SWE 621:
Software Modeling and Architectural Design

Lecture 3
Static Modeling

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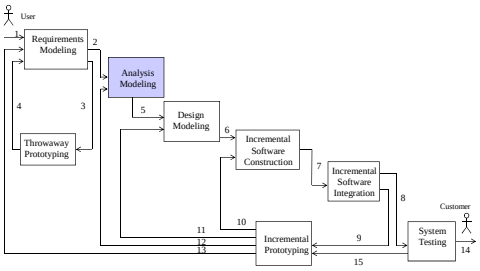
Steps in Using COMET/UML

1 Develop Software Requirements Model
- Develop Use Case Model (Chapter 6)

2 Develop Software Analysis Model
- Develop static model of problem domain (Chapter 7)
- Structure system into objects (Chapter 8)
- Develop statecharts for state dependent objects (Chapter 10)
- Develop object interaction diagrams for each use case (Chapter 9, 11)

3 Develop Software Design Model



Static Modeling

Section 4

Hassan Gomaa

References: H. Gomaa, Chapter 7 - *Software Modeling and Design*, Cambridge University Press, February 2011

H. Gomaa, "Chapter 8 - Designing Concurrent, Distributed, and Real-Time Applications with UML", Addison Wesley Object Technology Series, July, 2000

Static Modeling

- Originated with Rumbaugh Object Modeling Technique (OMT)
- Represents static structure of system
- Based on information (Entity-Relationship) modeling
- Static Modeling
  - In OO Analysis Modeling
    - Define classes in system
    - Defines attributes of classes
    - Defines relationships between classes
  - In OO Design Modeling
    - Defines operations of each class

Design Concepts
Objects and Classes

- Objects represent “things” in real world
  - Provide understanding of real world
  - Form basis for a computer solution
- An Object (object instance) is a single “thing”
  - E.g., an account, an employee
- A Class (object class) is a collection of objects with the same characteristics
  - E.g., account, employee
- Attribute
  - Data value held by object in class
  - E.g., account number, balance

