1. Section 9 Exercises

- Exercise 9-1: The matrix m is an array of 4 arrays, each with 6 members. If m is regarded as a 2-dimensional array, then

  m[1][2] is **75**

  m[2][5] is **88**

  m[4][1] is **a run-time error**

  m[3] references **{ 58, 72, 66, 57, 76, 73 }**

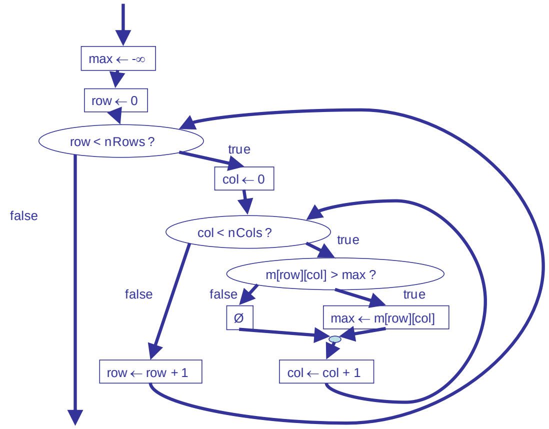
Program Memory

Exercise 9-2 - Max value in a matrix

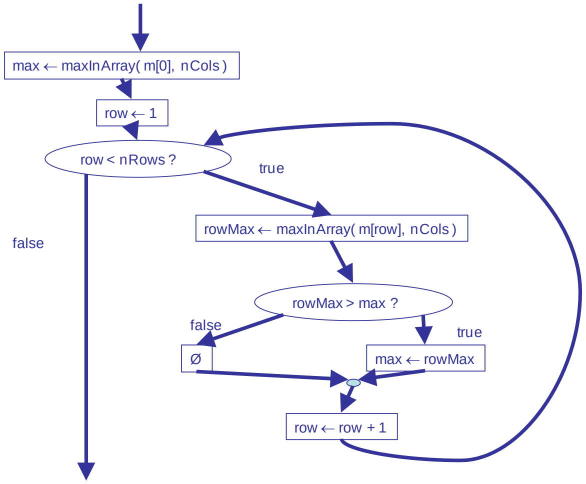
GIVENS:	m	(a matrix)
	nRows	(the number of rows in m)
	nCols	(the number of columns in m)
INTERMEDIATES:		
	row	(index of current row)
	rol	(index of current column)
RESULT:	max	(the maximum value in the matrix)

HEADER: max ← findMatrixMax(m, nRows, nCols)

BODY:

