Array topic index

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Tracing array code

Methods for working with arrays

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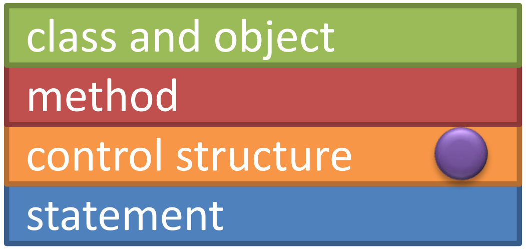
Arrays

How to store and work with large amounts of data



10 Managing Collections with Arrays

Dr James Montgomery, james.montgomery@utas.edu.au

The need for arrays

Task: Calculate the average age of a group of people

Possible (partial) solution:

```
int age1, age2, age3, age4;
int sum;
double average;
//Would read ages from user
//    (~8 lines of code)
//Would add those together,
//    storing total in sum
average = (double) sum / 4;
```

But what if fewer than 4 ages?

What if more?

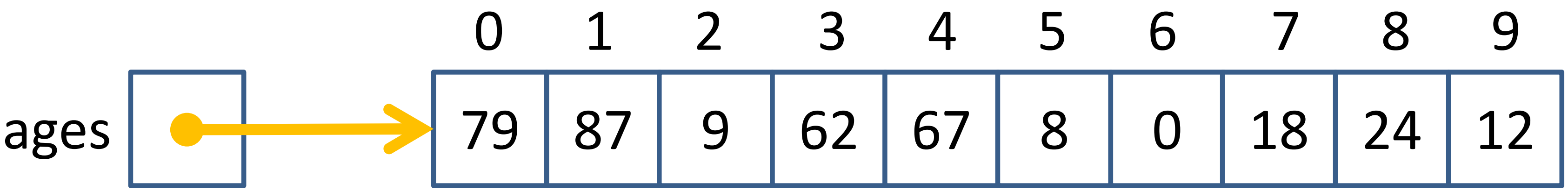
This solution can't scale and requires a lot of duplication

We need one variable name for a collection of ages

Arrays: the simplest data structure

An array is an ordered (and indexed) list of values of the same type (primitive or object)

Example: a list of 10 integer ages



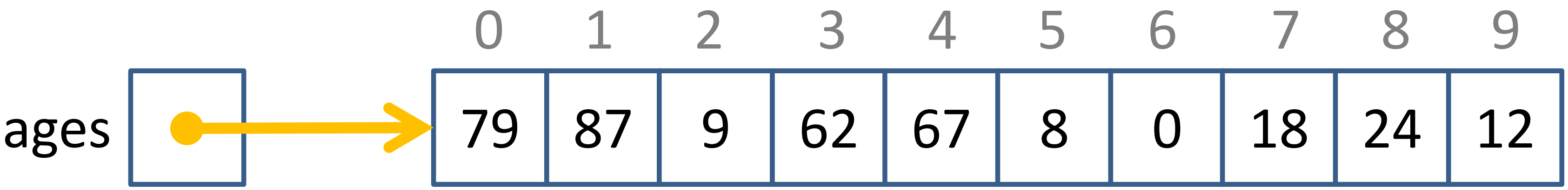
index of each element

	0	1	2	3	4	5	6	7	8	9
ages	79	87	9	62	67	8	0	18	24	12

array reference

the elements

Array elements are like other variables



ages

0	1	2	3	4	5	6	7	8	9
79	87	9	62	67	8	0	18	24	12

ages[*index*] is a single variable at position *index*

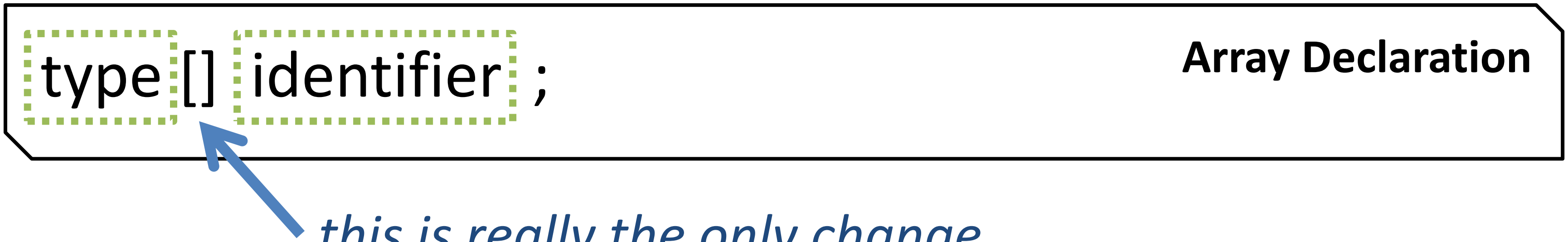
`ages[4]` is 67

```
int a = ages[4]; //a is now 67
ages[4] = ages[4] + 1; //happy birthday
```

