CS 635 Advanced Object-Oriented Design & Programming
Spring Semester, 2010
Doc 23 CRC Cards
29 Apr 2010

References

Wirfs-Brock, Designing Object-Oriented Software, 1990, Prentice Hall, chapters 1- 5

Mark Lorenz, Object-Oriented Software Development: A Practical Guide , 1993, Appendix I Measures and Metrics

Wikipedia

Software Development Process

Software Process

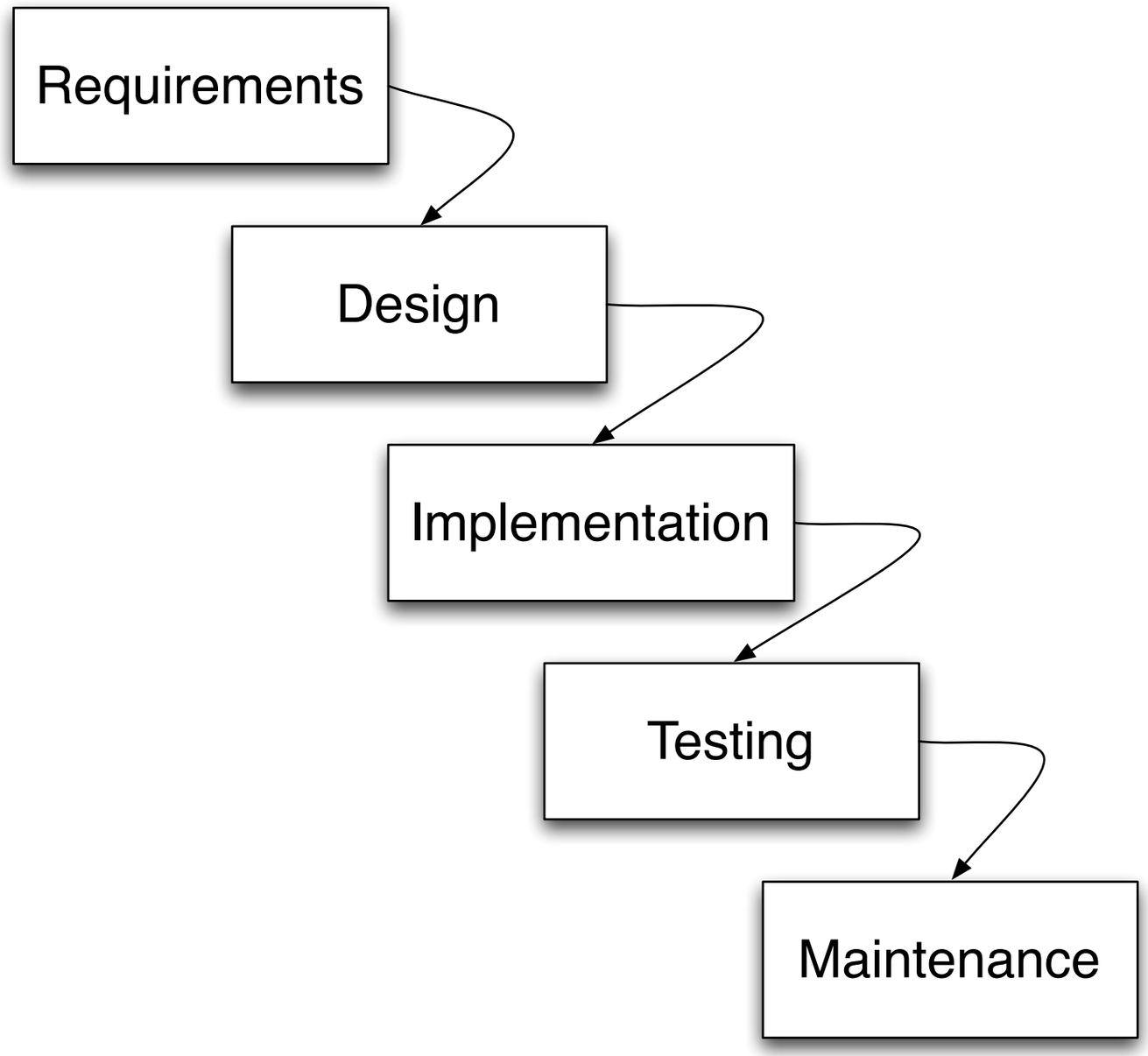
Structure imposed on the development of a software product

