Static specifications in UML: Class Models

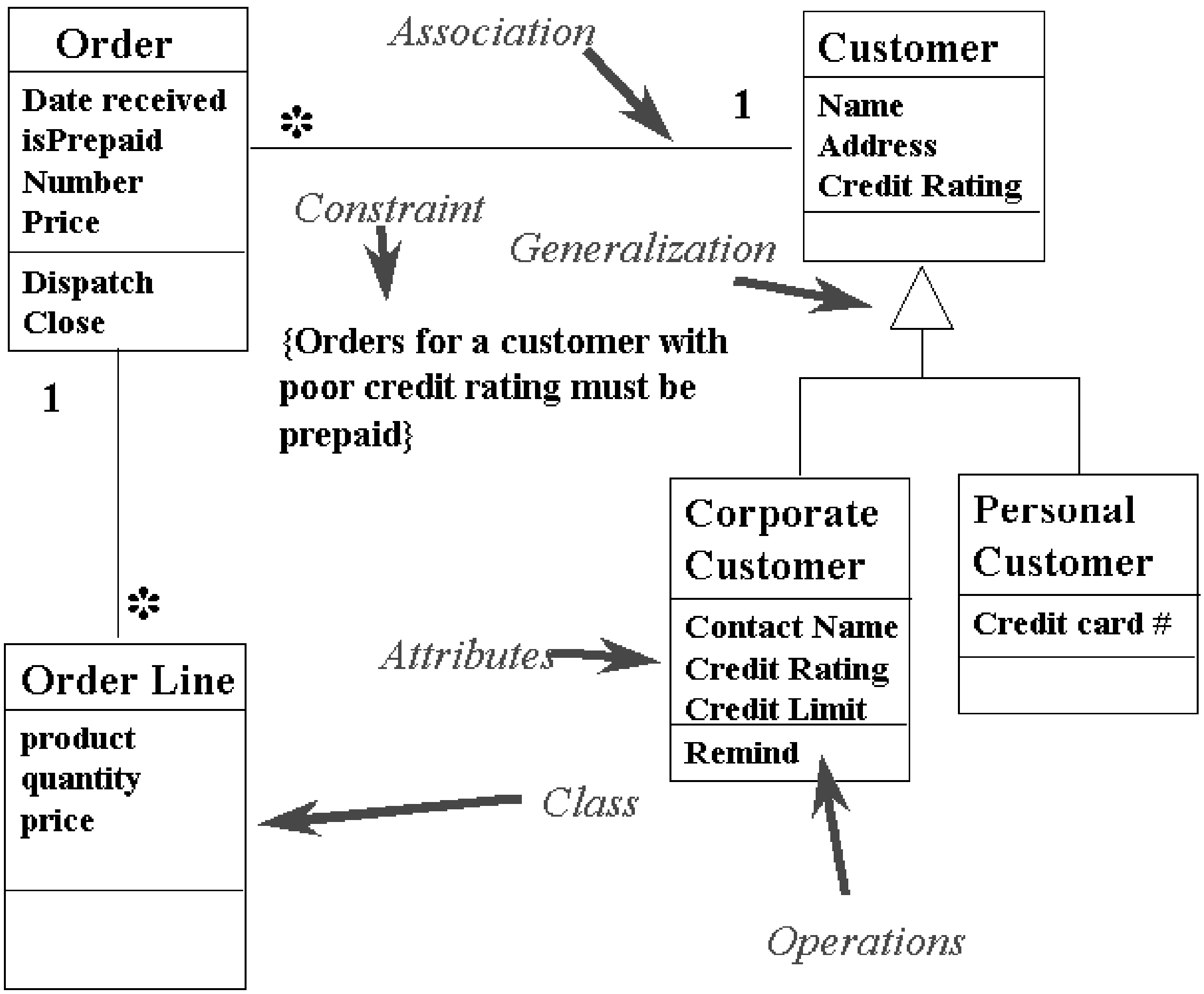
CS3: SEOC1

Note 4

Class Models

Class diagrams are used to document the static structure of OO systems. They indicate what classes there are, how they interrelate, and how they interact.

