Lectures 2 & 3: Introduction to Modeling & UML

- → Why Build Models?
- → What types of Models to build
- → Intro to UML
- → Class Diagrams
- → Relationship between UML and program code
- → Uses of UML

Getting started

- → You've just joined an ongoing project
  - Where do you start?
  - (oh, BTW, the project doesn't really have any documentation)
- → Reverse Engineering:
  - Recover design information from the code
  - Create higher level views to improve understanding
- → E.g. Structure of the code
  - Code Dependencies
  - Components and couplings
- → E.g. Behaviour of the code
  - Execution traces
  - State machines models of complex objects
- → E.g. Function of the code
  - What functions does it provide to the user?

Why build models?

→ Modelling can guide your exploration:

- It can help you figure out what questions to ask
- It can help to reveal key design decisions
- It can help you to uncover problems
  - e.g. conflicting or infeasible requirements, confusion over terminology, scope, etc

→ Modelling can help us check our understanding

- Reason about the model to understand its consequences
  - Does it have the properties we expect?
- Animate the model to help us visualize/validate the requirements

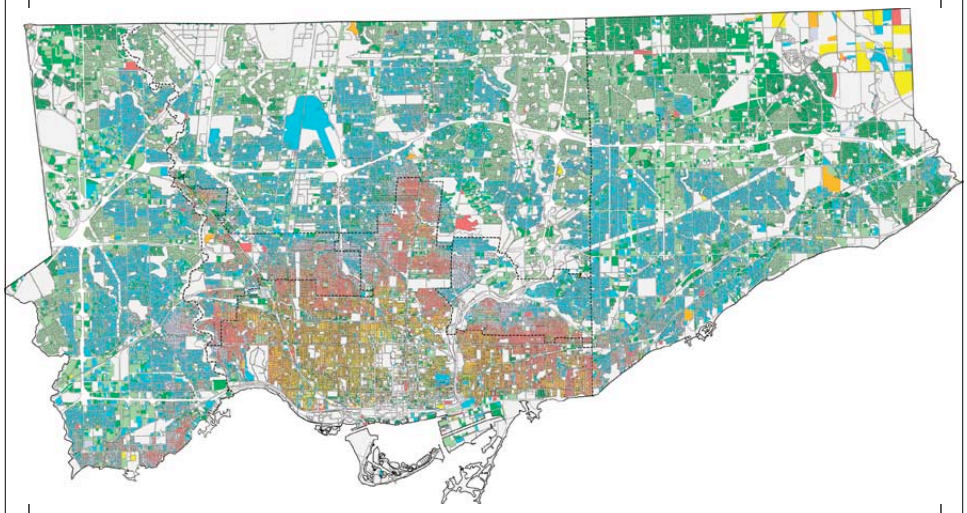
→ Modelling can help us communicate

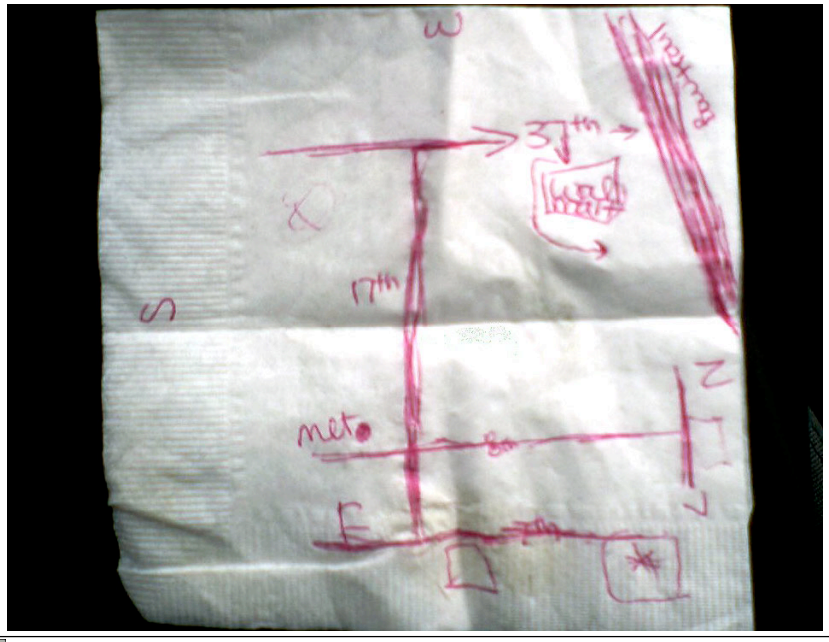
- Provides useful abstracts that focus on the point you want to make
- …without overwhelming people with detail

→ Throw-away modelling?

