Grouping objects

Collections and iterators

3.0

Main concepts to be covered

- Collections
- Loops
- Iterators
- Arrays

The requirement to group objects

- Many applications involve collections of objects:
  - Personal organizers.
  - Library catalogs.
  - Student-record system.
- The number of items to be stored varies.
  - Items added.
  - Items deleted.

A personal notebook

- Notes may be stored.
- Individual notes can be viewed.
- There is no limit to the number of notes.
- It will tell how many notes are stored.
- Explore the *notebook1* project.

Class libraries

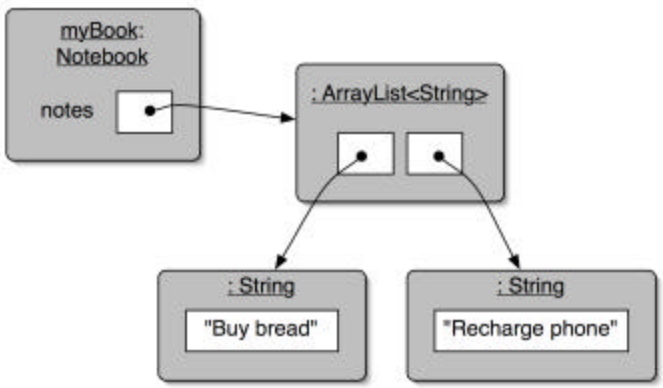
- Collections of useful classes.
- We don't have to write everything from scratch.
- Java calls its libraries, *packages*.
- Grouping objects is a recurring requirement.
  - The `java.util` package contains classes for doing this.


```
import java.util.ArrayList;

/**
 * ...
 */
public class Notebook
{
    // Storage for an arbitrary number of notes.
    private ArrayList<String> notes;

    /**
     * Perform any initialization required for the
     * notebook.
     */
    public Notebook()
    {
        notes = new ArrayList<String>();
    }

    ...
}
```

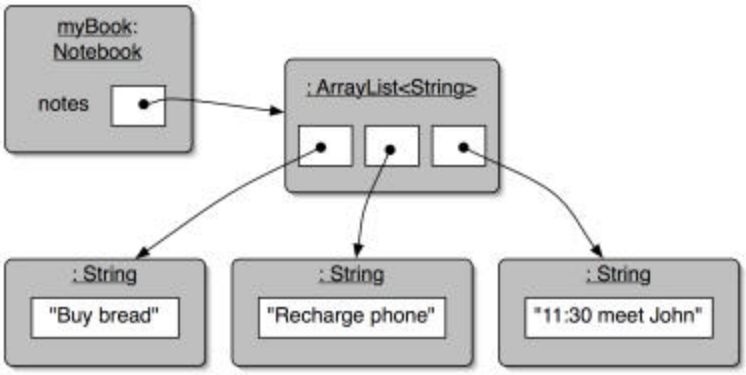
Collections

- We specify:
  - the type of collection: `ArrayList`
  - the type of objects it will contain: `<String>`
- We say, "ArrayList of String".

Object structures with collections



Adding a third note



Features of the collection

- It increases its capacity as necessary.
- It keeps a private count (`size()` accessor).
- It keeps the objects in order.
- Details of how all this is done are hidden.
  - Does that matter? Does not knowing how prevent us from using it?

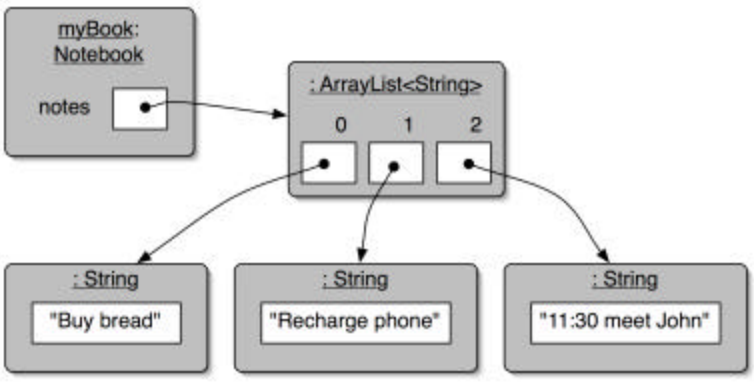
Using the collection

```
public class Notebook
{
    private ArrayList<String> notes;
    ...

    public void storeNote(String note)
    {
        notes.add(note);
    }

    public int numberOfNotes()
    {
        return notes.size();
    }

    ...
}
```

Adding a new note

Returning the number of notes (*delegation*)