`ages[4]` is now

Tip: *index* can be any integer expression

Declaring arrays



Array Declaration

type [] identifier ;

this is really the only change

```
int[] ages;
String[] names;
```

How would you declare an array of doubles?

Allocating space

Arrays are like objects: when declared they refer to **null**

identifier = new type [size];

Array Initialisation

```
ages = new int[10];
```

initially, every element is zero (or false if array of boolean, or null if array of objects)

or (better)

```
final int SIZE = 10;
ages = new int[SIZE];
```

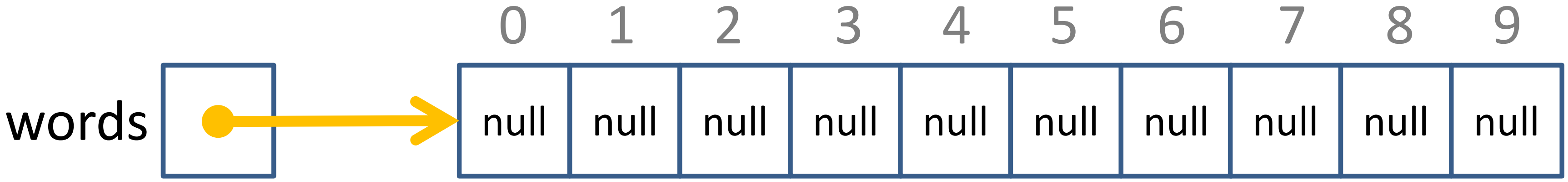
Can also declare and initialise all at once:

int[] ages = { 79, 87, 9, 62, 67, 8, 0, 18, 24, 12 };

Arrays of objects

```
String[] words = new String[10];
```

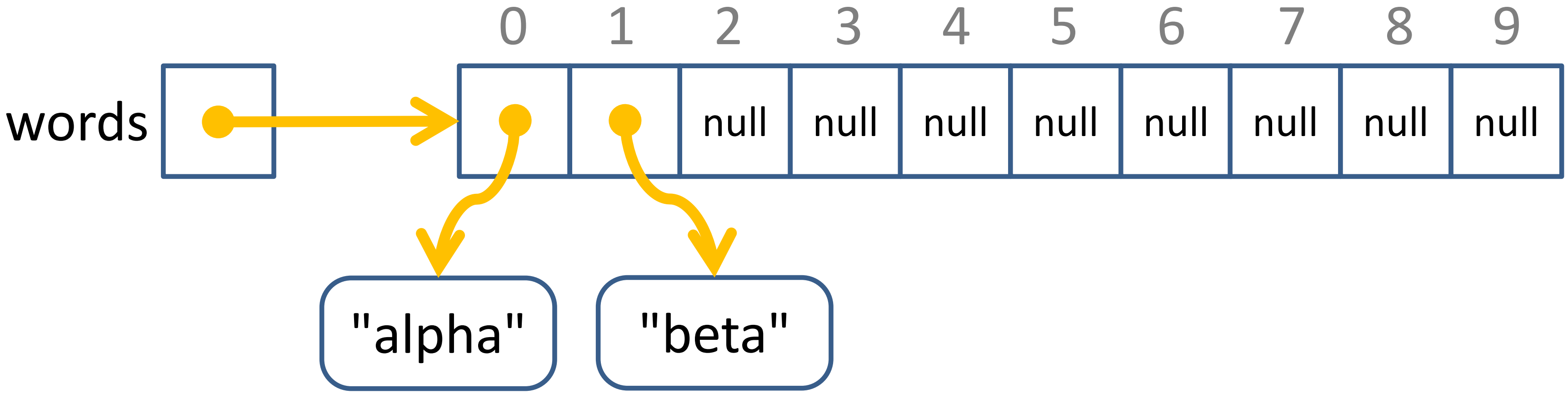
allocates space for 10 String references, but doesn’t create them



words

0	1	2	3	4	5	6	7	8	9
null	null	null	null	null	null	null	null	null	null

```
words[0] = "alpha";
words[1] = "beta";
```



words

0	1	2	3	4	5	6	7	8	9
		null	null	null	null	null	null	null	null

"alpha"

