# Chapter 10 – Software Reuse

Lecture 1

**by**
**Rajendra Dhakal, Ph.D.**
**Department of Computer Science & Engineering**
**Sejong University**
**2023**

## Topics covered

✧ The reuse landscape

1. Application frameworks
2. Software product lines
3. COTS product 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 a design process that is based on systematic software reuse.
- There has been a  major switch to reuse-based development over the past 10 years.

## 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.
- ✧ Object and function reuse
  - Software components that implement a single well-defined object or function may be reused.

# Benefits of software reuse

| Benefit | Explanation |
| --- | --- |
| Increased dependability | Reused software, which has been tried and tested in working systems, should be more dependable than new software. Its design and implementation faults should have been found and fixed. |
| Reduced process risk | The cost of existing software is already known, whereas the costs of development are always a matter of judgment. This is an important factor for project management because it reduces the margin of error in project cost estimation. This is particularly true when relatively large software components such as subsystems are reused. |
| Effective use of specialists | Instead of doing the same work over and over again, application specialists can develop reusable software that encapsulates their knowledge. |

# Benefits of software reuse

| Benefit | Explanation |
| --- | --- |
| Standards compliance | Some standards, such as user interface standards, can be implemented as a set of reusable components. For example, if menus in a user interface are implemented using reusable components, all applications present the same menu formats to users. The use of standard user interfaces improves dependability because users make fewer 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 may be reduced. |

# Problems with reuse

| Problem | Explanation |
| --- | --- |
| Increased maintenance costs | If the source code of a reused software system or component is not available, then maintenance costs may be higher because the reused elements of the system may become increasingly incompatible with system changes. |
| Lack of tool support | Some software tools do 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. This is particularly true for tools that support embedded systems engineering, less so for object-oriented development tools. |
| Not-invented-here syndrome | Some software engineers prefer to rewrite components because they believe they can improve on them. 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 people's software. |

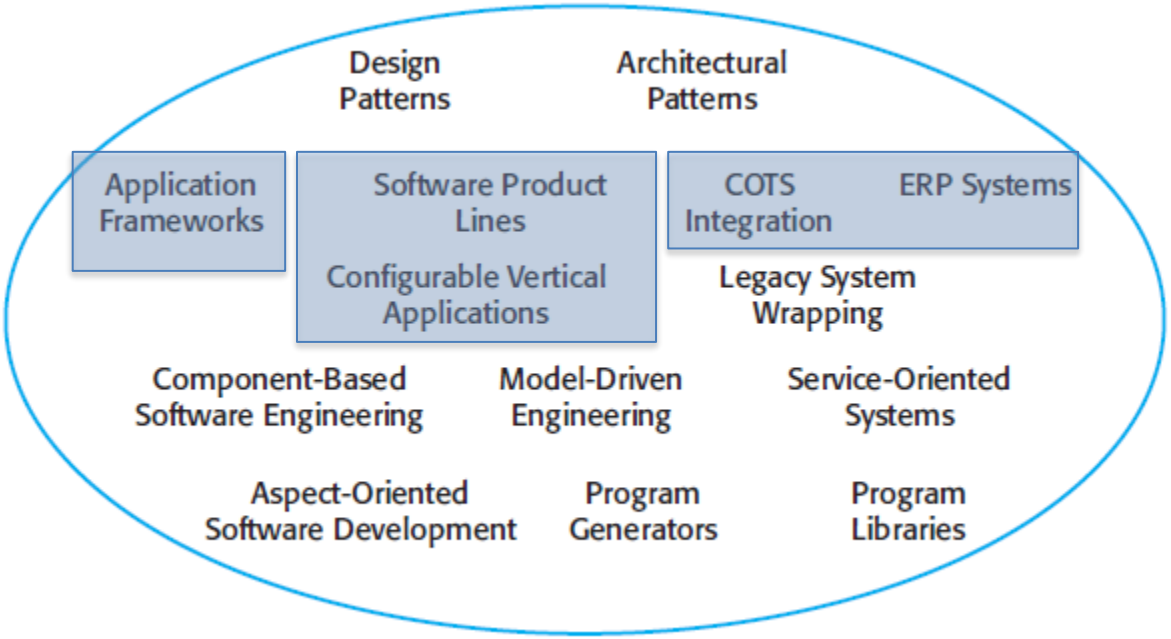
# Problems with reuse

| Problem | Explanation |
| --- | --- |
| Creating, maintaining, and using a component library | Populating a reusable component library and ensuring the software developers can use this library can be expensive. Development processes have to be adapted to ensure that the library is used. |
| Finding, understanding, and adapting reusable components | Software components have to be discovered in a library, understood and, sometimes, adapted to work in a new environment. Engineers must be reasonably confident of finding a component in the library before they 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.

