Software Reuse

Software reuse

- In most engineering disciplines, systems are designed by composing existing components that have been used in other systems.
- Software engineering has been more focused on original development but it is now recognised that to achieve better software, more quickly and at lower cost, we need to adopt a design process that is based on *systematic software reuse.*

Reuse-based software engineering

- Application system reuse
  - The whole of an application system may be reused either by incorporating it without change into other systems (COTS reuse) or by developing application families.
- Component reuse
  - Components of an application from sub-systems to single objects may be reused. Covered in Chapter 19.
- Object and function reuse
  - Software components that implement a single well-defined object or function may be reused.

Reuse benefits 1

Increased dependability	Reused software, that has been tried and tested in working systems, should be more dependable than new software. The initial use of the software reveals any design and implementation faults. These are then fixed, thus reducing the number of failures when the software is reused.
Reduced process risk	If software exists, there is less uncertainty in the costs of reusing that software than in the costs of development. This is an important factor for project management as it reduces the margin of error in project cost estimation. This is particularly true when relatively large software components such as sub-systems are reused.
Effective use of specialists	Instead of application specialists doing the same work on different projects, these specialists can develop reusable software that encapsulate their knowledge.

Reuse benefits 2

Standards compliance	Some standards, such as user interface standards, can be implemented as a set of standard reusable components. For example, if menus in a user interfaces are implemented using reusable components, all applications present the same menu formats to users. The use of standard user interfaces improves dependability as users are less likely to make mistakes when presented with a familiar interface.
Accelerated development	Bringing a system to market as early as possible is often more important than overall development costs. Reusing software can speed up system production because both development and validation time should be reduced.

Reuse problems 1

Increased maintenance costs	If the source code of a reused software system or component is not available then maintenance costs may be increased as the reused elements of the system may become increasingly incompatible with system changes.
Lack of tool support	CASE toolsets may not support development with reuse. It may be difficult or impossible to integrate these tools with a component library system. The software process assumed by these tools may not take reuse into account.
Not-invented-here syndrome	Some software engineers sometimes prefer to re-write components as they believe that they can improve on the reusable component. This is partly to do with trust and partly to do with the fact that writing original software is seen as more challenging than reusing other peopleÕs software.

Reuse problems 2

Creating and maintaining a component library	Populating a reusable component library and ensuring the software developers can use this library can be expensive. Our current techniques for classifying, cataloguing and retrieving software components are immature.
Finding, understanding and adapting reusable components	Software components have to be discovered in a library, understood and, sometimes, adapted to work in a n ew environment. Engineers must be reasonably confident of finding a component in the library before they will make routinely include a component search as part of their normal development process.

The reuse landscape

- Although reuse is often simply thought of as the reuse of system components, there are many different approaches to reuse that may be used.
- Reuse is possible at a range of levels from simple functions to complete application systems.
- The reuse landscape covers the range of possible reuse techniques.

Reuse approaches 1

Design patterns	Generic abstractions that occur across applications are represented as design patterns that show abstract and concrete objects and interactions.
Component-based development	Systems are developed by integrating components (collections of objects) that conform to component-model standards. This is covered in Chapter 19.
Application frameworks	Collections of abstract and concrete classes that can be adapted and extended to create application systems.
Legacy system wrapping	Legacy systems (see Chapter 2) that can be ÕwrappedÕ by defining a set of interfaces and providing access to these legacy systems through these interfaces.
Service-oriented systems	Systems are developed by linking shared services that may be externally provided.

Reuse approaches 2

Application product lines	An application type is generalised around a common architecture so that it can be adapted in different ways for different customers.
COTS integration	Systems are developed by integrating existing application systems.
Configurable vertical applications	A generic system is designed so that it can be configured to the needs of specific system customers.
Program libraries	Class and function libraries implementing commonly-used abstractions are available for reuse.
Program generators	A generator system embeds knowledge of a particular types of application and can generate systems or system fragments in that domain.
Aspect-oriented software development	Shared components are woven into an application at different places when the program is compiled.

Reuse planning factors

- The development schedule for the software.
- The expected software lifetime.
- The background, skills and experience of the development team.
- The criticality of the software and its non-functional requirements.
- The application domain.
- The execution platform for the software.

