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Analysis, Design and Implementation


Topic 4:
Static Analysis and Design

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Introduction

- In this lecture we are going to look at the process of building static models of software.
 - The static model covers those aspects that are **architectural**.
 - They include diagrams and notations that describe the relationship between elements of the system.
- The main notation we use to do this is the **class diagram**. (We saw how to draw these in an earlier lecture.)




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Static Models

- Static models represent the **time independent** view of a system - the view that does not change based on how much time has passed or how people have interacted with the system.
- They are not used to describe interactions with a system. They describe instead the architecture of a system.
- This is also often referred to as a **structural view**.




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Identifying Classes


- The most difficult thing when it comes to building class diagrams is working out which classes to include.
 - Usually we progress from a problem statement or a requirements specification.
- There are formal techniques that aid in identifying classes. We'll look at one called **Natural Language Analysis**.
- We apply this heuristic process to a description of a problem.

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Natural Language Analysis - 1


- Natural Language Analysis permits us to obtain a list of **candidate classes**, their relationships and their attributes.
- Natural Language Analysis (NLA) is the process of identifying verbs, adjectives and nouns in a piece of descriptive text.
 - Nouns relate to potential classes
 - Adjectives relate to potential attributes
 - Verbs relate to potential functionality that must be represented.

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Natural Language Analysis - 2


- We take a piece of text and identify each of these in turns, creating lists.
 - Not everything we identify will be useful or relevant. That is why they are **candidates**.
- Once we have our lists, we get rid of:
 - Duplicates
 - Irrelevancies
 - Candidates that are out with our project scope
- What we end up with is a 'first draft' of a representation of the system.

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NLA Example

- We need a system that allows us to manage our library. It needs to let us add, remove and manipulate books, as well as add, remove and manipulate customer details. It should keep a database of all the books that are available on the shelves and those that are in the storeroom. Patrons should be able to view our catalogue through a webpage and place holds on the books that they wish to reserve.

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NLA Example - Nouns

- We need a **system** that allows us to manage our **library**. It needs to let us add, remove and manipulate **books**, as well as add, remove and manipulate **customer details**. It should keep a **database** of all the **books** that are available on the **shelves** and those that are in the **storeroom**. **Patrons** should be able to view our **catalogue** through a **webpage** and place holds on the **books** that they wish to reserve.

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NLA Example - Verbs

- We need a **system** that allows us to [manage] our **library**. It needs to let us [add], [remove] and [manipulate] **books**, as well as [add], [remove] and [manipulate] **customer details**. It should [keep] a **database** of all the **books** that are available on the **shelves** and those that are in the **storeroom**. **Patrons** should be able to [view] our **catalogue** through a **webpage** and [place] holds on the **books** that they wish to [reserve].

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Candidates

- This gives us an initial list of possible classes and actions:

| Classes | Functionality |
|---|---|
| System, Library, Books, Customer Details, database, shelves, storeroom, patrons, catalogue, webpage | Manage library, add books, remove books, manipulate books, add customer details, remove customer details, manipulate customer details, keep a database, view the catalogue, place hold, reserve |

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Candidates

- We then remove those that are synonyms.
 - E.g. Customers and Patrons
- We remove those that are too high a level of abstraction.
 - E.g. Manipulate the library
- We remove those that are already part of our future design.
 - E.g. Keep a database
- We remove those that are outside our scope.

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Candidates

- Doing this gives us a smaller, more manageable list of candidates.
- This isn't the 'correct' design - it's just a starting point.
- We will refine as we go along.

| Classes | Functionality |
|--|---|
| Library, Books, Patron, database, shelves, storeroom, catalogue, webpage | add books, remove books, manipulate books, add customer details, remove customer details, manipulate customer details, view the catalogue, place hold |

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Constructing a Class Diagram

- Having been given a list of classes and actions, we need to assign actions to classes. We can use this to build up our first class representation.
- Assigning functionality can be difficult:
 - We want it to be stored as close to the data that it is using as possible.
 - We want it to be stored in as high a level of abstraction as it can to ensure maximum maintainability.
- Again, we don't need to get it right to begin with.

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Constructing a Class Diagram

- Constructing the class diagram will help refine our candidates.
 - If we have a class that has no functionality or data associated with it, we probably don't need it.
- If we have a class that contains only one single piece of data, it is probably better represented as an attribute in another class.
- At this point, we are still on the first draft.
 - This is the draft that lets us go back to those for whom we are building the software.

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Resolving Ambiguity - 1


- Most of the documents from which you work will be incomplete and ambiguous. Our NLA process lets us identify clearly where those ambiguities lie.
- Actions often imply certain attributes are required.
- Structural relationships between classes are often implied by the words used and the context in which they are used.
- Sometimes we can work it out ourselves, sometimes we need to ask follow-up questions.

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Resolving Ambiguity - 2

- As an example, look at the functionality we have linked to a book:
 - Add books (okay)
 - Remove books (okay)
 - Manipulate books (ambiguous)
- Perhaps that means 'edit' book details, but we'd need to check.
- If it means edit the details, what kinds of details do we need?

