# Object Model

# Overview

- Essential aspects of the Object Model:
  - Abstraction
  - Encapsulation
- Realization of the Object Model using:
  - Classes
  - Objects

# What is an ABSRACTION?

- An abstraction is one of the fundamental ways in which we handle *complexity.*

  *An abstraction denotes the essential **properties** of an object,*
  *which distinguish it from other objects, and*
  *thereby establishes well defined conceptual **boundaries**,*
  *relative to an observer's **perspective**.*

- Main problem in object-oriented system development (OOSD):

  *Choosing the right abstractions.*

- Abstractions can be about *tangible* things (vehicle, map) and *conceptual* things (meeting, dates, different processes).

# Example of an Abstraction

- Which essential details describe this “thingy”?
  - Abstraction name: `Light`
  - Light’s wattage, i.e. energy usage.
  - Light can be on or off.

  *Different lights (objects) will have the above properties defined.*

  *Other properties like shape, mat, color, socket size, etc. are less essential for this particular definition of the abstraction.*

  *Essential properties are dictated by the problem.*

# Modelling Abstraction using Classes

- A *class* defines
  - all attributes/properties/data, and
  - all methods/behaviors/operations

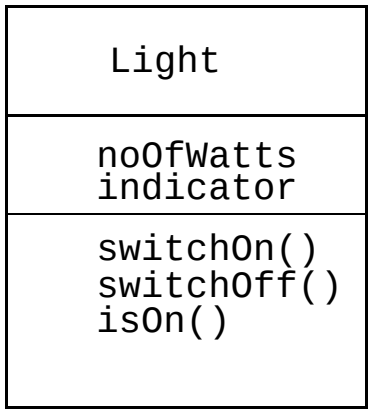
  of an abstraction.

Schematic specification of a class

**Class `Light`**

| Attributes: | Methods: |
|---|---|
| `noOfWatts` | `switchOn` |
| `indicator` | `switchOff` |
| | `isOn` |

Graphical Notation for a class




- UML: Unified Modelling Language (*http://www.rational.com/uml/*)

# Classes

- A class denotes a category of *objects*.
  - defines the properties and behaviors of the objects
  - defines a “template” or a “blue print” for creating objects (also called *instances*)

