Object-Oriented Design

- Objective: Develop logical solution that fulfills the requirements
  - define the classes that will be implemented in an object-oriented programming language.
  - Assign responsibilities to software components
  - Identify and apply design patterns.

Artifacts of Analysis/Architectural Modeling

- Conceptual Model
  - Static Structure diagram(s)
  - Sequence diagrams
  - Glossary
  - Other models and documents?
- Architectural Model
  - Stakeholder Needs
  - Architectural views

Larman's Approach to Design

- Develop real use cases
- Create interaction diagrams
- Develop design class diagrams
- Key issues:
  - Allocation of responsibility
  - Identification/application of design pattens

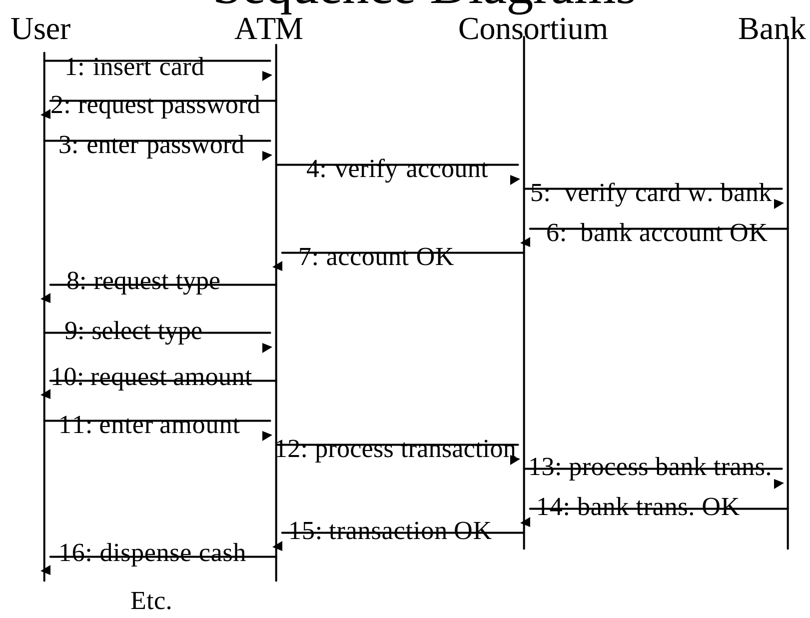
Design--Real Use Cases

- Real use cases describe user interaction with the system in concrete terms.
  - User interactions with system interface(s)
  - System interaction with interfaces
- Requires some definition of interface details.
- Remember, the "user" may be another software system or a hardware system rather than a human.

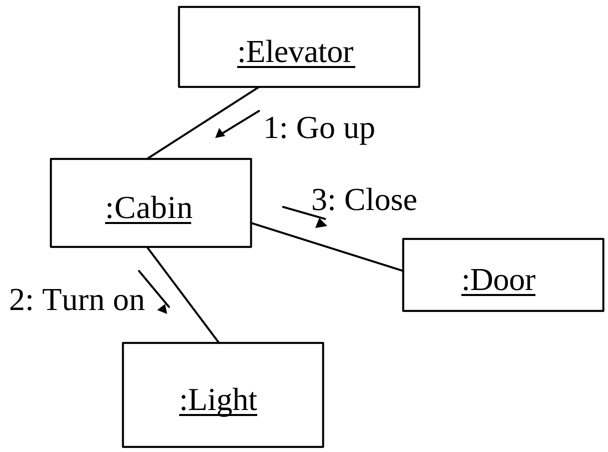
Design--Modeling System Interactions

- Interaction diagrams
  - sequence diagrams
  - collaboration diagrams
- Show the time-ordered interactions among system objects
- If contracts have been specified for system operations during analysis/architectural modeling, these provide a good starting point.

Sequence Diagrams

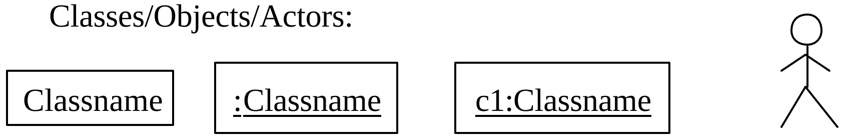


Collaboration Diagrams



Elements of Collaboration Diagrams

Classes/Objects/Actors:



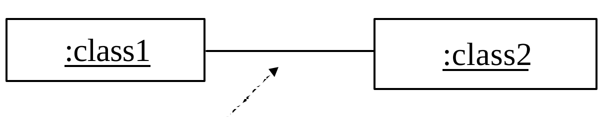
A class

An instance of class Classname

A named instance of class Classname

An actor

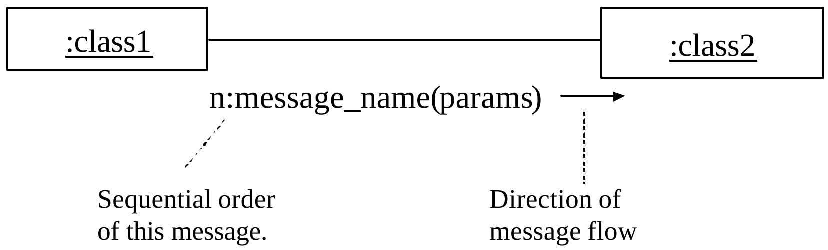
Links:



Denotes an instance of an association between class1 and class2

Collaboration Diagram Elements--Continued

Messages:



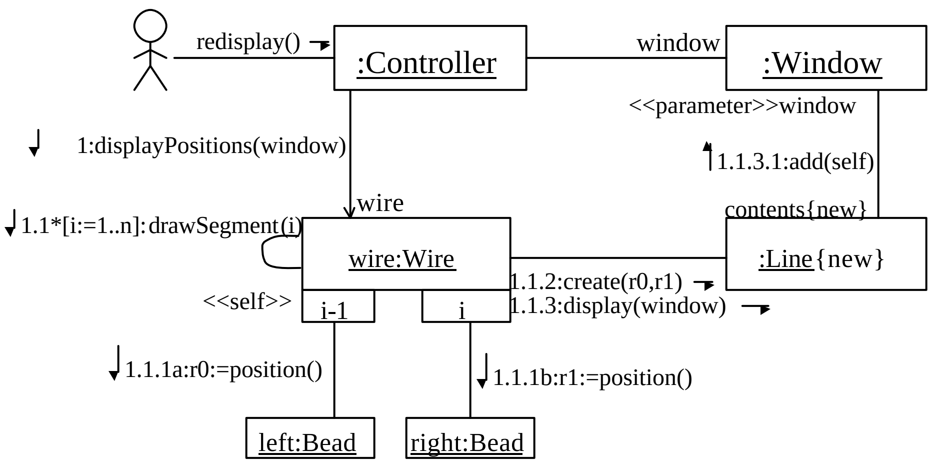
May also designate a return value:

n:return_value=message_name(params)

Collaboration Diagrams--Continued

- Additional Elements (see Chapter 17 of Larman for syntax and examples:
  - iterative messages
  - conditional messages
  - alternative paths
  - multiobjects

Collaboration Diagram Example



Design of Collaborations

- During the design of collaborations, important design decisions must be made.
  - Methods assigned to classes
    - operation
    - parameters
    - return values
  - Internal data (state) of objects is identified
  - Interactions among classes are identified.
  - Internal flow-of-control of objects is identified.

Using Patterns to Build Collaborations

- Design pattern: capture standard solutions (structures) that have evolved over time and have been successfully applied to previous problems.
- Why use patterns:
  - reuse
  - faster/more robust design
  - improved communication

Larman's Design Patterns

- GRASP--General Responsibility Assignment Patterns
  - Basic Patterns:
    - Expert
    - Creator
    - High Cohesion
    - Low Coupling
    - Controller
  - Advanced Patterns:
    - Polymorphism
    - Pure fabrication
    - Indirection
    - Don't Talk to Strangers

“Gang of Four” Patterns

- Design Patterns--Elements of Reusable Object Oriented Software, by Gamma, helm, Johnson, and Vlissides
  - Creational Patterns
    - Abstract Factory
    - Builder
    - Factory Method
    - Prototype
    - Singleton

