COMP 6471
Software Design Methodologies

Fall 2011

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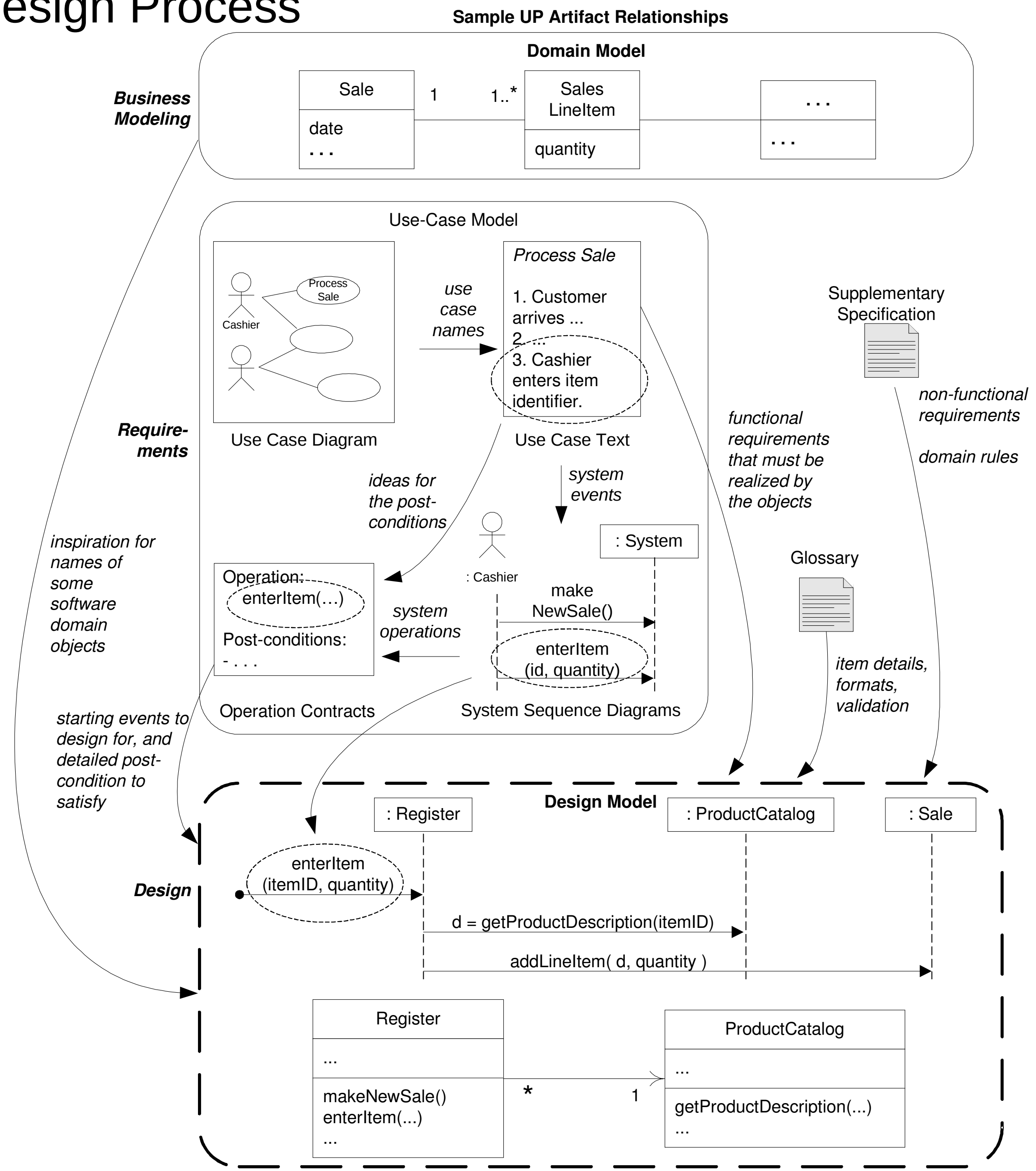
http://www.cs.concordia.ca/~gregb/home/comp6471-fall2011.html

Larman’s Design Process



Sample UP Artifact Relationships

Business Modeling

Domain Model

Sale

date

. . .

1

1..*

Sales LineItem

quantity

. . .

. . .

Use-Case Model

Process Sale

Cashier

Use Case Diagram

use case names

Process Sale

1. Customer arrives ...

2. ...

3. Cashier enters item identifier.

Use Case Text

Require- ments

ideas for the post- conditions

system events

: System

: Cashier

make NewSale()

enterItem (id, quantity)

Operation: enterItem(…)

Post-conditions:

- . . .

system operations

Operation Contracts

System Sequence Diagrams

Supplementary Specification

non-functional requirements

domain rules

functional requirements that must be realized by the objects

Glossary

item details, formats, validation

inspiration for names of some software domain objects

starting events to design for, and detailed post- condition to satisfy

Design

Design Model

: Register

: ProductCatalog

: Sale

enterItem (itemID, quantity)

d = getProductDescription(itemID)

addLineItem(d, quantity)

Register

...

makeNewSale()

enterItem(...)

...

*

1

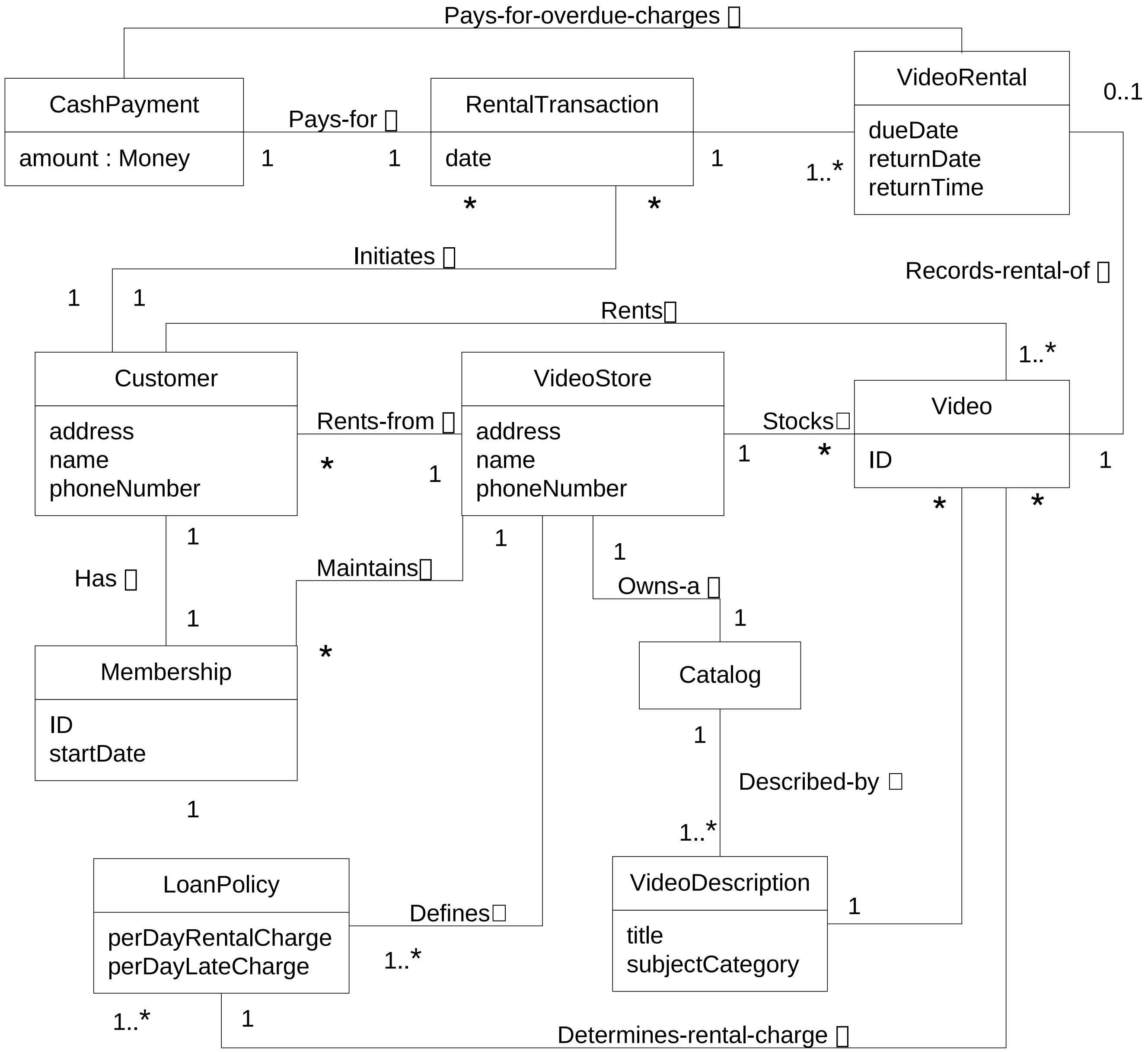
ProductCatalog

...

getProductDescription(...)

...