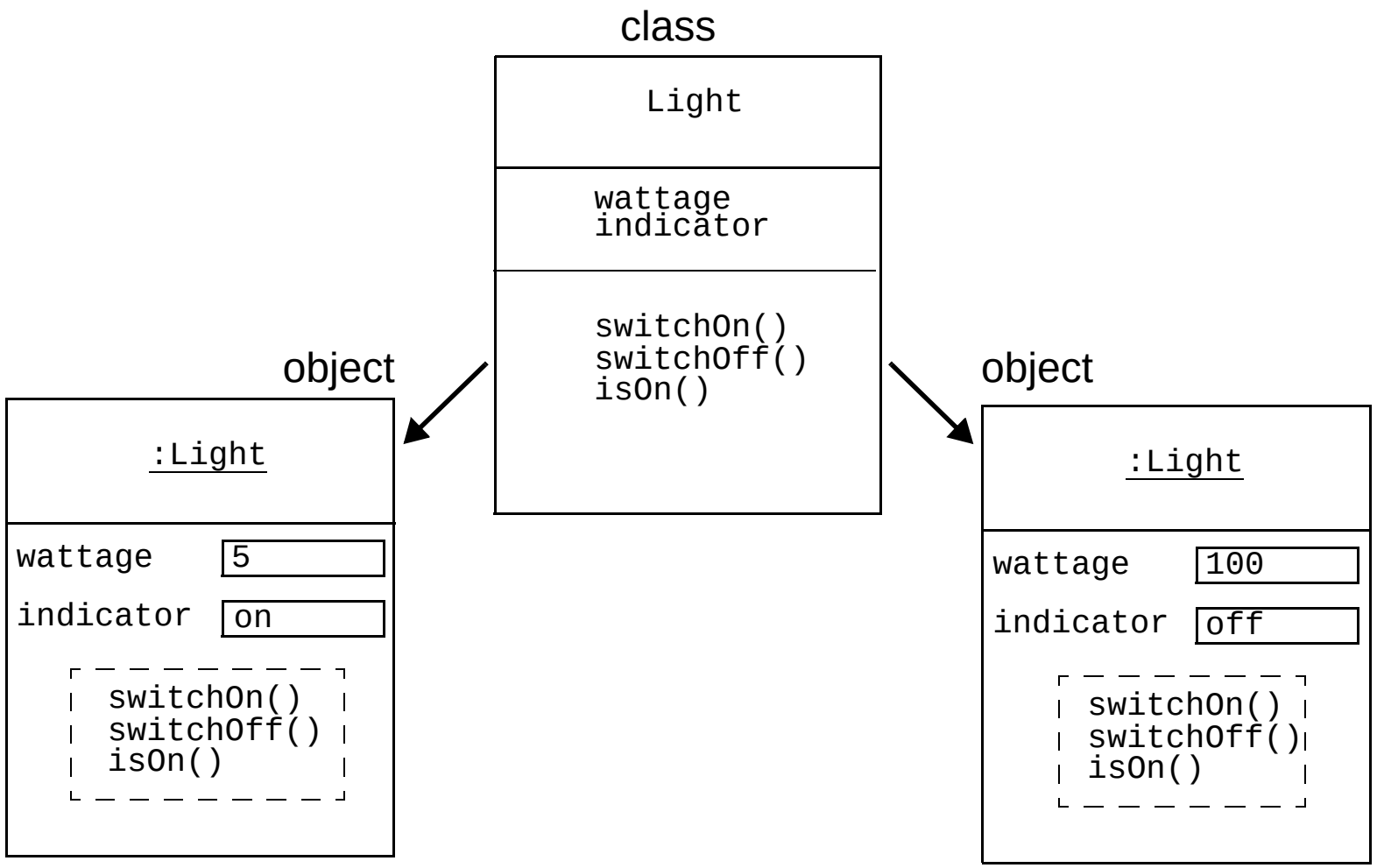
```
class Light {
    // Instance variables
    private int noOfWatts;          // wattage
    private boolean indicator;      // on or off

    // Instance methods
    public void switchOn()  { indicator = true; }
    public void switchOff() { indicator = false; }
    public boolean isOn()   { return indicator; }
}
```

# Terminology

| **Term:** | **Other synonyms:** |
|---|---|
| *class* | object-class |
| *object* | instance, object-instance, class-instance, occurrence |
| *(instance-)methods* | operations, behaviors, member functions, procedures, functions |
| *(instance-)variables* | attributes, properties, fields, data, data-member |
| *(instance-)members* | instance-variables *and* -methods |

