

Why Components?

„Software components are binary units of independent production, acquisition, and deployment that interact to form a functioning system“ (Szyperski 1997)

The rationale behind component software:

- Largely pushed by desktop – and Internet-based solutions.
- Complex technology to master – viable, component-based solutions will only evolve if benefits are clear.
- Benefits of traditional enterprise computing depend on enterprises willing to evolve substantially.

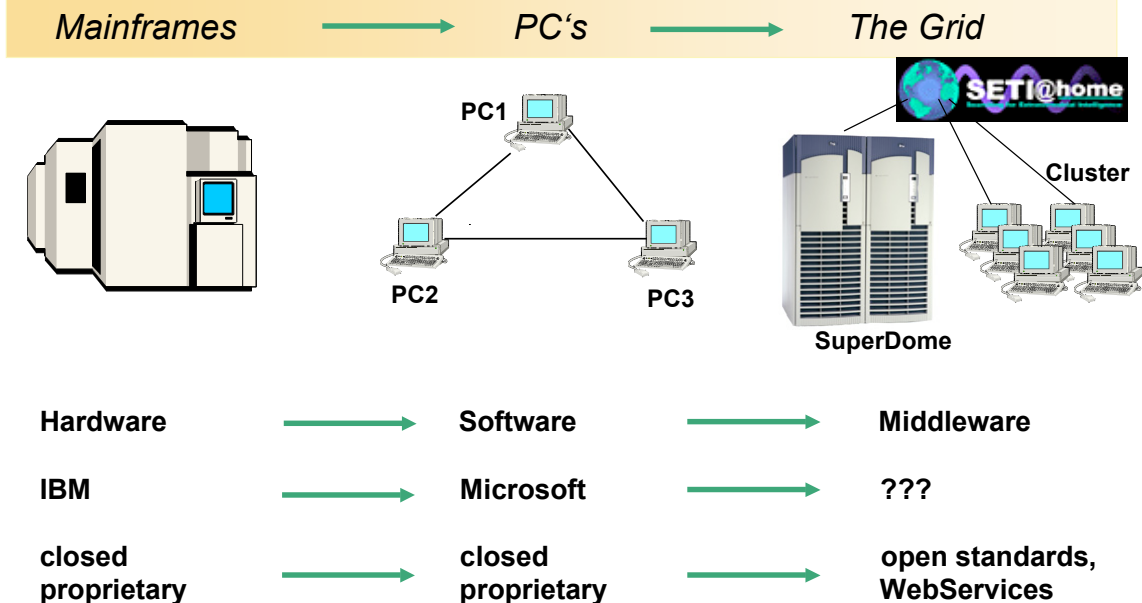
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How to Create Standards

- Historically, closed solutions with proprietary interfaces addressed most customers' needs.
- Attempts to create low-level connection standards or wiring standards are either product or standard-driven.
 - Microsoft standards have always been product-driven.
 - COM-driven, incremental, evolutionary, legacy-laden by nature.
- Standard-driven approaches usually originate in industry consortia.
 - Prime example: Object Management Group (OMG)
CORBA Beans as generalization of JavaSoft's Enterprise JavaBeans standards for components.
 - The EJB standard so far is not implementation language-neutral, bridging to existing services is non-trivial.

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The Shifting Paradigm



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The Internet World

- In the Internet world, the situation is different.
- Centralized control over what information is processed when and where is not an option.
- Content (web pages, documents) arrives at a user's machine and needs to be processed there and then.
- Monolithic applications have long reached their limit.
 - rapidly exploding variety of content types
 - open coding standards such as XML
- Flexibility of component software is its capability to dynamically grow to address changing needs.

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Terms and Concepts

Components:

- are a unit of independent deployment;
- are a unit of third-party composition;
- have no persistent state.

Implications:

- A Component needs to be well-separated from its environment and from other components.
- A component encapsulates its constituent features.
- Components are never partially deployed.

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Observations on Components

- Components need to come with clear specifications of what they provides and what they require.
 - Functional vs. non-functional properties
 - Well-defined interfaces and platform assumptions are essential.
 - Minimize hard-wired dependencies in favor of externally configurable providers.
- Components cannot be distinguished from copies of themselves.
- In any given process, there will be at most one copy of a particular component.
 - So, while it is useful to ask whether a particular component is available or not, it isn't useful to ask about the number of copies of that component.
- Many currently available components are heavyweights.
 - Database server, operating system services

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Terms and Concepts (contd.)

Objects:

- are units of instantiation (Each object has a unique identity);
- have state that can be persistent;
- encapsulate their state and behavior.

Implications:

- Objects cannot be partially instantiated.
- Since an object has individual state, it also needs a unique identity to identify the object, despite state changes, for its lifetime.
- Nothing but an object's abstract identity remains stable over time.

