SWE 621:
Software Modeling and Architectural Design

Lecture Notes on Software Design

Lecture 4- Object Structuring

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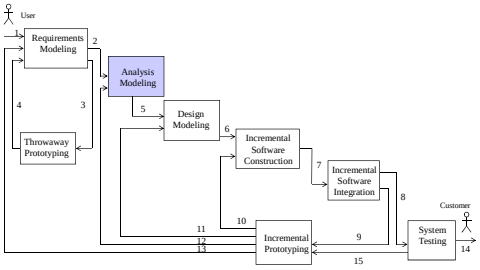
Steps in Using COMET/UML

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



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Lecture 4:
Object Structuring

Hassan Gomaa

References: H. Gomaa, Chapter 8 - *Software Modeling and Design*, Cambridge University Press, February 2011

H. Gomaa, Chapter 9 - *Designing Concurrent, Distributed, and Real-Time Applications with UML*, Addison Wesley Object Technology Series, July, 2000

Object Structuring Criteria

- Determine all software objects in system
  - Use Object Structuring Criteria
  - Guidelines for identifying objects
- Structuring criteria depicted using stereotypes
  - **Stereotype** defines a new building block that is derived from an existing UML modeling element but is tailored to the modeler's problem
  - Depicted using guillemets
    - «entity», «boundary», «control»
- Objects are categorized
  - A **category** is a specifically defined division in a system of classification

Object Structuring Criteria

- Boundary objects
  - User interaction object
  - Device I/O object
  - Proxy object
- Entity objects
  - Long living objects that store information
  - Determined during static modeling
- Control objects
- Application Logic Objects

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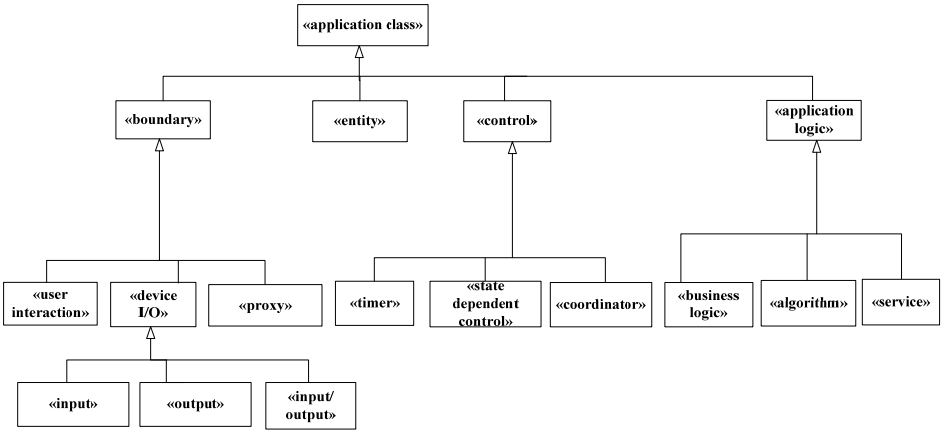
Figure 8.1: Classification of application classes using stereotypes



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Object Structuring Criteria

- Boundary objects
  - Interface to and communicate with external environment
  - Each software boundary object interfaces to an external (real-world) object
    - User interaction object
    - Device I/O object
    - Proxy object
- For each boundary object there is a corresponding external object
  - Also depicted using stereotype

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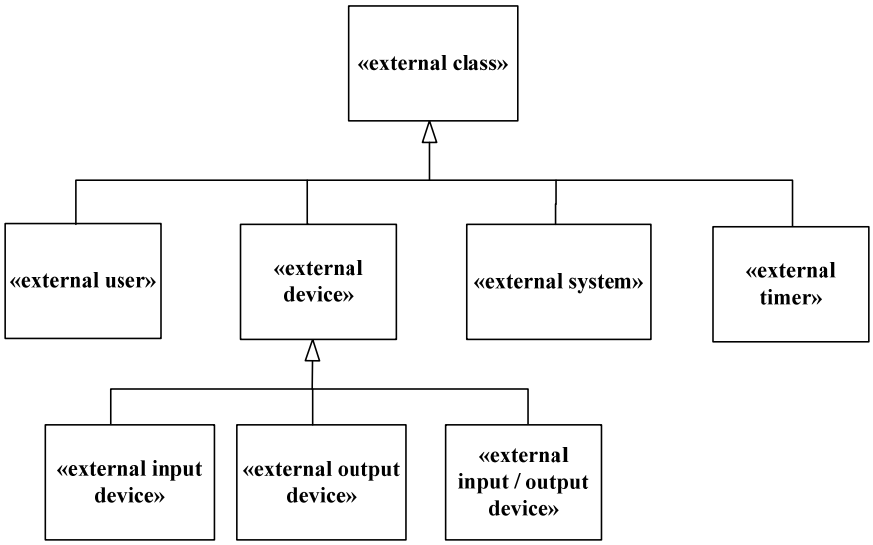
Figure 7.22 Classification of external classes using stereotypes



