Software models

- Software is *complex*
  - often more than what people can handle
  - not necessary to know all details at all times
- Models offer simplified view
  - concentrate on the important issues and omit the clutter
    - help to deal with software complexity
- Different models are needed in different contexts

Roles of software models

- Predictive (Designs)
  - created up-front, before implementation starts
  - predict how the software will be like
  - helpful for resource planning and risk assessment
- Extracted
  - extracted from an existing system, by analysis of the properties of the software
  - help answer specific questions about the software

Roles of software models (2)

- Prescriptive
  - correspond to an existing system and its code
  - set of rules on how to evolve the software
  - software engineers must guarantee that the models remain valid after they change the code
  - define constraints that need to be preserved during evolution

Criteria for successful software modeling

- Need to understand which details are essential and which are not
  - the important properties need to be retained by the model
- Models that miss important information are misleading and can lead to mistakes

UML (Unified Modeling Language)

- Readable
  - serves as a communication between the customer and the developer
  - widely used
- Helps comprehension of the system

UML diagrams

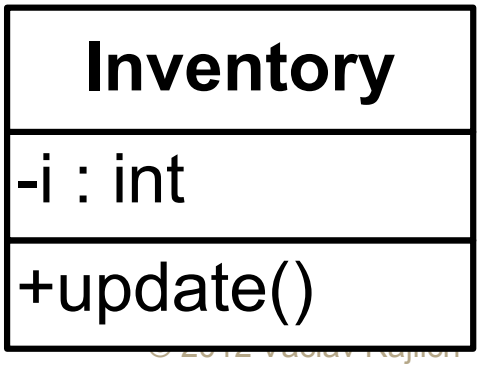
- Structure diagrams
  - **class diagrams**
  - component diagram
  - package diagram
  - implementation diagram
- Behavior diagrams
  - **activity diagram**
  - sequence diagram
  - collaboration diagram
  - state diagram
  - use case diagram
- Supported by tools: Rational Rose, Visio, Violet …

UML class diagrams

- Structural diagrams
- Represent the classes in the system and their relationships
- Can have different levels of precision and completeness
- Independent of the software technologies

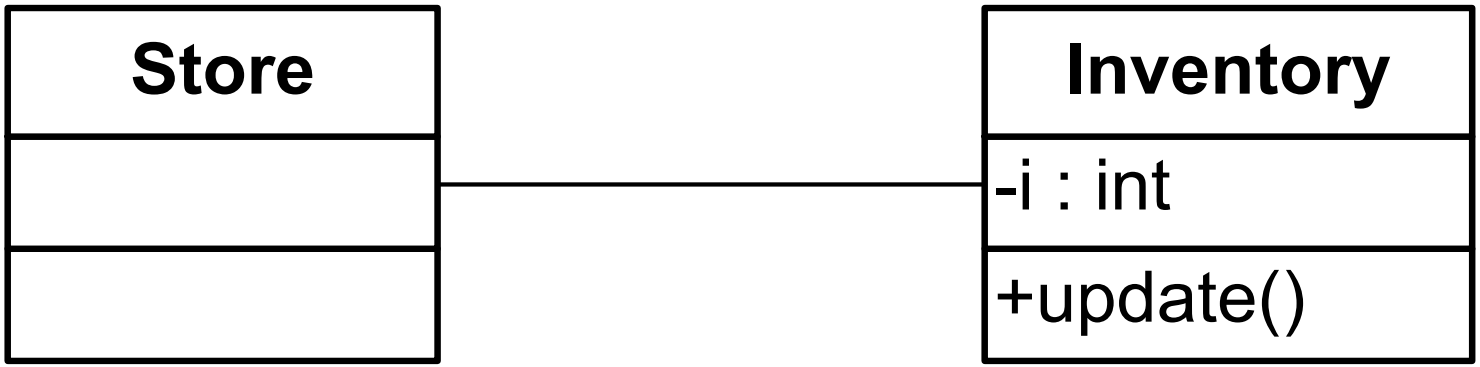
Class representation

- 3 compartments
  - class name
  - attributes (data members)
  - operations (function members)
- Supports different levels of detail
  - class name only



