Topic 2

Collections

Objectives

- Define the concepts and terminology related to collections
- Discuss the abstract design of collections

Collections

Collection: a group of items that we wish to treat as a conceptual unit

- ***Example***: a stamp collection

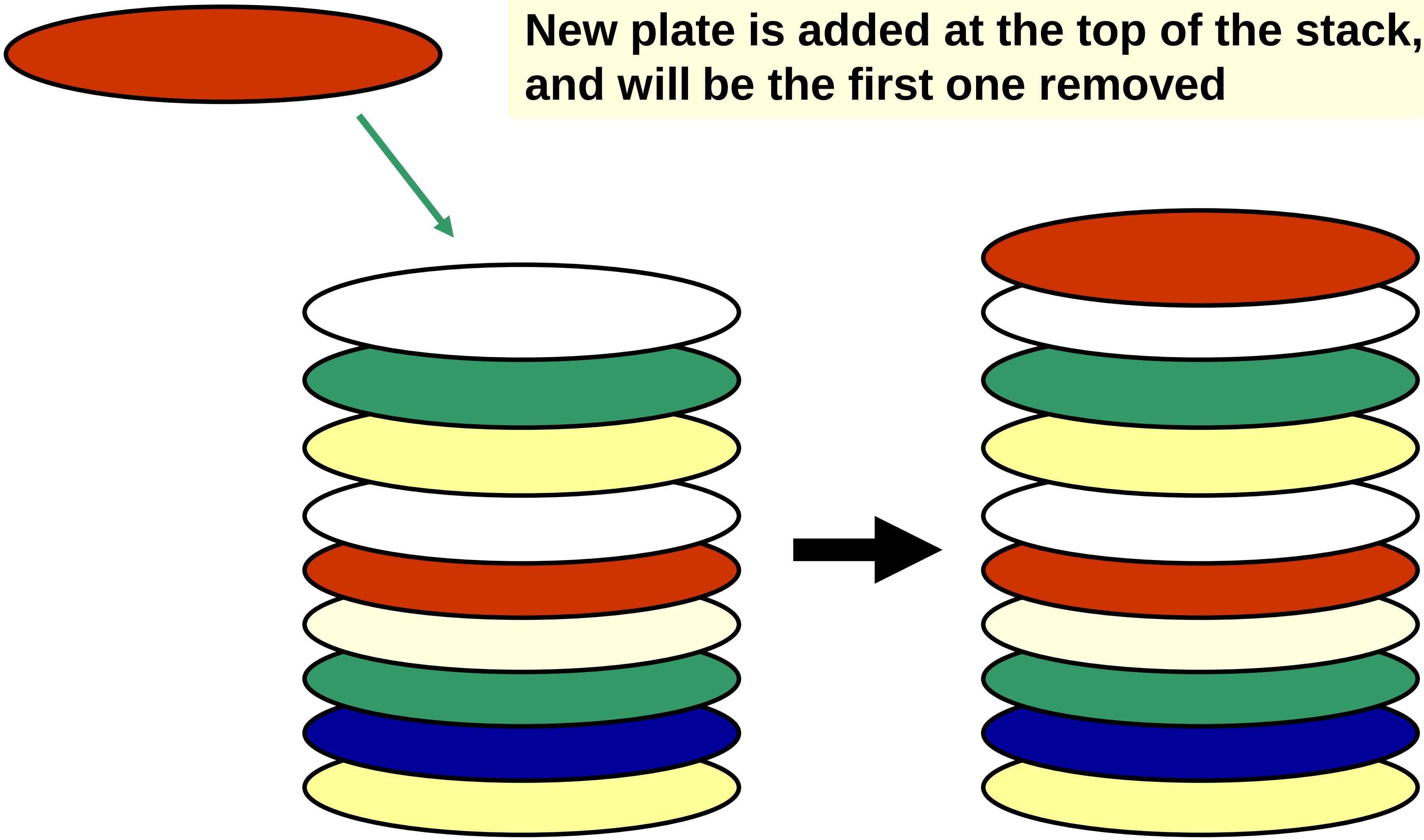
- In computer science, we have collections of items also
  - ***Examples***: stack, queue, list, tree, graph
- *The proper choice of a collection for a given problem can affect the efficiency of a solution!*

Examples of Collections

- What do collections look like?
  - ***Queue***: first item in is first item out
    - e.g. a lineup at a checkout counter
  - ***Stack***: last item in is first item out
    - e.g. a stack of plates in the cafeteria
  - ***List***: we can have ordered lists or unordered lists
    - e.g. a shopping list; a list of names and phone numbers; a to-do list

