3.1	Design quality, Design Concepts, The Design Model, Introduction to Pattern-Based Software Design
3.2	Software Architecture, Data Design, Design of Software Objects, Features and Methods, Cohesion and Coupling between Objects
3.3	User Interface Design: Rules, User Interface Analysis and Steps in Interface Design, Design Evaluation
3.4	Software Reuse, Component-Based Software Engineering

DESIGN QUALITY

- **Software design** is an "**iterative process**" through which **requirements are translated into a "blueprint"** for constructing the software.

  – Developers identify and prioritize the qualities of the system that they should optimize.

Design Guidelines

- **Design must implement all of the explicit requirements** contained in the analysis model, and it must accommodate all of the implicit requirements desired by the customer.

- **Design must be a readable, understandable** guide for those who generate code and for those who test and subsequently support the software.

- **Design should provide a complete picture of the software**, addressing the data, functional, and behavioral domains from an implementation perspective.

Quality Guidelines

- **A design should exhibit an architecture** that was :

1. Created using standard architectural patterns.(Peer,Layered,Client Server)
2. Composed of components that exhibit good design characteristics.
3. Can be implemented in an evolutionary fashion

- **A design should be modular:** logically partitioned into elements or subsystems

Quality Guidelines

- A design should contain **distinct representations** of data, architecture, interfaces, and components.

- A design should lead to **data structures that are appropriate** for the classes to be implemented and are drawn from recognizable data patterns.

- A design should lead to components that **exhibit independent functional characteristics.**

Quality Guidelines

- A design should lead to interfaces that **reduce the complexity** of **connections between components and with the external environment.**

- A design should be derived using a **repeatable method** that is driven by information obtained during software requirements analysis.

- A design should be represented using a **notation** that **effectively communicates its meaning.**

DESIGN PRINCIPLES

- The **design proces**s is a sequence of steps that enable the designer to **describe all aspects of the software to be built.**

1. **The design process should not suffer from "tunnel vision."-** A good designer should consider alternative approaches.

2. **The design should be traceable to the analysis model.-** means for tracking how requirements have been satisfied by the design model.

Design Principles

3. <u>The design should not reinvent the wheel</u>.

Design time should be invested in representing truly new ideas and integrating those patterns that already exist.

4. The design should "minimize the intellectual distance" between the software and the problem as it exists in the real world.

Structure of the software design should be replica of structure of the problem domain.

Design Principles

5. The design should exhibit uniformity and integration.

- format should be defined for a design team before design work begins.
- design is integrated if care is taken in defining interfaces between design components.

6. The design should be structured to accommodate change.

Design Principles

7. **The design should be structured to degrade gently, even when aberrant data, events, or operating conditions are encountered.**

- Well designed software should never “bomb.”
- It should be designed to accommodate **unusual circumstances,** and if it must terminate processing, do so in a graceful manner.

Design Principles

8. “Design is not coding, coding is not design”

- the level of abstraction of the design model is higher than source code.
- only design decisions made at the coding level address the small implementation details.

9. The design should be assessed for quality as it is being created, not after .

10. The design should be reviewed to minimize conceptual (semantic) errors.

Software Design Concepts

- Software Design concepts are **fundamental concepts** which **provides** the software designer with a **FOUNDATION from which more sophisticated design methods** can be applied for software design process

DESIGN CONCEPTS

1. ABSTRACTION
2. REFINEMENT
3. MODULARITY
4. SOFTWARE ARCHITECTURE
5. ARCHITECHTURAL MODELS
6. PATTERNS
7. INFORMATION HIDING
8. FUNCTIONAL INDEPENDENCE
9. REFACTORING

Abstraction

- Modular solution to any problem , many levels of abstraction can be posed.
- At the **highest** level of abstraction, a solution is stated in broad terms using the language of the problem environment.
- **lower** levels of abstraction, a more procedural orientation is taken.
- Each step in the software process is a refinement in the level of abstraction of the software solution.

- A **procedural abstraction** is a named sequence of instructions that has a specific and limited function. (algorithm)
- Example: word **DOOR** implies a long sequence of procedural steps
- A **data abstraction** is a named collection of data that describes a data object
- **Example: word DOOR** would encompass a set of attributes that describe the door
- **Control abstraction** implies a program control mechanism for coordinating activities

Refinement

- Refinement is process of elaboration
- top-down design strategy
- A program is developed by successively refining levels of procedural detail.

Stepwise Refinement

Open Door

walk to door;
reach for knob;

open door;

walk through;
close door.

repeat until door opens
turn knob clockwise;
if knob doesn't turn, then
    take key out;
    find correct key;
    insert in lock;
endif
pull/push door
move out of way;
end repeat

- Refinement causes the designer to **elaborate on the original statement, providing more and more detail** as each successive refinement (elaboration) occurs.

- Abstraction and refinement are complementary concepts.

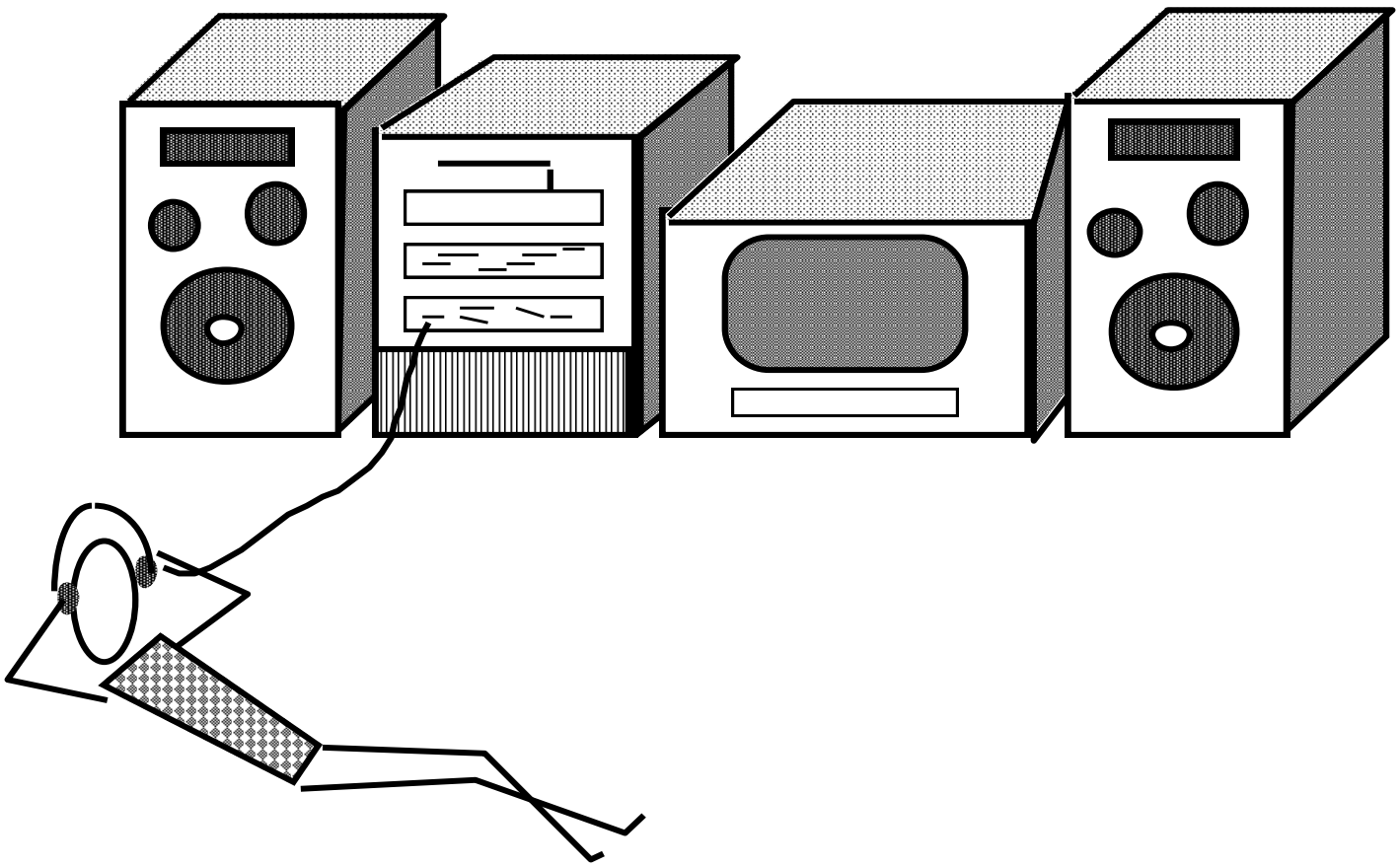
Modularity

- **software is divided** into separately named and addressable **components**, often called modules, that are **integrated to satisfy problem requirements.**

- **modularity** is the single attribute of software that **allows** a program to be **intellectually manageable.**

Modular Design

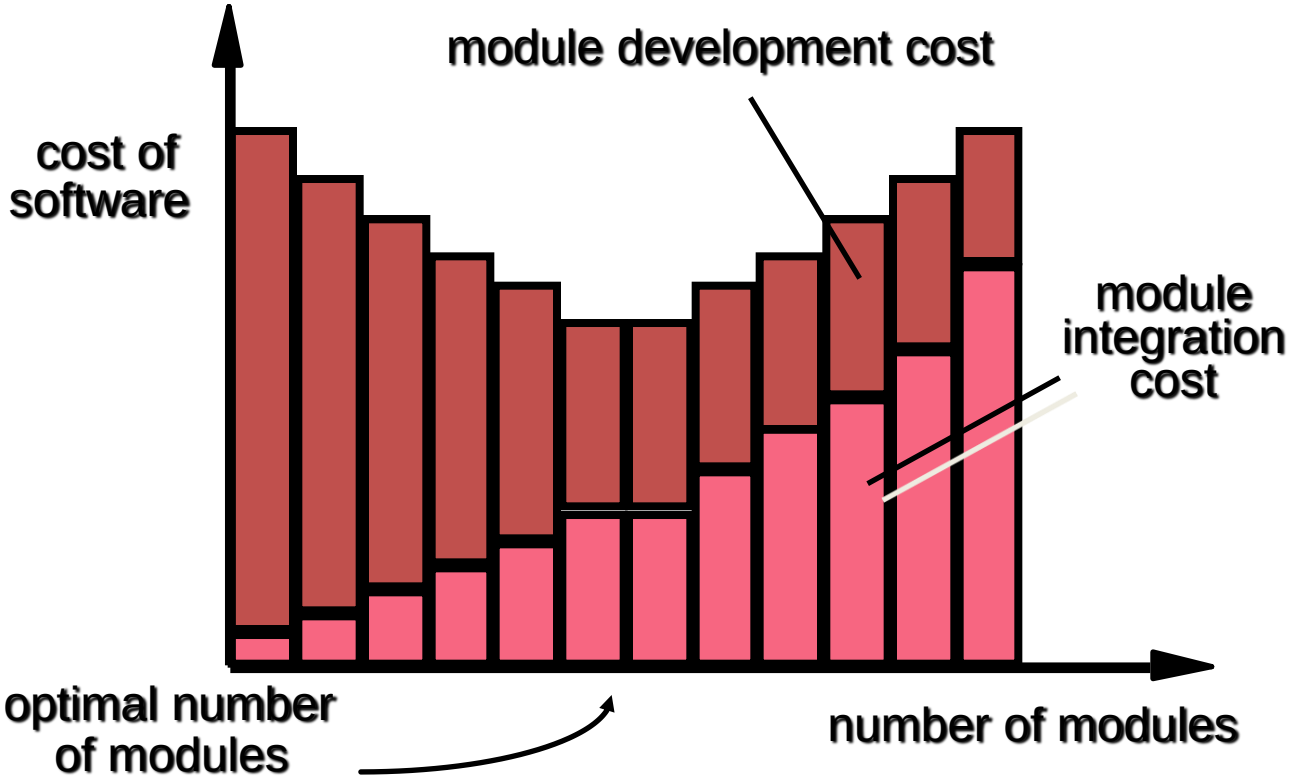
easier to build, easier to change, easier to fix ...



- "**divide and conquer**" conclusion
  - it's easier to solve a complex problem when you break it into manageable pieces - **an argument for modularity.**

Modularity: Trade-offs

What is the "right" number of modules for a specific software design?



5 criteria to define an effective modular system

1. **Modular decomposability –** systematic mechanism for **decomposing** the problem into sub problems.

2. **Modular composability – reusing** existing system into new system yield modular solution and not reinvent wheel.
3. **Modular understandability -** understood as **standalone** unit , it will be easier to build and easier to change.

4. **Modular continuity - small changes** to the system requirements - changes to **individual modules** rather system – change induced side effects minimized.

5. **Modular protection -** aberrant condition - error-induced side effects minimized.

Software Architecture

- Architecture—the overall structure of the software.
  - architecture is the **hierarchical** structure of program components (modules)
  - the manner in which these components **interact** and the structure of data that are used by the components.
  - Well designed architecture servers as **framework** for detailed design activities which can also help in reuse of design level concepts.

Properties of an architectural design:

1. **Structural properties:** This aspect of the architectural design representation defines the components of a system and their interaction with one another.