"beta"

Length of an array

Arrays have a `length` property (a read-only integer data member, not a method)

Given

```
int[] counts = new int[15];
String[] labels = new String[25];
```

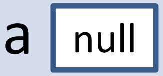
`counts.length` is 15 and
`labels.length` is

Tip: Attempting to access an element below 0 or above array's length – 1 results in an error

Quick summary

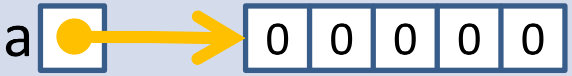
Declare an array reference

- syntax: *type*[] *identifier*;
- example: int[] a;



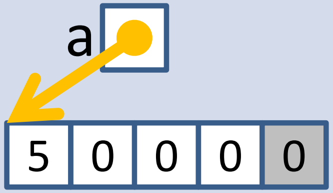
Allocate space

- syntax: *identifier* = new *type*[*size*];
- example: a = new int[5];



Access a specific element

- syntax: *identifier*[*index*];
- examples:
  - a[0] = 5;
  - int x = a[4];



And…

- *array*.length is length of array, as in a.length
- Array contents can be modified by methods

Tracing array code

- class and object
- method
- control structure ●
- statement

10 Managing Collections with Arrays

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Two alternatives

If the code appears to be reading the array only…

draw it off to the side of the tracing table

Line	sum	i
2	0	
3		0
6	1	
7		1
6	3	
7		2
6	7	
7		3
6	15	

	0	1	2	3
a	1	2	4	8

If it's modifying the array's contents…

incorporate it into the table

		a			
Line	i	0	1	2	3
1		1	2	4	8
2	0				
5		2			
6	1				
5			4		
6	2				
5				8	
6	3				

Demonstration

```
1.  int[] a = { 1, 2, 4, 8};
2.  int sum = 0;
3.  int i = 0;
4.
5.  while (i < a.length) {
6.      sum += a[i];
7.      i++;
8.  }
```

Line	sum	i
2	0	
3		0
6	1	
7		1
6	3	
7		2
6	7	
7		3
6	15	
7		4

	0	1	2	3
a	1	2	4	8

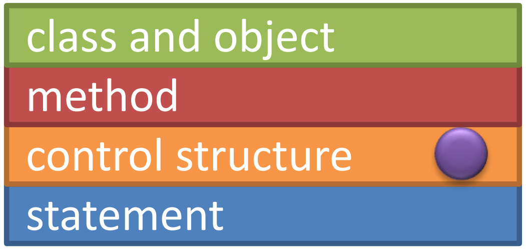
Demonstration

```
1.   int[] a = { 1, 2, 4, 8};
2.   int i = 0;
3.
4.   while (i < a.length) {
5.       a[i] = 2 * a[i];
6.       i++;
7.   }
```

		a			
Line	i	0	1	2	3
1		1	2	4	8
2	0				
5		2			
6	1				
5			4		
6	2				
5				8	
6	3				
5					16
6	4				

	0	1	2	3
a	2	4	8	16

Methods for working with arrays



class and object

method

control structure

statement

10 Managing Collections with Arrays

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Arrays as method arguments

Arrays are references, so when passed to a method the *reference* is copied

Changes to the elements persist after the method has finished

```
public static void main(String[] args) {
  int[] vals = { 2, 4, 6, 8, 10 };
  change(vals, 2, 100);
  System.out.println(vals[2]);
}

public static void change(int[] a, int index, int toVal) {

    a[index] = toVal;
}
```

What value is printed?