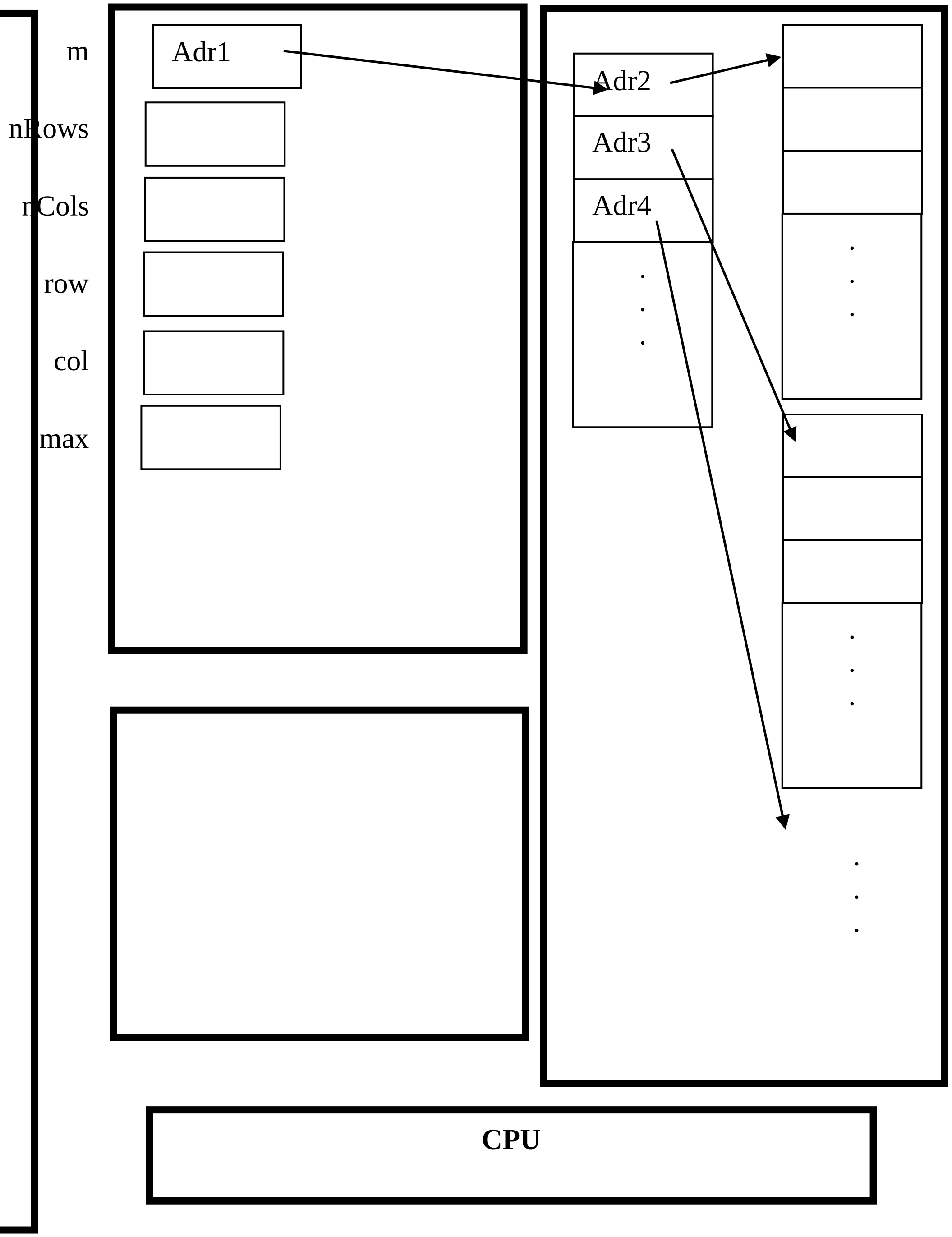


Alternative:



Working memory

Global Memory



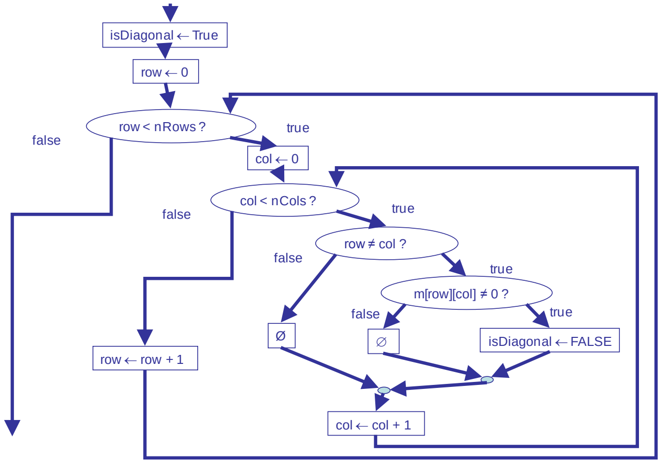
Program Memory

Exercise 9-3 – Diagonal-check algorithm

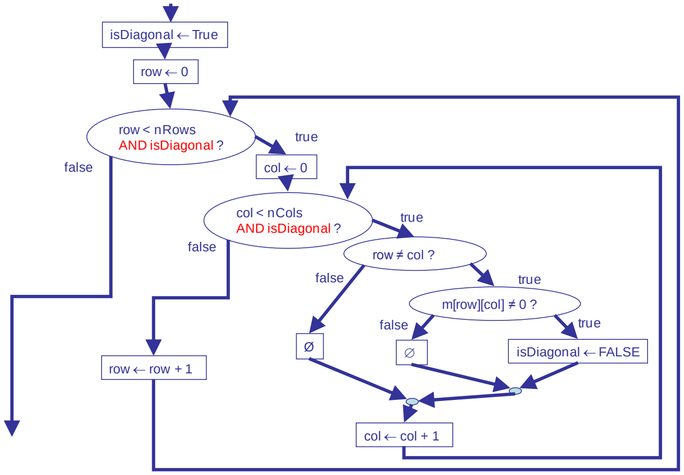
Working mem

Global Mem

GIVENS:	m	(a matrix)
	nRows	(the number of rows in m)
	nCols	(the number of columns in m)
INTERMEDIATES:		
	row	(index of current row)
	col	(index of current column)
RESULT:	isDiagonal	(TRUE if matrix is diagonal, false otherwise)
HEADER:	isDiagonal ← checkDiag(m, nRows, nCols)	
BODY:		



