# Chapter 4

# Software Reuse

***Don't reinvent the wheel, Do something smart!***

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## Introduction

- 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 recognized 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 15 years
- Standards, such as **web service** standards, have made it easier to develop general services and reuse them across a range of applications.

## Introduction...

- The software units that are reused may be
  - **System reuse**
    - Complete systems, which may include several application programs may be reused.
  - **Application reuse**
    - An application may be reused either by incorporating it without change into other or by developing application families.
  - **Component reuse**
    - Components of an application from sub-systems to single objects may be reused.
  - **Object and function reuse**
    - Small-scale software components that implement a single well-defined object or function may be reused.
  - ***‘concept reuse’*** *- rather than reuse a software component, you reuse an idea, a way, or working or an algorithm.*

# Introduction...

➢ Benefits of software reuse

| Benefit | Explanation |
|---|---|
| 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. |
| Effective use of specialists | Instead of doing the same work over and over again, application specialists can develop reusable software that encapsulates their knowledge. |
| 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. |

| Benefit | Explanation |
|---|---|
| Lower development costs | Development costs are proportional to the size of the software being developed. Reusing software means that fewer lines of code have to be written. |
| 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. |
| 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. |

## Introduction…

- Problems with reuse

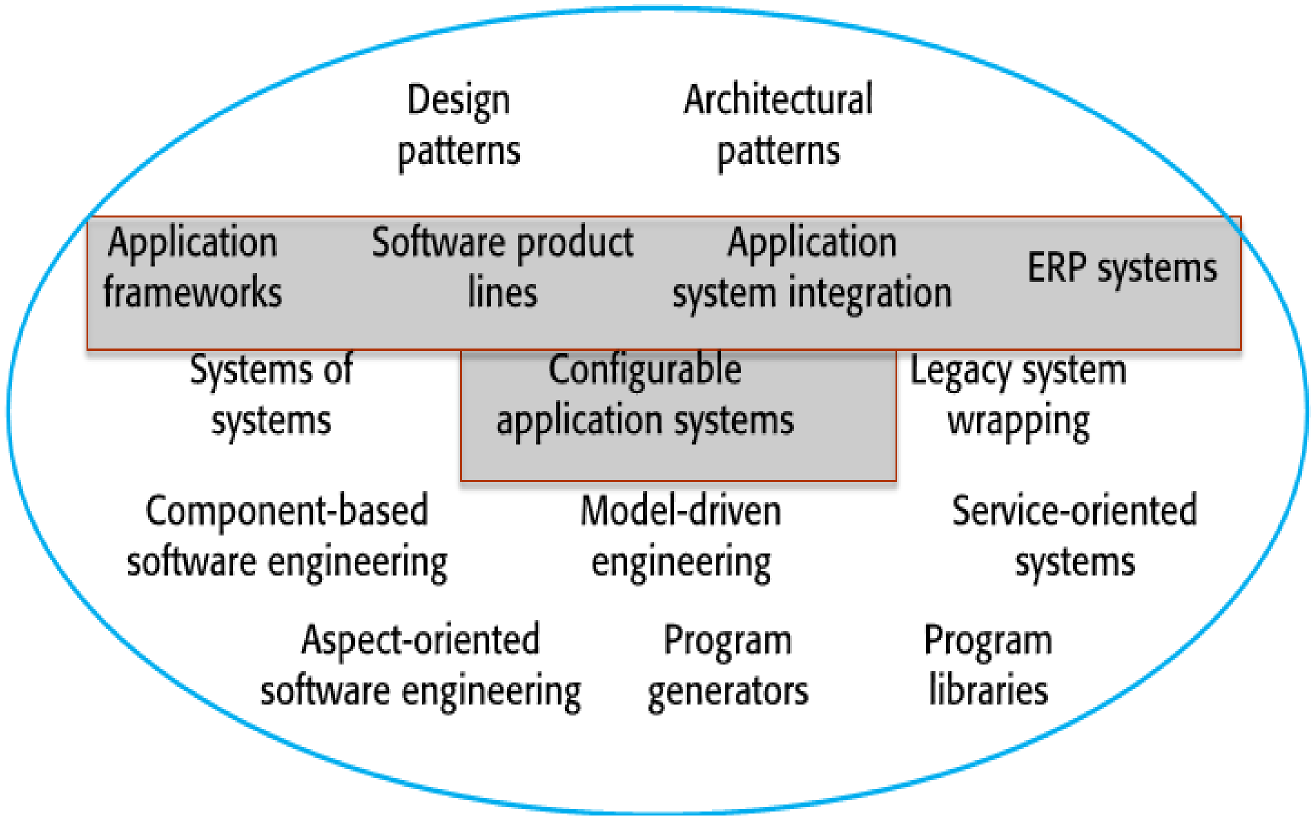
| Problem | Explanation |
|---|---|
| Creating, maintaining, & using a component library | Populating a reusable component library and ensuring the software developers can use this library can be expensive. Development processes have to be adapted to ensure that the library is used. |
| Finding, understanding, & 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. |
| 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. |

