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## Architectural Design IV

### Designing the Module Structure Design Principles



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## Architecture Design Process

Building architecture to address business goals:

1. Understand the goals for the system
2. Define the quality requirements
3. *Design the architecture*
  1. Views: which architectural structures should we use?  
(goals<->architectural structures<->representation)
  2. Documentation: how do we communicate design decisions?
  3. Design: how do we decompose the system?
4. Evaluate the architecture (is it a good design?)

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## Module Decomposition Strategies

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- How do we develop this structure so that the leaf modules make independent work assignments?
  - Dependencies are few
  - Decisions that might change are encapsulated
  - Interfaces are simple and well defined
- I.e. low *coupling*, high *cohesion*
  - Coupling: degree of interdependence **between** software modules
  - Cohesion: degree of relation or interdependence of elements within a module

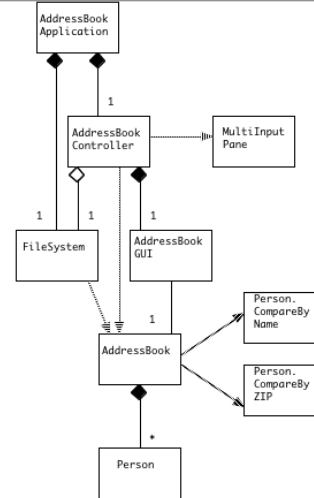
## Modular Decomposition

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- Design goals: modifiability, work assignments, maintainability, reusability, understandability, etc.
- Observed strategies only partially successful
  - Use-case driven OOD, heuristics
  - MVC Pattern
- What should be done differently?
  - Why did these approaches fail?

## Use Case Driven OO Process

- Address book design: in-class exercise
- Requirements
- Problem Analysis
  - Identify use cases from requirements
  - Identify domain classes operationalizing use cases (apply heuristics)
- OO Design (refinement)
  - Allocate responsibilities among classes
  - Identify object interactions supporting use cases
  - Identify supporting classes (& associations)
- Detailed Design
  - Design class interfaces (class attributes and services)



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## Decomposition Heuristics

- Heuristics: suppose we create objects by ...
  - Underline the nouns
  - Identify causal agents
  - Identify coherent services
  - Identify real-world items
  - Identify physical devices
  - Identify essential abstractions
  - Identify transactions
  - Identify persistent information
  - Identify visual elements
  - Identify control elements
  - Execute scenarios

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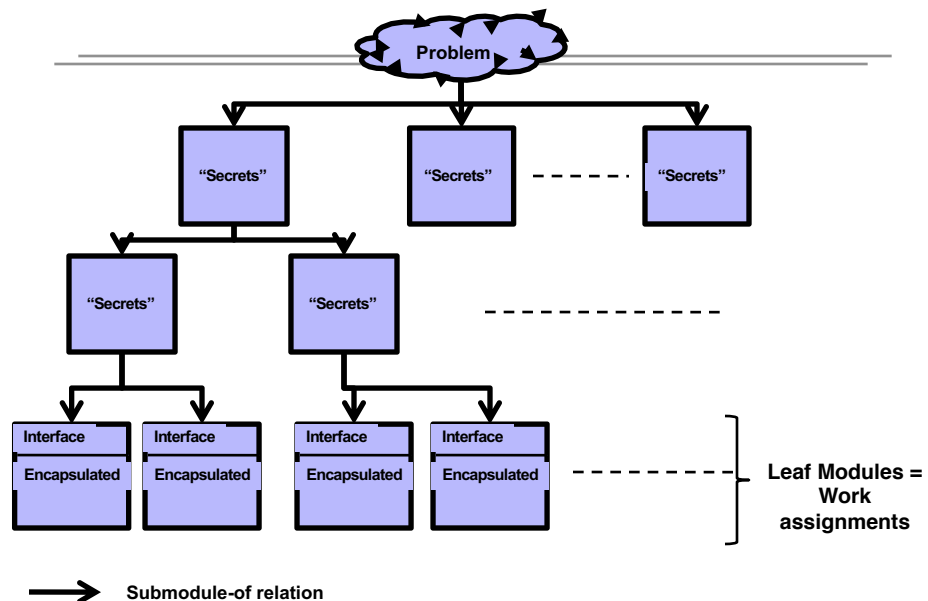
## Modular Structure

- Architecture = components, relations, and interfaces
- Components
  - Called modules
  - Leaf modules are work assignments
  - Non-leaf modules are the union of their submodules
- Relations (connectors)
  - submodule-of  $\Rightarrow$  implements-secrets-of
    - Module is an aggregate of its submodules
  - Constrained to be acyclic tree (hierarchy)
- Interfaces (externally visible component behavior)
  - Defined in terms of access procedures (services or method)
  - Services provide only access to module internals

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## Module Hierarchy



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## Design Principles

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- Principle (n): a comprehensive and fundamental rule, doctrine, or assumption
- Design Principles – rules that guide developers in making design decisions consistent with overall design goals and constraints
  - Guide the decision making process by helping choose between alternatives
  - Embodied in methods and techniques (e.g., for decompositions)

## Three Key Design Principles

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- Most solid first
- Information hiding
- Abstraction

## Principle: Most Solid First

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- View design as a sequence of decisions
  - Later decisions depend on earlier
  - Early decisions harder to change
- Most solid first: in a sequence of decisions, those that are least likely to change should be made first
- Goal: reduce rework by limiting the impact of changes
- Application: used to order a sequence of design decisions
  - Generally applicable to design decisions
  - Module decomposition – ease of change

