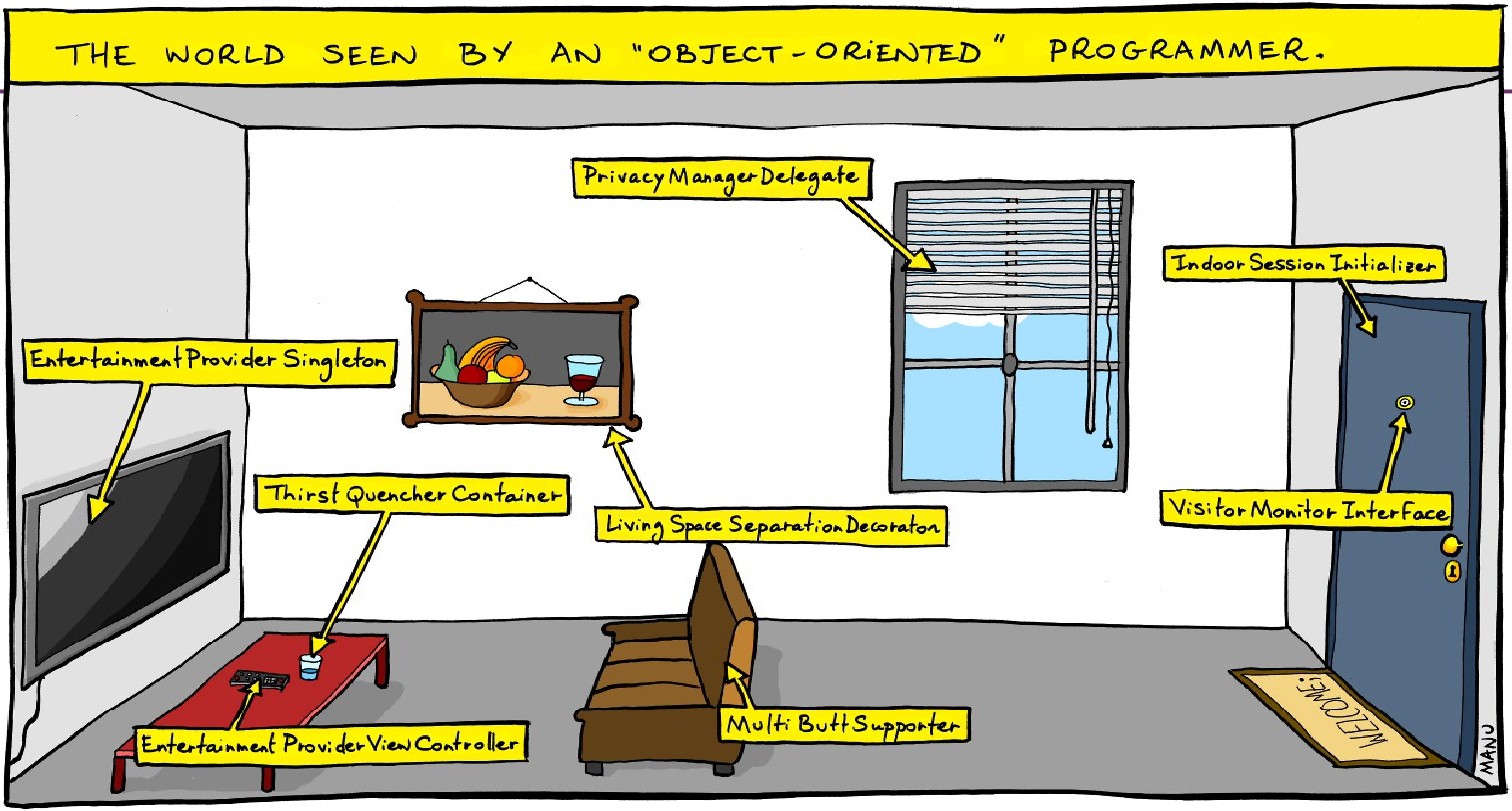
THE WORLD SEEN BY AN "OBJECT-ORIENTED" PROGRAMMER.
Privacy Manager Delegate
Indoor Session Initializer
Entertainment Provider Singleton
Thirst Quencher Container
Living Space Separation Decorator
Visitor Monitor Interface
Multi Butt Supporter
Entertainment Provider View Controller
WELCOME!
MANU

Object-Oriented Analysis and Design

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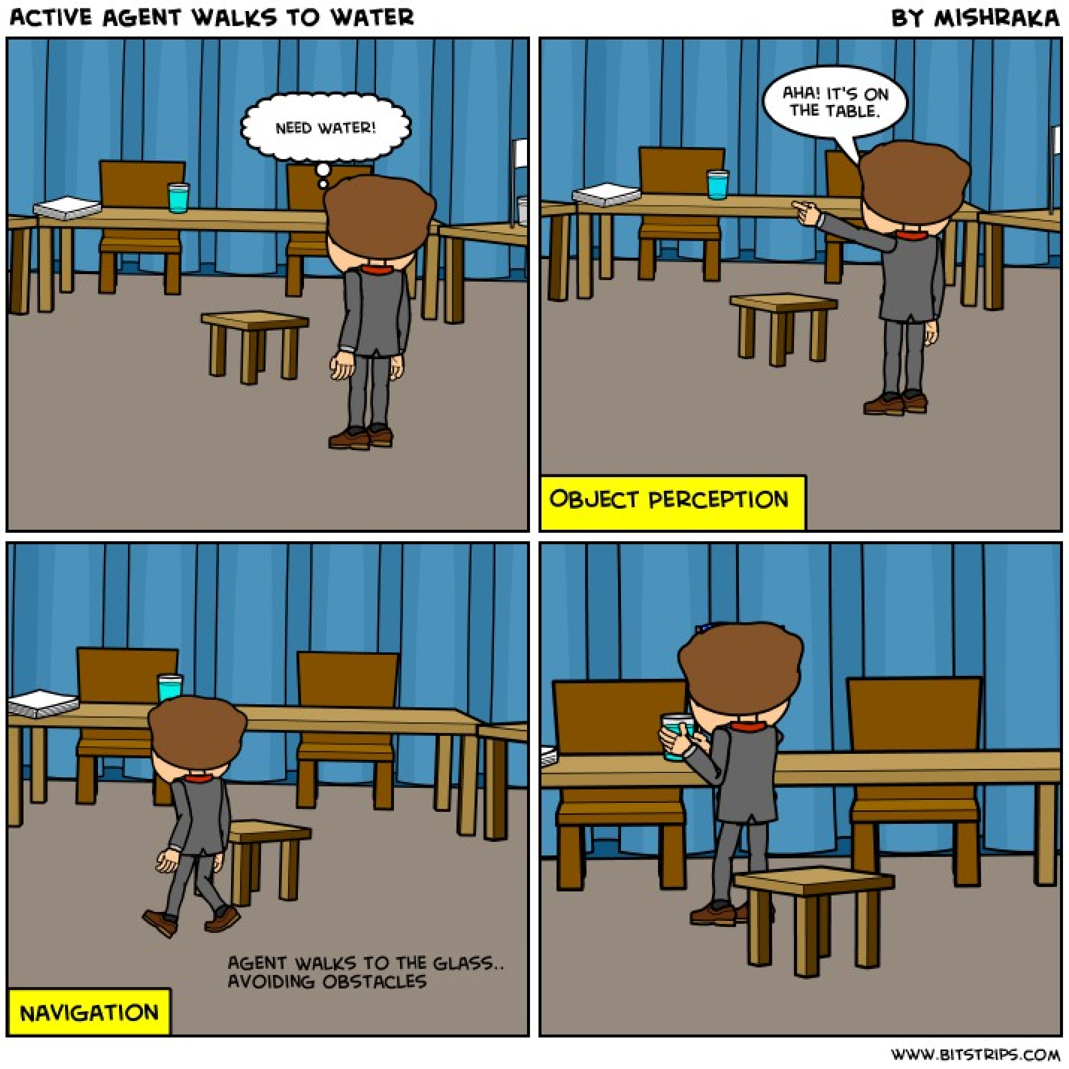
How to Think in Terms of Objects?

- The desired end result of OO design is a robust and functional object model —— a system.

- Don't try to conform to any standards or conventions when solving a problem.
- The whole idea is to be creative.



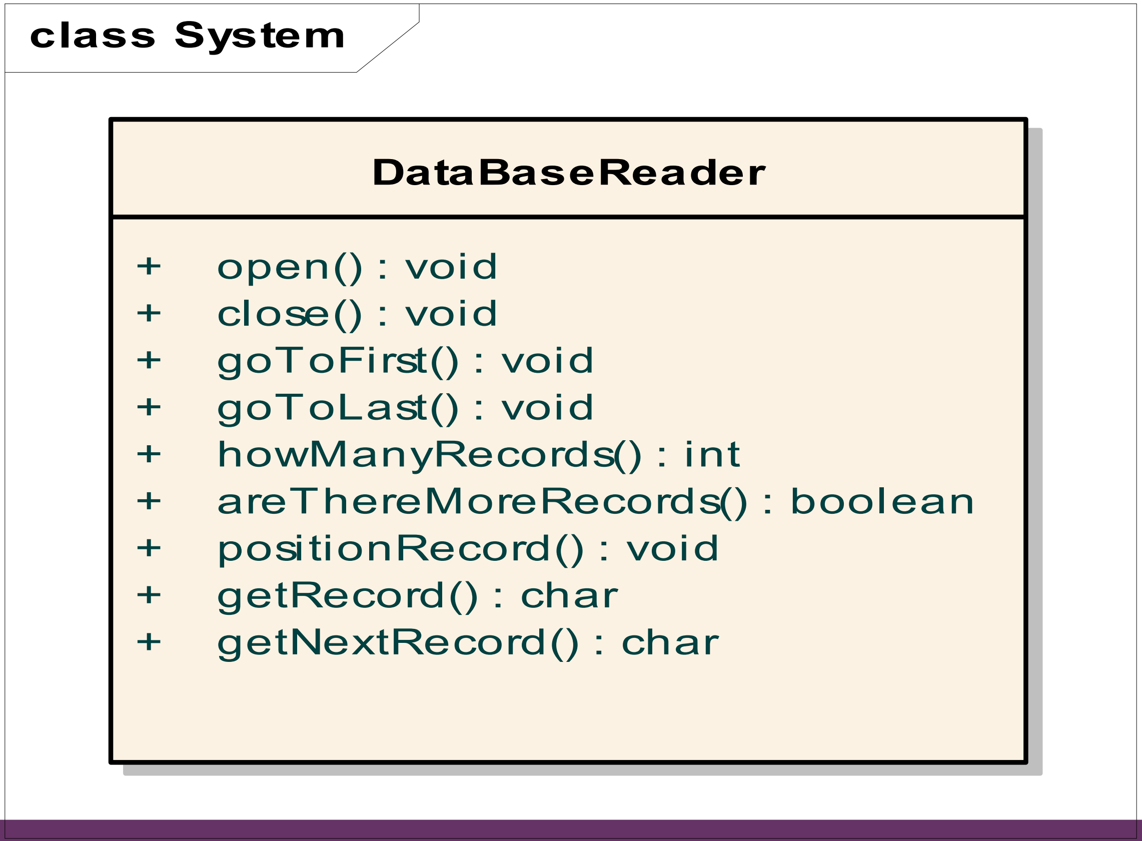
Three important things

- To develop a good sense of OO thought process:
  - ✧Knowing the difference between the interface and implementation
  - ✧Thinking more abstractly
  - ✧Giving the user the minimal interface possible

Object ID Focus Applications
RENTAL SERVICES Libraries, Cars & Laundries
LOGISTIC SERVICES Documents, Factories & Supply Chain Management
HEALTHCARE SERVICES Equipments, Devices & Pharmaceuticals

区分接口与实现

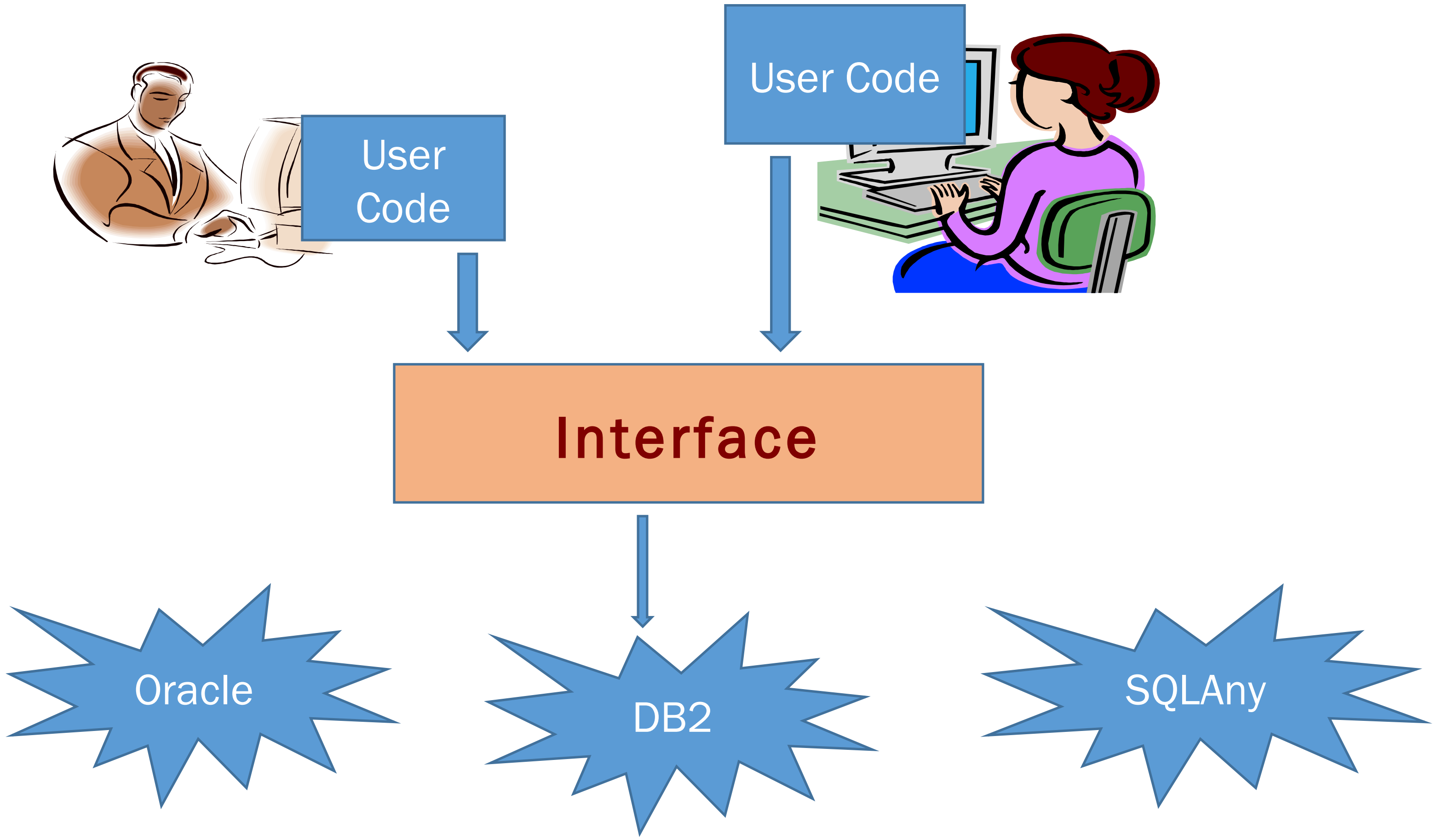
- 接口的标准化 vs. 实现的演进



```
public void open(string name) {
/* some application-specific processing */
/* call the Oracle API to open the DB*/
/* more application specific processing */
}
```

```
public void open(string name) {
/* some application-specific processing */
/* call the SQLAnywhere to open the DB*/
/* more application specific processing */
}
```