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User interaction object

- Interfaces to and interacts with a human user
  - Via standard I/O devices
    - keyboard, visual display, mouse
  - Support simple or complex user interfaces
    - Command line interface
    - Graphical user interface (GUI)

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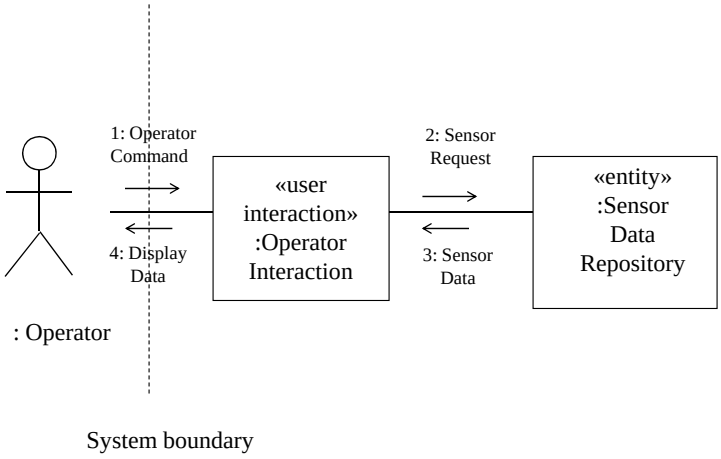
Figure 8.2 Example of user interaction object



Note: The dashed line for the system boundary is for illustrative purposes only and does not conform to the UML notation

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Object Structuring Criteria

- Proxy object
  - Interfaces to an external system
  - Hides details of **how** to communicate with external system
    - E.g., Robot Proxy
    - Interfaces to external (real-world) robot

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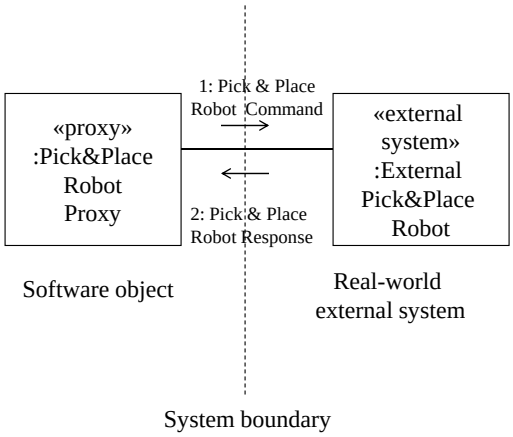
Figure 8.3 Example of proxy object



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Object Structuring Criteria

- Device I/O boundary object
  - Interfaces to I/O device
- Input object
  - E.g., Sensor Interface
- Output object
  - E.g., Actuator Interface
- I/O (Input/Output) object
  - E.g., ATM Card Reader Interface

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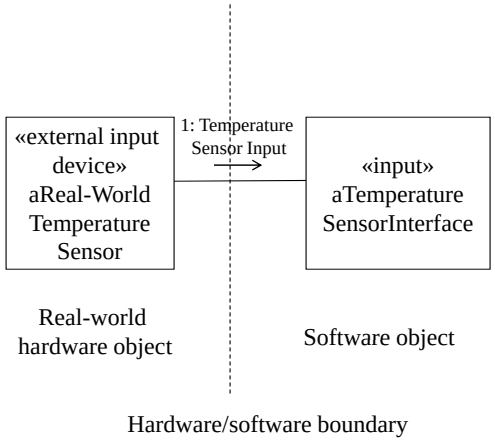
Figure 8.4 Example of input object



