

3 Design with Reuse

- Building software from reusable components.
- 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 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
- Function reuse
 - Software components that implement a single well-defined function may be reused

Reuse practice

- Application system reuse
 - Widely practised as software systems are implemented as application families. COTS reuse is becoming increasingly common

- Component reuse
 - Now seen as the key to effective and widespread reuse through component-based software engineering. However, it is still relatively immature
- Function reuse
 - Common in some application domains (e.g. engineering) where domain-specific libraries of reusable functions have been established

Benefits of reuse

- Increased reliability
 - Components exercised in working systems
- Reduced process risk
 - Less uncertainty in development costs
- Effective use of specialists
 - Reuse components instead of people
- Standards compliance
 - Embed standards in reusable components
- Accelerated development
 - Avoid original development and hence speed-up production

Requirements for design with reuse

- It must be possible to find appropriate reusable components
- The re-user of the component must be confident that the components will be reliable and will behave as specified
- The components must be documented so that they can be understood and, where appropriate, modified

Reuse problems

- Increased maintenance costs
- Lack of tool support
- Not-invented-here syndrome
- Maintaining a component library
- Finding and adapting reusable components

Generator-based reuse

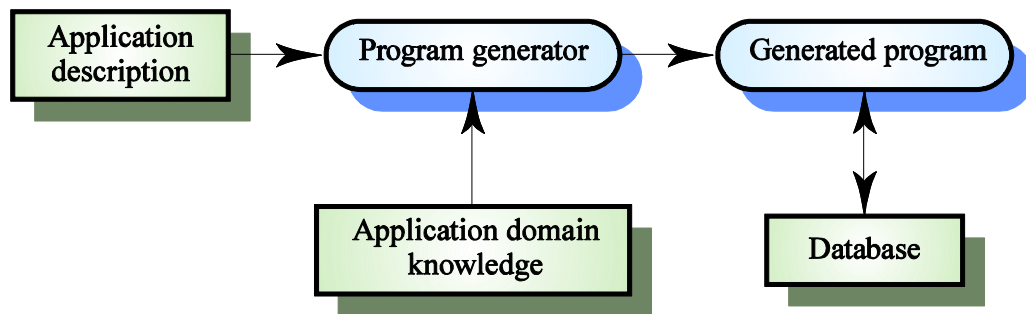
- Program generators involve the reuse of standard patterns and algorithms
- These are embedded in the generator and parameterised by user commands. A program is then automatically generated
- Generator-based reuse is possible when domain abstractions and their mapping to executable code can be identified
- A domain specific language is used to compose and control these abstractions

Types of program generator

- Application generators for business data processing
- Parser and lexical analyser generators for language processing
- Code generators in CASE tools

- Generator-based reuse is very cost-effective but its applicability is limited to a relatively small number of application domains
- It is easier for end-users to develop programs using generators compared to other component-based approaches to reuse

Reuse through program generation



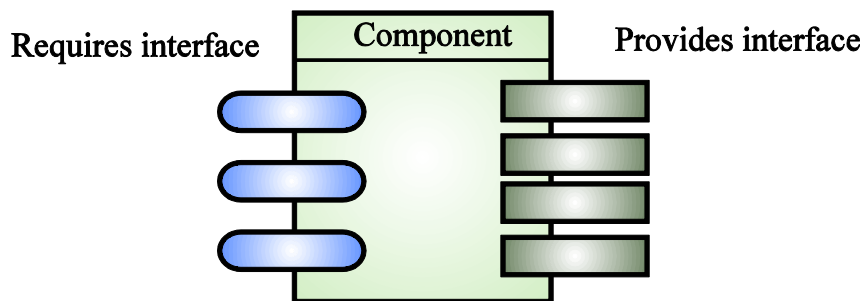
Component-based development

- Component-based software engineering (CBSE) is an approach to software development that relies on 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

Components

- Components provide a service without regard to where the component is executing or its programming language