Figure 2.2 UML notation for objects & classes

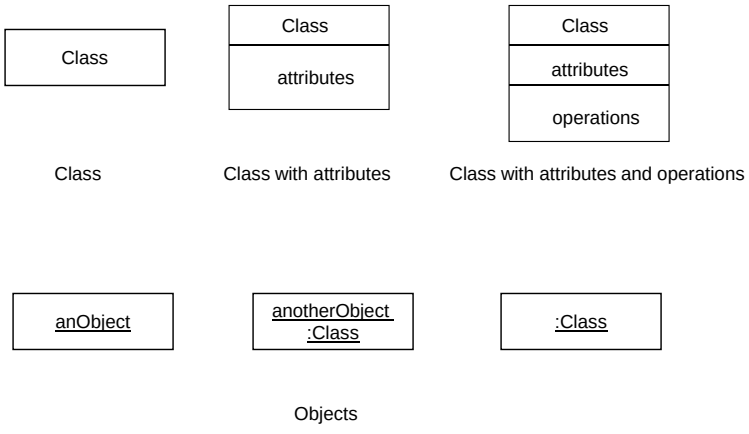


Figure 4.1 Example of classes and objects

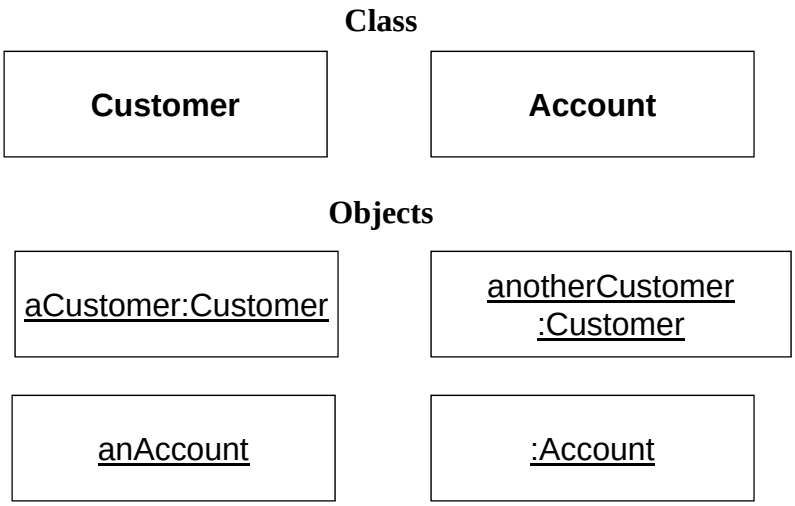
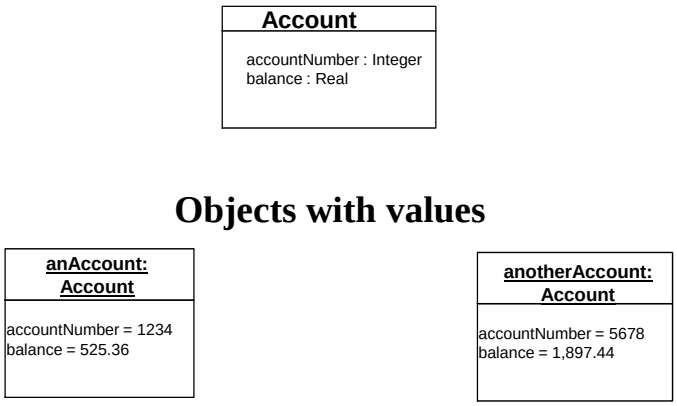


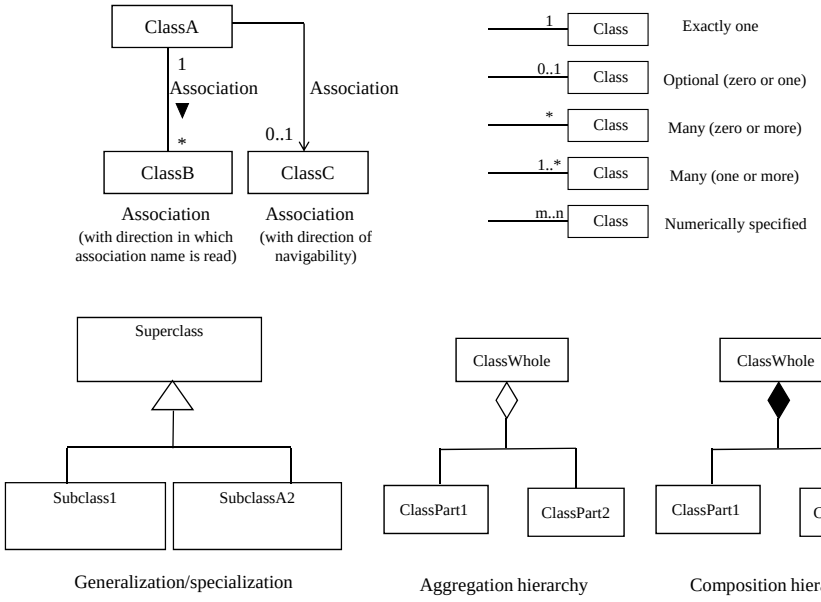
Figure 4.2 Example of class with attributes



Static Modeling

- Define structural relationships between classes
  - Depict classes and their relationships on class diagrams
- Relationships between classes
  - Associations
  - Composition / Aggregation
  - Generalization / Specialization
- Static Modeling during Analysis
  - System Context Class Diagram
    - Depict external classes and system boundary
  - Static Modeling of Entity classes
    - Persistent classes that store data

Figure 2.3 UML notation for relationship on class diagram



Associations

- Association is
  - static, structural relationship between classes
  - E.g, Employee works in Department
- Multiplicity of Associations
  - Specifies how many instances of one class may relate to a single instance of another class

Multiplicity of Associations

- 1-to-1 association
  - Company has President
- 1-to-many association
  - Bank manages Account
- Numerically specified association
  - Car has 2,4 Door
- Optional association (0 or 1)
  - Customer owns Debit Card
- Optional association (0, 1, or many)
  - Customer owns Credit Card
- Many-to-Many association
  - Course has Student
  - Student attends Course