Component-based software engineering

Component-based development

- Component-based software engineering (CBSE) is an approach to software development that relies on software reuse.
- It emerged from the failure of object-oriented development to support effective reuse. Single object classes are too detailed and specific.
- Components are more abstract than object classes and can be considered to be stand-alone service providers.

CBSE essentials

- Independent components specified by their interfaces.
- Component standards to facilitate component integration.
- Middleware that provides support for component inter-operability.
- A development process that is geared to reuse.

CBSE and design principles

- Apart from the benefits of reuse, CBSE is based on sound software engineering design principles:
  - Components are independent so do not interfere with each other;
  - Component implementations are hidden;
  - Communication is through well-defined interfaces;
  - Component platforms are shared and reduce development costs.

CBSE problems

- Component trustworthiness - how can a component with no available source code be trusted?
- Component certification - who will certify the quality of components?
- Emergent property prediction - how can the emergent properties of component compositions be predicted?
- Requirements trade-offs - how do we do trade-off analysis between the features of one component and another?

Components

- Components provide a service without regard to where the component is executing or its programming language
  - A component is an independent executable entity that can be made up of one or more executable objects;
  - The component interface is published and all interactions are through the published interface;

Component definitions

- Councill and Heinmann:
  - *A software component is a software element that conforms to a component model and can be independently deployed and composed without modification according to a composition standard.*
- Szyperski:
  - *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.*

Component as a service provider

- The component is an independent, executable entity. It does not have to be compiled before it is used with other components.
- The services offered by a component are made available through an interface and all component interactions take place through that interface.

Component characteristics 1

Standardised	Component standardisation means that a component that is used in a CBSE process has to conform to some standardised component model. This model may define component interfaces, component meta-data, documentation, composition and deployment.
Independent	A component should be independent Š it should be possible to compose and deploy it without having to use other specific components. In situations where the component needs externally provided services, these should be explicitly set out in a ŒequiresŒ interface specification.
Composable	For a component to be composable, all external interactions must take place through publicly defined interfaces. In addition, it must provide external access to information about itself such as its methods and attributes.

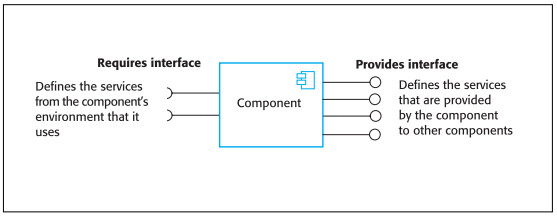
Component characteristics 2

Deployable	To be deployable, a component has to be self-contained and must be able to operate as a stand-alone entity on some component platform that implements the component model. This usually means that the component is a binary component that does not have to be compiled before it is deployed.
Documented	Components have to be fully documented so that potential users of the component can decide whether or not they meet their needs. The syntax and, ideally, the semantics of all component interfaces have to be specified.

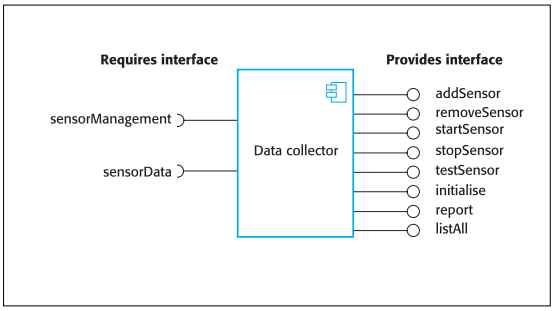
Component interfaces

- Provides interface
  - Defines the services that are provided by the component to other components.
- Requires interface
  - Defines the services that specifies what services must be made available for the component to execute as specified.

Component interfaces



A data collector component



Components and objects

- Components are deployable entities.
- Components do not define types.
- Component implementations are opaque.
- Components are language-independent.
- Components are standardised.

Component models

- A component model is a definition of standards for component implementation, documentation and deployment.
- Examples of component models
  - EJB model (Enterprise Java Beans)
  - COM+ model (.NET model)
  - Corba Component Model
- The component model specifies how interfaces should be defined and the elements that should be included in an interface definition.