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Observations on Objects

- Objects need a construction plan that describes the new object's state space, initial state, and behavior before the object can exist.
 - Such a plan may be explicitly available and is then called a class.
 - Alternatively, it may be implicitly available in the form of an object that already exists, that is close to the object to be created, and can be cloned.
 - A preexisting object might be called a prototype object.
- The newly instantiated object needs to be set to an initial state.
 - The initial state needs to be a valid state of the constructed object, but it may also depend on parameters specified by the client asking for the new object.
 - The code that is required to control object creation and initialization could be a static procedure, usually called a **constructor**.
 - Alternatively, it can be an object of its own, usually called an **object factory**, or **factory** for short.

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Object References and Persistent Objects

- The object's identity is usually captured by an object reference.
- Most programming languages do not explicitly support object references.
 - language-level references hold unique references of objects (usually their addresses in memory),
 - no direct high-level support to manipulate the reference as such.
- Distinguishing between an object and an object reference is important when considering persistence.
 - almost all so-called persistence schemes just preserve an object's state and class, but not its absolute identity.
 - An exception is CORBA, which defines interoperable object references (IORs) as stable entities (which are really objects). Storing an IOR makes the pure object identity persist.

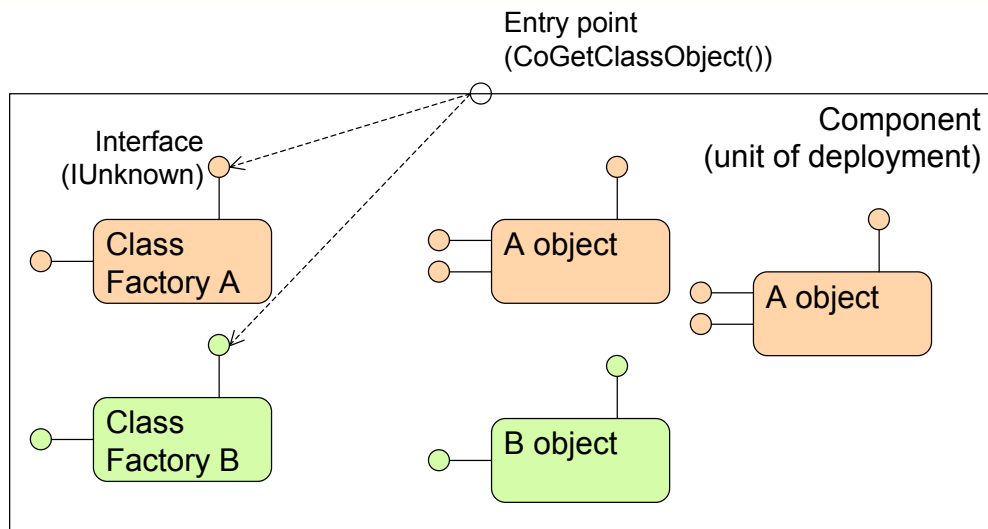
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Components and Objects

- A component comes to life through objects.
- It would normally contain one or more classes or immutable prototype objects.
 - In addition, it might contain a set of immutable objects that capture default initial state and other component resources.
 - No need for a component to contain only classes or any classes at all.
 - A component could contain traditional procedures and even have global (static) variables; or it may be realized in its entirety using a functional programming approach, an assembly language, or any other approach.
 - Objects created in a component, or references to such objects, can become visible to the component's clients, usually other components.
 - If only objects become visible to clients, there is no way to tell whether or not a component is purely object-oriented inside.

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Components and Objects illustrated



Components are rather on the level of classes than of objects

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Components and Objects (contd.)

- A component may contain multiple classes, but a class is necessarily confined to a single component;
- partial deployment of a class wouldn't normally make sense.
 - Just as classes can depend on other classes (inheritance), components can depend on other components (import).
 - The *superclasses* of a class do not necessarily need to reside in the same component as the class. Where a class has a *superclass* in another component, the *inheritance* relation *crosses* component *boundaries*.
 - Not clear, whether cross-component inheritance is a good thing.

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Modules and Components

- Components are rather close to modules (early 1980s).
 - The most popular modular languages are Modula-2 and Ada (packages).
 - Support of separate compilation,
 - Proper type-check across module boundaries.
- Eiffel: „a class is a better module“.
 - justified idea that modules would each implement one abstract data type (ADT).
 - However, modules can be used to package multiple entities, such as ADTs or classes, into one unit.
 - Modules do not have a concept of instantiation, while classes do.
- Recent language designs keep the modules and classes separate.
 - Oberon, Modula-3, and Component Pascal are examples
 - Where classes inherit from each other, they can do so across module boundaries.
 - Even modules that do not contain any classes can function as components.

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Modules and Components (contd.)

- Modules are not configurable:
 - There are no persistent immutable resources that come with a module, beyond what has been hardwired as constants in the code.
 - Resources parameterize a component (and are modified in builder tools).
 - Resources allow for versioning a component without needing to recompile.
- Resources are different from mutable component state!
 - Components are neither supposed to modify their own resources nor their code!
- Component technology unavoidably leads to modular solutions.
 - The software engineering benefits can thus justify initial investment into component technology, even if you don't foresee component markets.

