Inf1-OP

Collections

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February 7, 2019

Rigidity of arrays

- Length of array is fixed at creation time.
- Can't be expanded.
- Can't be shrunk.
- Arrays are part of Java language — uses special syntax.
- E.g., `myArray[i]` for accessing the ith element.

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- Arrays are part of Java language — uses special syntax.
- E.g., `myArray[i]` for accessing the ith element.

Arrays are not always optimal for handling data.

ArrayList

- Can grow and shrink as needed;
- provides methods for inserting and removing elements.

ArrayList

Declaration

```
ArrayList<String> cheers = new ArrayList<String>();
```

- This is an array list of strings; counterpart to `String[]`.
- Angle brackets indicate that `String` is a type parameter.
- Can replace `String` with e.g. `HotelRoom` to get different array list type.
- In general: use `ArrayList<E>` to collect objects of type `E`; but `E` cannot be a primitive type.

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- In general: use `ArrayList<E>` to collect objects of type `E`; but `E` cannot be a primitive type.

NB:

```
ArrayList<String> cheers = new ArrayList<>();
```

Since Java 8 the compiler can infer the type of the list in the constructor call.

ArrayList: Methods

- A newly constructed `ArrayList` has size `0`.
- `ArrayList` has various methods, which allow us to:
  - keep on adding new elements;
  - remove elements.
- The size changes after each addition / removal.

ArrayList: Adding

Adding Elements

```
ArrayList<String> cheers = new ArrayList<String>();
cheers.add("hip");
cheers.add("hip");
cheers.add("hooray");
int n = cheers.size(); // n gets value 3
```

- `add()` appends each element to the end of the list.

ArrayList: Printing

Printing an ArrayList

```
System.out.println(cheers);
```

Output

```
[hip, hip, hooray]
```

The compiler implicitly calls the `.toString()` method of the `cheers` object which in turn calls the `.toString()` method of each of its list elements.

ArrayList: More methods

Index of first occurrence

```
int ind = cheers.indexOf("hip");  // ind gets value 0
```

Adding element at an index

```
cheers.add(1, "hop"); // 2nd "hip" gets shunted along
```

Elements of `cheers`: `["hip", "hop", "hip", "hooray"]`

ArrayList: More methods

contains()

```
boolean isHip = cheers.contains("hip");  // isHip is true
```

remove()

```
cheers.remove("hip");  // removes first occurrence of "hip"
```

Elements of cheers: "hop", "hip", "hooray"

get(int index)

```
cheers.get(0);  // get the first element
                // returns "hop"
```

ArrayList and Loops

Looping over `ArrayList`:

Standard `for` loop

```
for (int i = 0; i < cheers.size(); i++) {
     System.out.println(cheers.get(i));
}
```

ArrayList and Loops

Looping over `ArrayList`:

Standard `for` loop

```
for (int i = 0; i < cheers.size(); i++) {
     System.out.println(cheers.get(i));
}
```

Enhanced `for` again

```
for (String s : cheers) {
     System.out.println(s);
}
```

ArrayList and Loops

Enhanced `for` again

```
for (String s : cheers) {
     System.out.print(s + "\thas index: ");
     System.out.println(cheers.indexOf(s));
}
```

Output

```
hop     has index: 0
hip     has index: 1
hooray  has index: 2
```

Wrapper Classes

Wrapper Classes:

- The type variable `E` in a generic type like `ArrayList<E>` must resolve to a reference type.
- So `ArrayList<int>` will not compile.
- All the primitive types can be turned into objects by using wrapper classes:

Primitive Type	*Wrapper Class*
`boolean`	`Boolean`
`char`	`Character`
`double`	`Double`
`int`	`Integer`
`long`	`Long`

NB Wrapper class names are always capitalized, always complete words.

Auto-boxing

- Conversion between primitive types and corresponding wrapper classes is automatic.
- Process of conversion is called auto-boxing

Auto-box example

```
Double batteryCharge = 2.75;
double x = batteryCharge;
```

Auto-box example

```
ArrayList<Double> data = new ArrayList<Double>();
data.add(29.95);
double x = data.get(0);
```

Custom Types in ArrayLists

You can also put your own data types into an `ArrayList`:

Circle List

```
ArrayList<Circle> data = new ArrayList<Circle>();
Circle c = new Circle(10);
data.add(c);
data.get(0).enlarge(2);
```