Figure 7.1 Example of one-to-one association

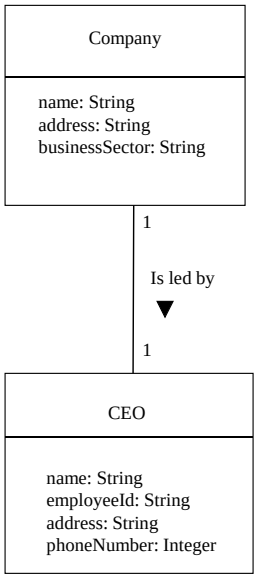


Figure 7.2 Example of one-to-many association

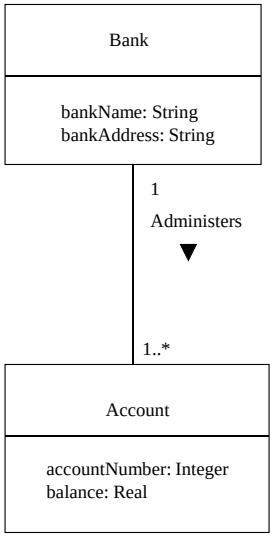


Figure 7.3 Numerically specified association

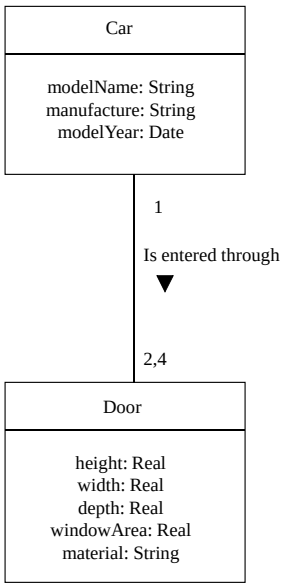


Figure 7.4 Optional (zero-or-one) association

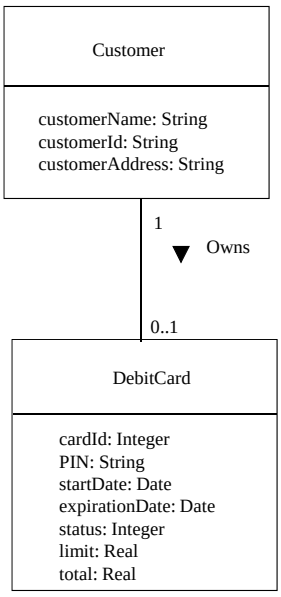


Figure 7.5 Optional (zero,one, or many) association

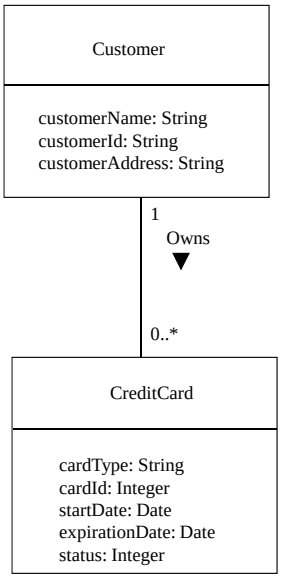
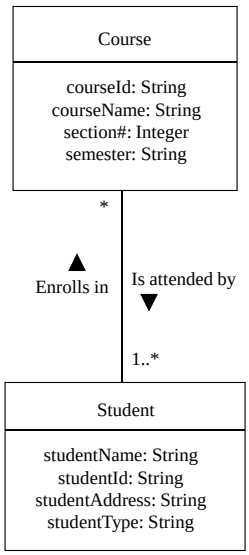


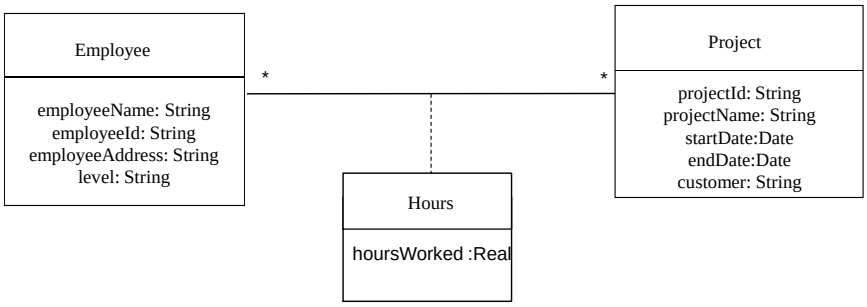
Figure 7.6 Many-to-many association



Association Class

- Class to model association between two or more classes
  - Usually for many- to- many associations
  - Attributes of Association Class
    - Attributes of association
- E.g., Many-to-many association between
  - Project and Employee classes
    - Project has Employee
    - Employee works on project
  - Association Class - Hours
    - Attribute - Hours Worked