- The exercise of modelling is more important than the model itself
- Time spent perfecting the models might be time wasted…

Maps as Abstractions





Dealing with problem complexity

→ Abstraction
- Ignore detail to see the big picture
- Treat objects as the same by ignoring certain differences
- (beware: every abstraction involves choice over what is important)

→ Decomposition
- Partition a problem into independent pieces, to study separately
- (beware: the parts are rarely independent really)

→ Projection
- Separate different concerns (views) and describe them separately
- Different from decomposition as it does not partition the problem space
- (beware: different views will be inconsistent most of the time)

→ Modularization
- Choose structures that are stable over time, to localize change
- (beware: any structure will make some changes easier and others harder)

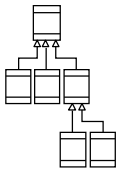
the Unified Modelling Language (UML)

→ Third generation OO method
- Booch, Rumbaugh & Jacobson are principal authors
  - Still evolving (currently version 2.0)
  - Attempt to standardize the proliferation of OO variants
- Is purely a notation
  - No modelling method associated with it!
  - Was intended as a design notation
- Has become an industry standard
  - But is primarily promoted by IBM/Rational (who sell lots of UML tools, services)

→ Has a standardized meta-model
- Use case diagrams
- Class diagrams
- Message sequence charts
- Activity diagrams
- State Diagrams
- Module Diagrams
- Platform diagrams
- …

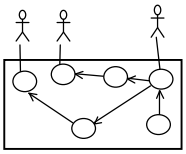
Modeling Notations

UML Class Diagrams



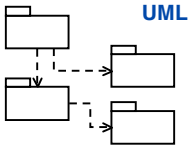
information structure
relationships between data items
modular structure for the system

Use Cases



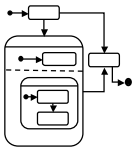
user's view
Lists functions
visual overview of the main requirements

UML Package Diagrams



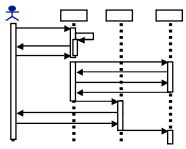
Overall architecture
Dependencies between components

(UML) Statecharts



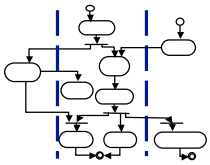
responses to events
dynamic behavior
event ordering, reachability, deadlock, etc

UML Sequence Diagrams



individual scenario
interactions between users and system
Sequence of messages

Activity diagrams

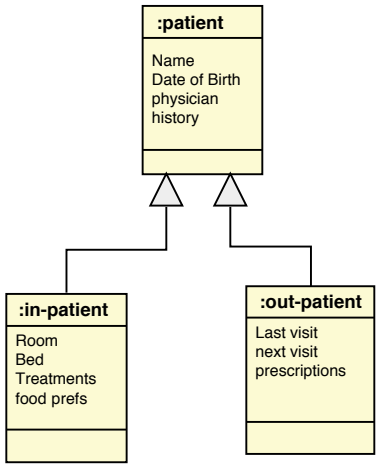


business processes;
concurrency and synchronization;
dependencies between tasks;