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ArrayList<Circle> data = new ArrayList<Circle>();
Circle c = new Circle(10);
data.add(c);
data.get(0).enlarge(2);
```

Some functionality will, however, not work properly unless you implement the necessary **Interfaces** (I will tell you more later).

Comparing Elements

```
Collections.sort(data);
Collections.reverse(data);
```

Nested ArrayLists

Since I can use any object type as type parameter, I can also create ArrayLists of ArrayLists.

Daily Temperature Lists

```
ArrayList<ArrayList<Double>> dailyTemp =
        new ArrayList<ArrayList<Double>>();
dailyTemp.add(new ArrayList<Double>());
dailyTemp.get(0).add(1.2);
dailyTemp.get(0).add(1.4);
dailyTemp.add(new ArrayList<Double>());
dailyTemp.get(1).add(2.0);
dailyTemp.get(1).add(1.9);
```

Output

```
[[1.0, 1.4], [2.0, 1.9]]
```

Lists of Lists

This is where type inference comes in handy.

Nested Lists

```
ArrayList<ArrayList<Double>> dailyTemp = new ArrayList<>();
dailyTemp.add(new ArrayList<>());
dailyTemp.get(0).add(1.0);
dailyTemp.get(0).add(1.4);
dailyTemp.add(new ArrayList<>());
dailyTemp.get(1).add(2.0);
dailyTemp.get(1).add(1.9);
```

Output

```
[[1.0, 1.4], [2.0, 1.9]]
```

Import

Importing:

- To get full access to Java API, we need to import classes.
- Not necessary if class is in same folder, or part of `java.lang` (e.g., `Math` library).
- To use `ArrayList`, add the appropriate `import` statement at top of your file:

Import example

```
import java.util.ArrayList;
```

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- To use `ArrayList`, add the appropriate `import` statement at top of your file:

Import example

```
import java.util.ArrayList;
```

Import example — Wrong!