Domain Model



Domain Model: Visualizing Concepts

Domain Models

- A Domain Model illustrates meaningful concepts in a problem domain.
- It is a representation of real-world things, not software components.
- It is a set of static structure diagrams; no operations are defined.
- It may show:
  - concepts
  - associations between concepts
  - attributes of concepts

Domain Analysis

- Domain analysis
  - *The wider business context for the system*
- Requirements
- Specification
- Architecture
- …

If software spends most of its time being changed and maintained, it’s important to understand the context in which it lives

- Changes will move the application around this contextual space
- Need to understand where it might go
- Changes are determined by the business context

What is a Domain?

Two categories

- A collection of current and future (software) applications that share a set of common characteristics
- A well-defined set of characteristics that accurately, narrowly, and completely describe a family of problems for which computer application solutions are being, and will be sought

E. Berard. *Essays in Object-Oriented Software Engineering*. Prentice Hall, 1992.

Domain Expert

- an individual who is both experienced and knowledgeable about a particular application domain
- must have detailed knowledge about available COTS products and the interface standards they adhere to
- there must be at least one domain expert for each application domain

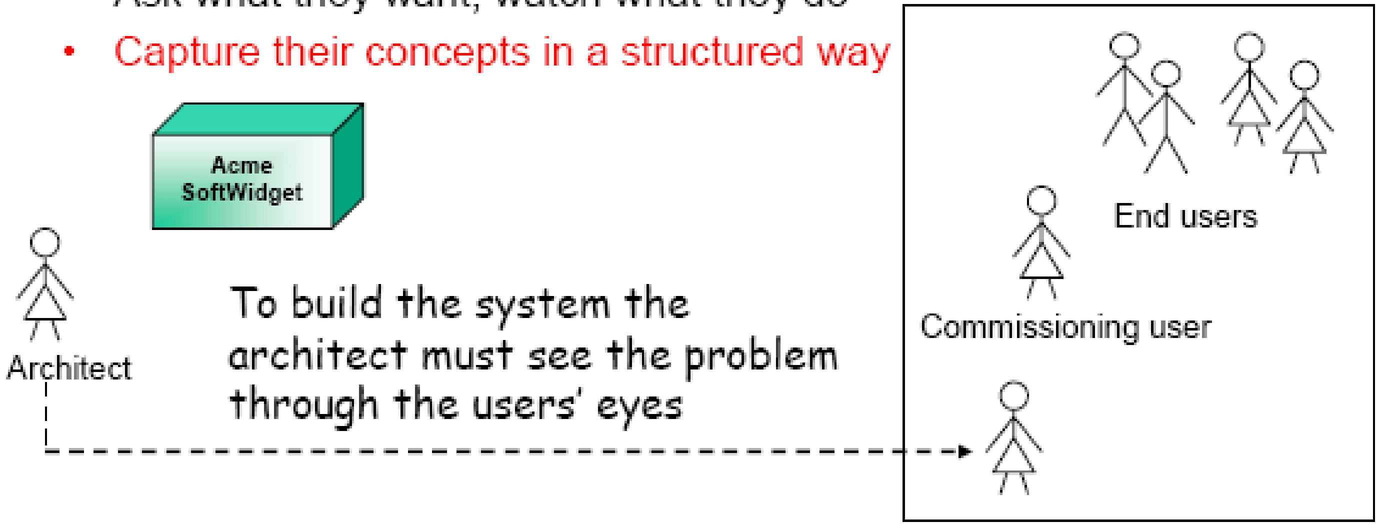
Domain Analyst

- responsible for the development of the appropriate domain analysis classification scheme and the criteria for selection of potentially reusable components
  - Determining opportunities for the composition of components into higher-level structures is also an important part of the domain analysis process.
  - The domain analyst will interact with the domain expert as part of this process.

Learning from Domain Experts

Conversations with *domain experts*

- Ask what they want, watch what they do
- Capture their concepts in a structured way



To build the system the architect must see the problem through the users' eyes

Idea is to become enough of a domain expert yourself that you understand what the users are saying

Domain Analysis Tasks

- characterize and understand the problem space
  - goal: factor out commonalties
- characterize and understand the solution space
  - both looking at what it is now and what it should be after factoring commonalties
- create a model of the Domain
  - Domain Engineering extends the domain analysis to include the actual design and construction of the new solution space

Domain Classifications

These classifications can help form the basis for developing an organizational reuse strategy.

categories:

- domain-independent software
- domain-specific software
- application-specific software

Domain Independent Software

e.g. graphical user interface functions, math libraries, abstract data types

- these account for about 20% of a typical application
  - therefore efforts at software reuse in this category can hope to reduce development effort by up to 20%
- horizontal reuse - can be shared among many domains

Domain Specific Software

e.g. aircraft navigation and control, geographical information management, library management, text editing, etc. — in general, code common to any program in a given domain

- can account for up to 80% of the code
  - software reuse in this category can hope to reduce development effort by up to 80%
- vertical reuse - reuse is within the domain only
- largest payoff points to concentration on vertical reuse

Application Specific Software

code for a single, specific application

- handles the unique details of a customer's requirements specification
- typically accounts for about 15% of an application
  - custom code, therefor little potential for reuse

Domain Modelling

After domain analysis the next step is to create a model of the domain.

The idea is to capture the business and understand it — don’t just concentrate on *this* application, study *all* applications in this business first.

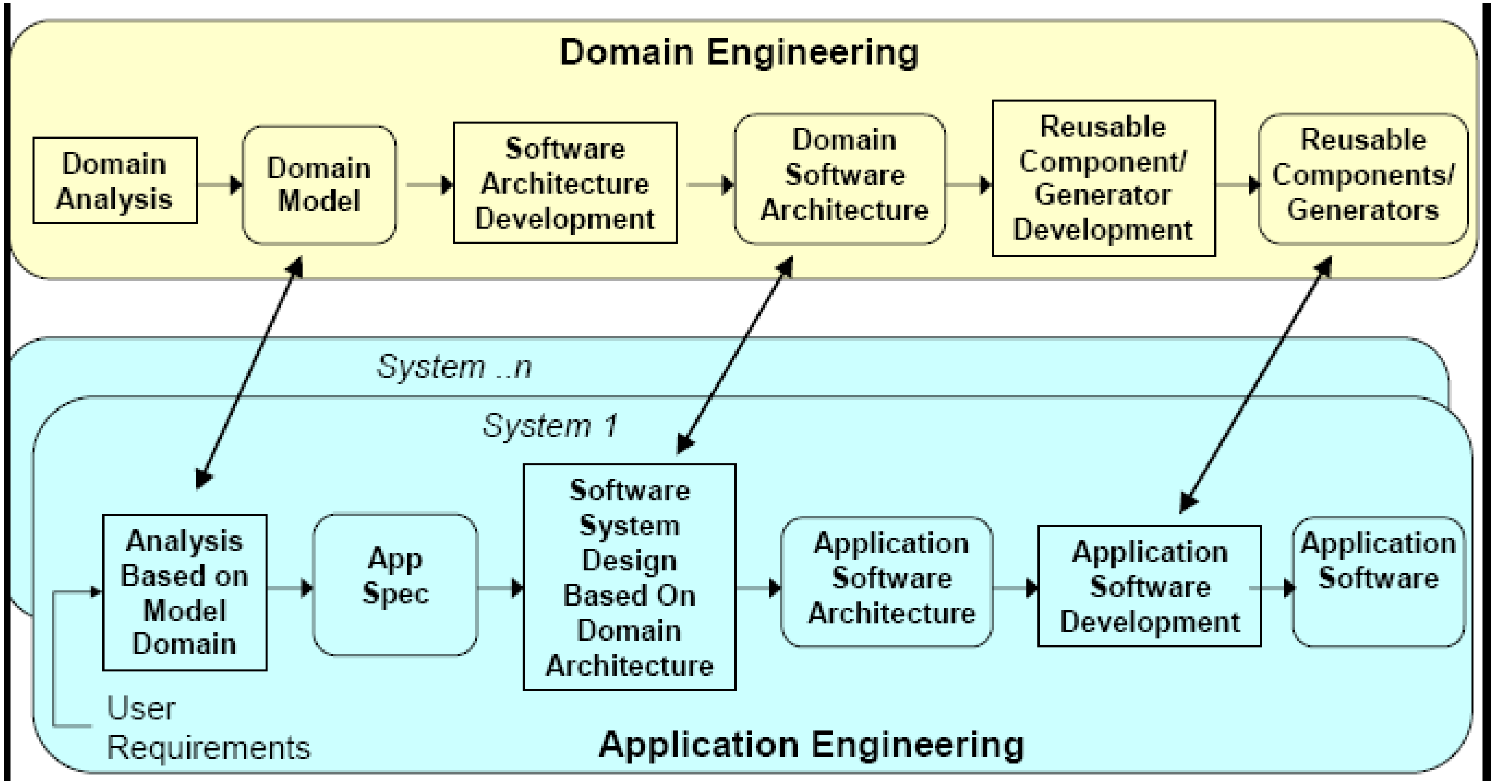
Together,they describe the environment in which the software has to live and work — and the context that will exert pressure on it to change.

