Other High-Level Design Languages

Unified Modeling Language

Object Description Language

Object-Oriented DBMS's

- Standards group: ODMG = Object Data Management Group.
- ODL = Object Description Language, like CREATE TABLE part of SQL.
- OQL = Object Query Language, tries to imitate SQL in an OO framework.

Framework – (1)

- ODMG imagines OO-DBMS vendors implementing an OO language like C++ with extensions (OQL) that allow the programmer to transfer data between the database and “host language” seamlessly.

Framework – (2)

- ODL is used to define *persistent* classes, whose objects are stored permanently in the database.
  - ODL classes look like Entity sets with binary relationships, plus methods.
  - ODL class definitions are part of the extended, OO host language.

ODL Overview

- A class declaration includes:
  1. A name for the class.
  2. Optional key declaration(s).
  3. Element declarations. An *element* is either an attribute, a relationship, or a method.

Class Definitions

class <name> {

<list of element declarations, separated by semicolons>

}

Attribute and Relationship Declarations

- Attributes are (usually) elements with a type that does not involve classes.

  attribute <type> <name>;

- Relationships connect an object to one or more other objects of one class.

  relationship <type> <name>

      inverse <relationship>;

Inverse Relationships

- Suppose class *C* has a relationship *R* to class *D*.
- Then class *D* must have some relationship *S* to class *C*.
- *R* and *S* must be true inverses.
  - If object *d* is related to object *c* by *R*, then *c* must be related to *d* by *S*.

Example: Attributes and Relationships

```
class Bar {
   attribute string name;
   attribute string addr;
   relationship Set<Beer> serves inverse Beer::servedAt;
}
class Beer {
   attribute string name;
   attribute string manf;
   relationship Set<Bar> servedAt inverse Bar::serves;
}
```

The type of relationship serves is a set of Beer objects.

The :: operator connects a name on the right to the context containing that name, on the left.

Types of Relationships

- The type of a relationship is either
  1. A class, like Bar. If so, an object with this relationship can be connected to only one Bar object.
  2. Set<Bar>: the object is connected to a set of Bar objects.
  3. Bag<Bar>, List<Bar>, Array<Bar>: the object is connected to a bag, list, or array of Bar objects.

Multiplicity of Relationships

- All ODL relationships are binary.
- Many-many relationships have Set<…> for the type of the relationship and its inverse.
- Many-one relationships have Set<…> in the relationship of the "one" and just the class for the relationship of the "many."
- One-one relationships have classes as the type in both directions.

Example: Multiplicity

```
class Drinker { …
   relationship Set<Beer> likes inverse Beer::fans;
   relationship Beer favBeer inverse Beer::superfans;
}
class Beer { …
   relationship Set<Drinker> fans inverse Drinker::likes;
   relationship Set<Drinker> superfans inverse
   Drinker::favBeer;
}
```

Many-many uses Set<…>
in both directions.

Many-one uses Set<…>
only with the "one."

Another Multiplicity Example

husband and wife are
one-one and inverses
of each other.

```
class Drinker {
   attribute ... ;
   relationship Drinker husband inverse wife;
   relationship Drinker wife inverse husband;
   relationship Set<Drinker> buddies
       inverse buddies;
}
```

buddies is many-many and its
own inverse. Note no :: needed
if the inverse is in the same class.

Coping With Multiway Relationships

- ODL does not support 3-way or higher relationships.
- We may simulate multiway relationships by a "connecting" class, whose objects represent tuples of objects we would like to connect by the multiway relationship.

Connecting Classes

- Suppose we want to connect classes X, Y, and Z by a relationship R.
- Devise a class C, whose objects represent a triple of objects (x, y, z) from classes X, Y, and Z, respectively.
- We need three many-one relationships from (x, y, z) to each of x, y, and z.

Example: Connecting Class

- Suppose we have Bar and Beer classes, and we want to represent the price at which each Bar sells each beer.
  - A many-many relationship between Bar and Beer cannot have a price attribute as it did in the E/R model.
- One solution: create class Price and a connecting class BBP to represent a related bar, beer, and price.

Example -- Continued

- Since Price objects are just numbers, a better solution is to:
  1. Give BBP objects an attribute price.
  2. Use two many-one relationships between a BBP object and the Bar and Beer objects it represents.

Example -- Concluded

- Here is the definition of BBP:

```
class BBP {
  attribute price:real;
  relationship Bar theBar inverse Bar::toBBP;
  relationship Beer theBeer inverse Beer::toBBP;
}
```

- Bar and Beer must be modified to include relationships, both called toBBP, and both of type Set<BBP>.