2. **Extra-functional properties:** like performance, capacity, reliability, security, adaptability, and other system characteristics.

3. Families of related systems:

The architectural design should draw upon repeatable patterns that are commonly encountered in the design of families of similar systems.

Different architectural models

1. **Structural models** represent architecture as an **organized collection of program components.**

2. **Framework models** identify **repeatable** architectural design frameworks (**patterns)**

3. **Dynamic models** address the behavioral aspects of the program architecture, indicating **changes in configuration of system.**

4. **Process models** focus on the design of the business or **technical proce**ss that the system must accommodate.

5. **Functional models** can be used to represent the **functional hierarchy** of a system.

Patterns

- Design pattern **describes a design structure** that **solves a particular design problem within a specific context.**
- **GENERAL REUSABLE SOLUTION TO A COMMONLY OCCURRING PROBLEM IN SOFTWARE DESIGN**

The intent of each design pattern is to provide a description that enables a designer to determine:

- whether the pattern is applicable to the **current work**
- **wh**ether the pattern can be reused
- whether the pattern can serve as a guide for **developing a similar**, but f**unctionally** or structurally **different pattern**.

Information Hiding

The intent of information hiding is to **hide the details of data structures and procedural processing** behind a module interface.

- Knowledge of the **details need not be known by users**

- independent modules that **communicate with one another only that information necessary** to achieve software function

- information hiding provides the **greatest benefits when modifications** are required.

- Because most data and procedural **detail are hidden** from other parts of the **software errors less likely to propagate.**

Functional Independence

Software should be designed such that **each module addresses a specific subset of requirements** and has a **simple interface with other program structure.**

- Software with effective modularity, that is, independent modules, is easier to develop.

- **Independent modules**

✓ easier to maintain (and test)

✓ effects caused by design or code modification limited

✓ error propagation is reduced

✓ reusable modules are possible.

- Functional independence is a **key to good design**, and **design** is the **key to software quality**.

- Independence is assessed using two qualitative criteria:

COHESION - the degree to which a module performs one and only one function.

COUPLING - the degree to which a module is "connected" to other modules in the system.

COHESION

- A cohesive module performs a **single task**, requiring **little interaction** with **other components** in other parts of a program.

- **High degree of cohesion is advisable but** it is also necessary and advisable for **components to perform multiple functions.**

COUPLING

- Coupling is an indication of **interconnection among modules** in a software structure.

- Coupling depends on the **interface complexity** between modules
  - entry point and type of data that passes through interface.

- In software design, one should strive for the lowest possible coupling.

- Simple connectivity among modules results in software that is **easier to understand** and **less** prone to a “**ripple effect**”

REFACTORING

Refactoring is the process of **changing a software system** in such a way that it **does not alter the external behavior** of the code [design] yet **improves its internal structure.**

- When software is refactored:

✓ the existing design is examined for redundancy

✓ unused design elements

✓ inefficient or unnecessary algorithms

✓ poorly constructed or inappropriate data structures,

✓ any other design failure that can be corrected to yield a better design.

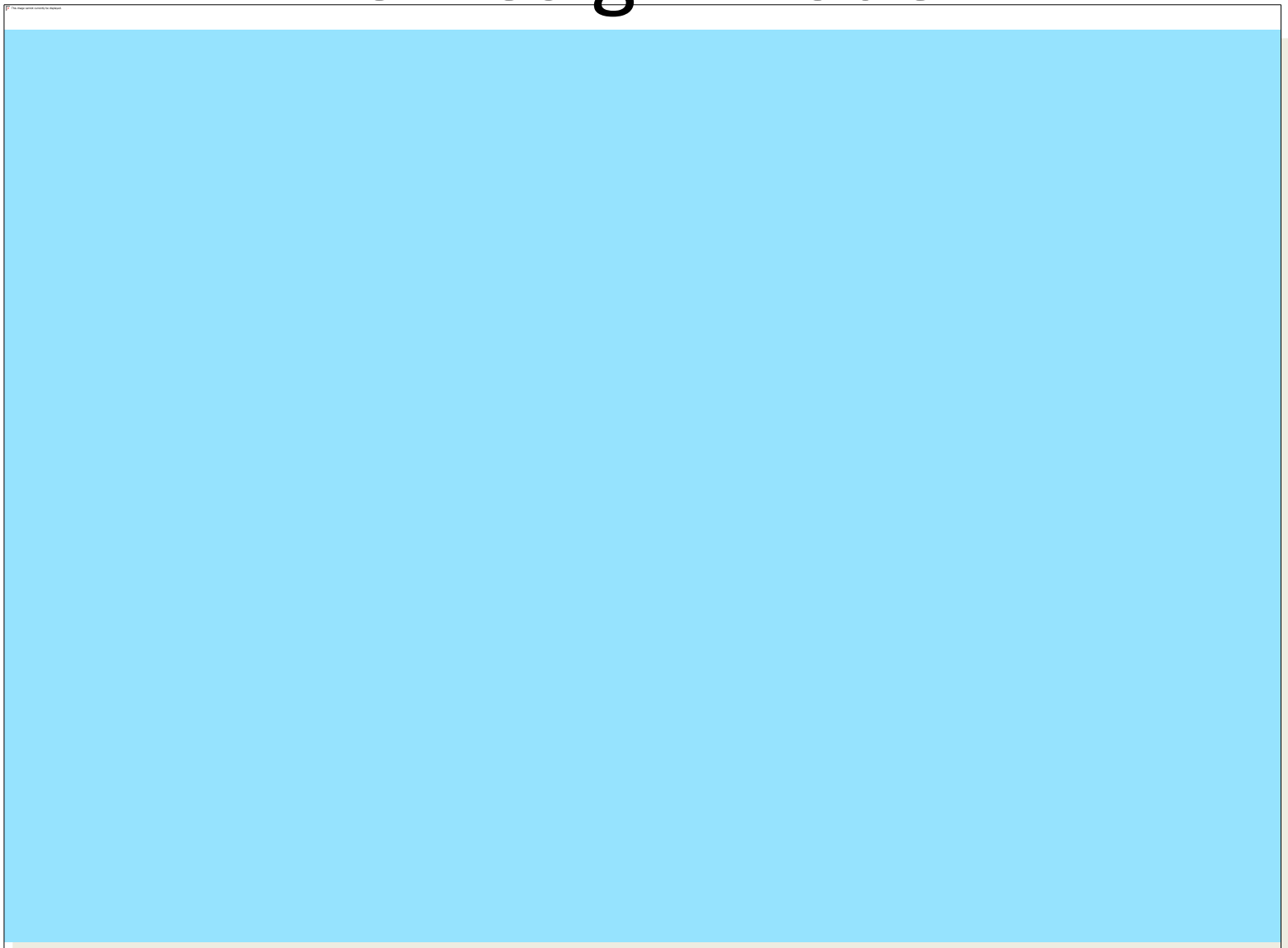
The Design Model

- The design model can be viewed in two different dimensions:

  - ✓The **process dimension** as design tasks are executed.

  - ✓The **abstraction dimension** represents the level of detail in each element

The Design Model



Elements of Design Model

- ✓ **Data Design Elements**
  - data structures
  - database architecture
- ✓ **Architectural Design Elements**

- The architectural design for software is the equivalent to the **floor plan** of a house.

3 sources for development of architecture model

(1) **information** about the **application domain** for the software to be built.

(2) **specific requirements** model elements (data flow diagrams , collaboration etc.)

(3) architectural **styles and patterns**

Elements of Design Model

✓ **Interface Design Elements**

– The interface design for software is analogous to a set of **detailed drawings**

3 important elements of interface design:

(1) the user interface **(UI)**

(2) **external interfaces** to other systems, devices, networks, or other producers or consumers of information

(3) **internal interfaces** between various design components.

➢ Interface design elements **allow external/ internal communication** and **collaboration** among various components.

Elements of Design Model

✓ **Component-Level Design Elements**

– The component-level design for software is equivalent to a **set of detailed drawings** (and specifications)
  – E.g. Each room of house.

✓ **Deployment-Level Design Elements**

– Deployment-level design elements indicate how **software functionality and subsystems** will be **allocated** within the software environment

DESIGN PATTERNS are used to represent some of the **best practices adapted by experienced object-oriented software developers.**

- A design pattern systematically names, motivates, and explains a general design that addresses a recurring design problem in object-oriented systems.

- It describes the **problem, the solution, when to apply the solution, and its consequences.**

- It also gives **implementation hints and examples**.

PATTERN-BASED SOFTWARE DESIGN

- The best designers in any field have an uncanny **ability to see patterns that characterize a problem** and corresponding patterns that can be combined to create a solution.

- **A description of a design pattern may also consider a set of design forces.**
  - ***Design forces*** **describe non-functional requirements** (e.g., ease of maintainability, portability) **associated with the software** for which the pattern is to be applied.

Pattern-based Software Design

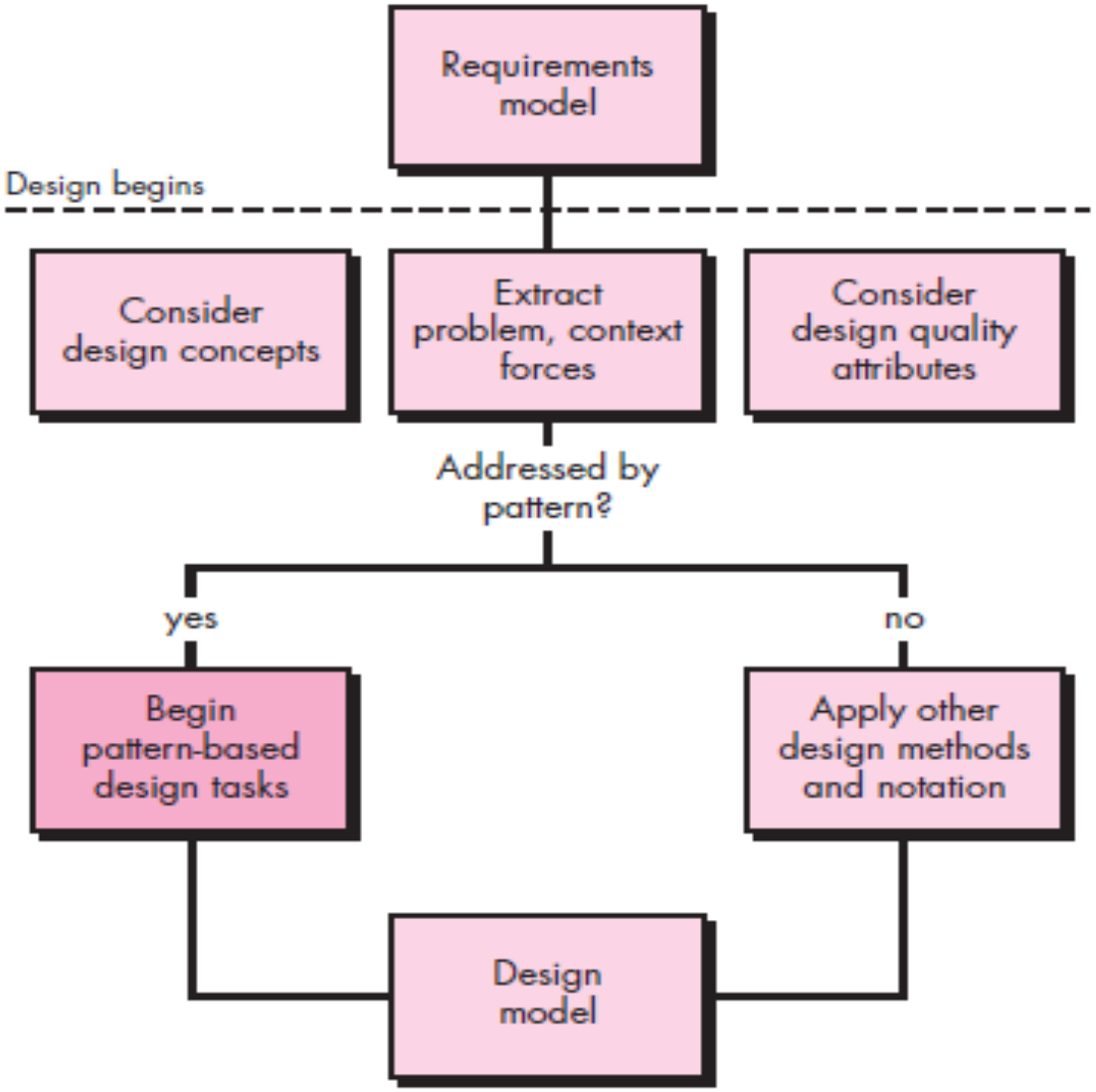
- The **pattern characteristics** (classes, responsibilities, and collaborations) indicate the attributes of the design that may be adjusted to enable the pattern to accommodate a **variety of problems (problem solving)**.

- Throughout the design process, one should look for every opportunity to **apply existing design patterns** rather than creating new ones.