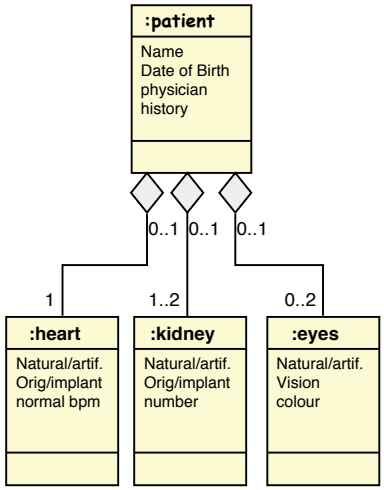
Intro: Object Classes in UML

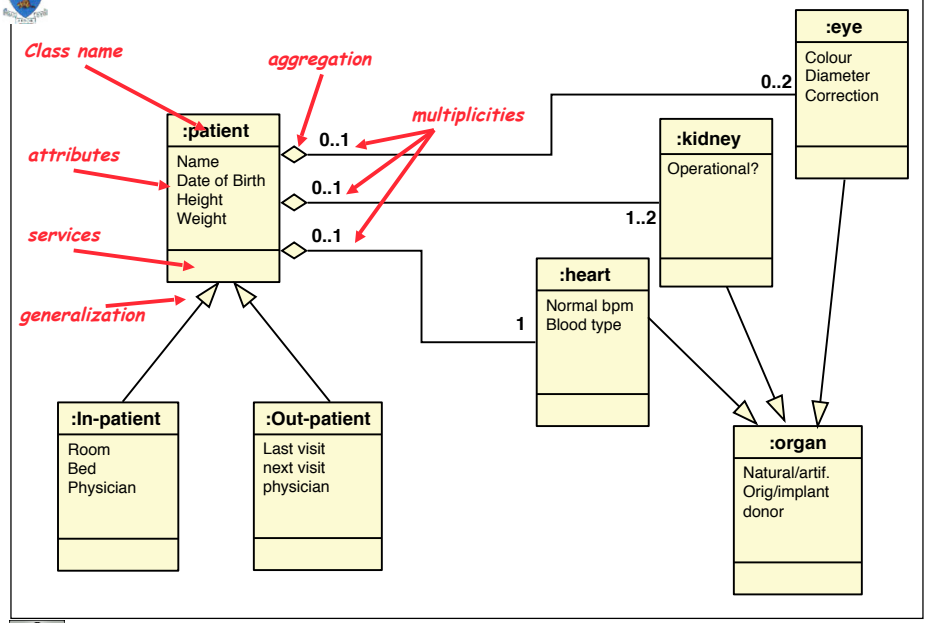
Source: *Adapted from Davis, 1990, p67-68*

Generalization (an abstraction hierarchy)



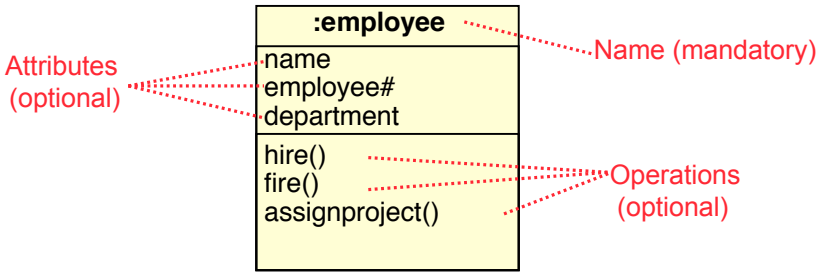
Aggregation (a partitioning hierarchy)



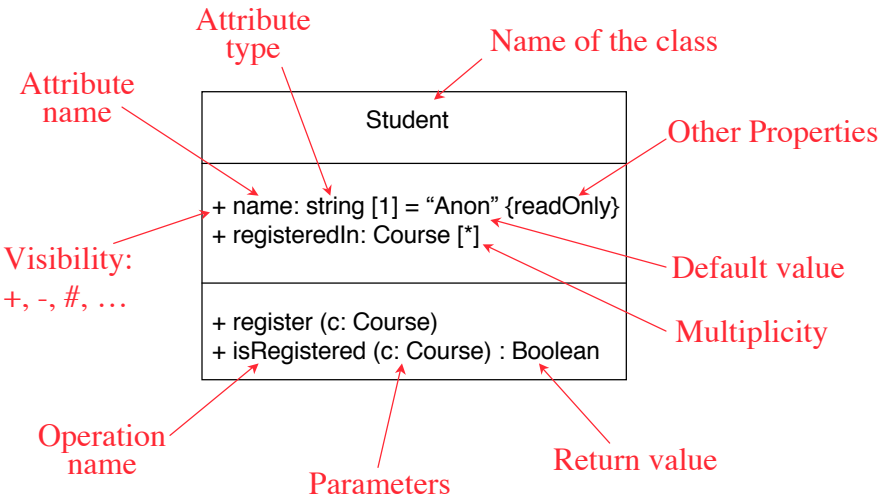


What are classes?

- **A class describes a group of objects with**
  - **similar properties (attributes),**
  - **common behaviour (operations),**
  - **common relationships to other objects,**
  - **and common meaning ("semantics").**
- **Examples**
  - **employee: has a name, employee# and department; an employee is hired, and fired; an employee works in one or more projects**



The full notation…



Objects vs. Classes

→ The instances of a class are called objects.

