



University of British Columbia
CPSC 111, Intro to Computation
Jan-Apr 2006

Tamara Munzner

Arrays II

Lecture 15, Thu Mar 2 2006

based on slides by Kurt Eiselt

<http://www.cs.ubc.ca/~tmm/courses/cpsc111-06-spr>

News

- Assignment 2
 - do not wait until last minute
 - corrections to ASCIIArtiste.java posted (Sun)
 - definitely read WebCT bboards!
- Remember CSLC available!
 - Mon-Thu 10-6, Fri 10-4, x150 (near Reboot)
- extra TA lab coverage for A2 help:
 - Sun 12-2 Parker
 - Tue 4-6 Hastings, 6-8 Leavitt

Reading

- This week: 8.1, 8.5-8.7, topics 6.3 and 6.4
- Next week: no new reading

Scope Revisited, With Diagrams

■ Common confusion on midterm: what's wrong?

```
public class RoachPopulation {
    private int myPopulation;
    private static final double KILL_PERCENT = 0.10;
    public RoachPopulation(int population) {
        this.myPopulation = population;
    }
    public void waitForDoubling(int newPopulation)
        newPopulation *= 2;
    }
    public int getRoaches() {
        return this.myPopulation
    }
}
```

```
public class RoachPopulationDriver {
    public static void main (String[] args) {
        RoachPopulation r = new RoachPopulation(10);
        int num = r.getRoaches();
        r.waitForDoubling();
        num = r.getRoaches();
    }
}
```

Recap: Array Declaration and Types

cansSold

0	185
1	92
2	370
3	485
4	209
5	128
6	84
7	151
8	32
9	563

- Just like ordinary variable, must
 - declare array before we use it
 - give array a type
- Since cansSold contains integers, make integer array:

```
int[] cansSold = new int[10]
```
- Looks like variable declaration, except:
 - empty brackets on the left tell Java that cansSold is an array...
 - the number in the brackets on the right tell Java that array should have room for 10 elements when it's created

Recap: Array Declaration and Types

```
public class ArrayTest1
{
    public static void main(String[] args)
    {
        cansSold = new int[10];
        cansSold[0] = 185;
        cansSold[1] = 92;
        cansSold[2] = 370;
        cansSold[3] = 485;
        cansSold[4] = 209;
        cansSold[5] = 128;
        cansSold[6] = 84;
        cansSold[7] = 151;
        cansSold[8] = 32;
        cansSold[9] = 563;

        // do useful stuff here
        System.out.println("Element 4 is " +
                           cansSold[4]);
    }
}
```

cansSold	
0	185
1	92
2	370
3	485
4	209
5	128
6	84
7	151
8	32
9	563

Recap: Array Declaration and Types

```
public class ArrayTest2
{
    public static void main(String[] args)
    {
        cansSold
        {
            int[] cansSold = {185, 92, 370, 485, 209,
                             128, 84, 151, 32, 563};

            // do useful stuff here
            System.out.println("Element 4 is " +
                               cansSold[4]);
        }
    }
}
```

0	185
1	92
2	370
3	485
4	209
5	128
6	84
7	151
8	32
9	563

- Can also use **initializer list**
- Right side of declaration does not include type or size
 - Java figures out size by itself
- Types of values on right must match type declared on left
- Initializer list may only be used when array is first declared

Histogram Loop Example

numbers

0	6	*****
1	8	*****
2	11	*****
3	18	*****
4	20	*****
5	17	*****
6	14	*****
7	10	*****
8	5	*****
9	2	**

- Now use same data as basis for histogram
 - Write one loop to look at value associated with each row of array
 - for each value print a line with that many asterisks
 - For example, if program reads value 6 from the array, should print line of 6 asterisks
 - Program then reads the value 8, prints a line of 8 asterisks, and so on.
- Need outer loop to read individual values in the array
- Need inner loop to print asterisks for each value

Objectives

- Understanding when and how to use
 - arrays of objects
 - 2D arrays

Storing Different Data Types

cansSold

0	185
1	92
2	370
3	485
4	209
5	128
6	84
7	151
8	32
9	563

Storing Different Data Types

cansSold		cashIn	
0	185	0	201.25
1	92	1	100.50
2	370	2	412.75
3	485	3	555.25
4	209	4	195.00
5	128	5	160.00
6	84	6	105.00
7	151	7	188.75
8	32	8	40.00
9	563	9	703.75

Could use two arrays of
same size but with different
types

Storing Different Data Types

- Write program to compare what's been collected from each machine vs. how much should have been collected?

cansSold	cashIn
0 185	0 201.25
1 92	1 100.50
2 370	2 412.75
3 485	3 555.25
4 209	4 195.00
5 128	5 160.00
6 84	6 105.00
7 151	7 188.75
8 32	8 40.00
9 563	9 703.75

Could use two arrays of same size but with different types

Storing Different Data Types

cansSold	cashIn
0 185	0 201.25
1 92	1 100.50
2 370	2 412.75
3 485	3 555.25
4 209	4 195.00
5 128	5 160.00
6 84	6 105.00
7 151	7 188.75
8 32	8 40.00
9 563	9 703.75

Could use two arrays of same size but with different types

- Write program to compare what's been collected from each machine vs. how much should have been collected?

```
public class ArrayTest4
{
    public static void main(String[] args)
    {
        double expected;
        int[] cansSold = {185, 92, 370, 485, 209,
                        128, 84, 151, 32, 563};
        double[] cashIn = {201.25, 100.50, 412.75,
                          555.25, 195.00, 160.00,
                          105.00, 188.75, 40.00,
                          703.75};
        for (int i = 0; i < cansSold.length; i++)
        {
            expected = cansSold[i] * 1.25;
            System.out.println("Machine " + (i + 1) +
                               " off by $" +
                               (expected - cashIn[i]));
        }
    }
}
```

Storing Different Data Types

cansSold	cashIn
0 185	0 201.25
1 92	1 100.50
2 370	2 412.75
3 485	3 555.25
4 209	4 195.00
5 128	5 160.00
6 84	6 105.00
7 151	7 188.75
8 32	8 40.00
9 563	9 703.75

Could use two arrays of same size but with different types

What happens when we run the program?

- Write program to compare what's been collected from each machine vs. how much should have been collected?

```
public class ArrayTest4
{
    public static void main(String[] args)
    {
        double expected;
        int[] cansSold = {185, 92, 370, 485, 209,
                        128, 84, 151, 32, 563};
        double[] cashIn = {201.25, 100.50, 412.75,
                          555.25, 195.00, 160.00,
                          105.00, 188.75, 40.00,
                          703.75};
        for (int i = 0; i < cansSold.length; i++)
        {
            expected = cansSold[i] * 1.25;
            System.out.println("Machine " + (i + 1) +
                               " off by $" +
                               (expected - cashIn[i]));
        }
    }
}
```

Storing Different Data Types

cansSold		cashIn		
0	185	0	201.25	Machine 0 off by \$30.0
1	92	1	100.50	Machine 1 off by \$14.5
2	370	2	412.75	Machine 2 off by \$49.75
3	485	3	555.25	Machine 3 off by \$51.0
4	209	4	195.00	Machine 4 off by \$66.25
5	128	5	160.00	Machine 5 off by \$0.0
6	84	6	105.00	Machine 6 off by \$0.0
7	151	7	188.75	Machine 7 off by \$0.0
8	32	8	40.00	Machine 8 off by \$0.0
9	563	9	703.75	Machine 9 off by \$0.0

Somebody has been stealing from the machines after all! We need an anti-theft plan...

Arrays With Non-Primitive Types

cansSold		cashIn	
0	185	0	201.25
1	92	1	100.50
2	370	2	412.75
3	485	3	555.25
4	209	4	195.00
5	128	5	160.00
6	84	6	105.00
7	151	7	188.75
8	32	8	40.00
9	563	9	703.75

- Great if you're always storing primitives like integers or floating point numbers
 - What if we want to store String types too?
 - remember that String is an object, not a primitive data type

Arrays With Non-Primitive Types

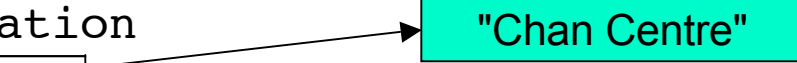
cansSold	cashIn	location
0 185	0 201.25	0
1 92	1 100.50	1
2 370	2 412.75	2
3 485	3 555.25	3
4 209	4 195.00	4
5 128	5 160.00	5
6 84	6 105.00	6
7 151	7 188.75	7
8 32	8 40.00	8
9 563	9 703.75	9

- Then we create **array of objects**
 - In this case objects will be Strings
- Array won't hold actual object
 - holds references: pointers to objects

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

Arrays of Objects

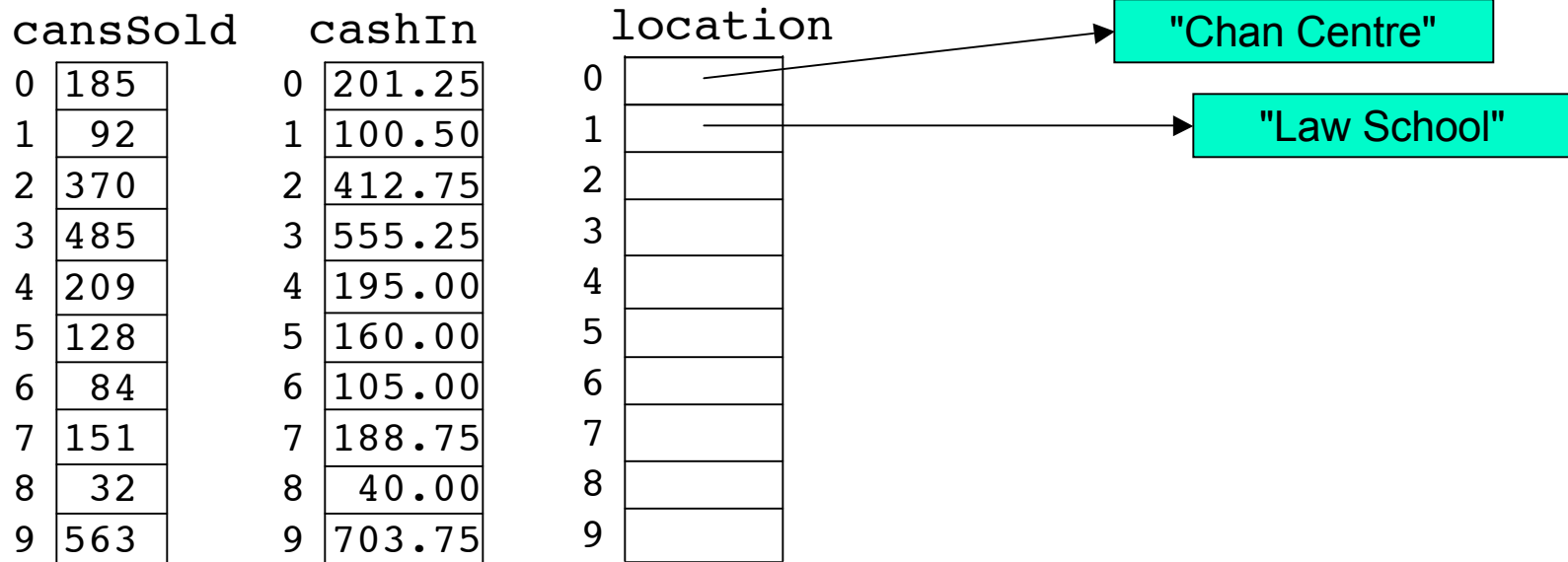
cansSold	cashIn	location
0 185	0 201.25	0
1 92	1 100.50	1
2 370	2 412.75	2
3 485	3 555.25	3
4 209	4 195.00	4
5 128	5 160.00	5
6 84	6 105.00	6
7 151	7 188.75	7
8 32	8 40.00	8
9 563	9 703.75	9