“Gang of Four” Patterns--Continued

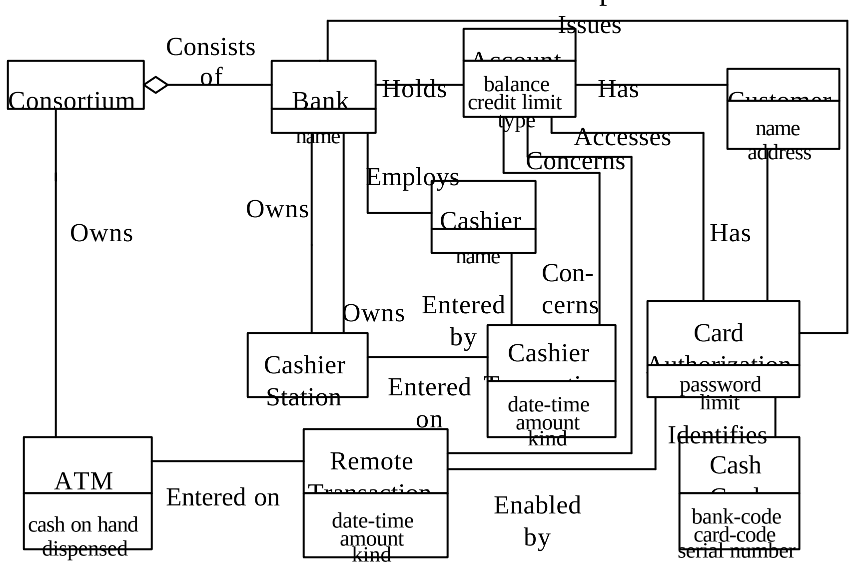
- Structural Patterns
  - Adapter
  - Bridge
  - Composite
  - Decorator
  - Façade
  - Flyweight
  - Proxy
- Behavioral Patterns
  - Chain of Responsibility
  - Command
  - Interpreter
  - Iterator
  - Mediator
  - Memento
  - Observer
  - State
  - Strategy
  - Template Method
  - Visitor

Overview of the GRASP Patterns

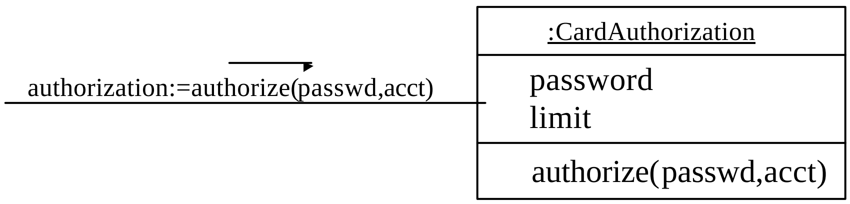
- Expert
  - Assign a responsibility to the information expert--ie. The class that has the necessary information to carry out the responsibility.
  - Basic idea:
    - To what class or object should a given responsibility be allocated--e.g. responsibility for authorizing an ATM transaction?
    - Identify the class that has the necessary information.
    - Assign a method to this class to carry out the responsibility.

Expert Pattern Example

ATM Transaction Authorization: Who is responsible?



Expert pattern Example--Continued



Expert Pattern--Benefits and Liabilities

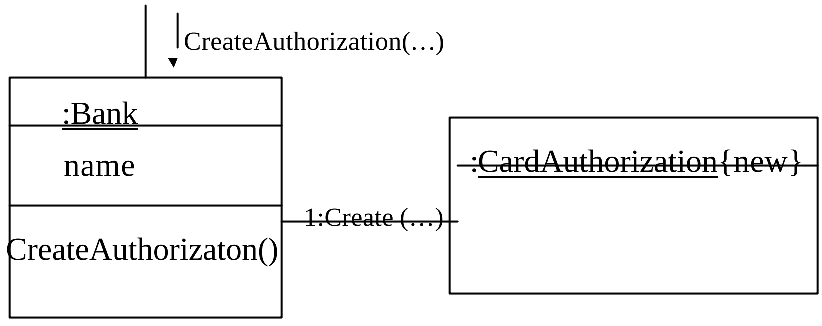
- Benefits:
  - Low coupling among objects--objects use their own information to carry out responsiblities
  - High cohesion--behavior is distributed across classes that have the required information.
- Liabilities:
  - May ignore higher-level structuring issues
  - Could result in “over-distribution” of responsiblities.

GRASP Patterns--Continued

- Creator Pattern: Assign class B the responsibility to create instances of class A under any of the following circumstances:
  - B *aggregates* objects of class A.
  - B *contains* objects of class A
  - B *records* instances of class A objects
  - B *closely uses* objects of class A.
  - B *has initializing data* for class A objects..

Creation Pattern Example

Who should create CardAuthorizaton objects?



Creator Pattern--Benefits and Liabilities

- Benefits:
  - Low Coupling--since creator already has associations with created class
- Liabilities:
  - No real drawbacks--this is just common sense.
  - Choice of creator may not always be unique.