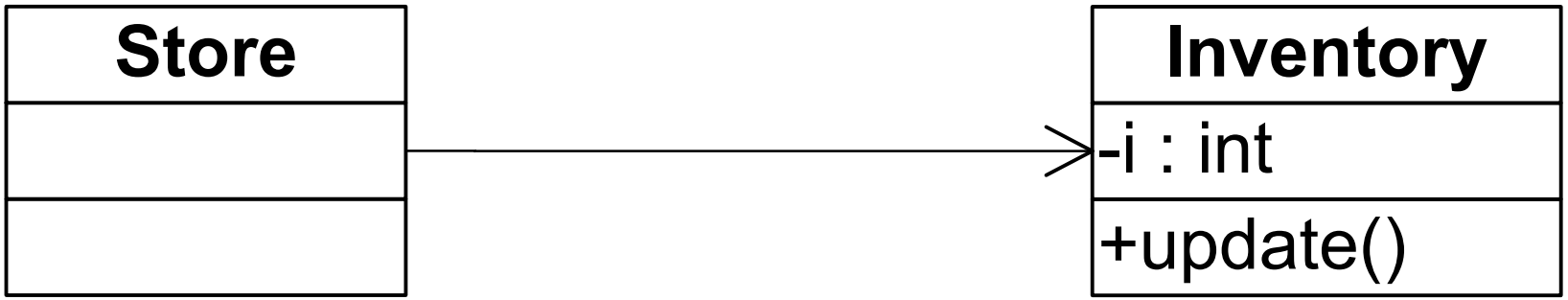
Association

- Associations are lines connecting class symbols



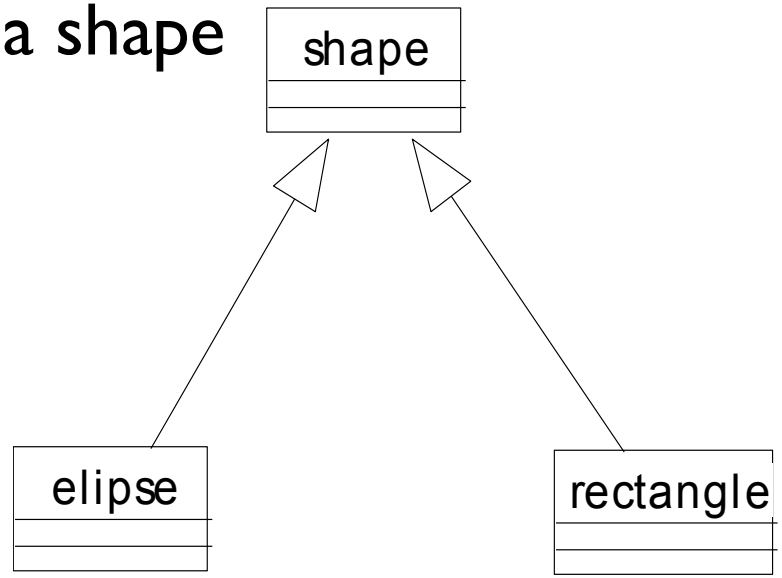
Adornments

- Adornments are at the ends of paths
  - arrow means navigation

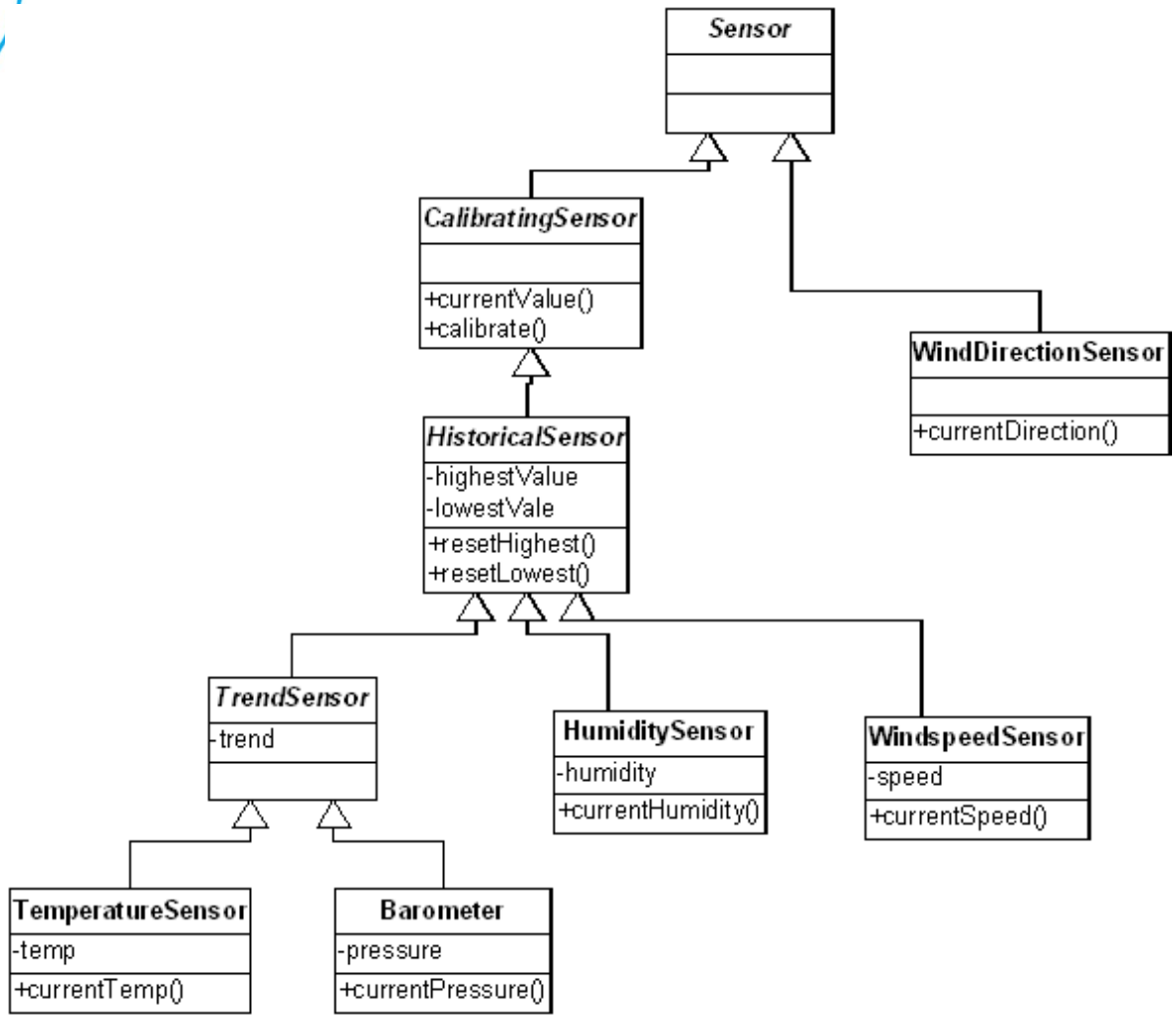


Generalization (inheritance)