- Now we can put references to Strings in our String array.

```
location[0] = "Chan Centre";
```

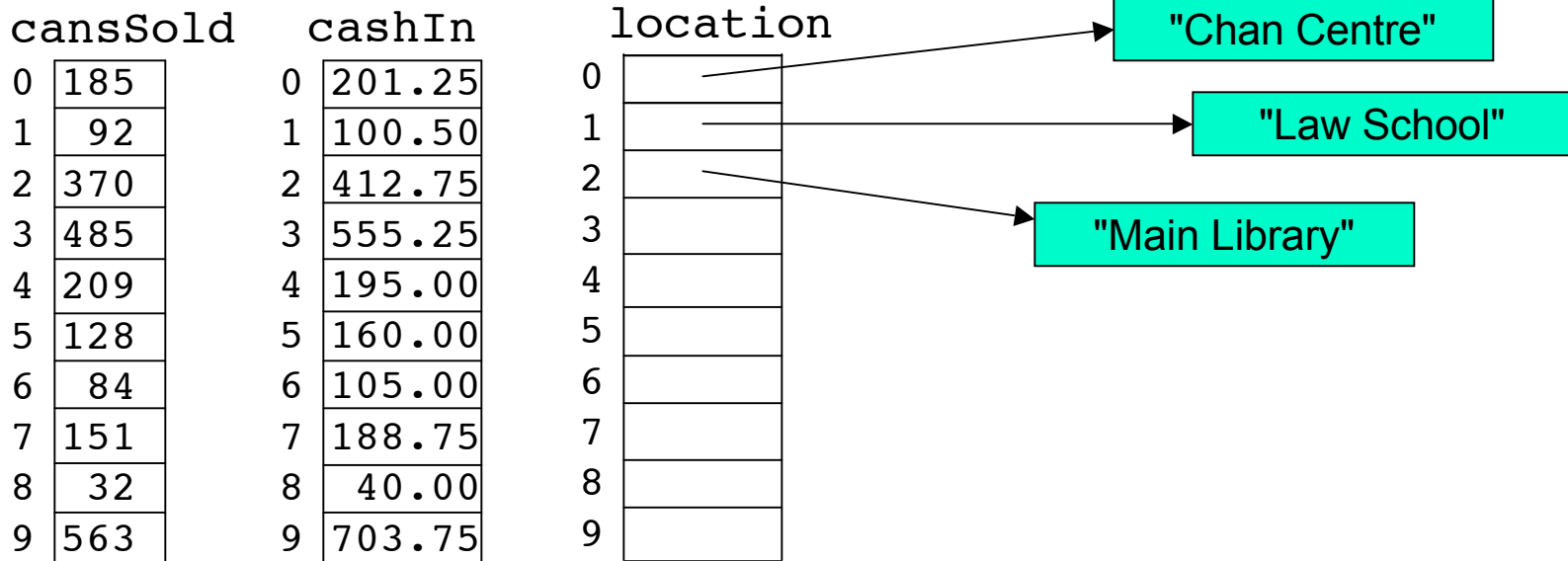
Arrays of Objects



- Now we can put references to Strings in our String array.

```
location[0] = "Chan Centre";  
location[1] = "Law School";
```

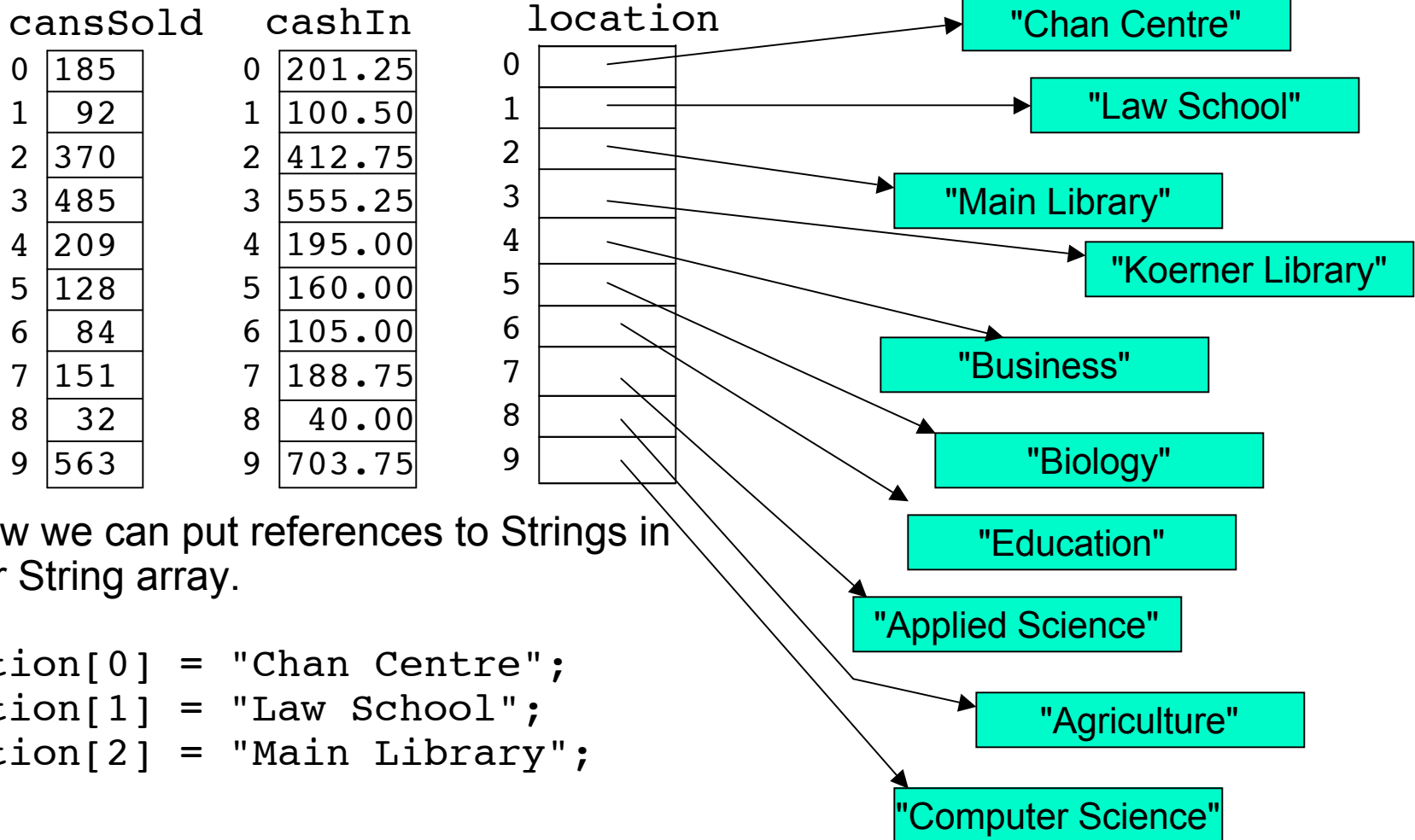
Arrays of Objects



- Now we can put references to Strings in our String array.

```
location[0] = "Chan Centre";  
location[1] = "Law School";  
location[2] = "Main Library";
```

Arrays of Objects

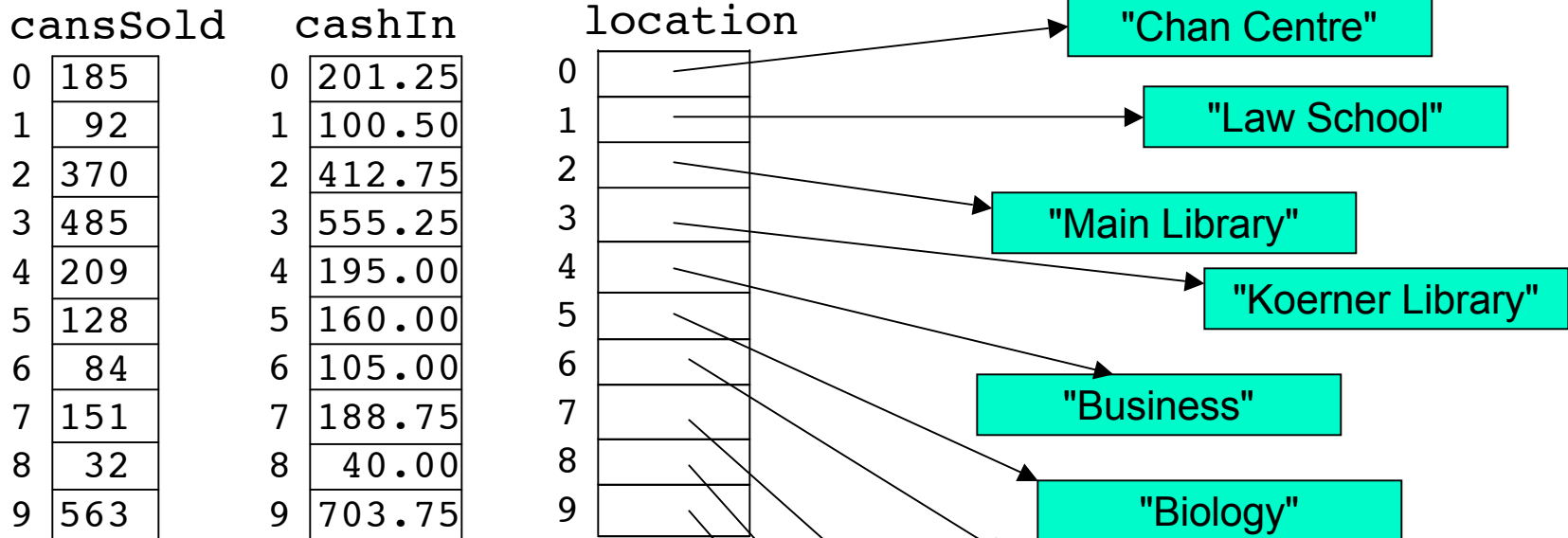


- Now we can put references to Strings in our String array.

```
location[0] = "Chan Centre";  
location[1] = "Law School";  
location[2] = "Main Library";
```

...and so on...