Arrays as method arguments

Arrays are references, so when passed to a method the *reference* is copied

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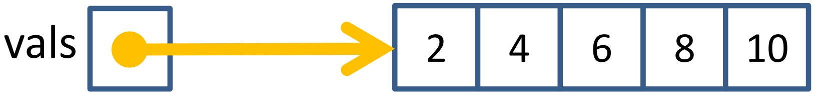
public static void main(String[] args) {
    int[] vals = { 2, 4, 6, 8, 10 };
    change(vals, 2, 100);
    System.out.println(vals[2]);
}

public static void change(int[] a, int index, int toVal) {

        a[index] = toVal;
}
```



Arrays as method arguments

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```
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   change(vals, 2, 100);
   System.out.println(vals[2]);
}

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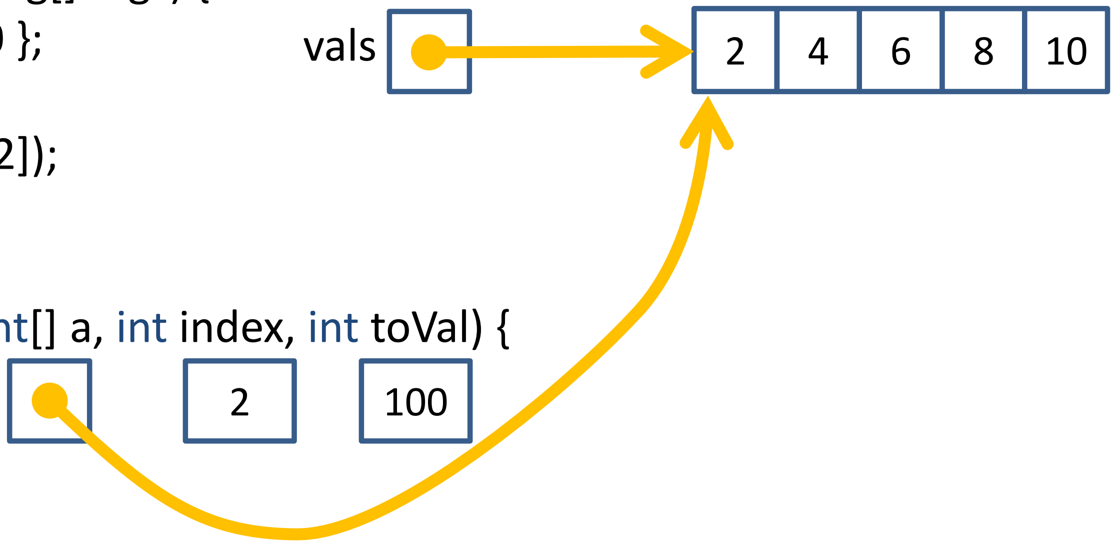
      a[index] = toVal;
}
```



Arrays as method arguments

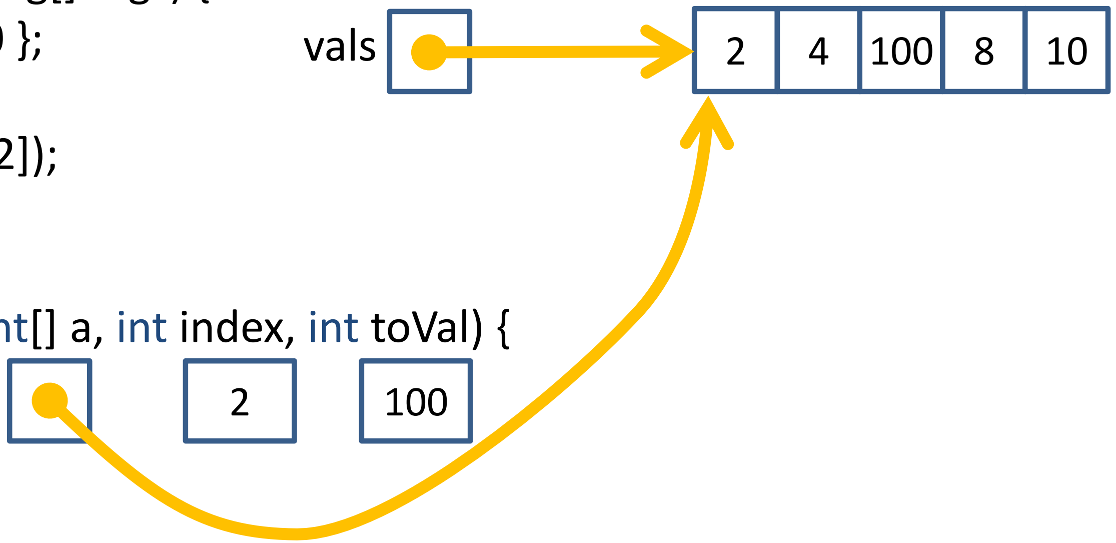
Arrays are references, so when passed to a method the *reference* is copied