PATTEN BASED SOFTWARE DESIGN

1. **PATTERN BASED DESIGN IN CONTEXT**
2. **THINKING IN PATTERNS**
3. **DESIGN TASKS**
4. **PATTERN ORGANIZING TABLE**
5. **COMMON DESIGN MISTAKES**

1. Pattern-Based Design in Context



Use methods and modeling tools available for architectural, component level, and interface design.

2. Thinking in Patterns

- "**NEW WAY OF THINKING**" when one **uses patterns** as part of the design activity.

- Good design begins by considering **context**—the big picture.

Approach that enables a designer to think in patterns

1. Context of **software build and requirements** to be understood.
2. Extract the **patterns** that are **present** at **level of abstraction.**
3. Begin design with “**big picture**” patterns that establish a **context or skeleton** for further design work.

4. “**Work inward from the context**” lower levels of abstraction that contribute to the design solution.

5. **Repeat steps 1 to 4** until the complete design is fleshed out.

6. **Refine the design** by adapting each pattern to the specifics of the software

3. Design Tasks

- **The following design tasks are applied when a pattern-based design philosophy is used:**

1. **Examine** the **requirements model and develop** a problem hierarchy.

2. Determine if a **reliable pattern language** has been **developed** for the problem domain.

3. Beginning with a broad problem, determine **whether one or more architectural patterns** is **available** for it.

4. Using the collaborations provided for the architectural pattern , **examine subsystem or component-level problems and search for appropriate patterns** to address them.

Repeat steps until all broad problems have been addressed

5. **User interface design problems** have been **isolated** **search** many user interface **design pattern** repositories for appropriate patterns.

6. **Compare various pattern** against the existing ones for better designing.

7. Be certain to refine the design as it is derived from patterns using **design quality criteria** as a guide.

4. Building a Pattern-Organizing Table

As pattern based design proceeds organizing and categorizing problem may occur.

- Solution: **A pattern-organizing table** can be implemented as a spreadsheet model

Pattern Organizing Table

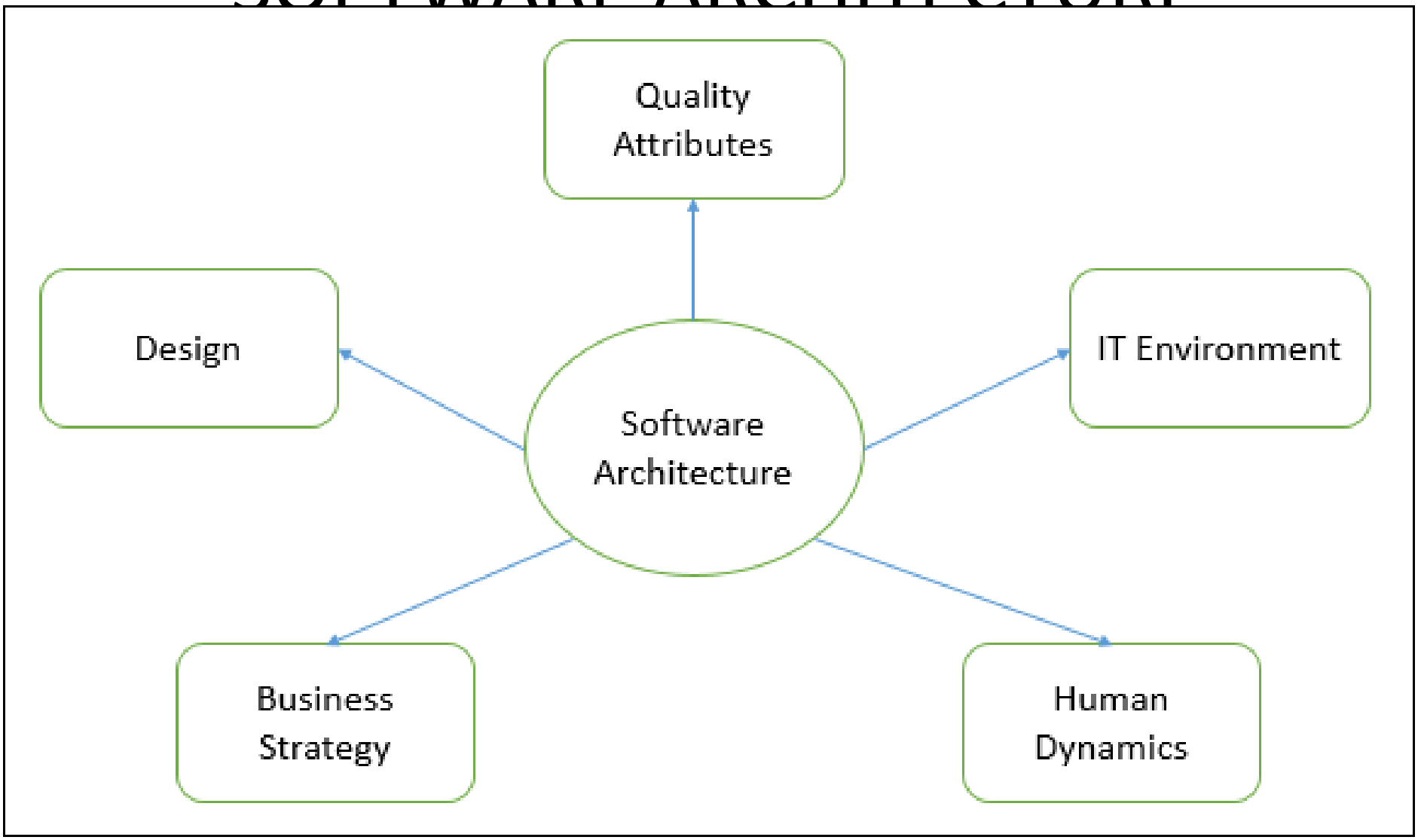
	Database	Application	Implementation	Infrastructure
Data/Content				
Problem statement …	PatternName(s)		PatternName(s)	
Problem statement …		PatternName(s)		PatternName(s)
Problem statement …	PatternName(s)			PatternName(s)
Architecture				
Problem statement …		PatternName(s)		
Problem statement …		PatternName(s)		PatternName(s)
Problem statement …				
Component-level				
Problem statement …		PatternName(s)	PatternName(s)	
Problem statement …				PatternName(s)
Problem statement …		PatternName(s)	PatternName(s)	
User interface				
Problem statement …		PatternName(s)	PatternName(s)	
Problem statement …		PatternName(s)	PatternName(s)	
Problem statement …		PatternName(s)	PatternName(s)	

5. Common Design Mistakes

A number of common mistakes occur when pattern-based design is used.

1. **Not enough time has been spent to understand the underlying problem.**
2. **Wrong pattern selected.**
3. **Quality standards ignored.**

SOFTWARE ARCHITECTURE



WHY ARCHITECTURE?

The architecture **is not the operational software**.

Rather, it is a representation that enables a software engineer to:

(1) **Analyze the effectiveness of the design** in meeting its stated requirements

(2) **Consider architectural alternatives** at a stage when making design changes is still relatively easy, and

(3) **Reduce the risks** associated with the construction of the software.

Why is Architecture Important?

- **Representations of software architecture are an enabler for communication** between all parties (stakeholders) interested in the development of a computer-based system.

- **The architecture highlights early design decisions** that will have a profound impact on all software engineering work that follows and, as important, on the ultimate success of the system as an operational entity.

- **Architecture "constitutes a relatively small, intellectually graspable model** of how the system is structured and how its components work together".

At the architectural level …

- **Design of one or more databases** to support the application architecture
- Design of methods for '**mining**' the content of multiple databases
  - **navigate through existing databases** in an attempt to extract appropriate business-level information
  - **Design of a data warehouse**—a large, independent database that has access to the data that are stored in databases that serve the set of applications required by a business

At the component level …

- **Refine data objects** and develop a set of **data abstractions**
- Implement data object attributes as one or more data structures
- **Review** data structures to ensure that appropriate **relationships** have been established
- **Simplify** data structures as required

Architectural Styles

The **software** uses a pattern or an **architectural style** where the pattern is a reusable solution for any problem faced during **software** design and development, while the **architectural style** is the **structure** of the **software** based on which the design is created.

EACH STYLE DESCRIBES A SYSTEM CATEGORY THAT ENCOMPASSES:

(1) A set of components (eg: A **database**, computational modules) that perform a function required by a system

(2) **A set of connectors** that enable "**communication**, coordination and cooperation" among components

(3) **Constraints** that define how components can be **integrated** to form the system

(4) **Semantic models** that enable a designer to **understand the overall properties of a system** by analyzing the known properties of its constituent parts.

Data-centered architectures

- A **data store** (e.g., a file or database) **resides at the center** of this architecture and is accessed frequently by other components.
- **Client software** accesses a **central repository.**
- Data-centered architectures promote **integrability.**
- New client components can be added easily.
- Client components independently execute processes.

Data-Centered Architecture

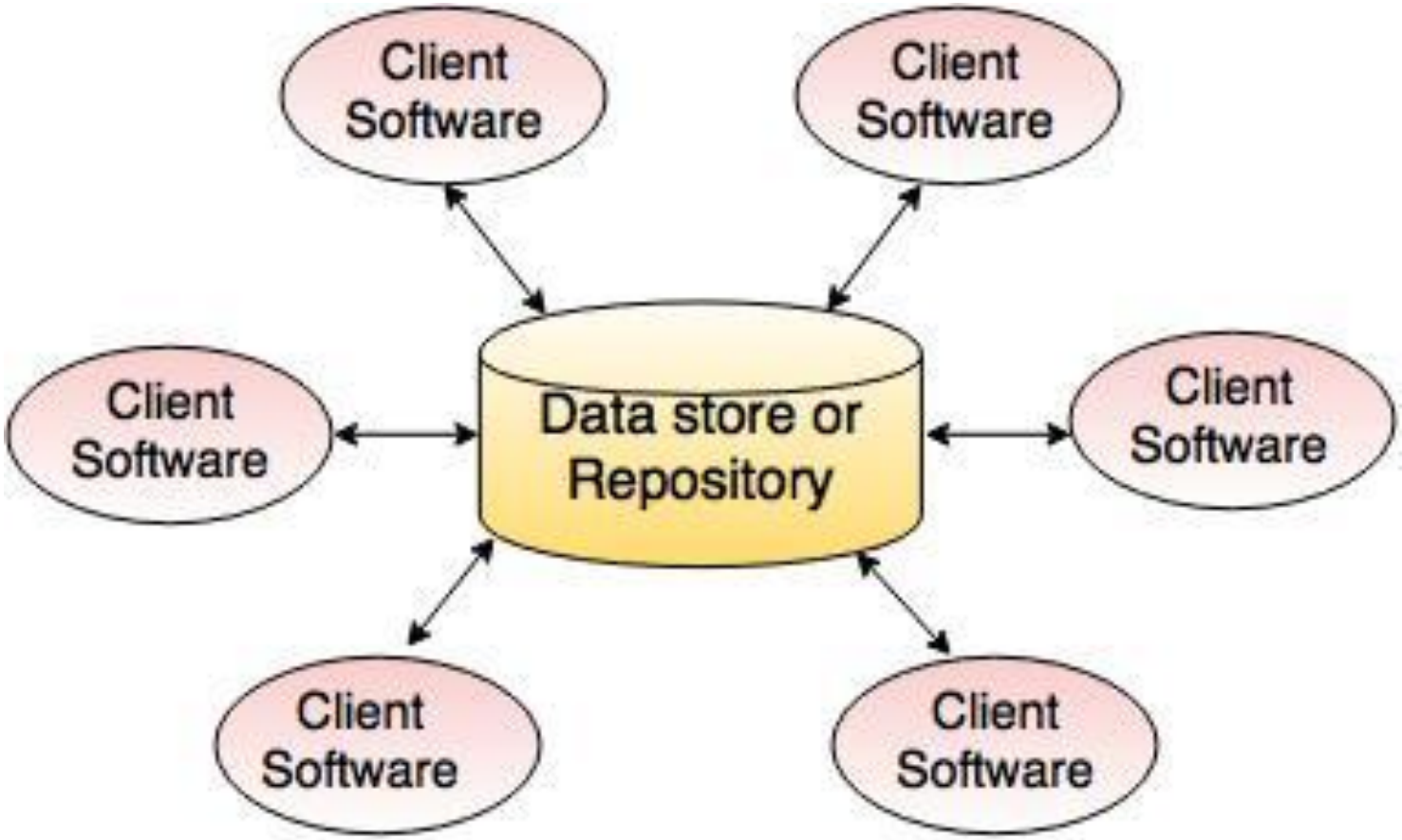
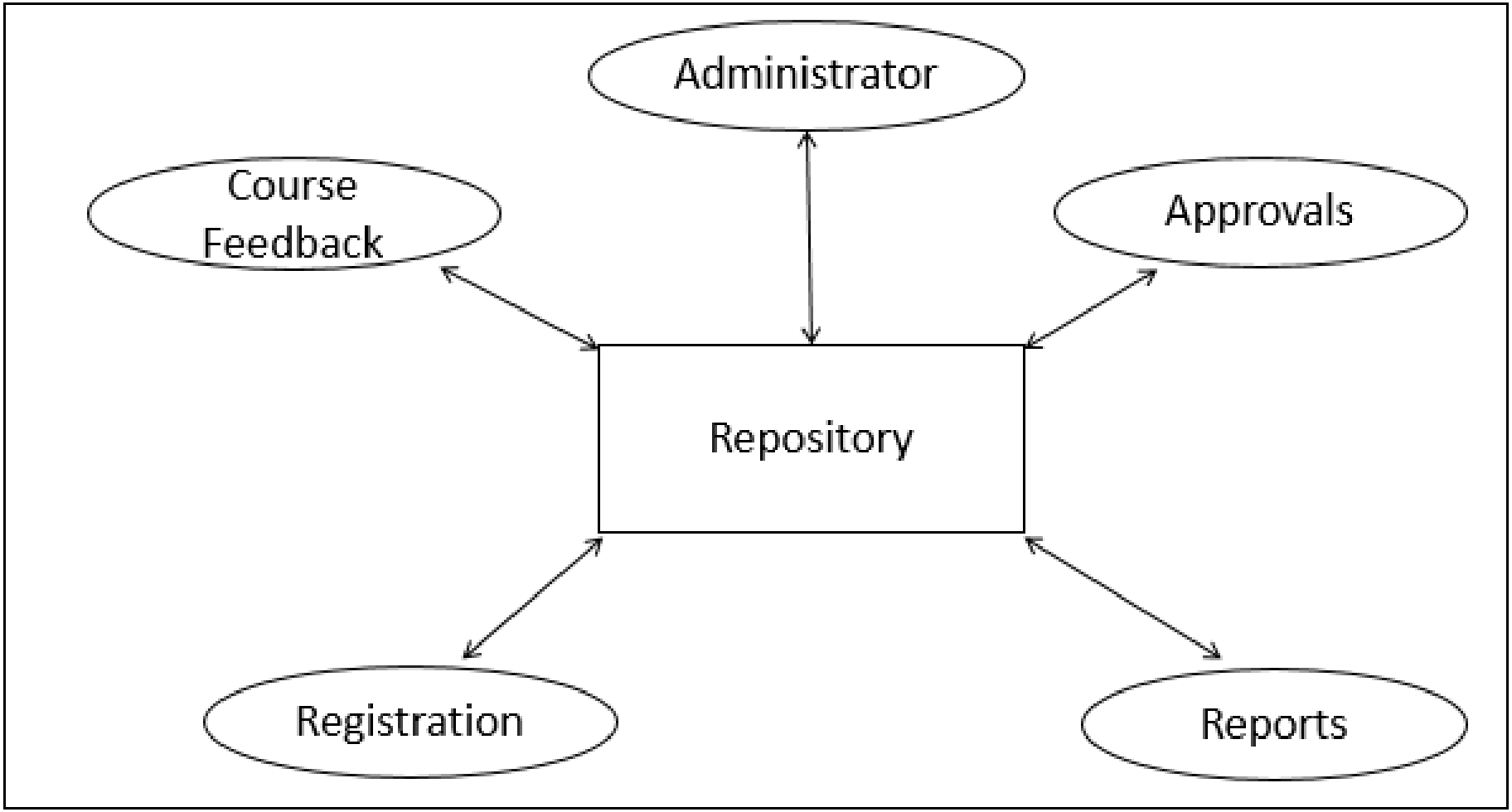