- "Is-a" relationship
  - rectangle is a shape
  - ellipse is a shape

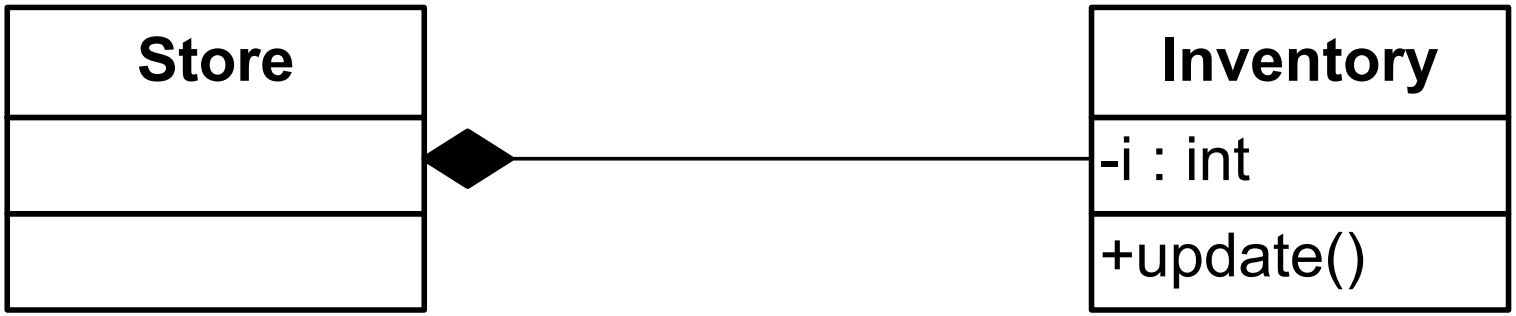


Generalization hierarchies

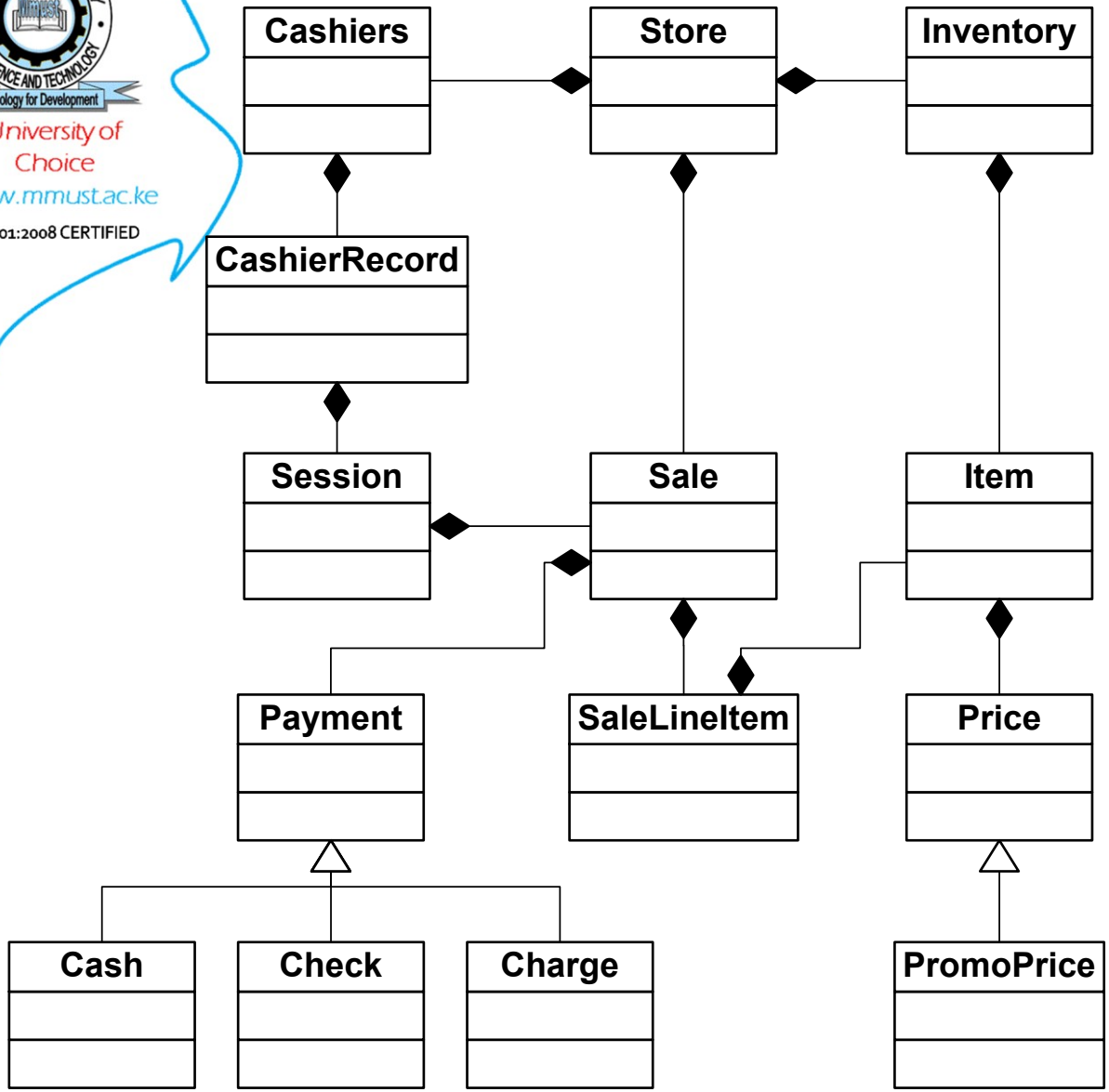


Composite/component

- "Part-of" relationship