The Interface

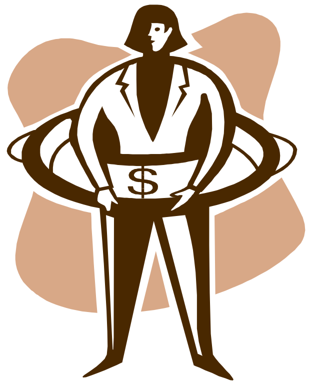


Using Abstract Thinking When Designing Interfaces

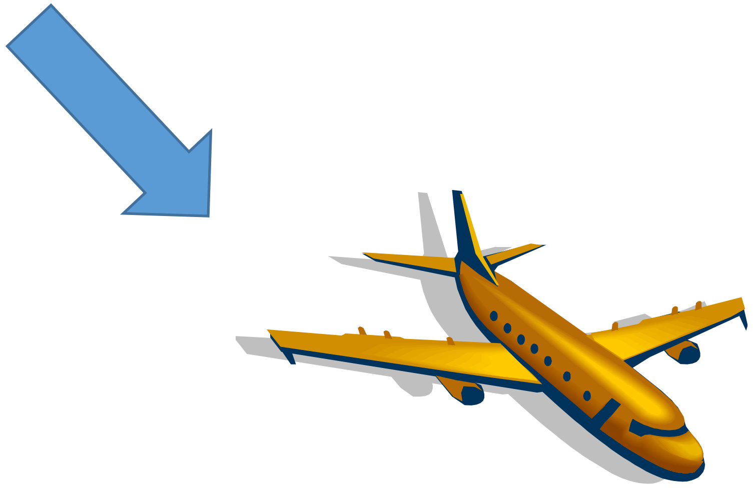
设计抽象的接口

抽象的接口

Abstract

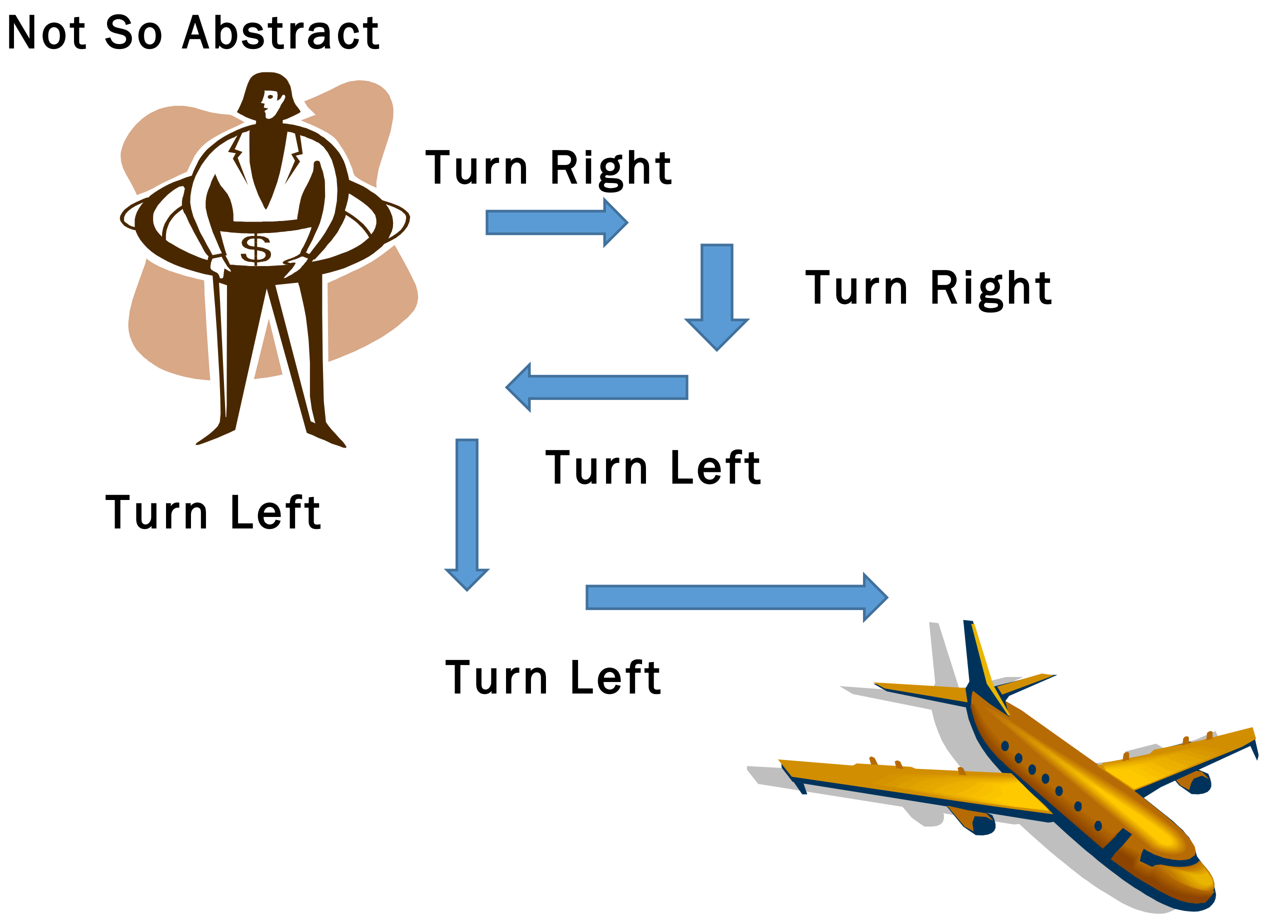


Take me to the Airport



不太抽象的接口

TAXI


Not So Abstract
Turn Right
Turn Right
Turn Left
Turn Left
Turn Left

Giving the User the Minimal Interface Possible

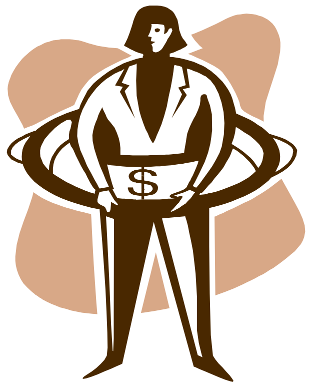
- Provide the user with as little knowledge of the inner workings of the class as possible:
  - Give the users only what they absolutely need
    只给必须的
  - Public interface are all the users will ever see
    只看公开的
  - Design class from user’s perspective, not IS/technical perspective
    只为用户考虑 最小用户负担原则

Determine the Users

- Customers ? 50%
- Services Principle

Provide Service:
As long as I make
a profit

Engage Service:
As long as I don’t
pay too much



Determine Object Behaviors

Use Cases!!!

Many earlier choice will not survive public interface cuts!

Identify Environmental Constraints

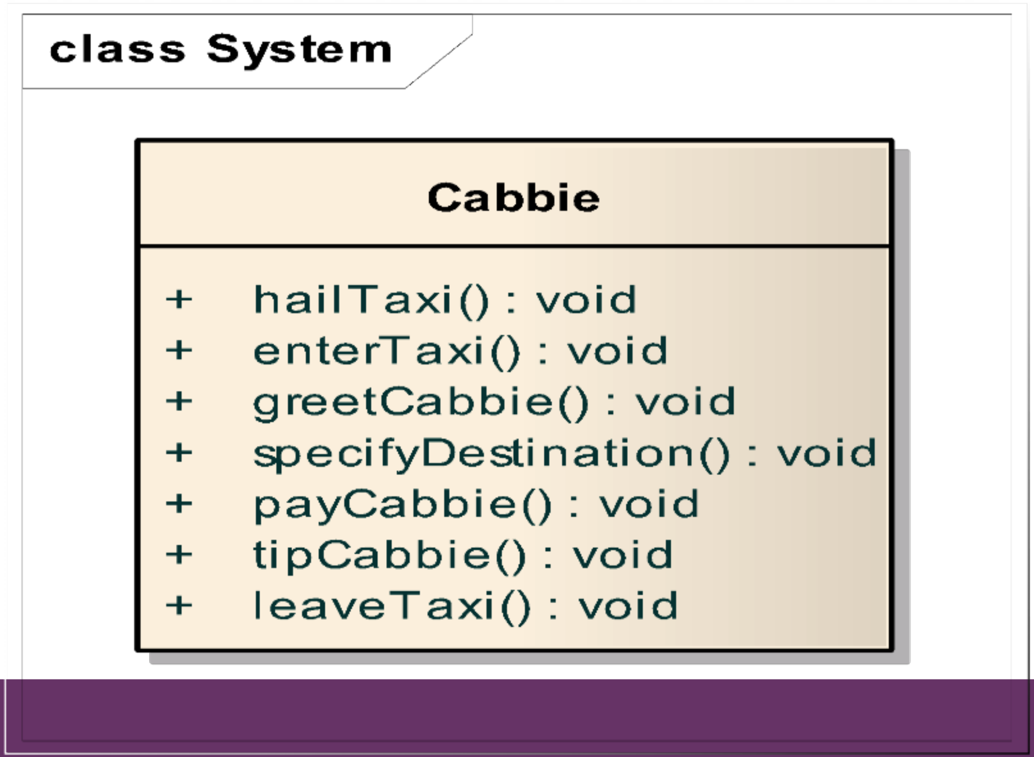
Environments impose limitations on what an object can do.

Pre/Post/Exceptions…

Identifying public Interfaces

- How to use taxi object:
  - Get into the taxi
  - Tell the cabbie where you want to go
  - Pay the cabbie
  - Give the cabbie a tip
  - Get out of the taxi.

- What to do to use Taxi:
  - Have a place to go
  - Hail a taxi
  - Pay the Cabbie Money



Identifying the Implementation

- **Anything other than the public interface** can be considered the implementation
- Users will **never** see any of it **ever**
    - methods signature (name and parameter list)
    - Actual code inside
- Anything considered implementation can **change w/o affecting the interface**
- Implementation provide **answers** to the user **expects**
- Interface provides how user sees the object, while the implementation is the **nuts and bolts** of the objects
- Implementation contains the **code** that **represents the state** of an objects

Object-Oriented Analysis (OOA)

- OOA is a collection of like-minded requirements modeling and analysis techniques for software systems.

- Proposed in the late 80's, such techniques have been influenced primarily by object-oriented programming, but also semantic data models and semantic networks.

- Basic idea: streamline software development by making objects, classes, methods and the like the atomic units out of which one builds requirements, designs and implementations.

Basic Concepts

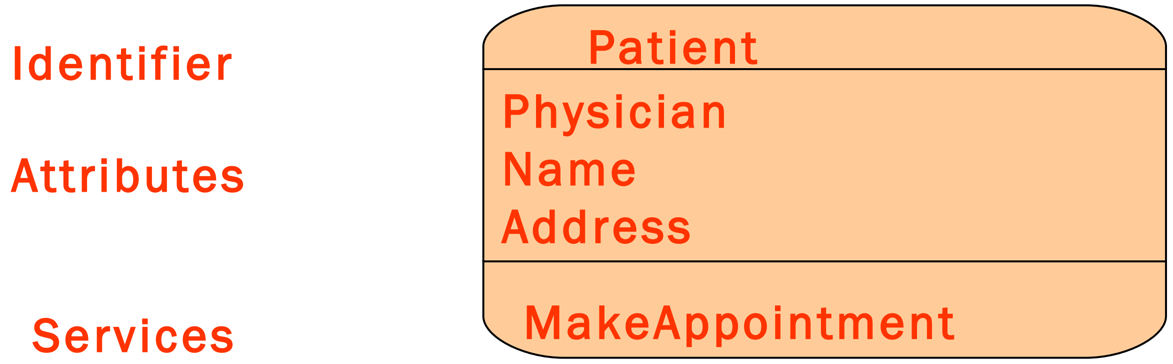
- Such techniques focus on the things that exist within the application domain, model them with objects.
- These techniques use classification, generalization, aggregation to structure object assemblies.
- Actions (services/activities) are associated with objects.
- State changes are effected by actions performed on objects.

Origins of Object-oriented Analysis

- Object-Oriented Programming – Tries to adopt as many of the O-O programming features to O-O design and analysis [Booch86]
- Database design – adopts semantic data modeling ideas, including E-R diagrams and generalization, aggregation, classification [Chen 76]
- Structured Analysis – including SADT and other Structured analysis techniques [Ross 77]
- Knowledge Representation – uses ideas from fr network representations [Borgida85]

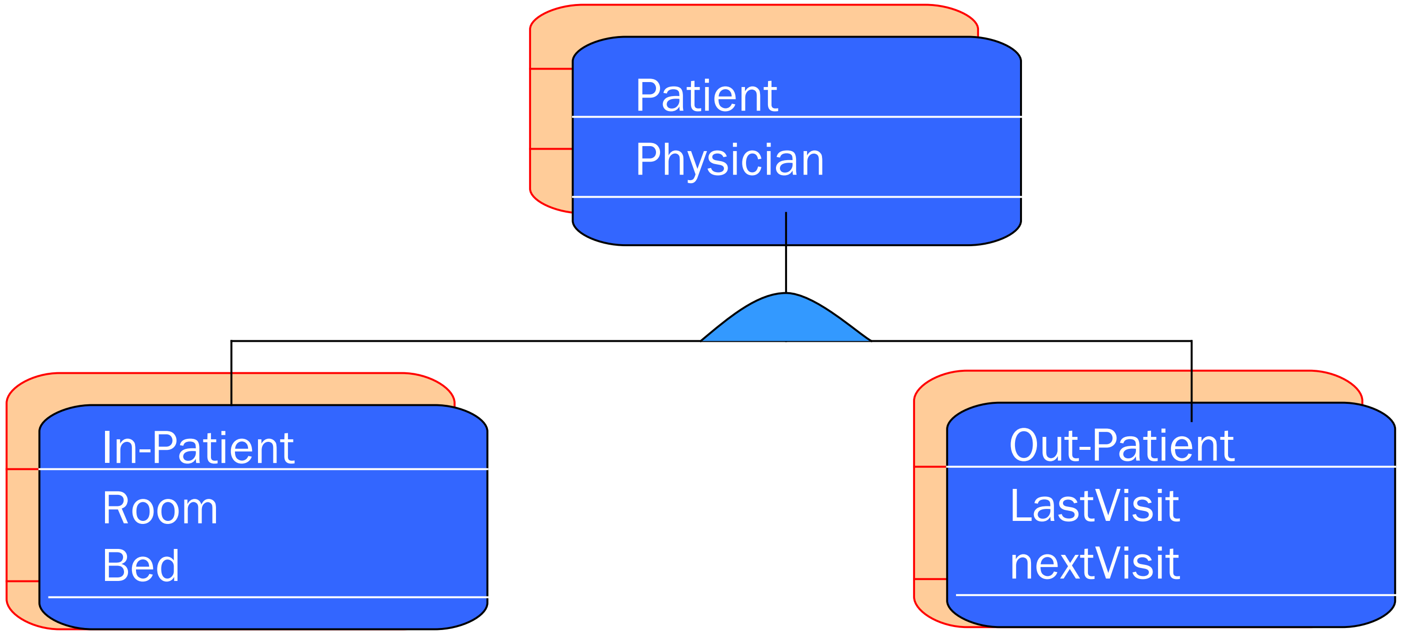
Coad's Object-oriented Analysis

- Proposed by Peter Coad *[Coad91]*
- An object is defined as a real world entity related to the problem domain, with "crisply defined boundaries".
- Objects are encapsulated with attributes and behavior.
- OOA offers five kinds of concepts: objects, attributes, structures, services and subjects.



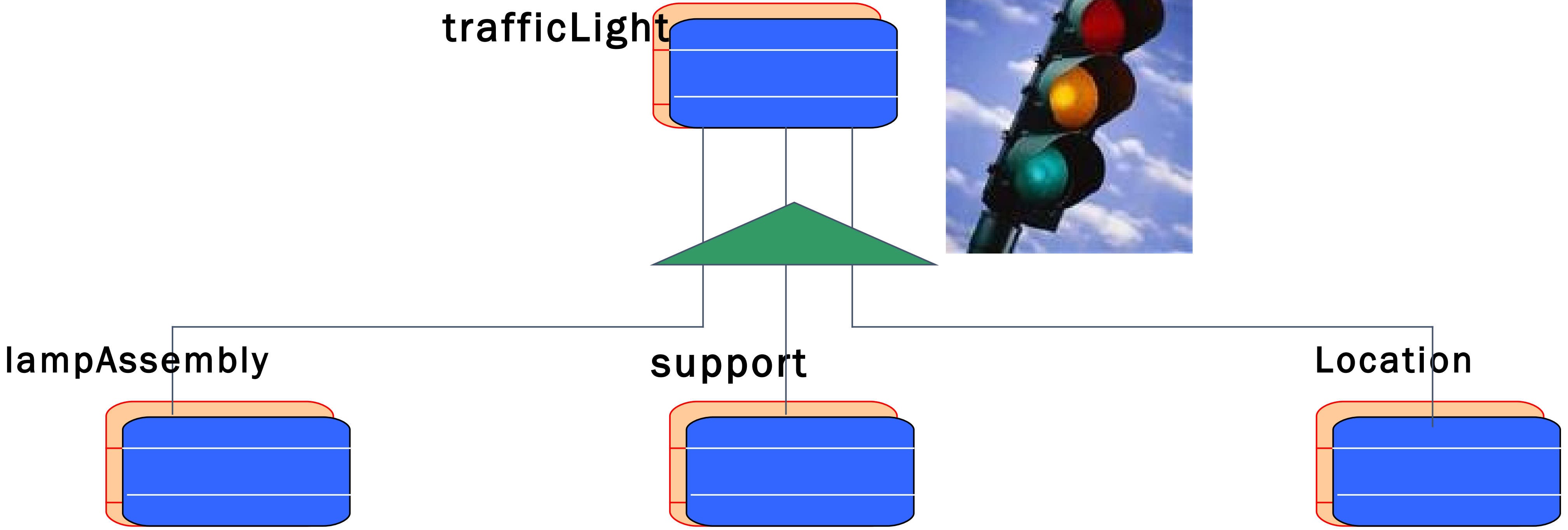
Gen-Spec Structures

- Gen-Spec (generalization/specialization) structures organize classes into taxonomies. Patients are either in-patients or out-patients. The physician attribute of patients is inherited by both in-patients and out-patients.