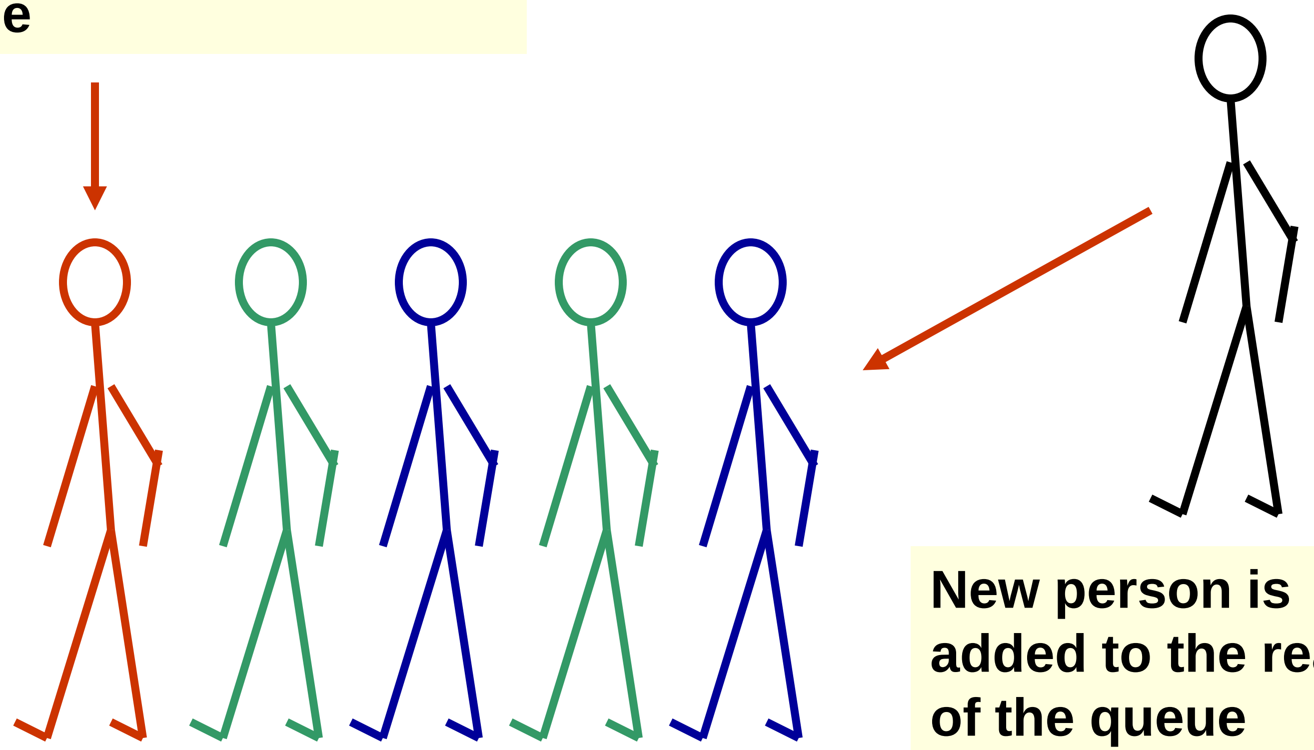
Example: stack of plates

New plate is added at the top of the stack, and will be the first one removed



Example: queue at checkout

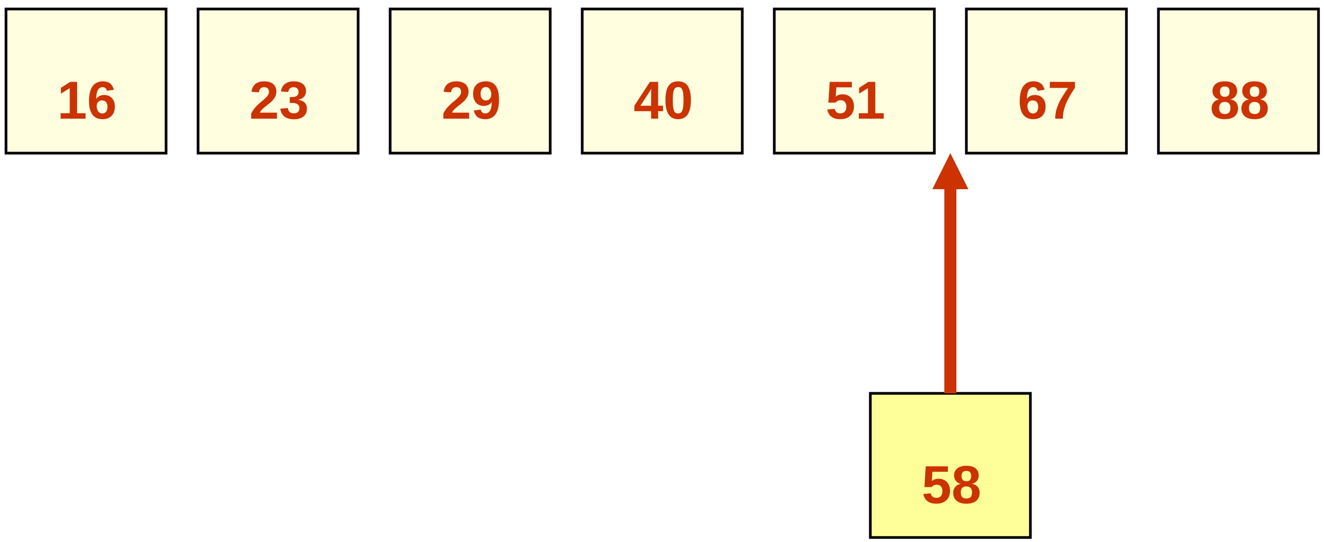
First person served will be the one at the front of queue