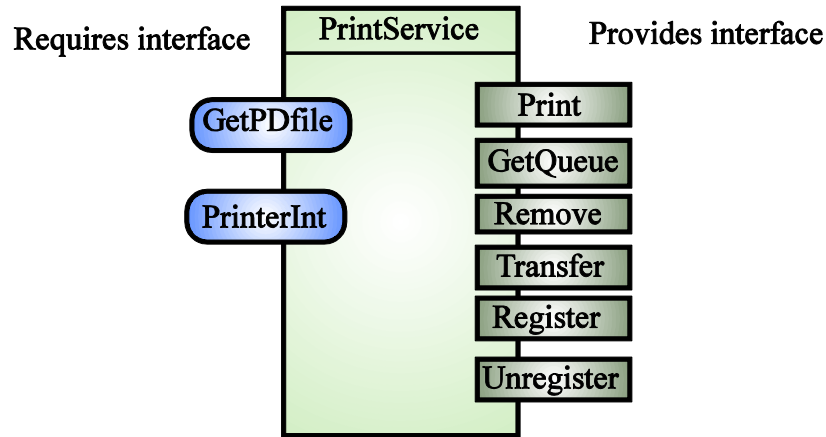
- A component is an independent executable entity that can be made up of one or more executable objects
- The component interface is published and all interactions are through the published interface
- Components can range in size from simple functions to entire application systems



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

Printing services component



Component abstractions

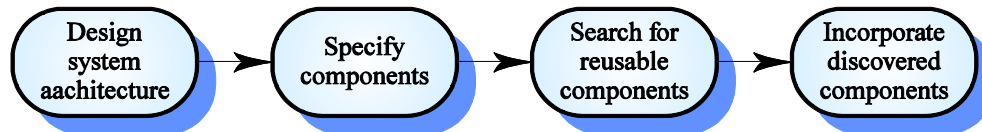
- *Functional abstraction*
 - The component implements a single function such as a mathematical function
- *Casual groupings*
 - The component is a collection of loosely related entities that might be data declarations, functions, etc.
- *Data abstractions*
 - The component represents a data abstraction or class in an object-oriented language
- *Cluster abstractions*
 - The component is a group of related classes that work together
- *System abstraction*
 - The component is an entire self-contained system

CBSE processes

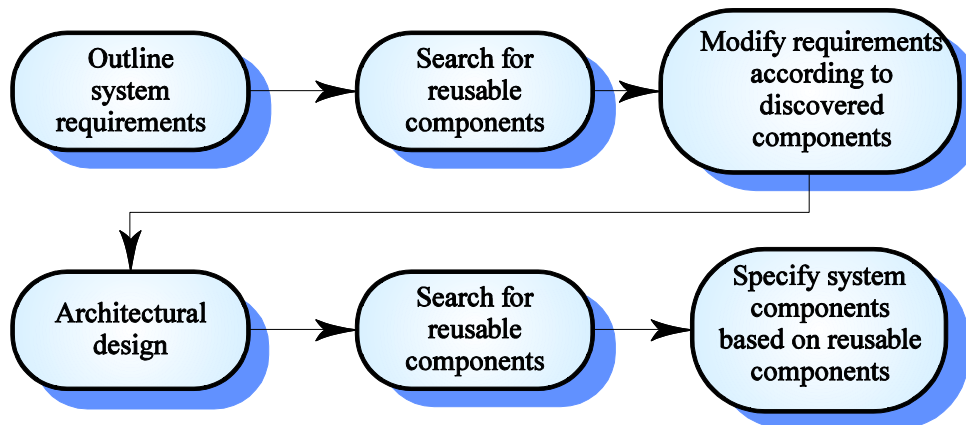
- Component-based development can be integrated into a standard software process by incorporating a reuse activity in the process

- However, in reuse-driven development, the system requirements are modified to reflect the components that are available
- CBSE usually involves a prototyping or an incremental development process with components being 'glued together' using a scripting language

An opportunistic reuse process



Development with reuse



CBSE problems

- Component incompatibilities may mean that cost and schedule savings are less than expected
- Finding and understanding components
- Managing evolution as requirements change in situations where it may be impossible to change the system components