## Introduction…

| Problem | Explanation |
|---|---|
| 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. |

# The reuse landscape

- 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.



## Approaches that support software reuse

| Approach | Description |
|---|---|
| Application frameworks | Collections of abstract and concrete classes are adapted and extended to create application systems. |
| Application system integration | Two or more application systems are integrated to provide extended functionality |
| Architectural patterns | Standard software architectures that support common types of application system are used as the basis of applications. |
| Aspect-oriented software development | Shared components are woven into an application at different places when the program is compiled. |
| Component-based software engineering | Systems are developed by integrating components (collections of objects) that conform to component-model standards. |

## Approaches that support software reuse…

| Approach | Description |
|---|---|
| Configurable application systems | Domain-specific systems are designed so that they can be configured to the needs of specific system customers. |
| Design patterns | Generic abstractions that occur across applications are represented as design patterns showing abstract and concrete objects and interactions. |
| ERP systems | Large-scale systems that encapsulate generic business functionality and rules are configured for an organization. |
| Legacy system wrapping | Legacy systems are ‘wrapped’ by defining a set of interfaces and providing access to these legacy systems through these interfaces. |
| Model-driven engineering | Software is represented as domain models and implementation independent models and code is generated from these models. |

## Approaches that support software reuse...

| Approach | Description |
|---|---|
| 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. |
| Program libraries | Class and function libraries that implement commonly used abstractions are available for reuse. |
| 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. |
| Systems of systems | Two or more distributed systems are integrated to create a new system. |

## Reuse planning factors

- Given this array of techniques for reuse, the key question is *"which is the most appropriate technique to use in a particular situation?"*
- Obviously, this depends on the
  - requirements for the system being developed,
  - the technology and reusable assets available, and
  - 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.

## Application Frameworks

- Object-oriented development suggested that one of the key benefits of using an object-oriented approach was that objects could be reused in different systems.
- However, experience has shown that objects are often **too small** and **are specialized** for a particular application.
- It has now become clear that object-oriented reuse is best supported in an object-oriented development process through larger-grain abstractions called **frameworks**
- So, what is framework?

*"..an integrated set of software artefacts (such as classes, objects and components) that collaborate to provide a reusable architecture for a family of related applications."*