Whole-Part Structures

- Whole-Part structures describe an object as an assembly of other objects. A traffic light consists of 0 to 3 lampAssemblies, a single support and a single location.

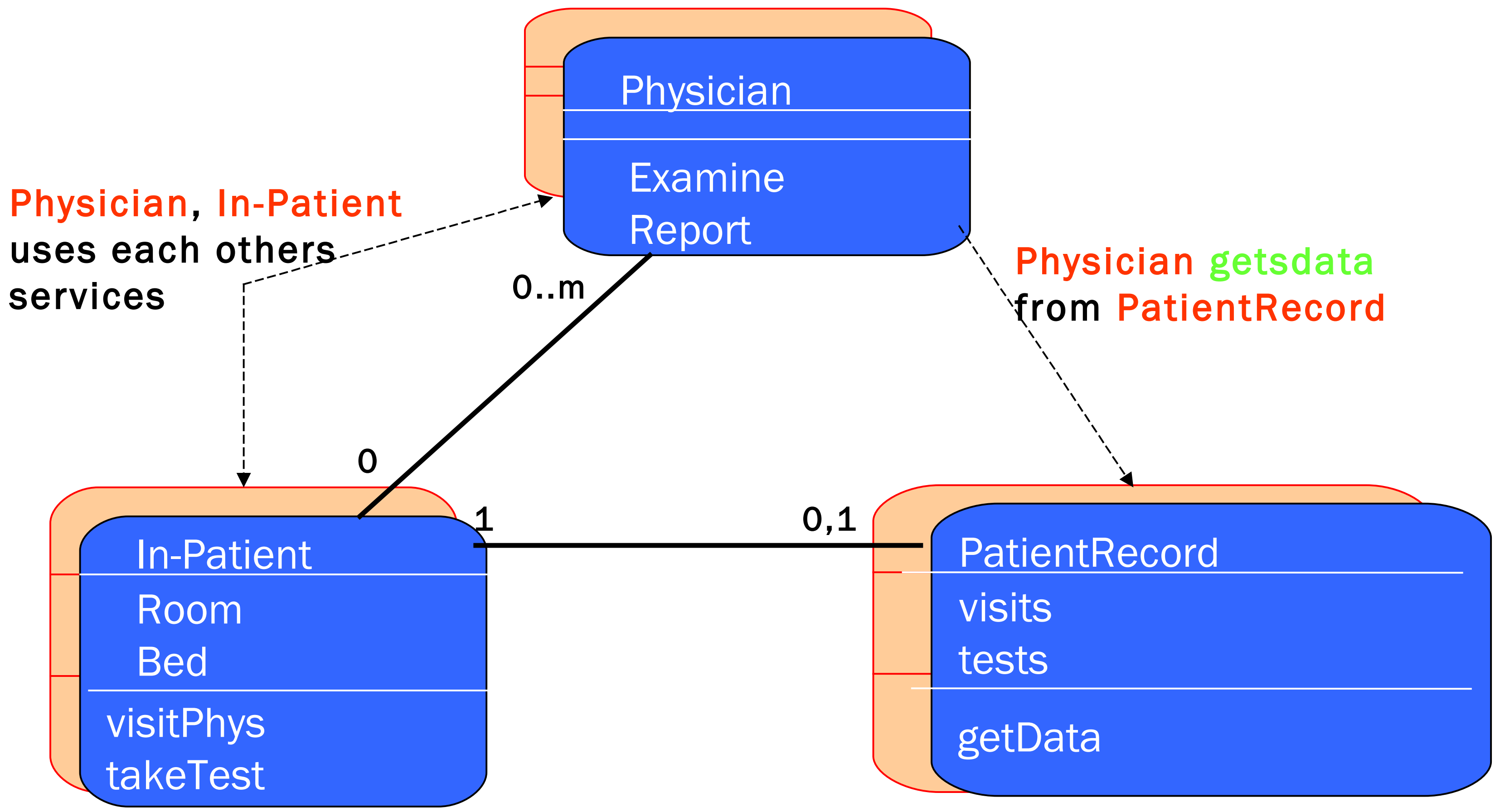


Services

- Objects provide services to other objects in their environments. For example, a physician object may provide services **examine**, **report.**
- Coad distinguishes three types of services:
  - Occurrence services, whereby objects are created, destroyed, changed, ...;
  - Calculate services, where an object performs a calculation for some other object;
  - Monitor services, where an object is monitoring some process to see if some condition applies;
- A special notation is used (dashed-line arrow) to indicate that an object is using services from another object.

OOA views the world with Smalltalk Glasses

Services and relationships



Methodology

- Identify objects and classes (i.e., generic objects)
- Identify structures and build generalization, aggregation hierarchies.
- Define subjects. These partition all the objects and classes of an object model into subject layers, which represent the application from a particular perspective. Often whole Gen-Spec or Part-Whole structures are grouped under one subject.
- Identify information that should be associated with each object. Place attributes at the right structural level.
- Define services for each class.

Terms of different approaches

OOA (Rumbaugh)	OOSE (Jacobson)	OOD (Booch)	OMT
		Metaclass	
Object	*Instance*	*Object*	*Object*
Gen-Spec	*Inheritance*	*inherits*	*Generalization*
Whole-Part	*Consists-of*		*Aggregation*
Instance conn.	*Acquaintance*		*Link*
Message	*Stimuli*	*Message*	*Event*
Message conn.	*Communication*		
Attribute	*Attribute*		*Attribute*
Service	*Operation*		*Operation*
Subject	*~View (subsystem)*		*Sheet*
(Execution thread)	*Use case*		*~Scenario*
(user)	*Actor*		

What is Good about OOA?

- Advances the state-of-practice!
- Earlier prevalent modeling techniques, such as structured analysis (SA), data flow diagrams (DFD), entity-relationship diagrams (ERD), … were:
  - Fragmented, e.g., use of data flow and entity-relationship diagrams
  - Weakly structured: see DFD and ERD
  - Informal: see DFD
  - Based on an outdated programming paradigm (structured programming)

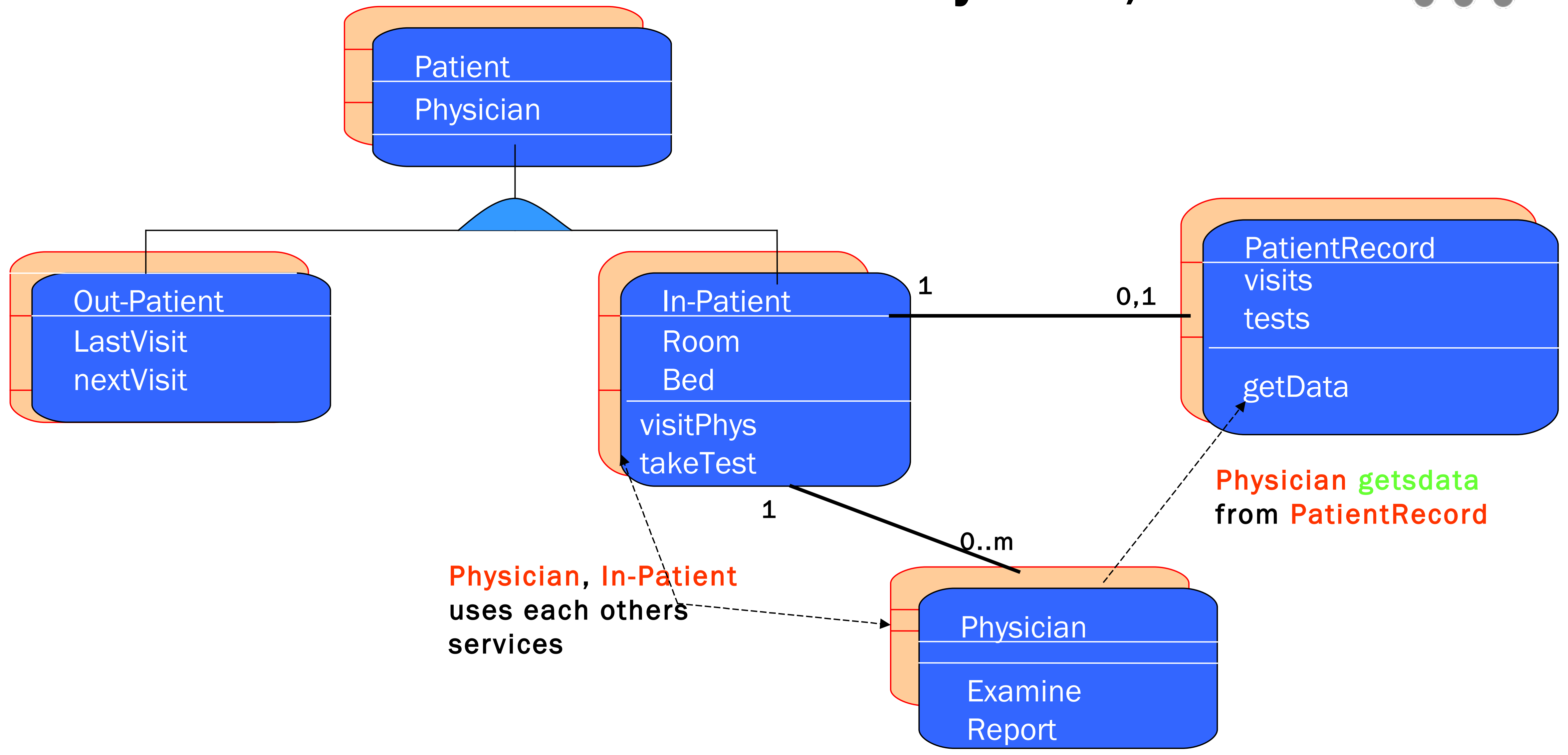
What is questionable about OOA?

- Is OOA intended for modeling software, or applications? If only the former, then it is meant for requirements modeling!

- Its ontological assumptions. Who says that **objects, relationships, services** and the like constitute a good set of primitive concepts for modeling the real world?...organizations?...people? ...industrial processes?

- The promise of easier design and implementation won't work for large systems where requirements, design and implementation have drastically different architectures and are based on very different concepts.

What does this model? ---A system, or the world?

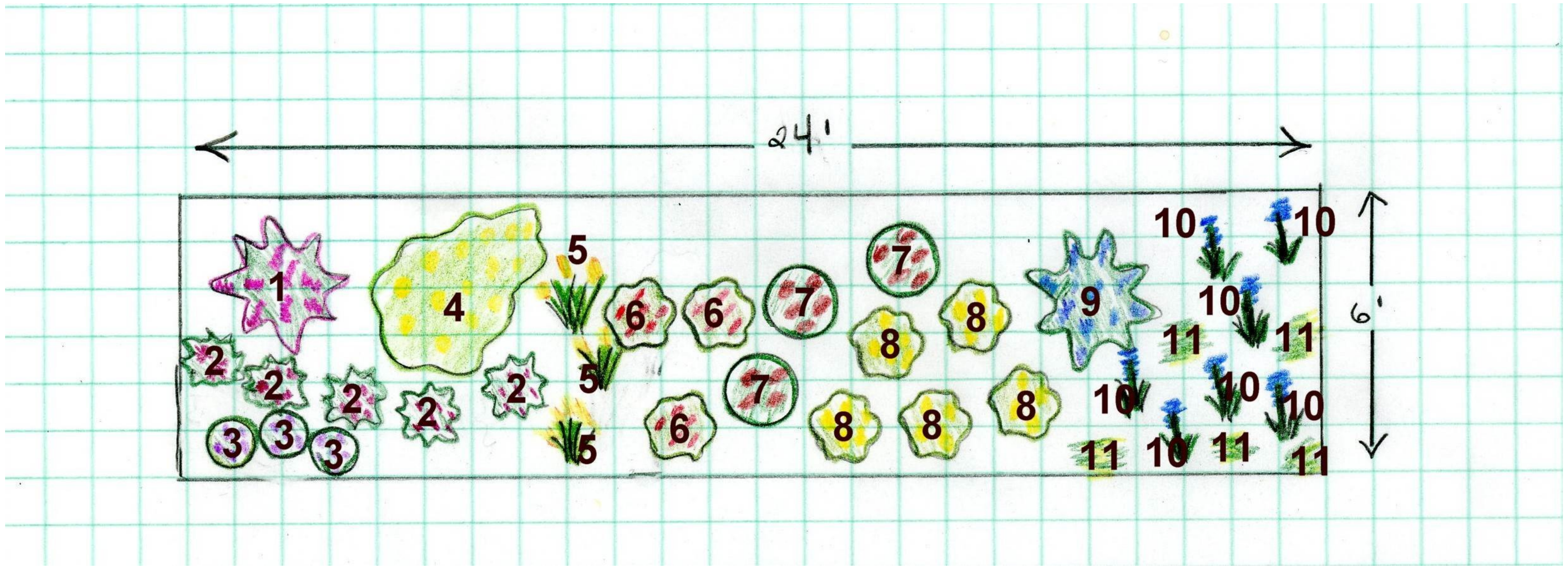


The ongoing design process

Despite the best intentions and planning, in all but the most trivial cases, the design is an ongoing process…

Even after a product is in testing, design changes pop up.

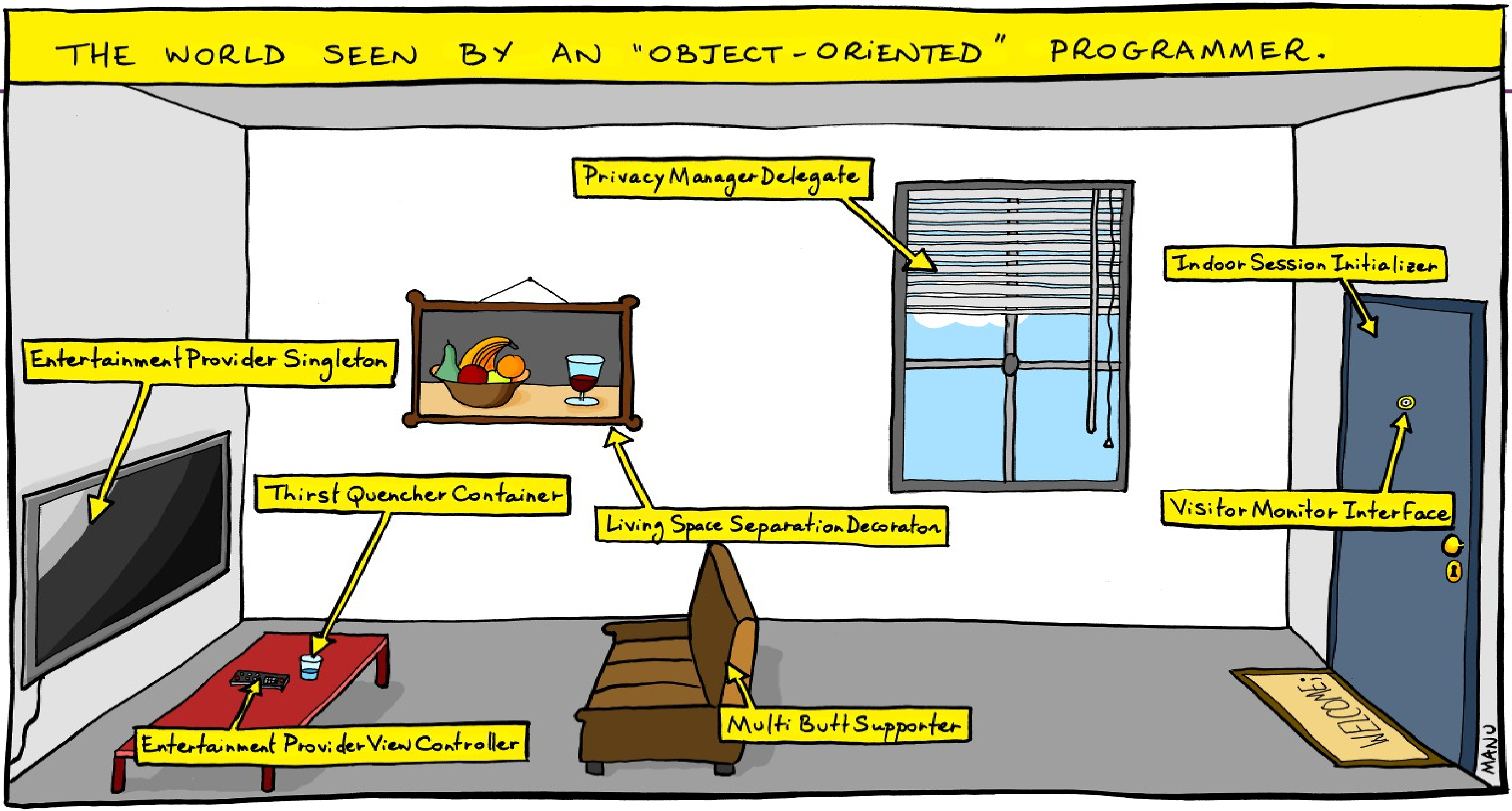
It is up to the project manager to draw the line that says when to stop changing a product and adding features.