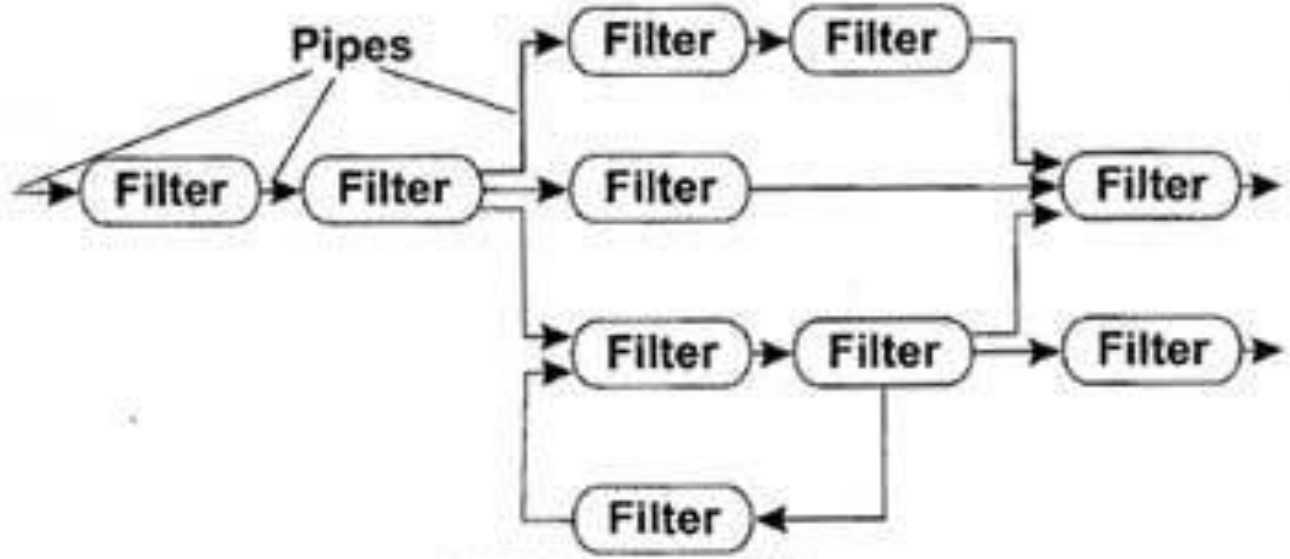
Fig.- Data centered architecture


Administrator
Course Feedback
Approvals
Repository
Registration
Reports

Data-flow architectures

- This architecture is applied when **input data** are to be **transformed through** a **series** of computational or manipulative **components into output data.**
- PIPE AND FILTER PATTERN
  - This architecture is applied when input data are to be transformed through a series of computational or manipulative components into output data
- Each filter works independently.
- If the data **flow degenerates into a single line** of transforms, it is termed **batch sequential.**

Data Flow Architecture



Data-flow Architecture

- **Data flow architecture** is a part of Von-neumann model of computation which consists of a single program counter, sequential execution and control **flow** which determines fetch, execution, commit order.
- **Data flow architecture** reduces development time and can move easily between design and implementation.

Application Areas

- Process control architecture is suitable in the following domains
  - **Embedded system software design,** where the system is manipulated by process control variable data.
  - Applications, which aim is to maintain specified properties of the outputs of the process at given reference values.
  - Applicable for car-cruise control and **building temperature control systems.**
  - **Real-time system software** to control automobile anti-lock brakes, nuclear power plants, etc.

Call and return architectures.

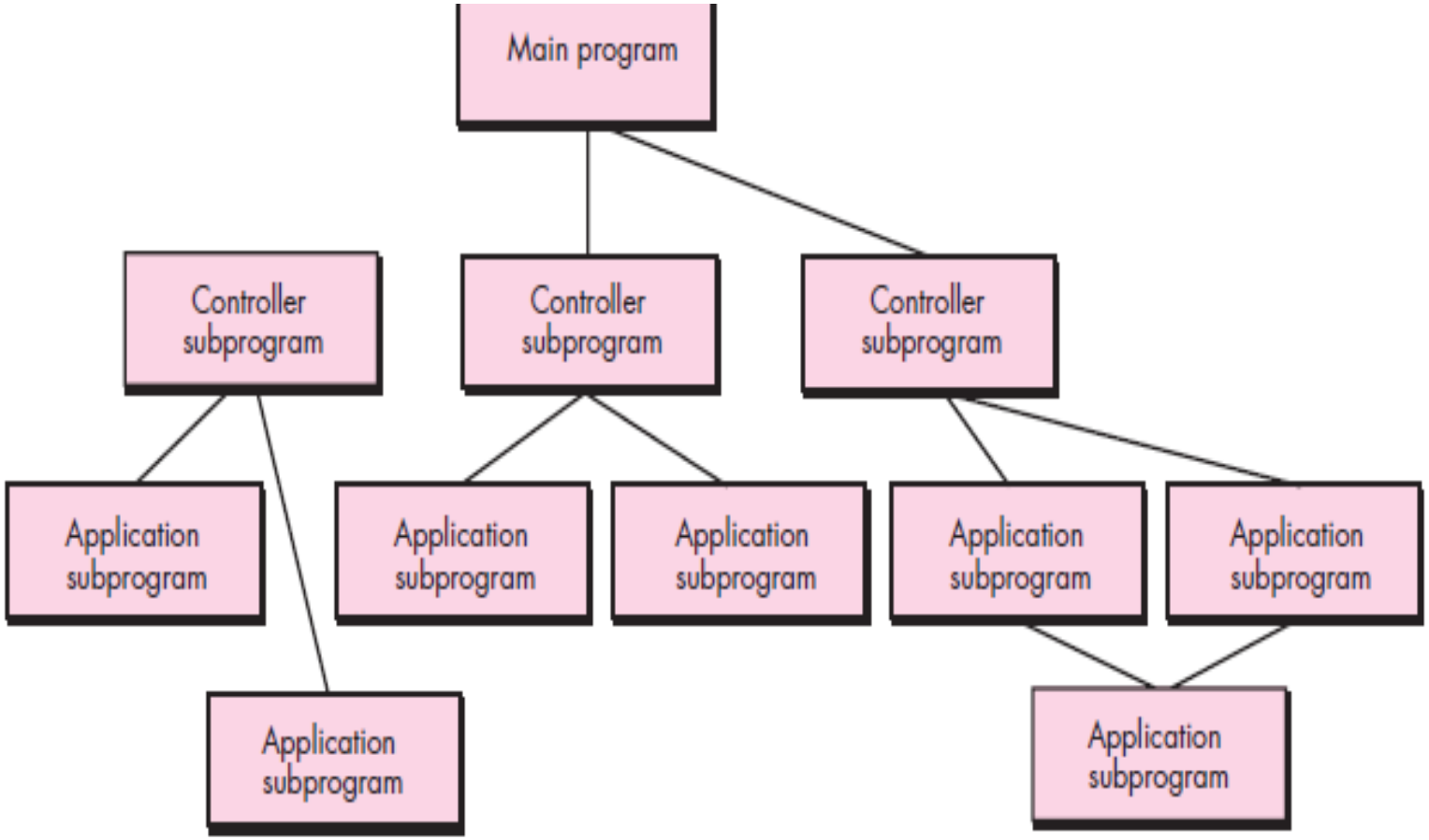
- This architectural style enables you to achieve a **program structure that is relatively easy to modify and scale.**

- **Sub styles of call and return architecture:**

1. **Main program/subprogram architectures: main program invokes a number of program components** that in turn may invoke still other components.

2. **Remote procedure call architectures:** The **components of a main program/subprogram** architecture are **distributed across multiple computers on a network.**

Call and return architectures.

