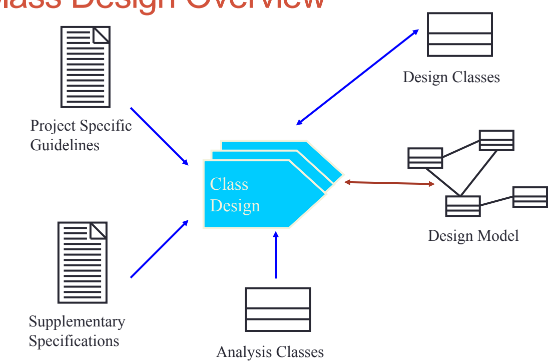
IT4490 - SOFTWARE DESIGN AND CONSTRUCTION

8. CLASS DESIGN

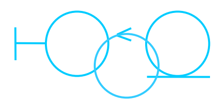
Some slides extracted from IBM coursewares

Class Design Overview

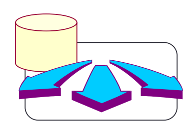


Content

Class Design Considerations



- Class stereotype
  - Boundary
  - Entity
  - Control
- Applicable design patterns



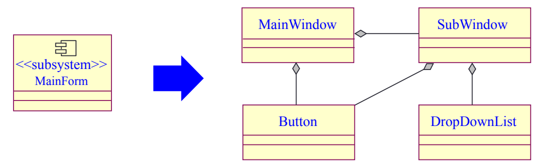
How Many Classes Are Needed?

- Many, simple classes means that each class
  - Encapsulates less of the overall system intelligence
  - Is more reusable
  - Is easier to implement
- A few, complex classes means that each class
  - Encapsulates a large portion of the overall system intelligence
  - Is less likely to be reusable
  - Is more difficult to implement

A class should have a single well-focused purpose.
A class should do one thing and do it well!

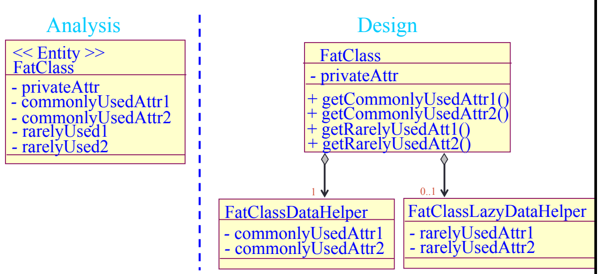
Strategies for Designing Boundary Classes

- User interface (UI) boundary classes
  - What user interface development tools will be used?
  - How much of the interface can be created by the development tool?
- External system interface boundary classes
  - Usually model as subsystem



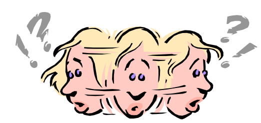
Strategies for Designing Entity Classes

- Entity objects are often passive and persistent
- Performance requirements may force some re-factoring



Strategies for Designing Control Classes

- What happens to Control Classes?
  - Are they really needed?
  - Should they be split?
- How do you decide?
  - Complexity
  - Change probability
  - Distribution and performance
  - Transaction management

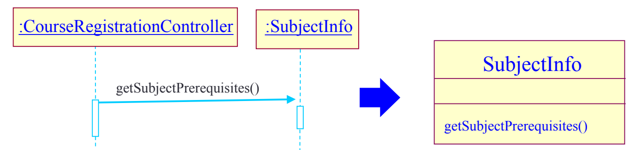


Content

1. Create Initial Design Classes
2. Define Operations/Methods
3. Define Relationships Between Classes
4. Define States
5. Define Attributes
6. Class Diagram

2.1. Define Operations

- Messages displayed in interaction diagrams



- Other implementation dependent functionality
  - Manager functions
  - Need for class copies
  - Need to test for equality

Name and Describe the Operations

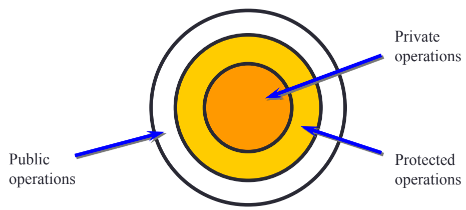
- Create appropriate operation names
  - Indicate the outcome
  - Use client perspective
  - Are consistent across classes
- Define operation signatures
  - operationName([direction]parameter: class,..) : returnType
    - Direction is **in** (default), **out** or **inout**
    - Provide short description, including meaning of all parameters

Guidelines: Designing Operation Signatures

- When designing operation signatures, consider if parameters are:
  - Passed by value or by reference
  - Changed by the operation
  - Optional
  - Set to default values
  - In valid parameter ranges
- The fewer the parameters, the better
- Pass objects instead of “data bits”

Operation Visibility

- Visibility is used to enforce encapsulation
- May be public, protected, or private



How Is Visibility Noted?