Figure 7.11 Example of association class



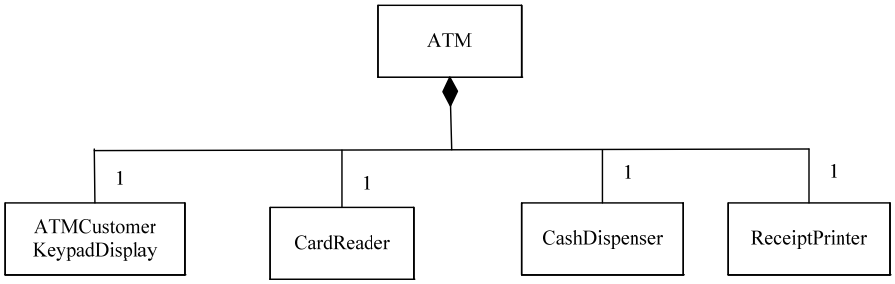
Composition/Aggregation Hierarchy

- Whole/Part Relationships
  - Show parts of more complex class
  - Composition is stronger relationship than aggregation
- IS PART OF Relationship
  - Between part classes and whole (composite or aggregate) class
- Composition is stronger relationship than aggregation

Composition Hierarchy

- Composition Hierarchy
  - Whole and part objects are created, live, die together
  - Often also has a physical association
  - Association between instances
- E.g., Composite class
    - ATM
  - Part classes

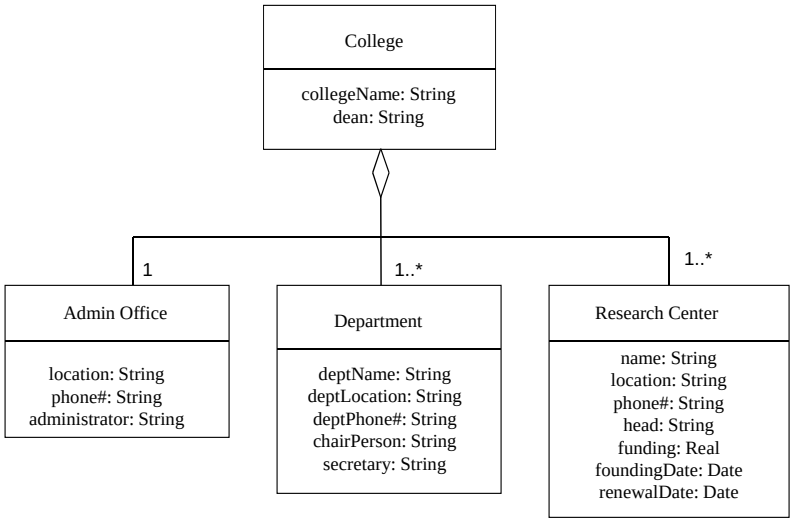
Figure 7.12 Example of composition hierarchy



Composition/Aggregation Hierarchy

- Aggregation Hierarchy
  - Part objects of aggregate object may be created and deleted independently of aggregate object
  - E.g., Aggregate class
    - College
  - Part classes
    - Admin Office IS PART OF College
    - Department IS PART OF College
    - Research Center IS PART OF College

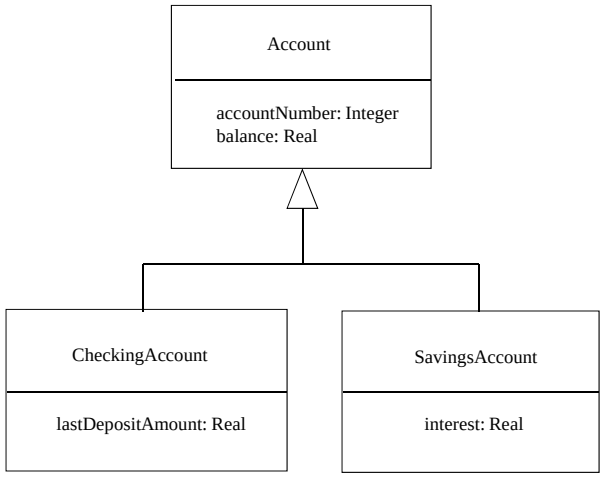
Figure 7.13 Example of aggregation hierarchy