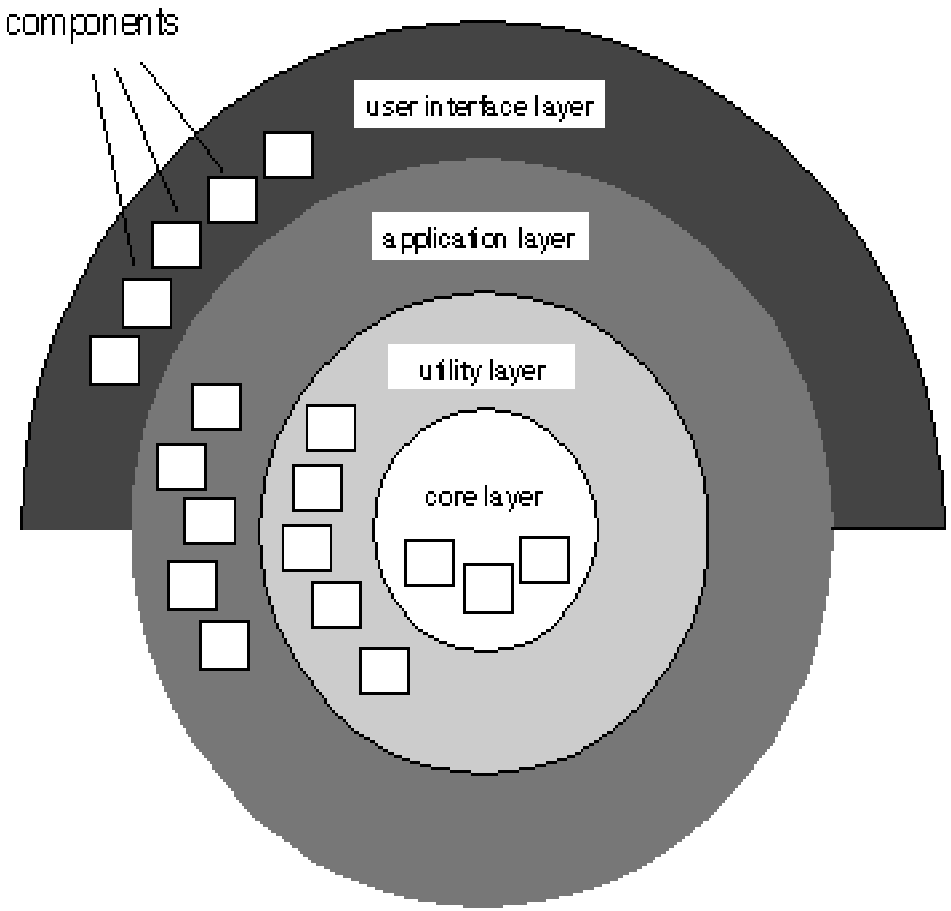


Layered architectures

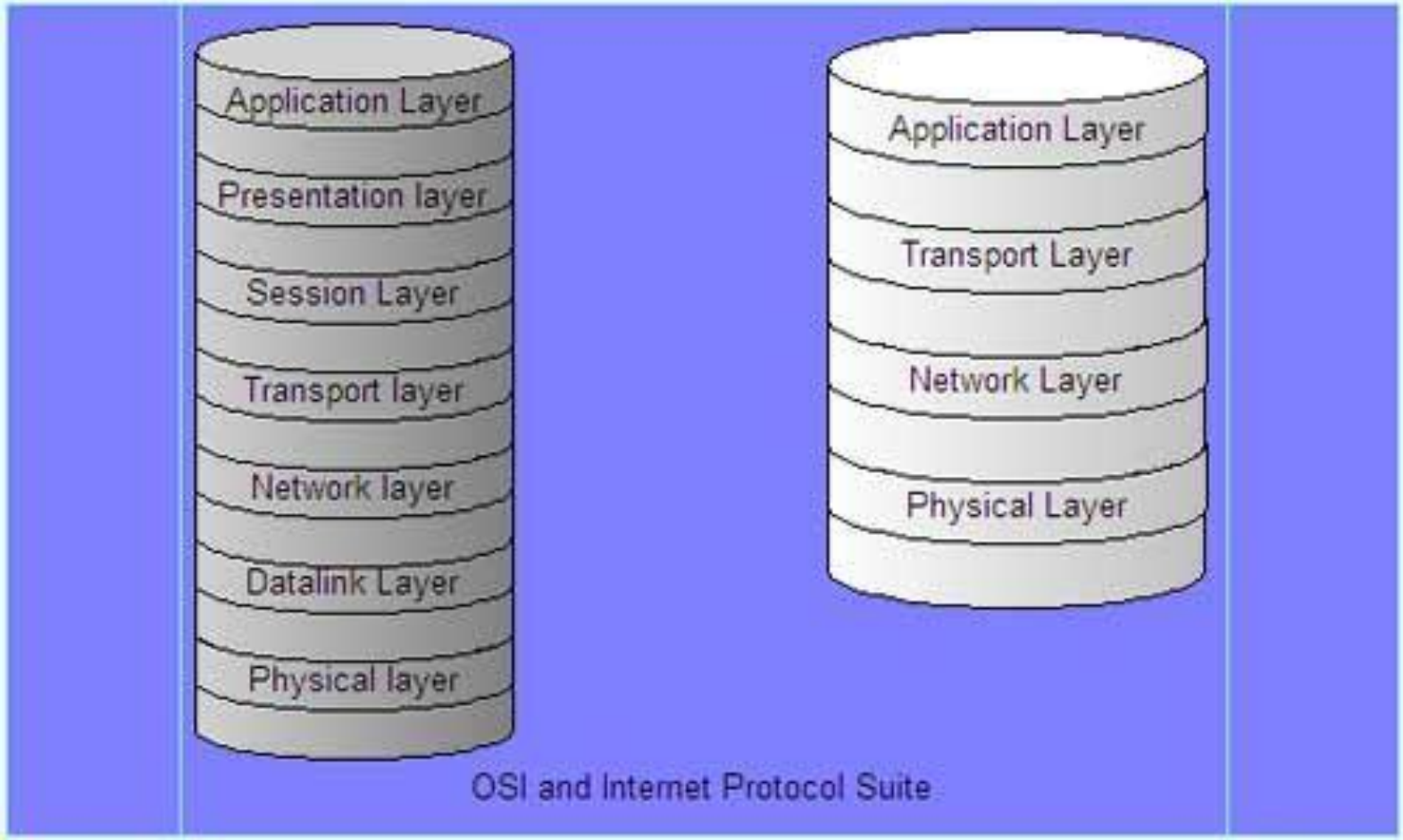
- Layered architecture focuses on the **grouping of related functionality within an application** into distinct layers that are stacked vertically on top of each other.

- A number of different layers are defined with each layer performing a well-defined set of operations.
  - Each layer will do some operations that becomes closer to machine instruction set progressively.
- At the **outer layer,** components will receive the **user interface** operations and at the **inner layers**, components will perform the **operating system interfacing**(communication and coordination with OS)
- Intermediate layers to utility services and application software functions.

Layered Architecture



- In layered architecture, several layers (components) are defined with each layer performing a well-defined set of operations.
- These layers are arranged in a hierarchical manner, each one built upon the one below it.
- Each layer provides a set of services to the layer above it and acts as a client to the layer below it.
- The interaction between layers is provided through protocols (connectors) that define a set of rules to be followed during interaction.
  - One common example of this architectural style is OSI-ISO (Open Systems Interconnection-International Organization for Standardization) communication system.


Application Layer
Presentation layer
Session Layer
Transport layer
Network layer
Datalink Layer
Physical layer
Application Layer
Transport Layer
Network Layer
Physical Layer
OSI and Internet Protocol Suite

Architectural Patterns

A software architecture may have a number of **architectural patterns** that **address** issues such as **concurrency, persistence, and distribution**

(1) CONCURRENCY—applications must **handle multiple tasks** in a manner that simulates parallelism.

- Example 1: **Operating System Process Management pattern** that provides built-in OS features that allow components to execute concurrently.

- Example 2: **Task Scheduler pattern** invokes the next concurrent object

Architectural Patterns

(2) DISTRIBUTION - The distribution problem addresses the manner in which systems or components within systems communicate with one another in a distributed environment.

- Example 1: **Broker pattern:** broker acts as a middle man to constitute communication.

Architectural Patterns

(3) PERSISTENCE - Data persists if it survives past the execution of the process that created it.

- **Persistent data are stored** in a database or file and **modified later**.

Example 1: **Database management system pattern** which stores and retrieves data.

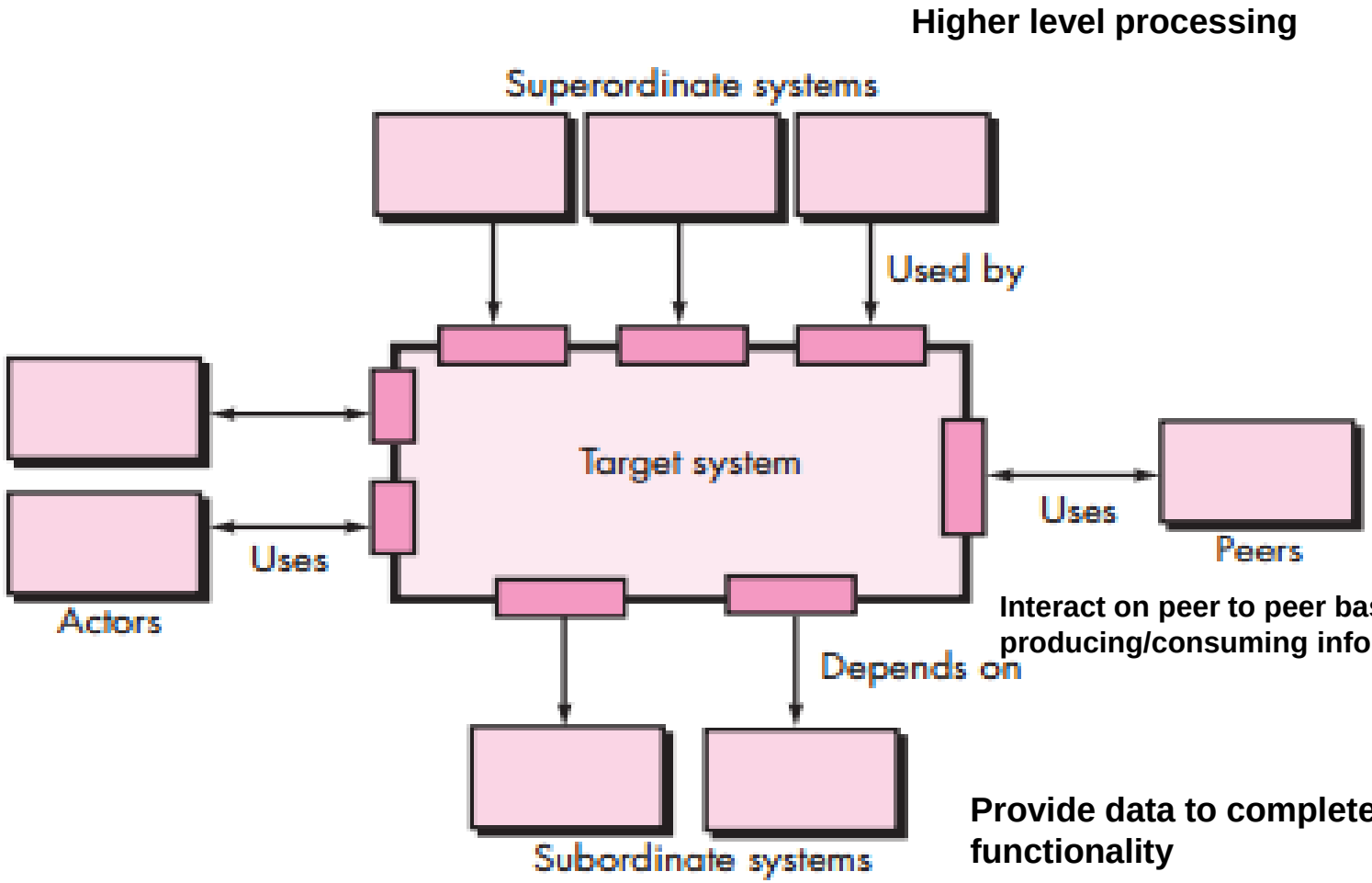
ARCHITECTURAL DESIGN

- **The software must be placed into context**
  - the **design** should **define** the **external entities** (other systems, devices, people) that the **software interacts** with and the **nature of the interaction**

- **A set of architectural archetypes should be identified**
  - An **archetype** is an abstraction (similar to a class) that **represents one element of system behavior**.

- The **designer specifies the structure** of the system by **defining and refining software components** that implement each archetype
- **QUESTIONS**

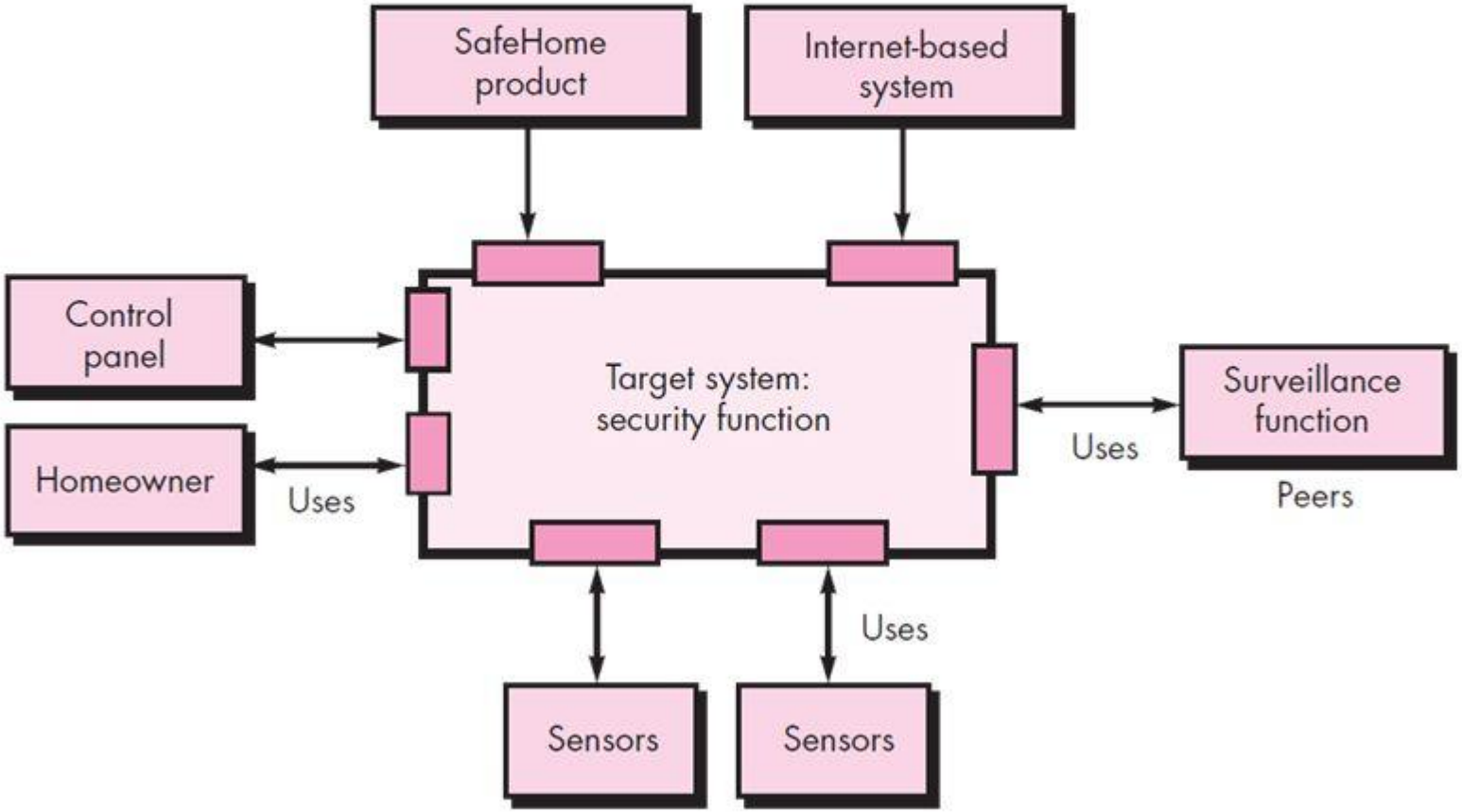
Architectural Context Diagram- model the manner in which **software interacts with entities external** to its boundaries.