# The reuse landscape



# Approaches that support software reuse

| Approach | Description |
|---|---|
| Architectural patterns | Standard software architectures that support common types of application systems are used as the basis of applications. |
| Design patterns | Generic abstractions that occur across applications are represented as design patterns showing abstract and concrete objects and interactions. |
| Component-based development | Systems are developed by integrating components (collections of objects) that conform to component-model standards. |
| Application frameworks | Collections of abstract and concrete classes are adapted and extended to create application systems. |
| Legacy system wrapping | Legacy systems are ‘wrapped’ by defining a set of interfaces and providing access to these legacy systems through these interfaces. |

# Approaches that support software reuse

| Approach | Description |
| --- | --- |
| Service-oriented systems | Systems are developed by linking shared services, which may be externally provided. |
| Software product lines | An application type is generalized around a common architecture so that it can be adapted for different customers. |
| COTS product reuse | Systems are developed by configuring and integrating existing application systems. |
| ERP systems | Large-scale systems that encapsulate generic business functionality and rules are configured for an organization. |
| Configurable vertical applications | Generic systems are designed so that they can be configured to the needs of specific system customers. |

# Approaches that support software reuse

| Approach | Description |
| --- | --- |
| Program libraries | Class and function libraries that implement commonly used abstractions are available for reuse. |
| Model-driven engineering | Software is represented as domain models and implementation independent models and code is generated from these models. |
| Program generators | A generator system embeds knowledge of a type of application and is used to generate systems in that domain from a user-supplied system model. |
| 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.

## 1. Application frameworks

- A framework in programming is a tool that provides ready-made components or solutions that are customized to speed up development. *E.g. Django*
- Frameworks are moderately large entities that can be reused. They are somewhere between system and component reuse.
- 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.

## 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.

## Web application frameworks (WAP)

- ✧ Support the construction of dynamic websites as a front-end for web applications.
- ✧ WAFs are now available for all of the commonly used web programming languages e.g. Java, Python, Ruby, etc.
- ✧ E.g. Spring for JAVA, Django for python, ASP.NET for C#, Ruby on Rails for Ruby

# WAF features

- *Security*
  - WAFs may include classes to help implement user authentication (login) and access.
- *Dynamic web pages*
  - Classes are provided to help you define web page templates and to populate these dynamically from the system database.
- *Database support*
  - The framework may provide classes that provide an abstract interface to different databases.
- *Session management*
  - Classes to create and manage sessions (a number of interactions with the system by a user) are usually part of a WAF.
- *User interaction*
  - Most web frameworks now provide AJAX (Asynchronous Javascript and XML) support (Holdener, 2008), which allows more interactive web pages to be created. AJAX is a technique for creating fast and dynamic web pages.

## Extending frameworks

- Frameworks are generic and are extended to create a more specific application or sub-system. They provide a skeleton architecture for the 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 which means that it takes a long time to use them effectively.

## 2. Software product lines

- Software product lines or application families are applications with generic functionality that can be *adapted and configured* for use in a specific context.
- A software product line is a set of applications with a common architecture and shared components, with each application specialized to reflect different requirements.
- For example, there may be a software product line for a family of printers.
- Adaptation may involve:
  - Component and system configuration;
  - Adding new components to the system;
  - Selecting from a library of existing components;
  - Modifying components to meet new requirements.

## Product line specialisation

- Platform specialization
  - Different versions of the application are developed for different platforms.
- Environment specialization
  - Different versions of the application are created to handle different operating environments e.g. different types of communication equipment.
- Functional specialization
  - Different versions of the application are created for customers with different requirements.
- Process specialization
  - Different versions of the application are created to support different business processes.