From Wikipedia http://en.wikipedia.org/wiki/Software_life_cycle

Software Development Activities

Requirements
Design
Implementation
Testing
Maintenance

Waterfall Methods



The waterfall method was first described in a paper by Winston W. Royce in 1970. In this paper Royce points out bad this method is. However for decades the paper was cited in support of using waterfall methods. Recently his son read the paper and pointed out that his father was against this method

Software development is a learn process

Learning is non-linear

What should it do

How to make it work

What is the design

That was the wrong way

Software development is a Group process

Large groups of people need structure to function

Iterative Methods

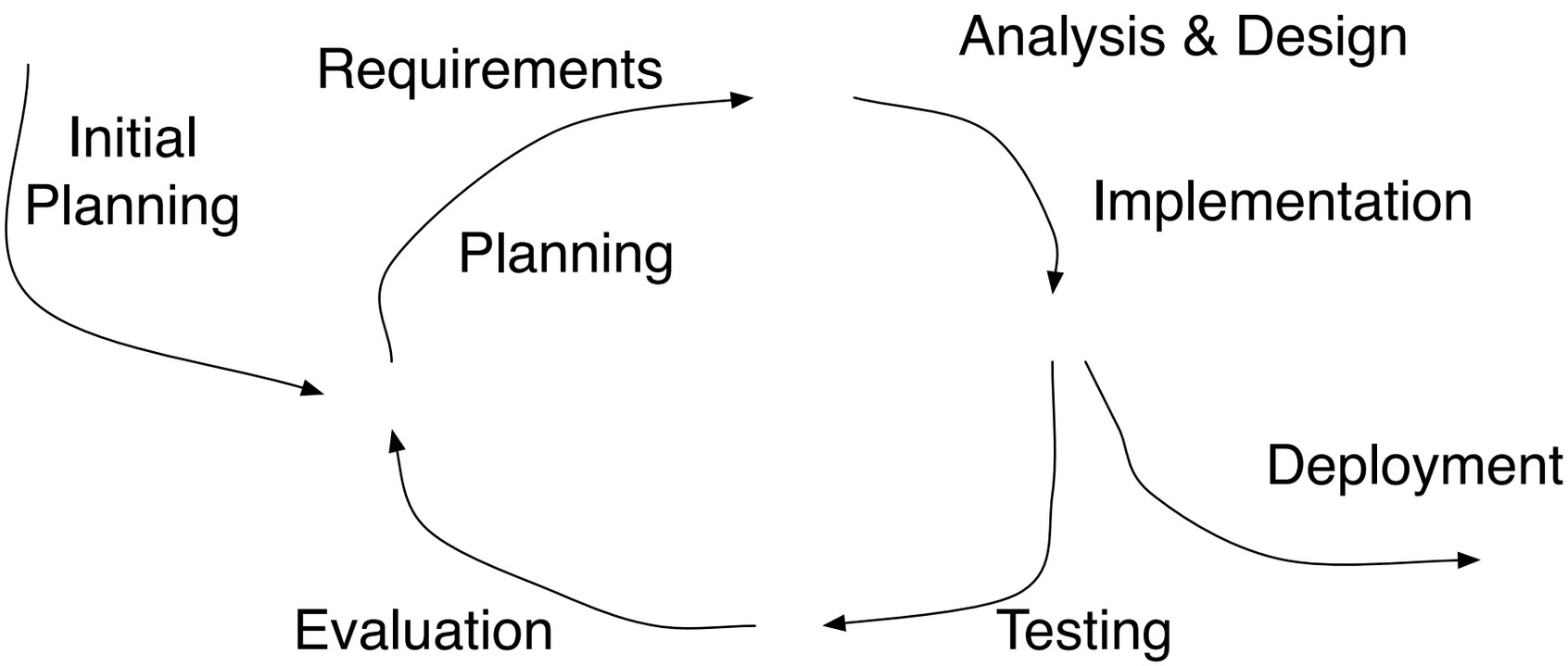


Image from http://en.wikipedia.org/wiki/Iterative_and_incremental_development

Rational Unified Process (RUP)