In an object-oriented world, we capture the objects, relationships and processes in the business:

- the people and roles in the organization
- the tasks they need to perform
- the interactions between these tasks

This provides good documentation for the business.

Applications Live in the Domain


Domain Engineering
Domain Analysis
Domain Model
Software Architecture Development
Domain Software Architecture
Reusable Component/ Generator Development
Reusable Components/ Generators
System ..n
System 1
Analysis Based on Model Domain
App Spec
Software System Design Based On Domain Architecture
Application Software Architecture
Application Software Development
Application Software
User Requirements
Application Engineering

OO Analysis and Domain Analysis

While OO analysis is focused on the features and functionality of a single system to be generated, a domain analysis focuses on the common and variant features across a family of systems.

Use cases and sequence diagrams are good for both OO and domain models.

- actors and their tasks
- sequences of actions and states

Class diagrams are good for OO models.

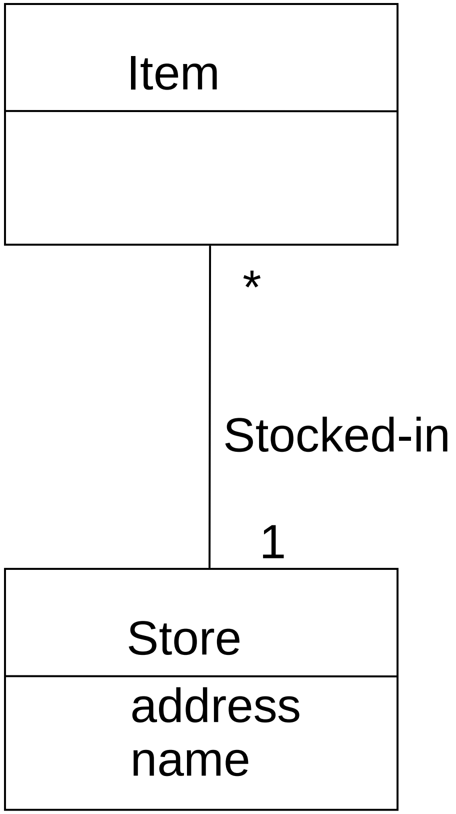
- the “things” in the system, seen through the users’ eyes

Domain Analysis Summary

- Domain analysis focuses on problems, not solutions.
- Domain analysis is about understanding the context for the application.
  - Understand all the applications, not just this one.
  - Talk to domain experts and watch them at work.
  - Think like the customer as far as possible.

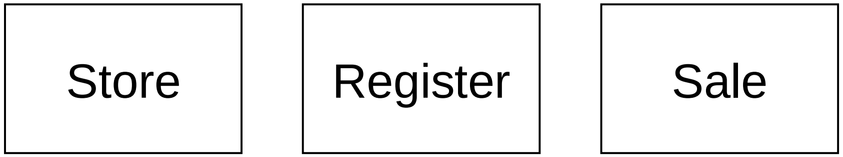
Domain models, software architectures and re-usable components are artifacts of domain engineering.

Domain Models



- A Domain Model is a description of things in the real world.
- A Domain Model is not a description of the software design.
- A concept is an idea, thing, or object.

Conceptual Classes in the POS Domain



Store

Register

Sale

Partial Domain Model.

A central distinction between object-oriented and structured analysis:

division by concepts (objects) rather than division by functions.

Strategies to Identify Conceptual Classes

- Use a conceptual class category list.
  - Make a list of candidate concepts.
- Use noun phrase identification.
  - Identify noun (and noun phrases) in textual descriptions of the problem domain, and consider them as concepts or attributes.
  - Use Cases are an excellent description to draw for this analysis.

Use a Conceptual Class Category List

Concept Category	Example
physical or tangible objects	Register
specifications, designs, or descriptions of things	ProductDescription
places	Store
transactions	Sale, Payment
transaction line items	SalesLineItem
roles of people	Cashier
containers of other things	Store, Bin

(See pp. 140-141 in Larman 3rd ed.)

Finding Conceptual Classes with Noun Phrase Identification

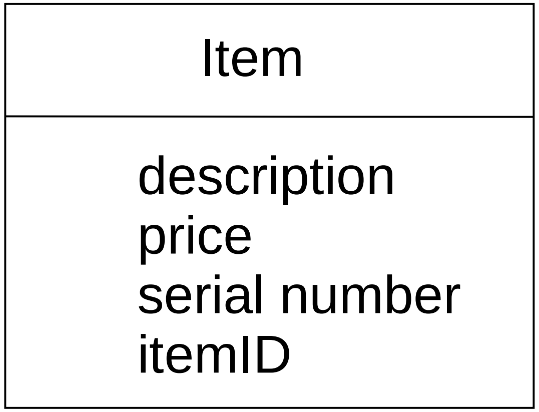
1. This use case begins when a **Customer** arrives at a **cash register** with items to purchase.
2. The **Cashier** starts a new sale.
3. **Cashier** enters an **item identifier**.

…

- Fully addressed Use Cases are an excellent description to draw for this analysis.
- Some of these noun phrases are candidate concepts; some may be attributes of concepts.
- A mechanical noun-to-concept mapping is not possible, as words in a natural language are (sometimes) ambiguous.

The Need for Specification or Description Conceptual Classes

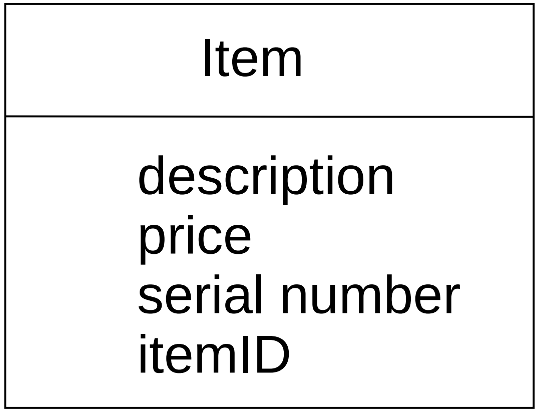
- What's wrong with this picture?



Item

description
price
serial number
itemID

The Need for Specification or Description Conceptual Classes

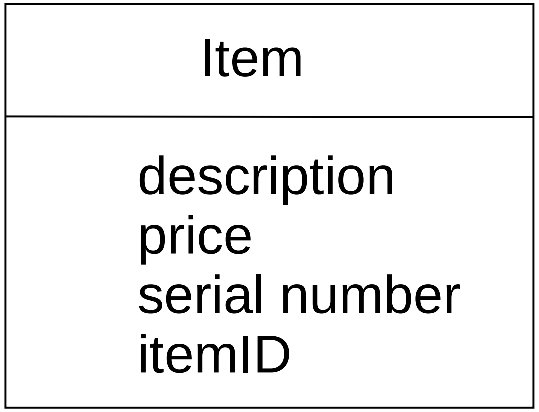


Item

description
price
serial number
itemID

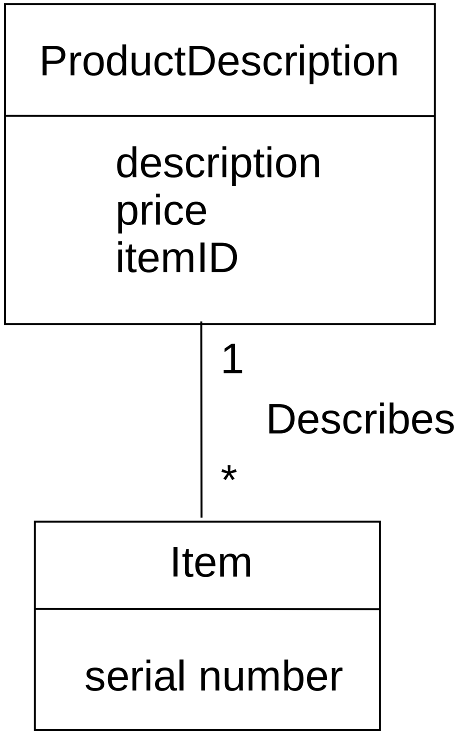
- What's wrong with this picture?
- Consider the case where all items are sold, and thus deleted from the computer memory.
- How much does an item cost?

The Need for Specification or Description Conceptual Classes



- The memory of the item’s price was attached to inventoried instances, which were deleted.
- Notice also that in this model there is duplicated data (description, price, itemID).