# Objects as Instances of Classes



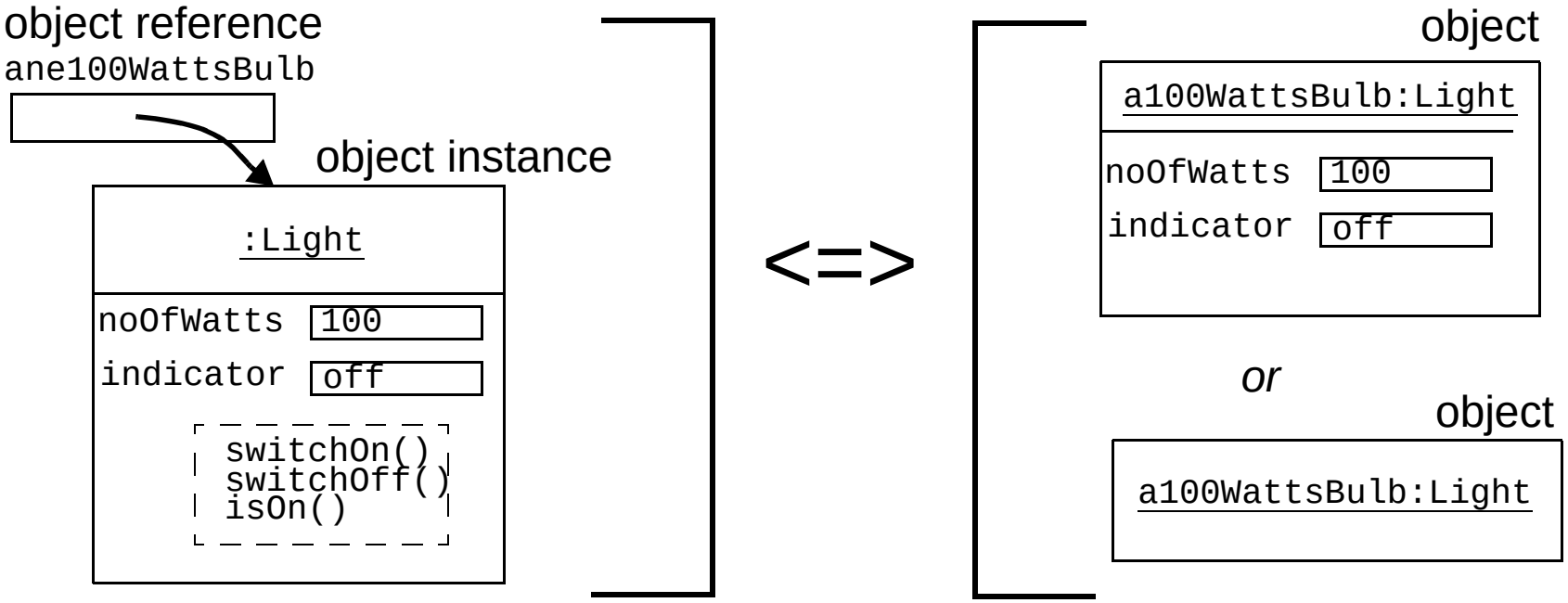
# Objects

- *Objects* contain *instance variables* (which can be references to other references, leading to *aggregation*).
- Values of an object's instance variables at any given time constitute its *state*.
- Each object is unique (i.e. has a unique id) even if the objects have the same state.
- Behavior of an object is implemented by methods.
  - Objects of the same class share method implementations.
- In Java, the `new` operator is used to create objects.

```
Light one100WattBulb = new Light(); // declaration + instantiation
```

  - the `new` operator takes a *constructor call* as argument.
  - A constructor is primarily used to set the *initial state* of the object.
- In Java, objects can only be manipulated by *object references* (ex. `one100WattBulb`).
  - A reference *denotes* an object.

# Object references

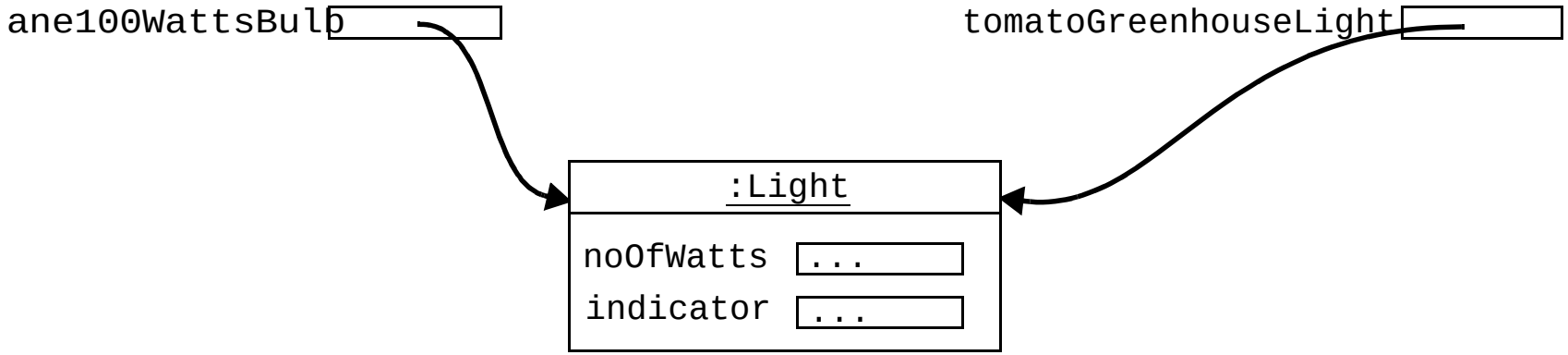



- When we *instantiate* a class to create an object,
  - we get a *reference* to the object, and
  - we must declare a (reference) variable to store the reference.
- A reference provides a handle for an object, and can be used to send *messages* to the object.
- *References are values which can be assigned, cast and passed as parameters.*

# Aliases

- An object can have several references, called *aliases*.

```
Light one100WattBulb = new Light();
Light tomatoGreenhouseLight = one100WattBulb;  // results in aliases
```




- Any alias of an object can be used to send messages to the object.