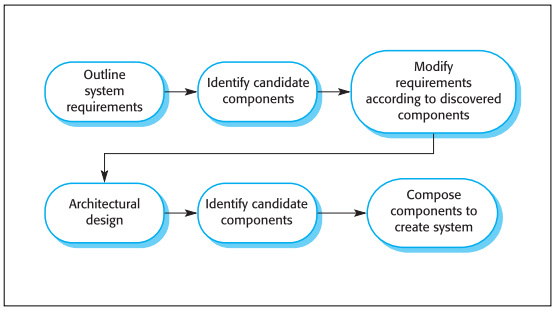
Middleware support

- Component models are the basis for middleware that provides support for executing components.
- Component model implementations provide:
  - Platform services that allow components written according to the model to communicate;
  - Horizontal services that are application-independent services used by different components.
- To use services provided by a model, components are deployed in a container. This is a set of interfaces used to access the service implementations.

The CBSE process

- When reusing components, it is essential to make trade-offs between ideal requirements and the services actually provided by available components.
- This involves:
  - Developing outline requirements;
  - Searching for components then modifying requirements according to available functionality.
  - Searching again to find if there are better components that meet the revised requirements.

The CBSE process



Component identification issues

- Trust. You need to be able to trust the supplier of a component. At best, an untrusted component may not operate as advertised; at worst, it can breach your security.
- Requirements. Different groups of components will satisfy different requirements.
- Validation.
  - The component specification may not be detailed enough to allow comprehensive tests to be developed.
  - Components may have unwanted functionality. How can you test this will not interfere with your application?

Ariane launcher failure

- In 1996, the 1st test flight of the Ariane 5 rocket ended in disaster when the launcher went out of control 37 seconds after take off.
- The problem was due to a reused component from a previous version of the launcher (the Inertial Navigation System) that failed because assumptions made when that component was developed did not hold for Ariane 5.
- The functionality that failed in this component was not required in Ariane 5.

Component composition

- The process of assembling components to create a system.
- Composition involves integrating components with each other and with the component infrastructure.
- Normally you have to write 'glue code' to integrate components.

Composition trade-offs

- When composing components, you may find conflicts between functional and non-functional requirements, and conflicts between the need for rapid delivery and system evolution.
- You need to make decisions such as:
  - What composition of components is effective for delivering the functional requirements?
  - What composition of components allows for future change?
  - What will be the emergent properties of the composed system?

Component development for reuse

- Components developed for a specific application usually have to be generalised to make them reusable.
- A component is most likely to be reusable if it associated with a stable domain abstraction (business object).
- For example, in a hospital stable domain abstractions are associated with the fundamental purpose - nurses, patients, treatments, etc.

Component development for reuse

- Components for reuse may be specially constructed by generalising existing components.
- Component reusability
  - Should reflect stable domain abstractions;
  - Should hide state representation;
  - Should be as independent as possible;
  - Should publish exceptions through the component interface.
- There is a trade-off between reusability and usability
  - The more general the interface, the greater the reusability but it is then more complex and hence less usable.

Changes for reusability

- Remove application-specific methods.
- Change names to make them general.
- Add methods to broaden coverage.
- Make exception handling consistent.
- Add a configuration interface for component adaptation.
- Integrate required components to reduce dependencies.

Legacy system components

- Existing legacy systems that fulfil a useful business function can be re-packaged as components for reuse.
- This involves writing a wrapper component that implements provides and requires interfaces then accesses the legacy system.
- Although costly, this can be much less expensive than rewriting the legacy system.

Adaptor components

- Address the problem of component incompatibility by reconciling the interfaces of the components that are composed.
- Different types of adaptor are required depending on the type of composition.
- An addressFinder and a mapper component may be composed through an adaptor that strips the postal code from an address and passes this to the mapper component.

Composition through an adaptor

- The component postCodeStripper is the adaptor that facilitates the sequential composition of addressFinder and mapper components.

```
address = addressFinder.location (phonenumber) ;
postCode = postCodeStripper.getPostCode (address) ;
mapper.displayMap(postCode, 10000)
```


Adaptor for data collector