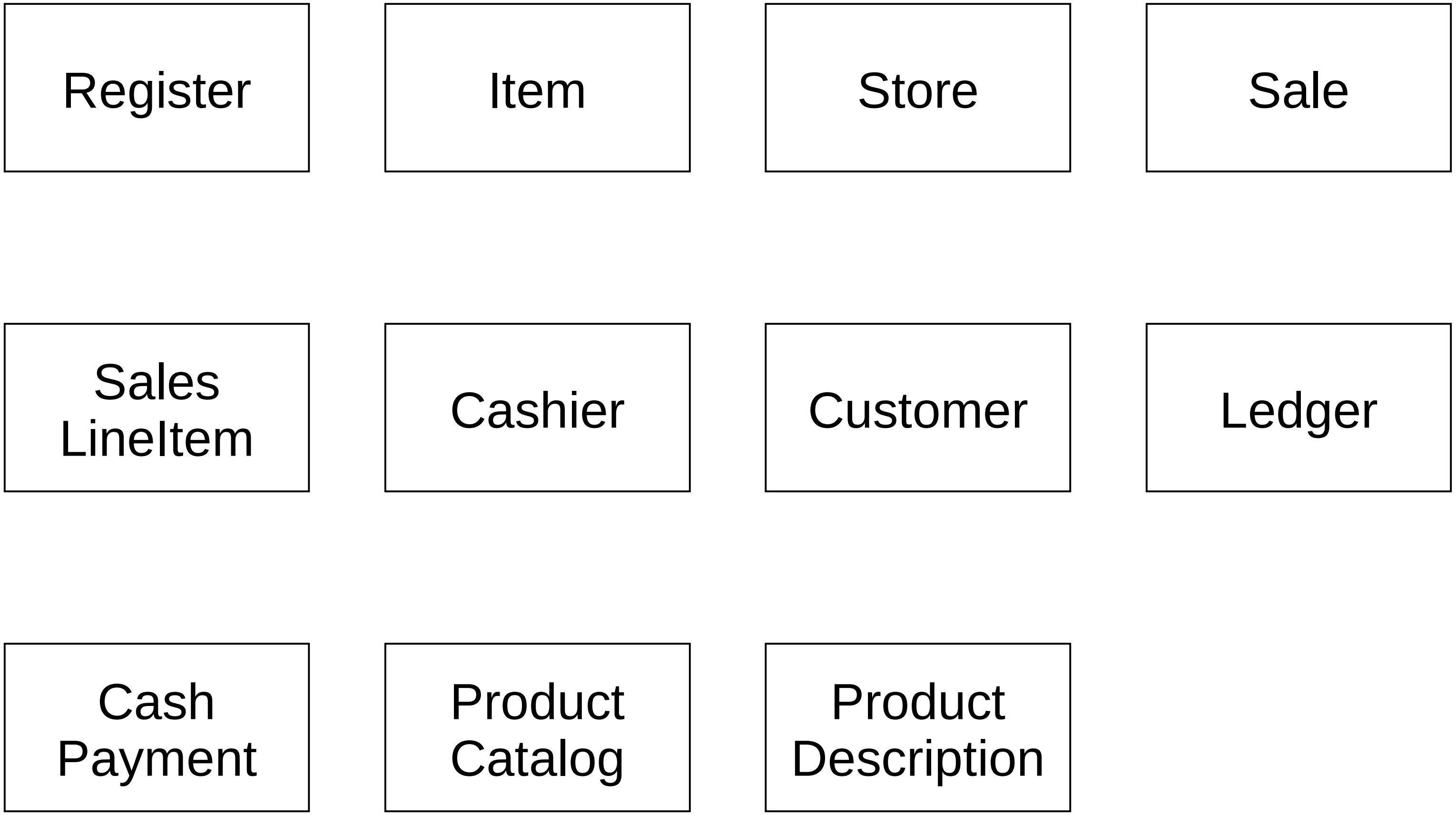
The Need for Specification or Description Conceptual Classes



Add a specification or description concept when:

- Deleting instances of things they describe results in a loss of information that needs to be maintained, due to the incorrect association of information with the deleted thing.
- It reduces redundant or duplicated information.

The NextGen POS (partial) Domain Model



Register

Item

Store

Sale

Sales LineItem

Cashier

Customer

Ledger

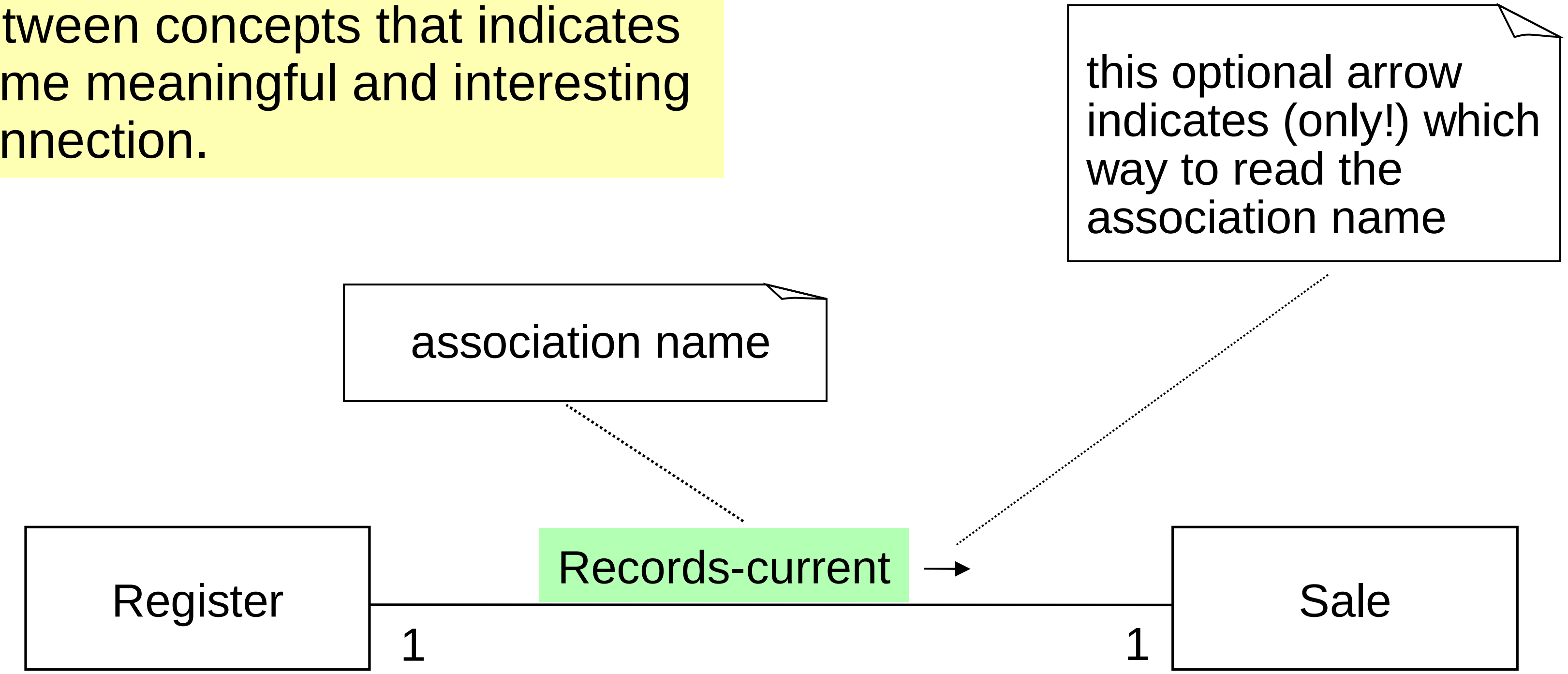
Cash Payment

Product Catalog

Product Description

Adding Associations

An association is a relationship between concepts that indicates some meaningful and interesting connection.


this optional arrow indicates (only!) which way to read the association name

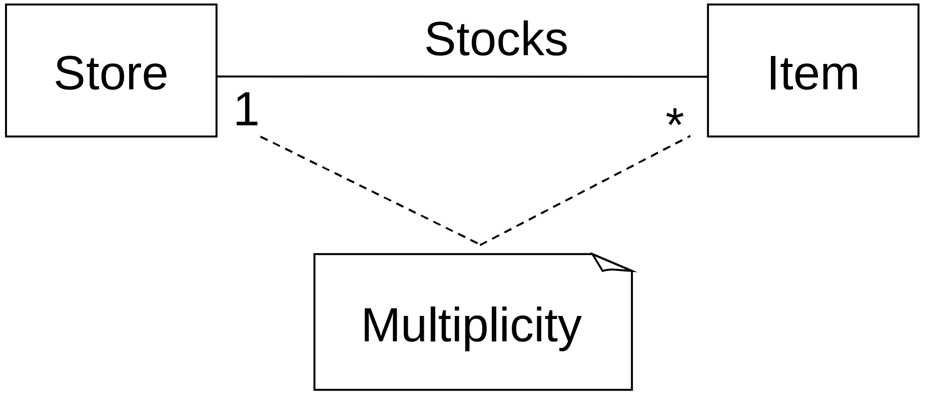
association name

Finding Associations – Common Associations List

Category	Examples
A is a physical part of B	Drawer - Register
A is a logical part of B	SalesLineItem - Sale
A is physically contained in/on B	Register - Store
A is logically contained in B	ItemDescription - Catalog
A is a description of B	ItemDescription - Item
A is a line item of a transaction or report B	SalesLineItem - Sale
A is known/logged/recorded/ captured in B	Sale - Register
A is a member of B	Cashier - Store
...	