- The following symbols are used to specify export control:
  - + Public access
  - # Protected access
  - - Private access

Class1
- privateAttribute
+ publicAttribute
# protectedAttribute
- privateOperation ()
+ publicOPeration ()
# protecteOperation ()

Scope

- Determines number of instances of the attribute/operation
  - Instance: one instance for each class instance
  - Classifier: one instance for all class instances
- Classifier scope is denoted by underlining the attribute/operation name

Class1
- classifierScopeAttr
- instanceScopeAttr
+ classifierScopeOp ()
+ instanceScopeOp ()

Course Registration CS: Operations for CourseOffering. and CourseRegistrationController

CourseOffering
+ getCourseOffering(String): CourseOffering.

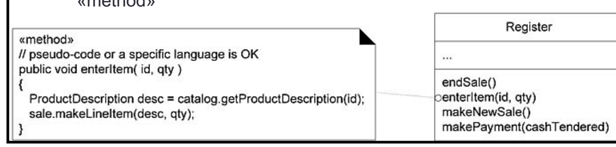
CourseRegistrationController
+ registerForCourse(String, String): void
- checkPrerequisiteCondition(): boolean
- checkTimeAndSubjectConfliction(): boolean
- checkCapacityConfliction(): boolean

2.2. Define Methods

- What is a method?
  - Describes operation implementation
- Purpose
  - Define special aspects of operation implementation
- Things to consider:
  - Special algorithms
  - Other objects and operations to be used
  - How attributes and parameters are to be implemented and used
  - How relationships are to be implemented and used

Operation vs. Method

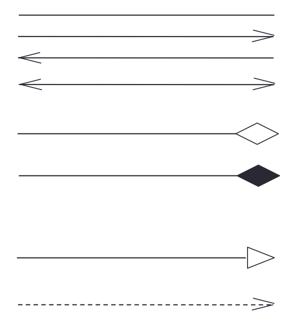
- An operation is *not* a method. A UML **operation** is a *declaration*, with a name, parameters, return type, exceptions list, and possibly a set of *constraints* of pre and post-conditions. But, it isn't an implementation — rather, methods are implementations
- A method may be illustrated several ways, including:
  - in interaction diagrams, by the details and sequence of messages
  - in class diagrams, with a UML note symbol stereotyped with «method»



Content

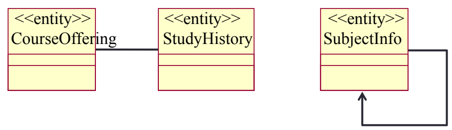
Class Relationships

- Association
  - Aggregation
    - Composition
- Inheritance
- Dependency

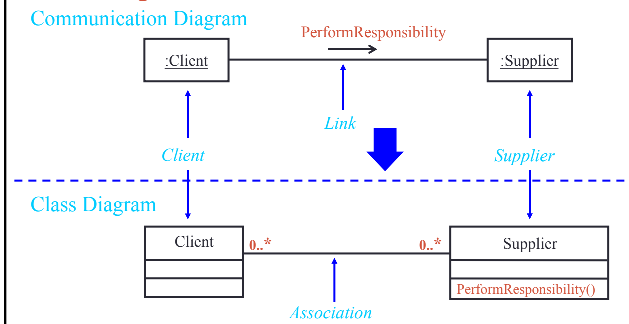


3.1. What is an Association?

- The semantic relationship between two or more classifiers that specifies connections among their instances
- A structural relationship, specifying that objects of one thing are connected to objects of another



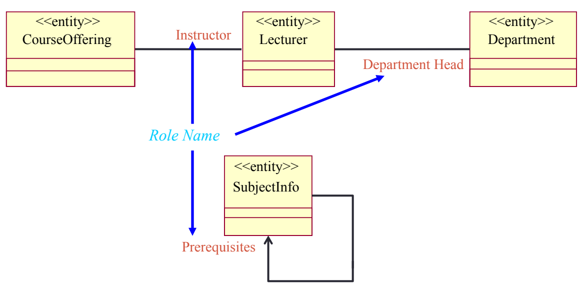
Finding Association



Relationship for every link!