```
import java.util.ArrayList<String>; // Don't use parameter
```

Java API

Look at sample Javadoc web page.
http://docs.oracle.com/javase/8/docs/api/

Maps / Associative Arrays

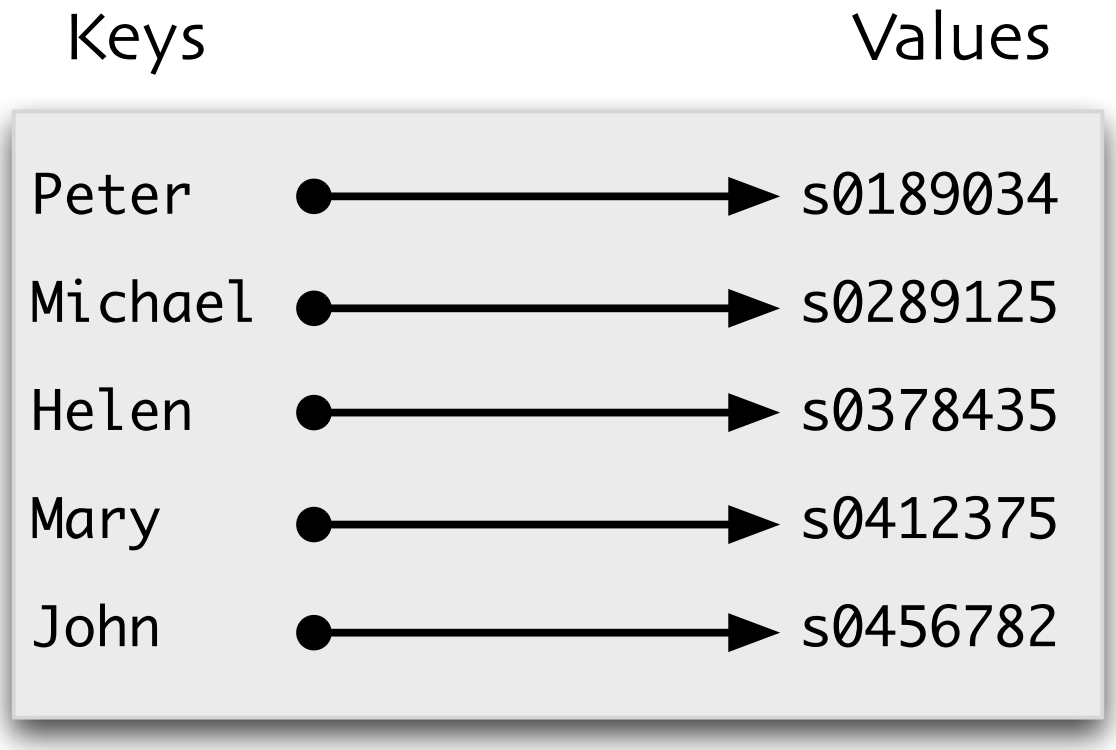
Associative Arrays

Associative array:

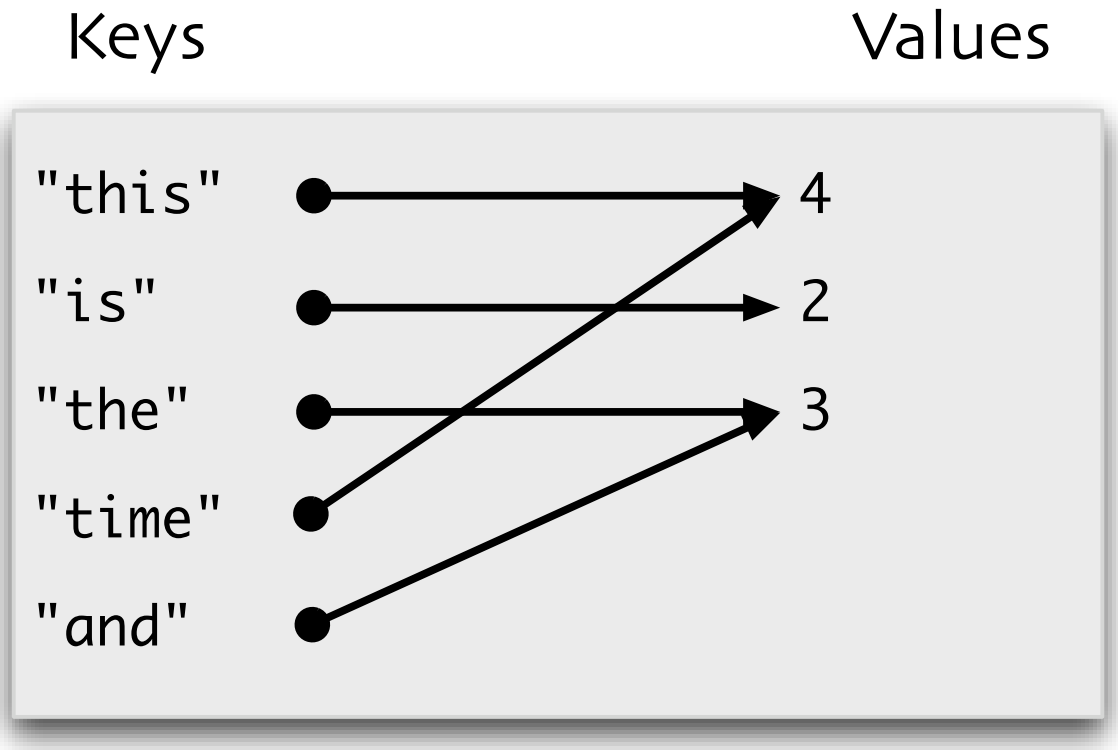
- Associates a collection of unique keys with values.
- Ordinary arrays: keys can only be integers.
- Associative arrays allow keys of many types, most notably strings.
- Examples:
  1. Given a person's name, look up a telephone number.
  2. Given an internet domain, look up its IP address.