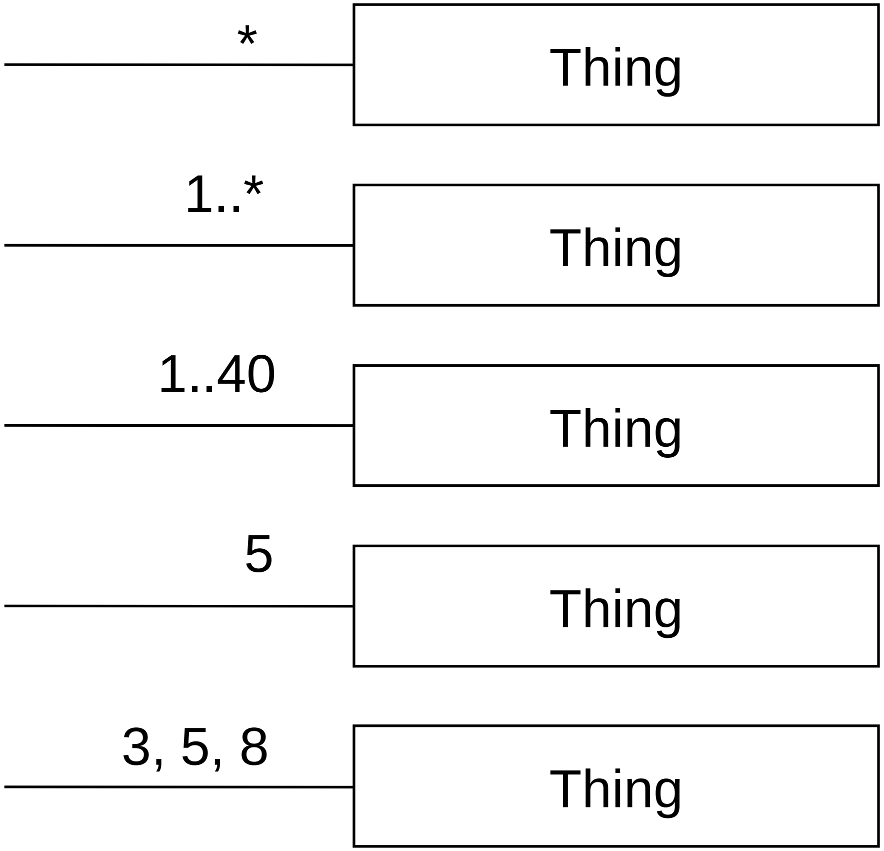
(See pp. 155-156 in Larman 3rd ed.)

Multiplicity



- Multiplicity defines how many instances of a type A can be associated with one instance of a type B, at a particular moment in time.
- For example, a single instance of a Store can be associated with “many” (zero or more) Item instances.

Multiplicity



* Thing

Zero or more;
“many”

1..* Thing

One or more

1..40 Thing

One to forty

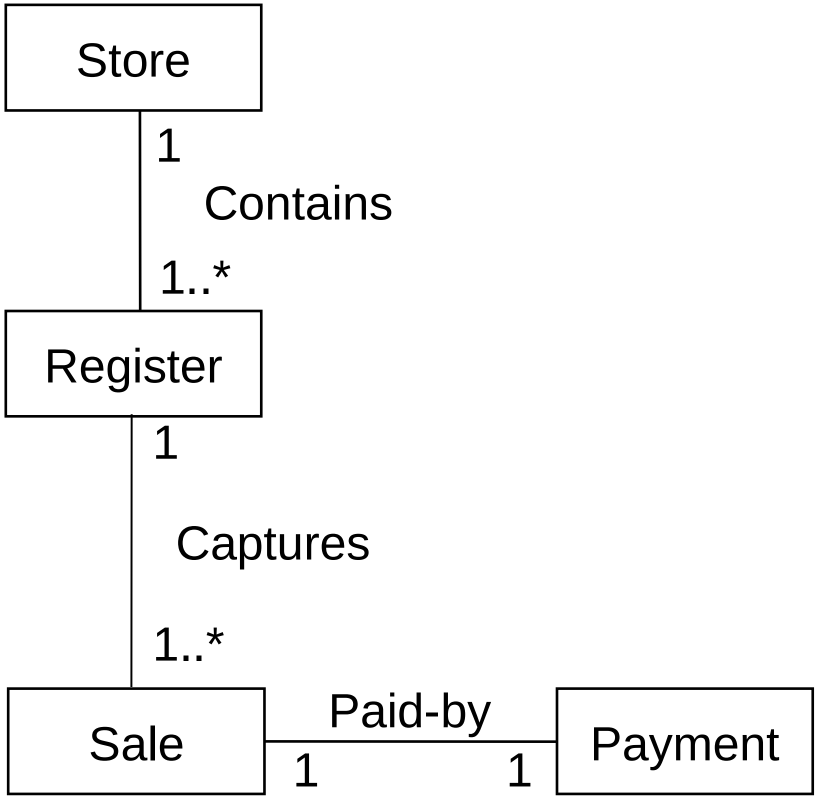
5 Thing

Exactly five

3, 5, 8 Thing

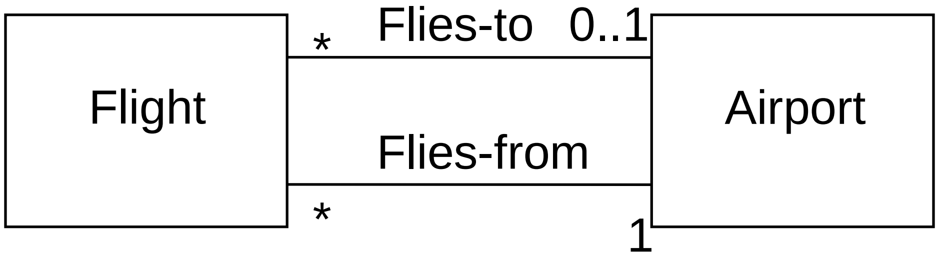
Exactly three, five
or eight.

Naming Associations



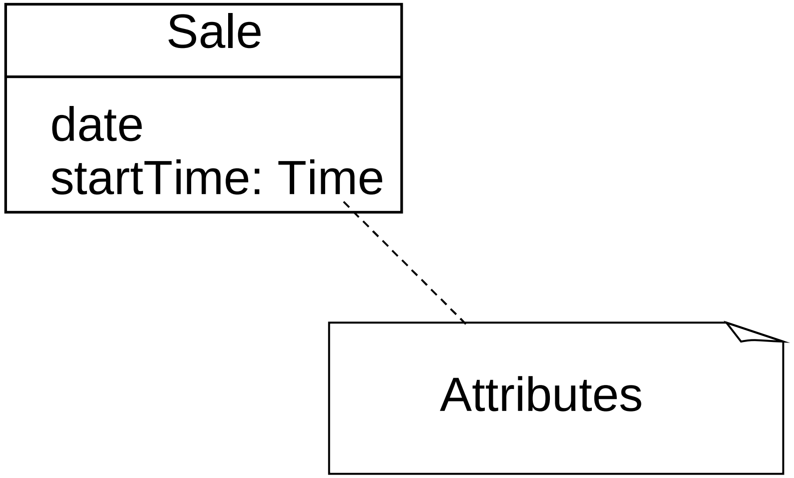
- Name an association based on a `ClassName-VerbPhrase-ClassName` format. Use specific terms rather than general ones (*e.g.* "`Paid-by`" instead of "`Uses`")
- Association names should start with a capital letter.
- A verb phrase should be constructed with hyphens.
- The default direction to read an association name is left to right, or top to bottom.

Multiple Associations Between Two Types



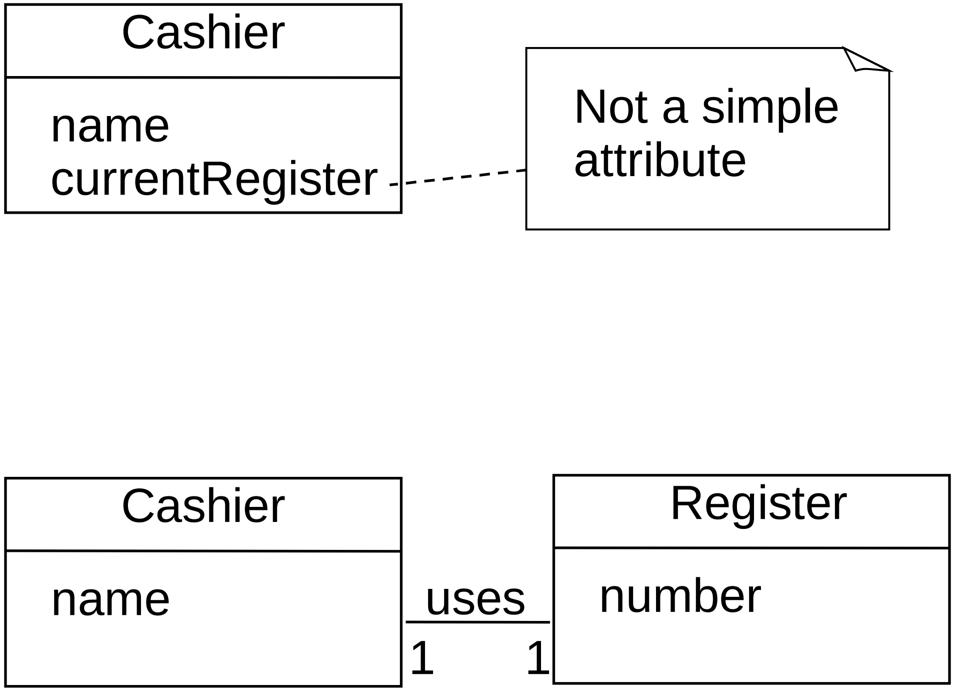
- It is not uncommon to have multiple associations between two types.
- In the example, not every flight is guaranteed to land at an airport.