Formal software process

Heavy weight

Developed by Rational Software

Unified three existing OO software processes

Unified Modeling Language (UML)
- Diagrams to support design

Contains
- 3 building blocks
- 4 project lifecycle phases
- 6 engineering disciplines

Process is highly configurable

Agile Manifesto

Value these	Over these
Individuals and interactions	processes and tools
Working software	comprehensive documentation
Customer collaboration	contract negotiation
Responding to change	following a plan

Agile Methodologies

Short development cycle
    1-4 weeks

Plan only for current cycle

Customer specifies priorities for cycle

Working software at end of cycle

Scrum
Extreme Programming (XP)

Why so many Processes?

People operate differently

Companies operate differently

Projects are different

Customers have different requirements

One OO Design Process

Exploratory Phase

Who is on the team?
What are their tasks, responsibilities?
Who works with whom?

Analysis Phase

Who's related to whom?
Finding sub teams
Putting it all together

This is known as the Responsibility-Driven process. See the Wirfs-Brock book listed in the references.

Exploratory Phase

Who is on the team?

What are the goals of the system?
What must the system accomplish?
What objects are required to model the system and accomplish the goals?

Finding the initial list of classes for the system

Exploratory Phase

What are their tasks, responsibilities?

What does each object have to know in order to accomplish its tasks?
What steps toward accomplishing each goal is it responsible for?

Candidate list of fields and methods

Exploratory Phase

Who works with whom?

With whom will each object collaborate in order to accomplish each of its responsibilities?
What is the nature of the objects' collaboration?

How do the objects interact

Finding Classes

Noun phrases in requirements specification or system description

Model physical objects

Disks Printers Airplanes

Model conceptual entities that form a cohesive abstraction

Window File Bank Account

If more than one word applies to a concept select the one that is most meaningful

Look at these phrases. Some will be obvious classes, some will be obvious nonsense, and some will fall between obvious and nonsense. Skip the nonsense, keep the rest. The goal is a list of candidate objects. Some items in the list will be eliminated, others will be added later. Finding good objects is a skill, like finding a good functional decomposition.

Finding Classes

Be wary of the use of adjectives

- Adjective-noun phrases may or may not indicate different objects
- Is selection tool different than creation tool?
- Is start point different from end point from point?

Be wary of passive voice

- A sentence is passive if the subject of the verb receives the action
- Passive:
  - The music was enjoyed by us
- Active:
  - We enjoyed the music

Model categories of classes

- Categories may become abstract classes
- Keep them as individual classes at this point

Finding Classes

Model known interfaces to outside world

User interfaces

Interfaces to other programs

Write a description of how people will use the system. This description is a source of interface objects.

Model the values of attributes, not the attributes themselves

Height of a rectangle

Height is an attribute of rectangle

Value of height is a number

Rectangle can record its height

Categories of Classes

Data Managers

- Principle responsibility is to maintain data
- Examples: stack, collections, sets

Data Sinks or Data Sources

- Generate data or accept data and process it further
- Do not hold data for long
- Examples: Random number generator, File IO classes