Structs and Enums

- Attributes can have a structure (as in C) or be an enumeration.
- Declare with

attribute [Struct or Enum] <name of struct or enum> { <details> } <name of attribute>;

- Details are field names and types for a Struct, a list of constants for an Enum.

Example: Struct and Enum

```
class Bar {
   attribute string name;
   attribute Struct Addr
      {string street, string city, int zip} address;
   attribute Enum Lic
      { FULL, BEER, NONE } license;
   relationship …
}
```

Names for the structure and enumeration

names of the attributes

Method Declarations

- A class definition may include declarations of methods for the class.
- Information consists of:
  1. Return type, if any.
  2. Method name.
  3. Argument modes and types (no names).
     - Modes are in, out, and inout.
  4. Any exceptions the method may raise.

Example: Methods

```
real gpa(in string)raises(noGrades);
```

1. The method gpa returns a real number (presumably a student's GPA).
2. gpa takes one argument, a string (presumably the name of the student) and does not modify its argument.
3. gpa may raise the exception noGrades.

The ODL Type System

- Basic types: int, real/float, string, enumerated types, and classes.
- Type constructors:
  - Struct for structures.
  - *Collection types* : Set, Bag, List, Array, and Dictionary (= mapping from a domain type to a range type).
- Relationship types can only be a class or a single collection type applied to a class.

ODL Subclasses

- Usual object-oriented subclasses.
- Indicate superclass with a colon and its name.
- Subclass lists only the properties unique to it.
  - Also inherits its superclass' properties.

Example: Subclasses

- Ales are a subclass of beers:

```
class Ale:Beer {
  attribute string color;
}
```

ODL Keys

- You can declare any number of keys for a class.
- After the class name, add:

  (key <list of keys>)

- A key consisting of more than one attribute needs additional parentheses around those attributes.

Example: Keys

```
class Beer (key name) { …
```

- name is the key for beers.

```
class Course (key
  (dept,number),(room, hours)){
```

- dept and number form one key; so do room and hours.