New person is added to the rear of the queue

Example: ordered list of numbers

New number must be added so that the ordering of the list is maintained



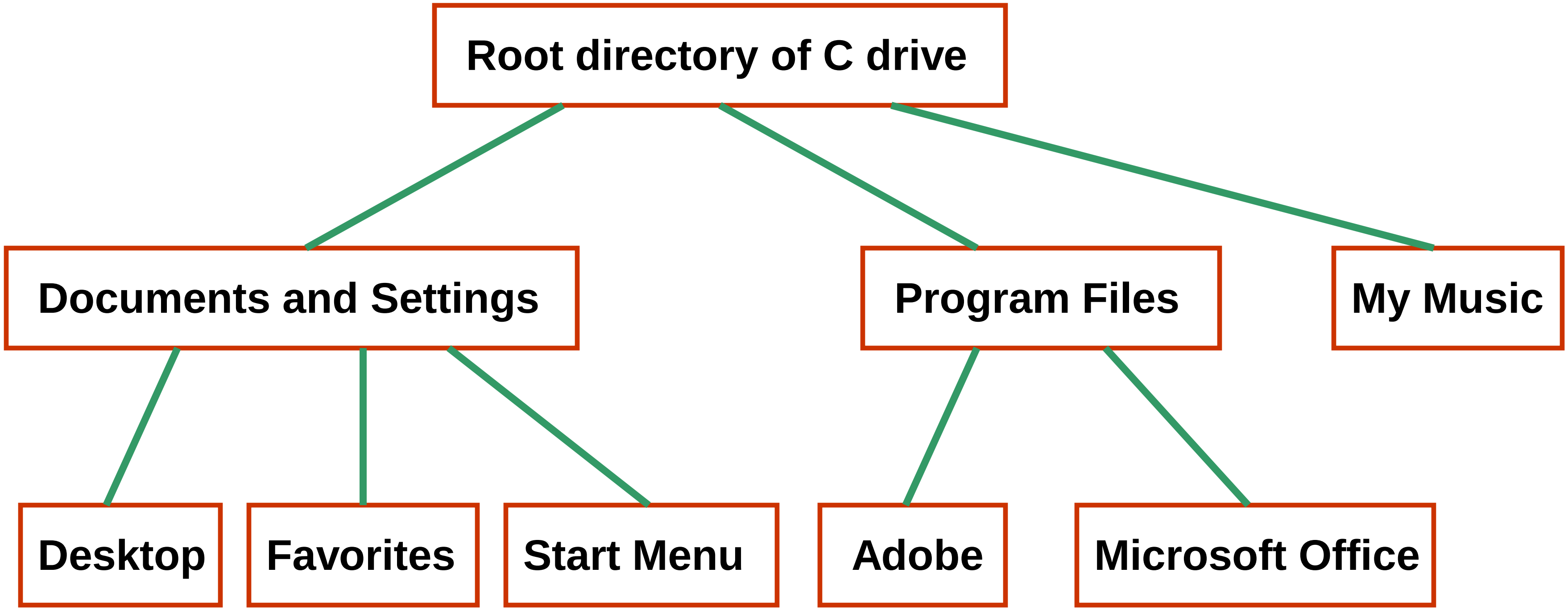
Examples of Collections

- The previous examples are ***linear collections***: items are organized in a "straight line"
  - Each item except the first has a unique ***predecessor***, and each item except the last has a unique ***successor*** within the collection

Examples of Collections

- We also have ***nonlinear collections***
- ***Hierarchical collections***: ***trees***
  - items are ordered in an "upside down tree"
  - Each item except the one at the top has a unique predecessor but may have *many* successors
  - ***Examples***: taxonomies, computer file systems