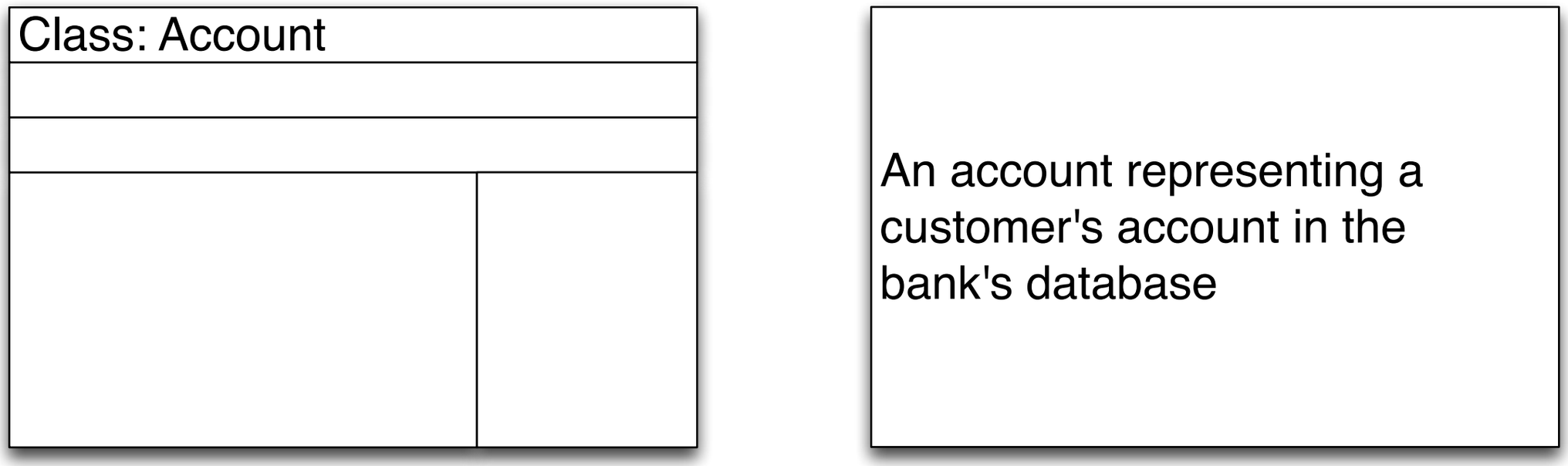
View or Observer classes

- Example: GUI classes

Facilitator or Helper classes

- Maintain little or no state information
- Assist in execution of complex tasks

Record Your Candidate Classes



Record the class name on the front of an index card. One class per card. Write a brief description of the overall purpose of the class. The front of the card will be filled in with information as the design process continues. If you prefer to use some other medium (8 1/2" by 11" sheets of paper, computer program) do so. The goal is a tool that will enhance exploring the model. Once you are experienced with object-oriented design, you may find better tools. However, while learning, it is hard to find a cheaper tool than index cards. Even when you have a fancy case tool you might find yourself using these cards to help with designing parts of programs.

Finding Abstract Classes

An abstract class springs from a set of classes that share a useful attribute. Look for common attributes in classes, as described by the requirement

Grouping related classes can identify candidates for abstract classes

Name the superclass that you feel each group represents

Record the superclass names

Class: Drawing	
Superclass name	
Subclass name	

Finding Abstract Classes

If you can't name a group:

- List the attributes shared by classes in the group and derive the name from those attributes
- Divide groups into smaller, more clearly defined groups

If you still can't find a name, discard the group

Responsibilities

The knowledge an object maintains

The actions an object can perform

General Guidelines

Consider public responsibilities, not private ones

Specify what gets done, not how it gets done

Keep responsibilities in general terms

Define responsibilities at an implementation-independent level

Keep all of a class's responsibilities at the same conceptual level

Identifying Responsibilities

Requirements specification

- Verbs indicate possible actions
- Information indicates object responsibilities

The classes

- What role does the class fill in the system?
- Statement of purpose for class implies responsibilities

Walk-through the system

- Imagine how the system will be used
- What situations might occur?
- Scenarios of using system

Scenarios

Scenario

A sequence of events between the system and an outside agent, such as a user, a sensor, or another program

Outside agent is trying to perform some task

The collection of all possible scenarios specify all the existing ways to use the system

Normal case scenarios

Interactions without any unusual inputs or error conditions

Special case scenarios

Consider omitted input sequences, maximum and minimum values, and repeated values

Error case scenarios

Consider user error such as invalid data and failure to respond

Identifying Scenarios

Read the requirement specification from user's perspective

Interview users of the system

Normal ATM Scenario

The ATM asks the user to insert a card; the user inserts a card.

The ATM accepts the card and reads its serial number.

The ATM requests the password; the user enters "1234."

The ATM verifies the serial number and password with the ATM consortium; the consortium checks it with the user's bank and notifies the ATM of acceptance.

The ATM asks the user to select the kind of transaction; the user selects "withdrawal."

The ATM asks the user for the amount of cash; the user enters "$100."