Arrays of Objects

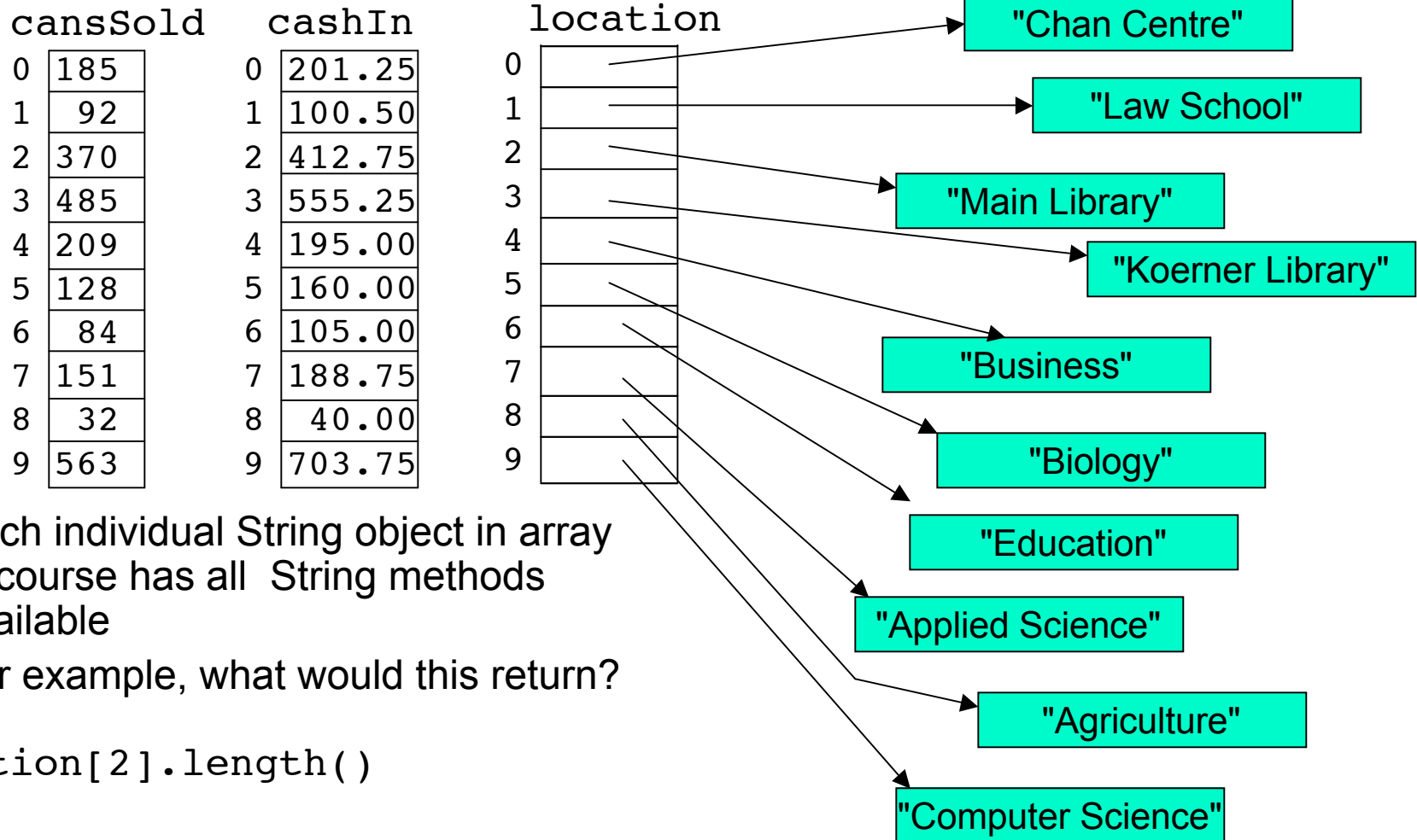


- Or we could have done this:

```
String[] location =  
{"Chan Centre", "Law School",  
"Main Library", .... };
```

"Computer Science"

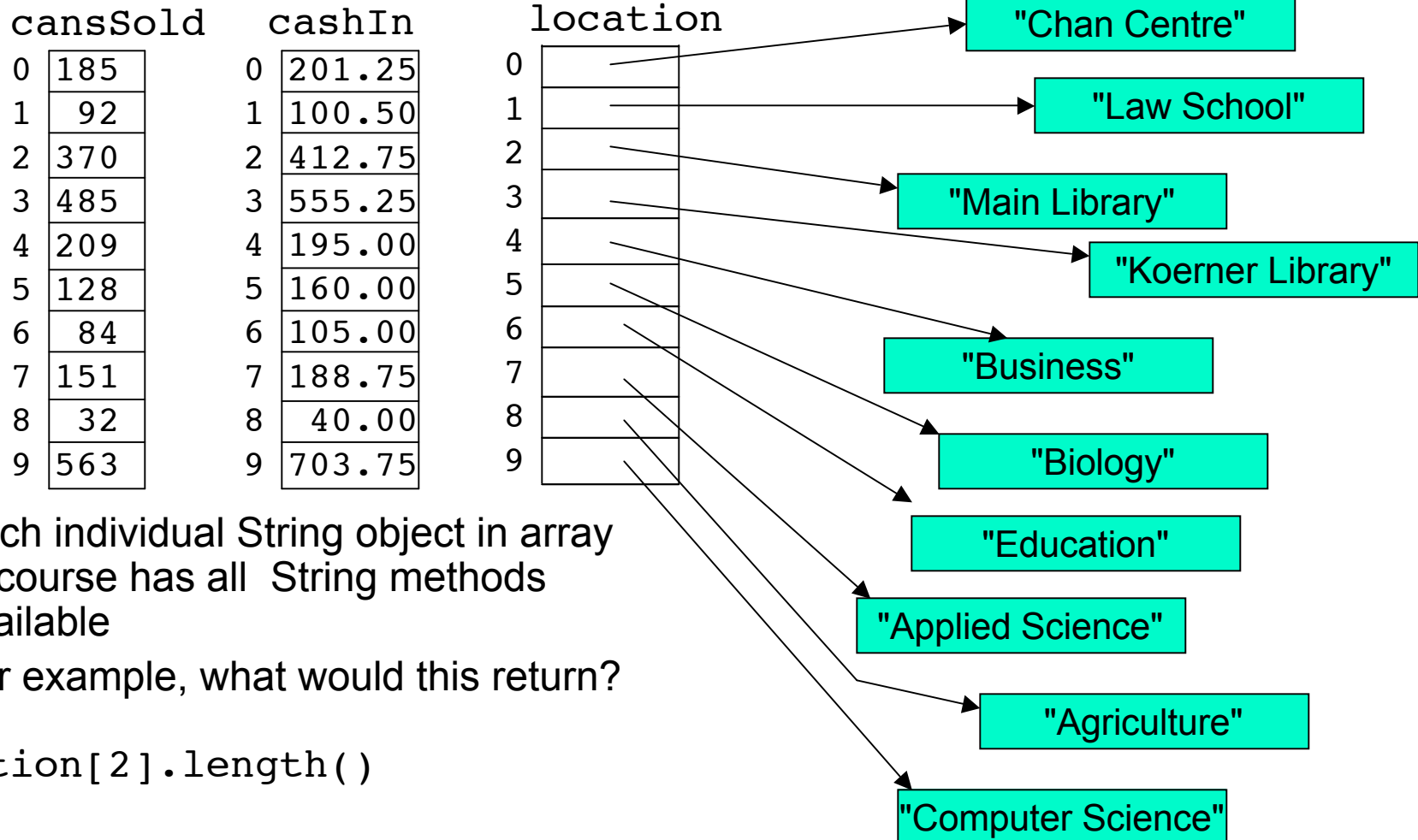
Arrays of Objects



- Each individual String object in array of course has all String methods available
- For example, what would this return?

`location[2].length()`

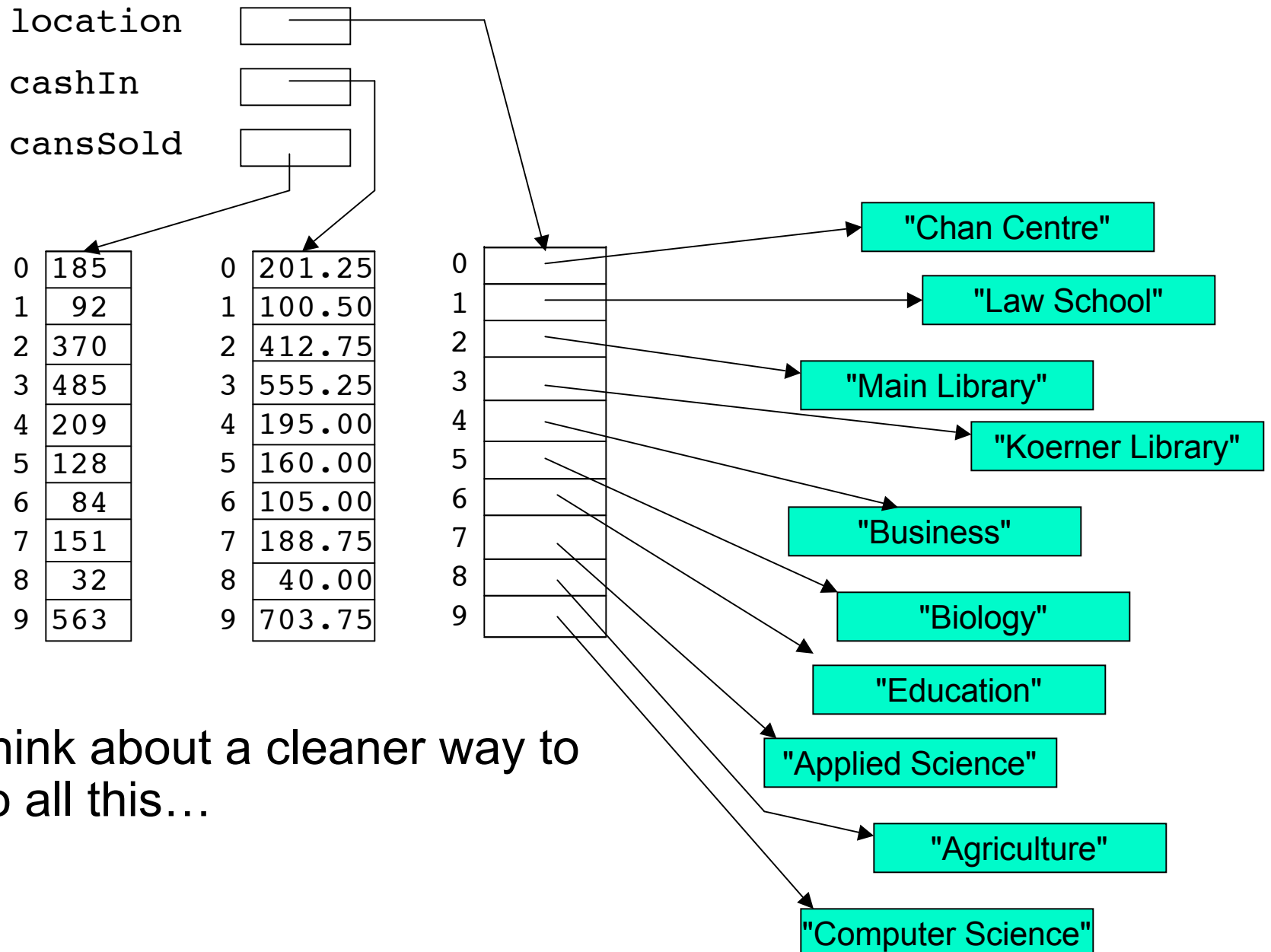
Arrays of Objects



- Each individual String object in array of course has all String methods available
- For example, what would this return?