Changes to the elements persist after the method has finished

```
public static void main(String[] args) {
   int[] vals = { 2, 4, 6, 8, 10 };
   change(vals, 2, 100);
   System.out.println(vals[2]);
}

public static void change(int[] a, int index, int toVal) {

→      a[index] = toVal;
}
```



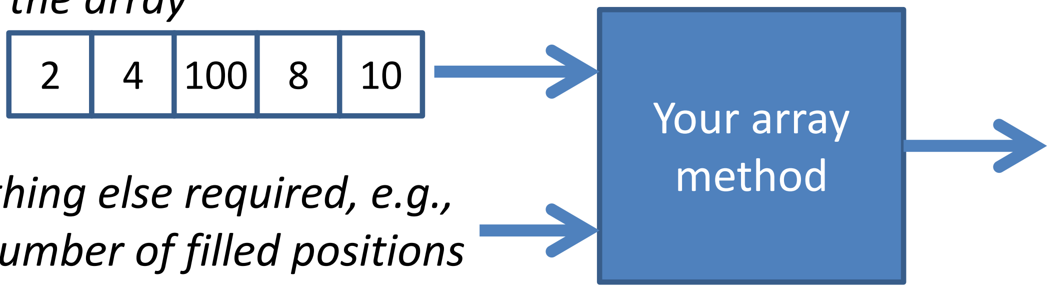
see ElementChange.java

Manipulating Arrays

If working on the entire array, write a method (it can be reused on different arrays of the same type)

Data in

Data out



the array

2	4	100	8	10

Anything else required, e.g.,

- *number of filled positions*
- *a value to search for*
- *value to multiply each element by*

Depends on the task, e.g.,

- *sum of elements*
- *index of found value*
- *maybe nothing*

The algorithm: simplest is to traverse the array and do “something” with each element

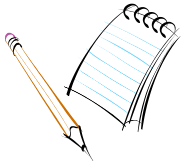
I – Set index to 0

T – index < length of array

B – Do “something” with element at that index

U – increment index

Print an array

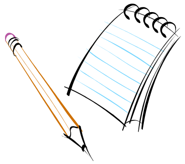


Task: Write a method to display all the elements of an array of ints

```
public static ______ display(int[] a, __________) {
  for (int i = 0; i < ______________ ; i++) {
    __________________________________________ ;
  }
}
```

Can also be done by using java.util.Arrays.toString()

Print an array



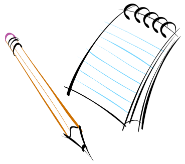
Task: Write a method to display all the elements of an array of ints

```java
public static void display(int[] a) {
    for (int i = 0; i < a.length; i++) {
        System.out.println("element " + i + ":" + a[i]);
    }
}
```

see DisplayFillAndSum.java

Can also be done by using java.util.Arrays.toString()

Fill an array



Task: Write a method to fill an entire array of ints with a given value

```
public static ______ fill(int[] a, ___________) {
    for (int i = 0; i < _____________ ; i++) {
        __________________________________________ ;
    }
}
```

Can also be done by using java.util.Arrays.fill()

Fill an array

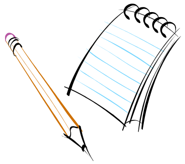
Task: Write a method to fill an entire array of ints with a given value

```
public static void fill(int[] a, int value) {
    for (int i = 0; i < a.length; i++) {
        a[i] = value;
    }
}
```

see DisplayFillAndSum.java

Can also be done by using java.util.Arrays.fill()

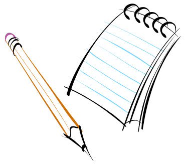
Sum the values in an array



Task: Write a method to calculate the sum of values in an array of integers

```
public static ______ sum(int[] a, _________) {
    _________________ ;
    for (int i = 0; i < _____________ ; i++) {
        ________________________________________ ;
    }
    __________________ ;
}
```