Application frameworks

- Frameworks are a sub-system design made up of a collection of abstract and concrete classes and the interfaces between them
- The sub-system is implemented by adding components to fill in parts of the design and by instantiating the abstract classes in the framework
- Frameworks are moderately large entities that can be reused
- Framework classes
- System infrastructure frameworks
 - Support the development of system infrastructures such as communications, user interfaces and compilers
- Middleware integration frameworks
 - Standards and classes that support component communication and information exchange
- Enterprise application frameworks
 - Support the development of specific types of application such as telecommunications or financial systems

Extending frameworks

- Frameworks are generic and are extended to create a more specific application or sub-system
- Extending the framework involves
 - Adding concrete classes that inherit operations from abstract classes in the framework
 - Adding methods that are called in response to events that are recognised by the framework
- Problem with frameworks is their complexity and the time it takes to use them effectively
- Model-view controller

- System infrastructure framework for GUI design
- Allows for multiple presentations of an object and separate interactions with these presentations

MVC framework involves the instantiation of a number of Model-view controller

COTS product reuse

- COTS - Commercial Off-The-Shelf systems
- COTS systems are usually complete application systems that offer an API (Application Programming Interface)
- Building large systems by integrating COTS systems is now a viable development strategy for some types of system such as E-commerce systems
- COTS system integration problems
- Lack of control over functionality and performance
 - COTS systems may be less effective than they appear
- Problems with COTS system inter-operability
 - Different COTS systems may make different assumptions that means integration is difficult
- No control over system evolution
 - COTS vendors not system users control evolution
- Support from COTS vendors
 - COTS vendors may not offer support over the lifetime of the product

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

Reusable components

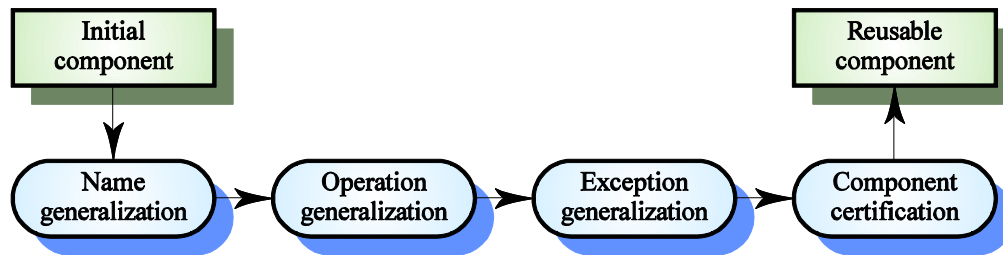
- The development cost of reusable components is higher than the cost of specific equivalents. This extra reusability enhancement cost should be an organization rather than a project cost
- Generic components may be less space-efficient and may have longer execution times than their specific equivalents

Reusability enhancement

- Name generalisation
 - Names in a component may be modified so that they are not a direct reflection of a specific application entity
- Operation generalisation
 - Operations may be added to provide extra functionality and application specific operations may be removed
- Exception generalisation
 - Application specific exceptions are removed and exception management added to increase the robustness of the component

- Component certification
 - Component is certified as reusable

Reusability enhancement process



Design patterns

- A design pattern is a way of reusing abstract knowledge about a problem and its solution
- A pattern is a description of the problem and the essence of its solution
- It should be sufficiently abstract to be reused in different settings
- Patterns often rely on object characteristics such as inheritance and polymorphism
- Pattern elements
 - Name
 - A meaningful pattern identifier
 - Problem description
 - Solution description
 - Not a concrete design but a template for a design solution that can be instantiated in different ways
 - Consequences
 - The results and trade-offs of applying the pattern

- Multiple displays
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- Key points
- Design with reuse involves designing software around good design and existing components
- Advantages are lower costs, faster software development and lower risks
- Component-based software engineering relies on black-box components with defined requires and provides interfaces
- COTS product reuse is concerned with the reuse of large, off-the-shelf systems

Key points

- Software components for reuse should be independent, should reflect stable domain abstractions and should provide access to state through interface operations
- Application families are related applications developed around a common core
- Design patterns are high-level abstractions that document successful design solutions

Assignment: Model your final year project using object oriented analysis and design (OOAD). Use CASE tools for the modeling and an object oriented programming language such as Java, C# or C++ for the implementation.

(30/6/2016).