GRASP Patterns--Continued

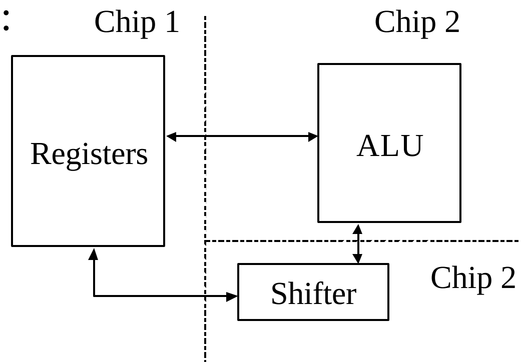
- Low Coupling Pattern: Assign responsibility so that coupling remains low.
- Coupling: degree of interaction among objects
- (Potential) advantages of low coupling:
  - reduced complexity
  - more opportunities for reuse
  - easier to modify

GRASP Patterns--Continued

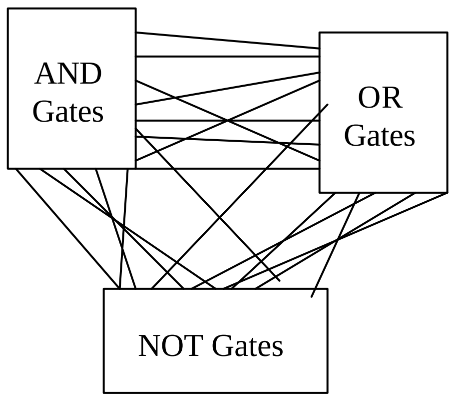
- High Cohesion Pattern: Assign responsibilities so that cohesion is high.
- Cohesion: The degree of interaction (relatedness) among responsibilities within as class.
- (Potential) advantages of high cohesion:
  - Good “packaging” of functionality
  - Enhances reuse.
  - Enhances maintainability

More About Coupling and Cohesion

- An analogy: Consider the design of a computer to be partitioned across three chips.
- Approach 1:



Design of a 3-Chip CPU--Second Approach:



Which approach makes more sense? Why?

Cohesion

- Meyers Defined Seven Levels of Cohesion
  - 7. Functional Cohesion
  - 7 Informational Cohesion
  - 5. Communicational Cohesion
  - 4. Procedural Cohesion
  - 3. Temporal Cohesion
  - 2. Logical Cohesion
  - 1. Coincidental Cohesion

(GOOD)

(BAD)

Types of Cohesion

- Coincidental
  - module performs multiple, unrelated actions
  - This amounts to arbitrary modularization
- Logical
  - module performs a set of related actions, one of which is selected by the calling module.
  - E.g , a module performing all input/output functions for a complex system.
- Temporal
  - module performs a series of actions related in time.
  - E.g., module containing all system initialization actions.

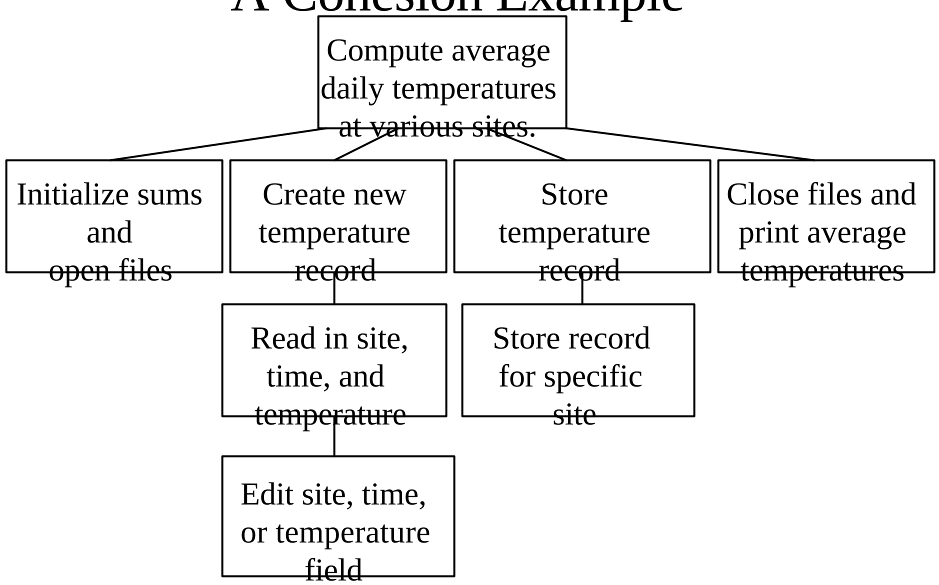
Types of Cohesion--Continued

- Procedural
  - module performs a set of weakly-connected actions corresponding to the sequence of steps in some operation
  - E.g., all of the operations involved in an ATM transaction
- Communicational
  - module performs a sequence of steps, related to some operation, which operate on the same data.
  - E.g., update a database, record update to audit trail, print the update.

Types of Cohesion--Continued

- Informational
  - module performs a set of independent actions, all of which operate on the same data strucure
  - E.g., implementation of an Abstract Data Type
- Functional Cohesion
  - module performs one coherent action or achieves a single objective
  - E.g., “calculate sales commision.”

