
From Domain Classes and Use Cases to Design Classes

CRC Cards Technique

("Responsibility-Driven Design")

- Informal, non-detailed
- Used for group brain-storming
- End result is a first cut at **classes** for an object-oriented model,
- Not intended to provide a **complete** design

Use-Case Input

- A good **starting point** for CRC analysis is a clear statement of all of the use-cases.
- Use-cases drive the introduction of CRC cards.
- Use-cases, or their accompanying scenarios, can be used as a kind of script for the **role-playing method** of checking the CRC cards.
- The role-playing could be replaced with sequence diagrams.

CRC

- Stands for:
 - Classes
 - Responsibilities
 - Collaborations
- (Not as in "CRC Handbook": "Chemical Rubber Company")

CRC

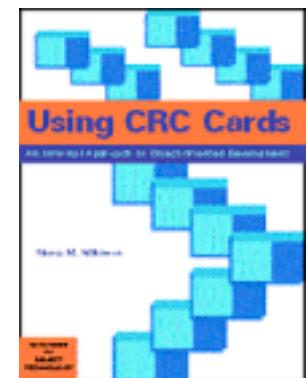
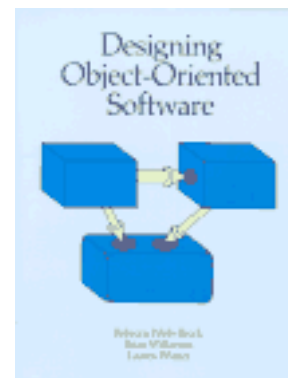
- Stands for:
 - Classes (of objects)
 - Responsibilities (of the objects in each class)
 - Collaborations (with objects in other classes)
 - In UML, these will be examples of "associations"
- Remember that an application may have "singleton" classes (classes instantiated only once).

Origin of CRC

- Kent Beck and Ward Cunningham, formerly of Tektronix in Oregon
- Rebecca Wirfs-Brock popularized with "Responsibility-Driven Design" (RDD)

References

- Rebecca Wirfs-Brock, Brian Wilkerson, Lauren Wiener, *Designing Object-Oriented Software*, Prentice-Hall, 1990.
- David Bellin and Susan Simone, *The CRC Card Book*, Addison Wesley Longman, 1997.



The Basic Idea

- Develop set of cards or cards images.
- Each card represents one class.
- A card contains:
 - The **name** of the class.
 - The **responsibilities** of the class.
 - **Collaborations**: other classes with which this class inter-operates, in conjunction with the attendant responsibility.

CRC cards represent a *static* view of the system's classes

- Domain class diagrams similarly static.
- Must eventually be augmented by dynamic description, e.g. sequence diagrams.
- Informal dynamic description can be acted out with "role-playing", similar to the creation of scenarios for use cases.

Image of CRC cards

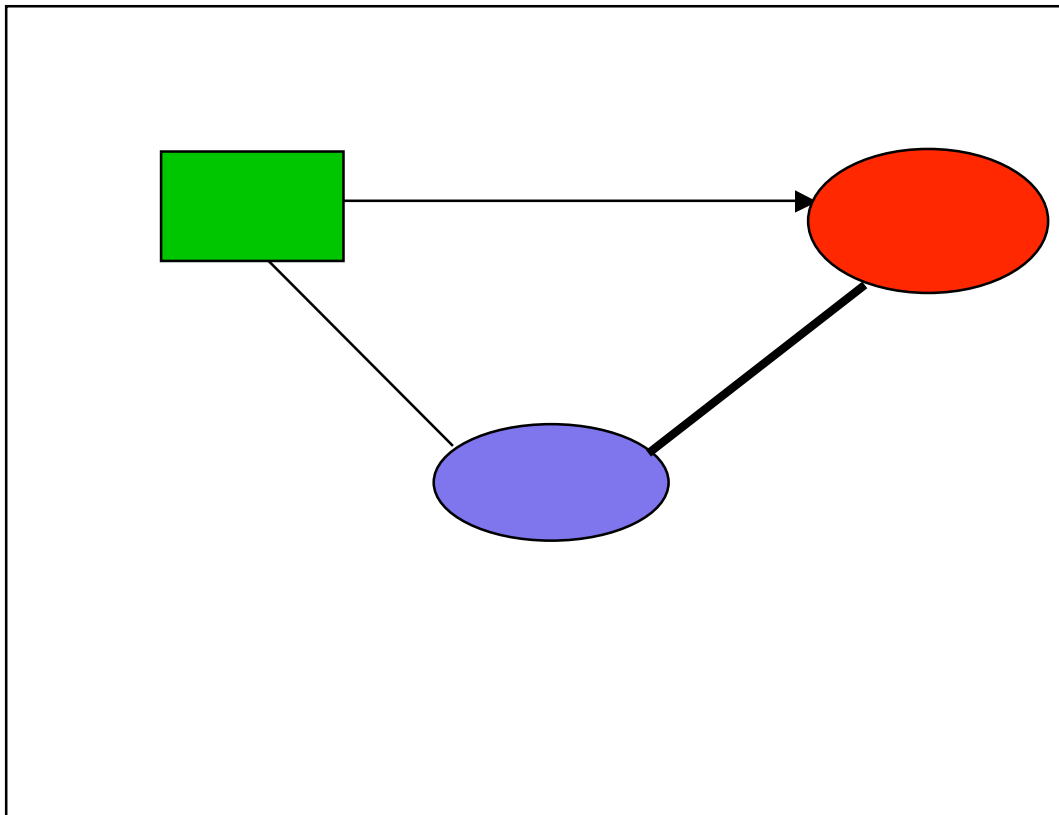
Class Name	super class
	sub-classes
Responsibilities	Collaborations
_____	_____
_____	_____
_____	_____