Generalization / Specialization Hierarchy

- Some classes are similar but not identical
  - Have some attributes in common, others different
- Common attributes abstracted into generalized class (superclass)
  - E.g., Account (Account number, Balance)
- Different attributes are properties of specialized class (subclass)
  - E.g., Savings Account (Interest)
- IS A relationship between subclass and superclass
  - Savings Account IS A Account

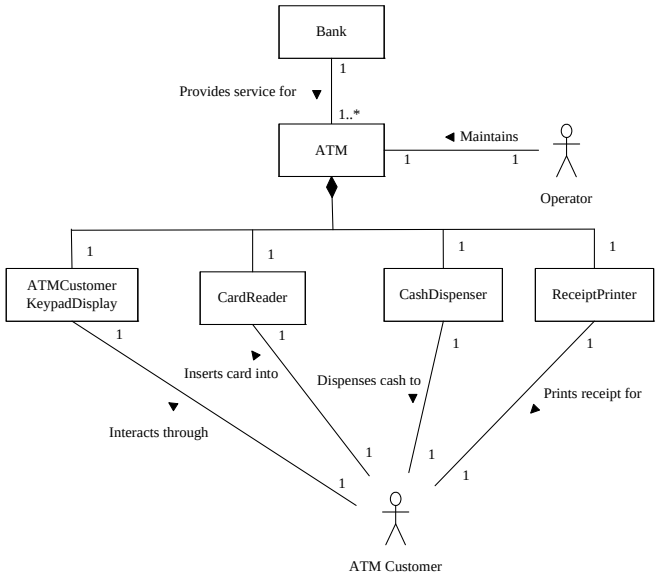
Figure 7.14 Generalization / specialization hierarchy



Static Modeling of Problem Domain

- During Analysis Modeling
  - Conceptual static model
  - Emphasizes real-world classes in the problem domain
  - Does not initially address software classes
  - Emphasis on
    - Physical classes
      - Have physical characteristics (can see, touch)
    - Entity classes
      - Data intensive classes

Figure 7.18 Conceptual static model for Banking System



Software System Context Class Diagram

- Defines boundary between system and external environment
  - May be depicted on Software System Context Class Diagram
- System
  - Depicted as one aggregate «software system» class
- External environment
  - External classes that software system interfaces to
- Categories of external classes
  - «external I/O device»
  - «external user»
  - «external system»
  - «external timer»

Associations on Software System Context Class Diagram

- Software System Context Class Diagram shows
  - Association between software system and external class
  - Multiplicity of association (1 to 1, 1..* to 1, etc.)
- Associations have standard names
  - «external input device» Inputs to «software system»
  - «software system» Outputs to «external output device»
  - «external user» Interacts with «software system»
  - «external system» Communicates with «software system»
  - «external timer» Signals «software system»