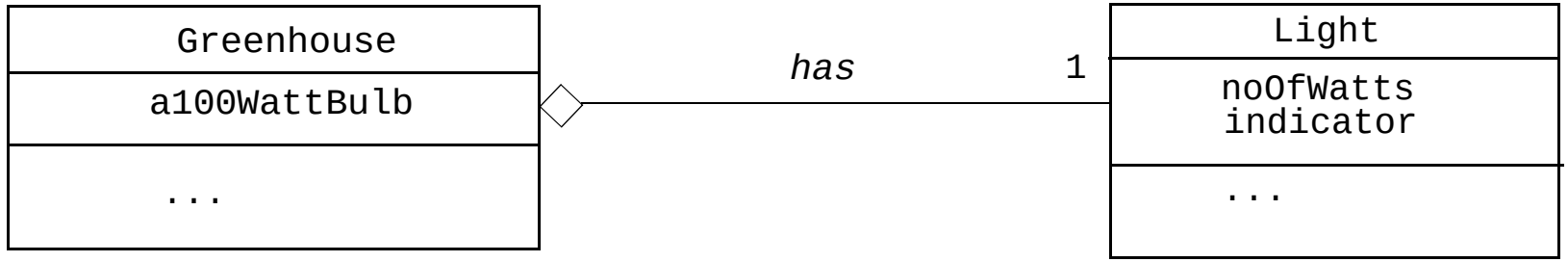
```
// ...
tomatoGreenhouseLight.switchOn();
if (one100WattBulb.isOn())
    System.out.println("Light in the tomato greenhouse is on.");
// ...
```

# Aggregation

- In Java, objects cannot contain other objects, they can only have *references* to other objects.

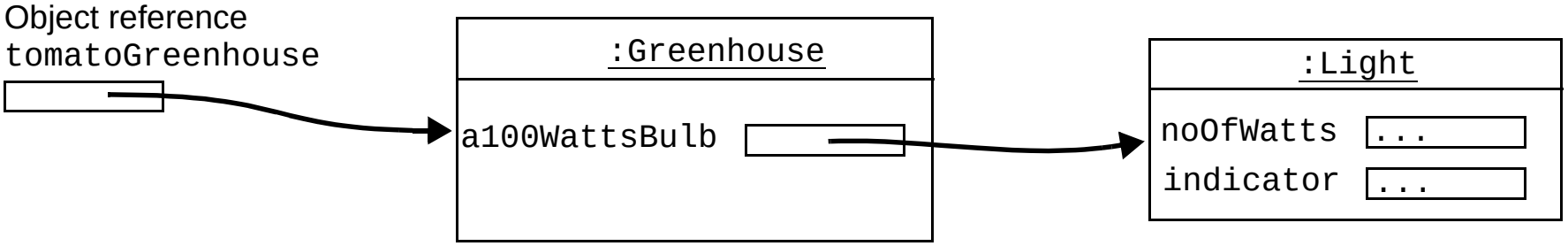
```
class Greenhouse {
    Light a100WattBulb;
    Greenhouse() {
        Light a100WattBulb = new Light();
        // ...
    }
    // ...
}
```

- *Class-diagram* can be used to depict aggregation (*static view*).



```
// Some client
Greenhouse tomatoGreenhouse = new Greenhouse();
```