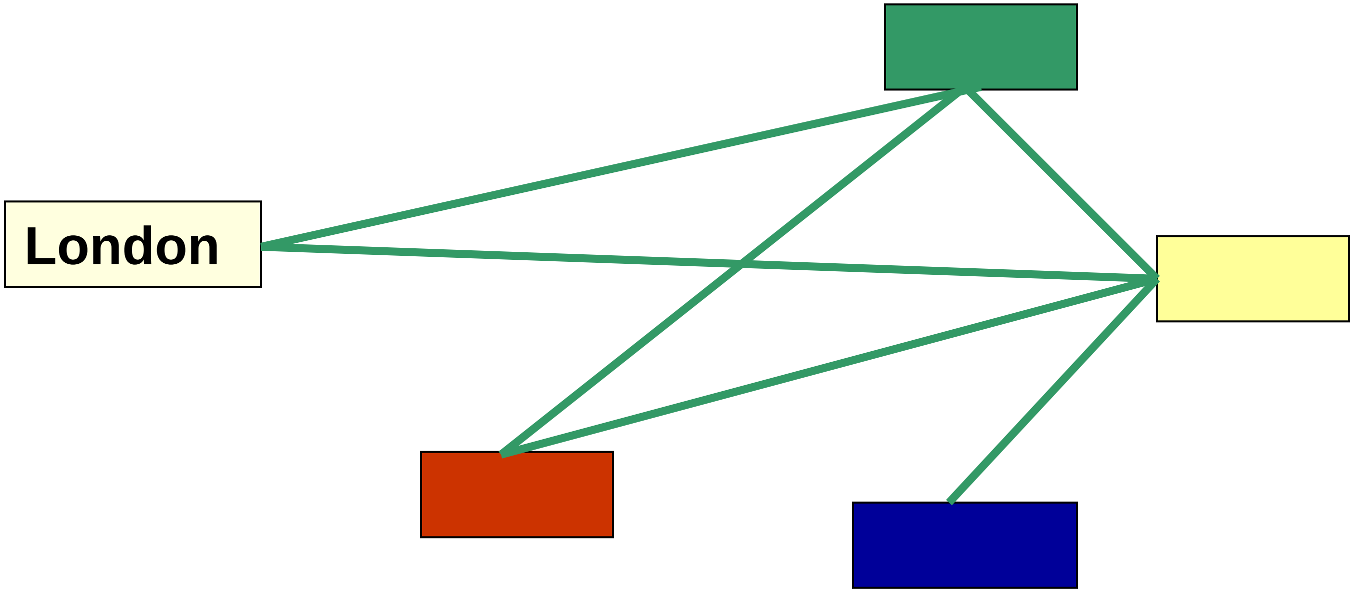
Example of a tree: computer file system



Examples of Collections

- Another nonlinear collection is a ***graph***: items can have *many* predecessors and *many* successors
  - ***Example***: maps of airline routes between cities

Example of a graph: airline routes between cities



Abstraction

- In solving problems in computer science, an important design principle is the notion of ***abstraction***
- Abstraction separates the ***purpose*** of an entity from its ***implementation***
  - ***Example in real life***: a car (we do not have to know how an engine works in order to drive a car)
  - ***Examples in computer systems***: a computer, a file
  - ***Example in Java***: class, object

Abstraction

- Abstraction provides a way of dealing with the complexity of a ***large*** system
- We will deal with each collection in a general way, as a data abstraction
- We will think of ***what*** we want to do with the collection, independently of ***how*** it is done
  - For example, we may want to add something to a queue, or to remove it from the queue

Collection as an Abstraction

- Example: think of a queue of customers
  - Suppose ***what*** we want to do is to deal with the first customer in the queue, i.e. *dequeue* a customer
  - ***How*** is this dequeue done?
    - We may not need to know, if someone else looked after the details
    - Or, if we are involved in the "how"
      - We may choose to program in Java or some other language
      - There may be several ways of implementing a queue that differ in efficiency

Collection as an Abstraction

- In other words, we want to *separate*
  - The ***interface*** of the collection: ***what*** we need in order to interact with it, i.e. the operations on the collection
    - This is from the perspective of a *user* of the collection
  - The ***implementation*** of the collection: the underlying details of ***how*** it is coded
    - This is from the perspective of a *writer* of the collection code

Issues with Collections

- For each collection that we examine, we will consider:
  - How does the collection operate conceptually?
  - How do we formally define its interface?
  - What kinds of problems does it help us solve?
  - In what ways might we implement it?
  - What are the benefits and costs of each implementation?

Abstract Data Types (ADTs)

- ***Data type***: a set of values and the operations defined on those values
  - Example: integer data type (**int**)
    - Values? operations?
- ***Abstract data type*** : a *collection of data* together with the *set of operations* on that data
  - Why ***abstract***? It's a data type whose values and operations are ***not*** inherently defined in a programming language
  - ***Examples***: stack, queue, list, tree

Data Structures

- ***Data structure:*** a construct within a *programming language*, used to *implement* a collection
  - ***Example***: array
- So, what is the difference between the terms "***abstract data type***" and "***data structure***"?
  - *(Note that sometimes the terms are used interchangeably, in generalizations about "data structures")*