- Objects are represented as:

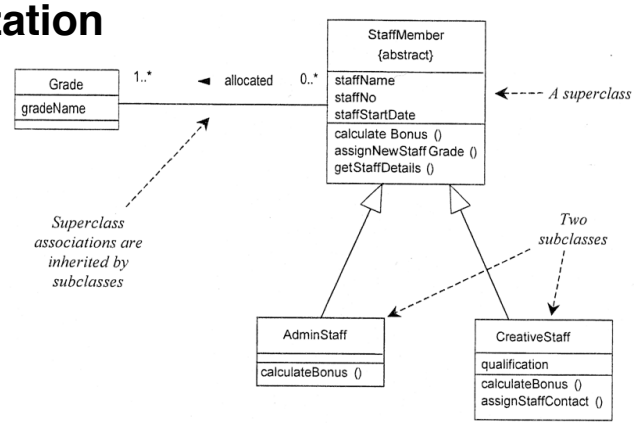
Fred_Bloggs:Employee
name: Fred Bloggs Employee #: 234609234 Department: Marketing

- Two different objects may have identical attribute values (like two people with identical name and address)

→ Objects have associations with other objects

- E.g. Fred_Bloggs:employee is associated with the KillerApp:project object
- But we will capture these relationships at the class level (why?)
- Note: Make sure attributes are associated with the right class
  - E.g. you don't want both managerName and manager# as attributes of Project! (…Why??)

Generalization



→ Notes:

- Subclasses inherit attributes, associations, & operations from the superclass
- A subclass may override an inherited aspect
  - e.g. AdminStaff & CreativeStaff have different methods for calculating bonuses
- Superclasses may be declared {abstract}, meaning they have no instances
  - Implies that the subclasses cover all possibilities
  - e.g. there are no other staff than AdminStaff and CreativeStaff

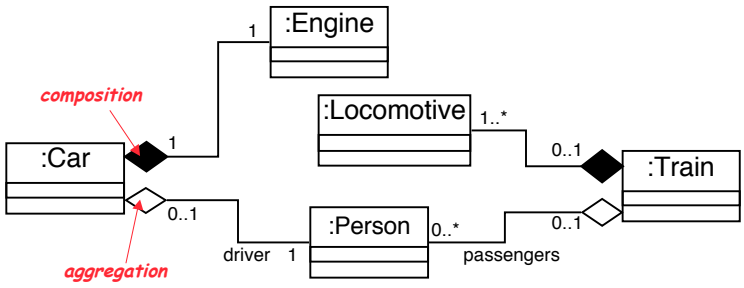
Aggregation and Composition

→ Aggregation

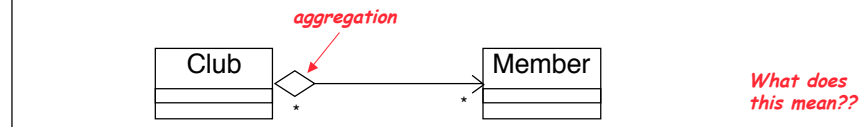
- This is the "Has-a" or "Whole/part" relationship

→ Composition

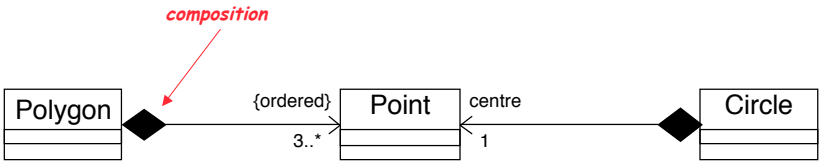
- Strong form of aggregation that implies ownership:
  - if the whole is removed from the model, so is the part.
  - the whole is responsible for the disposition of its parts



Aggregation / Composition (Refresher)



What does this mean??



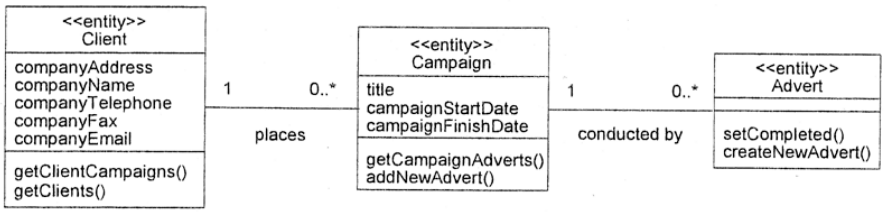
Note: No sharing - any instance of point can be part of a polygon or a circle, but not both

Associations

→ Objects do not exist in isolation from one another

- A relationship represents a connection among things.
- In UML, there are different types of relationships:
  - Association
  - Aggregation and Composition
  - Generalization
  - Dependency
  - Realization