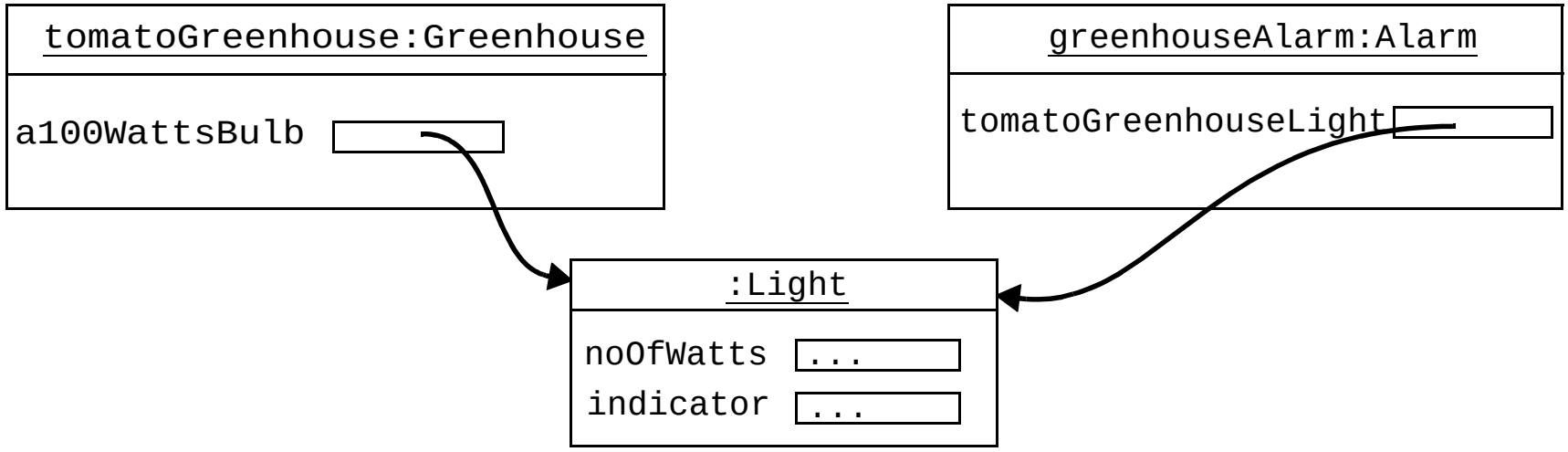
- *Dynamic view* at runtime:




  - Value of the instance variable `a100WattsBulb` is the reference to an object of class `Light`.

# Sharing Constituent Objects

- Aggregate objects can share constituent objects by aliases.



# Communication between Objects

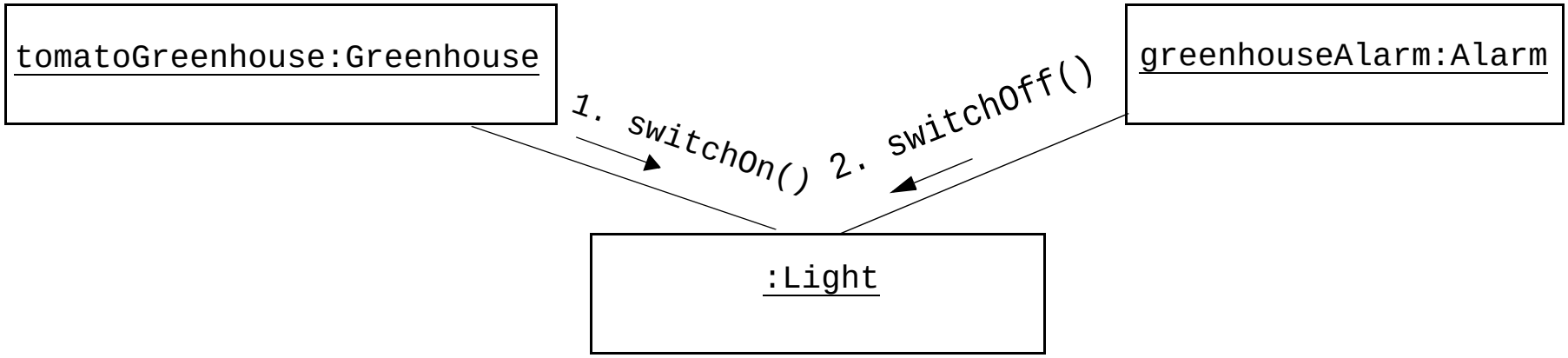
- Given a reference to an object, we can use the reference to invoke methods on the object to elicit particular behavior from the object.

```
// ...
Boolean onFlag = one100WattBulb.isOn(); // call returns a value
if (!onFlag)
    one100WattBulb.switchOn();          // call does not return a value
// ...
```