Use index cards, or single PowerPoint slides.

Limiting the size of a card is an attempt at preventing the class from becoming too complex.

Sample Application: A graph-drawing program

Possible screen image



**Typical Application
Use-Cases:**

- Draw shape
- Move shape
- Resize shape
- Connect shapes
- Erase shape
- Erase connector

Example of CRC card for a graph-drawing program (1)

Class



Shape

Example of CRC card for a graph-drawing program (2)

Responsibilities



Shape

Remember size

Remember position

Remember fill color

Remember border

Remember connectors

Change size

Change position

Example of CRC card for a graph-drawing program (3)

Shape

Remember size

Remember position

Remember fill color

Remember border → Line

Remember connectors → Connector


Change size

Change position

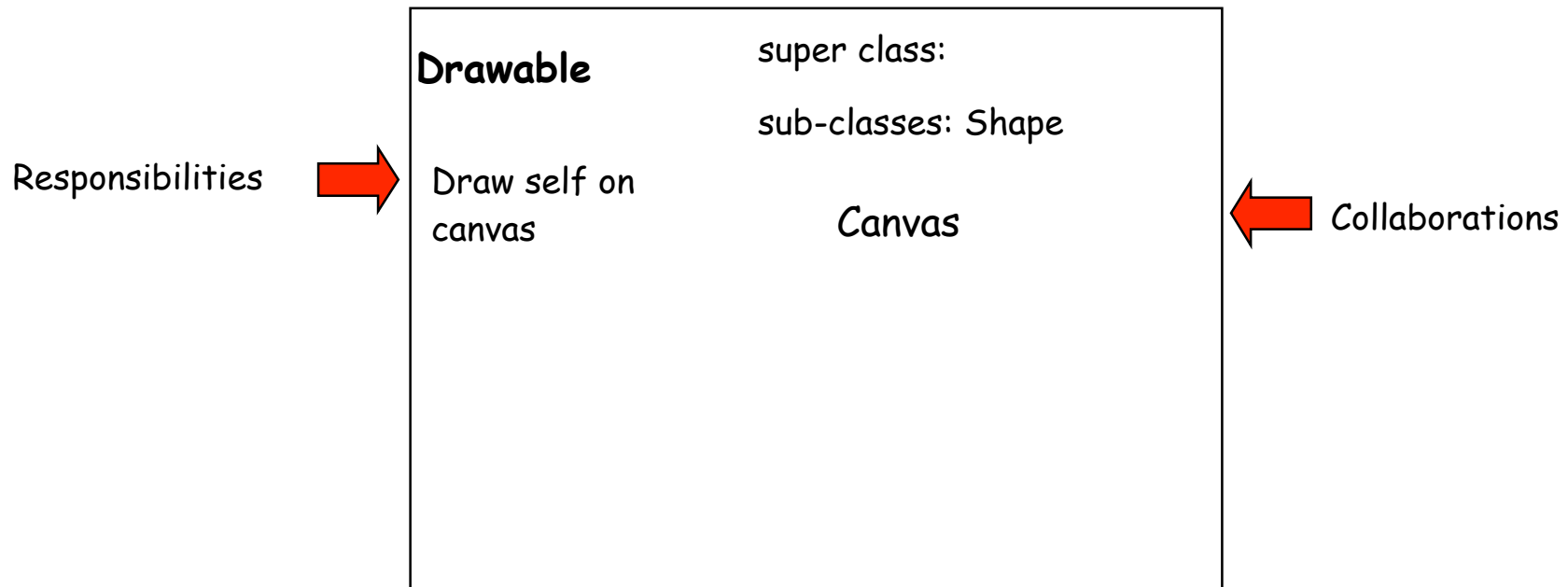
← Collaborations

Example of CRC card for a graph-drawing program (4)