3.1.1. What Are Roles?

- The “face” that a class plays in the association



3.1.2. What Is Multiplicity?

- Multiplicity is the number of instances one class relates to ONE instance of another class.
- For each association, there are two multiplicity decisions to make, one for each end of the association.
  - For each instance of Professor, many Course Offerings may be taught.
  - For each instance of Course Offering, there may be either one or zero Professor as the instructor.

Multiplicity Indicators

Unspecified	
Exactly One	1
Zero or More	0..*
Zero or More	*
One or More	1..*
Zero or One (optional value)	0..1
Specified Range	2..4
Multiple, Disjoint Ranges	2, 4..6

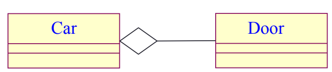
What Does Multiplicity Mean?

- Multiplicity answers two questions:
  - Is the association mandatory or optional?
  - What is the minimum and maximum number of instances that can be linked to one instance?

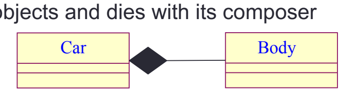
3.1.3. Association Types

- Association
  - use-a
  - Objects of one class are associated with objects of another class

- Aggregation
  - has-a/is-a-part
  - Strong association, an instance of one class is made up of instances of another class

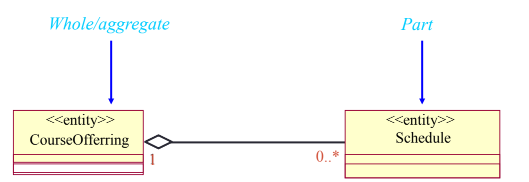


- Composition
  - Strong aggregation, the composed object can't be shared by other objects and dies with its composer
  - Share life-time



Review: What Is Aggregation?

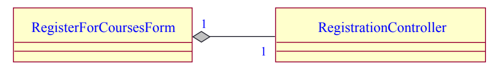
- A special form of association that models a whole-part relationship between an aggregate (the whole) and its parts
  - An aggregation is an "is a part-of" relationship.
- Multiplicity is represented like other associations.



Review: What is Composition?

- A special form of aggregation with strong ownership and coincident lifetimes of the part with the aggregate.
- The whole “owns” the part and is responsible for the creation and destruction of the part.
  - The part is removed when the whole is removed.
  - The part may be removed (by the whole) before the whole is removed.

“Register for course” Use case



Association or Aggregation?

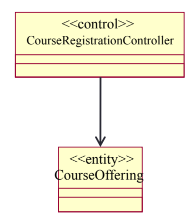
- If two objects are tightly bound by a whole-part relationship
  - The relationship is an aggregation.

- If two objects are usually considered as independent, although they are often linked
  - The relationship is an association.

When in doubt, use association.

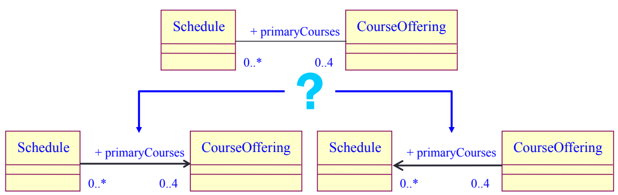
3.1.4. Navigability

- Indicates that it is possible to navigate from an associating class to the target class using the association



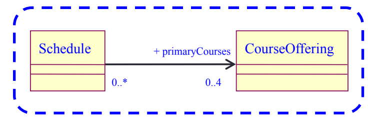
Navigability: Which Directions Are Really Needed?