Annotated Example Class Diagram



Quality of Class Models

- identify the classes and their relationships
- desirable to build the system quickly and cheaply (and to meet requirements):
  - all required behaviour can be realised simply from objects in the classes of the system
  - the system *is* some collection of objects in the classes we have (there may be a GUI that coordinates human interaction with the objects)
- desirable to make the system easy to maintain and modify
  - the classes should be derived from the domain – avoid abstract objects introduced to "simplify" implementation
  - don't incorporate short lived features of the system as classes

How to Build Class Models

What drives design: Driven by criterion of completeness either of data or responsibility

- **Data Driven Design:** identify all the data and see it is covered by some collection of objects of the classes of the system.
- **Responsibility Driven Design:** identify all the responsibilities of the system and see they are covered by a collection of objects of the classes of the system

How to Build Class Models (cont)

Noun identification: As described in note 3:

- **Identify noun phrases:** look at the use cases and other requirements documents and identify noun phrases. Do this systematically and do not eliminate possibilities at this stage.
- **Eliminate inappropriate candidates:** those which are redundant, vague, an event or operation, in the meta-language, outside system scope, an attribute of the system.
- **Validate the model:** using CRC cards – see later.

What are Classes?

- A description of a group of objects all with similar roles in the system.
- Objects derive from:

Things: tangible, real-world objects, e.g. wards, beds, patients, ...

Roles: classes of actors in systems, e.g. nurses, managers, ...

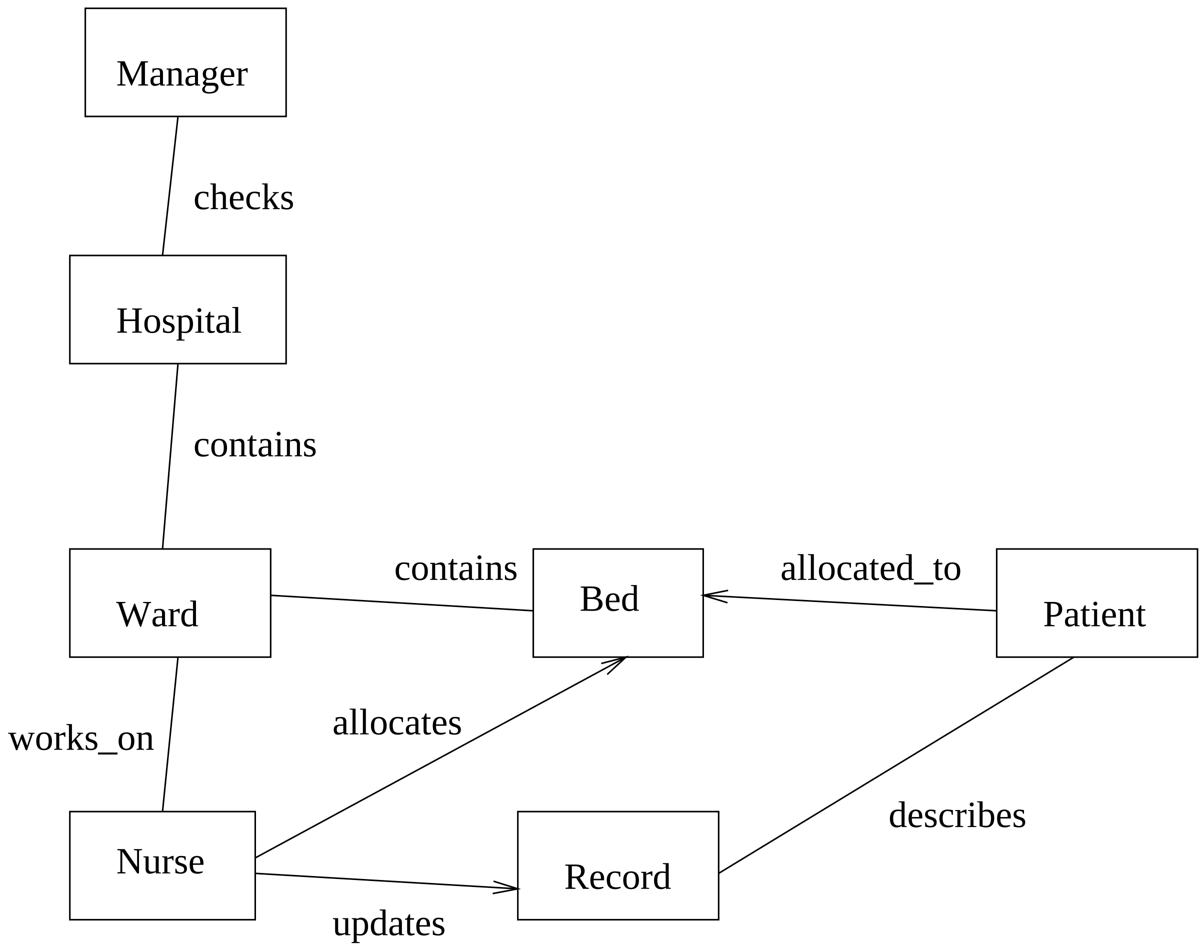
Events: admission, discharge, updates, ...(likely if there is an audit trail where these are treated as objects).