→ Class diagrams show classes and their relationships



Association Multiplicity

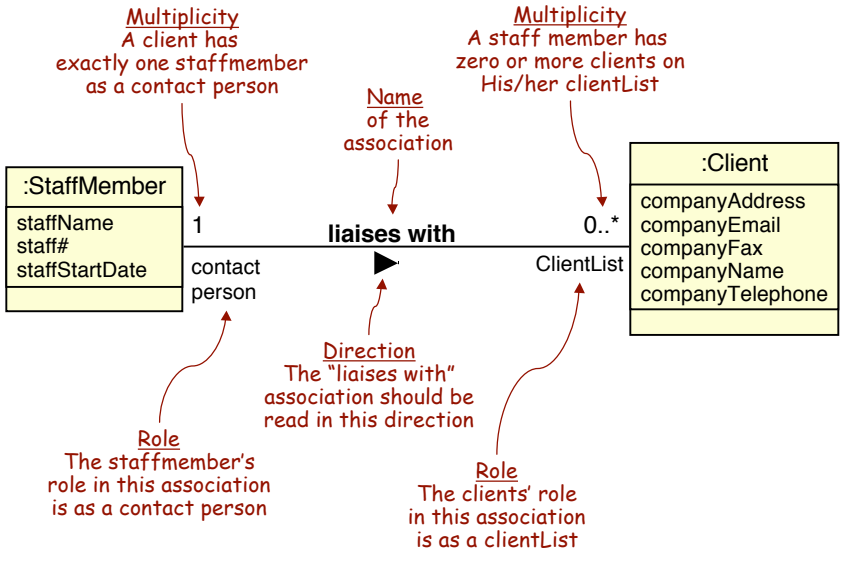
→ Ask questions about the associations:

- Can a campaign exist without a member of staff to manage it?
  - If yes, then the association is optional at the Staff end - zero or more (0..*)
  - If no, then it is not optional - one or more (1..*)
  - If it must be managed by one and only one member of staff - exactly one (1)
- What about the other end of the association?
  - Does every member of staff have to manage exactly one campaign?
  - No. So the correct multiplicity is zero or more.

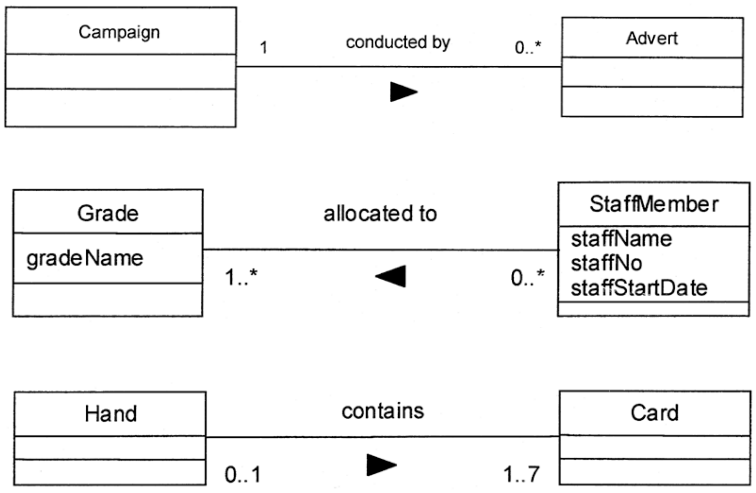
→ Some examples of specifying multiplicity:

Optional (0 or 1)	0..1	
Exactly one	1	= 1..1
Zero or more	0..*	= *
One or more	1..*	
A range of values	2..6	