- Explore interaction diagrams
- Even when both directions seem required, one may work
  - Navigability in one direction is infrequent
  - Number of instances of one class is small

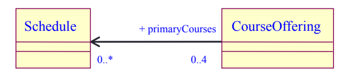


Example: Navigability Refinement

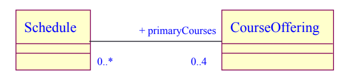
- Total number of Schedules is small, or
- Never need a list of the Schedules on which the CourseOffering appears



- Total number of CourseOffering is small, or
- Never need a list of CourseOffering on a Schedule



- Total number of CourseOffering and Schedules are not small
- Must be able to navigate in both directions



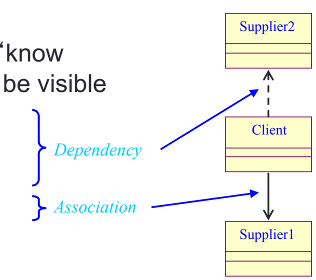
3.2. Dependency

- What Is a Dependency?
  - A relationship between two objects

- Purpose
  - Determine where structural relationships are NOT required
- Things to look for :
  - What causes the supplier to be visible to the client

Dependencies vs. Associations

- Associations are structural relationships
- Dependencies are non-structural relationships
- In order for objects to "know each other" they must be visible
  - Local variable reference
  - Parameter reference
  - Global reference
  - Field reference



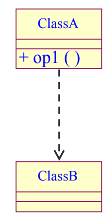
Associations vs. Dependencies in Collaborations

- An instance of an association is a link
  - All links become associations unless they have global, local, or parameter visibility
  - Relationships are context-dependent
- Dependencies are transient links with:
  - A limited duration
  - A context-independent relationship
  - A summary relationship

A dependency is a secondary type of relationship in that it doesn't tell you much about the relationship. For details you need to consult the collaborations.

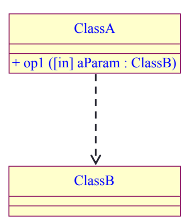
3.2.1. Local Variable Visibility

- The op1() operation contains a local variable of type ClassB



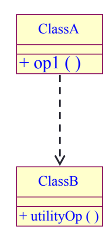
3.2.2. Parameter Visibility

- The ClassB instance is passed to the ClassA instance



3.2.3. Global Visibility

- The ClassUtility instance is visible because it is global



Identifying Dependencies: Considerations

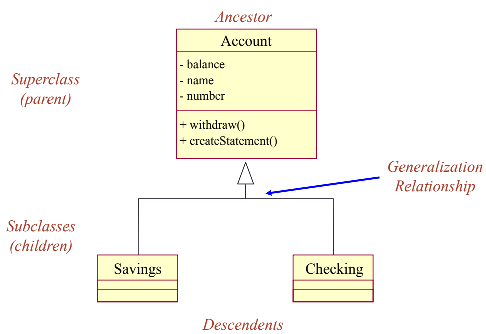
- Permanent relationships — Association (field visibility)
- Transient relationships — Dependency
  - Multiple objects share the same instance
    - Pass instance as a parameter (parameter visibility)
    - Make instance a managed global (global visibility)
  - Multiple objects don't share the same instance (local visibility)
- How long does it take to create/destroy?
  - Expensive? Use field, parameter, or global visibility
  - Strive for the lightest relationships possible

3.3. Generalization

- A relationship among classes where one class shares the structure and/or behavior of one or more classes.
- Defines a hierarchy of abstractions where a subclass inherits from one or more superclasses.
  - Single inheritance
  - Multiple inheritance
- Is an "is a kind of" relationship.

Example: Single Inheritance

- One class inherits from another



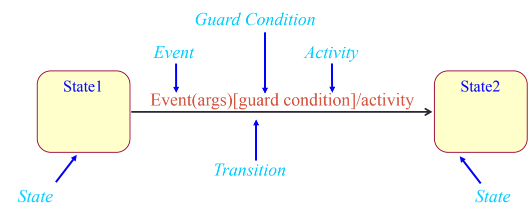
Content

4. Define States

- Purpose
  - Design how an object's state affects its behavior
  - Develop state machines to model this behavior
- Things to consider:
  - Which objects have significant state?
  - How to determine an object's possible states?
  - How do state machines map to the rest of the model?

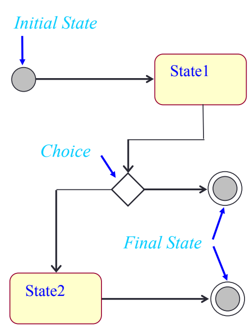
What is a State Machine?