Designing with Objects

The truth is:

You can create a very bad OO design just as easily as you can create a very bad non-OO design...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Visitor Monitor Interface
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Entertainment Provider View Controller
WELCOME!
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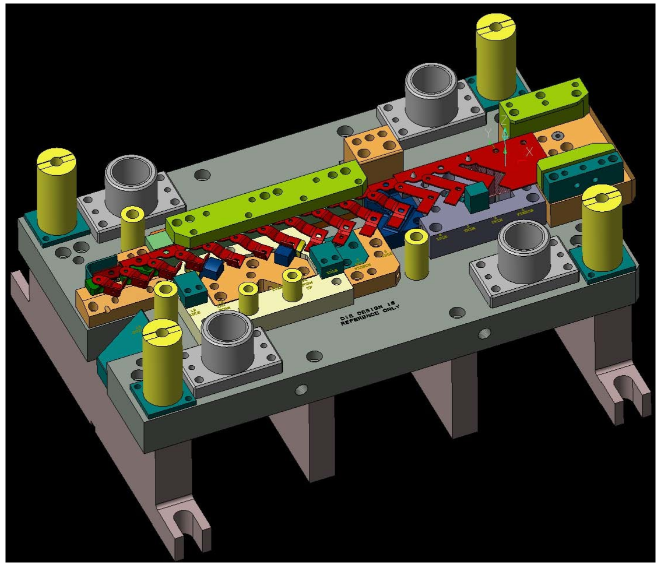
Object Oriented Analysis

- Background
  - Model the requirements in terms of objects and the services they provide
  - Grew out of object oriented design
    - Applied to modelling the application domain rather than the program
- Motivation
  - OO is (claimed to be) more 'natural'
    - As a system evolves, the functions it performs need to be changed more often than the objects on which they operate…
    - …a model based on objects (rather than functions) will be more stable over time…
    - …hence the claim that object-oriented designs are more maintainable
  - OO emphasizes importance of well-defined interfaces between objects
    - compared to ambiguities of dataflow relationships

NOTE: OO applies to requirements engineering because it is a modeling tool. But we are modeling domain objects, not the design of the new system

A solid OO design process

- Doing the proper analysis
- Developing a statement of work that describes the system
- Gathering the requirements from this statement of work
- Developing a prototype for the user interface
- Identifying the classes
- Determining the responsibilities of each class
- Determining how the various classes interact with each other
- Creating a high-level model that describes the system to be



Blackjack

- The objective is to get a card total that is closest or equal to 21.
- To win, you must beat the Dealer's hand without exceeding a card total of 21.
- You always play against the Dealer, no matter how many players are at the table.
- In Blackjack, face cards, cards from 2 to 10, carry their face value.
- An Ace can either be counted as 1 or 11, whichever is better for the owner.
- Picture cards, Jack, Queen, and King, carry a value of 10.

Blackjack

- To begin, you need to place a bet. Most casinos define a limit on the bet that you can place.
- If you are the only player at table, after you place your bet, you are dealt two cards face up. You and the Dealer both can see those cards.
- The Dealer is also dealt two cards, one card face up and the card face down. The Dealer's hidden card is called the Hole Card, and the visible card is called Up Card.
- If multiple players are playing at the table, each player is dealt one card face up and the Dealer is dealt the hole card. Again, each player is dealt another card face up. Consecutively, the Dealer is dealt the up card.

Blackjack

- After the cards are dealt, you can decide to improve your hand by drawing more cards. Once you are satisfied with your hand, you fold and stand.
- After you stand, the Dealer tries to improve their hand, without exceeding a card total of 21. If your hand beats the Dealer's you win, otherwise you lose.
- You win when:
  - You get a hand better than the Dealer's, without exceeding the total of 21.
  - The Dealer goes bust, you win automatically.
  - Remember, in case you and the Dealer get identical hand total, it ends up in a tie. And in that case, your bet is returned to you.
- You lose when:
  - Your hand total exceeds 21.

Using CRC card to discover classes

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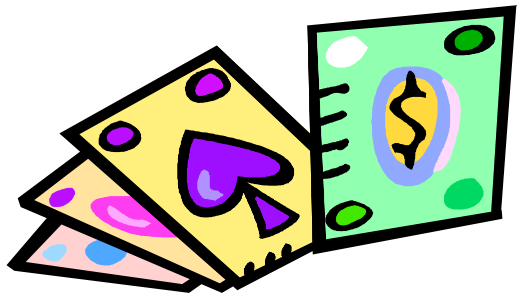
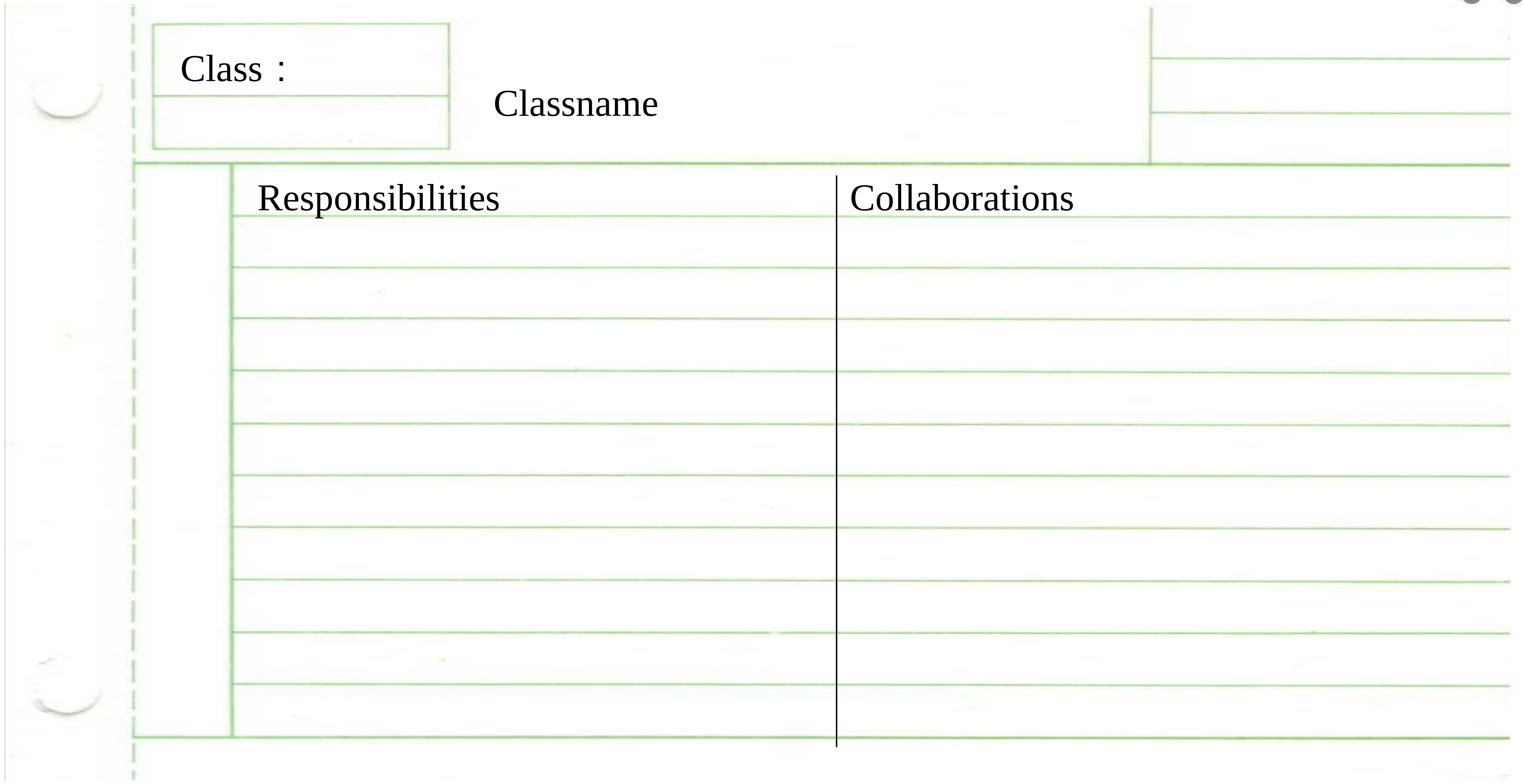
Let's play some game ☺

- We will create a program that simulates a game of Blackjack.
- Assume that a customer has come to you with a proposal that includes a very well-written statement of work and a rule book about how to play blackjack.
- We are going to design the system, not how to implement the game…
- This will culminate in the discovery of the classes, along with their responsibilities and collaborations.
- Here is the requirements:



CRC Card



Class :

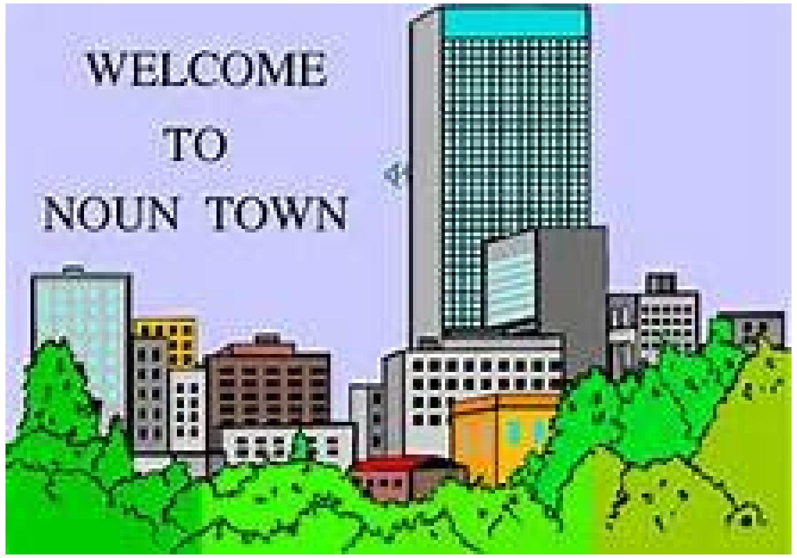
Classname

Responsibilities	Collaborations

Identifying the Blackjack Classes

Classes correspond to nouns… but…

Remember: Don't try to get things right the first time…



Nearly anything can be an object…

Source: *Adapted from Pressman, 1994, p242*

- External Entities
  - …that interact with the system being modeled
    - E.g. people, devices, other systems
- Things
  - …that are part of the domain being modeled
    - E.g. reports, displays, signals, etc.
- Occurrences or Events
  - …that occur in the context of the system
    - E.g. transfer of resources, a control action, etc.
- Roles
  - played by people who interact with the system
- Organizational Units
  - that are relevant to the application
    - E.g. division, group, team, etc.
- Places
  - …that establish the context of the problem being modeled
    - E.g. manufacturing floor, loading dock, etc.
- Structures
  - that define a class or assembly of objects
    - E.g. sensors, four-wheeled vehicles, computers, etc.

Some things cannot be objects:

- *procedures (e.g. print, invert, etc)*
- *attributes (e.g. blue, 50Mb, etc)*

Blackjack Game

- The objective is to get a card total that is closest or equal to 21. To win, you must beat the Dealer's hand without exceeding a card total of 21.
- You always play against the Dealer, no matter how many players are at the table.
- Card Ranks
- In Blackjack, face cards, cards from 2 to 10, carry their face value. An Ace can either be counted as 1 or 11, whichever is better for the owner. Picture cards, Jack, Queen, and King, carry a value of 10.

Blackjack

- To begin, you need to place a bet. Most casinos define a limit on the bet that you can place.
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Blackjack

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  - Remember, in case you and the Dealer get identical hand total, it ends up in a tie. And in that case, your bet is returned to you.
- You lose when:
  - Your hand total exceeds 21.

A list of possible objects

- Game
- Blackjack
- Dealer
- Players
- Player
- Cards
- Card
- Deck
- Hand
- Face Value
- Suit
- Winner
- Ace
- Face card
- King
- Queen
- Jack
- Bet

Initial BlackJack Classes

Card

Deck

Hand

Dealer

Player

Bet

Identifying the Classes' Responsibilities

Responsibilities relate to actions, so select the verbs...

Remember:

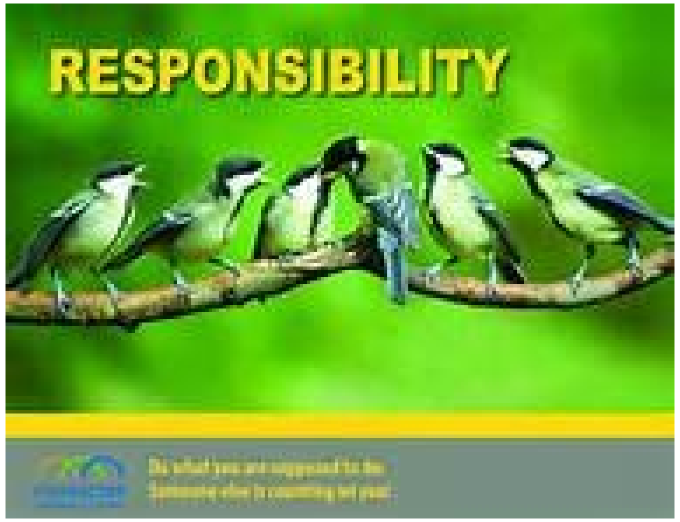
1.Not all verbs will end up as responsibilities

2. Need to combine several verbs sometimes

3. Some may popup later

4.Keep revising and updating both

5. When two classes share a resp., each class have it.



Possible responsibilities for our classes

- Card
  - Know its face value
  - Know its suit
  - Know its value
  - Know whether it is a face card
  - Know whether it is an ace
  - Know whether it is a joker
- Bet
  - Know the type of bet
  - Know the value of the current bet
  - Know how much the player has left to bet
  - Know whether the bet can be covered
- Deck
  - Shuffle
  - Deal the next card
  - Know how many cards are left in the deck
  - Know whether there is a full deck to begin
- Hand
  - Know how many cards are in the hand
  - Know the value of the hand
  - Show the hand

Possible responsibilities for our classes

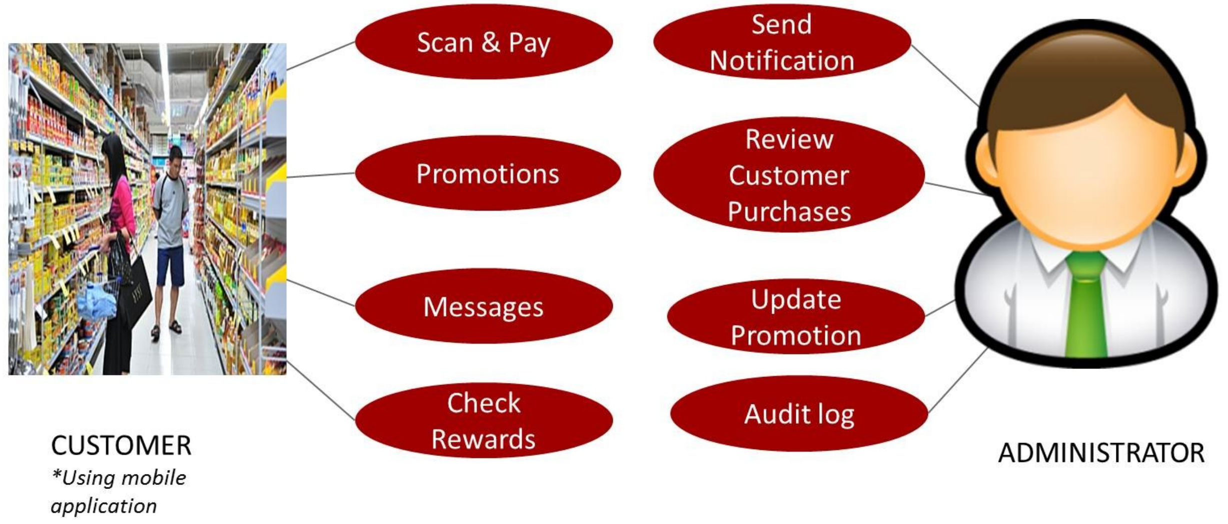
- Dealer
  - Deal the cards
  - Shuffle the deck
  - Give a card to a player
  - Show the dealer hand
  - Calculate the value of the dealer's hand
  - Know the number of cards in the dealer's hand
  - Request a card
  - Determine the winner
  - Start a new hand
- Player
  - Request a card
  - Show the player's hand
  - Calculate the value of the player's hand
  - Know how many cards are in the hand
  - Know whether the hand value is over 21
  - Know whether the hand value is equal to 21 (and if it is a blackjack)
  - Know whether the hand is below 21

Identifying the Collaborations: Using UML Use Cases

Identify the objects and the messages exchanges…

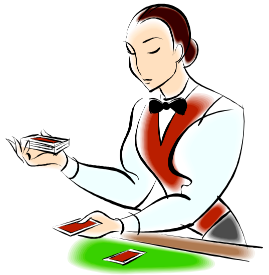
Remember:

The purpose is not to document all possible scenarios, but to refine the classes and responsibilities …



An Example Scenario

- Dealer



- Dealer shuffles deck
- Dealer deals initial card
- Dealer adds cards to dealer's hand
- Hand returns value of dealer's hand to dealer
- Dealer deals player another card
- Dealer asks player whether he wants another card
- Dealer gets the vale of the player's hand
- Dealer sends or requests bet value from players

- Player

Player makes bet

Player adds card to player's hand

Hand returns value of player's hand to player

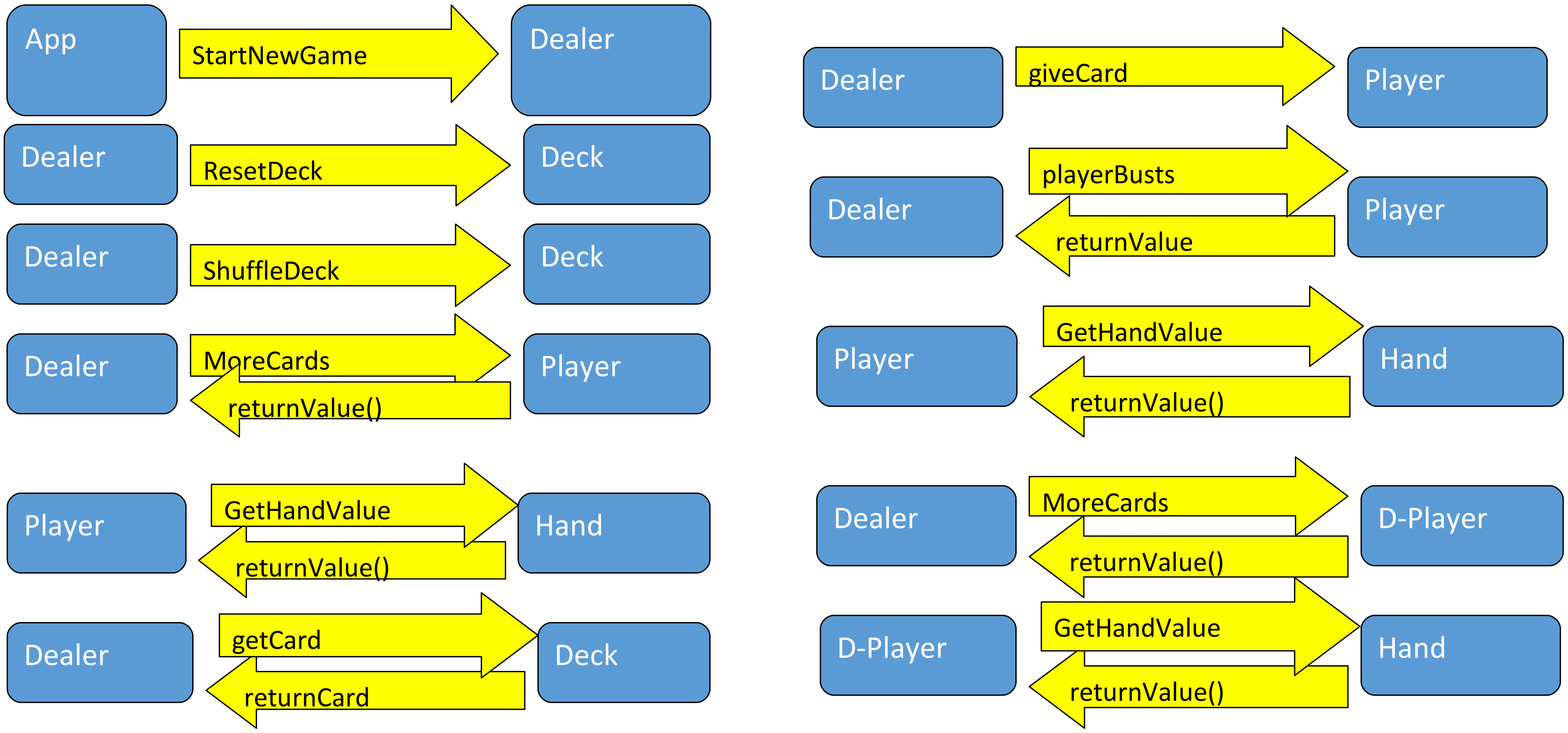
Dealer asks player whether he wants another card

Player adds the card to player's hand

Hand returns value of player's hand to player

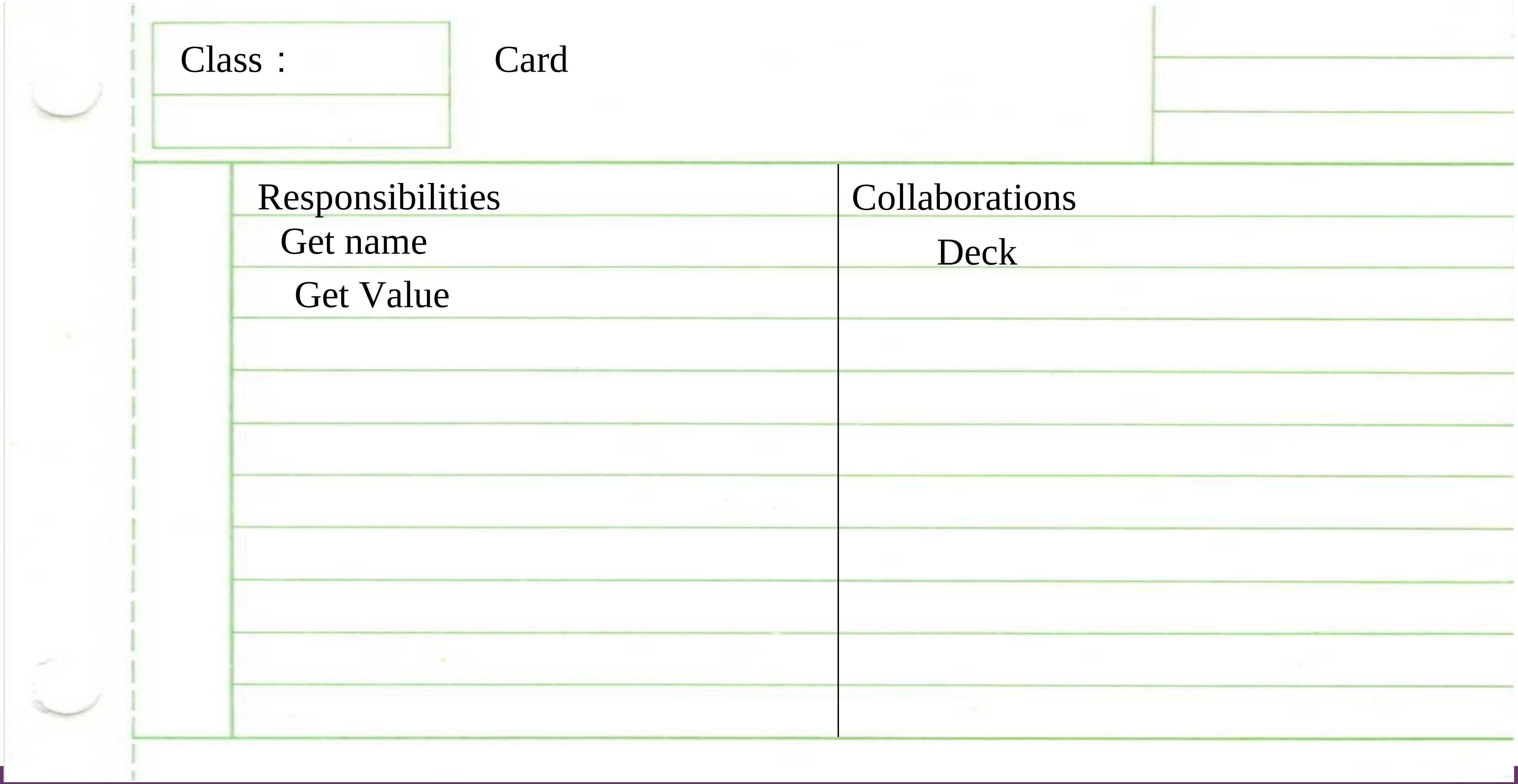
Player adds to/subtracts from player's bet attribute

Determine Collaborations



CRC Cards we get

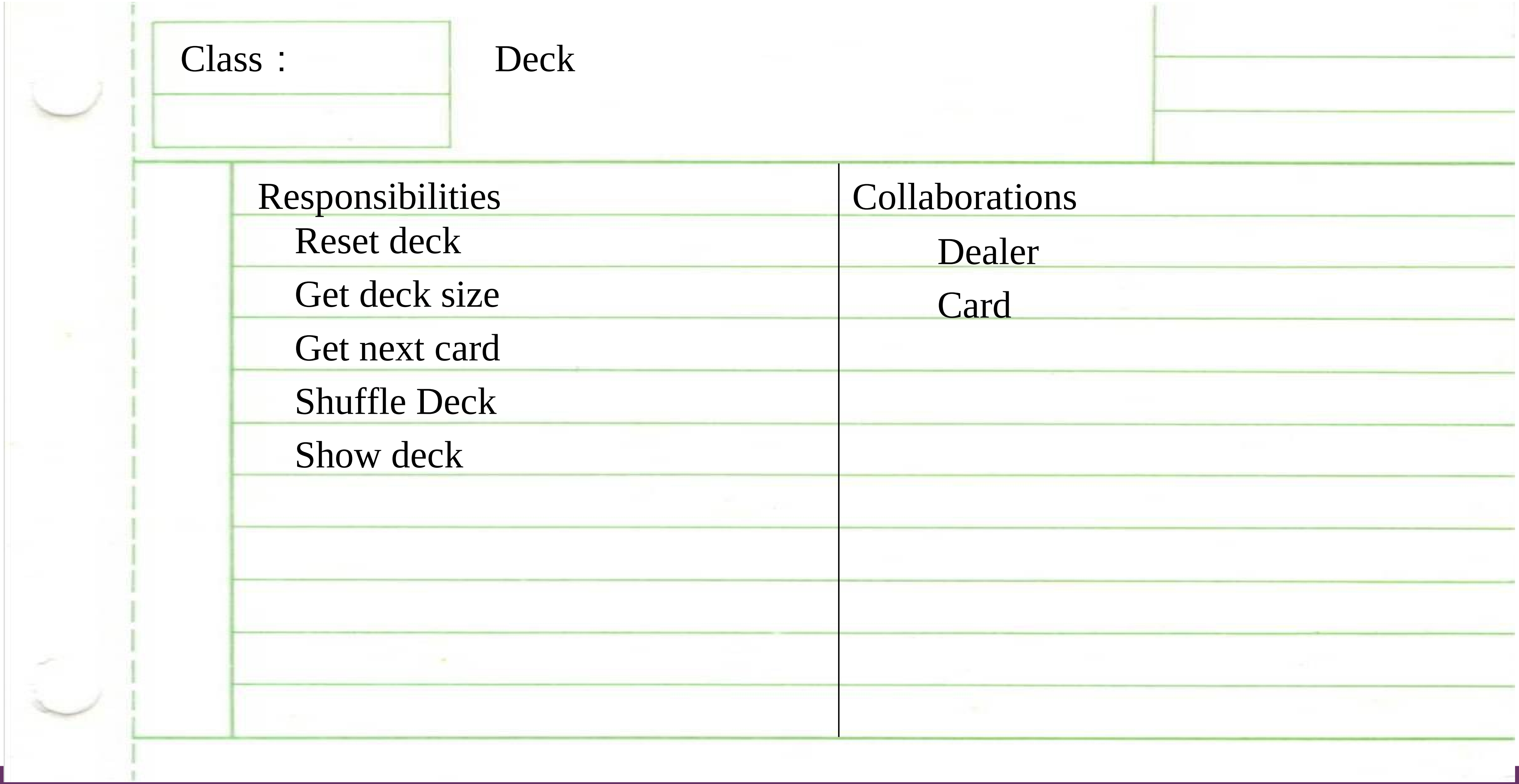
Card



Class : Card

Responsibilities	Collaborations
Get name	Deck
Get Value	

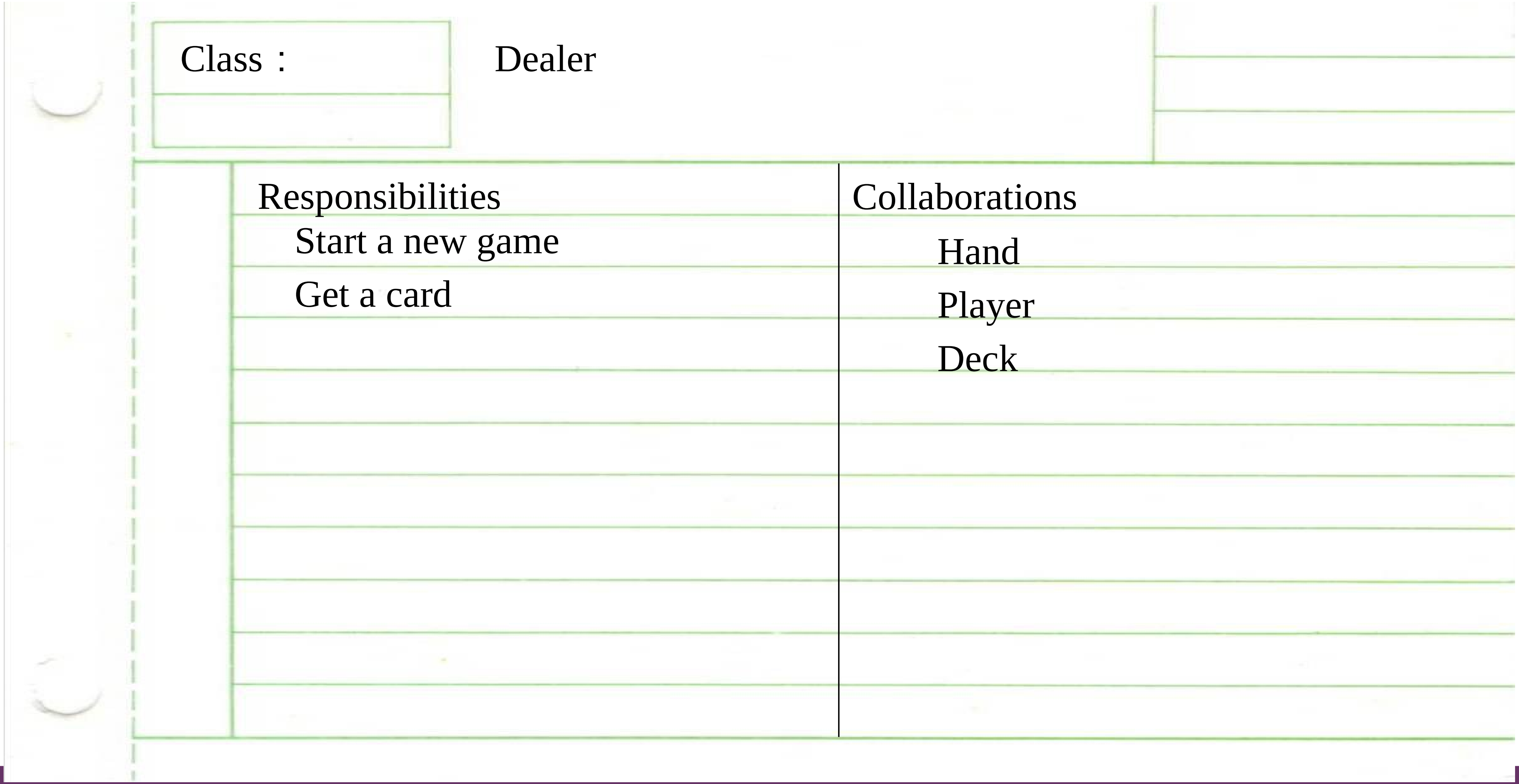
Deck



Class : Deck

Responsibilities	Collaborations
Reset deck	Dealer
Get deck size	Card
Get next card	
Shuffle Deck	
Show deck	