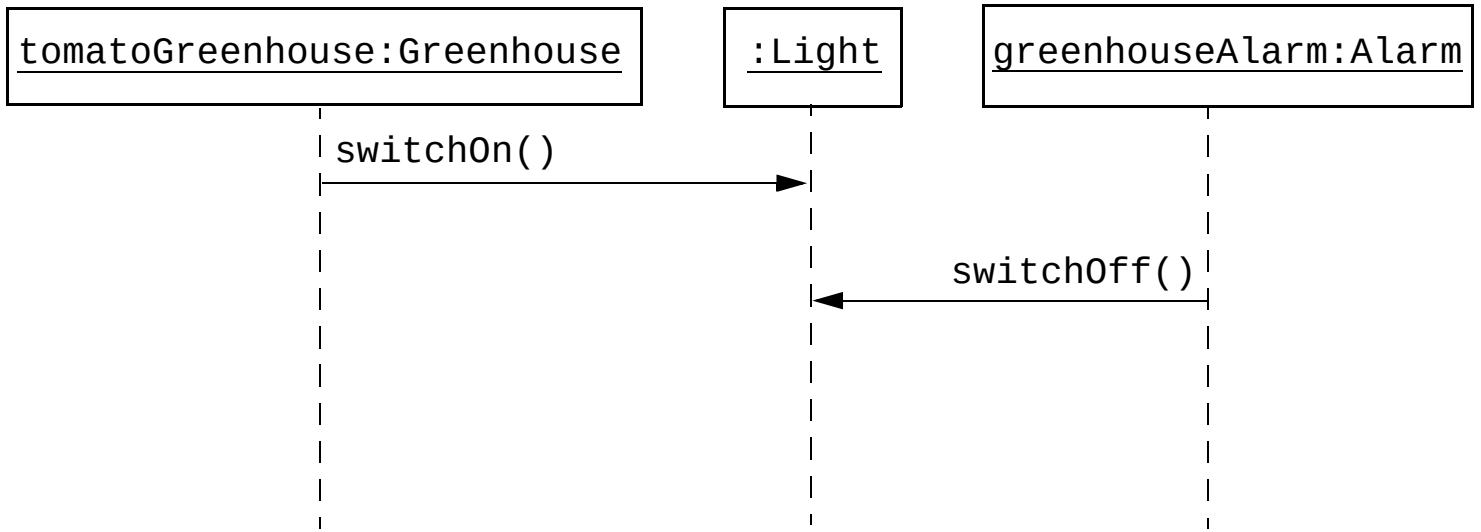
- Objects communicate by calling methods on each other, and return values when appropriate.
- *In OOSD, understanding the communication between objects is an essential part of designing the system.*

# Interaction Diagrams

## Collaboration Diagram




## Sequence Diagram



# Static Members

- There are cases where *members* should only belong to the class, and not be part of any object instantiated from the class.
- Clients can call *static methods* and access *static variables* by using the class name or object references of the class.

**Terminology:**

| | |
|---|---|
| static methods | *class-methods* which only belong to the class |
| static variables | *class-variables* which only belong to the class |
| static members | static variables *and* methods |

*Example:*

We wish to keep track of how many objects of class `Light` have been created.

- We need a "global" counter, but it should not be instantiated with any object of the class.
- We need a "global" method which can be called to find out how many instances have been created.

```
class Light {
    // Instance variables
    private int noOfWatts;          // wattage
    private boolean indicator;      // on or off
    private String location;        // placement
    // Static variable
    private static int counter;     // no. of Light objects created
    // Instance methods
    public void switchOn()  { indicator = true; }
    public void switchOff() { indicator = false; }
    public boolean isOn()   { return indicator; }
    // Static methods
    public static void writeCount() {
         System.out.println("Number of lights: " + counter);
    }
    //...
}
```

# Inheritance

- Classes can be *extended*.
- A *subclass* inherits members (variables and methods) from its *superclass*.

```
class LightBulb extends Light {
    private boolean mat;
    // ...
    public int isMat() { return mat; }
}

class TubeLight extends Light {
    private int tubeLength;
    // ...
    public int getTubeLength() { return tubeLength; }
}
```