- A directed graph of states (nodes) connected by transitions (directed arcs)
- Describes the life history of a reactive object



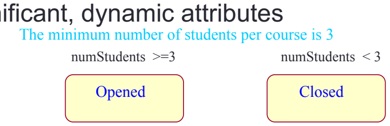
Pseudo States

- Initial state
  - The state entered when an object is created
  - Mandatory, can only have one initial state
- Choice
  - Dynamic evaluation of subsequent guard conditions
  - Only first segment has a trigger
- Final state
  - Indicates the object's end of life
  - Optional, may have more than one

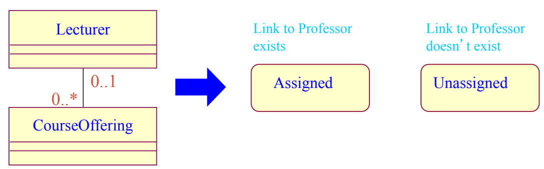


Identify and Define the States

- Significant, dynamic attributes

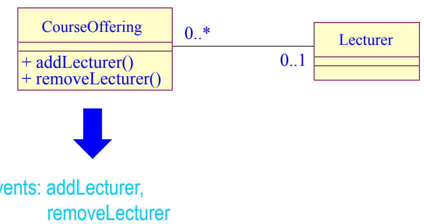


- Existence and non-existence of certain links



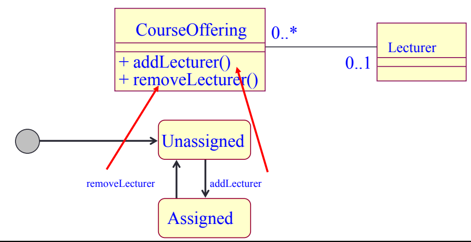
Identify the Events

- Look at the class interface operations



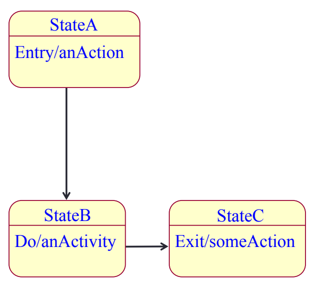
Identify the Transitions

- For each state, determine what events cause transitions to what states, including guard conditions, when needed
- Transitions describe what happens in response to the receipt of an event

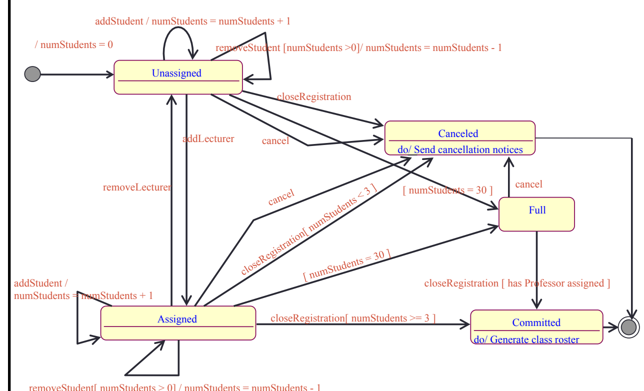


Add Activities

- Entry
  - Executed when the state is entered
- Do
  - Ongoing execution
- Exit
  - Executed when the state is exited



Example: State Machines

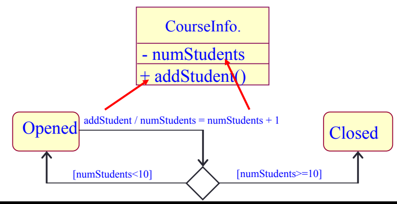


Which Objects Have Significant State?

- Objects whose role is clarified by state transitions
- Complex use cases that are state-controlled
- It is not necessary to model objects such as:
  - Objects with straightforward mapping to implementation
  - Objects that are not state-controlled
  - Objects with only one computational state

How Do State Machines Map to the Rest of the Model?