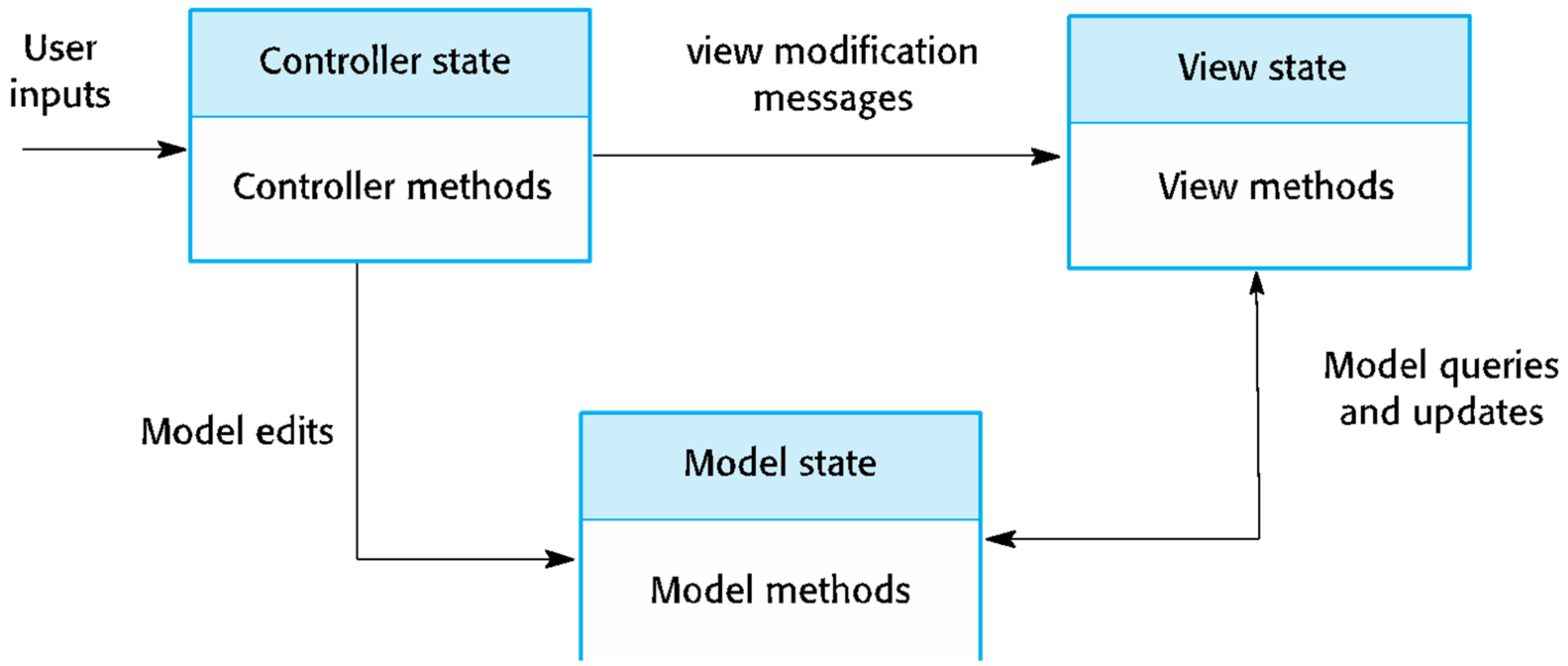
## Application Frameworks…

- 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.
- Frameworks provide support for generic features that are likely to be used in all applications of a similar type.
- Frameworks support design reuse in that they provide a skeleton architecture for the application as well as the reuse of specific classes in the system.
- Frameworks are language-specific.

## Application Frameworks…

- **Web application frameworks**
  - Support the construction of dynamic websites as a front-end for web applications.
    - **Examples:** Joomla, Drupal, Wordpress, …
  - WAFs are now available for all of the commonly used web programming languages e.g. Java, Python, Ruby, etc.
  - Interaction model is based on the Model-View-Controller composite pattern
  - 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 patterns

## Application Frameworks…



The Model-View-Controller pattern

## Application Frameworks...

- **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 support, which allows more interactive web pages to be created.