Note: The dashed line for the hardware/software boundary is for illustrative purposes only and does not conform to the UML notation

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Depicting External Classes and Boundary Classes

- Start from system context class diagram
  - Shows external classes
  - System (aggregate class)
- Each **external class** must interface to
  - software **boundary class**
- UML
  - System shown as aggregate class
  - External classes are outside the system class
  - Boundary classes are inside the system class

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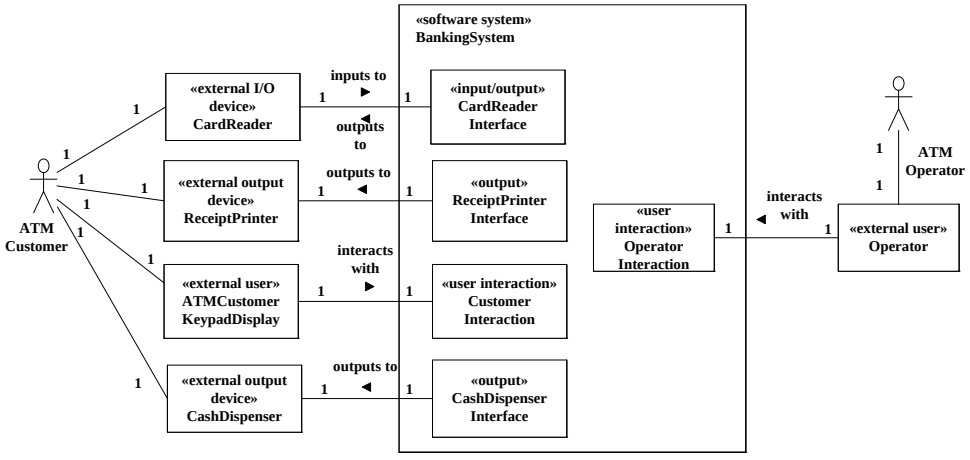
Figure 8.7 Banking System external classes and software boundary classes



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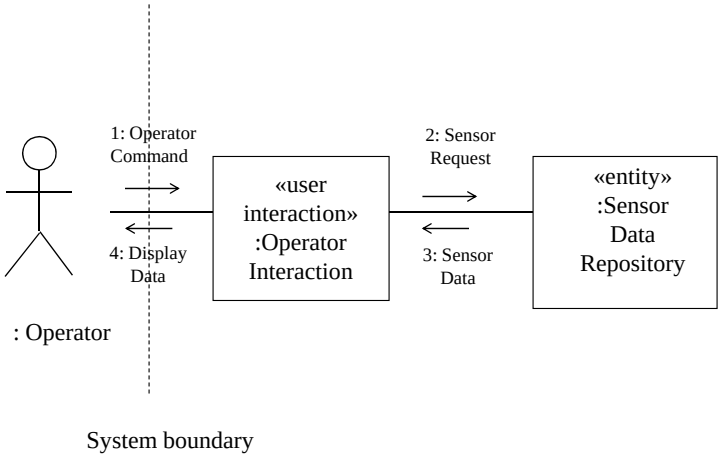
Object Structuring Criteria

- Entity objects
  - Long lasting objects that store information
    - Same object typically accessed by many use cases
    - Information persists over access by several use cases
      - E.g., Account, Customer
  - Entity classes and relationships shown on static model
  - Entity classes often mapped to relational database during design

Figure 8.2 Example of entity object



Note: The dashed line for the system boundary is for illustrative purposes only and does not conform to the UML notation

Object Structuring Criteria

- Control objects
  - Provides overall coordination for execution of a group of objects
  - Makes overall decisions
  - Decides when, and in what order, other objects participate in interaction sequence
    - Entity objects
    - Boundary objects
- Control objects
  - Coordinator object
  - State dependent control object
  - Timer object

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Figure 8.10 Coordinator object

Coordinator object
- Provides sequencing for group of objects
- Is not state dependent