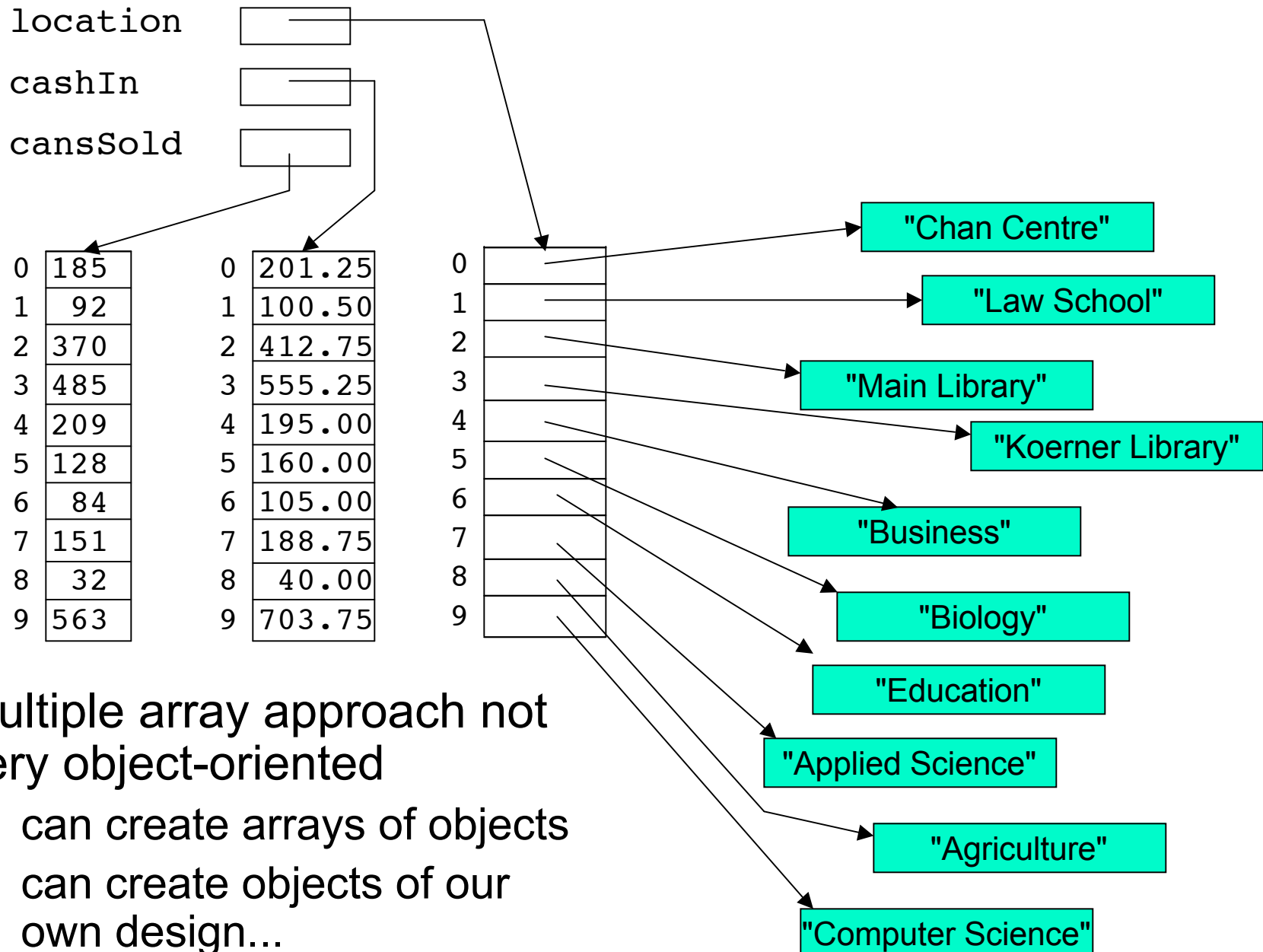
`location[2].length()`

Arrays of Objects



- Think about a cleaner way to do all this...

Arrays and Object Design



Arrays and Object Design

- Cokematic object design - contains
 - number of cans remaining: integer
 - location: String,
 - number of cans sold: integer
 - cash collected: double

Cokematic

- Cokematic object design - contains
 - number of cans remaining: integer
 - location: String,
 - number of cans sold: integer
 - cash collected: double

```
public class Cokematic
{
    private int numberOfCans;
    private String location;
    private int cansSold;
    private double cashIn;

    public Cokematic(int cans, String loc, int sold, double cash)
    {
        numberOfCans = cans;
        location = loc;
        cansSold = sold;
        cashIn = cash;
        System.out.println("Adding machine");
    }
}
```

Cokematic

- Cokematic object design - contains
 - number of cans remaining: integer
 - location: String,
 - number of cans sold: integer
 - cash collected: double

```
public void buyCoke()
{
    if (numberOfCans > 0)
    {
        numberOfCans = numberOfCans - 1;
        cansSold = cansSold + 1;
        cashIn = cashIn + 1.25;
        System.out.println("Have a Coke");
        System.out.println(numberOfCans + " remaining");
    }
    else
    {
        System.out.println("Sold out.");
    }
}
```

```
public String getLocation()
{
    return location;
}

public int getCansSold()
{
    return cansSold;
}

public double getCashIn()
{
    return cashIn;
}

public void reloadMachine(int newCans)
{
    numberOfCans = numberOfCans + newCans;
    System.out.println("reloading machine");
}

public int getNumberOfCans()
{
    return numberOfCans;
}

public String toString()
{
    return (location + " sold: " + cansSold + " left: " + numberOfCans
    + " made: " + cashIn);
}
}
```

Cokematic

- In driver, executing

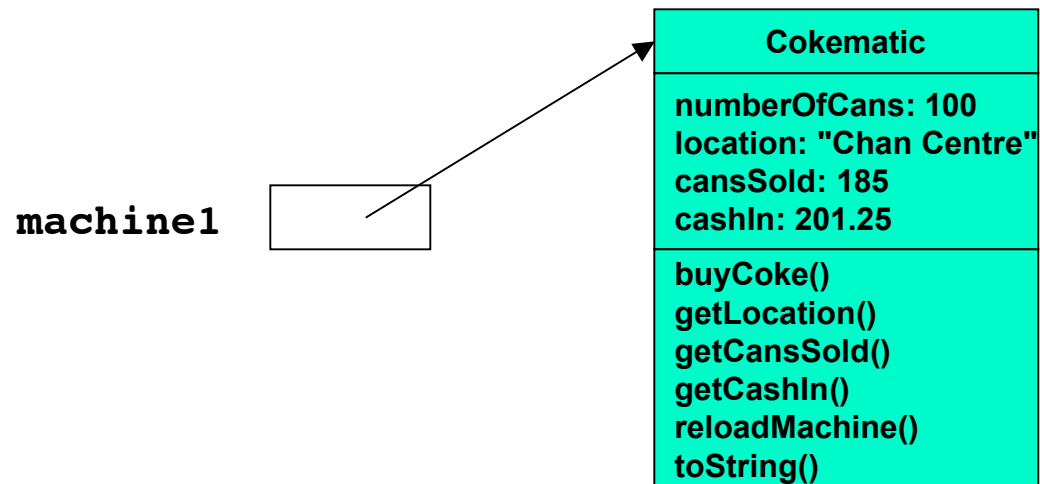
```
Cokematic machine1 = new Cokematic(100, "Chan Centre",  
                                   185, 201.25);
```

Cokematic

- In driver, executing

```
Cokematic machine1 = new Cokematic(100, "Chan Centre",  
                                   185, 201.25);
```

- Results in

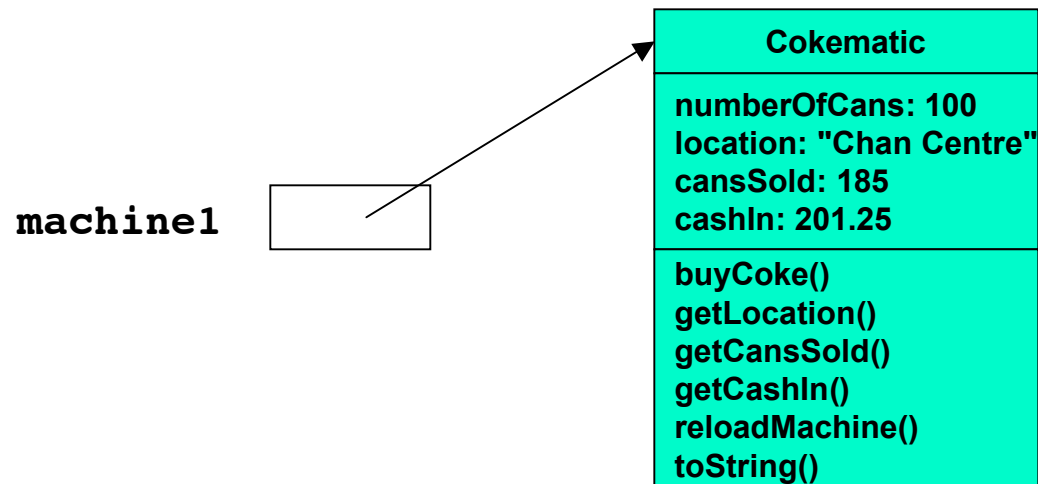


Cokematic

- In driver, executing

```
Cokematic machine1 = new Cokematic(100, "Chan Centre",  
                                   185, 201.25);
```

- Results in



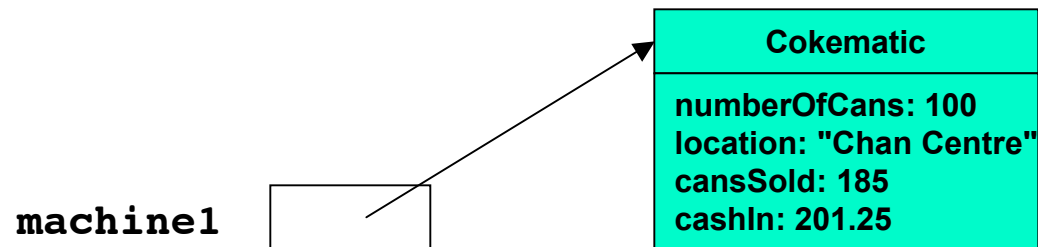
- Note: leaving out methods in UML diagrams from now on to fit on page

Cokematic

- In driver, executing

```
Cokematic machine1 = new Cokematic(100, "Chan Centre",  
                                   185, 201.25);
```

- Results in



- Note: leaving out methods in UML diagrams from now on to fit on page

CokeEmpire

- Contains array of Cokematic objects

```
public class CokeEmpire
{
    private Cokematic[] collection;    // what does this do?

    public CokeEmpire()
    {
        collection = new Cokematic[10];    // what does this do?
    }

    public void addCokematic(int index, int cans, String loc, int sold,
                             double cash)
    {
        collection[index] = new Cokematic(cans, loc, sold, cash);
    }

    public Cokematic getCokematic(int index)
    {
        return collection[index];
    }
}
```

CokeEmpire

- In driver, executing:

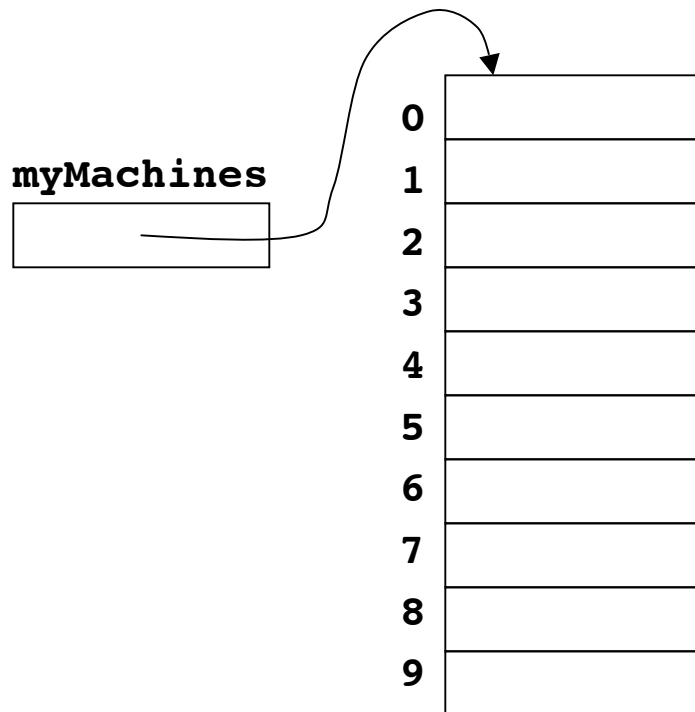
```
CokeEmpire myMachines = new CokeEmpire();
```