## Application Frameworks…

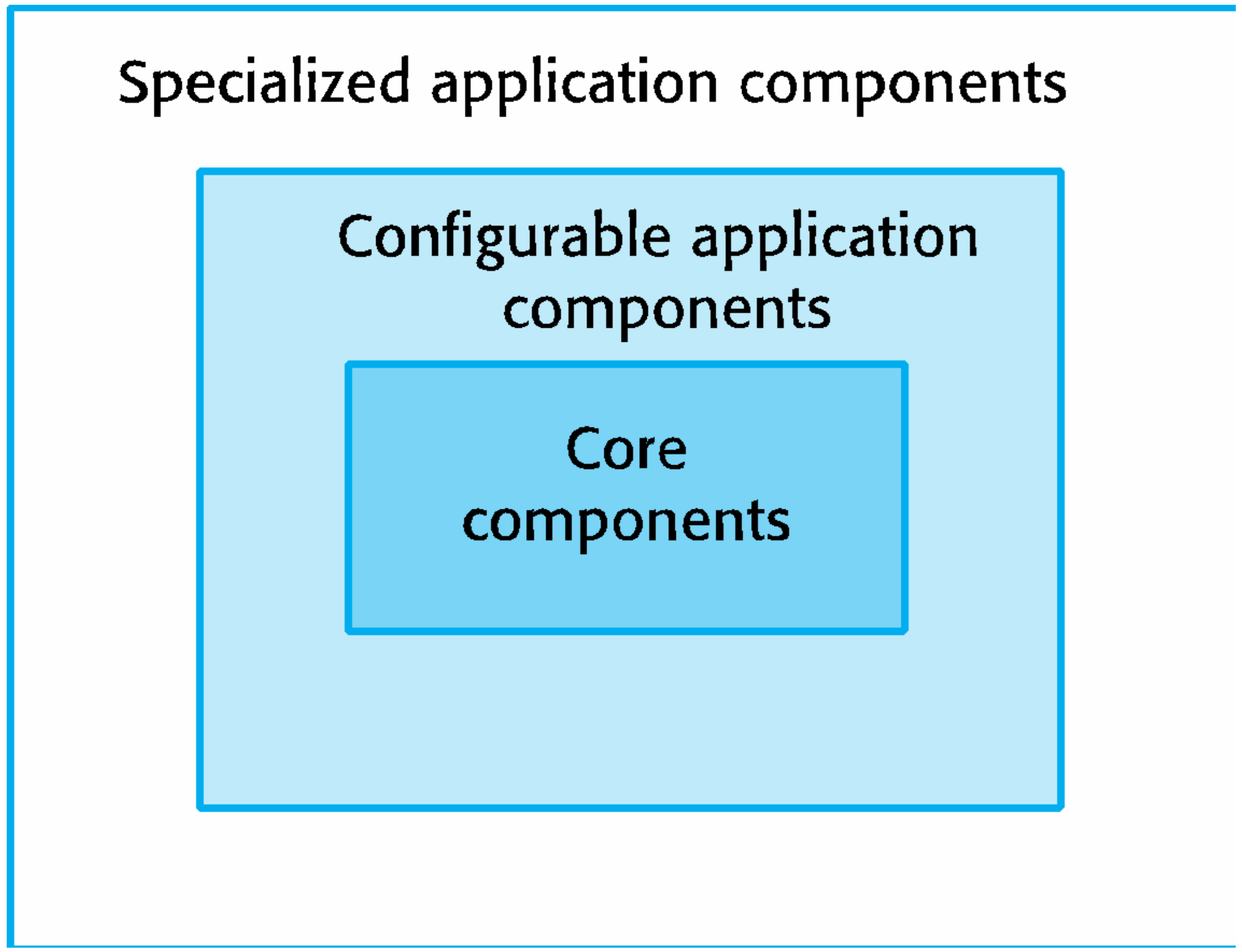
- **Extending frameworks**
  - Frameworks are generic and are extended to create a more specific application or sub-system.
    - They provide a skeleton architecture for the system.
  - Extending the framework involves
    - Adding concrete classes that inherit operations from abstract classes in the framework
    - Adding methods  that are called in response to events (=callbacks) that are recognized by the framework.
  - Problem with frameworks is their complexity which means that it takes a long time to use them effectively.

## 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.
- 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.

## Software product lines...

Base systems for a software product line


Specialized application components
Configurable application components
Core components

## Software product lines...

- **Base systems for a software product line...**
  - Core components
    - provide infrastructure support
    - These are not usually modified when developing a new instance of the product line.
  - Configurable components
    - that may be modified and configured to specialize them to a new application.
    - Sometimes, it is possible to reconfigure these components without changing their code by using a built-in component configuration language.
  - Specialized, domain-specific components
    - some or all of which may be replaced when a new instance of a product line is created.