  3. Given a geo-location, look up its GPS coordinates.
  4. Given a word, look up its frequency in a text.
- Relationship between key and value: mapping.

Java: associative arrays are implemented by type `HashMap`.

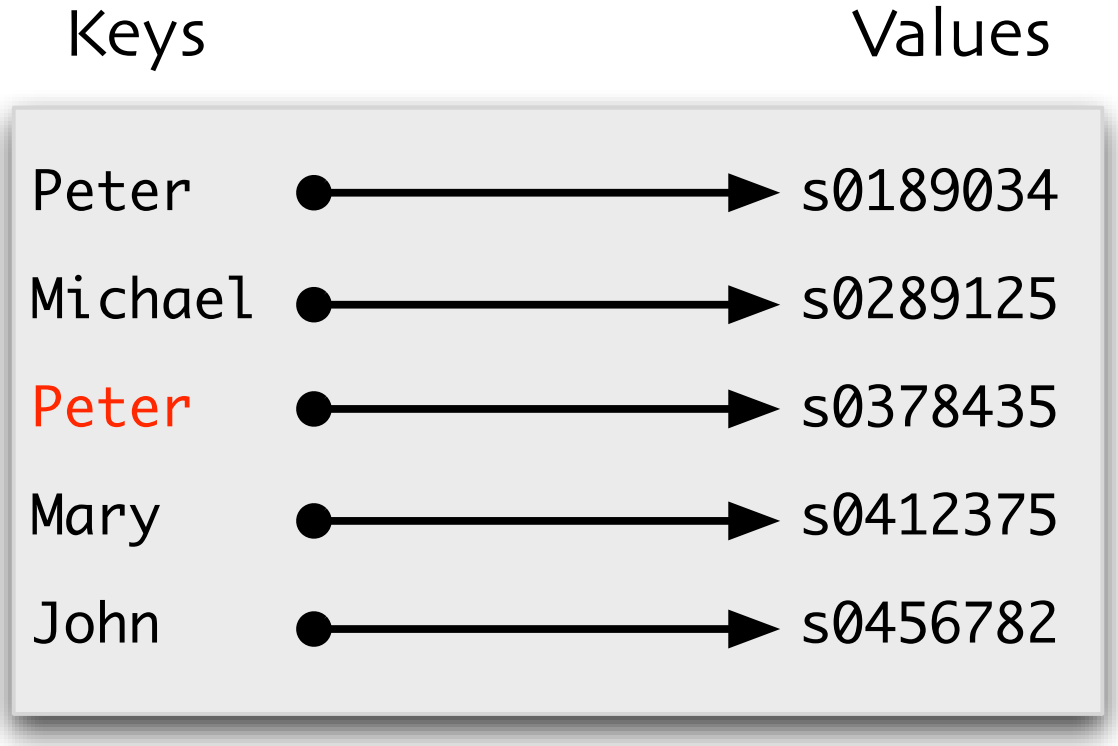
Map People to their Matric Nos.



Map Words to Length

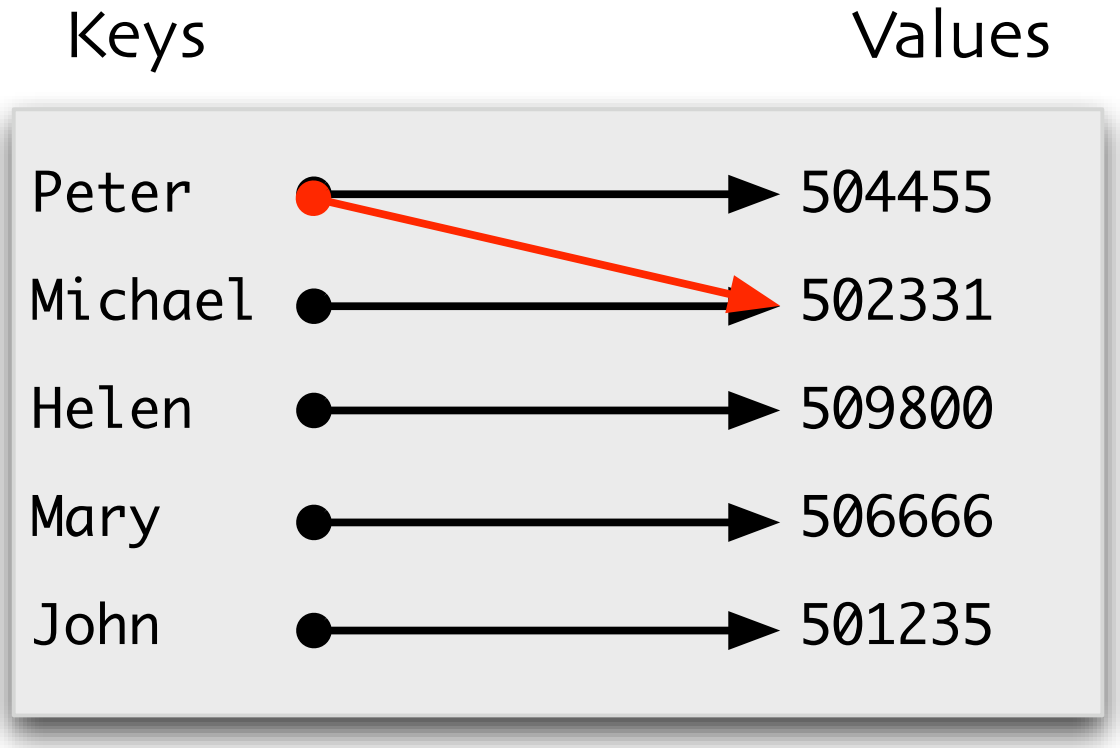


Map People to their Matric Nos: Wrong!



NB Keys must be unique.

Map People to their Telephone Nos: Wrong!



- A given key can only be mapped to one value.
- However, type of value can be array, or some other object.

HashMap

Import HashMap