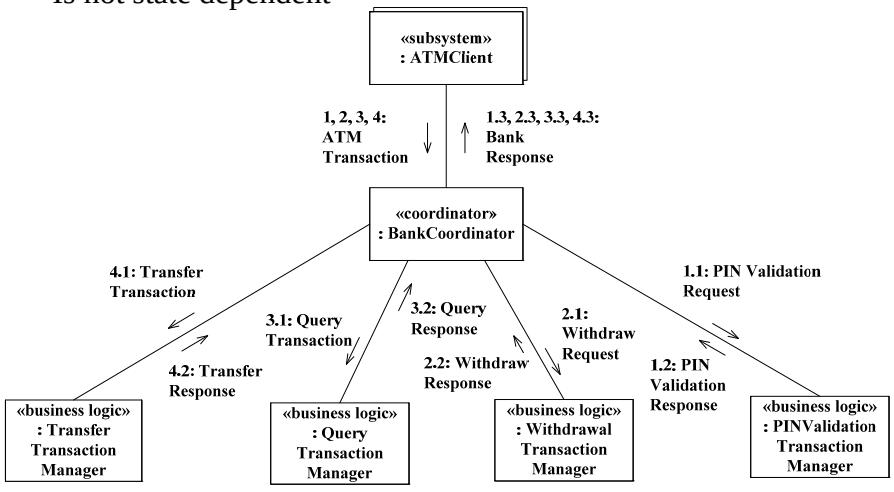

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Figure 8.11 State dependent control object

State dependent control object
- Defined by finite state machine or state transition table
- Controls other objects

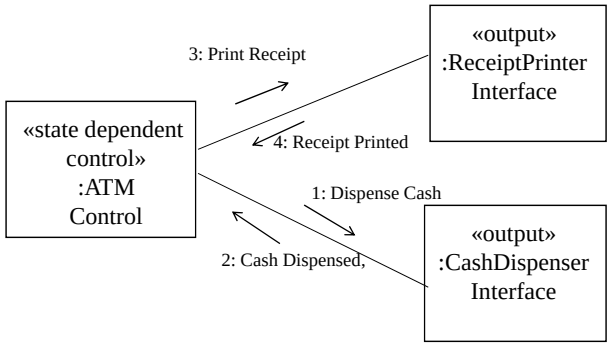

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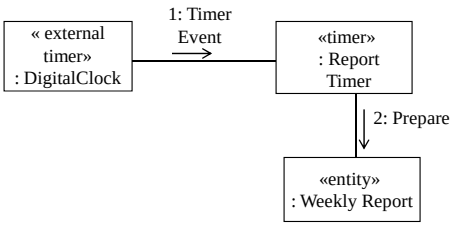
Figure 8.12 Timer object

Timer object
- Activated periodically



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Object Structuring Criteria

- Application Logic Objects
  - Business Logic Object
    - Defines business specific application logic (rules) for processing a client request
    - Usually accesses more than one entity object
  - Algorithm Object
  - Service object

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Figure 8.13b Business logic object