## Software product lines...

### Application frameworks

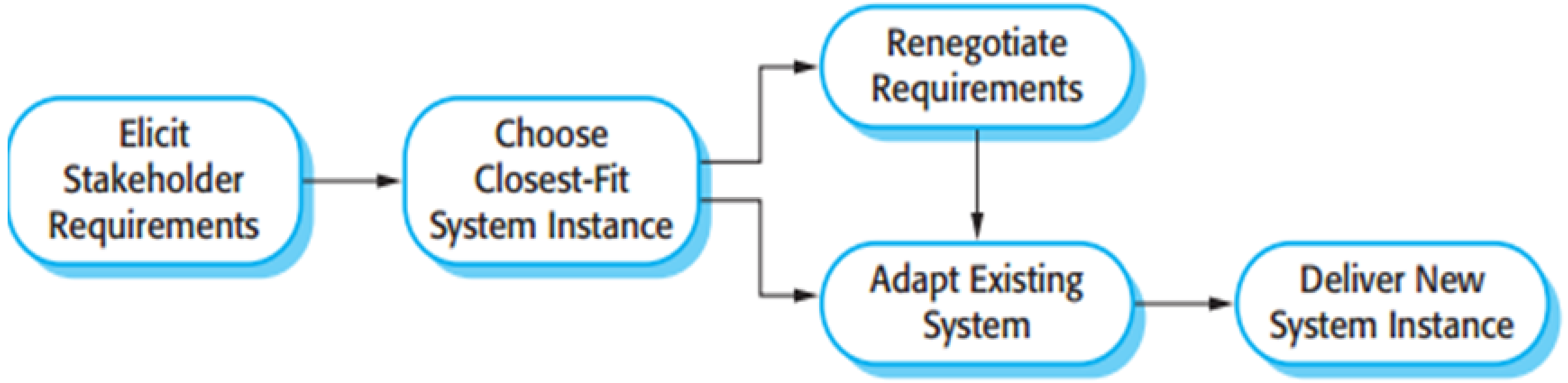
- Application frameworks rely on object-oriented features such as polymorphism to implement extensions.
- Application frameworks focus on providing technical rather than domain-specific support.
- Software product lines are made up of a family of applications, usually owned by the same organization.

### Product lines

- Product lines need not be object-oriented (e.g. embedded software for a mobile phone)
- Product lines embed domain and platform information.
- Product lines often control applications for equipment.
- Software product lines are made up of a family of applications, usually owned by the same organization.

## Software product lines…

- **Product instance development**
  - To create a specific version of a system, you may have to modify individual components.
    - For example for vehicle dispatcher system the police have a large number of vehicles but a small number of vehicle types, whereas the fire service has many types of specialized vehicles. Therefore, you may have to define a different vehicle database structure when implementing a system for these different services.
  - The steps involved in extending a software product line to create a new application is shown below


Elicit Stakeholder Requirements
Choose Closest-Fit System Instance
Renegotiate Requirements
Adapt Existing System
Deliver New System Instance

## Software product lines...

- **Product instance development....**
  - Elicit stakeholder requirements
    - Use existing family member as a prototype
  - Choose closest-fit family member
    - Find the family member that best meets the requirements
  - Re-negotiate requirements
    - Adapt requirements as necessary to capabilities of the software
  - Adapt existing system
    - Develop new modules and make changes for family member
  - Deliver new family member
    - Document key features for further member development

## Application system reuse

- An application system product is a software system that can be adapted for different customers without changing the source code of the system.
- Application systems have generic features and so can be used/reused in different environments.
- Application system products are adapted by using built-in configuration mechanisms that allow the functionality of the system to be tailored to specific customer needs.
  - For example, in a hospital patient record system, separate input forms and output reports might be defined for different types of patient.

## Application system reuse…

- Benefits of application system reuse
  - As with other types of reuse, more rapid deployment of a reliable system may be possible.
  - It is possible to see what functionality is provided by the applications and so it is easier to judge whether or not they are likely to be suitable.
  - Some development risks are avoided by using existing software. However, this approach has its own risks.
  - Businesses can focus on their core activity without having to devote a lot of resources to IT systems development.
  - As operating platforms evolve, technology updates may be simplified as these are the responsibility of the COTS product vendor rather than the customer.