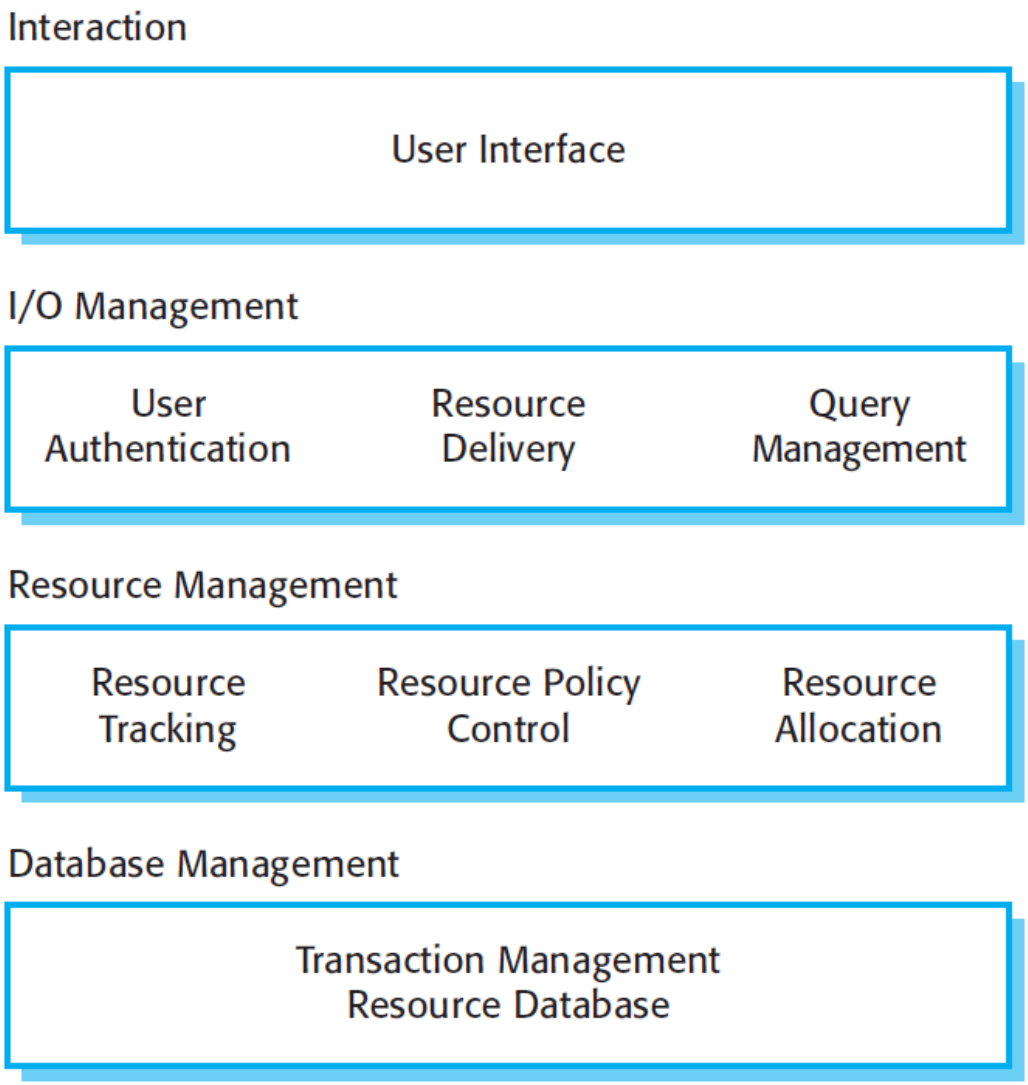
## Product line architectures

- Architectures must be structured in such a way to separate different sub-systems and to allow them to be modified.
- Software product lines are made up of a family of related applications, owned by the same organization. When you create a new application, your starting point is often the closest member of the application family, not the generic core application.