  - inventory is part of a store

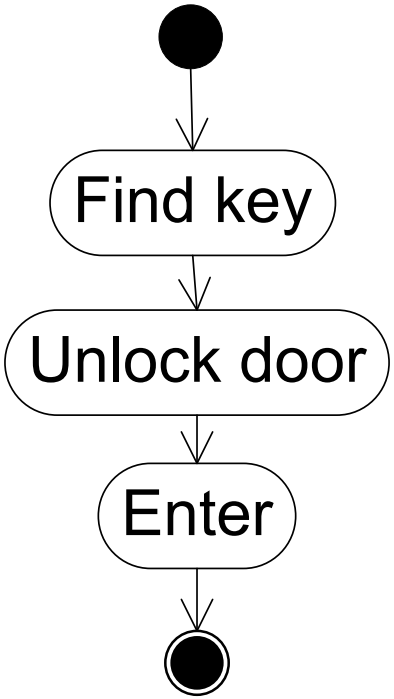


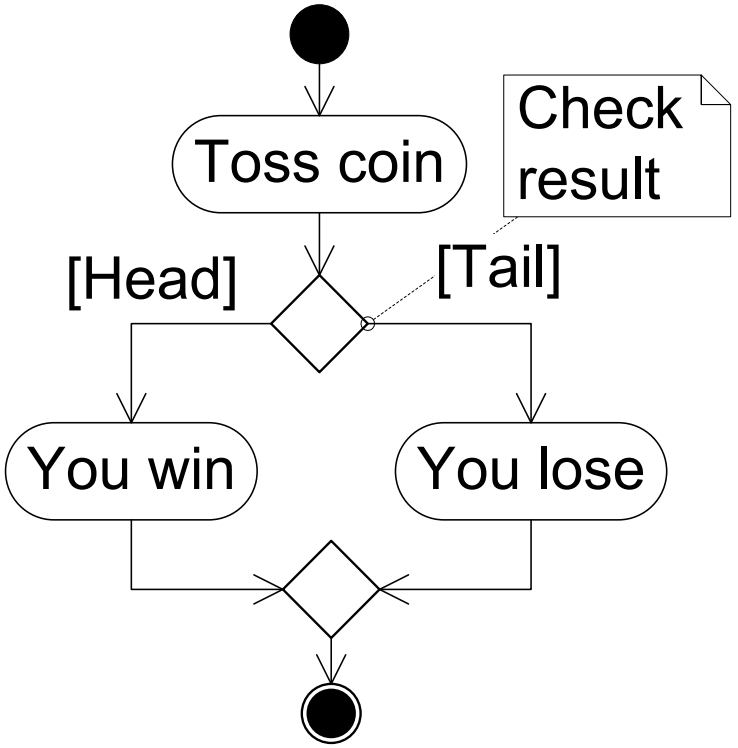
PoS



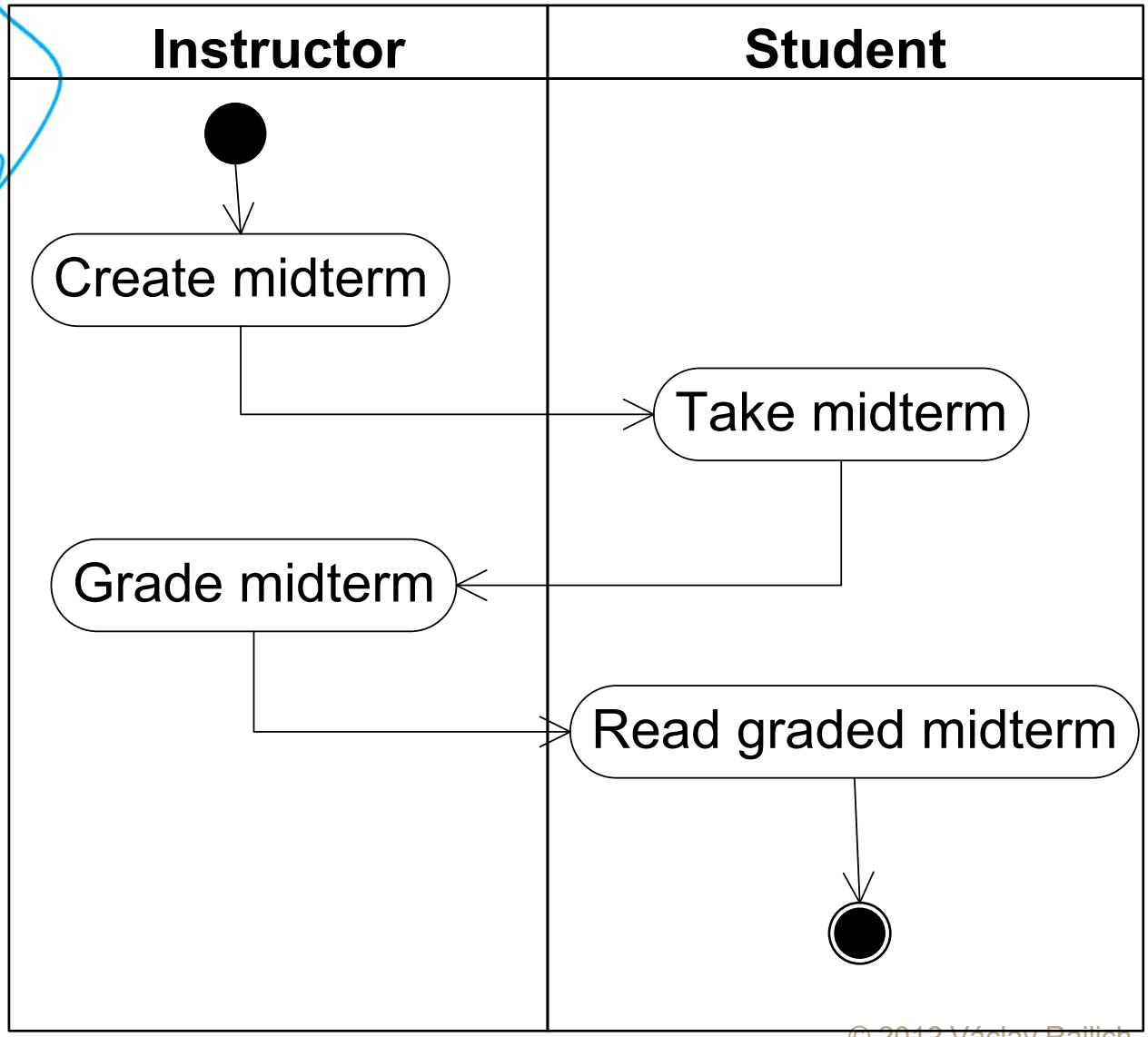
Activity diagram

- *Activities* are decomposed into *actions*





Swim lanes



Class dependency graphs (CDG)

- Depict classes and their dependencies
- Different from UML class diagrams
  - in small but significant details
- Extracted form the existing code
- Used during software evolution