Adding Attributes



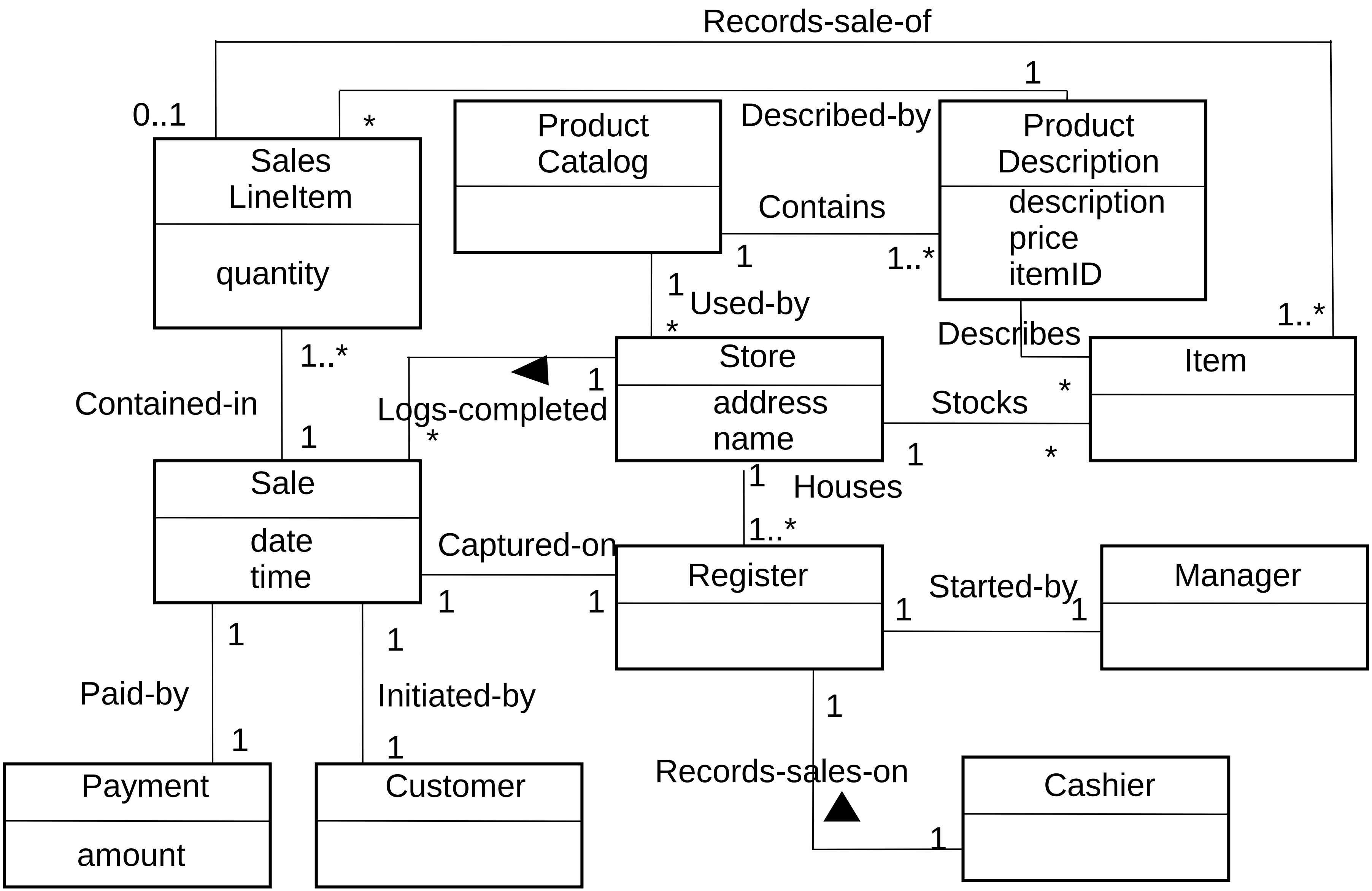
- An attribute is a logical data value of an object.
- An attribute should be added when requirements suggest or imply a need to remember information.
- For example, a sales receipt normally includes a date and time.
- The Sale concept would need date and time attributes.

Valid Attribute Types



- Keep attributes simple.
- The type of an attribute should not normally be a complex domain concept, such as Sale or Airport.
- Attributes in a Domain Model should preferably be
  - pure data values: Boolean, Date, Number, String, …
  - simple attributes: color, phone number, zip code, universal product code (UPC), ...

Domain Model Conclusion



Records-sale-of

0..1

1

*

Described-by

Sales LineItem

quantity

Product Catalog

Product Description

description
price
itemID

Contains

1

1..*

1

Used-by

*

1..*

Describes

1..*

Contained-in

1

Store

address
name

Item

1

Logs-completed

*

Stocks

*

1

*

1

Houses

1..*

Sale

date
time

Captured-on

1

1

Register

Started-by

1

1

Manager

1

Paid-by

1

1

Initiated-by

1

1

Records-sales-on

1

Payment

amount

Customer

Cashier

Refining the Domain Model

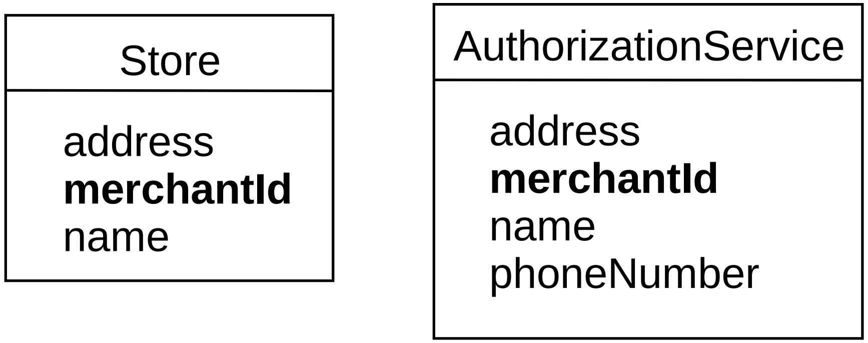
(a brief return to Week 2, Chapter 16 and Chapter 31)

Association Classes

Example:

- Authorization services assign a merchant ID to each store for identification during communications.
- A payment authorization request from the store to an authorization service requires the inclusion of the merchant ID that identifies the store to the service.
- Consider a store that has a different merchant ID for each service (*e.g.* ID for Visa is XXX, ID for MC is YYY, etc.).
- Question: Where in the conceptual model should the merchant ID attribute reside?