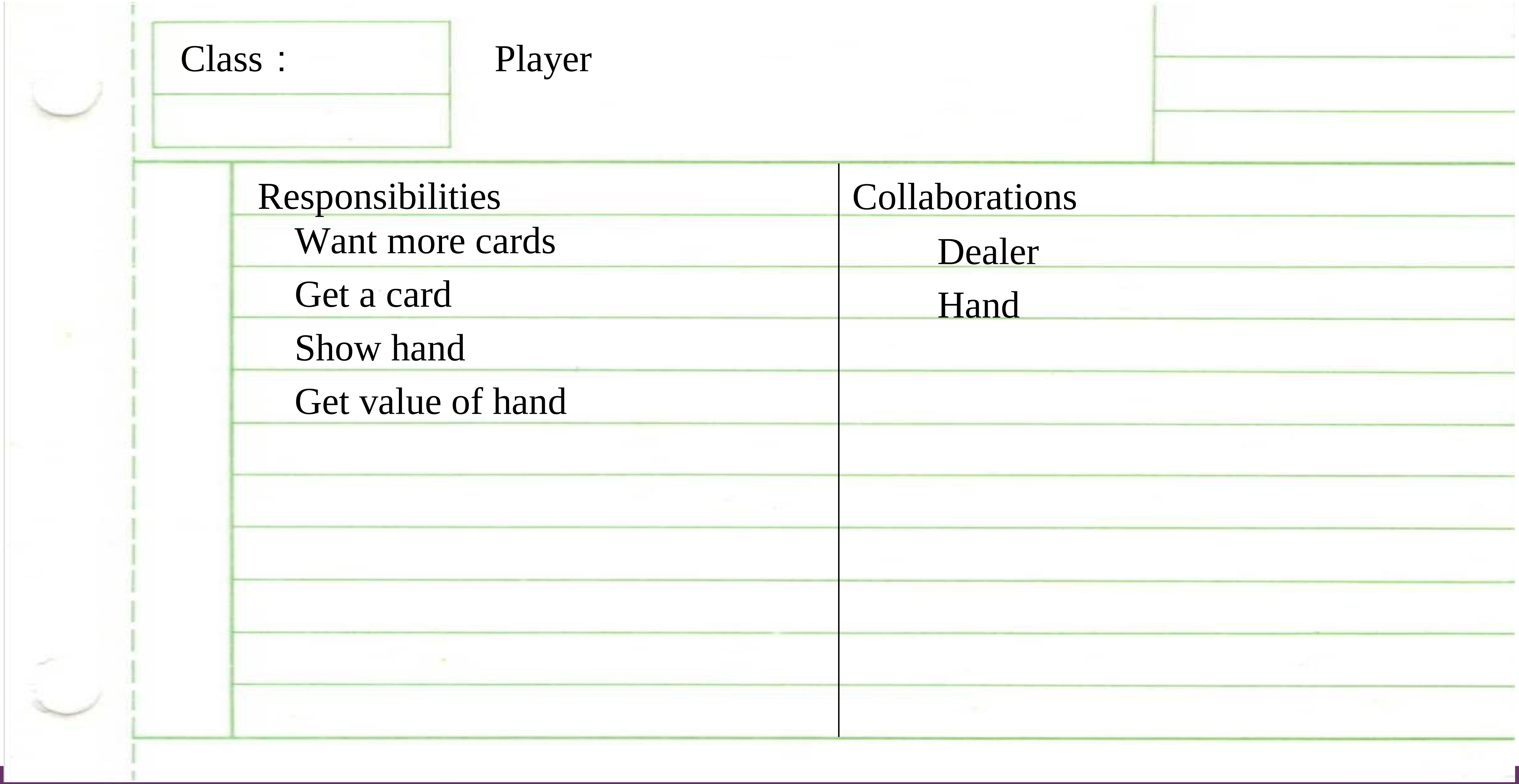
Dealer



Class : Dealer

Responsibilities	Collaborations
Start a new game	Hand
Get a card	Player
	Deck

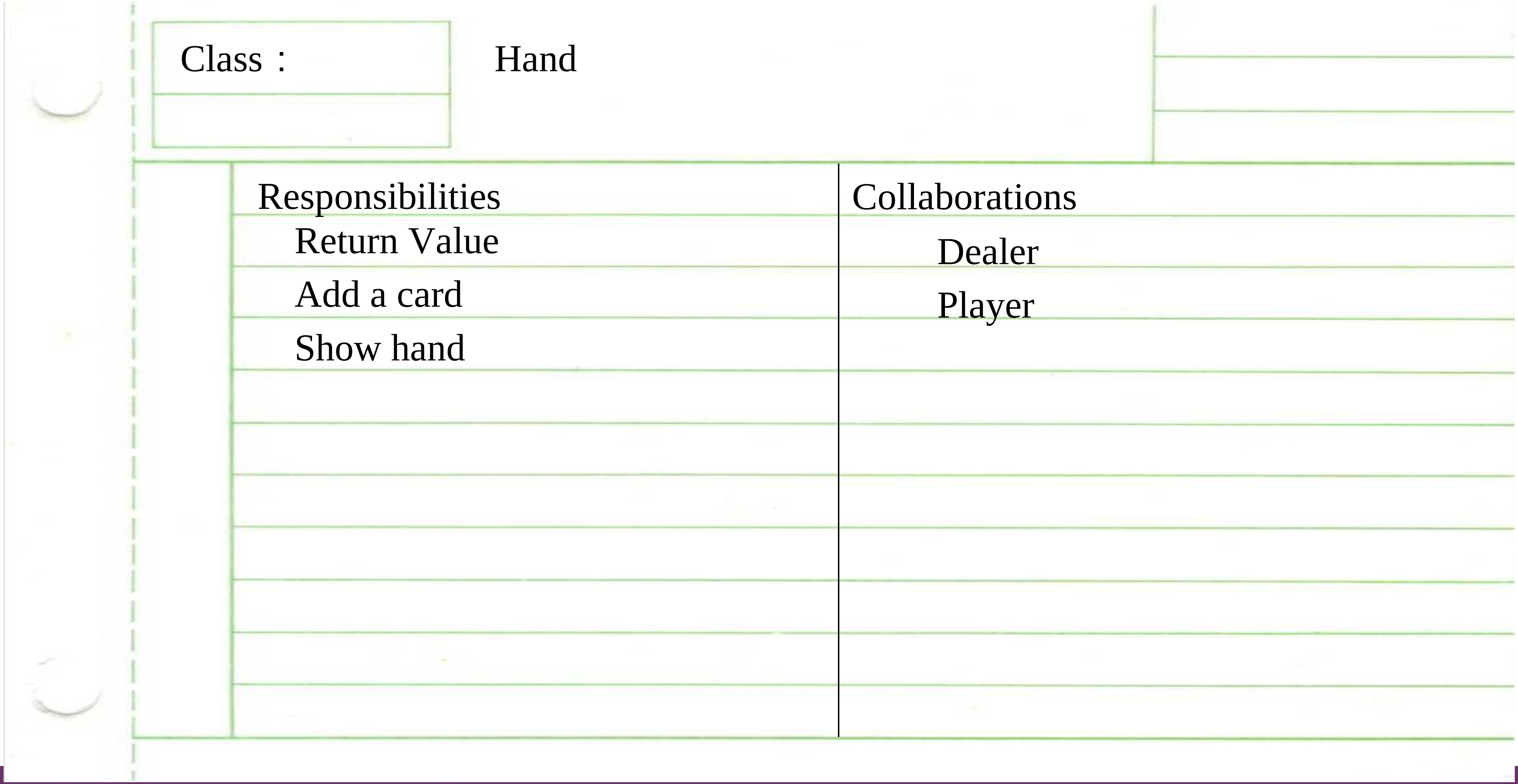
Player



Class : Player

Responsibilities	Collaborations
Want more cards	Dealer
Get a card	Hand
Show hand	
Get value of hand	

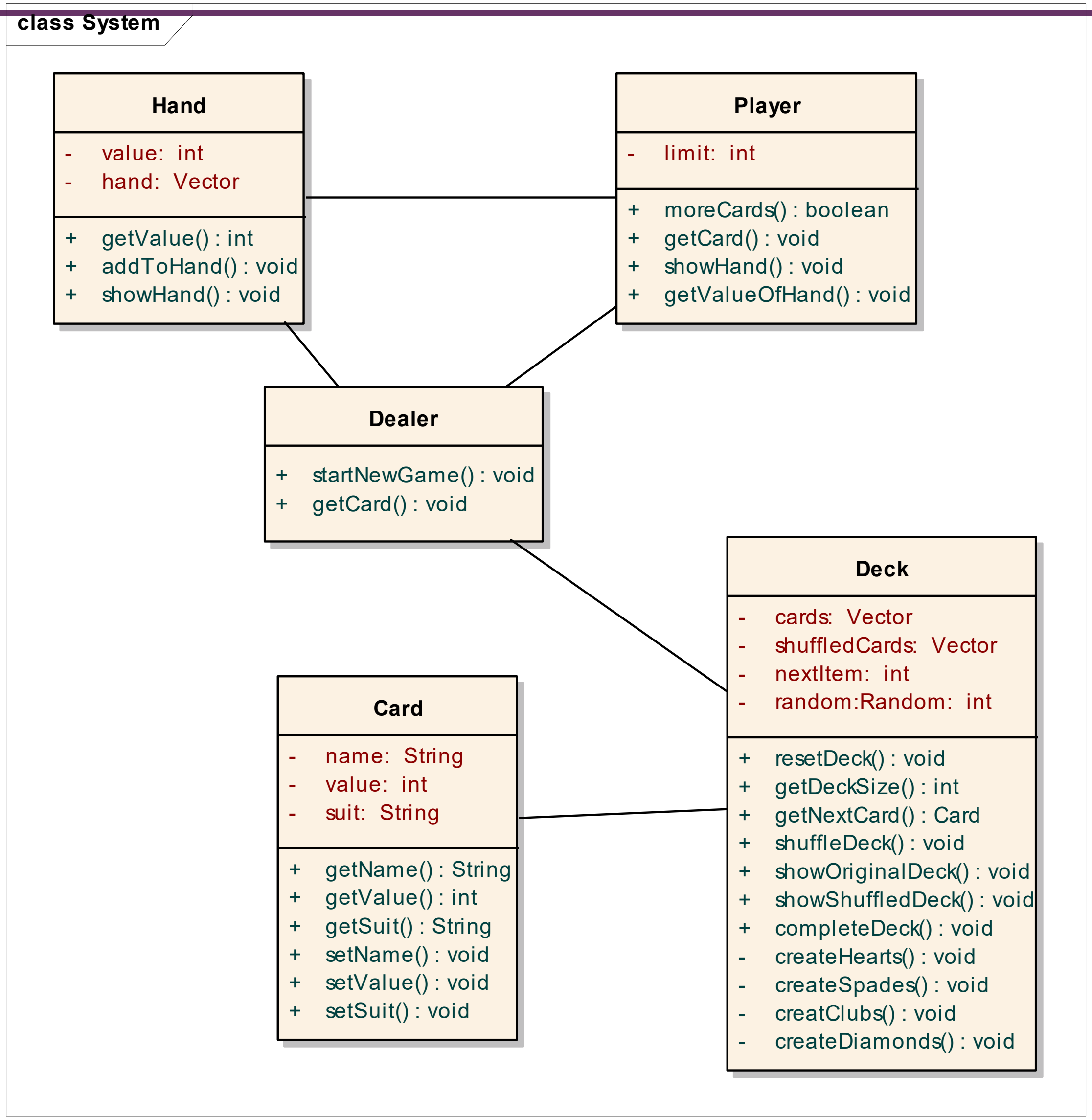
Hand



Class : Hand

Responsibilities	Collaborations
Return Value	Dealer
Add a card	Player
Show hand	

UML Class diagram for BlackJack



Object Oriented Modelling

- Object Oriented Analysis
  - Rationale
  - Identifying Classes
  - Attributes and Operations
- UML Class Diagrams
  - Associations
  - Multiplicity
  - Aggregation
  - Composition
  - Generalization

UML Class Diagram

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Modelling principles

- Facilitate Modification and Reuse
  - **Experienced analysts reuse their past experience**
    - they reuse components (of the models they have built in the past)
    - they reuse structure (of the models they have built in the past)
  - **Smart analysts plan for the future**
    - they create components in their models that might be reusable
    - they structure their models to make them easy to modify
- Helpful ideas:
  - **Abstraction**
    - strip away detail to concentrate on the important things
  - **Decomposition (Partitioning)**
    - Partition a problem into independent pieces, to study separately
  - **Viewpoints (Projection)**
    - Separate different concerns (views) and describe them separately
  - **Modularization**
    - Choose structures that are stable over time, to localize change
  - **Patterns**
    - Structure of a model that is known to occur in many different applications

Modelling Principle 1: Partitioning

- Partitioning
  - captures aggregation/part-of relationship
- Example:
  - goal is to develop a spacecraft
  - partition the problem into parts:
    - guidance and navigation;
    - data handling;
    - command and control;
    - environmental control;
    - instrumentation;
    - etc
  - Note: this is not a design, it is a problem decomposition
    - actual design might have any number of components, with no relation to these sub-problems
  - However, the choice of problem decomposition will probably be reflected in the design

Modelling Principle 2: Abstraction

***Source:** Adapted from Davis, 1990, p48 and Loucopoulos & Karakostas, 1995, p78*

- Abstraction
  - **A way of finding similarities between concepts by ignoring some details**
  - **Focuses on the general/specific relationship between phenomena**
    - Classification groups entities with a similar role as members of a single class
    - Generalization expresses similarities between different classes in an 'is_a' association
- Example:
  - requirement is to handle faults on the spacecraft
  - might group different faults into fault classes

based on location:

- **instrumentation fault,**
- **communication fault,**
- **processor fault,**
- **etc**

OR

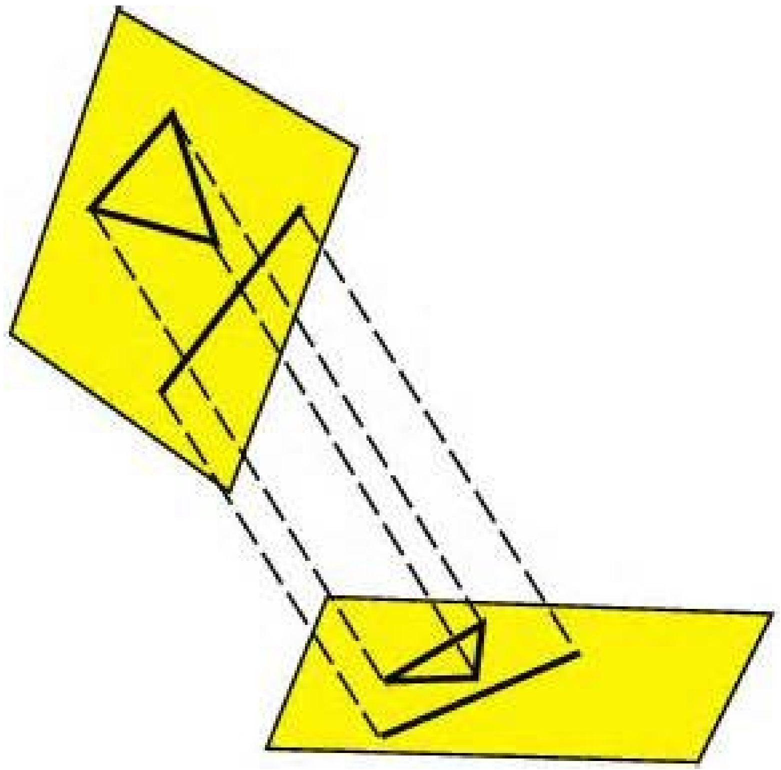
based on symptoms:

- **no response from device;**
- **incorrect response;**
- **self-test failure;**
- **etc...**

Modelling Principle 3: Projection

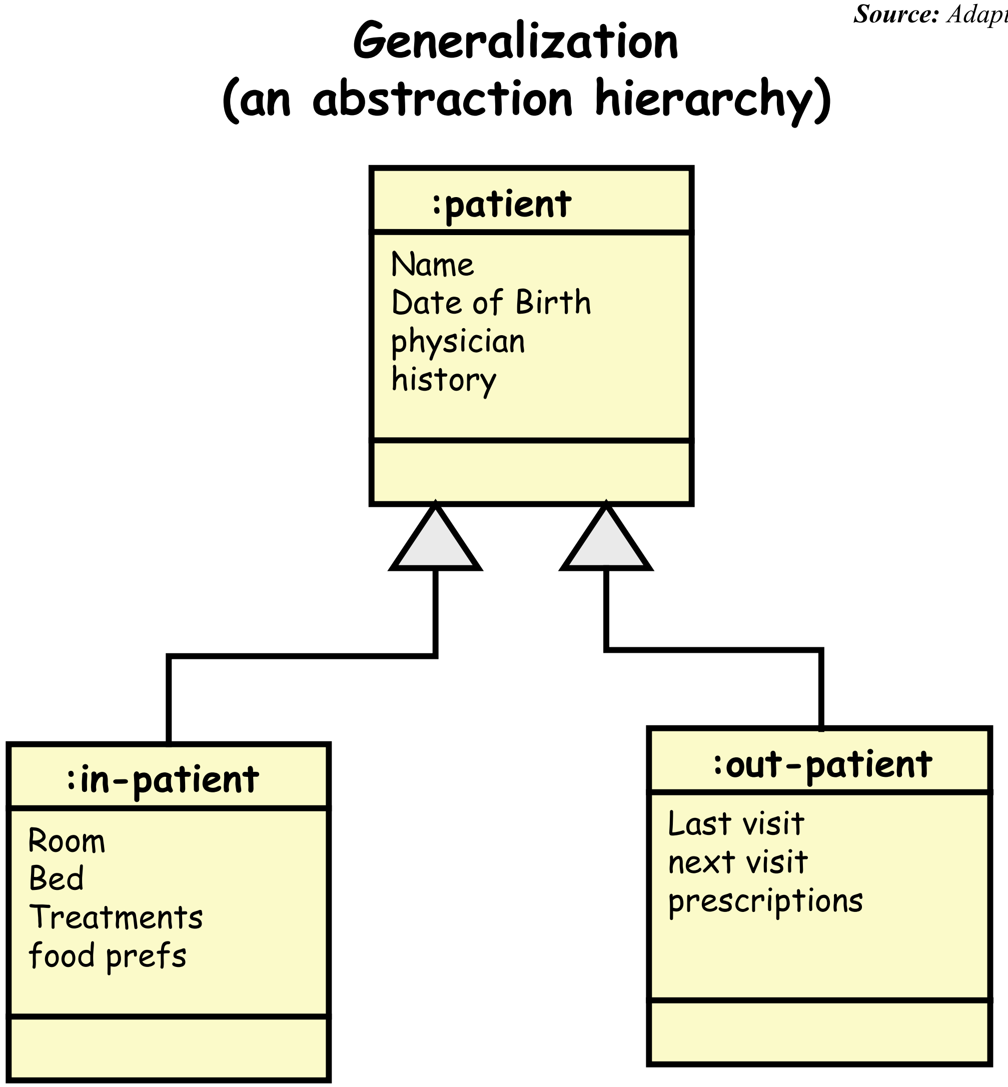
Source: Adapted from Davis, 1990, p48-51