Class responsibilities

- Each class in the program plays a role
  - assumes a certain responsibility
  - class Item is responsible for items sold in the store
- Supplier class
  - helps class Item to fulfill its responsibility
  - class Price is supplier class of Item

Clients, suppliers, dependencies

- Class B helps class A to fulfill its responsibilities:
  - B is *supplier* of class A
  - A is *client* of class B
  - there is *dependency* of class A on class B
    - denoted (A,B)

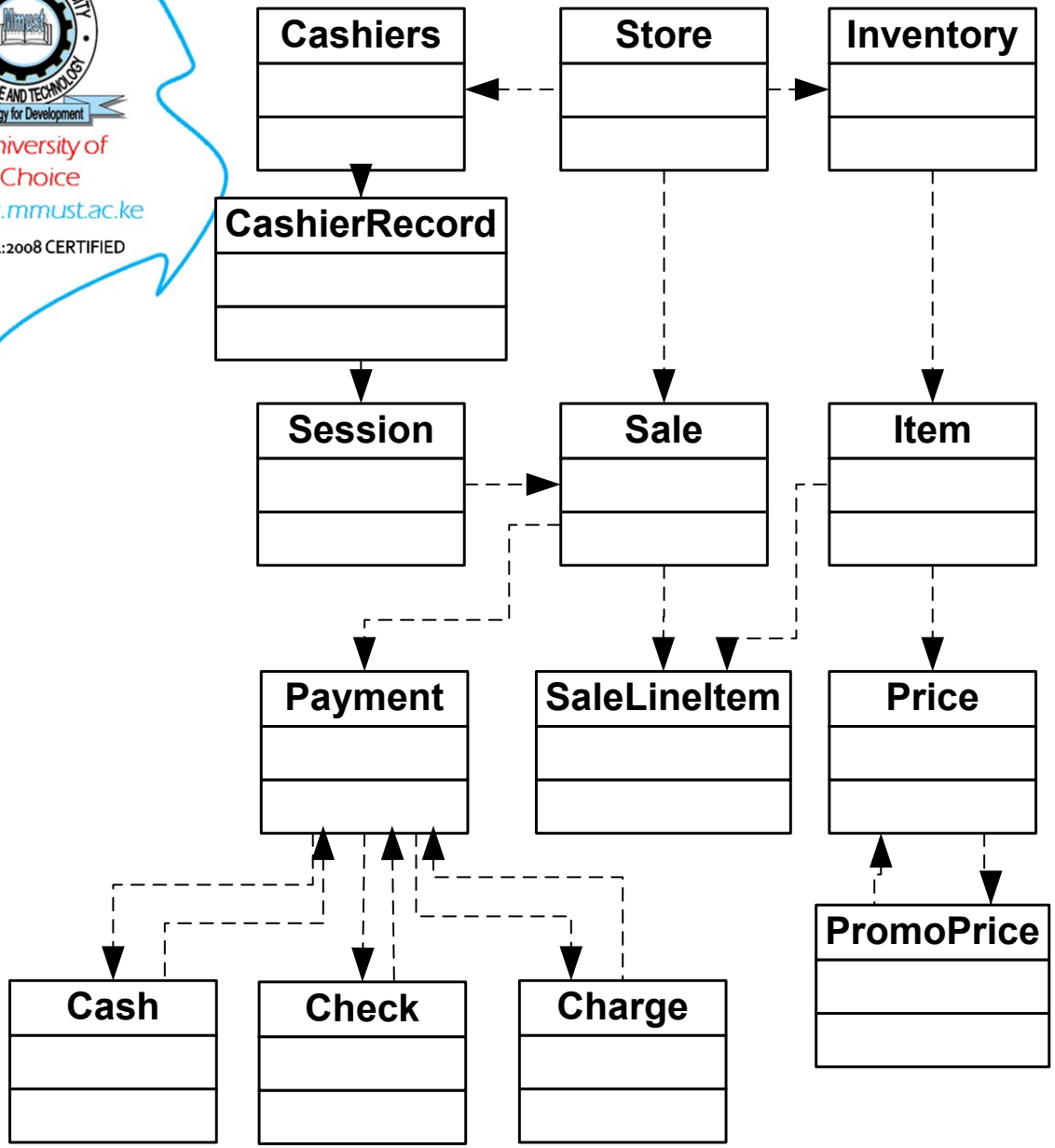
Dependency examples

- If there is a part-of relation between classes A and B, there is also a dependency (A,B)
- If there is a non-polymorphic inheritance of X from Y, then (X,Y) is a dependence
- If there is a polymorphic inheritance between X and Y, then both (X,Y) and (Y,X) are dependencies.

