Please sit with your project group (if you have one)

Class, Responsibility, and Collaboration

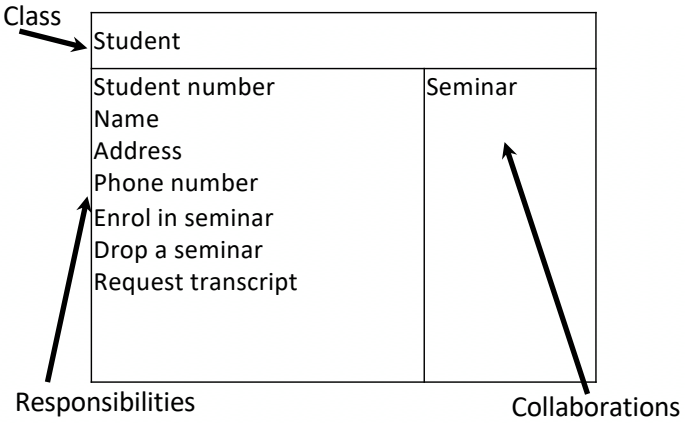
CRC Cards

- A tool and method for systems analysis and design.
- Part of the Object-Oriented development paradigm.
- Highly interactive and human-intensive.
- Final result: initial set of classes and their relationships.
- *What* rather than *How*.
- Benefits:
  - Cheap and quick: all you need is index cards.
  - Simple, easy methodology.
  - Forces you to be concise and clear.
  - Input from every team member.

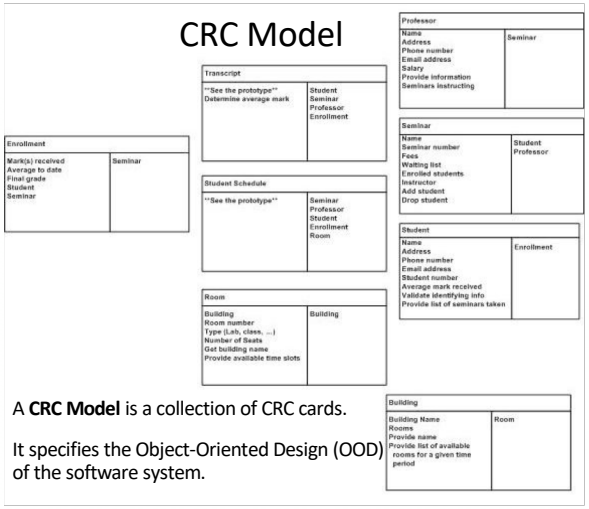
What is a CRC Card?

- **CRC** stands for **C**lass, **R**esponsibility and **C**ollaboration.
  - **Class**
    - An object-oriented class name
    - Include information about super- and sub-classes
  - **Responsibility**
    - What information this class stores
    - What this class does
    - The behaviour for which an object is accountable
  - **Collaboration**
    - Relationship to other classes
    - Which other classes this class uses

What does a CRC Card Look Like?



CRC Model



A **CRC Model** is a collection of CRC cards.

It specifies the Object-Oriented Design (OOD) of the software system.

How to Create a CRC Model?

- Typically, you are given a description (in English) of the requirements for a software system.
- You work in a team.
- Ideally, you all gather around a table.
- You need a set of index cards and some pens.
- Coffee / other beverages are optional.

How to Create a CRC Model?

- Read the description. Again. And again.
- Identify core **classes** (simplistic advice: look for nouns).
- Create a card per class (begin with class names only).
- Add **responsibilities** (simplistic advice: look for verbs).
- Which other classes does this class need to talk to to fulfil its responsibilities? Add **collaborators**.
- Add more classes as you discover them.
- Put classes away if they become unnecessary. (But don't tear them up yet!)
- Refine by identifying abstract classes, inheritance, etc.
- Keep adding/refining until everyone on the team is satisfied.

How Can We Tell It Works?

- A neat technique: a **Scenario Walk-through**.
- Select a scenario and choose a plausible set of inputs for it.
- Manually "execute" each scenario.
  - Start with initial input for scenario and find a class that has responsibility for responding to that input.
  - Trace through the collaborations of each class that participates in satisfying that responsibility.
  - Make adjustments as necessary.
  - Repeat until scenario has "stabilized" (that is, no further adjustments are necessary).

Developing a CRC Model

Example

- Consider this description of a software system:
  - *You are developing a software system to facilitate restaurant reviews. Each restaurant corresponds to a certain price range, neighbourhood, and cuisines it serves. Restaurants that serve alcohol must have a license, which they need to renew every year. The system should also report how long, on average, customers wait for take out in restaurants that offer take-out service. When reviewers leave a review for a restaurant, they must specify a recommendation (Thumbs Up or Thumbs Down) and can also leave a comment. An owner of a restaurant can respond to a review with a comment. All users of the system log in with their username. Users can choose to be contacted by email ...*

Key Steps

A key part of developing the model involves careful analysis of the problem specification. We must:

- **Identify important nouns.**
  Underline nouns that may make sensible classes or that describe information a class could be responsible for storing.
- **Choose potential classes.**
  From the nouns identified, write down the ones that are potential classes.
- **Identify verbs that describe responsibilities.**
  In the problem description, circle verbs that describe tasks that a class may be responsible for doing.