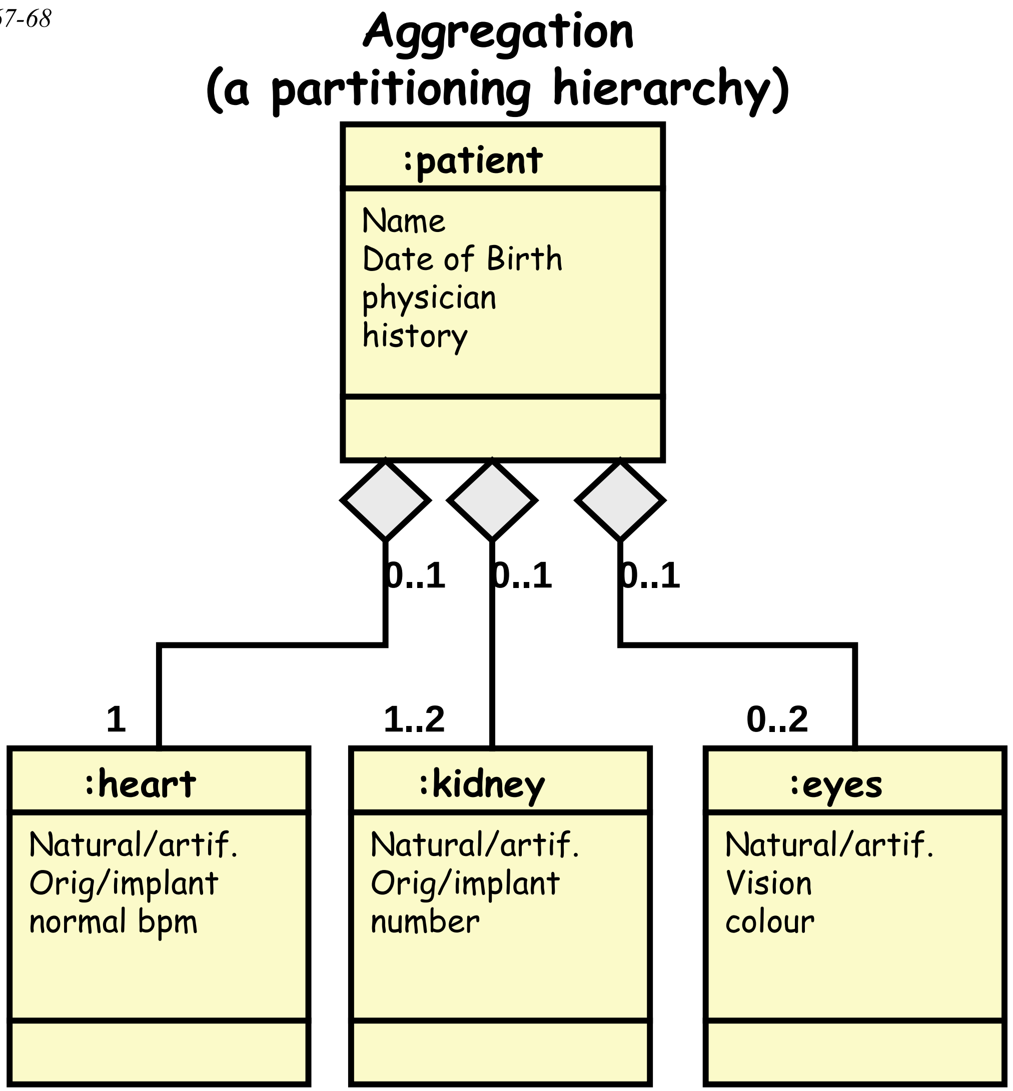
- Projection:
  - **separates aspects of the model into multiple viewpoints**
    - similar to projections used by architects for buildings
- Example:
  - **Need to model the requirements for a spacecraft**
  - **Model separately:**
    - safety
    - commandability
    - fault tolerance
    - timing and sequencing
    - Etc…
- Note:
  - **Projection and Partitioning are similar:**
    - Partitioning defines a 'part of' relationship
    - Projection defines a 'view of' relationship
  - **Partitioning assumes a the parts are relatively independent**



A brief UML example

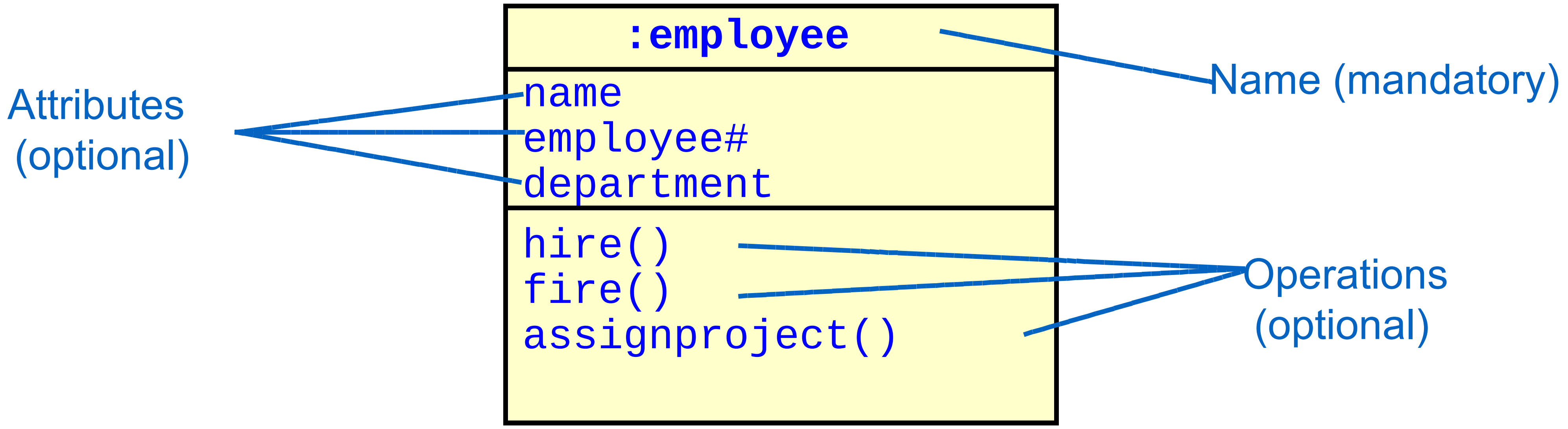
Source: *Adapted from Davis, 1990, p67-68*





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



Finding Classes

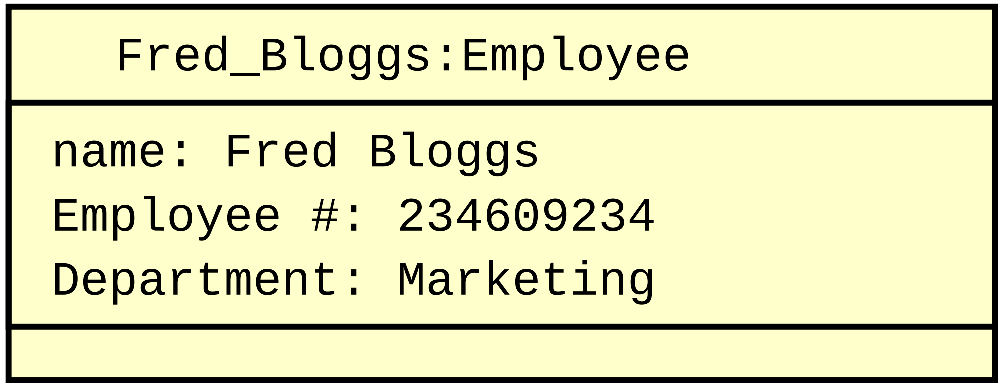
- Finding classes source data:
  - Look for nouns and noun phrases in stakeholders' descriptions of the problem
    - include in the model if they explain the nature or structure of information in the application.
- Finding classes from other sources:
  - Reviewing background information;
  - Users and other stakeholders;
  - Analysis patterns;
- It's better to include many candidate classes at first
  - You can always eliminate them later if they turn out not to be useful
  - Explicitly deciding to discard classes is better than just not thinking about them

Selecting Classes

- Discard classes for concepts which:
  - Are beyond the scope of the analysis;
  - Refer to the system as a whole;
  - Duplicate other classes;
  - Are too vague or too specific
    - e.g. have too many or too few instances
  - Coad & Yourdon's criteria:
    - Retained information: Will the system need to remember information about this class of objects?
    - Needed Services: Do objects in this class have identifiable operations that change the values of their attributes?
    - Multiple Attributes: If the class only has one attribute, it may be better represented as an attribute of another class
    - Common Attributes: Does the class have attributes that are shared with all instances of its objects?
    - Common Operations: Does the class have operations that are shared with all instances of its objects?
  - External entities that produce or consume information essential to the system should be included as classes

Objects vs. Classes

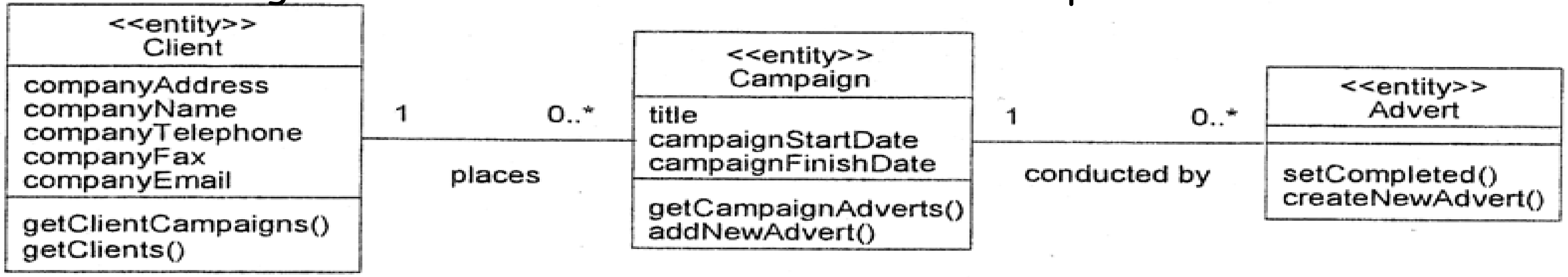
- The instances of a class are called objects.
  - Objects are represented as:



  - 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??)

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
  - Note: The last two are not useful during requirements analysis
- Class diagrams show classes and their relationships