The ATM verifies that the amount is within predefined policy limits and asks the consortium to process the transaction; the consortium passes the request to the bank, which confirms the transaction and returns the new account balance.

The ATM dispenses cash and asks the user to take it; the user takes the cash.

The ATM asks whether the user wants to continue; the user indicates no.

The ATM prints a receipt, ejects the card and asks the user to take them; the user takes the receipt and the card.

The ATM asks a user to insert a card.

Special Case ATM Scenario

The ATM asks the user to insert a card; the user inserts a card.

The ATM accepts the card and reads its serial number.

The ATM requests the password; the user enters "9999."

The ATM verifies the serial number and password with the ATM consortium; the consortium checks it with the user's bank and notifies the ATM of rejection.

The ATM indicates a bad password and asks the user to reenter it; the user hits "cancel."

The ATM ejects the card and asks the user to take it; the user takes the card.

The ATM asks a user to insert a card.

Assigning Responsibilities

Assign each responsibility to the class(es) it logically belongs to

Evenly Distribute System Intelligence

Intelligence:

- What the system knows
- Actions that can be performed
- Impact on other parts of the system and users

Example: Personnel Record

Dumb version

- A data structure holding name, age, salary, etc.

Smart version

- An object that:
- Matches security clearance with current project
- Salary is in proper range
- Health benefits change when person gets married

Evenly Distribute System Intelligence

The extremes:

- A dictator with slaves
- Dumb data structure with all intelligence in main program and few procedures
- Class with no methods
- Class with no fields

Object utopia

- All objects have the same level of intelligence

Reality

- Closer to utopia than to dictator with slaves

Reality check

- Class with long list of responsibilities might indicate budding dictator

Metric Rules of Thumb

The average method size should be less than

8 lines of code (LOC) for Smalltalk

24 LOC for C++

Bigger averages indicate object-oriented design problems

The average number of methods per class should be less than 20

Bigger averages indicate too much responsibility in too few classes

The average number of fields per class should be less than 6.

Bigger averages indicate that one class is doing more than it should

The class hierarchy nesting level should be less than 6

Start counting at the level of any framework classes you use or the root class if you don't

From Mark Lorenz, *Object-Oriented Software Development: A Practical Guide* , 1993, Appendix I Measures and Metrics

Assigning Responsibilities

State responsibilities as generally as possible

Assume that each kind of drawing element knows how to draw itself. It is better to say "drawing elements know how to draw themselves" than "a line knows how to draw itself, a rectangle knows how to draw itself, etc."