Interactions: meeting, handover, ...(again, likely if there is some degree of reflection on the action of the system within the system)

Associations between Classes

- Class A and B are *associated* if:
  - an object of class A sends a message to an object of class B.
  - an object of class A creates an object of class B
  - an object of class A has attributes that are objects of class B (or collections of such objects).
  - an object of class A accepts messages having objects of class B as an argument
- design associations early – keep them conceptual initially – think about methods later
- but don't forget about implementations.

Initial Class Diagram for HIS



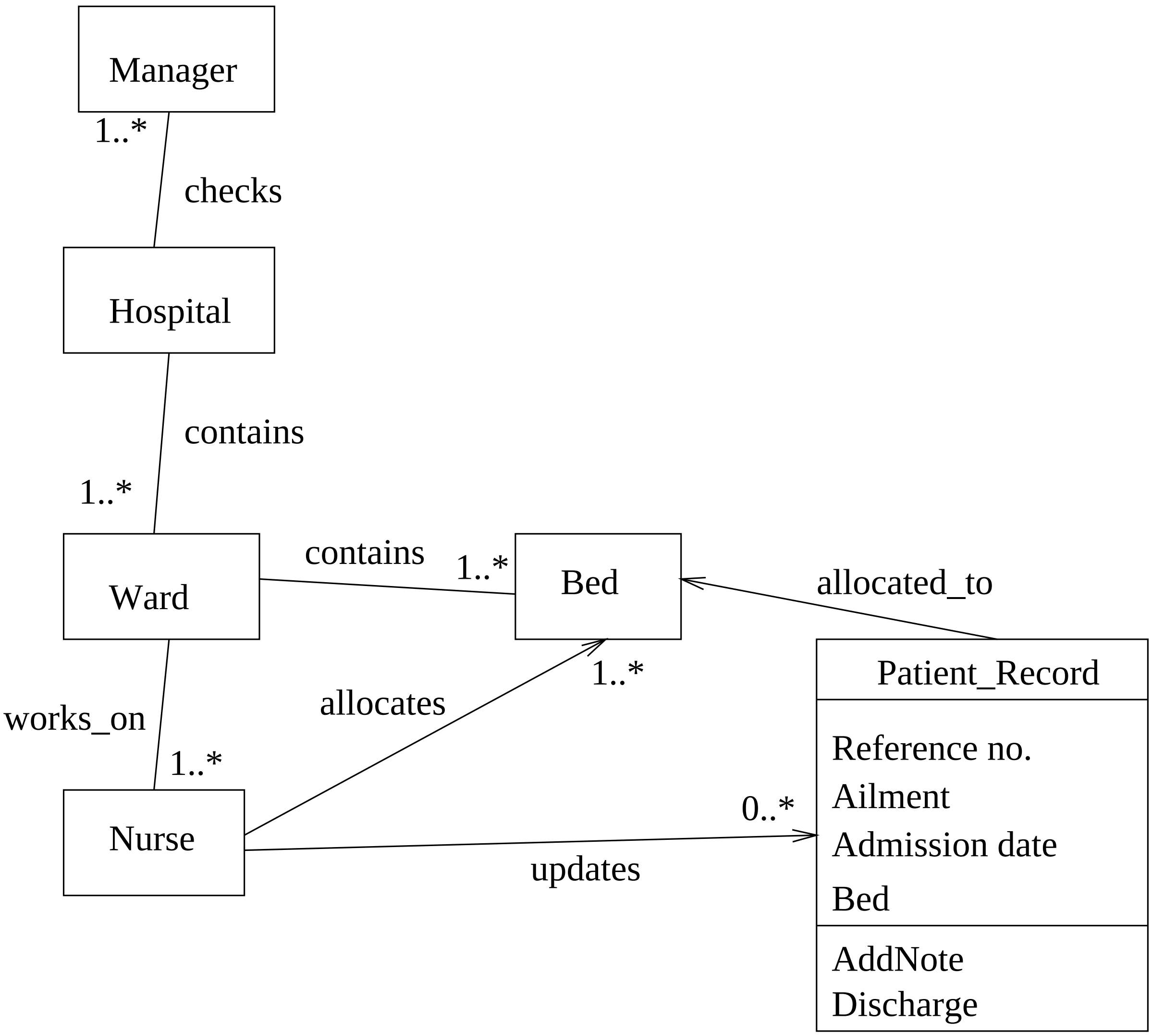
Multiplicities

- These label association links between classes and indicate then number of objects of a particular class that are related to objects of an associated class.
- A multiplicity can be:
  - a number
  - a range m..n (typically 0..n or 1..n)
  - the unspecified multiplicity: *
  - a list of multiplicities

Attributes and Operations

- after considering classes we need to think about attributes (these determine the state of an object), and the methods in a class (these define how it interacts)
- *Attributes* occupy the second compartment of a class icon. These represent the state of an object of the class (omit any that are used purely to implement the class).
- *Methods* are listed in the final compartment of the class icon, here we just specify their arguments and return values.

Revised Class Diagram for HIS



Generalisation

- Important relationship between classes.
- If we had a system with classes `Nurse` and `Sister` we might consider a generalisation `NursingStaff` that include the functions common to the two original classes.
- We expect:
  - An object of the more specialised class to be good for use as a member of the generalised class.