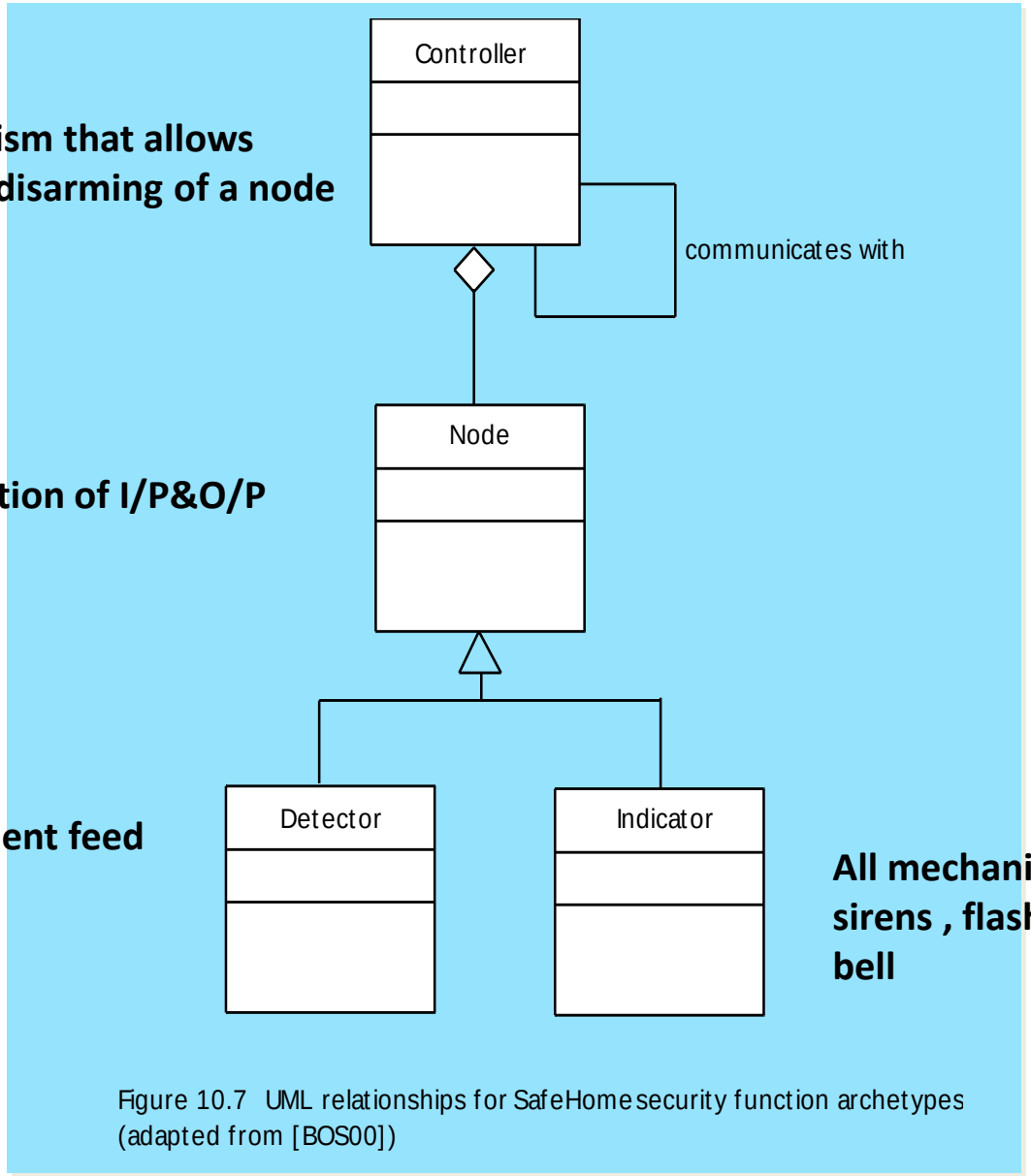
GENERIC STRUCTURE

Architectural Context Diagram

- ACD for the *SafeHome* security function



Archetypes - An archetype is a class or **pattern that represents a CORE ABSTRACTION that is critical to the design** of an architecture for the target system.



Mechanism that allows arming/disarming of a node

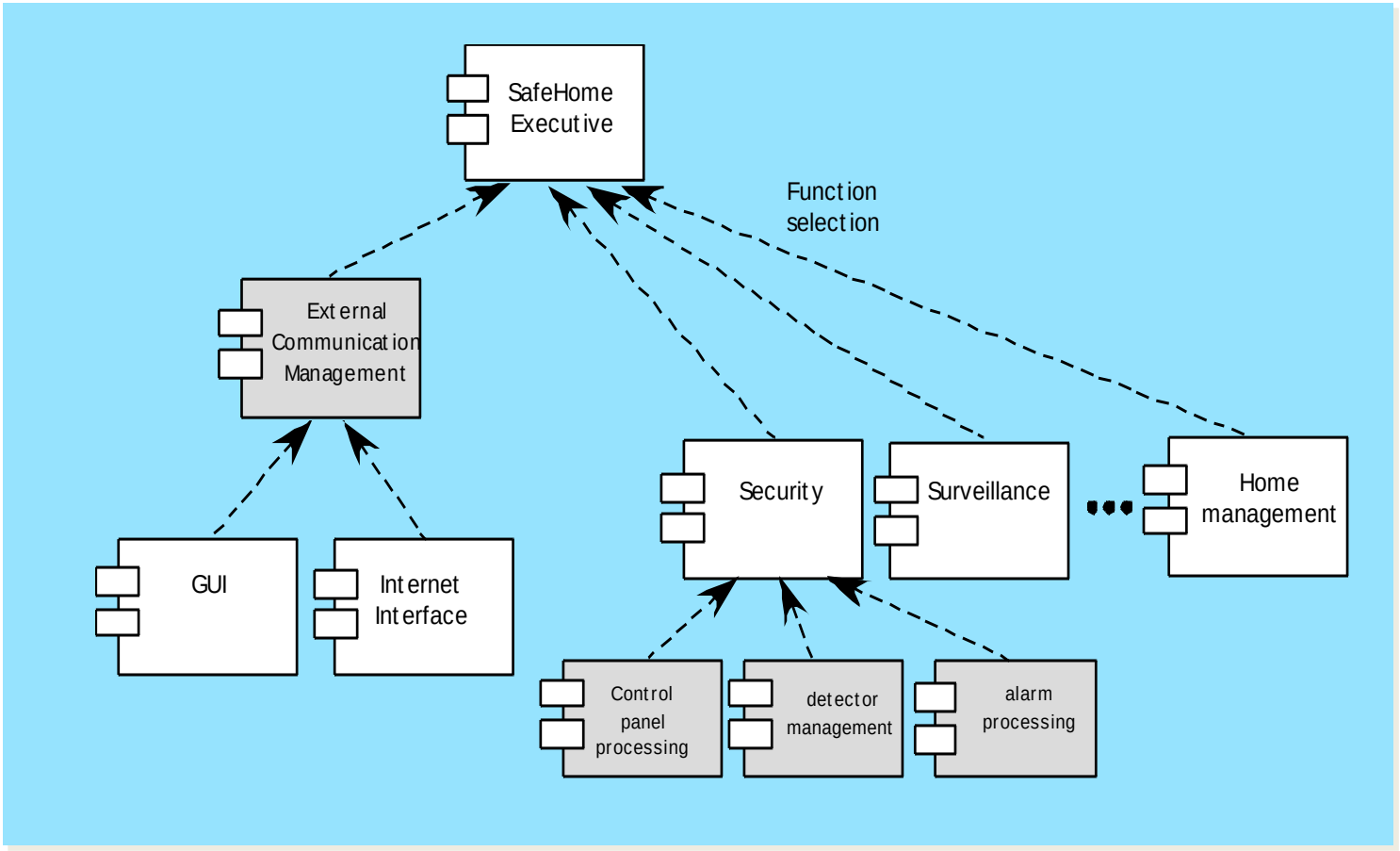
Collection of I/P&O/P

Sensing equipment feed info

All mechanisms-alarm sirens , flashing lights , bell

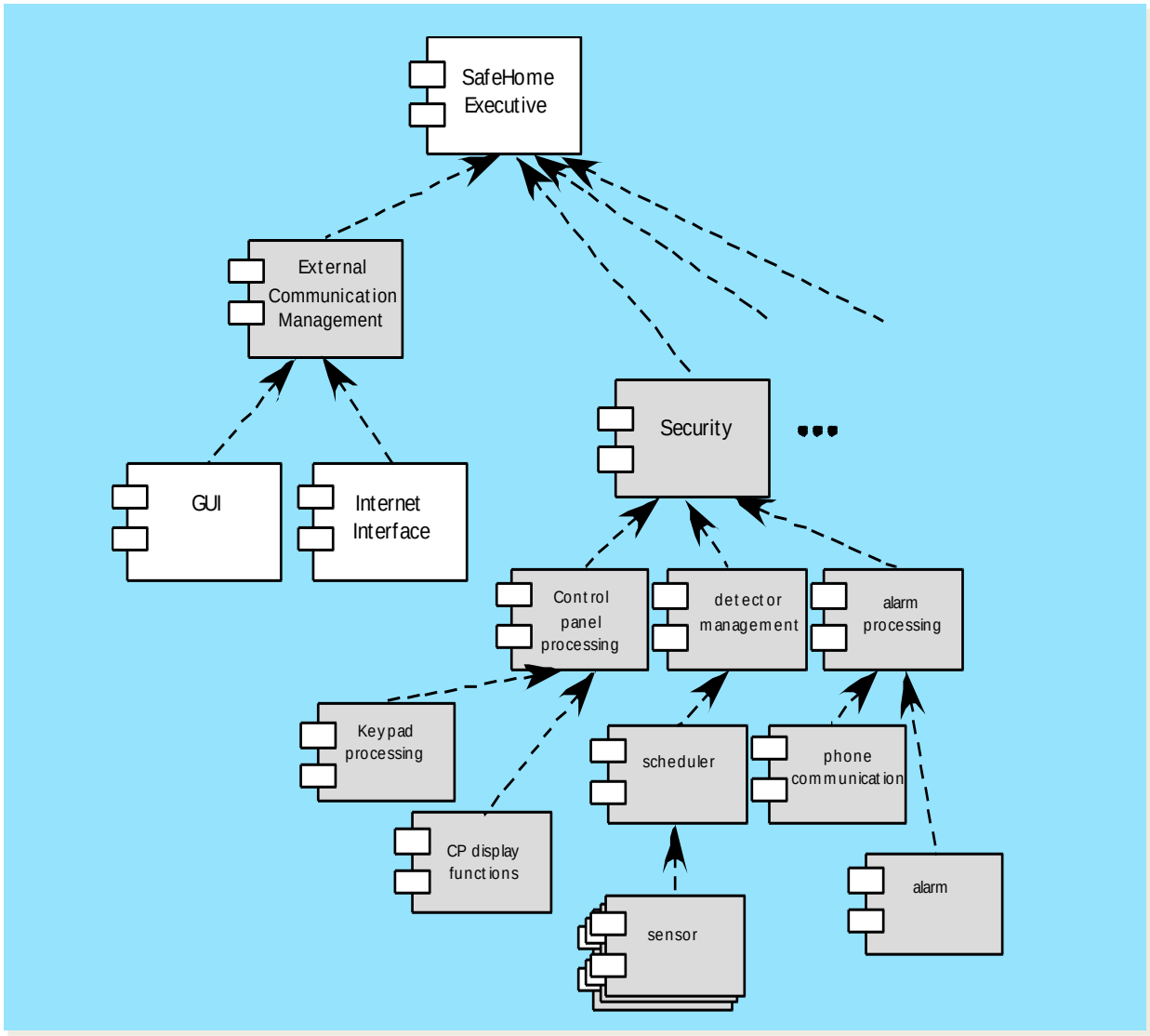
Figure 10.7 UML relationships for SafeHome security function archetypes (adapted from [BOS00])

Refining Architecture into Component



COMPONENT STRUCTURE

Refined Component Structure - A well-designed habitat allows for the **successful evolution of all the components needed in a software system.**



COHESION

- **Consistency and Organization** of different units.
  - Cohesion is the internal glue that keeps the module together.
  - A good software design will have high cohesion.
- Cohesion implies that a component or class **encapsulates** only attributes and operations that are **closely related to one another** and to the class or component itself.