Shape	super class: Drawable
	sub-classes: Rect, Oval, Group
Remember size	
Remember position	
Remember fill color	
Remember border	Line
Remember connectors	Connector
Change size	
Change position	

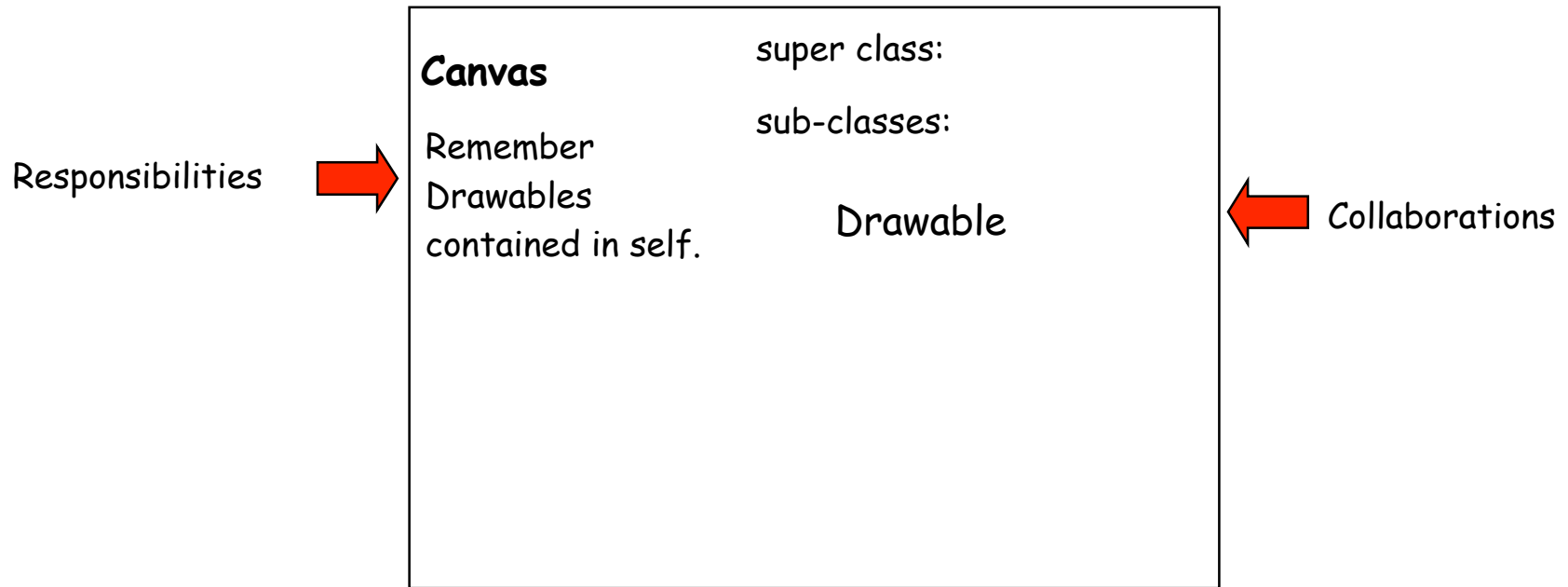
 Super- and Sub-classes

Example of CRC card for a graph-drawing program (5)



Note: The Drawable doesn't necessarily need to *remember* a Canvas, since the Canvas could be passed as an argument to the *draw* method.

Example of CRC card for a graph-drawing program (6)



Note:

- Responsibilities are usually for *members* (objects) of the class rather than the class itself, although
- Class-wide responsibility is possible (corresponding to **static method**)

Attribute Value vs. Object

- An object of a class typically has one or more *attributes*.
- Attributes have *values* that specify or describe the object.
- A value might or might not deserve the distinction of being an object itself; It depends on what we intend to do with the attribute.
- A would-be attribute that is object-valued is actually a *collaboration* (*association* in UML).

Immutable Objects

- Some objects only "know", but don't "do" anything.
- They can't be changed once created, and therefore are called *immutable*.
- Values of attributes are often either immutable objects or scalars (non-objects).
- Can immutable objects have collaborations?