Keep behavior with related information

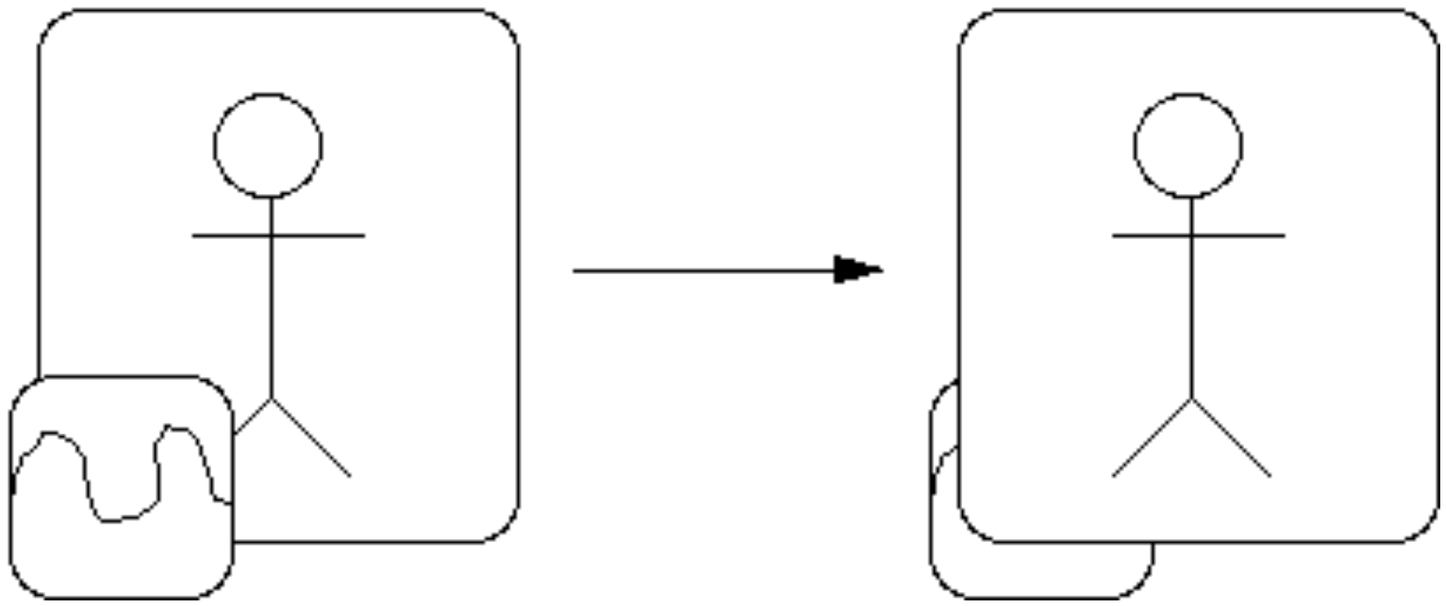
Abstraction implies we should do this

Keep information about one thing in one place

If two or more objects need the same information:

- Create a new object to hold the information
- Collapse the objects into a single object
- Place information in the more natural object

Share Responsibilities



Who is responsible for updating screen when window moves?

Examining Relationships Between Classes

is-kind-of or is-a

- Implies inheritance
- Place common responsibilities in superclass

is-analogous-to

- If class X is-analogous-to class Y then look for superclass

is-part-of or has-a

- If class A is-part-of class B then there is no inheritance
- Some negotiation between A and B for responsibilities may be needed

Example:

- Assume A contains a list that B uses
- Who sorts the list? A or B?

Common Difficulties

Missing classes

A set of unassigned responsibilities may indicate a need for another class

Group related unassigned responsibilities into a new class

Arbitrary assignment

Sometimes a responsibility may seem to fit into two or more classes

Perform a walk-through the system with each choice

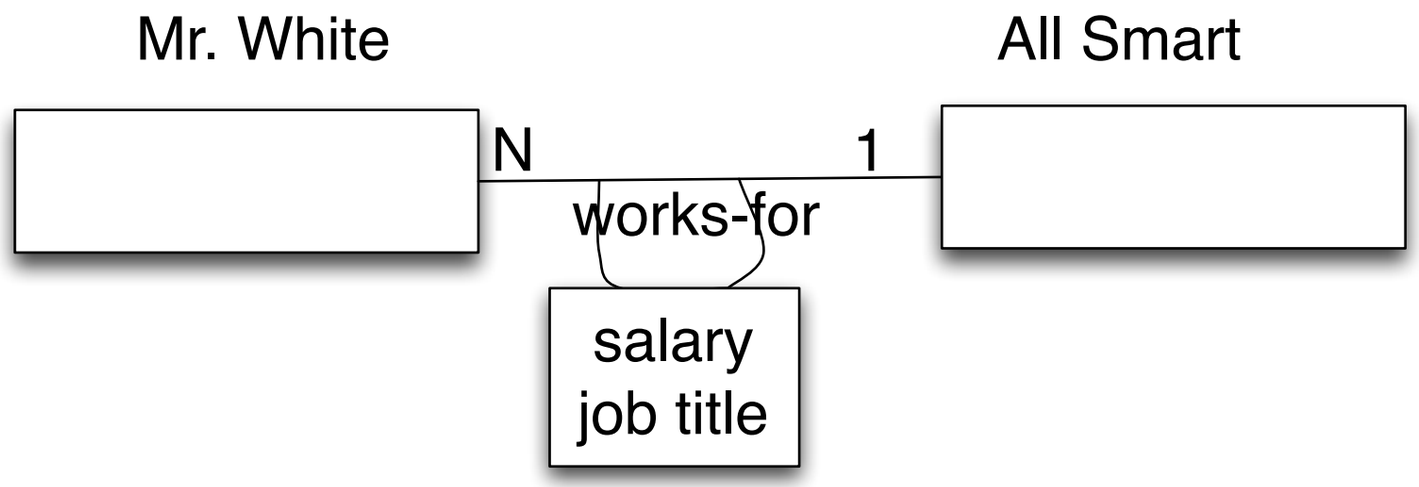
Ask others

Explore ramifications of each choice

If the requirements change then which choice seems better?