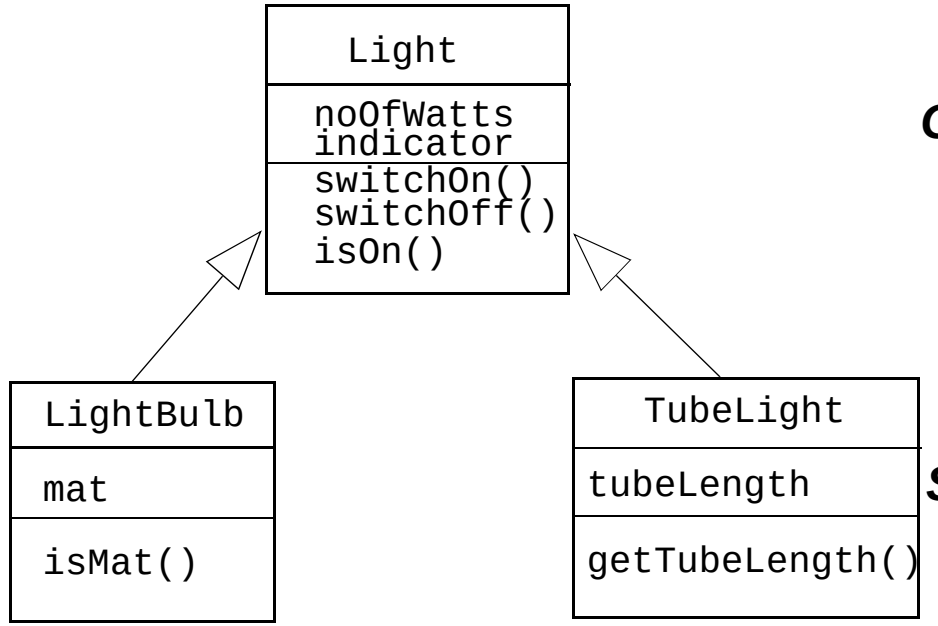
This is called *implementation inheritance*.

*Extensibility by inheritance*

# Inheritance Hierarchy

***Superclass***
***(base class, parent class)***

***Subclass***
***(derived class, child class)***




***Generalization***

***Specialization***

# Encapsulation

- In OOSD, *abstraction* for an object comes before its *implementation*.
- *Abstraction* focuses on visible behavior of an object (called the *contract* or *interface*), whereas *encapsulation* focuses on *implementation* which give this behavior.
- Encapsulation leads to separation of contract and implementation.
  - Objects are regarded as “black boxes” whose internals are hidden.

A class has 2 *views*:

- *Contract* which corresponds to our abstraction of behaviors common to all instances of the class.
  - specification/documentation on how *clients* (i.e. other objects) can use instances of the class, in particular, how each method should be called.
  - WHAT the class offers.
- *Implementation* which corresponds to *representation* of the abstraction and the *mechanisms* which give provide the desired behaviors.
  - comprises of the instance variables and Java instructions which, when executed, give the desired behavior.
  - HOW the class implements its behaviors - *not a concern of the clients*.

*This separation of concerns has major implications in system design.*

# Interfaces - *Programming by Contract*

- Java allows *contracts* to be defined by using *interfaces*.

```
interface ISwitch {
    void switchOn();
    void switchOff();
    boolean isOn();
}
```

- Classes can *implement* interfaces, thereby guaranteeing that they will honor the contract.

```
class Light implements ISwitch {
    // same as before
}
```