- Events may map to operations
- Methods should be updated with state-specific information
- States are often represented using attributes
  - This serves as input into the "*Define Attributes*" step



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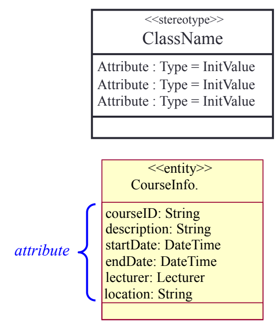
Review: What Is an Attribute?



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5.1. Finding Attributes

- Properties/characteristics of identified classes
- Information retained by identified classes
- "Nouns" that did not become classes
  - Information whose value is the important thing
  - Information that is uniquely "owned" by an object
  - Information that has no behavior

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5.1. Finding Attributes (2)

- Examine method descriptions
- Examine states
- Examine any information the class itself needs to maintain

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5.2. Attribute Representations

- Specify name, type, and optional default value
  - attributeName : Type = Default
- Follow naming conventions of implementation language and project
- Type should be an elementary data type in implementation language
  - Built-in data type, user-defined data type, or user-defined class
- Specify visibility
  - Public: + Private: - Protected: #

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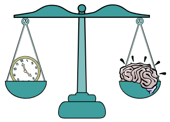
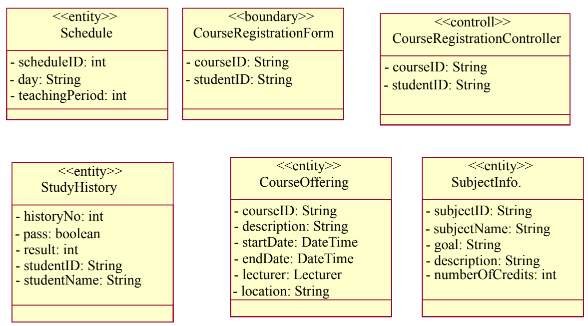
5.3. Derived Attributes

- What is a derived attribute?
  - An attribute whose value may be calculated based on the value of other attribute(s)
- When do you use it?
  - When there is not enough time to re-calculate the value every time it is needed
  - When you must trade-off runtime performance versus memory required



Example: Define Attributes



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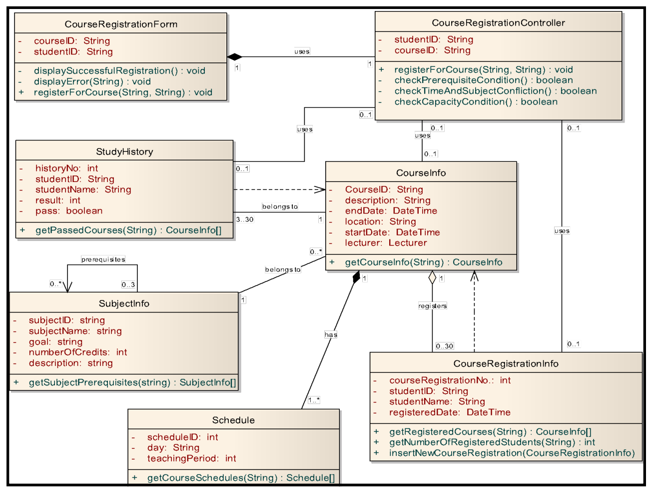
6. Class diagram

- Static view of a system
- When modeling the static view of a system, class diagrams are typically used in one of three ways, to model:
  - The vocabulary of a system
  - Collaborations
  - A logical database schema



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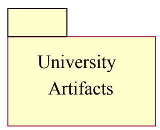
Review: What Is a Package?

- A general purpose mechanism for organizing elements into groups.
- A model element that can contain other model elements.
- A package can be used:
  - To organize the model under development
  - As a unit of configuration management



Review points: Classes

- Clear class names
- One well-defined abstraction
- Functionally coupled attributes/behavior
- Generalizations were made
- All class requirements were addressed
- Demands are consistent with state machines
- Complete class instance life cycle is described
- The class has the required behavior

Review points: Operations

- Operations are easily understood
- State description is correct
- Required behavior is offered
- Parameters are defined correctly
- Messages are completely assigned operations
- Implementation specifications are correct
- Signatures conform to standards
- All operations are needed by Use-Case Realizations

Review points: Attributes

- A single concept
- Descriptive names
- All attributes are needed by Use-Case Realizations

Review points: Relationships

- Descriptive role names
- Correct multiplicities

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Question?