Index numbering



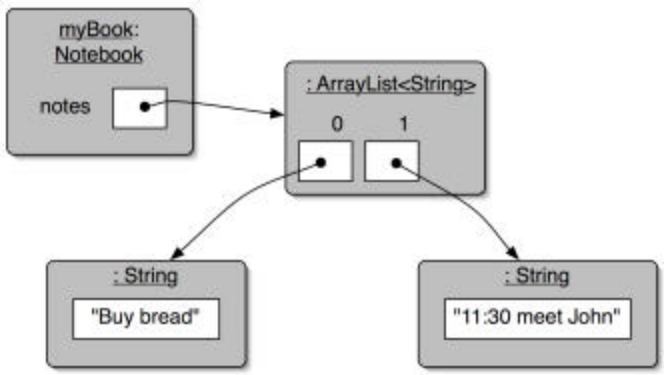
Retrieving an object

```
public void showNote(int noteNumber)
{
    if(noteNumber < 0) {
        // This is not a valid note number.
    }
    else if(noteNumber < numberOfNotes()) {
        System.out.println(notes.get(noteNumber));
    }
    else {
        // This is not a valid note number.
    }
}
```

Index validity checks

Retrieve and print the note

Removal may affect numbering



Generic classes

- Collections are known as *parameterized* or *generic* types.
- `ArrayList` implements list functionality:
  - **`add`**, **`get`**, **`size`**, etc.
- The type parameter says what we want a list of:
  - **`ArrayList<Person>`**
  - **`ArrayList<TicketMachine>`**
  - etc.

Review

- Collections allow an arbitrary number of objects to be stored.
- Class libraries usually contain tried-and-tested collection classes.
- Java's class libraries are called *packages*.
- We have used the `ArrayList` class from the `java.util` package.

Review

- Items may be added and removed.
- Each item has an index.
- Index values may change if items are removed (or further items added).
- The main `ArrayList` methods are `add`, `get`, `remove` and `size`.
- `ArrayList` is a parameterized or generic type.

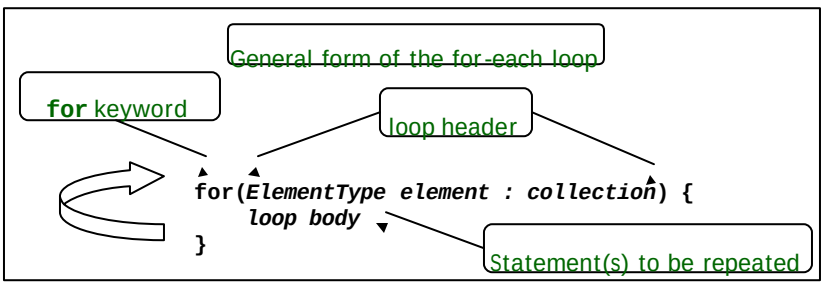
Iteration

- We often want to perform some actions an arbitrary number of times.
  - E.g., print all the notes in the notebook. How many are there?
- Most programming languages include *loop statements* to make this possible.
- Java has several sorts of loop statement.
  - We will start with its *for-each loop*.

Iteration fundamentals

- We often want to repeat some actions over and over.
- Loops provide us with a way to control how many times we repeat those actions.
- With collections, we often want to repeat things once for every object in a particular collection.

For-each loop pseudo code



Pseudo-code expression of the actions of a for-each loop

For each *element* in *collection*, do the things in the *loop body*.

A Java example

```
/**
 * List all notes in the notebook.
 */
public void listNotes()
{
    for(String note : notes) {
        System.out.println(note);
    }
}
```

for each *note* in *notes*, print out *note*

The while loop

- A for-each loop repeats the loop body for each object in a collection.
- Sometimes we require more variation than this.
- We can use a boolean condition to decide whether or not to keep going.
- A while loop provides this control.

While loop pseudo code

General form of a while loop

`while` keyword

boolean test

```
while(loop condition) {
    loop body
}
```

Statements to be repeated

Pseudo-code expression of the actions of a while loop

while we wish to continue, do the things in the loop body

A Java example

```
/**
 * List all notes in the notebook.
 */
public void listNotes()
{
    int index = 0;
    while(index < notes.size()) {
        System.out.println(notes.get(index));
        index++;
    }
}
```

Increment *index* by 1

while the value of *index* is less than the size of the collection, print the next note, and then increment *index*

for-each versus while

- for-each:
  - easier to write.
  - safer: it is guaranteed to stop.
- while:
  - we don't *have* to process the whole collection.
  - doesn't even have to be used with a collection.
  - take care: could be an *infinite loop*.