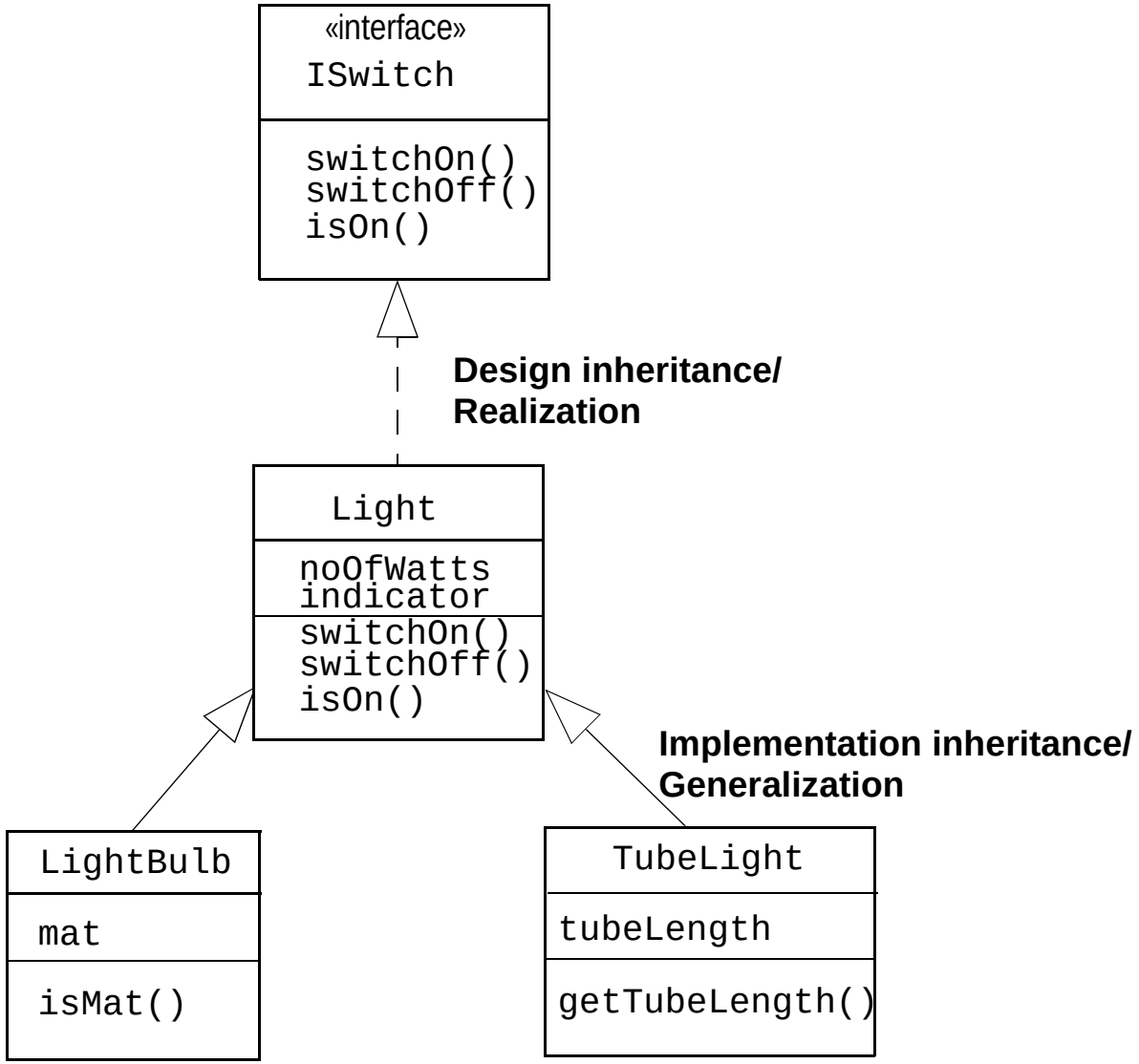
  This is also called *design inheritance*.

  *Note that subclasses* `LightBulb` *and* `TubeLight` *also implement the* `ISwitch` *interface.*

- *Programming by contract* uses interfaces, and not concrete implementations of them.

```
// ...
public void SwitchOnAllLights(ISwitch[] lights) {
    for (int i = 0; i < lights.length; i++)
        lights[i].switchOn();
}
// Elements of array lights can be objects of Light, TubeLight or LightBulb.
```

# Inheritance Hierarchy



# OOP (Object-oriented Programming)

*OOP is an implementation methodology,*

*where a program is organized as a collection of co-operating* ***objects****,*

*where each object is* ***an instance of a class****, and*

*where all classes are members in a hierarchy of classes based on* ***inheritance*** *relationships.*

- If the last criteria is not fulfilled, the implementation methodology is called *OBP* (*Object-based Programming*).
- One major consequence of OOP is that it promotes *code-reuse*, i.e. that classes can be "recycled".

**Data + Methods = Objects**

# Programming Methodology: *Structured Programming*

- "Internals" of objects implemented using structured programming.
- Operations/actions in methods are described by using the following *control structures*:
  - sequence (block)
  - conditionals
  - repetition (loops)
- Structured programming leads to methods that are easier:
  - to understand,
  - to test and debug,
  - to modify and maintain.