Association Classes



Store

address
merchantId
name

AuthorizationService

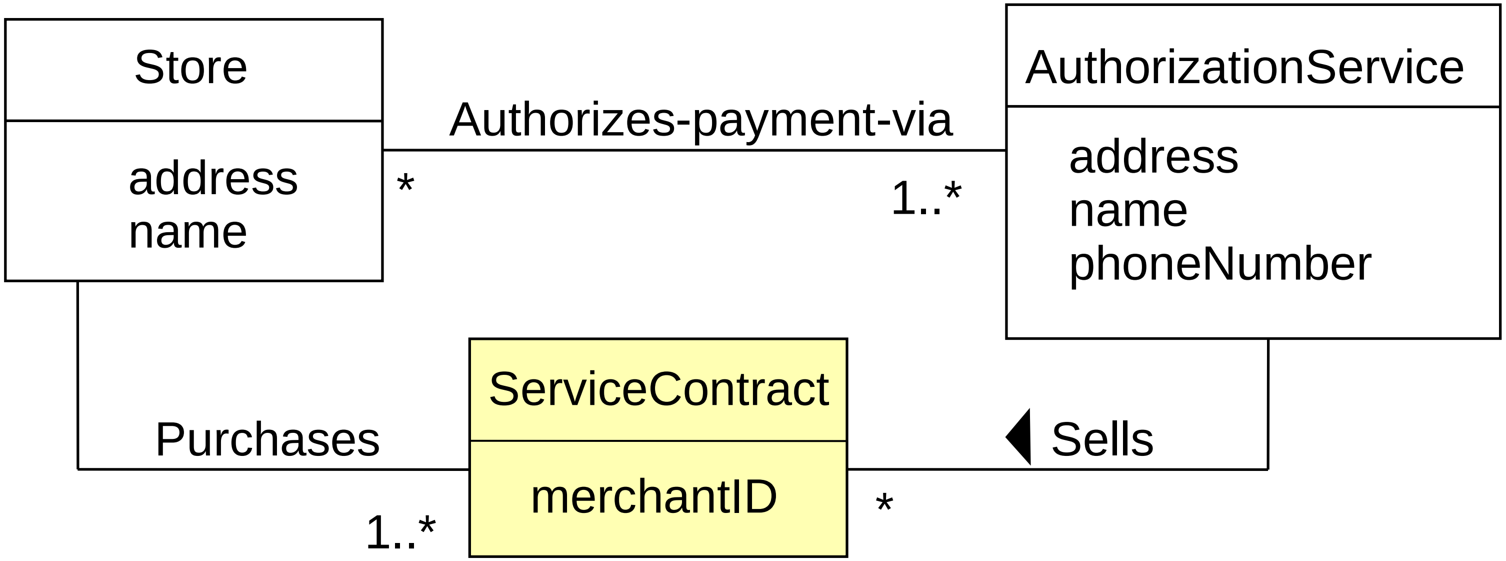
address
merchantId
name
phoneNumber

- Where in the conceptual model should the merchant ID attribute reside?
- Placing the merchantID in the Store is incorrect, because a Store may have more than one value for merchantID.
- ...but the same is true with placing it in the AuthorizationService

Association Classes

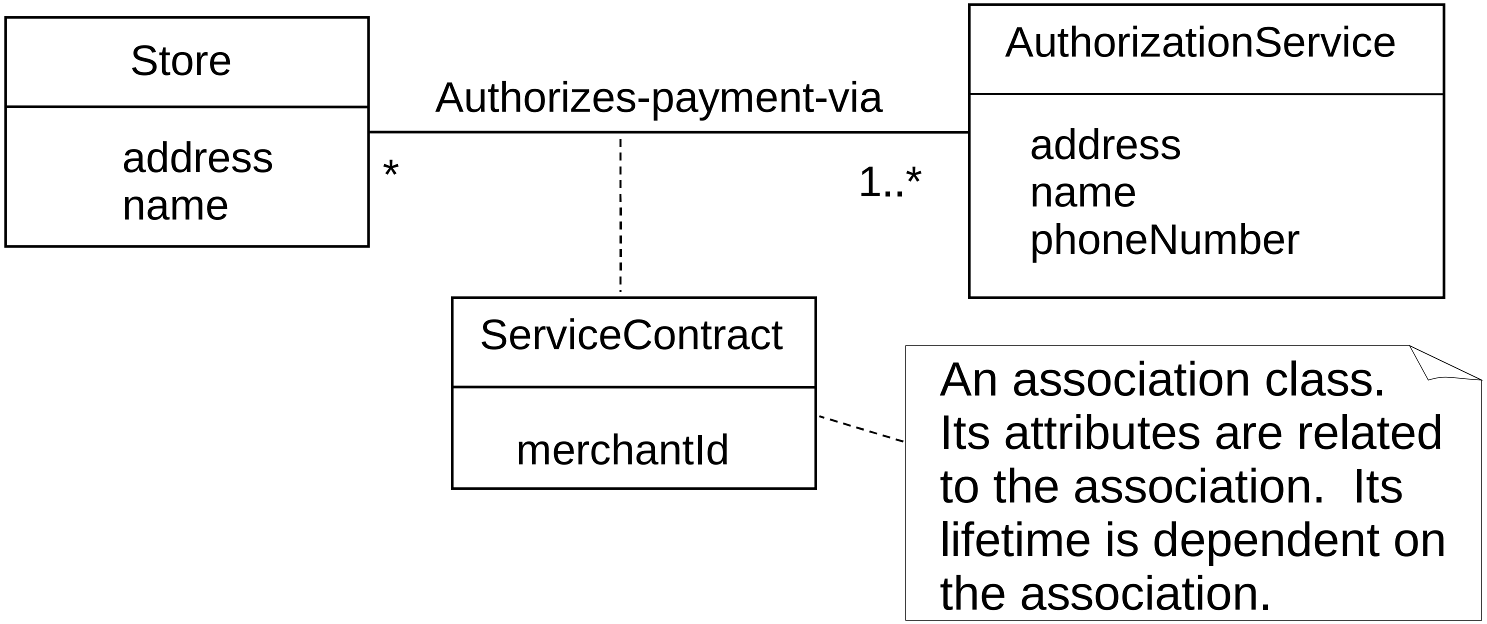
principle:

In a conceptual model, if a class C can simultaneously have many values for the same kind of attribute A, do not place attribute A in C. Instead, place it in another type that is associated with C.



Association Classes

- The merchantID is an attribute related to the association between the Store and AuthorizationService; it depends on their relationship.
- ServiceContract may then be modeled as an association class.



An association class. Its attributes are related to the association. Its lifetime is dependent on the association.

Association Classes

- Association classes are in some sense similar to description classes, as discussed in week 2.

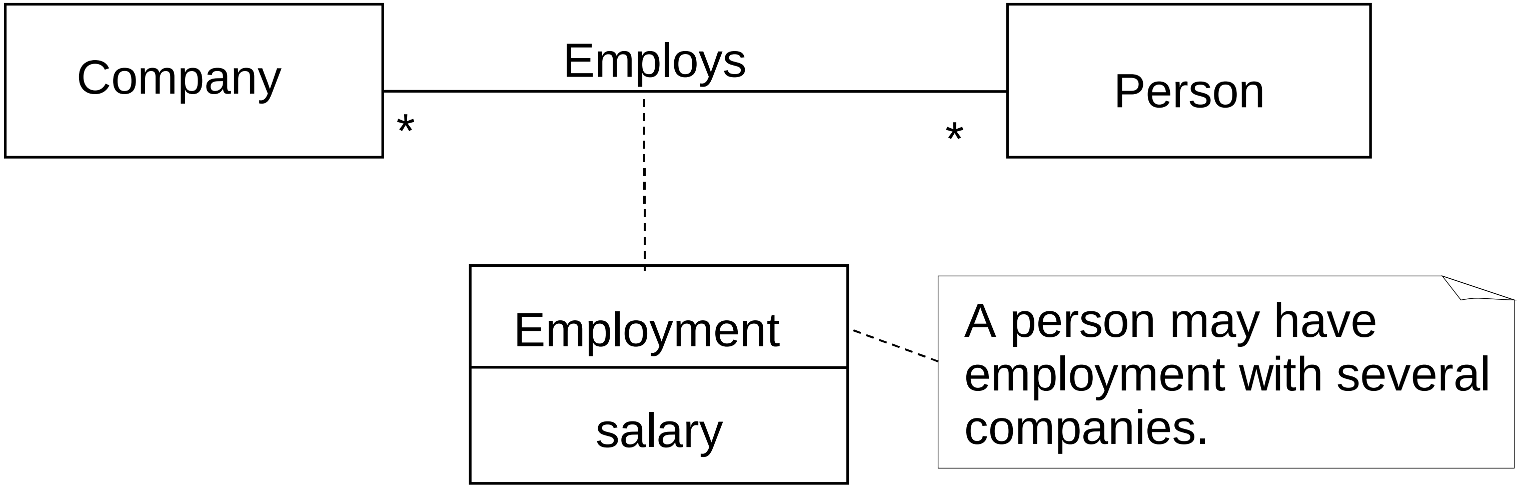
- The difference is in what they represent: a description class models the description of an item (*e.g.* the price of an item in the POS system), while an association class models an association between two or more other classes.

Guidelines for Association Classes

Consider using an association class when:

- An attribute is related to an association.
- Instances of the association class have a lifetime dependency on the association.
- There is a many-to-many association between two concepts.

The presence of a many-to-many association between two concepts is a clue that a useful associative type may exist.



A person may have employment with several companies.