## Information Hiding

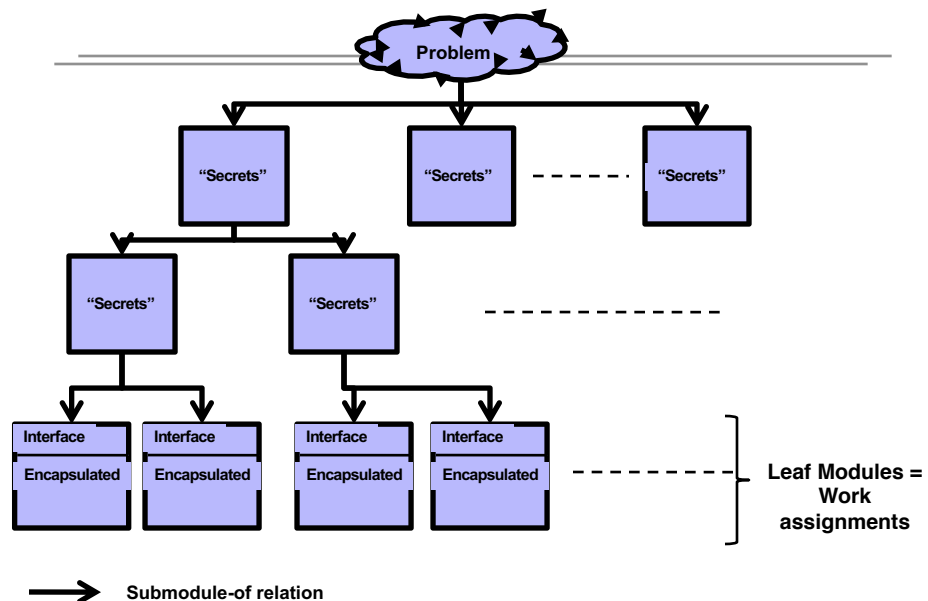
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- Design principle of limiting dependencies between components by hiding information other components should not depend on
- An information hiding decomposition is one following the design principles that (Parnas):
  - System details that are likely to change independently are put in different modules
  - The interface of a module reveals only those aspects considered unlikely to change
  - Details other modules should not depend on are encapsulated

## Decomposition Strategy

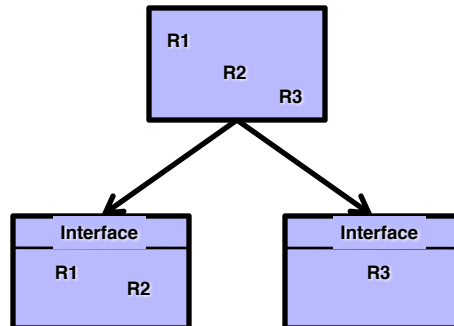
- Decompose recursively
  - If a module holds decisions that are likely to change independently, then decompose it into submodules
  - Decisions that are likely to change together are allocated to the same submodule
  - Decisions that change independently should be allocated to different submodules
- Stopping criteria
  - Each module contains only things likely to change together
  - Each module is simple enough to be understood fully, small enough that it makes sense to throw it away rather than re-do
- Define the Interfaces
  - Anything that other modules should not depend on become secrets of the module (e.g., implementation details)
  - If the module has an interface, only things not likely to change can be part of the interface

## Module Hierarchy



## Effects of Changes

- Consider what happens to communication among module developers
- Suppose we have groups of requirements R1 – R3:
  - R1 and R3 are related and likely to change together
  - R2 is likely to change independently
- Suppose we put R1 and R2 in the same module and assign to different teams
  - What happens when R1 changes?
  - R2?
- Suppose R1 and R3 are put in the same module?



## Abstraction

- General: disassociating from specific instances to represent what the instances have in common
  - Abstraction defines a *one-to-many relationship*  
E.g., one type, many possible implementations
- Modular decomposition: Interface design principle of providing only essential information and suppressing unnecessary detail



## Abstraction

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- Two primary uses
- Reduce Complexity
  - Goal: manage complexity by reducing the amount of information that must be considered at one time
  - Approach: Separate information important to the problem at hand from that which is not
    - Abstraction suppresses or hides “irrelevant detail”
    - Examples: stacks, queues, abstract device
- Model the problem domain
  - Goal: leverage domain knowledge to simplify understanding, creating, checking designs
  - Approach: Provide components that make it easier to model a class of problems
    - May be quite general (e.g., type real, type float)
    - May be very problem specific (e.g., class automobile, book object)

## Address Book Reconsidered

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- Consider address book design based on principles

## Lessons on Patterns

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- Patterns are often misused
- Using a pattern correctly requires understanding it
  - “Correctly” – such that the pattern’s design goals are realized in your design
  - “Understanding” – you understand what the pattern is supposed to accomplish, how it works, and how to apply it in your context

## Lessons on Patterns (2)

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- A pattern is a three part rule that expresses a relation between [Schmidt]:
  1. A particular problem context
  2. A set of competing forces (goals and constraints) in that context
  3. A software *configuration* that *resolves* the set of forces
    - *Configuration* == objects, interfaces, relations
    - *Resolves* == concurrently addresses the goals and constraints

## Summary

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- Heuristics and patterns are guidelines
  - Do not guarantee qualities
  - Must understand how and why they work to apply effectively
- Principles are more direct – achieve qualities *by construction*
- Good design requires careful thinking
  - Which goals are we trying to achieve
  - How design decisions address those goals

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## Questions?