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Component: A Definition

“A software component is a unit of composition with contractually specified interfaces and explicit context dependencies only. A software component can be deployed independently and is subject to composition by third parties.”

(Workshop on Component-Oriented Programming, ECOOP, 1996.)

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Interfaces

- A component's interfaces define its access points.
 - These points let clients access the component's services.
 - Components may have multiple interfaces.
 - Each access point may provide a different service.
- Interface specifications have contractual nature.
 - Component and clients are developed in mutual ignorance.
 - The standardized contract forms ground for successful interaction.
- Economy of scale:
 - interfaces should be simple, extensible and fulfill a market need.
- Common media to advertise interfaces is required
 - Unique naming scheme (e.g., ISBN numbers).
 - Component identifier is not required to carry any meaning.

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Classes and Interfaces

- Interfaces are used to express type-compatibility between multiple independent classes
 - Interfaces express what is common across classes
 - Interfaces allow classes to share a common design
 - Interfaces identify subsets of the set of all possible objects
 - Interfaces enable real polymorphism
- Interfaces are used to constrain the types of objects a variable/parameter/field can refer to
- Classes are used to manufacture objects in memory
- Components expose interfaces rather than classes

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Explicit Context Dependencies

- Besides specifying provided interfaces, components are also required to specify their needs.
 - What does the deployment environment need to provide, so that the components can function (so-called context dependencies).
 - For example, a mail-merge component would specify that it needs a file system interface.
- Problems with today's components:
 - The list of required interfaces is not normally available.
 - Emphasis is usually just on provided interfaces.
- Non-functional component properties are not addressed
 - CPU/memory usage, timing behavior, fault-tolerance properties.

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Context Dependencies – the Reality

- In reality, several component worlds coexist, compete, and conflict with each other.
 - OMG's CORBA, Microsoft's COM+, Sun's JavaBeans (EJB).
 - Component worlds are fragmented by the various computing platforms.
(This is not likely to change anytime soon.)
 - A component's context dependencies specification must include its required interfaces and the component world (or worlds) for which it has been prepared.
- Markets for cross-component-world integration.
 - Bridging solutions (i.e., OMG's „COM and CORBA Interworking“ spec).
 - .NET might develop towards a bridge among component worlds.

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Component-Based Programming vs. Component Assembly

- Component technology == “visual assembly” ?
 - Wiring components is surprisingly productive for simple applications
 - plumbing instead of programming: JavaSoft's BeanBox
- Look behind the scenes:
 - Visual assembly tools register event listeners with event sources
 - Not the graph of particular assembled objects that is saved but enough information to generate a new graph of same topology
 - The newly generated graph and the original graph will not share common objects: the object identities are all different.
- The stored graph represents persistent state
 - but not persistent objects
 - Tools could hard-code component assembly; but object graph might be easier to modify at runtime

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Persistent Objects

- Only supported in two contexts:
 - object-oriented databases, still restricted to a small niche of the database market.
 - CORBA-based objects.
- Object identity is preserved when storing objects.
 - Cannot be used to save state and topology but not identity.
 - Expensive deep copy of the saved graph required to undo the effort of saving the universal identities of the involved objects.
- Persistent identity is a heavyweight concept.
 - can always be added where needed.

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Persistent Objects (contd.)

- Neither COM nor JavaBeans support persistent objects.
 - Emphasis on saving the state and topology of a graph of objects.
 - Java terminology: “object serialization.”
(object graph serialization would be more precise.)
 - COM says „persistence“ although object identity is not preserved.
 - COM’s persistence mechanisms is equivalent to a deep copy of the object graph.
- COM monikers are objects that resolve to other objects.
 - Monikers may carry a stable unique identifier (a surrogate) and the information needed to locate that particular instance.
 - Java does not yet offer a standard like COM monikers.

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Component Objects

- Components carry instances that act at run time:
 - As prescribed by their generating component.
 - In the simplest case, a component is a class and the carried instances are objects of that class.
 - Most components will consist of many classes.
- JavaBeans are externally represented by a single class:
 - One kind of object representing all possible uses of that component.
- COM components are more flexible:
 - Arbitrary collection of objects; clients see sets of unrelated interfaces.
- JavaBeans and CORBA merge multiple interfaces:
 - One implementing class only.
 - Important cases not properly handled (i.e.; multiple versions of an interface).
 - The OMG's CORBA Components proposal fixes this problem.

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The Ultimate Difference

- Components capture the static nature of a software fragment.
- Objects capture its dynamic nature.
 - Simply treating everything as dynamic can eliminate this distinction.
- Good software engineering practices strengthen the static description of systems as much as possible.
 - Dynamics can always be superimposed where needed.
 - Meta-programming and just-in-time compilation simplify this soft treatment of the boundary between static and dynamic.

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The Ultimate Difference (Contd.)

- It is advisable to explicitly capture as many static properties of a design or architecture as possible.
- This is the role of components and architectures that assign components their place.
- The role of objects is to capture the dynamic nature of the arising systems built out of components.
- Component objects are objects carried by identified components.
 - Both components and objects together will enable the construction of next-generation software.

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