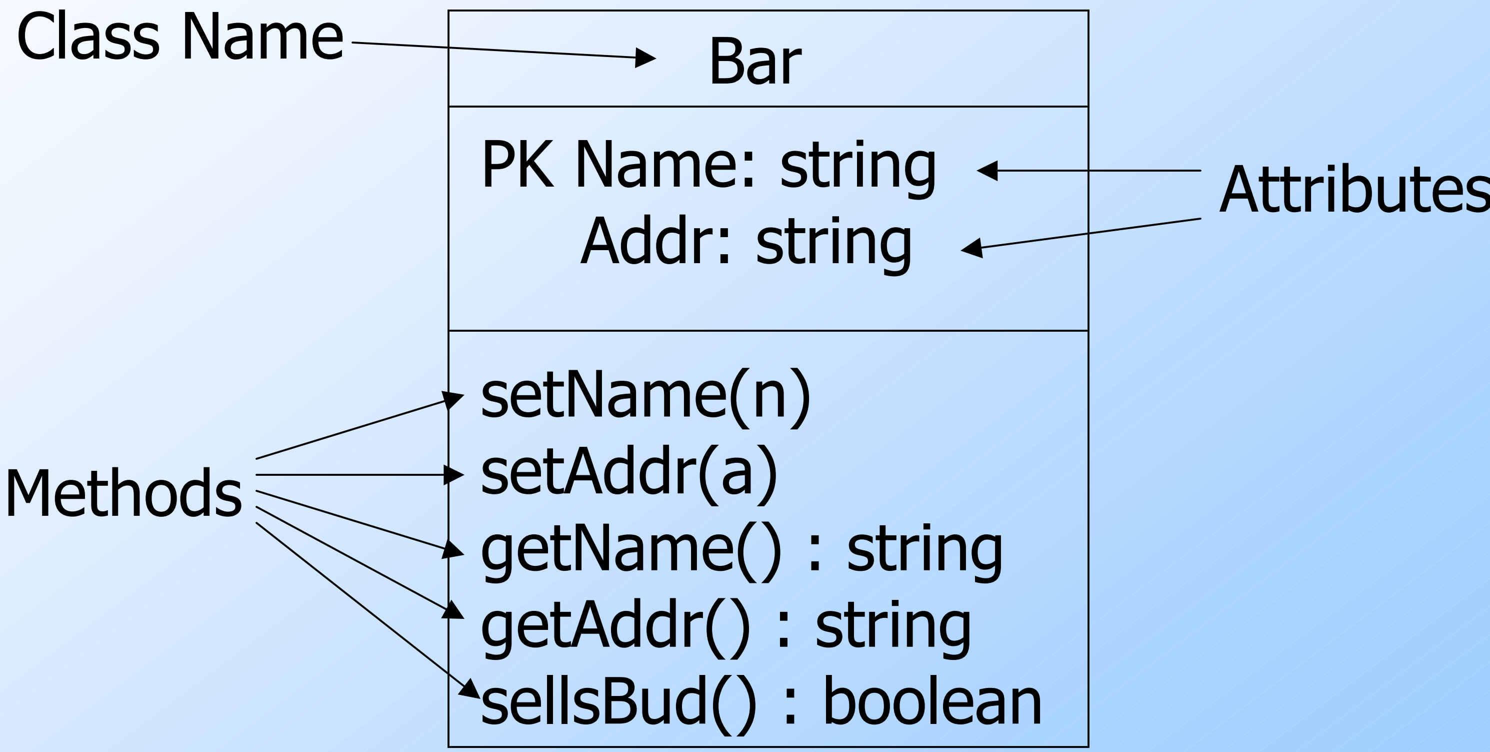
UML

- UML is designed to model software, but has been adapted as a database modeling language.
- Midway between E/R and ODL.
  - No multiway relationships as in E/R.
  - But allows attributes on binary relationships, which ODL doesn't.
  - Has a graphical notation, unlike ODL.

Classes

- Sets of objects, with attributes (*state*) and methods (*behavior*).
- Attributes have types.
- PK indicates an attribute in the primary key (optional) of the object.
- Methods have declarations: arguments (if any) and return type.

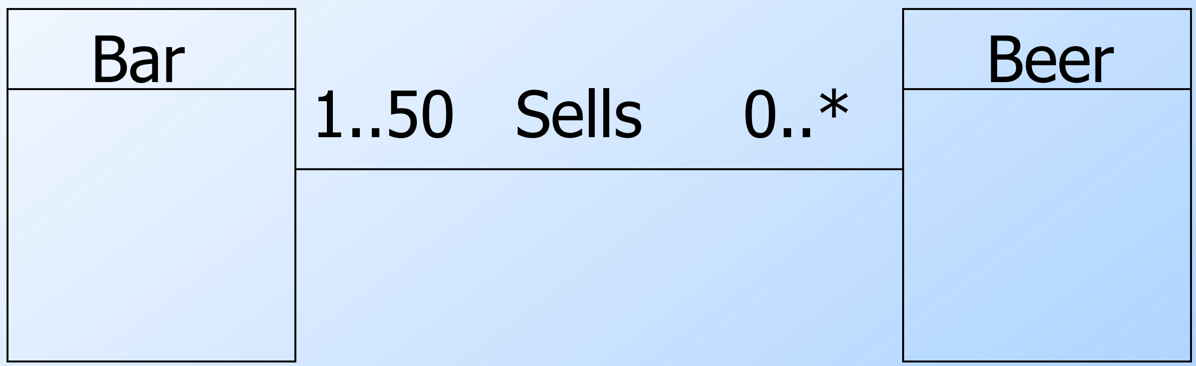
Example: Bar Class



Associations

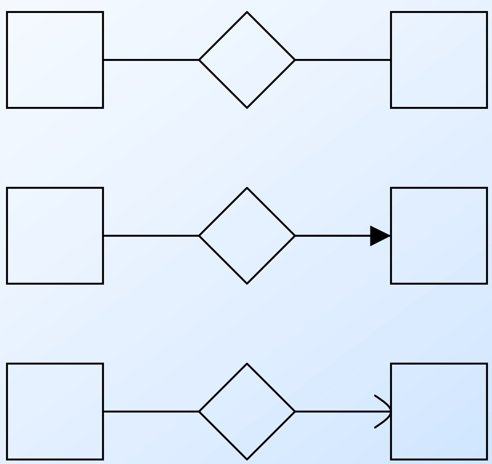
- Binary relationships between classes.
- Represented by named lines (no diamonds as in E/R).
- Multiplicity at each end.
  - *m* ..*n* means between *m* and *n* of these associate with one on the other end.
  - * = "infinity"; e.g. 1..* means "at least one."