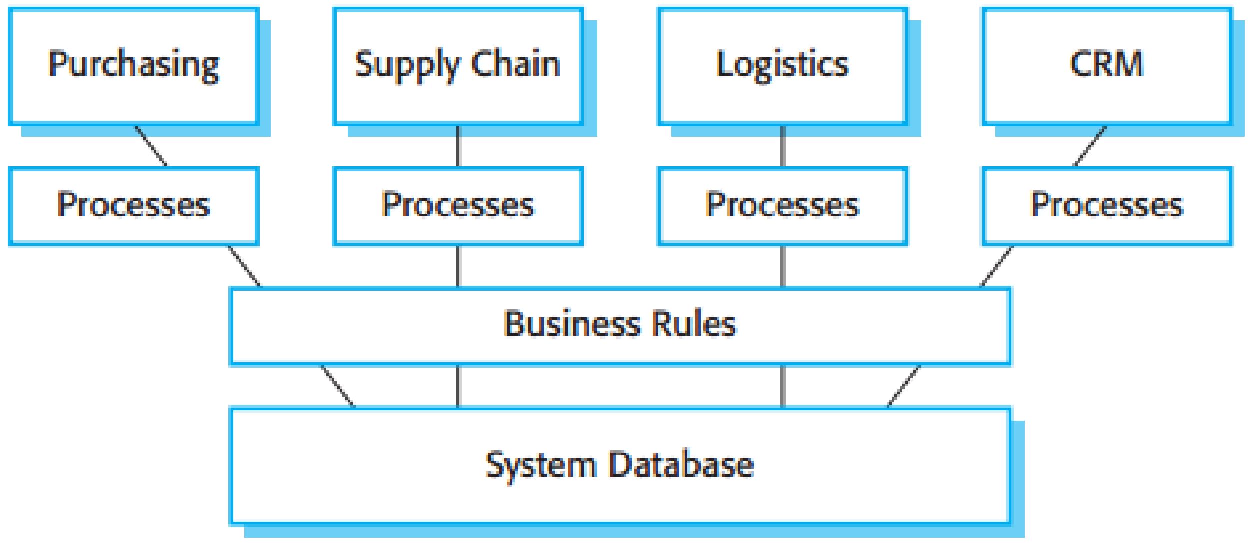
## Application system reuse…

- Problems of application system reuse
  - Requirements usually have to be adapted to reflect the functionality and mode of operation of the COTS product.
  - The COTS product may be based on assumptions that are practically impossible to change.
  - Choosing the right COTS system for an enterprise can be a difficult process, especially as many COTS products are not well documented.
  - There may be a lack of local expertise to support systems development.
  - The COTS product vendor controls system support and evolution.

## ERP systems

- An Enterprise Resource Planning (ERP) system is a generic system that supports common business processes such as ordering and invoicing, manufacturing, etc.
- These are very widely used in large companies - they represent probably the most common form of software reuse.
- The generic core is adapted by including modules and by incorporating knowledge of business processes and rules.

The architecture of an ERP system



## ERP systems…

- ERP architecture
  - A number of modules to support different business functions.
  - A defined set of business processes, associated with each module, which relate to activities in that module.
  - A common database that maintains information about all related business functions.
  - A set of business rules that apply to all data in the database.

## ERP systems…

- ERP Configuration
  - Selecting the required functionality from the system.
  - Establishing a data model that defines how the organization's data will be structured in the system database.
  - Defining business rules that apply to that data.
  - Defining the expected interactions with external systems.
  - Designing the input forms and the output reports generated by the system.
  - Designing new business processes that conform to the underlying process model supported by the system.
  - Setting parameters that define how the system is deployed on its underlying platform.

## Configurable application systems

- Configurable application systems are generic application systems that may be designed to support a particular business type, business activity or, sometimes, a complete business enterprise.
  - For example, an application system may be produced for dentists that handles appointments, dental records, patient recall, etc.
- Domain-specific systems, such as systems to support a business function (e.g. document management) provide functionality that is likely to be required by a range of potential users.

# Configurable application systems…

- Configurable Application Systems Vs Application System Integration

| Configurable application systems | Application system integration |
|---|---|
| Single product that provides the functionality required by a customer | Several heterogeneous system products are integrated to provide customized functionality |
| Based around a generic solution and standardized processes | Flexible solutions may be developed for customer processes |
| Development focus is on system configuration | Development focus is on system integration |
| System vendor is responsible for maintenance | System owner is responsible for maintenance |
| System vendor provides the platform for the system | System owner provides the platform for the system |