  - The behaviour of the two specific classes on receiving the same message should be similar.

Checking for Generalisations

- Suppose we claim class `A` is a generalisation of class `B`. Then we can check by seeing if the sentence: "Every `B` is an `A`."
- *Every engineer is a worker.*
- *Engineer is a profession. Every engineer is a profession.*

Design by Contract

- The contract is described by:
  - Pre- and post-conditions on the operations
  - Class invariants
- A specialisation of a class must keep to the contract of the superclass by: ensuring operations observe the pre and post conditions on the methods and that the class invariant is maintained.

Implementing Generalisations

- In Java this is done by creating the subclass by extending the super class.
- Inheritance increases the coupling of a system.
- Modifying the superclass methods may require changes in many subclasses of that class.
- Restrict inheritance to *conceptual* relationships.
- Avoid using inheritance when some other association is more appropriate e.g. `Engineer` might inherit from `Person` but not from `Qualification` that might be a part of an `Engineer`.

Class Diagrams and Class Models

- Class model develops by iteration
- A class model represents the a view of the system at some level of abstraction
- A class diagram is a way of representing the model
- One model may need several diagrams to describe it, and a particular class may make several appearances in the diagrams.

Common Domain Modelling mistakes

- Overly specific noun-phrase analysis
- Counter-intuitive or incomprehensible class and association names
- Assigning multiplicities to associations too soon
- Addressing implementation issues too early:
  - presuming a specific implementation strategy
  - committing to implementation constructs
  - tackling implementation issues (eg, integrating legacy systems)
- Optimising for reuse before checking use cases achieved
- "Premature pattern-isation"