Definition of CDG

- directed graph G = (C,D)
  - vertices C are classes of the program
  - edges D are dependencies

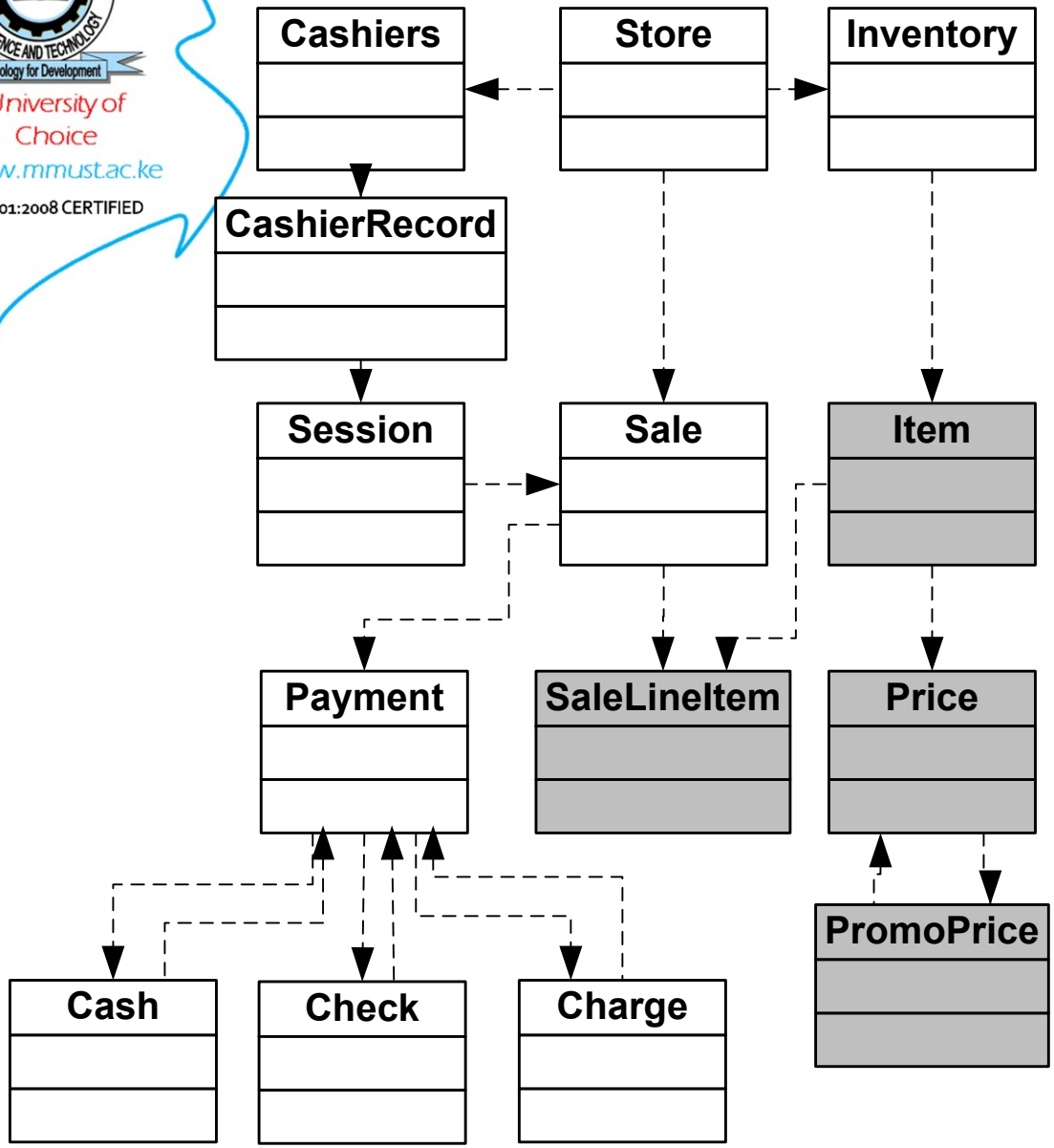
CDG



Supplier slice

- Set of all suppliers, suppliers of suppliers, …
- Let (C,D) be a CDG
  - A ∈ C be a class
  - then supplier slice S(A) =
    {X | X = A or
    there is a dependency <Y, X> ∈ D such that Y ∈ S(A)}

Supplier slice of Item



Class responsibilities, cont.

- *Local responsibility*
  - class assumes it alone and unaided
- *Composite responsibility*
  - assumed by the whole supplier slice
  - class itself may be unable to implement everything that is expected from it
  - it delegates some of the responsibilities to its suppliers

Contracts

- Composite responsibilities are sometimes expressed by *contracts*
  - between a class and its clients
  - clients request something
  - they have to make the request within reasonable bounds
    - they cannot request items that the store does not sell
- Bounds are described by the *precondition*
- Results of the action is *postcondition*

Examples of contracts

- Contract of "Average_calculator"
  - *precondition*: A non-empty list of student names and grades
  - *postcondition*: the grade point average
- Contract of "Checking_withdrawal"
  - *precondition*: amount to be withdrawn W, current balance in the account B, $0 \leq W \leq B$
  - *postcondition*: the printed check, the new balance in the account.