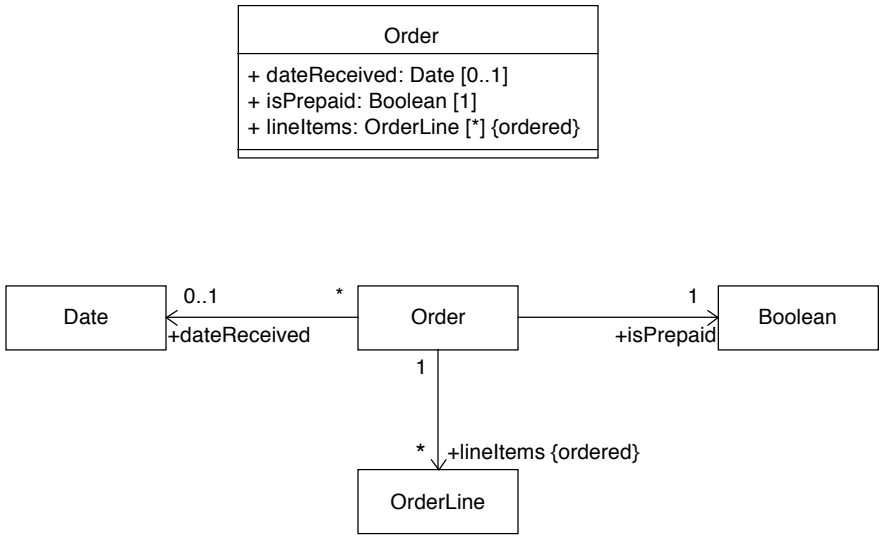
Class associations



More Examples



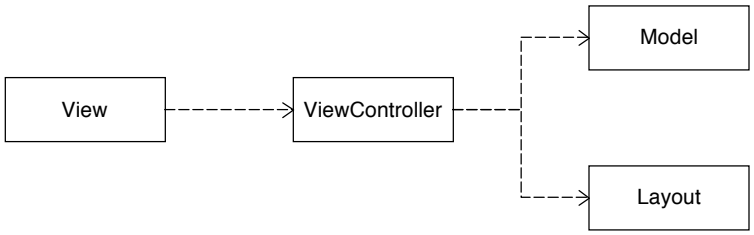
Navigability / Visibility



Bidirectional Associations

Hard to implement correctly!

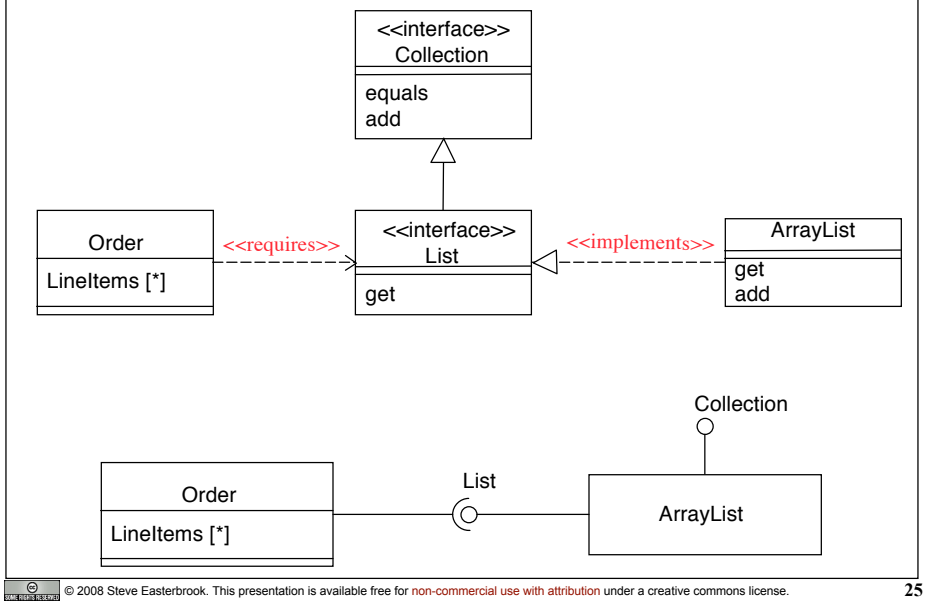
Dependencies



→ **Example Dependency types:**

- **<<call>>**
- **<<use>>**
- **<<create>>**
- **<<derive>>**
- **<<instantiate>>**
- **<<permit>>**
- **<<realize>>**
- **<<refine>>**
- **<<substitute>>**
- **<<parameter>>**

Interfaces

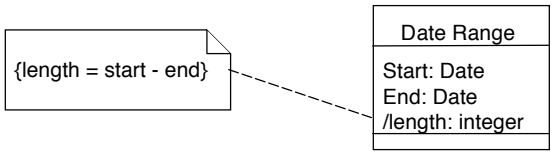


Annotations

→ Comments

- -- can be used to add comments within a class description

→ Notes



→ Constraint Rules

- Any further constraints {in curly braces}
- e.g. {time limit: length must not be more than three months}

What UML class diagrams can show

- **Division of Responsibility**
  - Operations that objects are responsible for providing
- **Subclassing**
  - Inheritance, generalization
- **Navigability / Visibility**
  - When objects need to know about other objects to call their operations
- **Aggregation / Composition**
  - When objects are part of other objects
- **Dependencies**
  - When changing the design of a class will affect other classes
- **Interfaces**
  - Used to reduce coupling between objects