Sum the values in an array



Task: Write a method to calculate the sum of values in an array of integers

```
public static int sum(int[] a) {
    int total = 0;
    for (int i = 0; i < a.length; i++) {
        total += a[i];
    }
    return total;
}
```

see DisplayFillAndSum.java

Tip: working with partially filled arrays

When storing a collection of items it is common to have an array larger than the collection (to have space to add more items)

This leads to this common pattern:

```
type[] identifier = new type[SIZE];
int count = 0;
```

as in

```
int[] data = new int[10];
int count = 0;
```

Then methods to work on the array also take the value of count

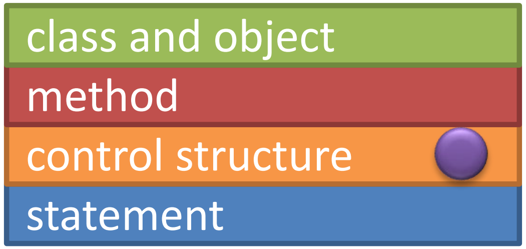
```
public static void display(int[] a, int count)

public static int sum(int[] a, int count)

public static int add(int[] a, int count, int value) //returns the new number of stored values
```

Multidimensional arrays

An advanced topic



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10 Managing Collections with Arrays

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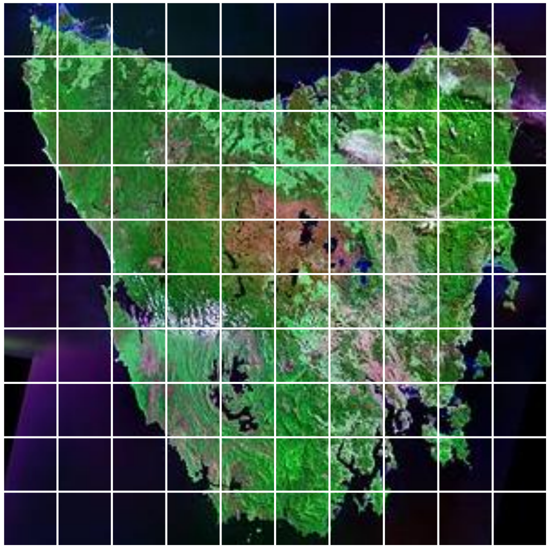
Multidimensional arrays