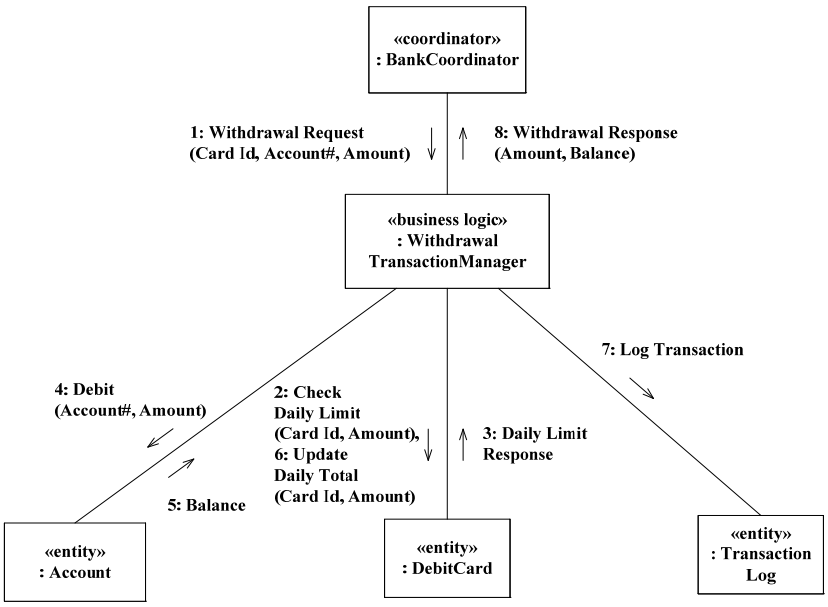

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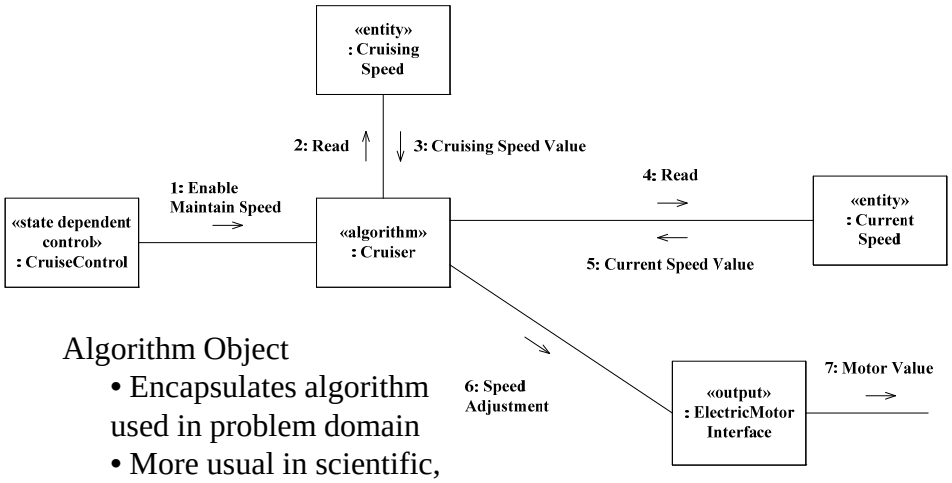
Figure 8.14 Example of algorithm object



Algorithm Object

- Encapsulates algorithm used in problem domain
- More usual in scientific, engineering, real-time domains

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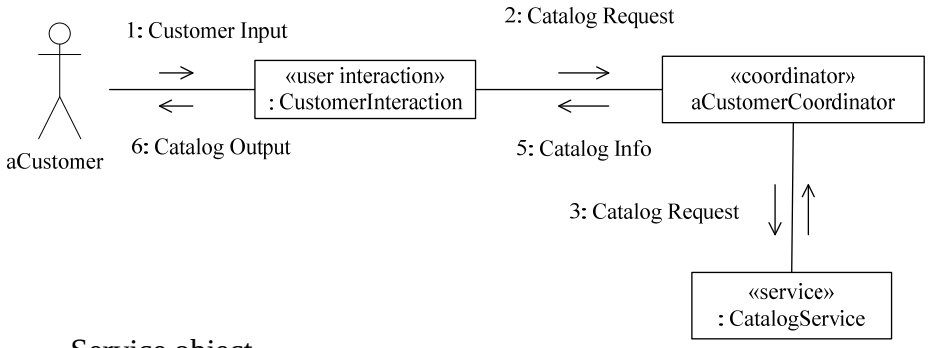
Figure 8.15 Example of Service object



Service object

- Provides a service to other objects
- Responds to requests from client objects

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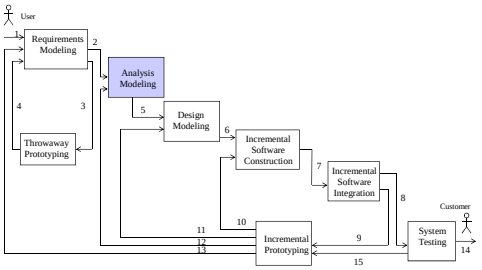

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Case Study: Banking System

- Multiple Automated Teller Machines (ATM)
  - Customer inserts ATM Card
  - Enters Personal Identification Number (PIN)
  - ATM Transactions
    - PIN Validation
    - Withdraw Funds from Checking or Savings Account
    - Query Account
    - Transfer funds between accounts
- Banking System maintains information about
  - Customers
  - Debit cards
  - Checking and Savings Accounts

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Figure 21.1 Banking System use case model