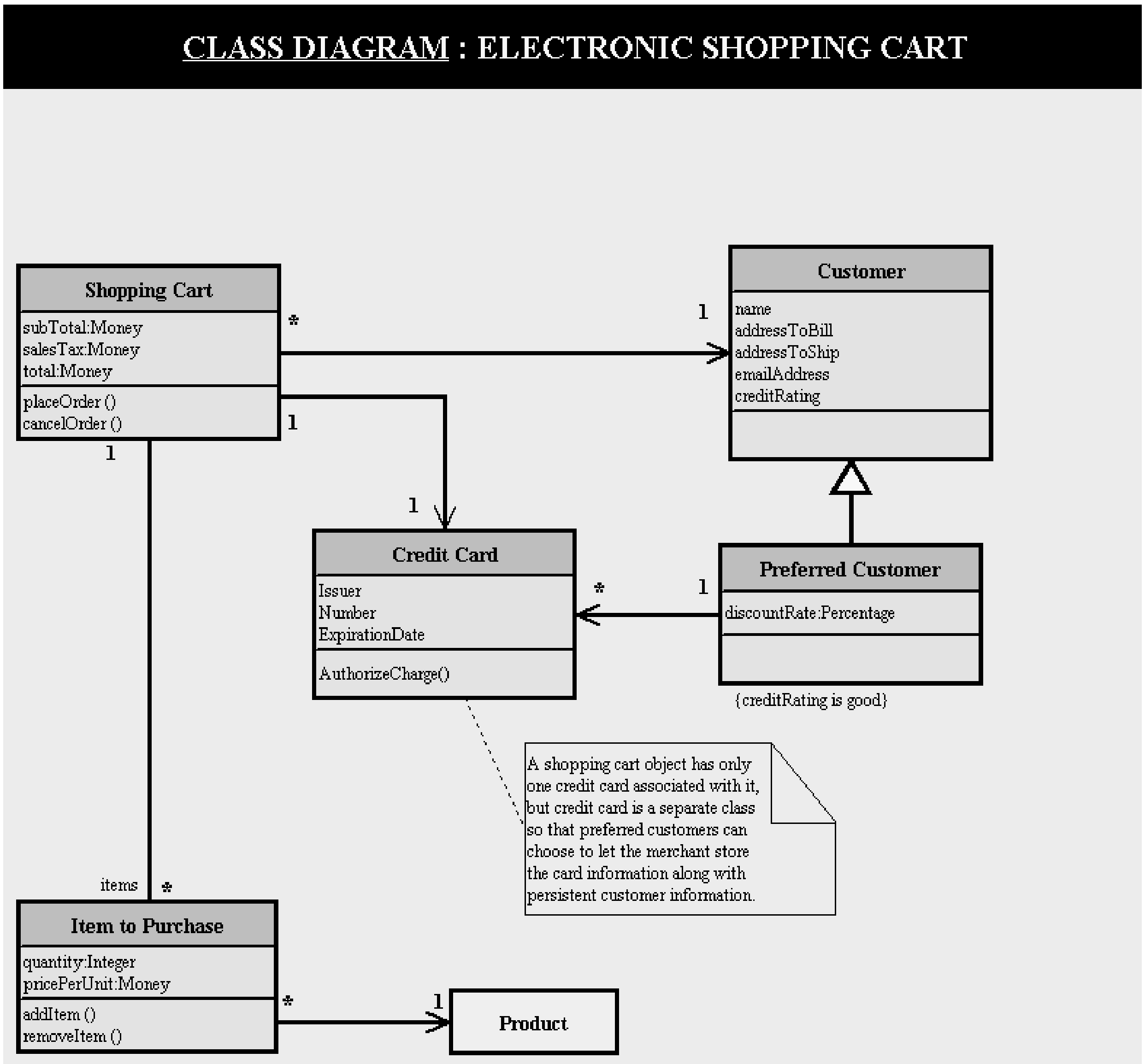
Class and Object Pitfalls

- Confusing basic class relationships
  - is-a
  - has-a
  - is-implemented-using
- Poor use of inheritance:
  - violating encapsulation and/or increasing coupling
  - base classes do too much or too little
  - Not preserving base class invariants
  - confusing interface inheritance with implementation inheritance
  - using multiple inheritance to invert *is-a*
- "Object ooze":
  - Poor encapsulation
  - Bloated objects
  - Swiss army knife classes
- Object spaghetti; object hyperspaghetti