A Cohesion Example



Coupling

- Five levels of coupling:
  - 5. Data Coupling
  - 4. Stamp Coupling
  - 3. Control Coupling
  - 2. Common Coupling

(GOOD)

↕

(BAD)

Types of Coupling

- Content Coupling
  - one module directly references the content of the other.
  - E.g. module A branches to a local label of module B.
- Common Coupling
  - two modules share access to the same global data
  - E.g., modules use global variables to pass arguments

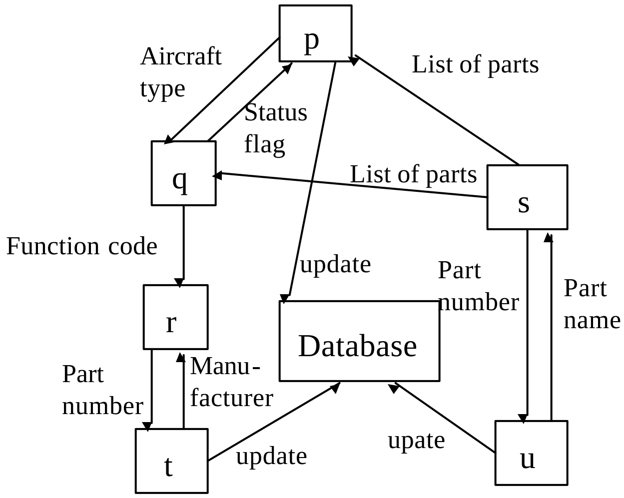
Types of Coupling--Continued

- Control Coupling
  - one module explicitly controls the logic of another
  - E.g. a control switch is passed as an argument
- Stamp Coupling
  - a data structure is passed as an argument but called module only operates on some individual components of the data structure
  - E.g., an employee record is passed to a module which only needs the salary field.

Data Coupling

- Data Coupling
  - all data exchanged by modules are homogeneous data items.
  - I.e., either simple data values or data structures in which all elements are used by the called module.

Coupling Example



GRASP Patterns--Continued

- Controller Pattern
  – Assign responsibility for handling a system event to one of the following *controller classes*:
    - One representing the overall “system”, business, or organization
      – façade controller
    - One that represents an active real-world entity that might be responsible for the task
      – role controller
    - One that represents an artificial hander of all system events associated with some collaboration
      – use-case controller

Controller Pattern--Continued

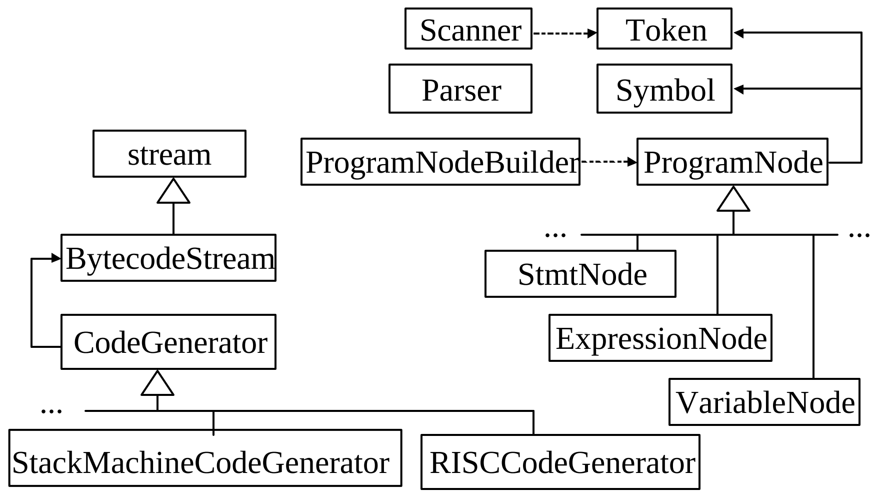
- System event--generated by external actor
  - associated with system operations.
  - E.g. user selecting a function on ATM screen.
- Controller--object responsible for handling a system event.
- Possible choices for ATM transaction
  - System or ATM--façade controller
  - Teller--role controller
  - ATMTransactonHandler--use-case controller

Controller Classes--Which Type to Use:

- Façade controller
  - places all system event handling in a single class
  - may become too complex and incohesive if the number and range of system events is high.
- Role controller
  - attempts to mimic behavior of a human agent
  - may suffer from imperfect or awkward analogy
- Use-case controller
  - allocates controller responsibility on a per-collaboration basis
  - best choice if system has many events spread across several operations.

Controller Pattern Example

A Compiler:



Controller Classes--Additional Issues

- Separation of presentation (interface objects) from event-handling responsibility
  - E.g. GUI objects shouldn't process user input events.
  - GUI object may select the appropriate controller class to handle a given event.