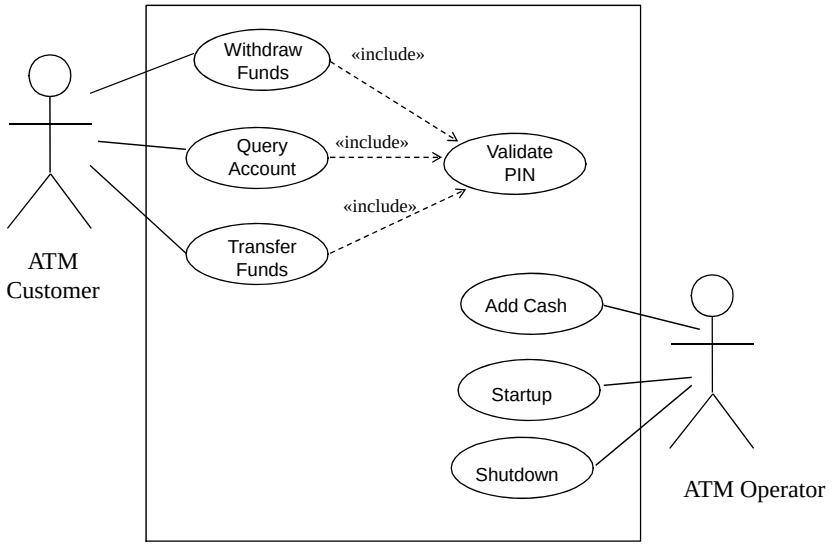

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Figure 21.3 Banking System class context diagram

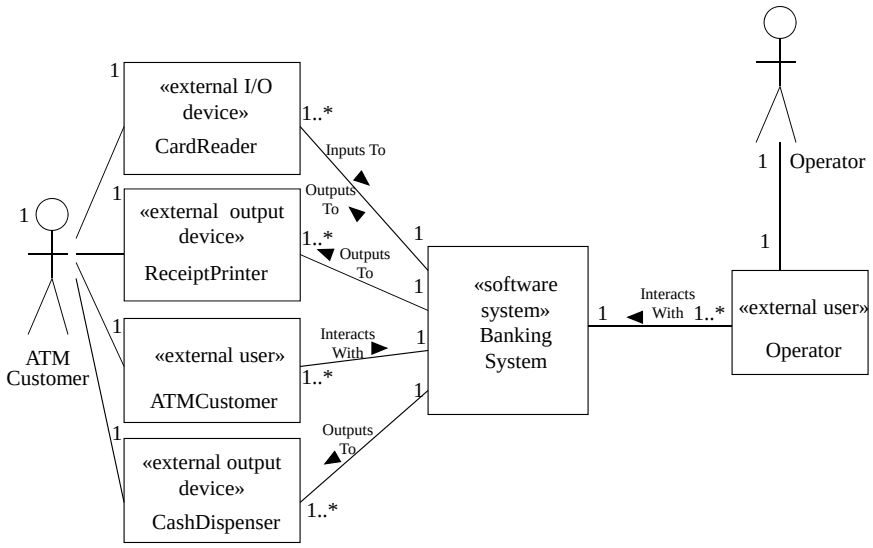

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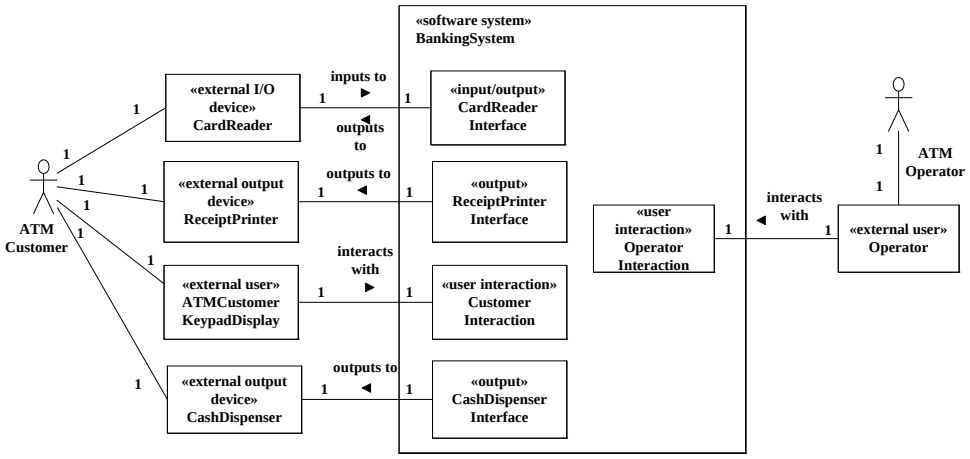
Figure 21.9 Banking System external classes and software boundary classes



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