```
import java.util.HashMap;
```

HashMap

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import java.util.HashMap;
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Declare HashMap

```
HashMap<String, Integer> map
    = new HashMap<String, Integer>();
```

- HashMap takes two type parameters.
- Here, String is type of key, Integer is type of value.

HashMap

Import HashMap

```
import java.util.HashMap;
```

Declare HashMap

```
HashMap<String, Integer> map
    = new HashMap<String, Integer>();
```

- `HashMap` takes two type parameters.
- Here, `String` is type of key, `Integer` is type of value.

NB: There is a different type called `Hashtable` which is the same for our purposes.

Mapping Words to their Lengths

Goal: Given a string of words, derive an associative array that maps each word to its length.

1. Split the string on whitespace, to yield words.
2. For each word `w`, add it as a key, and associate it with value `w.length()`.
3. When we add the same key again, we overwrite the previous association — wasteful but harmless in this case.

`split()` method of `String`

```
String sent = "this is the time and this is the record of the ti
String[] words = sent.split(" "); // split on whitespace
```

HashMap: Add and retrieve mappings

- put(*Key*, *Value*): put *Value* as the value of *Key* in wordLengths.

```
HashMap<String, Integer> wordLengths = new HashMap<String, Integer>();
for (String word : words) {
      wordLengths.put(word, word.length());
    }
```

add a key-value pair to the mapping

- get(*Key*): get the value of *Key* in wordLengths.

```
int wl = wordLengths.get("record"); // value is 6
```

HashMap: Add and retrieve mappings

`wordLengths.keySet()`: the set of keys in `wordLengths`.

```
[of, record, time, is, the, this, and]
```

HashMap: Add and retrieve mappings

`wordLengths.keySet()`: the set of keys in `wordLengths`.

```
[of, record, time, is, the, this, and]
```

Q How do we list all key-value pairs in a map?

A Loop over the set of keys.

```
for (String key : wordLengths.keySet()) {
      System.out.printf("%s => %s\n", key, wordLengths.get(key));
      }
```

Output

```
of => 2
record => 6
time => 4
is => 2
the => 3
this => 4
```

HashMap: Printing

Output

```
System.out.println(wordLengths);
```

Output

```
{of=2, record=6, time=4, is=2, the=3, this=4, and=3}
```

Format is {*Key1*=*Value1*, *Key2*=*Value2*, ... }

Custom Types in HashMaps

You can also put your own data types into a `HashMap`:

Circle Values

```
HashMap<String, Circle> data = new HashMap<String, Circle>();
data.put("Small", new Circle(2));
data.put("Large", new Circle(200));
```

Custom Types in HashMaps

You can also put your own data types into a `HashMap`:

Circle Values

```
HashMap<String, Circle> data = new HashMap<String, Circle>();
data.put("Small", new Circle(2));
data.put("Large", new Circle(200));
```

Using custom types as keys, is more tricky: You will have to make sure they have an `equals` method and produce the same hash code. - **Not part of this course**.

Nested HashMaps

Similar to `ArrayLists`, you can also write nested `HashMaps`.

Circle Organiser

```
HashMap<String, ArrayList<Circle>> data = new HashMap<>();
data.put("Large", new ArrayList<>());
data.put("Small", new ArrayList<>());
data.get("Large").add(new Circle(200));
data.get("Large").add(new Circle(300));
data.get("Small").add(new Circle(5));
data.get("Small").add(new Circle(6));
System.out.println(data);
```

Let's assume `Circle` implements `toString`.

Output

```
Small=[5, 6], Large=[200, 300]
```

ArrayList & HashMap

- Use `ArrayList` when you want your arrays to be able to grow, or you want to easily insert and remove items in the middle of an array.
- Use `HashMap` when you want to use keys other than a predetermined list of integers.
- For more on `ArrayList` and `HashMap`, look at the Java API:

`http://docs.oracle.com/javase/8/docs/api/`

Reading

Java Tutorial

pp423-505, i.e. Chapter 12 *Collections*, stopping at *Algorithms*.

The book sections contain more material than we talked about. I don't expect you to remember all the different kinds of collections, but I do expect you to be able to look them up and use them.