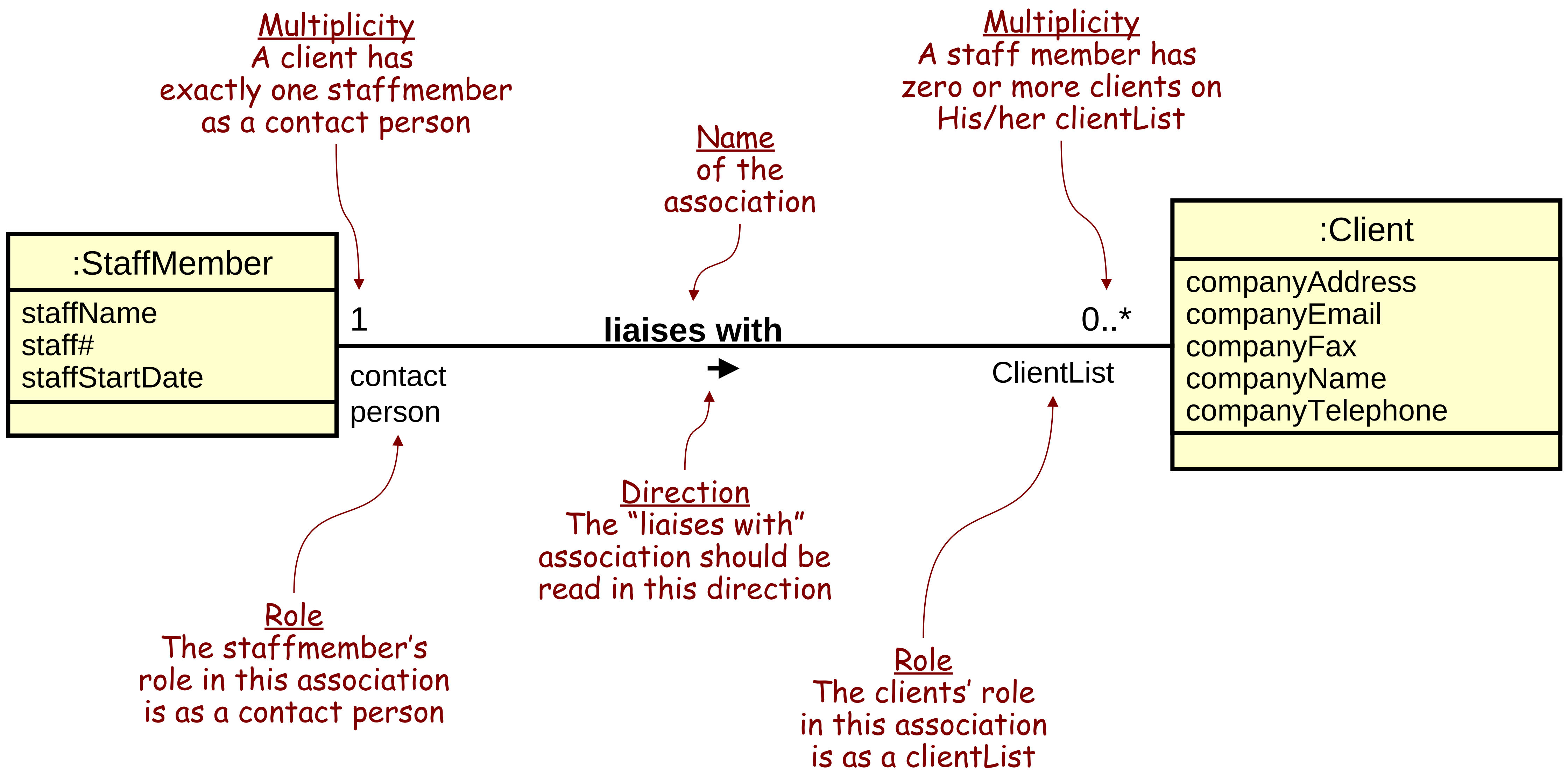


Association Multiplicity

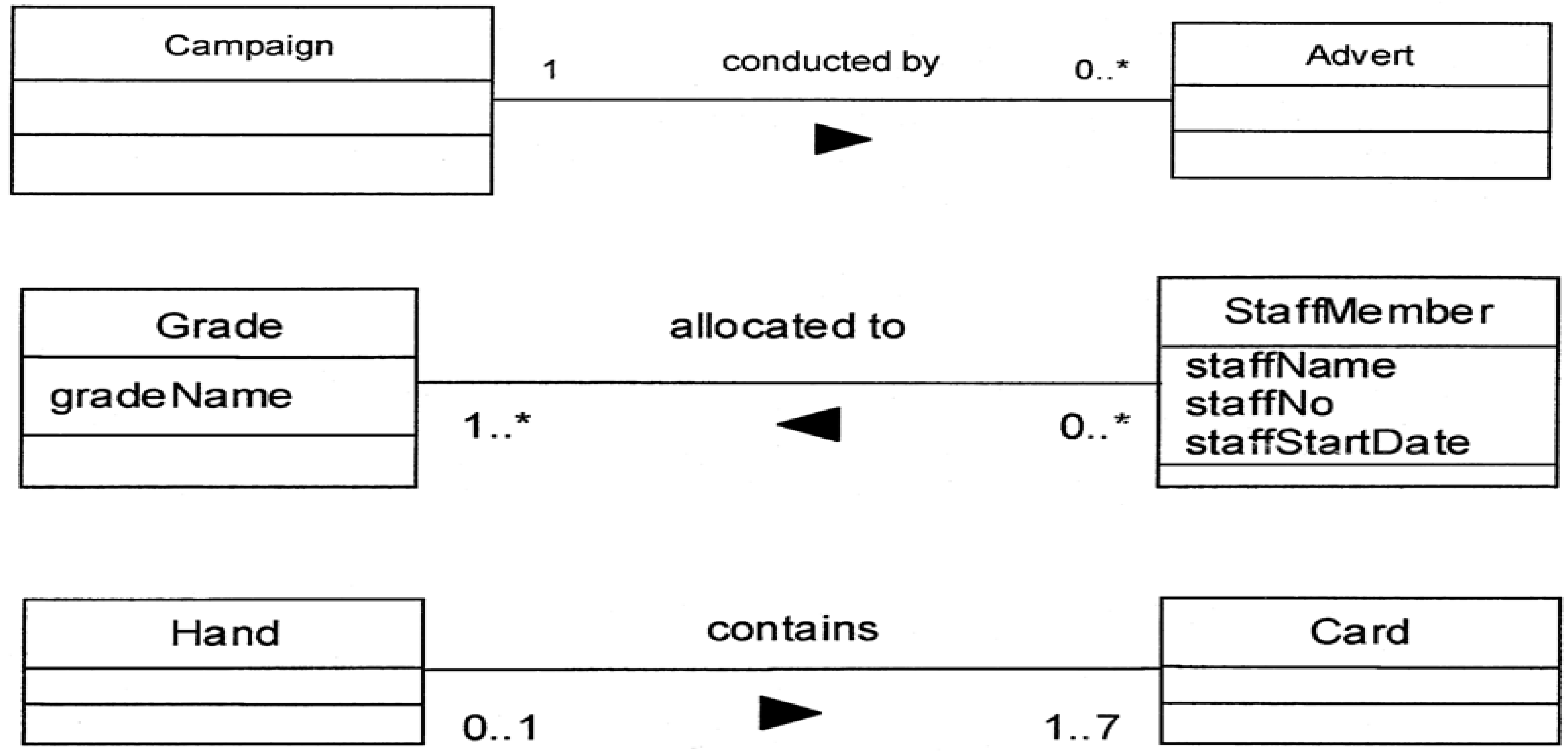
- Ask questions about the associations:
  - **Can a campaign exist without a member of staff to manage it?**
    - If yes, then the association is optional at the Staff end - zero or more (0..*)
    - If no, then it is not optional - one or more (1..*)
    - If it must be managed by one and only one 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

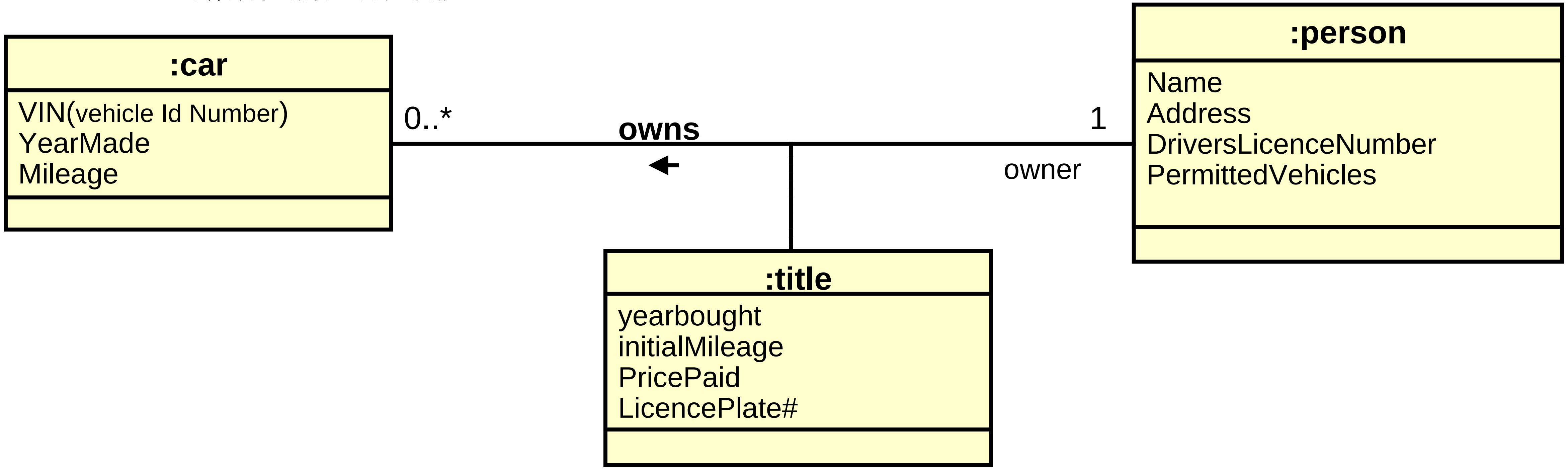


More Examples



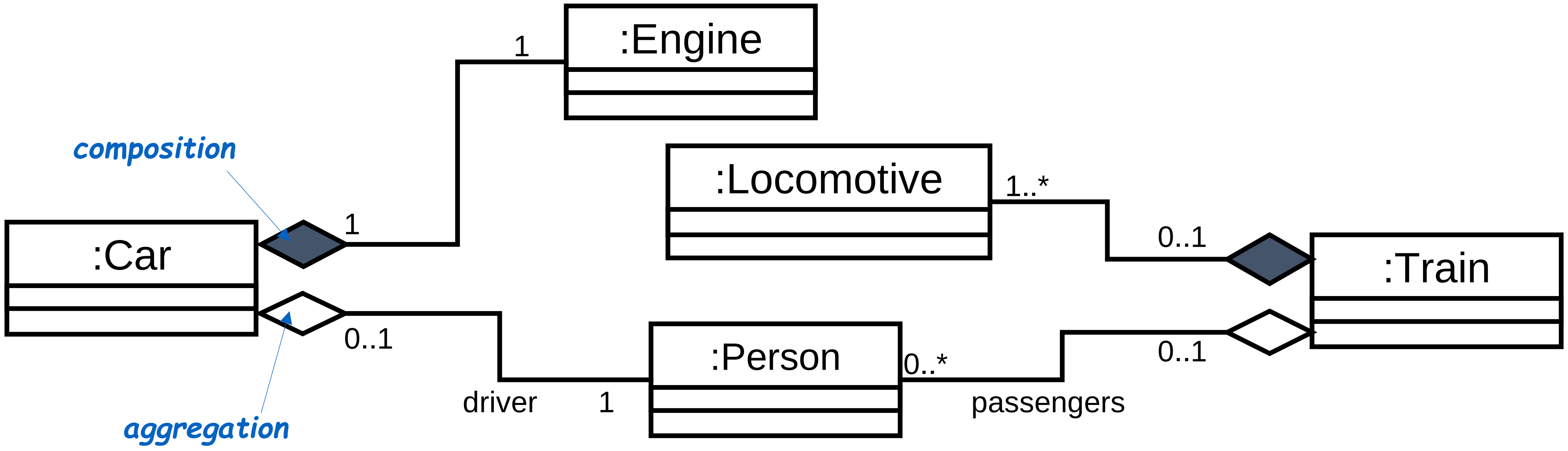
Association Classes

- Sometimes the association is itself a class
    - …because we need to retain information about the association
    - …and that information doesn't naturally live in the classes at the ends of the association
        - E.g. a "title" is an object that represents information about the relationship between an owner and her car



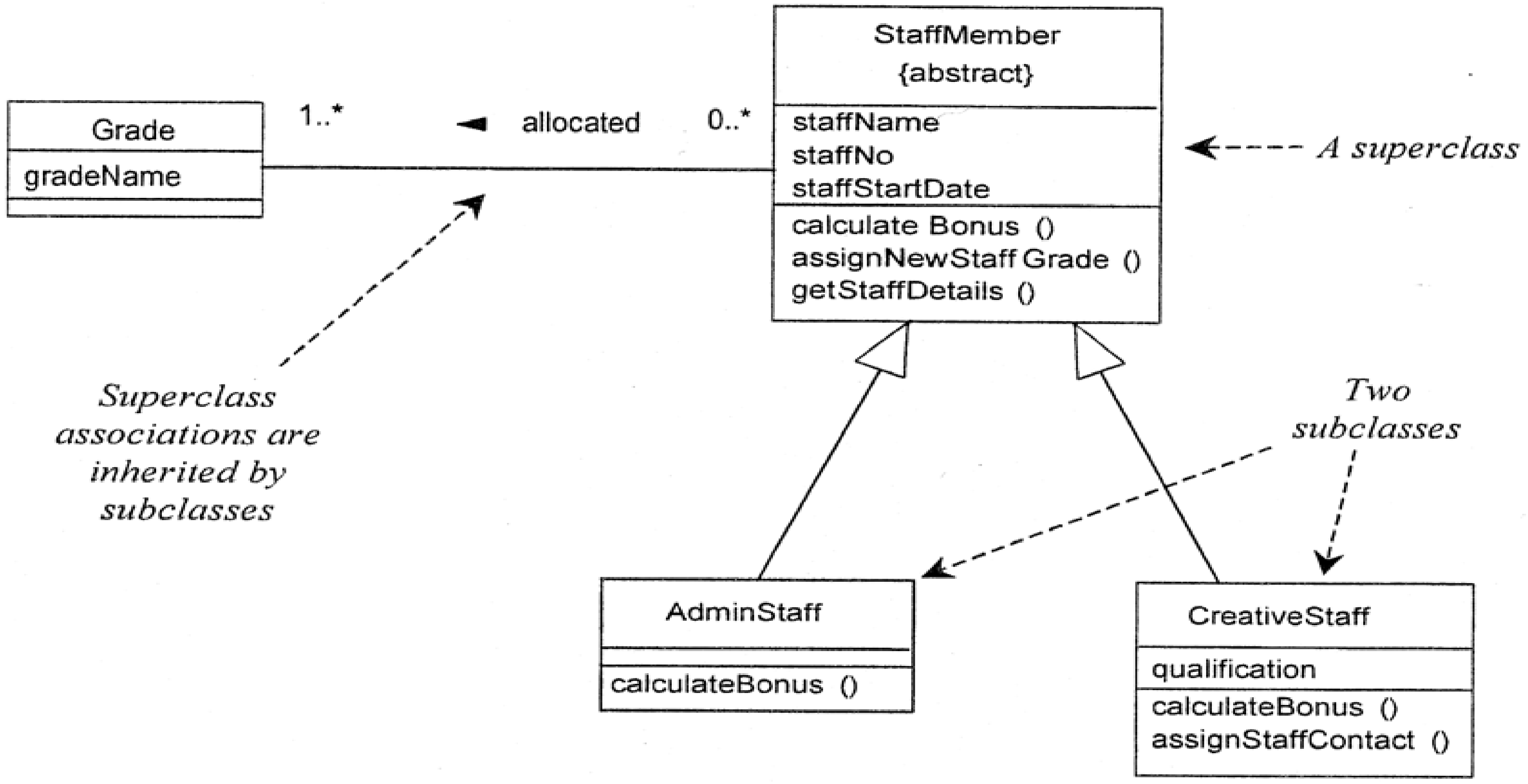
Aggregation and Composition

- 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



Generalization

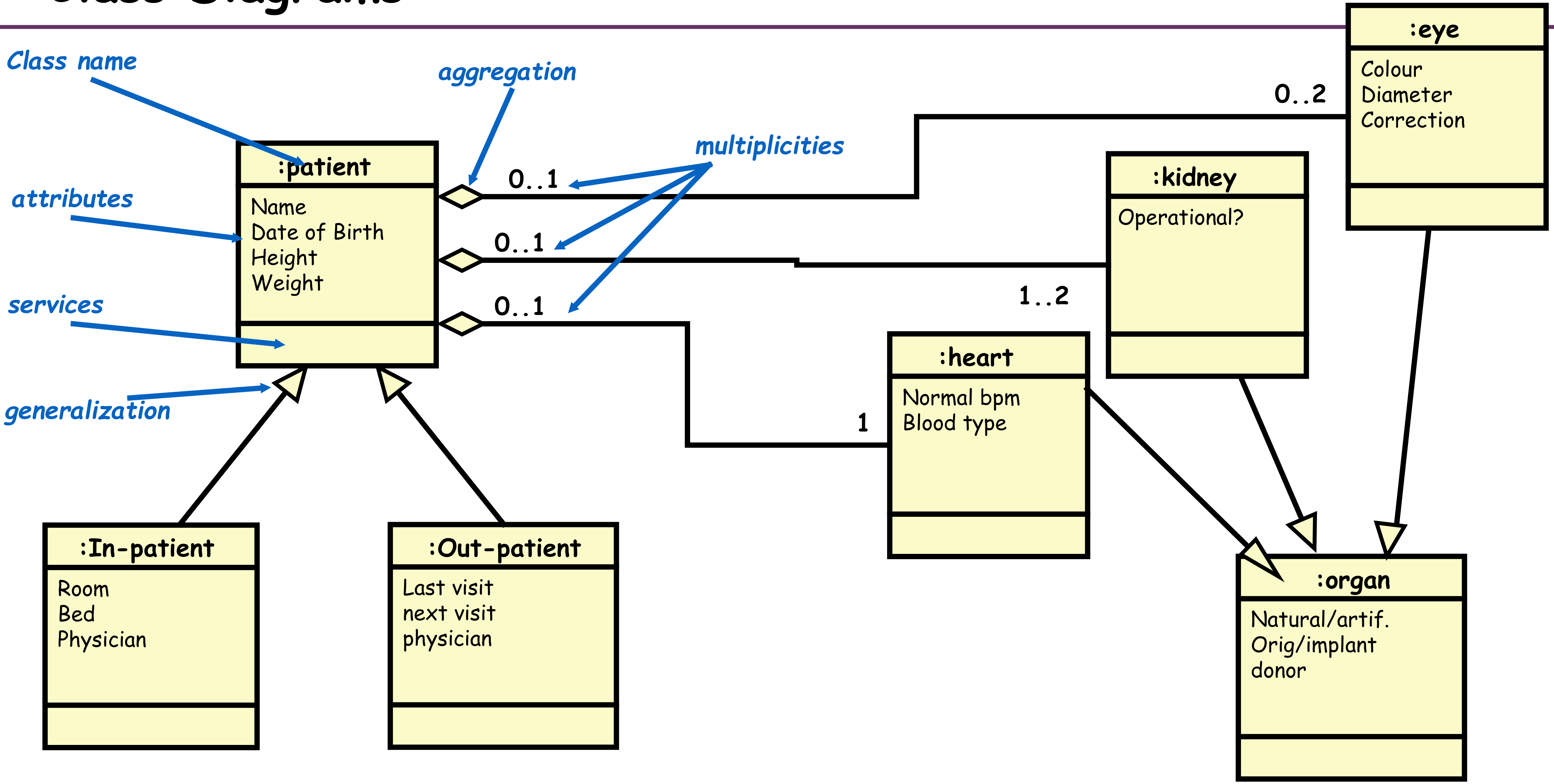
- Subclasses inherit attributes, associations, & operations from the superclass
- A subclass may override an inherited aspect
  - e.g. AdminStaff & CreativeStaff have different methods for calculating bonuses
- Superclasses may be declared {abstract}, meaning they have no instances
  - Implies that the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



More on Generalization

- Usefulness of generalization
  - Can easily add new subclasses if the organization changes
- Look for generalizations in two ways:
  - **Top Down**
    - You have a class, and discover it can be subdivided
    - Or you have an association that expresses a "kind of" relationship
    - E.g. *"Most of our work is on advertising for the press, that's newspapers and magazines, also for advertising hoardings, as well as for videos"*
  - **Bottom Up**
    - You notice similarities between classes you have identified
    - E.g. *"We have books and we have CDs in the collection, but they are all filed using the Dewey system, and they can all be lent out and reserved"*
- But don't generalize just for the sake of it
  - Be sure that everything about the superclass applies to the subclasses
  - Be sure that the superclass is useful as a class in its own right
    - I.e. not one that we would discard using our tests for useful classes
  - Don't add subclasses or superclasses that are not relevant to your analysis

Class Diagrams



Summary

- Understand the objects in the application domain
  - **Identify all objects that stakeholders refer to**
  - **Decide which objects are important for your analysis**
  - **Class diagrams good for:**
    - Visualizing relationships between domain objects
    - Exploring business rules and assumptions via multiplicities
    - Specifying the structure of information to be (eventually) stored
- OO is a good way to explore details of the problem
  - Avoids the fragmentary nature of structured analysis
  - provides a coherent way of understanding the world
- But beware…
  - **temptation to do design rather than problem analysis**
    - In RE, class diagrams DO NOT represent programming (e.g. Java) classes
  - **For analysis, use UML diagrams as sketches, not as blueprints**
    - But may become blueprints when used in a specification