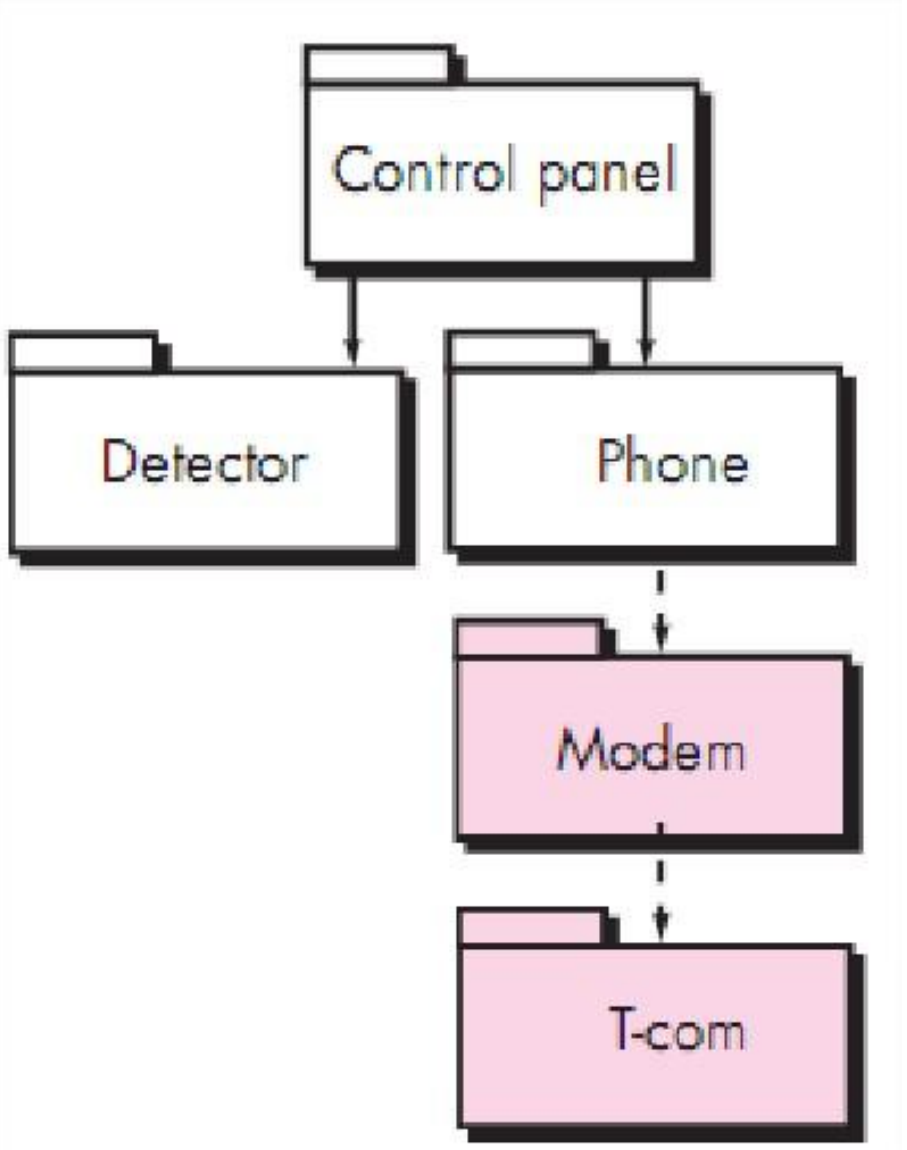
DIFFERENT TYPES OF COHESION

1) FUNCTIONAL

- Every essential element for a single computation is contained in the component.
- A functional cohesion performs the **task and functions**.
  - Based on **operations** , this level of cohesion occurs when a component **performs a targeted computation** and then returns a result.

(2) LAYER

- Exhibited by packages, comp
- This type of cohesion occ **accesses the services of a lo do not access higher layers.**
  - **Eg :- SafeHome system**



(3) COMMUNICATIONAL

- **All operations that access the same data are defined** within one class.
- Focus is only on data in question
- Two elements operate on the same input data or contribute towards the same output data.
  - Example- update record into the database and send it to the printer.

COUPLING

- **Coupling** is the degree of interdependence between **software** modules;
  - a measure of how closely connected two routines or modules are;
  - the strength of the relationships between modules.
- **Coupling** is a qualitative measure of the **degree to which classes are connected to one another**.

DIFFERENT TYPES OF COUPLING

(1) Content coupling :-Occurs when one component secretly modifies data that is internal to **another component**

(2) Common coupling:- Occurs when a number of components **all make use of a global variable**. Common coupling can **lead to error propagation.**

Coupling

(3) Control coupling – Occurs when **one operation controls flow of another operation** and control signals are sent. Changes done to an operation are to be monitored for errors.

(4) Stamp coupling – Occurs when systems **operation are in nested state** , modifying the system becomes complex.

Similar to common coupling but here global data is accessible to selected routines.

Coupling

(5) Data coupling - Occurs when operations **pass long strings of data arguments.**

B/W of communication increases complexity increases maintenance becomes difficult.

(6) Routine call coupling - Occurs when one operation invokes another

(7) Type use coupling. Occurs when component **A** uses a data type defined in component **B.**

If the type definition changes, every component that uses the definition must also change.

Coupling

(8) Inclusion or import coupling. Occurs when component **A** imports or includes a package or the content of component **B**.

(9) External coupling - Occurs when **a component communicates or collaborates with infrastructure components** (e.g., operating system functions,

database capability, telecommunication functions).

This type of coupling is necessary but it should also be limited.

USER INTERFACE DESIGN RULES

Regardless of the domain, user interface, or intended device (computer, tablet or phone) for a particular website or application and there are certain universal “Golden Rules” of user interface design.

- **MANDEL’S GOLDEN RULES**

  The golden rules are divided into three groups:

- **PLACE USERS IN CONTROL**
- **REDUCE USERS’ MEMORY LOAD**
- **MAKE THE INTERFACE CONSISTENT**

1. PLACE THE USER IN CONTROL

- A system or user interface **should be designed keeping user in mind.**

- Interface designed should be **easy to use and build.**

- Number of design principles that allow the user to maintain control:

(1) Define interaction modes in a way that does not force a user into unnecessary or undesired actions.

Example: Spell Checking mode

(2) Provide for flexible interaction.

Because different **users have different interaction preferences**, choices should be provided.

Example: software might allow a user to interact via keyboard commands, mouse movement, a digitizer pen etc.

(3) Allow user interaction to be interruptible and undoable.

(4) Hide technical internals from the casual user.

(5) Design for direct interaction with objects that appear on the screen.

Example: Zoom option

2. Reduce the User's Memory Load

- The **more a user has to remember**, the **more error-prone the interaction** with the system will be.

- Well-designed user interface does not tax the user's memory
- Defines design principles that enable an interface to reduce the user's memory load:

(1) Reduce demand on short-term memory

– complex tasks demand on short term memory is high - interface designed to reduce dependency.

(2) Establish meaningful defaults

- “reset” option should be available for enabling original default values.

(3) Define shortcuts that are intuitive (easy to use).

(4) The visual layout of the interface should be based on a real-world metaphor.

(5) Disclose information in a progressive fashion - The interface should be organized hierarchically.

3. Make the Interface Consistent

"Things that look different should act different. Things that look the same should act the same."

(1) Allow the user to put the current task into a meaningful context.

- Complex layers to be implemented with clear indication to the user about the context of the work at hand.

(2) Maintain consistency across a family of applications.

- A set of applications (or products) should all implement the same design rules - consistency is maintained for all interaction.

(3) If past interactive models have created user expectations, do not make changes unless there is a compelling reason to do so.

Place Users in Control

- Use modes judiciously (modeless)
- Allow users to use either the keyboard or mouse (flexible)
- Allow users to change focus (interruptible)
- Display descriptive messages and text(Helpful)
- Provide immediate and reversible actions, and feedback (forgiving)
- Provide meaningful paths and exits (navigable)
- Accommodate users with different skill levels (accessible)
- Make the user interface transparent (facilitative)
- Allow users to customize the interface (preferences)
- Allow users to directly manipulate interface objects (interactive)

Reduce Users' Memory Load

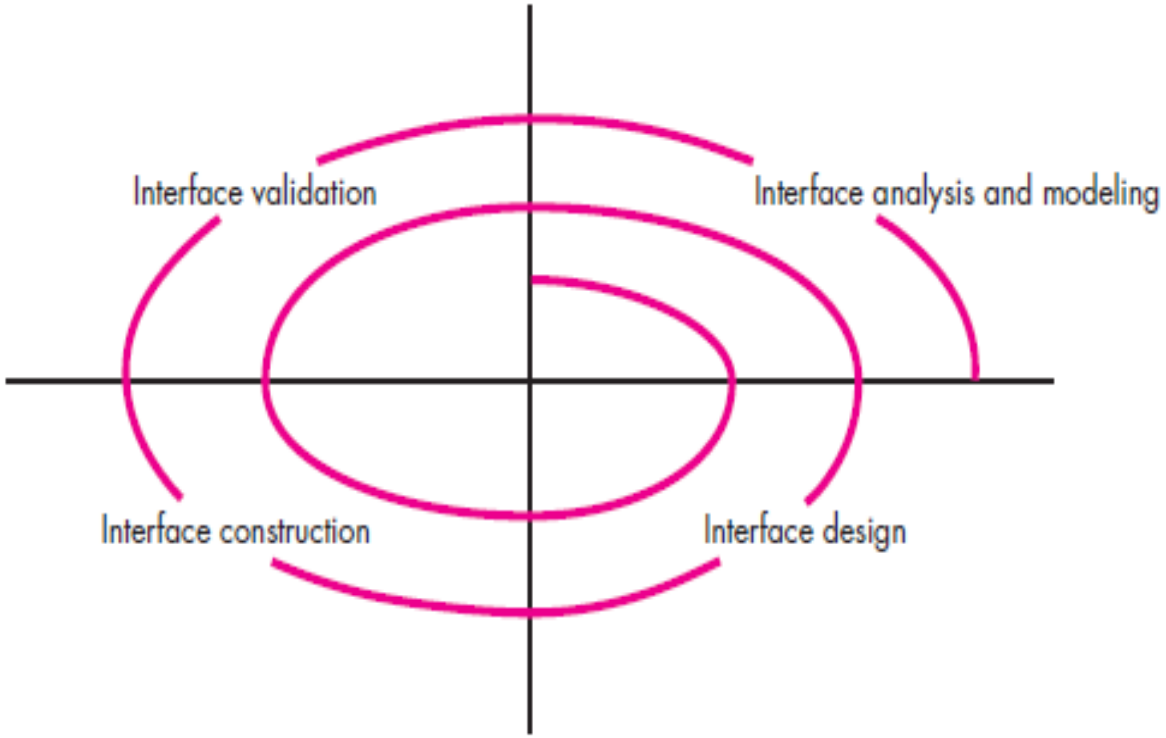
- Relieve short-term memory (remember)
- Rely on recognition, not recall (recognition)
- Provide visual cues (inform)
- Provide defaults, undo, and redo (forgiving)
- Provide interface shortcuts (frequency)
- Promote an object-action syntax (intuitive)
- Use real-world metaphors (transfer)
- User progressive disclosure (context)
- Promote visual clarity (organize)

Make the Interface Consistent

- Sustain the context of users' tasks (continuity)
- Maintain consistency within and across products (experience)
- Keep interaction results the same (expectations)
- Provide aesthetic appeal and integrity (attitude)
- Encourage exploration (predictable)

USER INTERFACE DESIGN PROCESS

- The analysis and design process for user interfaces is iterative and can be represented using a spiral model.



The user interface design process

(1) Interface analysis **–** focuses on the **profile of the users** who will interact with the system. Different **user categories** are **defined**.

- Once **general requirements** have been **defined**, a more **detailed *task analysis*** is conducted.

(2) I*nterface design* – is to **define a set of interface objects and actions** that enable a user to perform all defined tasks to **meet goals** defined.

The user interface design process

(3) Interface construction - normally begins with the **creation of a prototype** that enables usage scenarios to be evaluated.

(4) Interface validation - focuses on

(1) the ability of the interface to implement **every user task correctly**, **accommodate all task va**riations, and to **achieve all general user requi**rements;

(2) the degree to which the **interface is easy to use** and **easy to learn**

(3) the **users' acceptance** of the **interface** as a useful tool in their work

INTERFACE ANALYSIS

- **Understand the problem before you attempt to design a solution.**

(1) the people (**end users**) who will interact with the system through the interface.