Relations

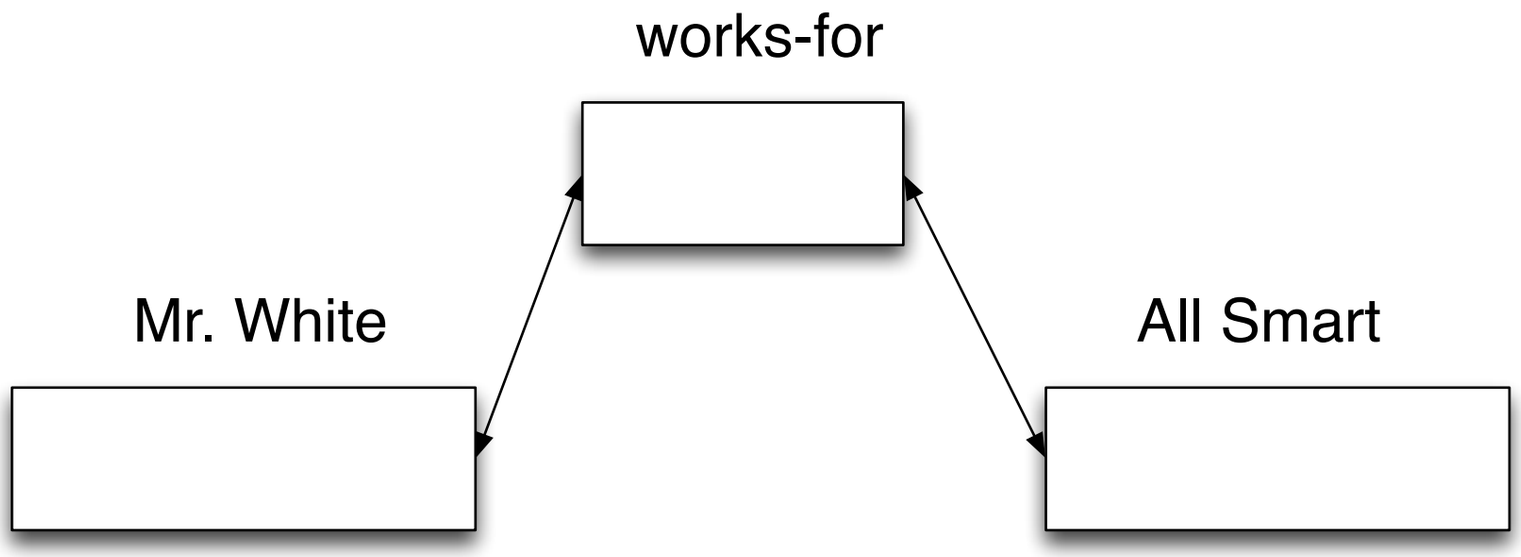
Model View



If need both directions

Two Pointers

If need both directions



Recording Responsibilities

Class: Drawing	
List responsibilities here	

Class: Drawing	
Know which elements it contains Maintain ordering between elements	

Collaboration

Represents requests from a client to a server in fulfillment of a client responsibility

Interaction between objects

Finding Collaborations

Examine class responsibilities for dependencies

For each responsibility:

- Is class capable of fulfilling this responsibility?
- If not, what does it need?
- From what other class can it acquire what it needs?

For each class:

- What does this class do or know?
- What other classes need the result or information?
- If class has no interactions, discard it

Finding Collaborations

Examine scenarios

Interactions in the scenarios indicate collaboration

Common Collaboration Types

The is-part-of relationship

X is composed of Y's

Composite classes

Drawing is composed of drawing elements

Some distribution of responsibilities required

Container classes

Arrays, lists, sets, hash tables, etc.

Some have no interaction with elements

Recording Collaborations

Class: Drawing	
Know which elements it contains Maintain ordering between elements	 Drawing element