CokeEmpire

- In driver, executing

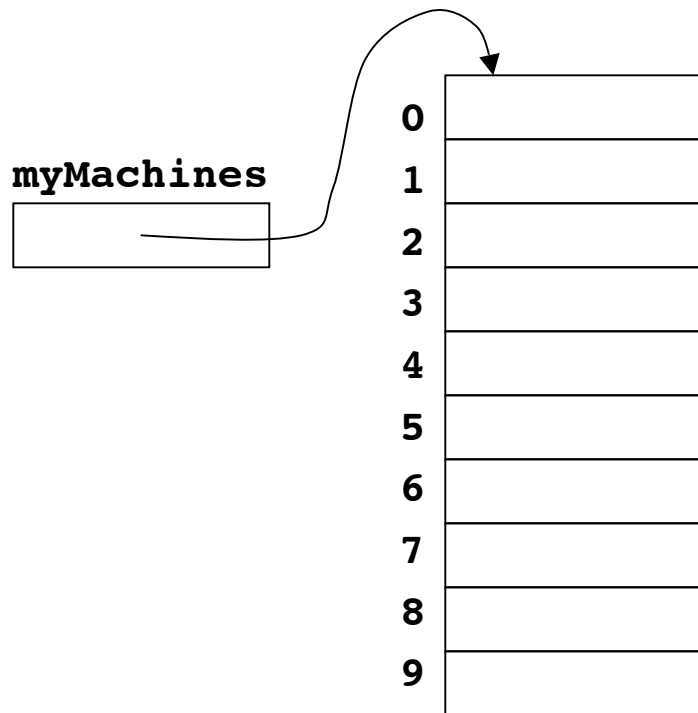
```
CokeEmpire myMachines = new CokeEmpire();
```

- results in



CokeEmpire

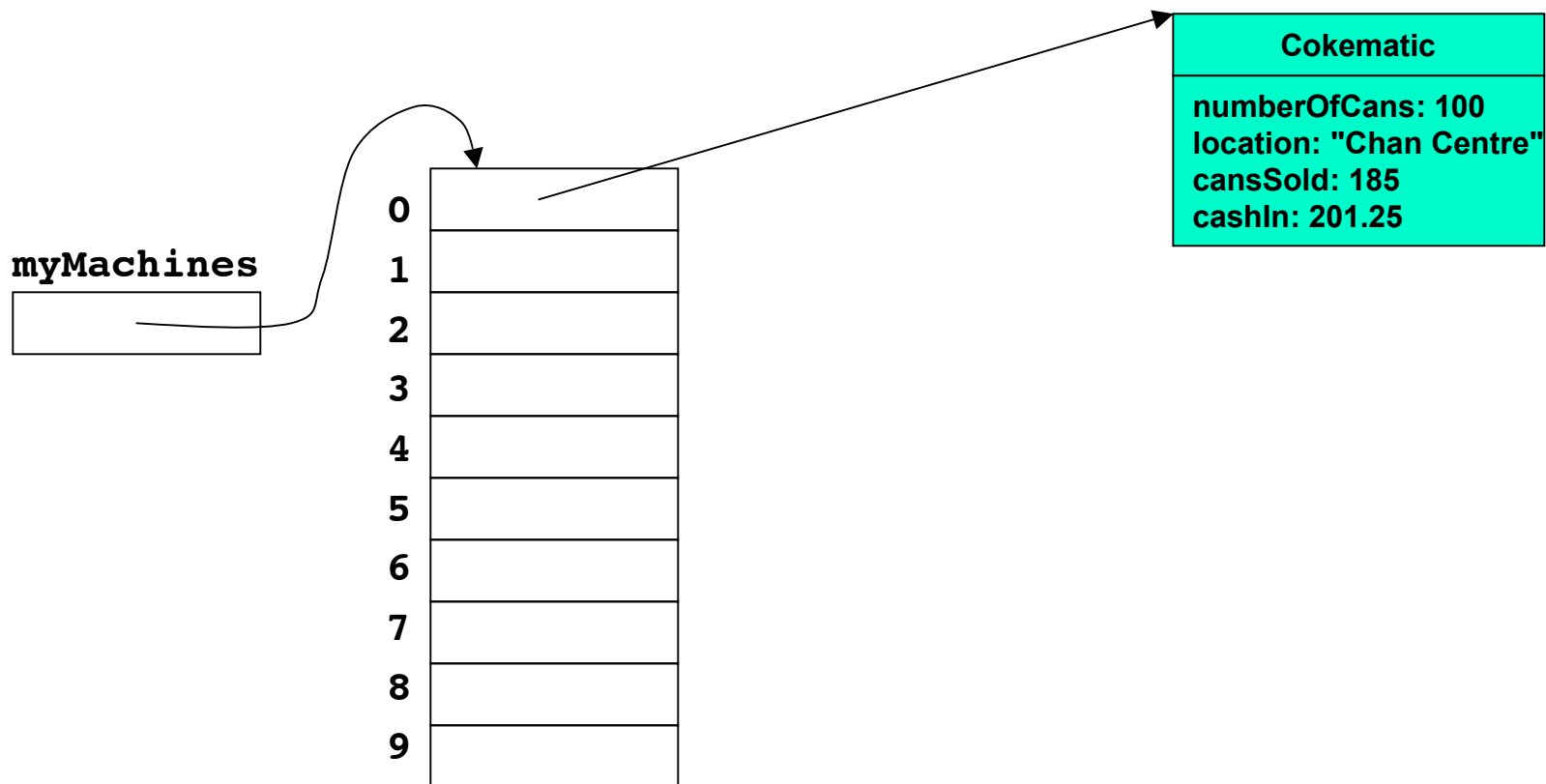
- Populate array with Cokematic objects



CokeEmpire

- Populate array with Cokematic objects

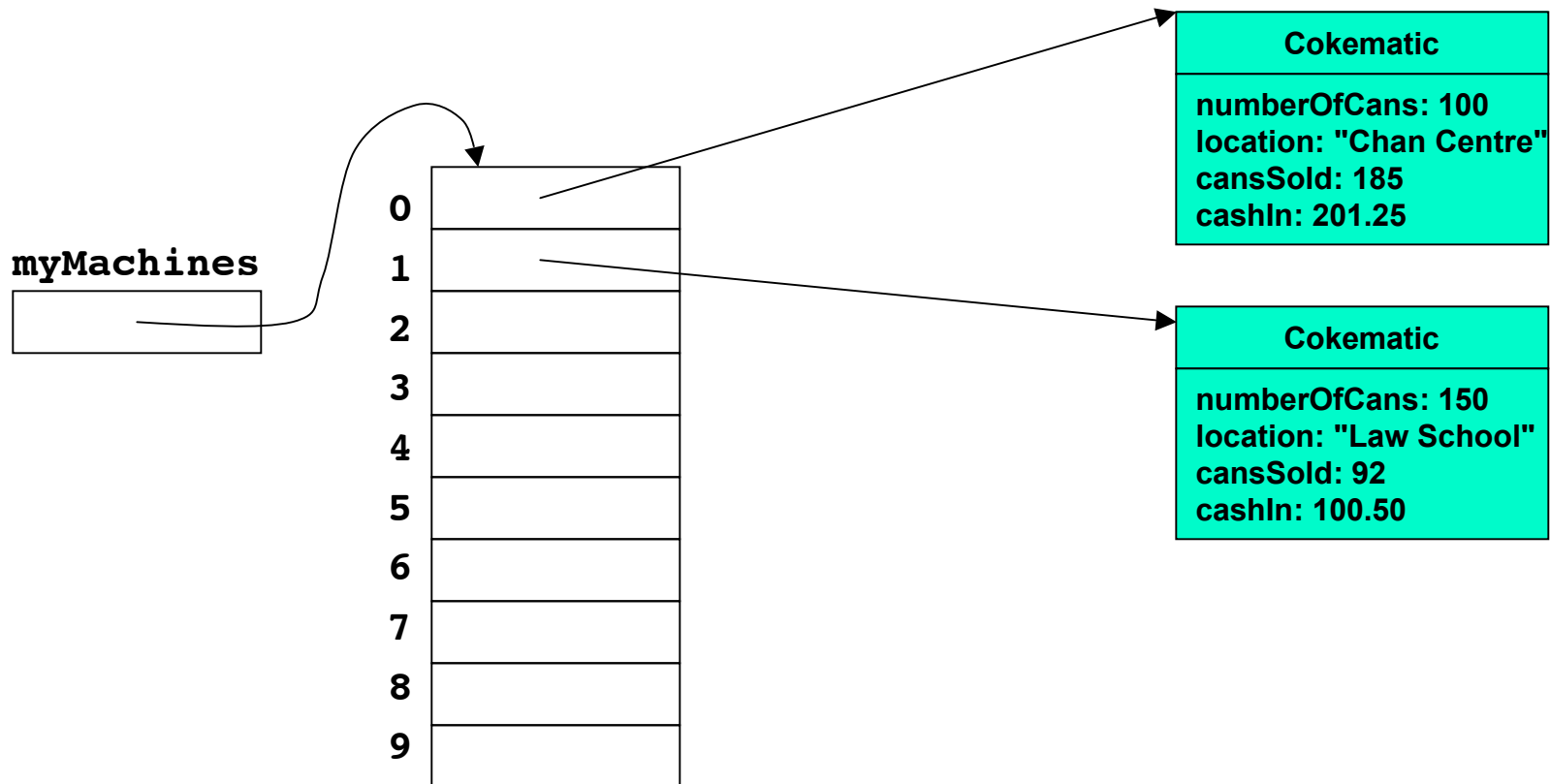
```
myMachines.addCokematic(0, 100, "Chan Centre", 185, 201.25);
```