Example: Association

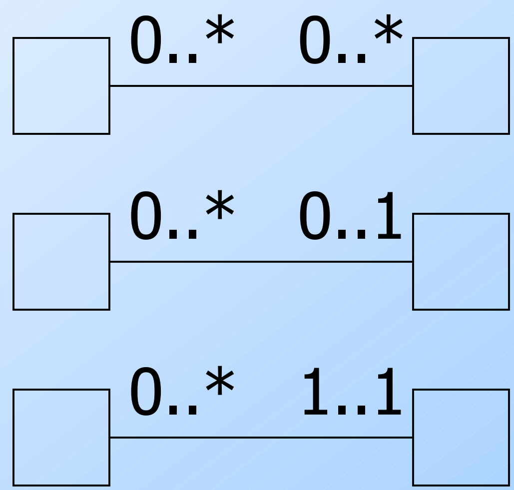


Comparison With E/R Multiplicities

E/R



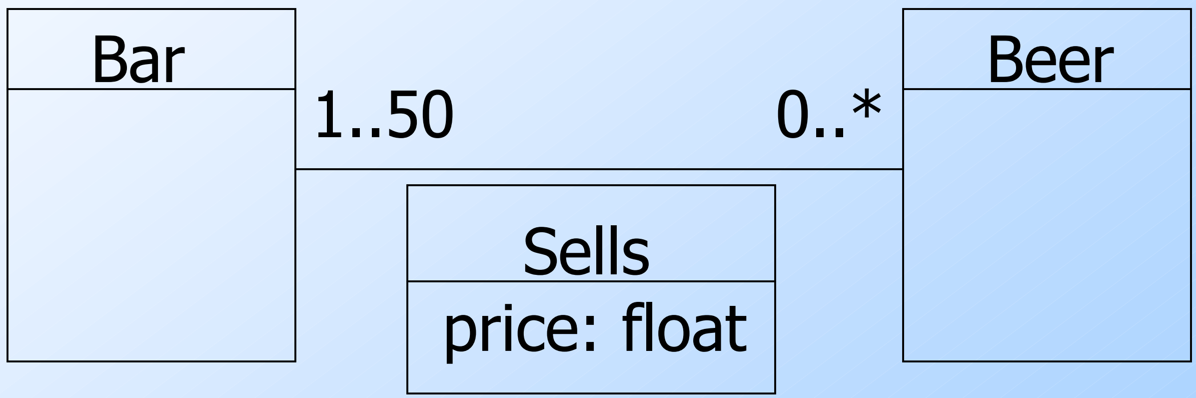
UML



Association Classes

- Attributes on associations are permitted.
  - Called an *association class*.
  - Analogous to attributes on relationships in E/R.

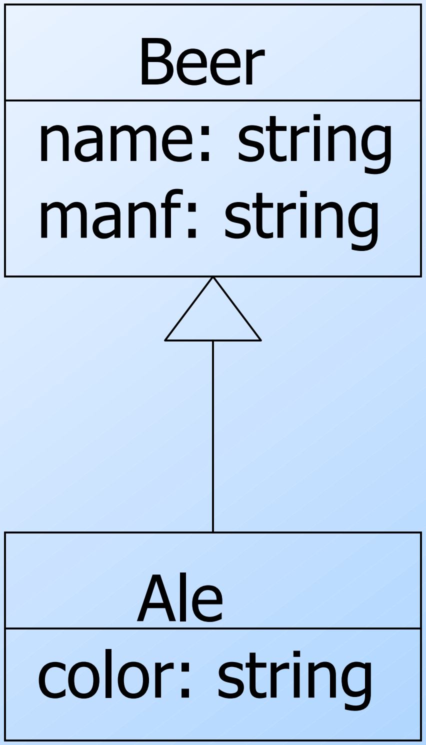
Example: Association Class



Subclasses

- Like E/R, but subclass points to superclass with a line ending in a triangle.
- The subclasses of a class can be:
  - *Complete* (every object is in at least one subclass) or *partial*.
  - *Disjoint* (object in at most one subclass) or *overlapping*.