CRC Team Structure

- Usually ≤ 6 person team is recommended
- The team can include clients as well as developers (even though we are partly in the design phase)
 - 1-2 domain experts
 - 1-2 analysts
 - experienced object-oriented designer
 - leader

Once the CRC cards are constructed ...

- Team can engage in **role-playing** to verify that use-case **scenarios** make sense for chosen CRC.
- Each person can role-play one or more class cards.
- If something doesn't work, change the class accordingly.
- Revision of use-cases might also be indicated.

Use-Case to Class

Traceability Matrix Example

(from the graph-drawing example)

Class: Responsibility

Use Case

	Drawing: remember components	Shape: draw	Shape: remember position	Shape: remember size	Shape: remember connectors	Connector: draw	Connector: remember start	Connector: remember end
Draw shape	x	x	x	x				
Move shape		x	x		x			
Erase shape	x				x		x	x
Resize shape		x	x	x	x			
Connect shapes	x				x	x	x	x
Erase connector	x				x			

Contracts

- Pre- and Post-Conditions of a Use Case could be considered as a **contract**:
 - Environment ensures pre-condition
 - Use-case ensures the post-condition

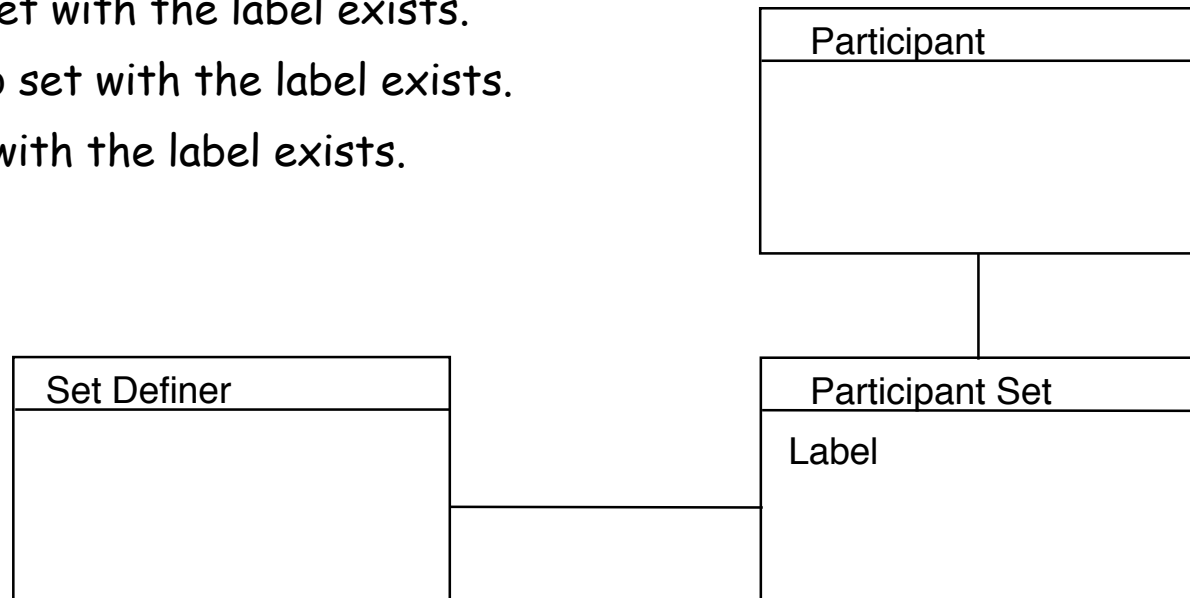
Use of Pre- and Post-Conditions

- Post-condition can be considered a precise statement of what is accomplished by a use-case.
- Pre-condition can be considered a precise statement of what can be assumed.

Example Use Case from Meeting Scheduler:

DissolveSet: Dissolve a Participant Set Having a Given Label

- Goal: To enable a set definer to dissolve a set no longer used.
- Actors: Set definer
- Initiator: Set definer
- Description: The set definer dissolves an existing list. Participants on are notified.
- **Pre-conditions:** A set with the label exists.
- **Post-conditions:** No set with the label exists.
- Exception: No set with the label exists.
- Options
- Scenario



Strength of Conditions

- The stronger the pre-condition, the easier life is for the implementer.
- The stronger the post-condition, the harder it is.

Post-Conditions are Not Actions

- Post-conditions are properties of state, not actions.
- They do not address how the property is obtained, only **that** it is obtained.

"Design by Contract"

- This is a slogan being pushed by Bertrand Meyers (inventor of the Eiffel language).
- Meyers' interpretation is quite strict, and relates to class implementation (more later).