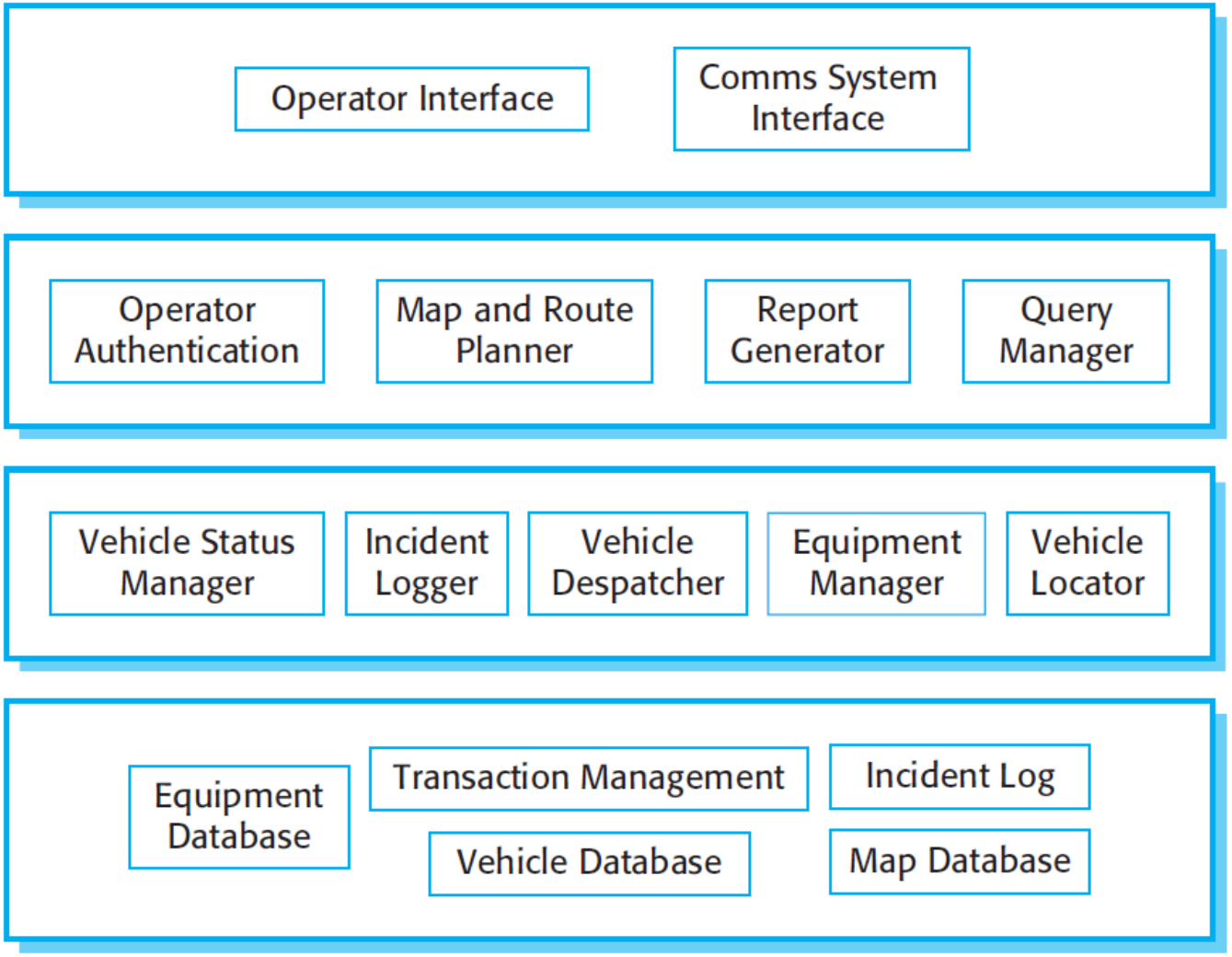
## Vehicle dispatching (Example)

- This vehicle dispatching system is an example of a resource management architecture
- A specialised resource management system where the aim is to allocate resources (vehicles) to handle incidents.
- Adaptations include: The components at different level
  - At the UI level, there are components for operator display and communications;
  - At the I/O management level, there are components that handle authentication, reporting and route planning;
  - At the resource management level, there are components for vehicle location and dispatch, managing vehicle status and incident logging;
  - The database includes equipment, vehicle and map databases.

# The architecture of a resource allocation system



# The product line architecture of a vehicle dispatcher



## Class Work Exercises

Q. Most desktop software, such as word processing software, can be configured in a number of different ways. Examine software that you regularly use and list the configuration options for that software. Suggest difficulties that users might have in configuring the software. If you use Microsoft Office or Open Office, these are good examples to use for this exercise.

## Key points

- Most new business software systems are now developed by reusing knowledge and code from previously implemented systems.
- There are many different ways to reuse software. These range from the reuse of classes and methods in libraries to the reuse of complete application systems.
- The advantages of software reuse are lower costs, faster software development and lower risks. System dependability is increased. Specialists can be used more effectively by concentrating their expertise on the design of reusable components.
- Application frameworks are collections of concrete and abstract objects that are designed for reuse through specialization and the addition of new objects. They usually incorporate good design practice through design patterns.