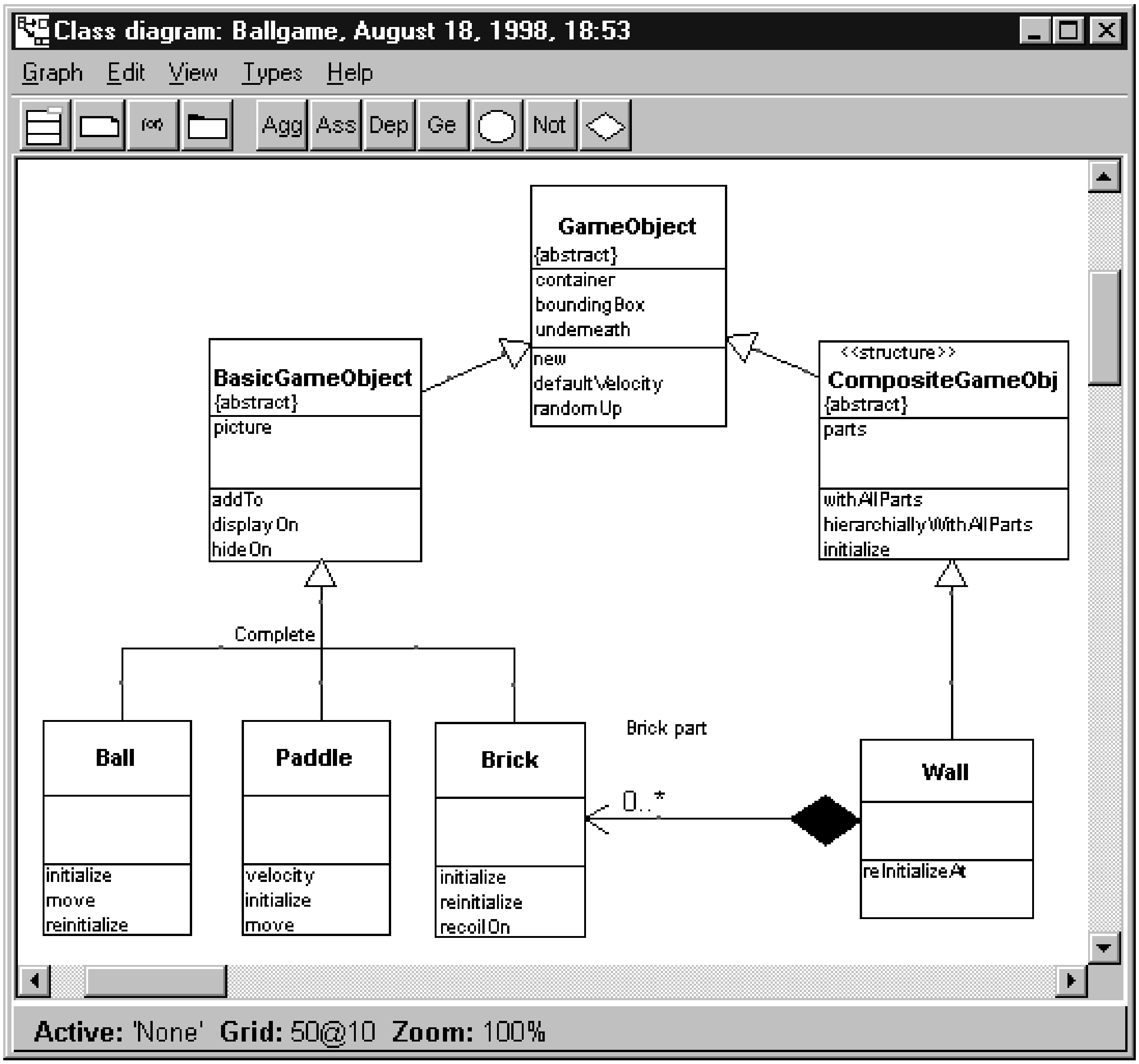
Summary

- A class model describes the static structure of an OO system
- The class models consists of class icons and associations between the icons.
- Associations may have multiplicities associated with them.
- Class icons give the name, attributes and method names and types of a class.
- Class diagrams get developed iteratively as the project progresses. It may be useful to delay decisions on attributes and methods until the main associations are sorted out.

Further Example Class Diagrams (1)



Further Example Class Diagrams (2)



Further Example Class Diagrams (3)