Roles as Concepts vs. Roles in Associations

In a conceptual model, a real-world role may be

- modeled as a discrete concept

or

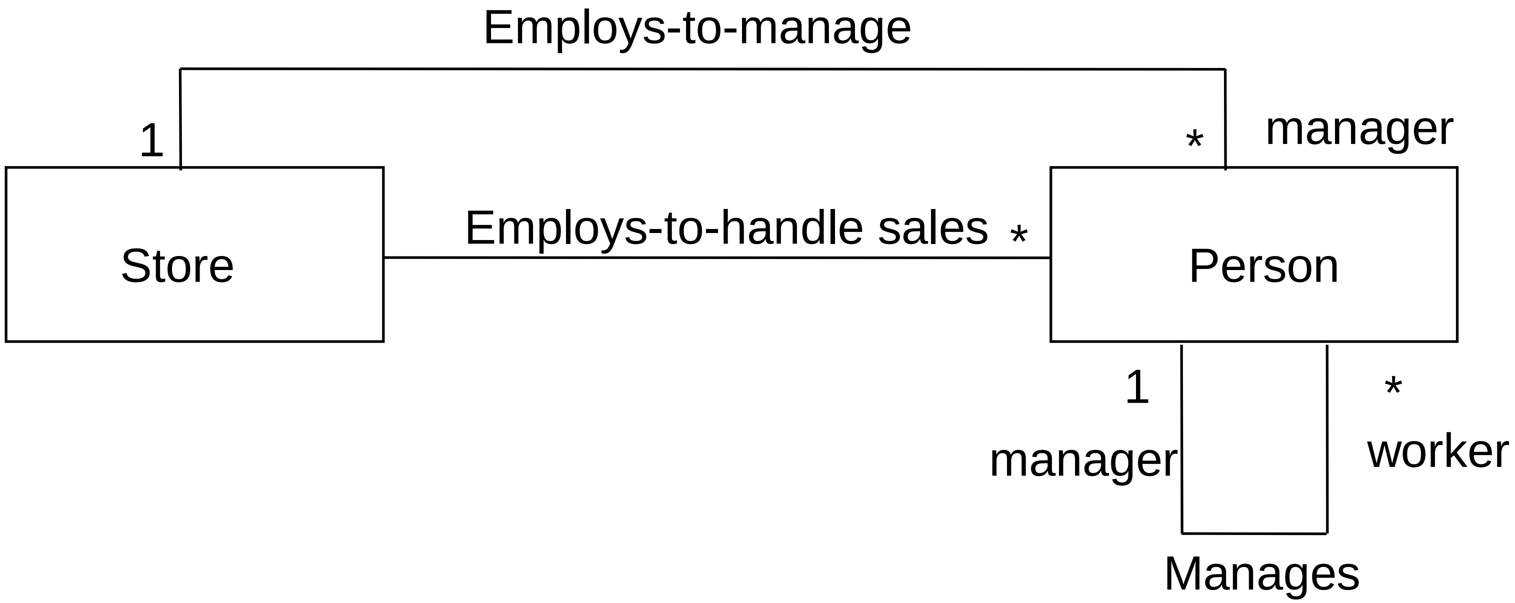
- expressed as a role in an association

Each approach has its own advantages.

(Recall that a "role" in modelling terms is the name given to one end of an association.)

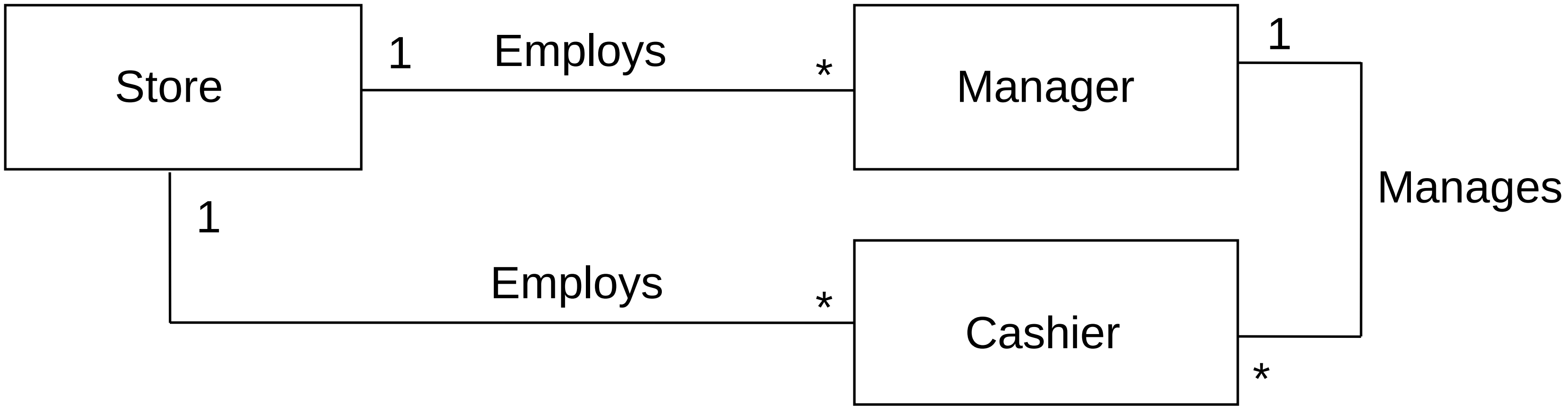
Roles in Associations

a relatively accurate way to express the notion that the same instance of a person takes on multiple (and dynamically changing) roles in various environments



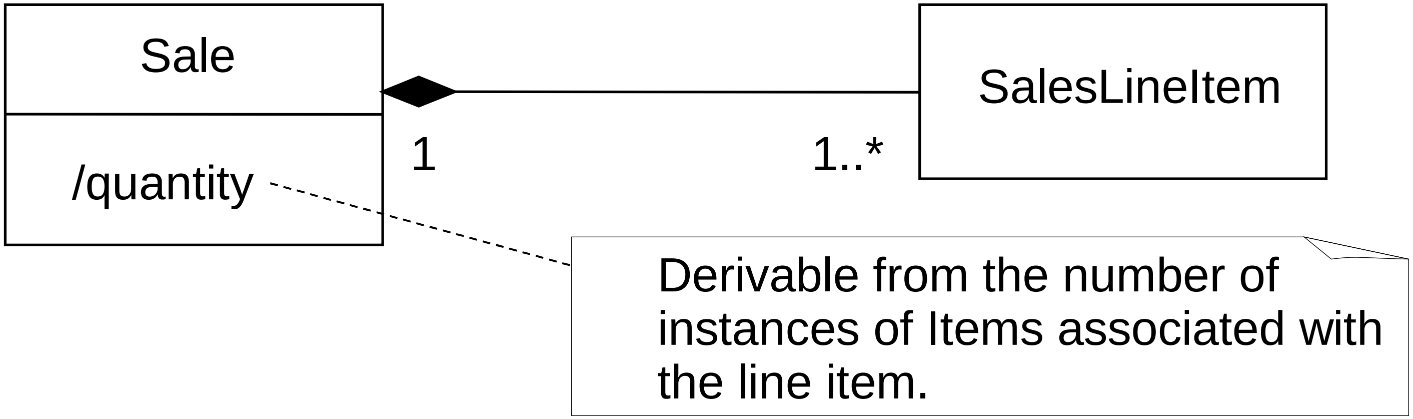
Roles as Concepts

- modeling roles as concepts provides ease and flexibility in adding unique attributes, associations, and additional semantics
- also easier, because Java, C++ etc. don't provide an easy way to dynamically change the class of an existing object

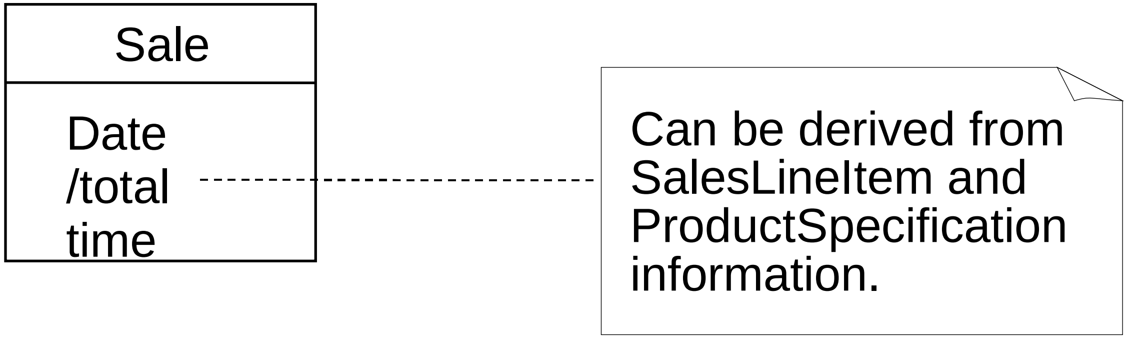


Derived Elements

- a derived element can be computed from existing attributes
- derived elements should be shown (only) when doing so makes the diagram easier to understand



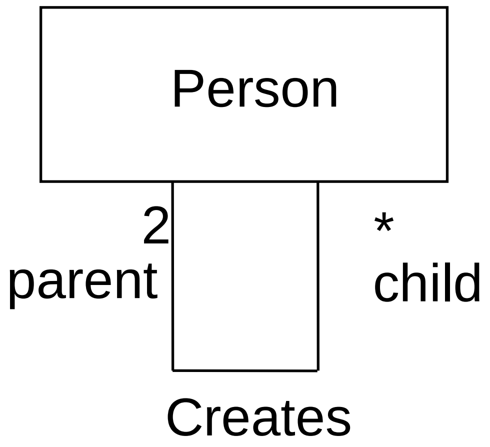
Derivable from the number of instances of Items associated with the line item.



Can be derived from SalesLineItem and ProductSpecification information.

Recursive or Reflexive Associations

A concept may have an association to itself; this is known as a recursive or reflective association.


Person
2
parent
*
child
Creates