Figure 7.23 Banking System software context class diagram

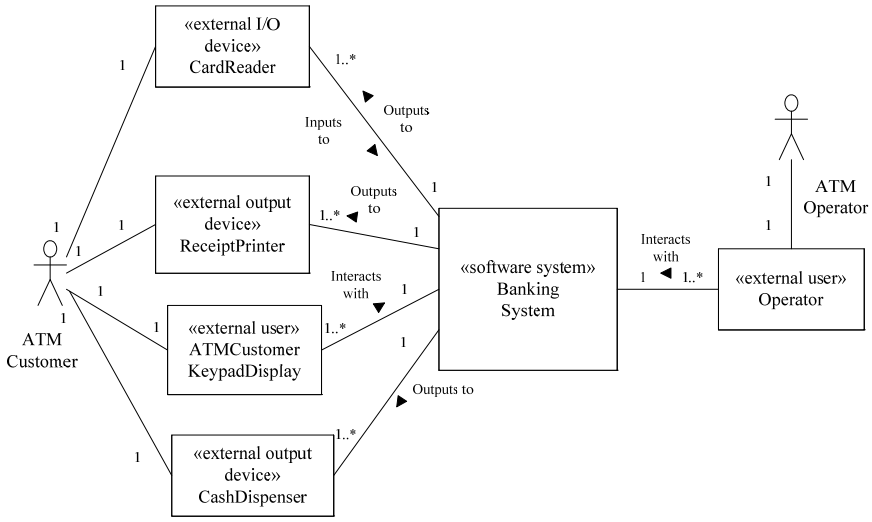
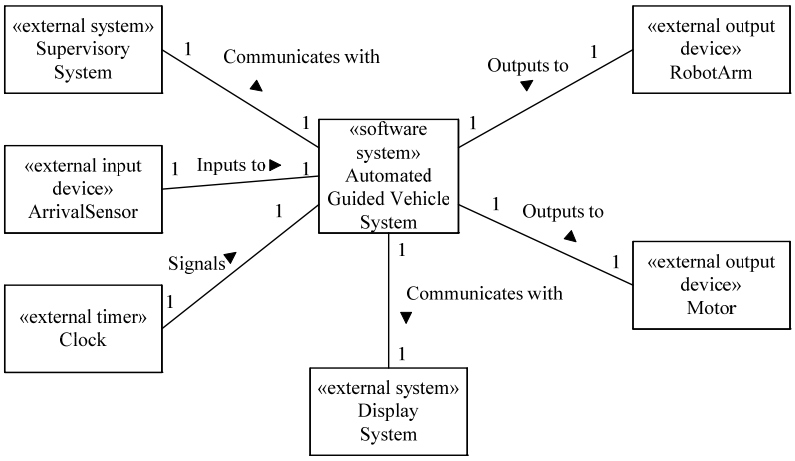


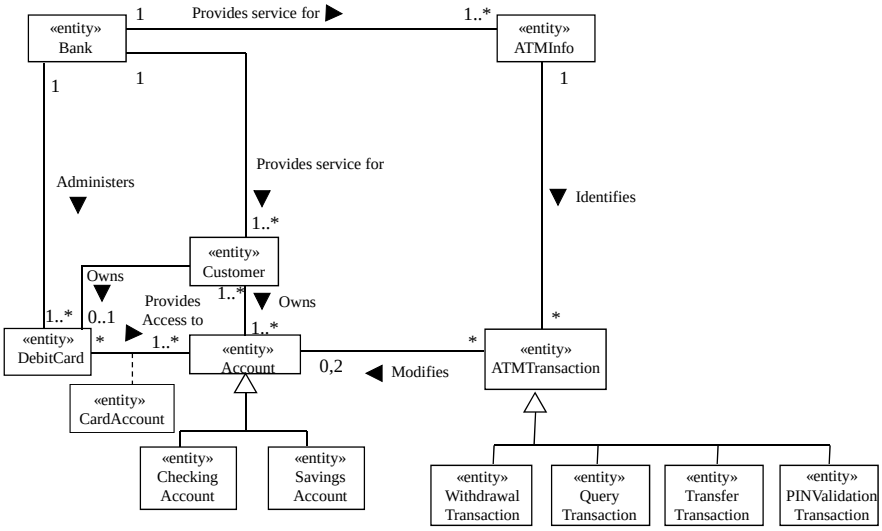
Figure 7.24 Factory Automation System software context class diagram



Static Modeling of Entity Classes

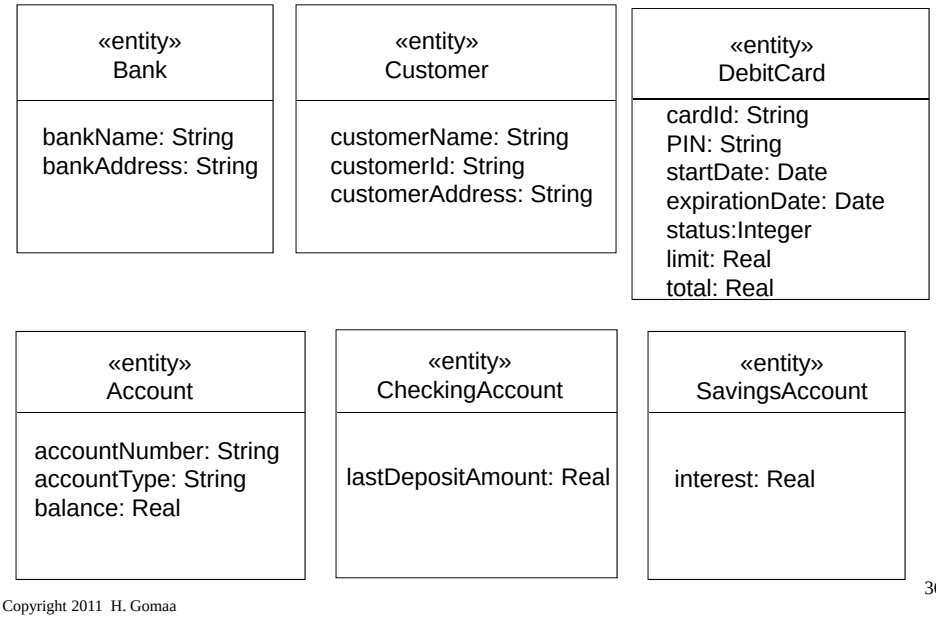
- Entity classes
  - Data intensive classes
  - Store long-living (persistent) data
  - Especially important for Information Systems
    - Many are database intensive
  - Also important for many real-time and distributed applications
- During analysis modeling
  - Model entity classes in the problem domain
  - Attributes
  - Relationships