CokeEmpire

- Populate array with Cokematic objects

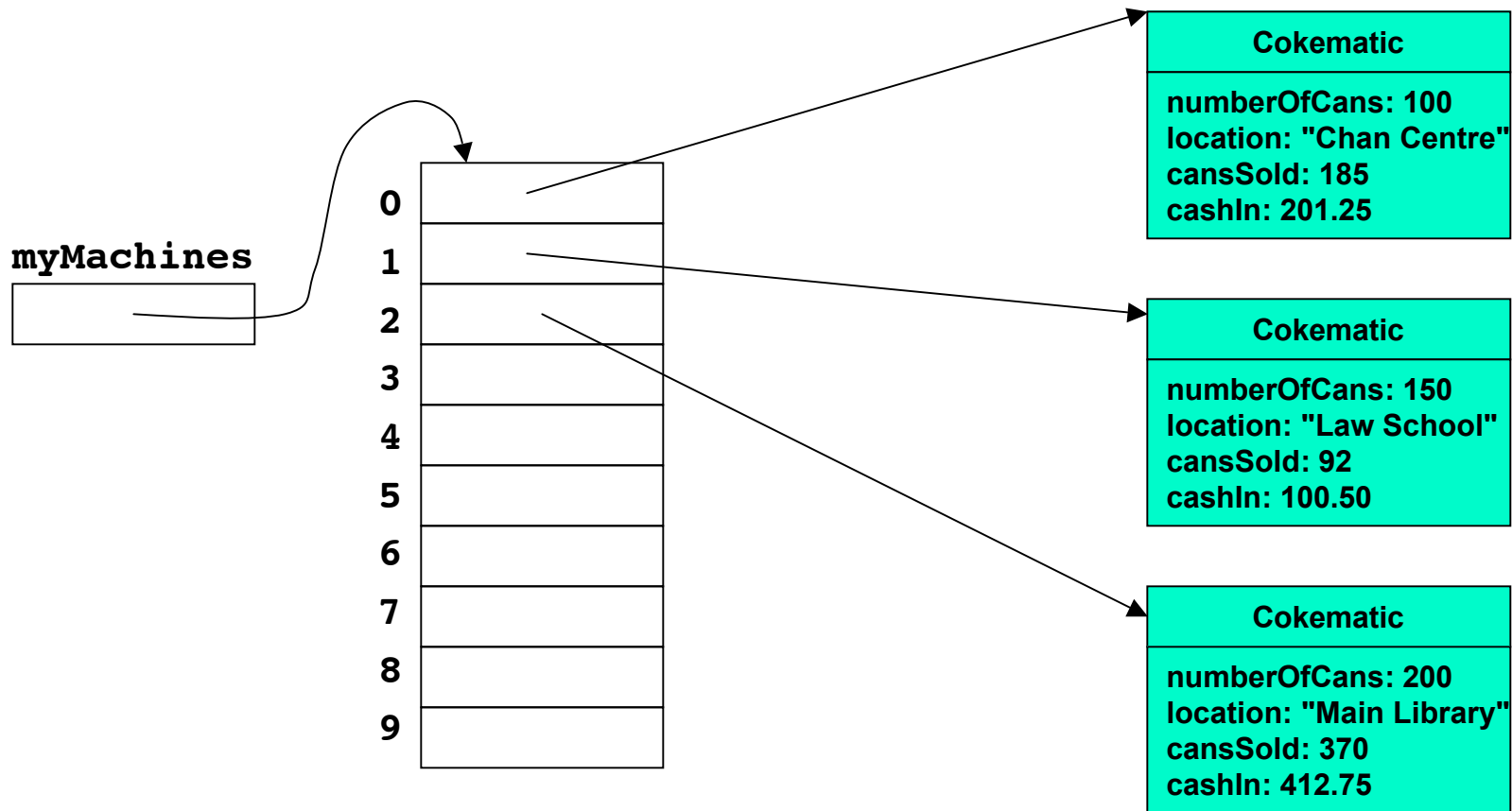
```
myMachines.addCokematic(1, 150, "Law School", 92, 100.50);
```



CokeEmpire

- Populate array with Cokematic objects

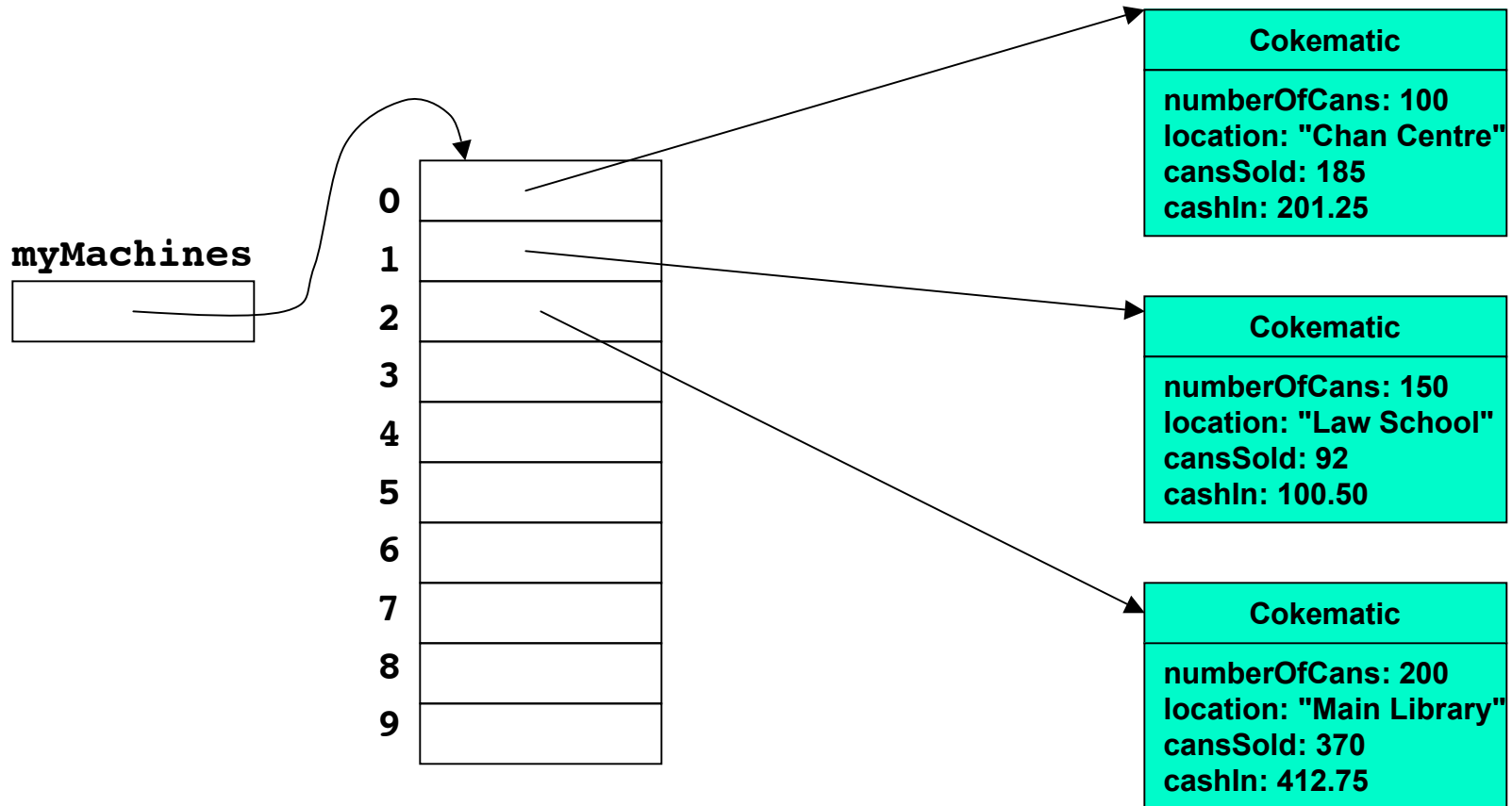
```
myMachines.addCokematic(2, 200, "Main Library", 370, 412.75);
```



CokeEmpire

- What does this return?

```
myMachines.getCokematic(1).getCansSold()
```



CokeEmpire

- What does this return?

```
myMachines.getCokematic(1).getCansSold()
```

myMachines

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Cokematic
numberOfCans: 100
location: "Chan Centre"
cansSold: 185
cashIn: 201.25

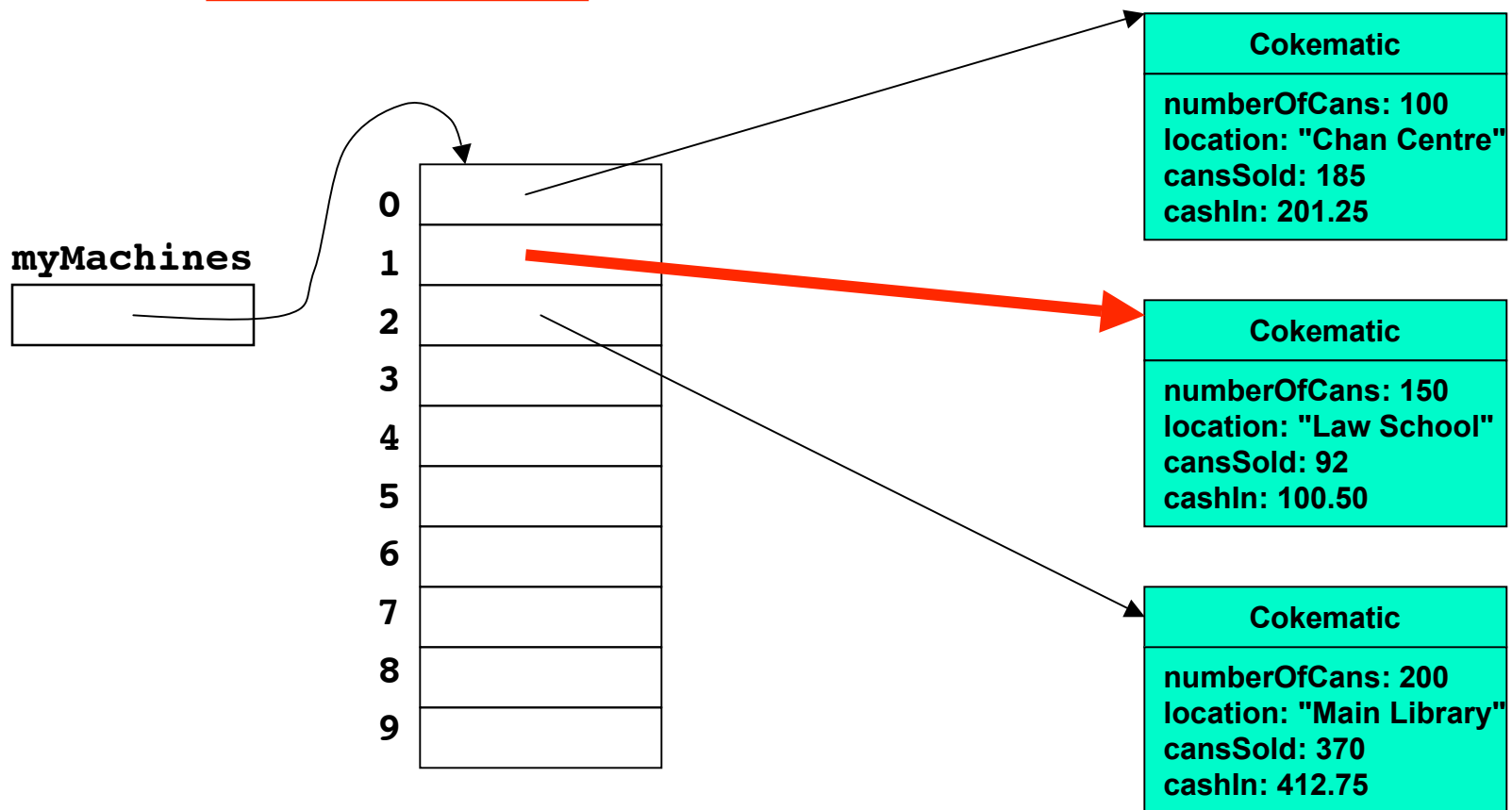
Cokematic
numberOfCans: 150
location: "Law School"
cansSold: 92
cashIn: 100.50

Cokematic
numberOfCans: 200
location: "Main Library"
cansSold: 370
cashIn: 412.75

CokeEmpire

- What does this return?