Arrays can have more than one dimension

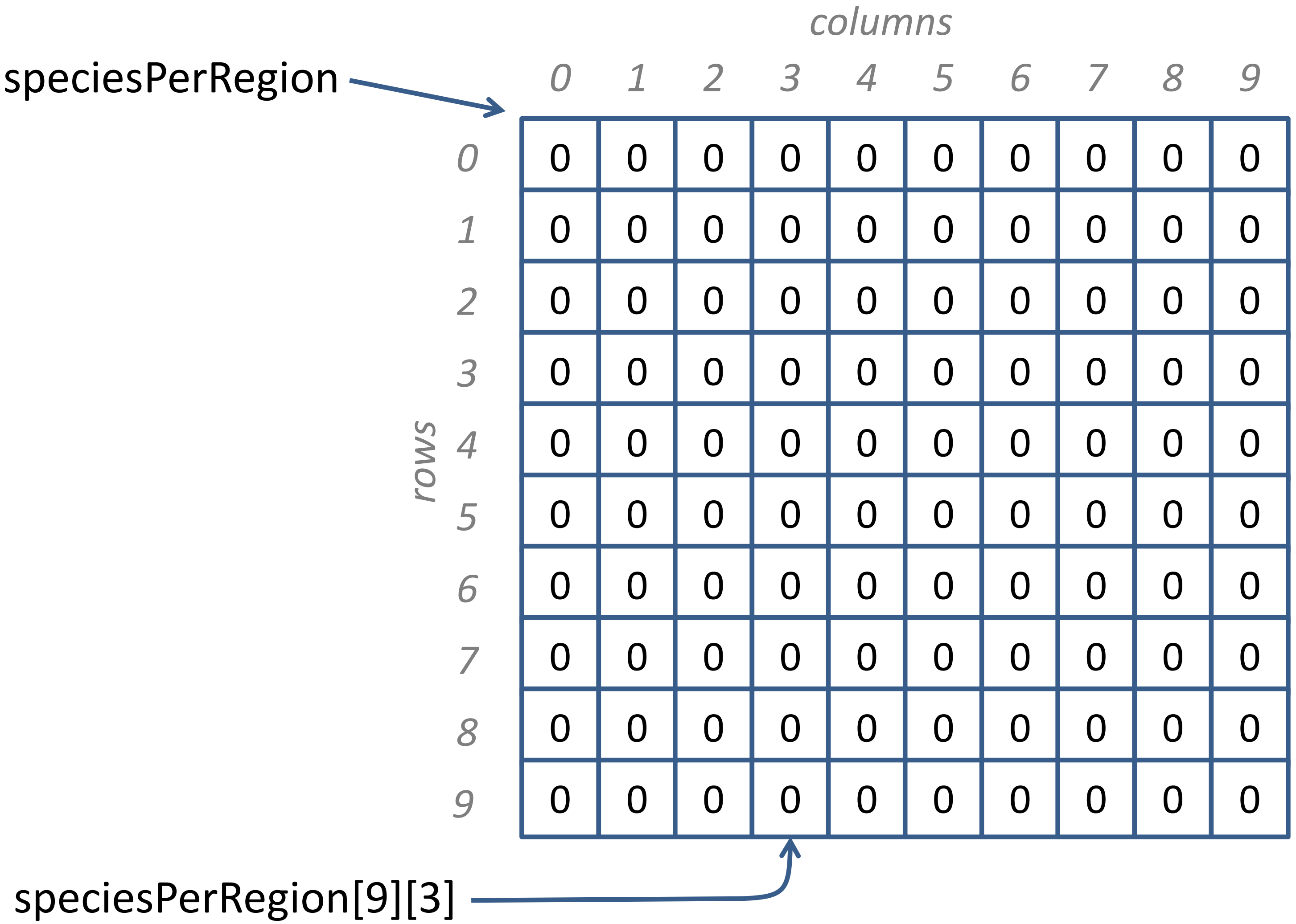
2D arrays (matrices) are common



```
final int ROWS = 10, COLS = 10;
int[][] speciesPerRegion = new int[ROWS][COLS];
```

Logical structure of a 2D array

```
final int ROWS = 10, COLS = 10;
int[][] speciesPerRegion = new int[ROWS][COLS];
```