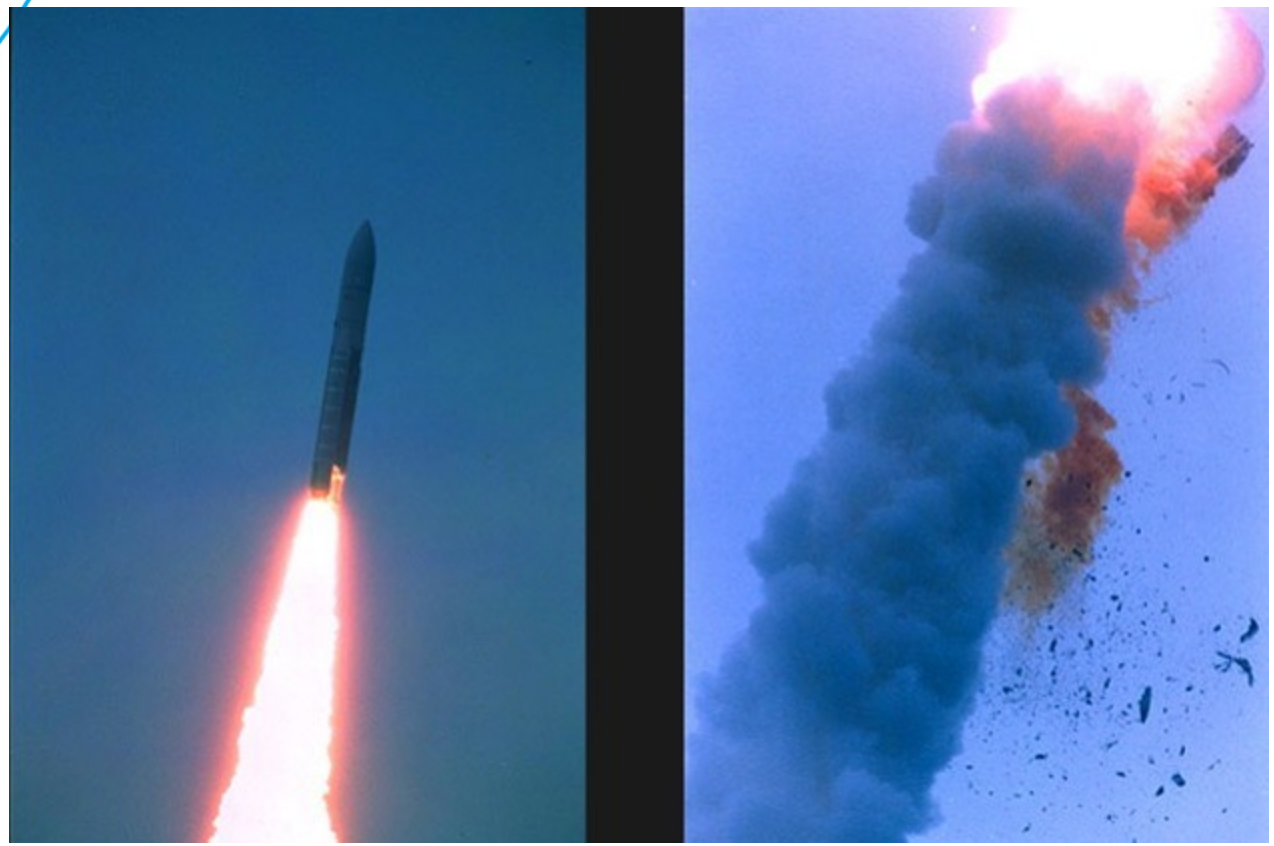
Ariane 5 disaster

- Ariane is a series of rockets
- European space program
- Ariane 5 crashed after launch in 1996
- Loss approximately half billion dollars
- Cause: software error

Ariane 5 software error

- Inertial Reference System (IRS)
  - IRS is a supplier to the rest of the software
  - deals with "horizontal bias"
  - precondition: horizontal bias must fit within 16-bit integer
  - IRS was used in the earlier versions of Ariane
- Clients of IRS in Arianne 5 violated this precondition
- Boooom!!!!

Ariane 5



Formality of contracts

- Contracts are described by formal logic
  - special assertion language
- Plain English
  - verbal description of contracts
- Contracts are only tacit
  - not recorded anywhere
  - all programmers must rediscover them
    - misunderstandings and errors
    - very common practice
    - not recommended

CDG and UML

- CDG and UML class diagrams are similar
- Software engineers sometimes use the more popular UML class diagrams instead of CDG
  - they should make sure that the diagram contains all dependencies
  - direction of dependencies may be missing in UML, have to be filled in!