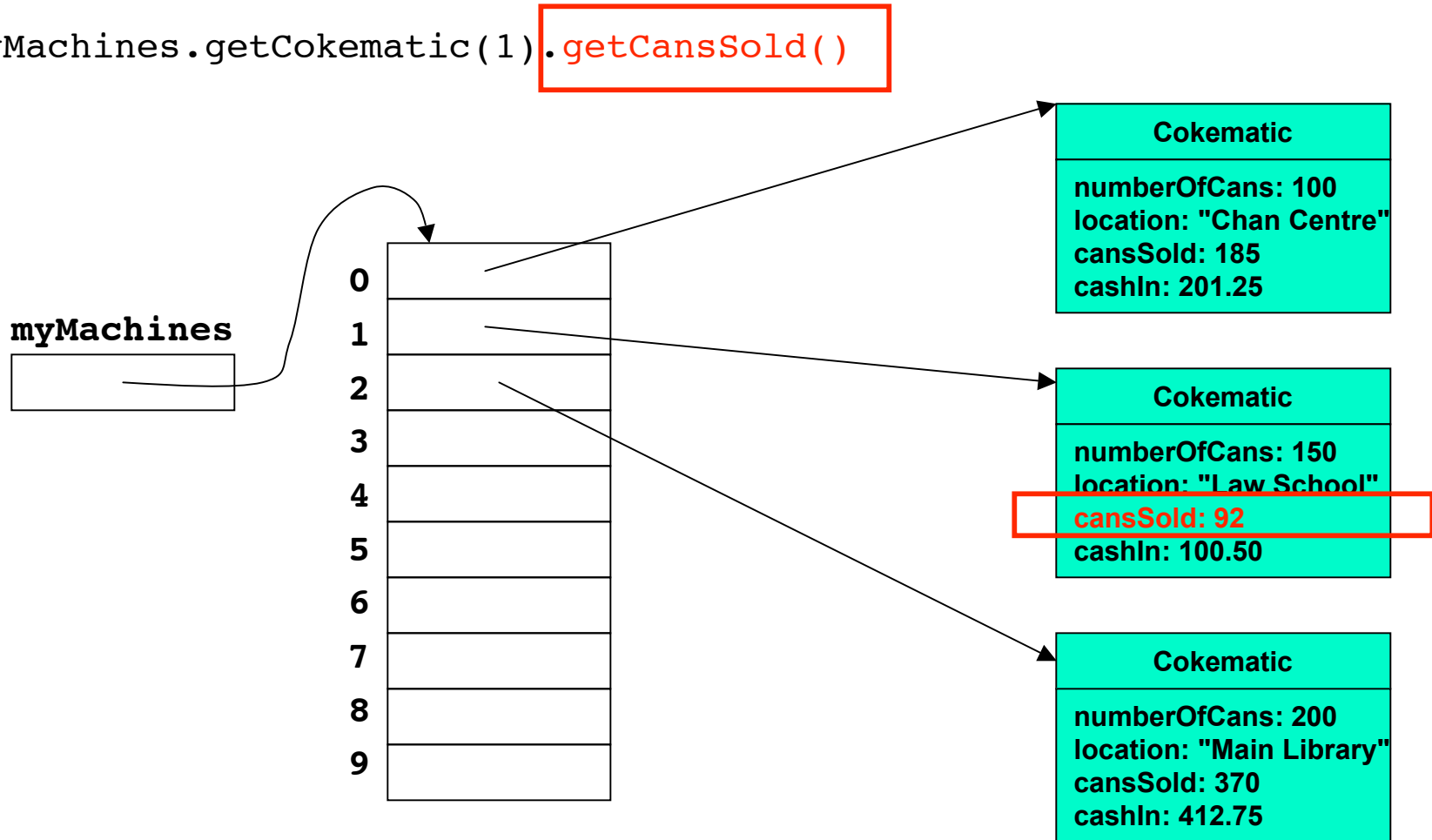
```
myMachines.getCokematic(1).getCansSold()
```



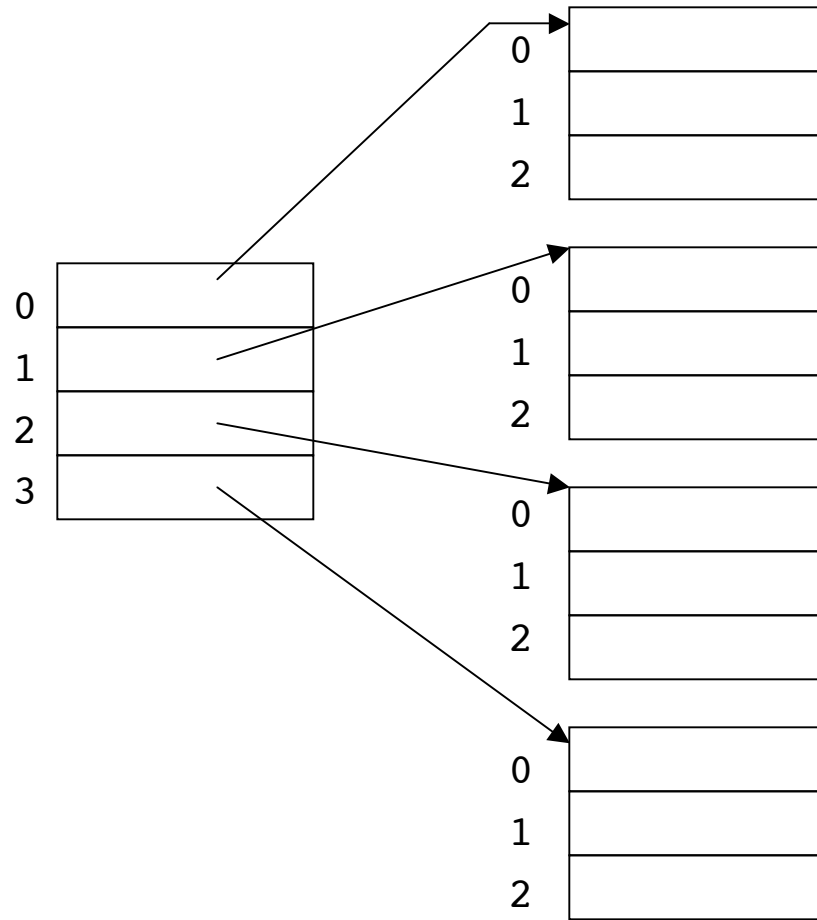
CokeEmpire

- What does this return?

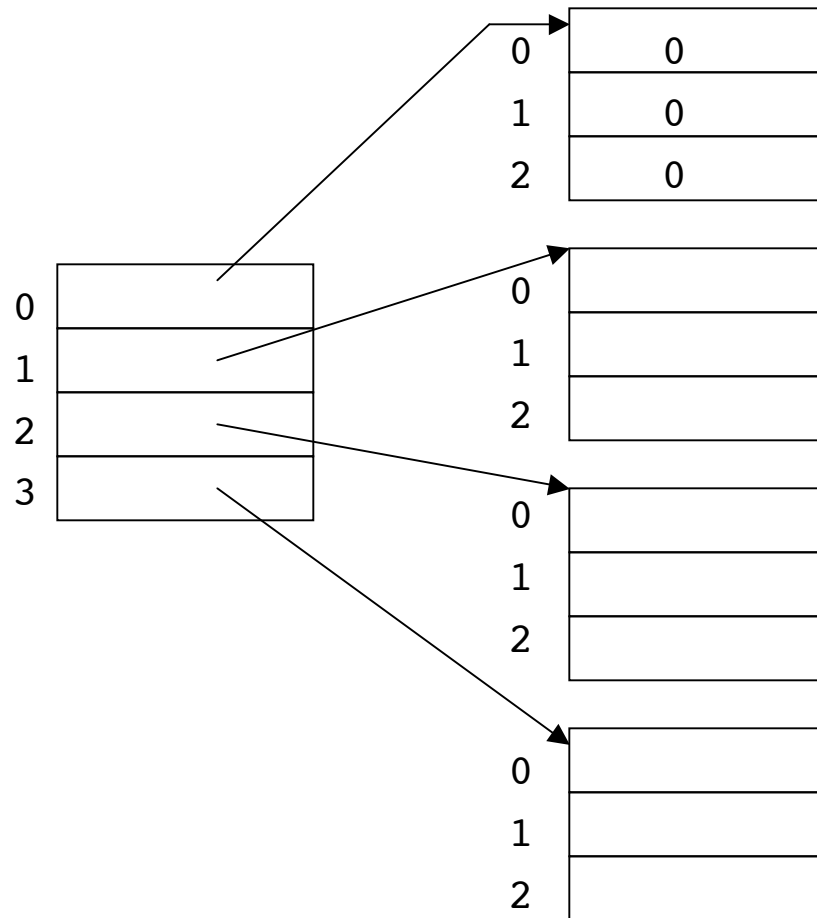
```
myMachines.getCokematic(1).getCansSold()
```