speciesPerRegion

columns

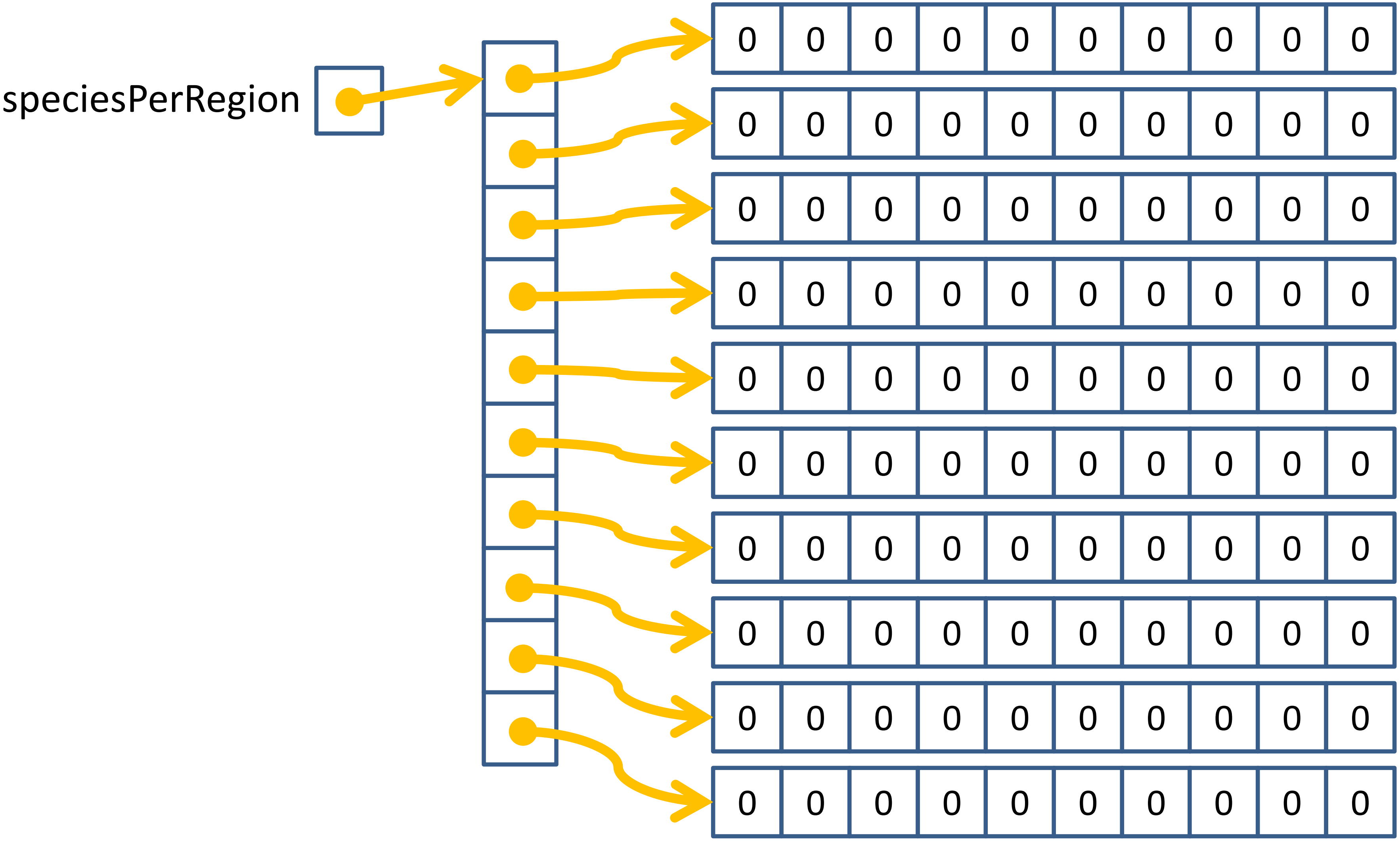
rows

	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0

speciesPerRegion[9][3]

A 2D array is really a 1D array of arrays

```
final int ROWS = 10, COLS = 10;
int[][] speciesPerRegion = new int[ROWS][COLS];
```



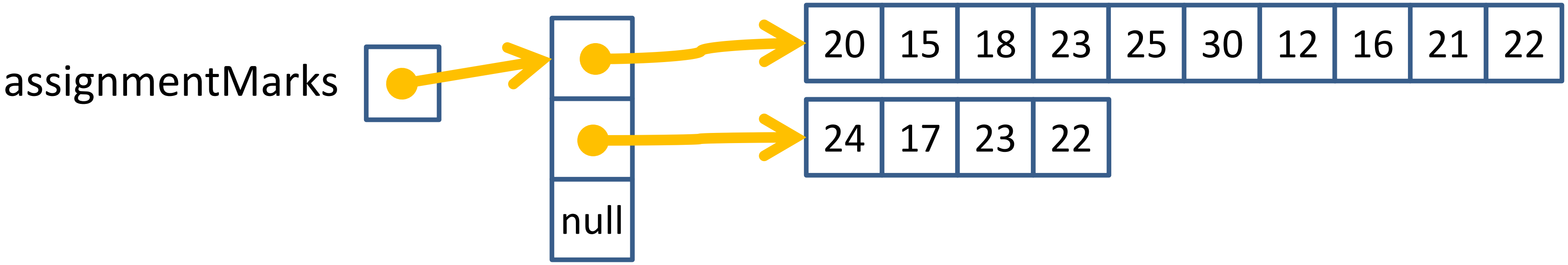
speciesPerRegion

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

An advanced topic: ragged arrays

The rows of a 2D array can instantiated with different lengths

```
int[][] assignmentMarks = new int[3][];
…
assignmentMarks[0] = new int[10];
…
assignmentMarks[1] = new int[4];
```



Tip: ‘ragged’ is pronounced like ra-gid, not rag’d

Displaying a (ragged) 2D array

Use a nested loop for the columns

```
public void display2D(int[][] m) {
    for (int row = 0; row < m.length; row++) {
        for (int col = 0; col < m[row].length; col++) {
            System.out.print(m[row][col] + " ");
        }
        System.out.println(); //adds the newline
    }
}
```