While without a collection

```
// Print all even numbers from 0 to 30.
int index = 0;
while(index <= 30) {
    System.out.println(index);
    index = index + 2;
}
```

Searching a collection

```
int index = 0;
boolean found = false;
while(index < notes.size() && !found) {
    String note = notes.get(index);
    if(note.contains(searchString)) {
        // We don't need to keep looking.
        found = true;
    }
    else {
        index++;
    }
}
// Either we found it, or we searched the whole
// collection.
```


Using an Iterator object

`java.util.Iterator`

returns an **`Iterator`** object

```
Iterator<ElementType> it = myCollection.iterator();
while(it.hasNext()) {
    call it.next() to get the next object
    do something with that object
}
```

```
public void listNotes()
{
    Iterator<String> it = notes.iterator();
    while(it.hasNext()) {
        System.out.println(it.next());
    }
}
```

Index versus Iterator

- Ways to iterate over a collection:
  - for-each loop.
    - Use if we want to process every element.
  - while loop.
    - Use if we might want to stop part way through.
    - Use for repetition that doesn't involve a collection.
  - Iterator object.
    - Use if we might want to stop part way through.
    - Often used with collections where indexed access is not very efficient, or impossible.
- Iteration is an important programming *pattern*.

The *auction* project

- The *auction* project provides further illustration of collections and iteration.
- One further point to follow up: the `null` value.
  - Used to indicate, 'no object'.
  - We can test if an object variable holds the null variable.

Review

- Loop statements allow a block of statements to be repeated.
- The for-each loop allows iteration over a whole collection.
- The while loop allows the repetition to be controlled by a boolean expression.
- All collection classes provide special `Iterator` objects that provide sequential access to a whole collection.

Fixed-size collections

- Sometimes the maximum collection size can be pre-determined.
- Programming languages usually offer a special fixed-size collection type: an *array*.
- Java arrays can store objects or primitive-type values.
- Arrays use a special syntax.

The *weblog-analyzer* project

- Web server records details of each access.
- Supports webmaster's tasks.
  - Most popular pages.
  - Busiest periods.
  - How much data is being delivered.
  - Broken references.
- Analyze accesses by hour.

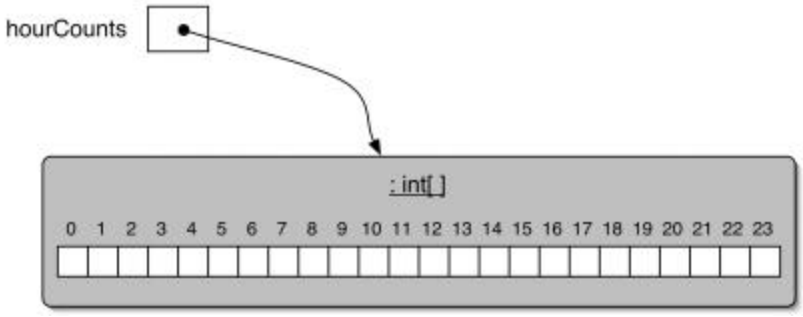
Creating an array object

```
public class LogAnalyzer
{
    private int[] hourCounts;
    private LogfileReader reader;

    public LogAnalyzer()
    {
        hourCounts = new int[24];
        reader = new LogfileReader();
    }
    ...
}
```

Array variable declaration

Array object creation

The hourCounts array



Using an array

- Square-bracket notation is used to access an array element: `hourCounts[...]`
- Elements are used like ordinary variables.
  - On the left of an assignment:
    - `hourCounts[hour] = ...;`
  - In an expression:
    - `adjusted = hourCounts[hour] – 3;`
    - `hourCounts[hour]++;`

The for loop

- There are two variations of the for loop, *for-each* and *for*.
- The for loop is often used to iterate a fixed number of times.
- Often used with a variable that changes a fixed amount on each iteration.

For loop pseudo-code

General form of a for loop

```
for(initialization; condition; post-body action) {
    statements to be repeated
}
```

Equivalent in while-loop form

```
initialization;
while(condition) {
    statements to be repeated
    post-body action
}
```

A Java example

for loop version

```
for(int hour = 0; hour < hourCounts.length; hour++) {
    System.out.println(hour + ": " + hourCounts[hour]);
}
```

while loop version

```
int hour = 0;
while(hour < hourCounts.length) {
    System.out.println(hour + ": " + hourCounts[hour]);
    hour++;
}
```


for loop with bigger step

```
// Print multiples of 3 that are below 40.
for(int num = 3; num < 40; num = num + 3) {
    System.out.println(num);
}
```

Review

- Arrays are appropriate where a fixed-size collection is required.
- Arrays use special syntax.
- For loops offer an alternative to while loops when the number of repetitions is known.
- For loops are used when an index variable is required.