployment (installation), composition and activation of components.
- For delivering and deploying a component is required a standardized archive format that packages component code and meta-data

An implementation of a component platform is often called a *container*

Responsibilities of the container

- life cycle management
- system services
- security
- dynamic deployment and activation of new components
  - e.g., resolve dependencies dynamically or activate components requested in method calls



Contracts

- What is in a contract?
  - *Set of provided* interfaces.
    - Some of these may be required by the component platforms
  - *Set of required* interfaces.
    - These must be offered by other components available in the container
  - 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

Summerizing the elements of a component model

- Interfaces
- Naming
- Meta data (including dependencies)
- Interoperability
- Customization
- Composition
- Evolution support
- Packaging and deployment

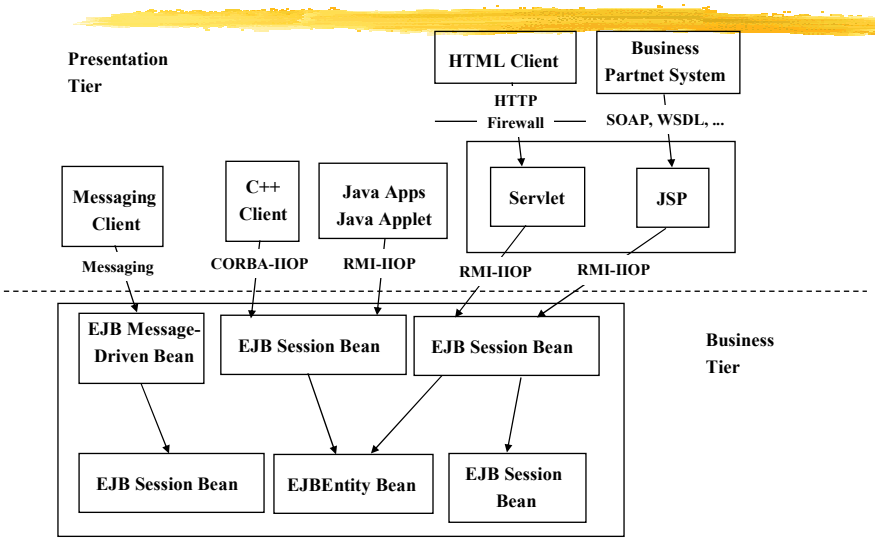
Key players

- OMG and components
  - CORBA v3 standard with CORBA Component Model (CCM)
- Microsoft and components
  - Development of COM/DCOM, COM+ and .NET
- SUN and components
  - Development of Java Beans and EJB

Enterprise Java Beans (EJB)

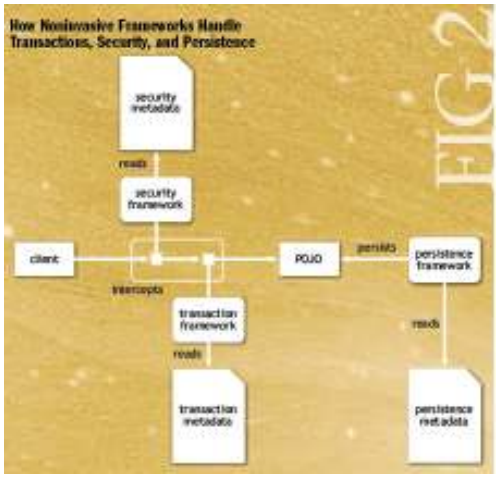
- Component architecture for deployable server side components in Java.
- EJB 3.0: based on Metadata facility in Java 5
  - annotations in source code
- Literature:
  - http://java.sun.com/j2ee/overview.html
- Three types of enterprise beans
  - Session beans (verb)
    - POJO with "session bean" annotations (meta-data)
    - Transient, application logic (business rules …)
  - Entity beans (noun)
    - POJO with "entity bean" annotation (but not considered as a component)
    - Persistent, data-related logic (updates state of entities)
  - Message driven beans
    - Logic for receiving asynchronous messages and potentially call other beans

Client-interaction with EJB component system



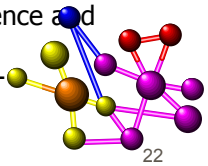
EJB 3.0 implicit middleware

- Meta data inspected by service framework.
- Necessary ”interceptors” weaved in
- Use of ”interceptors” to perform system level functions at runtime
- Persistence specified by annotating the relevant attributes in the source code and mapping to database (O/R mapping)



Connection-oriented programing and EJB

- No support for connection-oriented programming!!
  - Follows traditional object-oriented composition (third party can not bind EJBs, but an EJB can specify dependencies to other components)
  - A strength is automatic composition of component-instances with appropriate services and resources that component-instances are dependent on
    - Automatic configuration of necessary implicit middleware servcies based on needs specified by annotations or in the deployment-descriptor (transactions, persistence and security)
  - (JavaBeans do have support for connection-oriented programming)

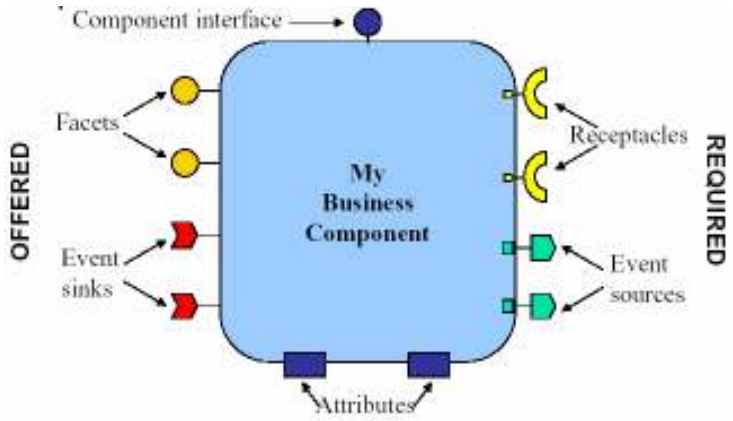


CORBA Component Model (CCM)

- What is CCM?
  - A *language independent* component model for the server side of a multi-tired architecture that supports implementation, management, configuration and deployment of CORBA applications
- Important properties
  - An underlying *component model*
  - A packaging technology for deployment of binary, *multi-lingual* executable units
  - A *container framework* that offers implicit middleware for security, transactions, persistence and event based communication

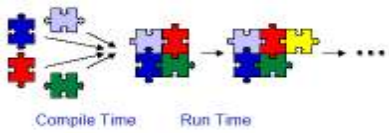
A CORBA component

- Support for connection-oriented programming
  - Connect/disconnect operations pon Receptacles
  - Or based on scripting-language (part of CCM deployment descriptor)



Composing adaptive software using components

- Importance and interest in adaptive software is increasing dramatically
  - mobile, ubiquitous and autonomic computing
- Components play a major part
- Compositional adaptation
  - dynamic adaptation of architecture of component-based application
    - change component impl
    - redeploy component
    - parameter adaptation
    - change overall architectural framework
    - combinations of the above



- More later (student presentations)

Summary

- Components
  - Programming according to LEGO-principle
  - Contractually specified interfaces and composition
  - Support for connection oriented programming
- Component architecture
  - Contractually specified interfaces between components and application servers
  - Realizes ”implicit middleware”
  - Java: EJB, CORBA: CCM, Microsoft: COM+/.NET