Arrays of Arrays

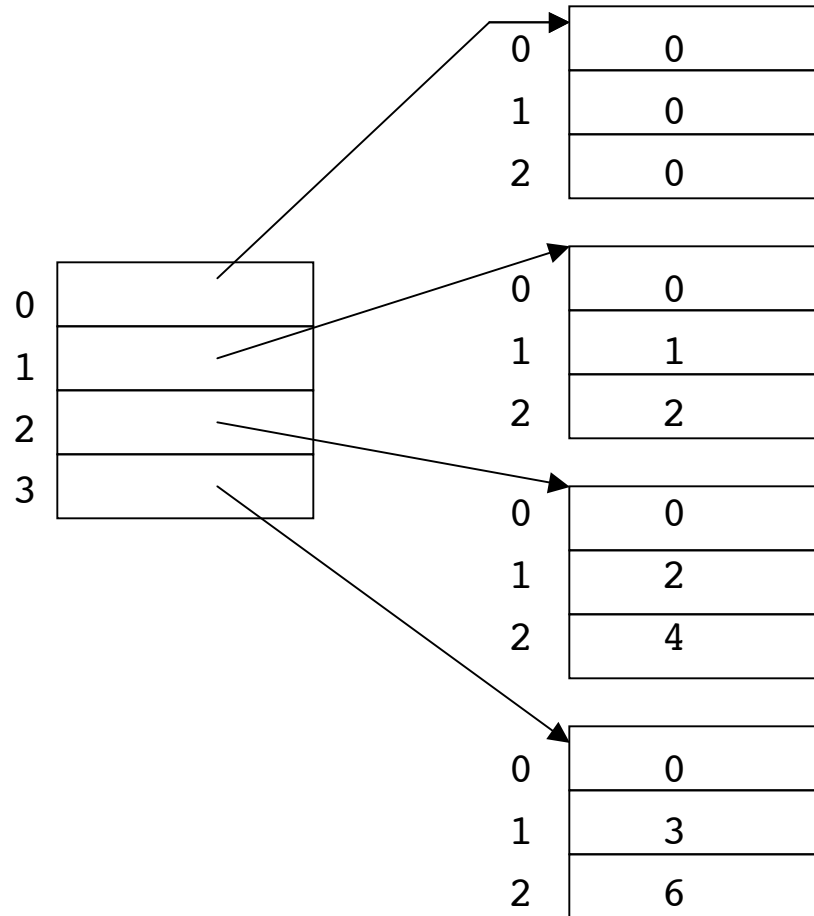


Arrays of Arrays



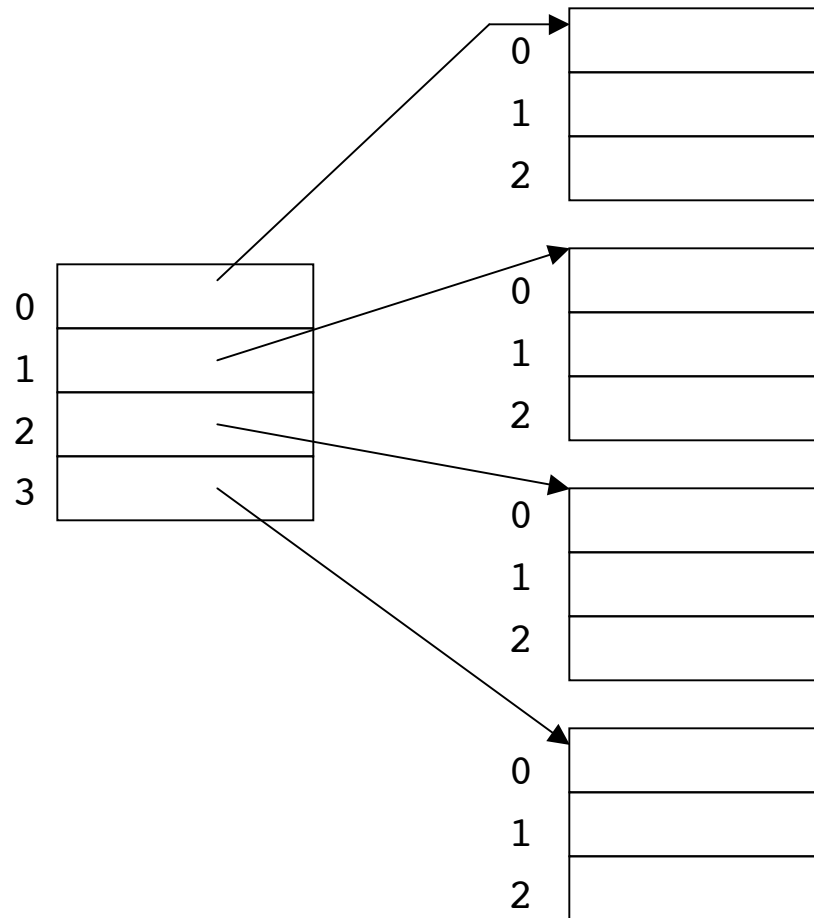
- In any given array, all data must be of same type

Arrays of Arrays



- In any given array, all data must be of same type
- All arrays in array of arrays must be of same type

Arrays of Arrays



- In any given array, all data must be of same type
- All arrays in array of arrays must be of same type
- So easier to use a two-dimensional array!

Two-Dimensional Arrays

		columns		
		0	1	2
rows	0	0	0	0
	1	0	1	2
	2	0	2	4
	3	0	3	6

- In Java, 2D array implemented internally as array of arrays
 - but externally syntax of 2D array may seem easier to use

Two-Dimensional Arrays

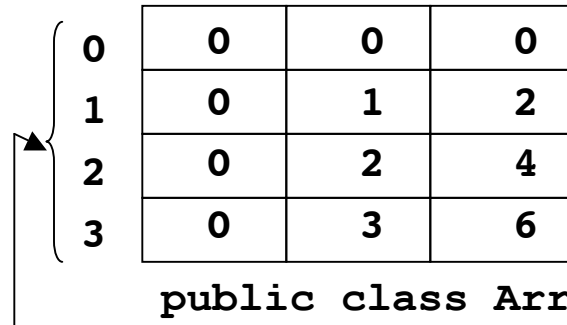
		columns		
		0	1	2
rows	0	0	0	0
	1	0	1	2
	2	0	2	4
	3	0	3	6

- In Java, 2D array implemented internally as array of arrays
 - but externally syntax of 2D array may seem easier to use
- Typical control structure for computing with 2D array is nested loop
 - loop within another loop
- Let's write program to
 - load array with values shown
 - print contents of array

Two-Dimensional Arrays

columns

0 1 2



A 4x3 grid representing a 2D array. The columns are labeled 0, 1, and 2. The rows are labeled 0, 1, 2, and 3. A vertical arrow on the left points upwards from the label 'rows' to the row indices. A horizontal arrow at the top points right from the label 'columns' to the column indices.

0	0	0	0
1	0	1	2
2	0	2	4
3	0	3	6

rows

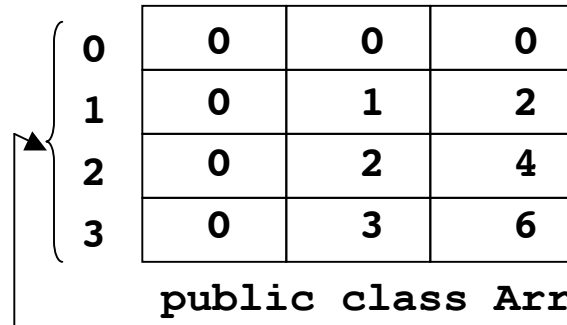
```
public class ArrayTest5 {  
    public static void main(String[] args) {
```

```
    }  
}
```

Two-Dimensional Arrays

columns

0 1 2



A diagram showing a 4x3 grid of numbers. The columns are labeled 0, 1, and 2. The rows are labeled 0, 1, 2, and 3. A vertical arrow on the left points upwards from the word 'rows' to the row indices. A horizontal arrow at the top points right from the word 'columns' to the column indices.

0	0	0	0
1	0	1	2
2	0	2	4
3	0	3	6

rows

```
public class ArrayTest5 {  
    public static void main(String[] args) {  
        int[][] multTable = new int[4][3];
```

```
    }  
}
```

Two-Dimensional Arrays

columns

0 1 2

0	0	0	0
1	0	1	2
2	0	2	4
3	0	3	6

rows

```
public class ArrayTest5 {  
    public static void main(String[] args) {  
        int[][] multTable = new int[4][3];
```

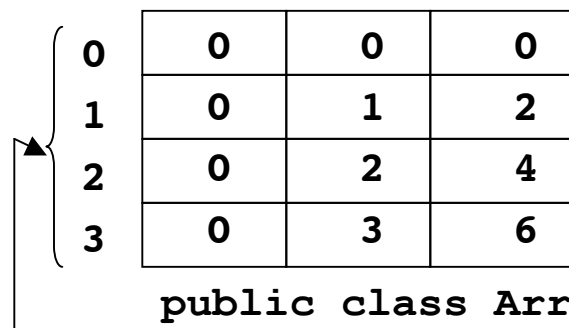
```
        for (int col = 0; col < multTable[row].length; col++) {  
            multTable[row][col] = row * col;  
        }
```

```
    }  
}
```

Two-Dimensional Arrays

columns

0 1 2



A 4x3 grid of cells representing a 2D array. The columns are labeled 0, 1, and 2 above the grid. The rows are labeled 0, 1, 2, and 3 to the left of the grid. A vertical arrow on the left points downwards from row 0 to row 3, labeled 'rows'. A horizontal arrow at the top points from column 0 to column 2, labeled 'columns'.

0	0	0	0
1	0	1	2
2	0	2	4
3	0	3	6

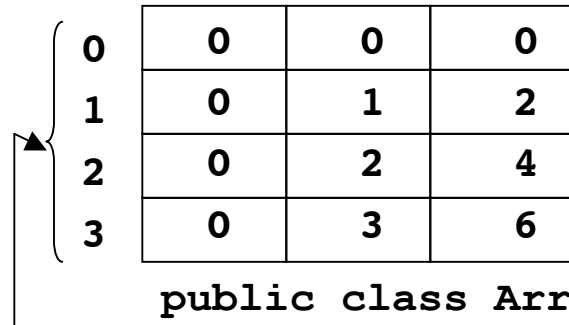
rows

```
public class ArrayTest5 {  
    public static void main(String[] args) {  
        int[][] multTable = new int[4][3];  
  
        for (int row = 0; row < multTable.length; row++){  
            for (int col = 0; col < multTable[row].length; col++) {  
                multTable[row][col] = row * col;  
            }  
        }  
    }  
}
```

Two-Dimensional Arrays

columns

0 1 2



A diagram showing a 4x3 grid of cells. The columns are labeled 0, 1, and 2 at the top. The rows are labeled 0, 1, 2, and 3 on the left. A vertical arrow on the left points downwards and is labeled 'rows'. A horizontal arrow at the top points to the right and is labeled 'columns'. The grid contains the following values:

	0	1	2
0	0	0	0
1	0	1	2
2	0	2	4
3	0	3	6

rows

```
public class ArrayTest5 {
    public static void main(String[] args) {
        int[][] multTable = new int[4][3];

        for (int row = 0; row < multTable.length; row++){
            for (int col = 0; col < multTable[row].length; col++) {
                multTable[row][col] = row * col;
            }
        }

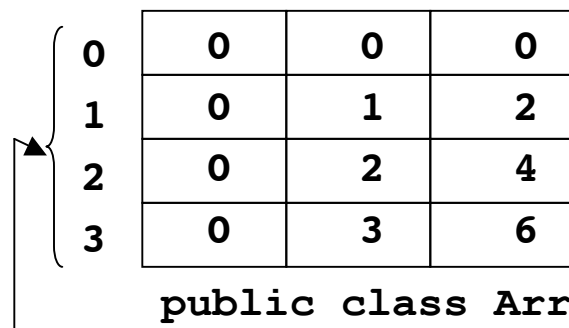
        for (int col = 0; col < multTable[0].length; col++){
            System.out.print(multTable[0][col] + " ");
        }

    }
}
```


Two-Dimensional Arrays

columns

0 1 2



A diagram showing a 4x3 grid of cells. The columns are labeled 0, 1, and 2 at the top. The rows are labeled 0, 1, 2, and 3 on the left. A vertical arrow on the left points downwards and is labeled 'rows'. A horizontal arrow at the top points to the right and is labeled 'columns'. The grid contains the following values:

	0	1	2
0	0	0	0
1	0	1	2
2	0	2	4
3	0	3	6

rows

```
public class ArrayTest5 {
    public static void main(String[] args) {
        int[][] multTable = new int[4][3];

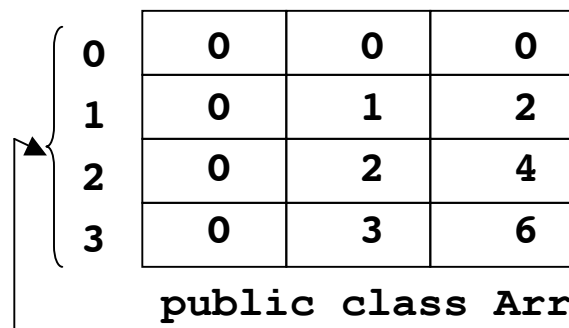
        for (int row = 0; row < multTable.length; row++){
            for (int col = 0; col < multTable[row].length; col++) {
                multTable[row][col] = row * col;
            }
        }

        for (int row = 0; row < multTable.length; row++){
            for (int col = 0; col < multTable[row].length; col++){
                System.out.print(multTable[row][col] + " ");
            }
        }
    }
}
```

Two-Dimensional Arrays

columns

0 1 2



A diagram showing a 4x3 grid of numbers. The columns are labeled 0, 1, and 2. The rows are labeled 0, 1, 2, and 3. A vertical arrow on the left points downwards and is labeled 'rows'. A horizontal arrow at the top points to the right and is labeled 'columns'. The grid contains the following values:

	0	1	2
0	0	0	0
1	0	1	2
2	0	2	4
3	0	3	6

rows

```
public class ArrayTest5 {
    public static void main(String[] args) {
        int[][] multTable = new int[4][3];

        for (int row = 0; row < multTable.length; row++){
            for (int col = 0; col < multTable[row].length; col++) {
                multTable[row][col] = row * col;
            }
        }

        for (int row = 0; row < multTable.length; row++){
            for (int col = 0; col < multTable[row].length; col++){
                System.out.print(multTable[row][col] + " ");
            }
            System.out.println();
        }
    }
}
```