(2) the **tasks that end users must perfo**rm to do their work,

(3) the **content that is presented** as part of the interface

(4) the **environment** in which these **tasks will be conducted**

INTERFACE ANALYSIS STEPS

(1) User Analysis

- **User Interviews.**
- **Sales input** - Sales people meet with users on a regular basis and can gather information.
- **Marketing input.**
- **Support input -** Support staff talks with users on a daily basis.

Interface Analysis Steps

(2) Task Analysis and Modeling

- In task analysis and modeling information about the tasks and subtasks performed by the user , their workflow and hierarchy is to be gathered.

1. **Use cases.**
2. **Task elaboration** - stepwise elaboration (also called functional decomposition or stepwise refinement) for software to accomplish some desired function.

Interface Analysis Steps

3. **Object elaboration**

4. **Workflow analysis -** When a number of different users, makes use of a user interface workflow analysis becomes important.

5. **Hierarchical representation -** Once workflow has been established, a task hierarchy can be defined for each user type.

Interface Analysis Steps

(3) Analysis of Display Content - the presentation of a variety of different types of content.

- For modern applications, display content can range from character-based reports (e.g., a spreadsheet), graphical displays (e.g., a histogram, a 3-D model, a picture of a person), or specialized information (e.g., audio or video files).

(4) Analysis of the Work Environment

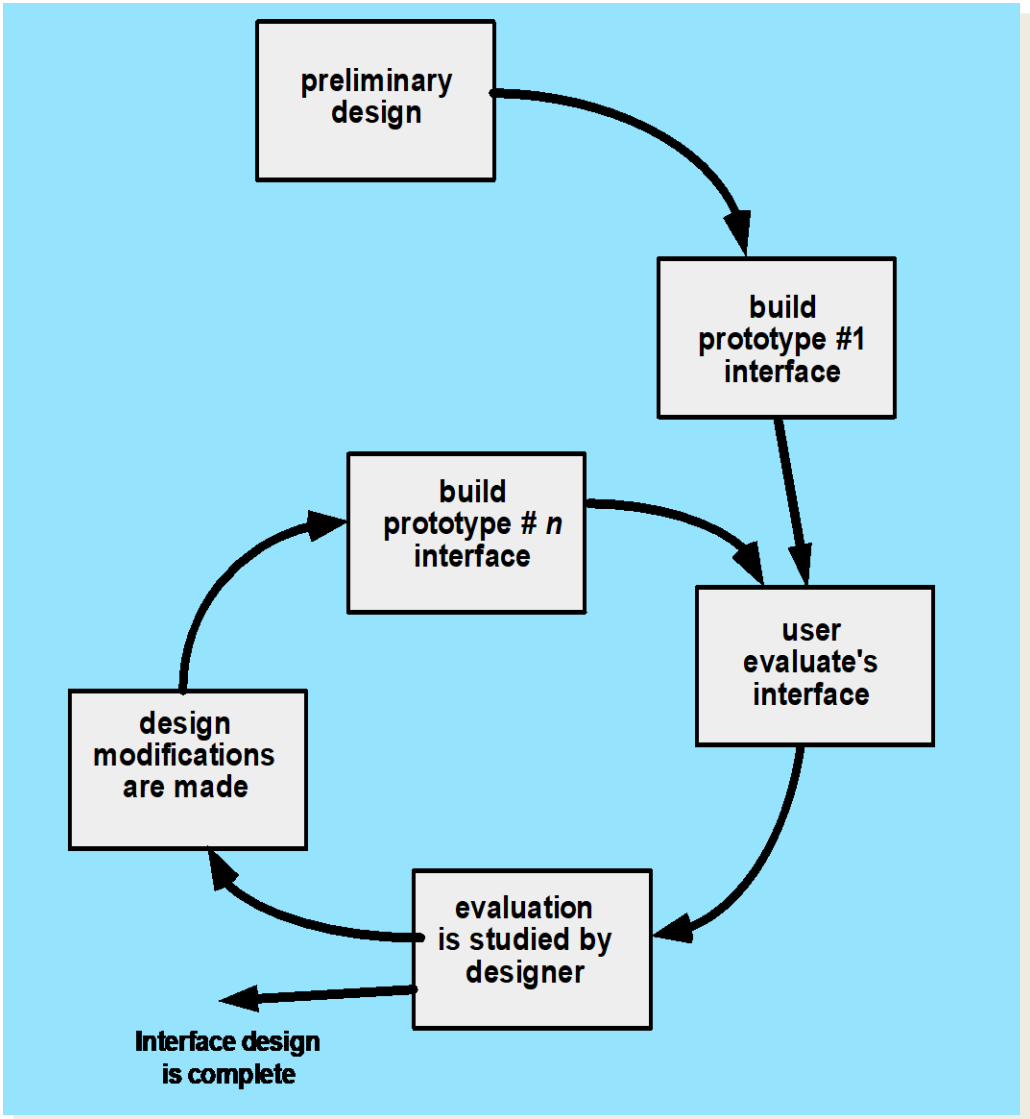
INTERFACE DESIGN STEPS

- Using **information developed during interface analysis**, define interface objects and actions (operations).
- **Define events (user actions) that will cause the state of the user interface to change**. Model this behavior.
- Depict each **interface state as it will actually look to the end-user.**
- **Indicate how the user interprets the state of** the system from information provided through the **interface.**

DESIGN ISSUES

- Response time
- Help facilities
- Error handling
- Menu and command labeling
- Application accessibility – for physically challenged users
- Internationalization

Design Evaluation Cycle



Design with Reuse

- Building software from reusable components.

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 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 or by configuring the application for different customers.
  - application families that have a common architecture, but which are tailored for specific customers, may be developed.

Reuse-based software engineering

- **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 function, such as a mathematical function, or an object class may be reused

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

Component-based software engineering

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

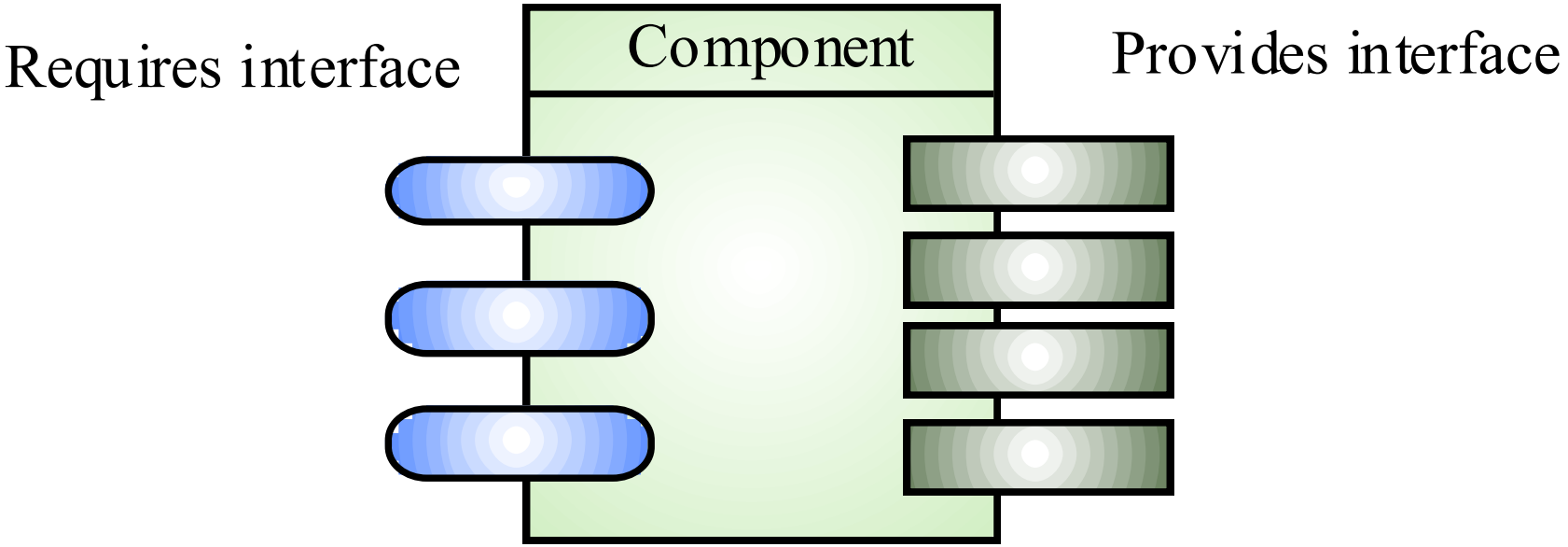
- It emerged from the failure of object-oriented development to support effective reuse. Single object classes are too detailed and specific

- **Components are more abstract than object classes** and can be considered to be stand-alone service providers

Component-based software engineering

- Components can range in size from simple functions to entire application systems

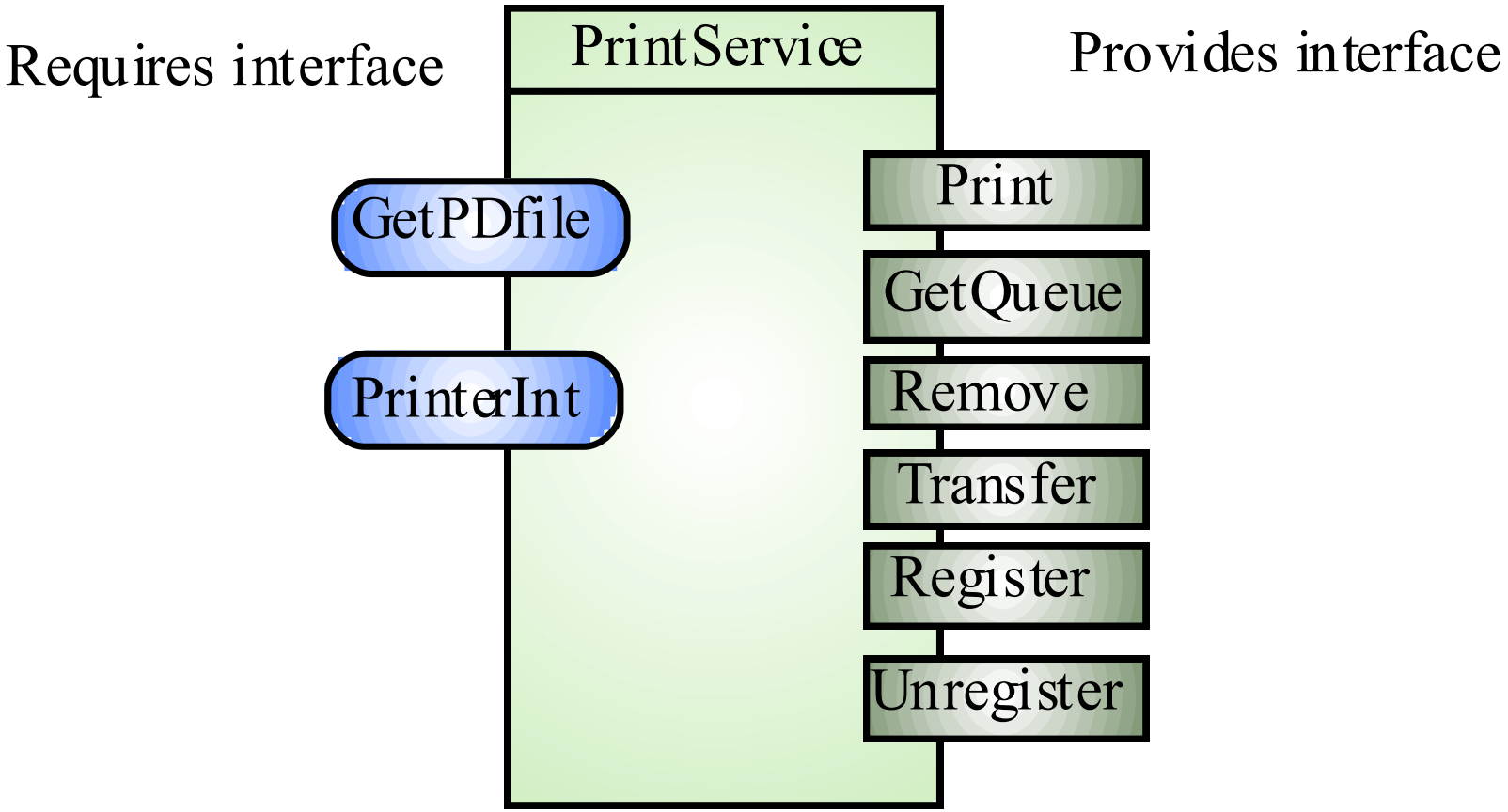
Component interfaces



Component Interfaces

- These interfaces reflect the services that the component provides and the services that the component requires to operate correctly
- **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

Example: 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

- CBSE processes are software processes that support component-based software engineering.

- They take into account the possibilities of reuse and the different process activities involved in developing and using reusable components.

CBSE processes

- There are two types:

1. **Development for reuse**

- This process is concerned with **developing components or services that will be reused** in other applications.

- It usually involves generalizing existing components.

2. Development with reuse

- This is the process of **developing new applications using existing components and services**.

CBSE processes - **Development for reuse**

- CBSE for reuse is the process of developing reusable components and making them available for reuse through a component management system.

CBSE processes - Development with reuse