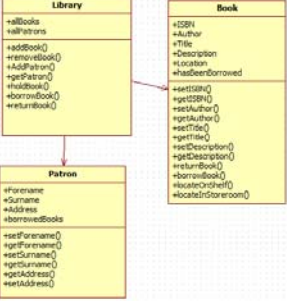
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First Draft Class Diagram



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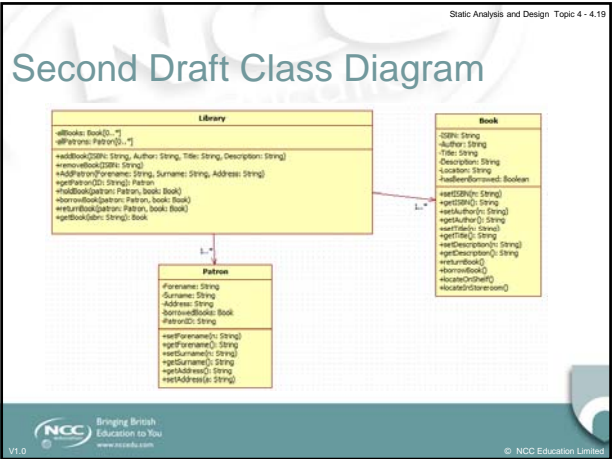
First Draft Class Diagram

- Our first class diagram doesn't include a lot of detail. It's mostly so we can go back to the client and check we have the right structure.
- Note here that we don't include the web page in our class diagram. It's not part of the 'engine' of our system – we will address it later.
- Once we are sure we have the right structure, we can fill in missing detail.

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Second Draft Class Diagram

- We can't write our program from the class diagram.
 - We don't know how any of the methods we have specified will actually work yet.
- All the class diagram gives us is an 'at a glance' view of how the classes interrelate, and what their available functionality is.
- This is part of the **static** view of the program.
 - It doesn't matter what a user does, the relationship between classes in the code is not going to be altered.

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Return Types and Parameters


- Notice in our second draft that we include the data types and parameter lists of operations. And yet, we don't know how the methods will work!
- We know (roughly) what kind of information is going to be needed for a method to function, and we simply supply that information.
- Though we don't yet know the details of how, for example, the addBook method will work, we do know the data it is going to need.

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Implementing Class Diagrams - 1


- The class diagram lends itself to implementation in any object oriented language.
 - One of the benefits of UML is that it does not require a particular implementation language.
- The class diagrams gives us the information we need to create the structural connections between each of the classes.
 - We do this by implementing them as *stub* methods (methods without any code).

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Implementing Class Diagrams - 2


- Normally, we would wait until we've done a few iterative drafts of the design before we start writing code. That way we don't waste time on models that are only going to be changed.
- A lot of user benefit can be obtained by including the user in the process, and rapid, early prototyping is a great way to do that.
- Prototyping can also highlight structural problems.

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Prototyping

- Prototyping is the process of building an early version of the software.
- It falls into two categories.
 - Throw-away prototyping, where the code is written and then discarded when the project is implemented 'for real'.
 - Incremental prototyping, where the prototype is continually refined and eventually evolves into the finished product.
- The former allows for the development of cleaner systems. The latter allows for more efficiency in development.

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Library Class

```
import java.util.*;

public class Library {
    private ArrayList<Book> allBooks;
    private ArrayList<Patron> allPatrons;

    public void addBook(String ISBN, String Author, String Title, String
Description) {
    }
    public void removeBook(String ISBN) {
    }
    public void AddPatron(String Forename, String Surname, String Address) {
    }
    public Patron getPatron(String ID) {
        return null;
    }
    public void holdBook(Patron patron, Book book) {
    }
    public void borrowBook(Patron patron, Book book) {
    }
    public void returnBook(Patron patron, Book book) {
    }
    public Book getBook(String isbn) {
        return null;
    }
}



```

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Class Implementation


- The other two classes are implemented in the same way:
 - The UML diagram tells us the name, type and parameters of methods.
 - The UML tells us the classes and how they relate.
- Our sole responsibility in writing the code from these diagrams is that it **compiles**.
 - There is no need for it to actually do anything, that will come later.

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Implementation - 1


- Implementation of code from a UML diagram is not a clerical task. It requires you to make some choices.
- In the code for the library, multiplicity of books and patrons has been implemented as an ArrayList.
 - That is a judgement call on the behalf of the developer.
- The UML diagram will describe some of the code you need. You will have to make choices of implementation as you go along.

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Implementation - 2


- Remember that the class diagram is (at best) an evolving document. It should change as your understanding of the system changes.
 - Most CASE tools (starUML included) offer facilities for automatically generating code from UML diagrams.
 - However, automated solutions are never entirely accurate.
 - They also cannot make judgement calls for you.
- However, initial prototypes will reveal structural deficiencies.

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Structural Deficiencies


- No design is perfect. They are created by imperfect humans, after all.
- Mistakes will be made.
- The more you explore the models you build, the easier it will be to see where there are deficiencies in your class diagrams:
 - Missing attributes and operations
 - Associations not honoured
- Ensure at all stages that you have a system that will compile!

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Conclusion


- Class diagrams can be difficult to construct. So we use Natural Language Analysis to give us a starting point.
- Candidate classes and attributes serve as the first step towards an accurate representation of a system.
 - We need to exercise considerable judgement in deciding what is and is not a suitable candidate.
- The class diagram gives a static view of the system.
 - It is architecture, not functionality.

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Any Questions?



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