Identify important nouns

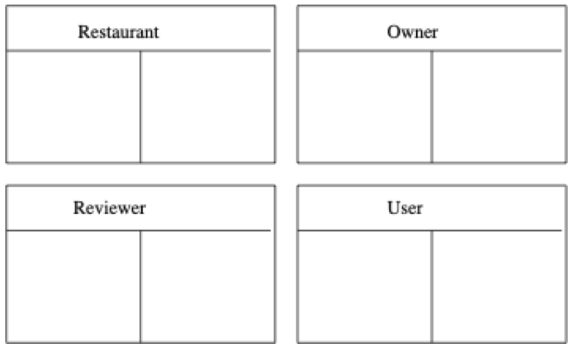
- Let's begin by underlining nouns.
  - *Each restaurant corresponds to a certain price range, neighbourhood, and cuisines it serves. Restaurants that serve alcohol must have a license, which they need to renew every year. The system should also report how long, on average, customers wait for take out in restaurants that offer take-out service. When reviewers leave a review for a restaurant, they must specify a recommendation (Thumbs Up or Thumbs Down) and can also leave a comment. An owner of a restaurant can respond to a review with a comment. All users of the system log in with their username. Users can choose to be contacted by email and ...*

Choose potential classes

- But which ones are the main players? These are potential classes.
  - *Each* **restaurant** *corresponds to a certain price range, neighbourhood, and cuisines it serves. Restaurants that serve alcohol must have a license, which they need to renew every year. The system should also report how long, on average, customers wait for take out in restaurants that offer take-out service. When* **reviewers** *leave a review for a restaurant, they must specify a recommendation (Thumbs Up or Thumbs Down) and can also leave a comment. An* **owner** *of a restaurant can respond to a review with a comment. All* **users** *of the system log in with their username. Users can choose to be contacted by email and ...*

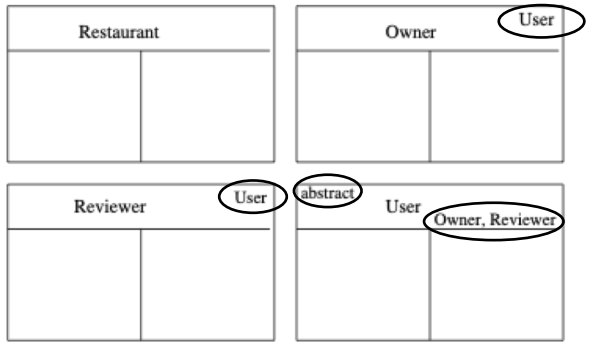
We can start building the model

- One class goes on each CRC card:



We can start to identify inheritance

- Adding parent class (upper RHS) and child classes (lower RHS):

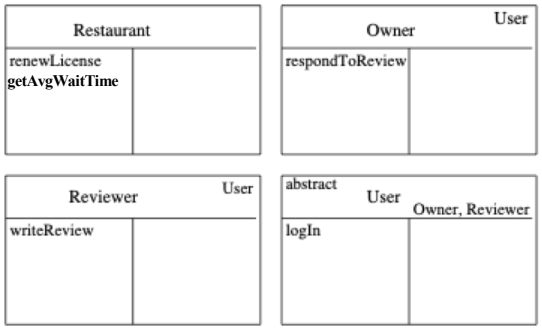


Identify verb phrases that describe responsibilities.

- And what are the classes responsible for *doing*?
  - *Each* **restaurant** *corresponds to a certain price range, neighbourhood, and cuisines it serves. Restaurants that serve alcohol must have a license, which they need to* ***renew*** *every year. The system should also* ***report how long, on average, customers wait for take out*** *in restaurants that offer take-out service. When* **reviewers** ***leave a review*** *for a restaurant, they must specify a recommendation (Thumbs Up or Thumbs Down) and can also leave a comment. An* **owner** *of a restaurant can* ***respond to a review*** *with a comment. All* **users** *of the system* ***log in*** *with their username. Users can choose to be contacted by email and ...*

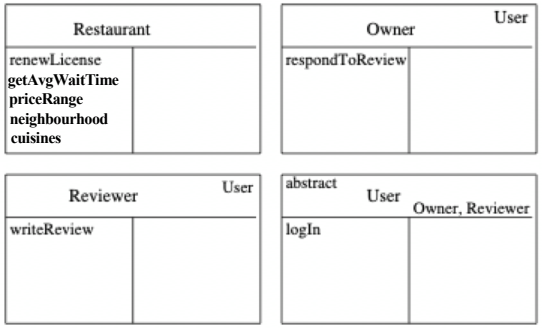
Example

- Adding some "what they do" responsibilities:



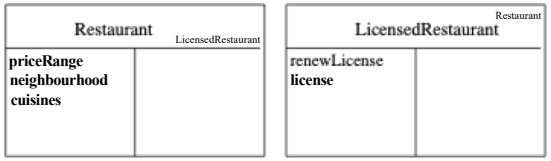
Example

- Adding some "what they store" responsibilities for `Restaurant`:

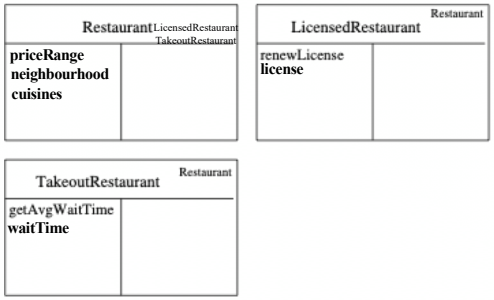


A problem with class `Restaurant`

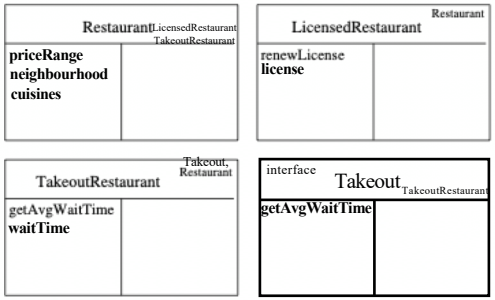
- What about the responsibility of storing licenses? But not all restaurants have licenses!
- Solution: We need a new type of `Restaurant`. Also, move `renewLicense` responsibility.



- What about the responsibility of storing wait times? Not all Restaurants offer takeout!
- Solution: We need a hierarchy.



- What if a restaurant is both a `LicensedRestaurant` and a `TakeOutRestaurant`?
- Solution: Use an interface.

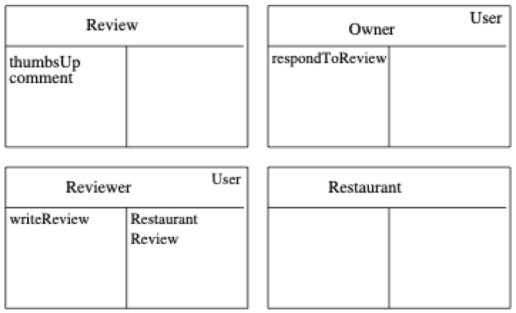


Expanding the Model

- Let's look more closely at reviews.
  - *Each* **restaurant** *corresponds to a certain price range, neighbourhood, and cuisines it serves. Restaurants that serve alcohol must have a license, which they need to* ***renew*** *every year. The system should also* ***report how long, on average, customers wait for take out*** *in restaurants that offer take-out service. When* **reviewers** ***leave a review*** *for a restaurant, they must specify a recommendation (Thumbs Up or Thumbs Down) and can also leave a comment. An* **owner** *of a restaurant can* ***respond to a review*** *with a comment. All* **users** *of the system* ***log in*** *with their username. Users can choose to be contacted by email and ...*

Example

- To write a review... it looks like we need a `Review` class.

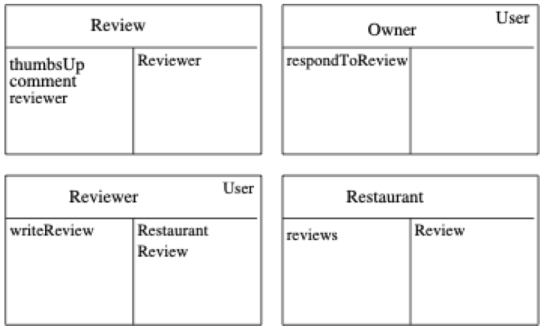


Example

- We have some design decisions to make:
  - Does a `Review` know which `Restaurant` it is for?
  - Does a `Review` know who wrote it?
  - Where do `Reviews` live? With a `Restaurant`? With a `Reviewer`?

Example

- Make your decisions. Here is one possibility:

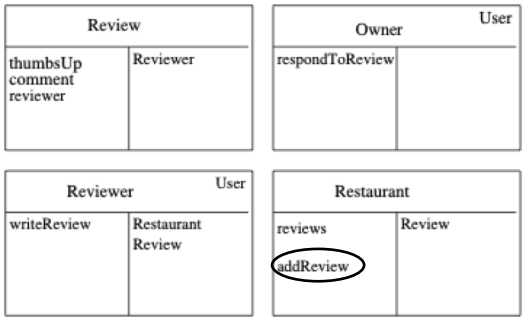


Example

- Let's see if this works...
- Scenario: *write a review*.
- Scenario walk-through:
  - To write a review, a `Reviewer` needs to:
    - create a `Review`
    - provide it to the `Restaurant`
    - the `Restaurant` needs to add it
  - We are missing the last responsibility...

Example

- Adding the new responsibility.



Exercise -- for practice at home

- Continue building the CRC Model by completing a scenario walkthrough for the `respondToReview` scenario.
- Now execute a scenario walk-throughs to convince yourself that your design works.
- Complete the model by adding all functionality in the description.