Example: Subclasses



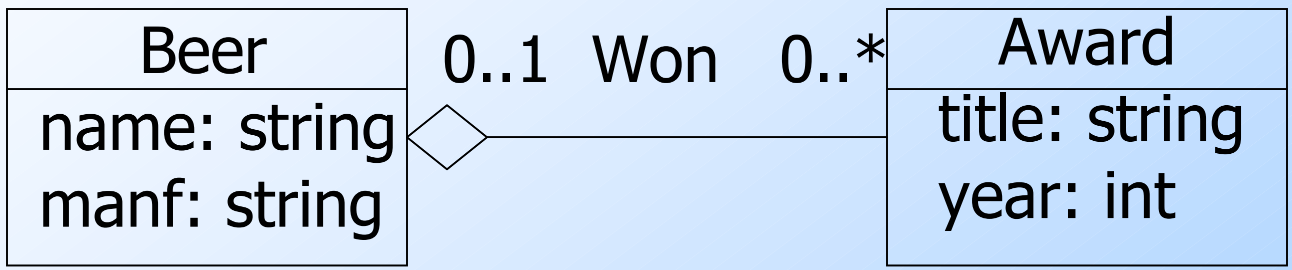
Conversion to Relations

- We can use any of the three strategies outlined for E/R to convert a class and its subclasses to relations.
  1. E/R-style: each subclass' relation stores only its own attributes, plus key.
  2. OO-style: relations store attributes of subclass and all superclasses.
  3. Nulls: One relation, with NULL's as needed.

Aggregations

- Relationships with implication that the objects on one side are "owned by" or are part of objects on the other side.
- Represented by a diamond at the end of the connecting line, at the "owner" side.
- Implication that in a relational schema, owned objects are part of owner tuples.

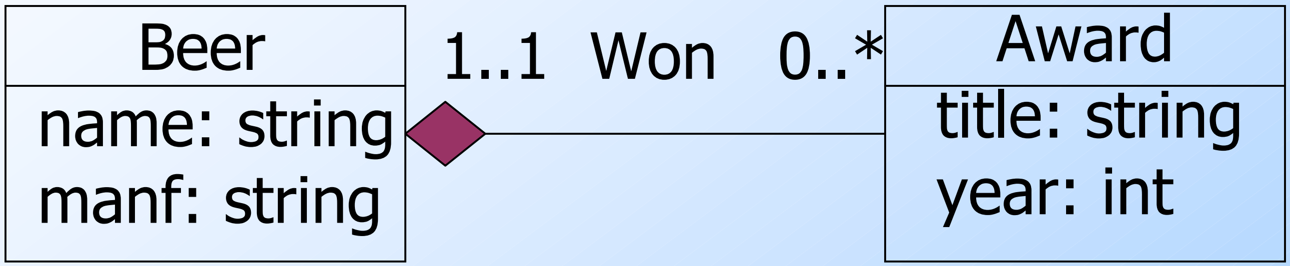
Example: Aggregation



Compositions

- Like aggregations, but with the implication that every object is definitely owned by one object on the other side.
- Represented by solid diamond at owner.
- Often used for subobjects or structured attributes.

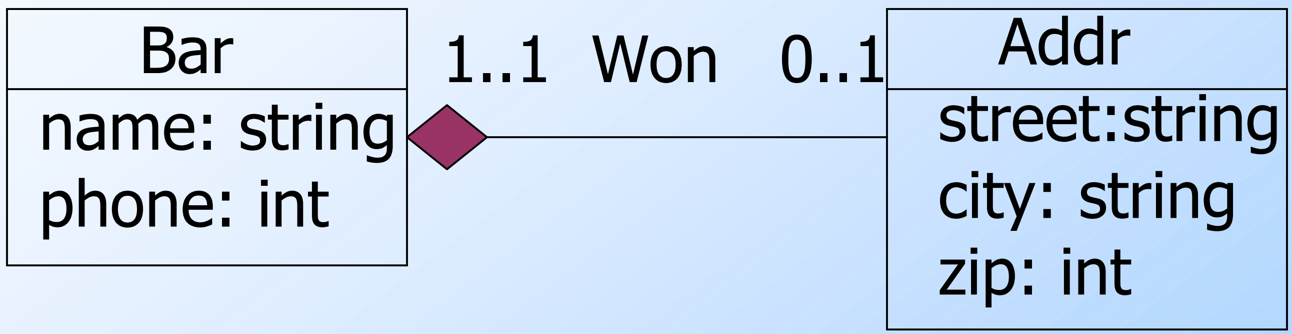
Example: Composition



Conversion to Relations

- We could store the awards of a beer with the beer tuple.
- Requires an object-relational or nested-relation model for tables, since there is no limit to the number of awards a beer can win.

Example: Composition



Conversion to Relations

- Since a bar has at most one address, it is quite feasible to add the street, city, and zip attributes of Addr to the Bars relation.
- In object-relational databases, Addr can be one attribute of Bars, with structure.