Figure 21.4 Conceptual static model for Banking System - entity classes



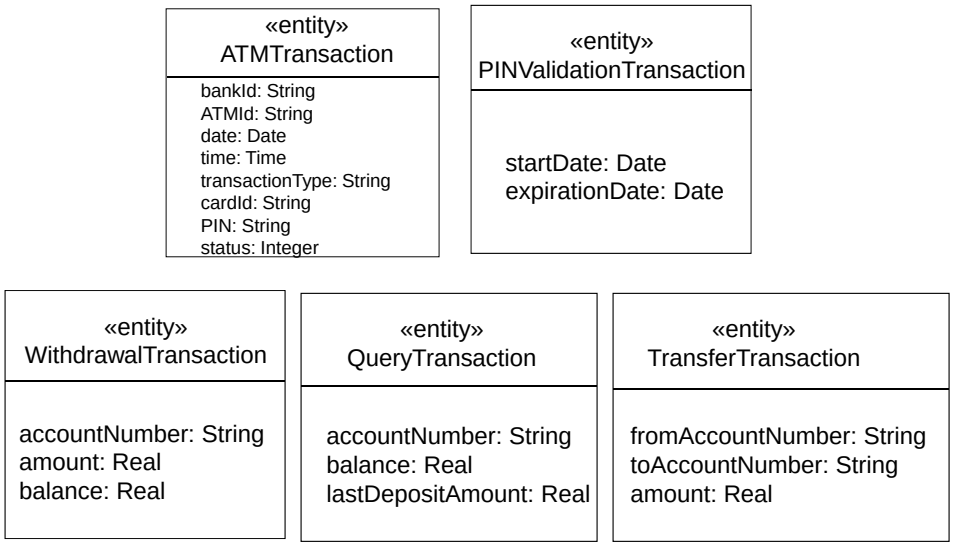
35

Figure 21.5 Conceptual static model for Banking System



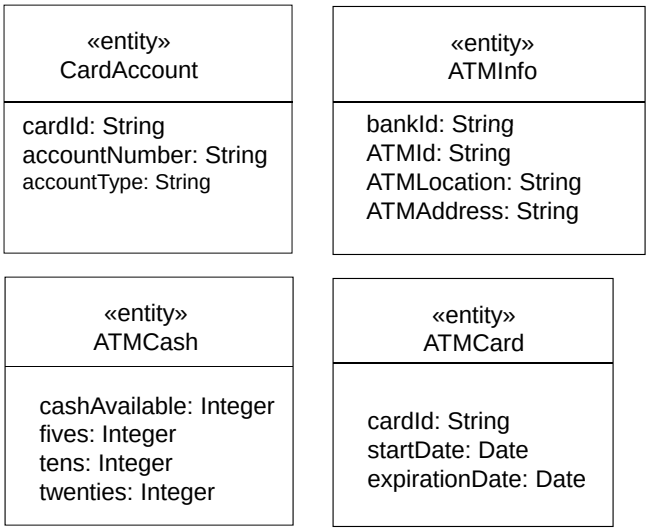
36

Figure 21.6 Conceptual static model for Banking System



37

Figure 21.7 Conceptual static model for Banking System



38

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