Efficient Version

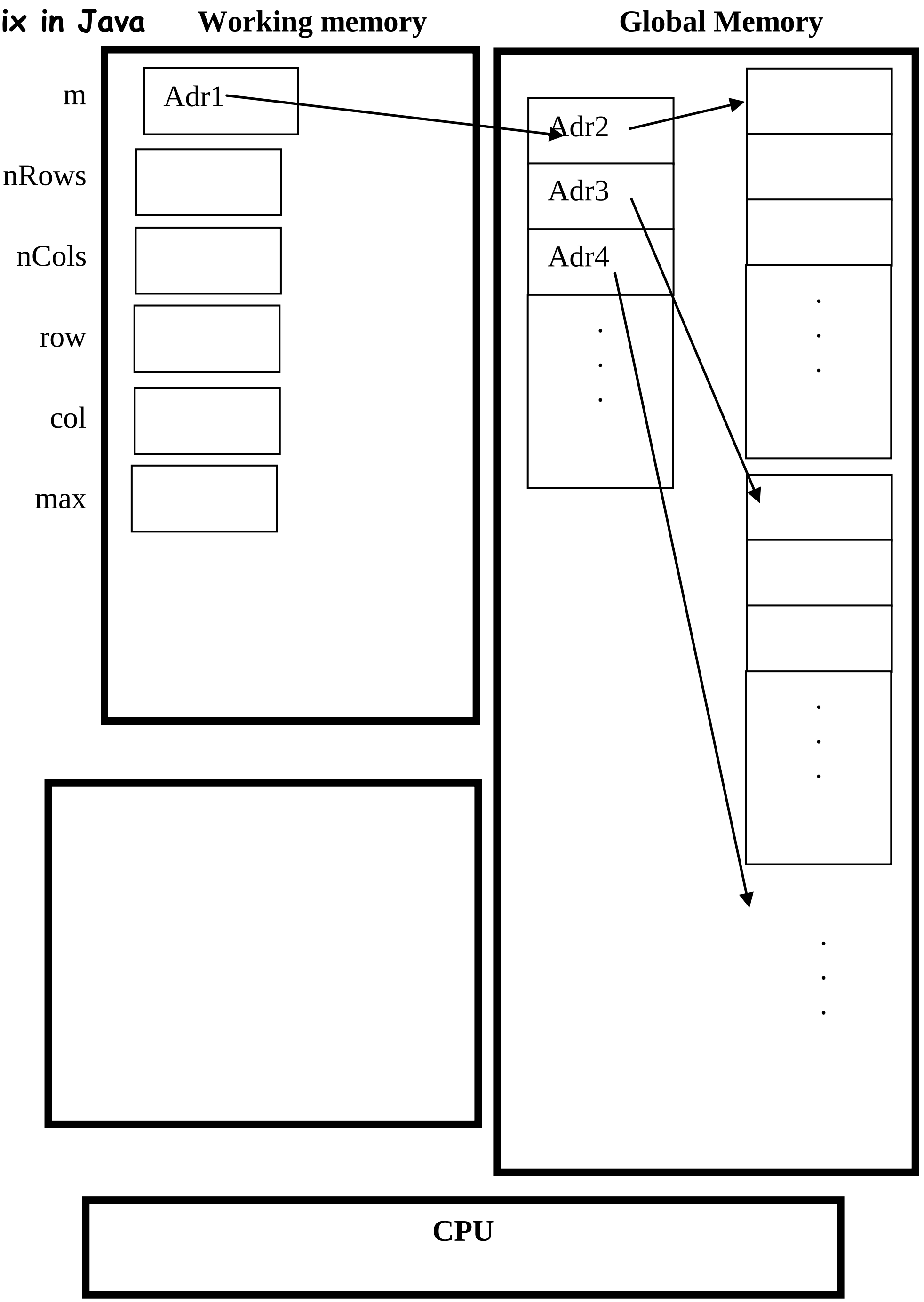


CPU

Program Memory

Exercise 9-4 – Max value in a matrix in Java

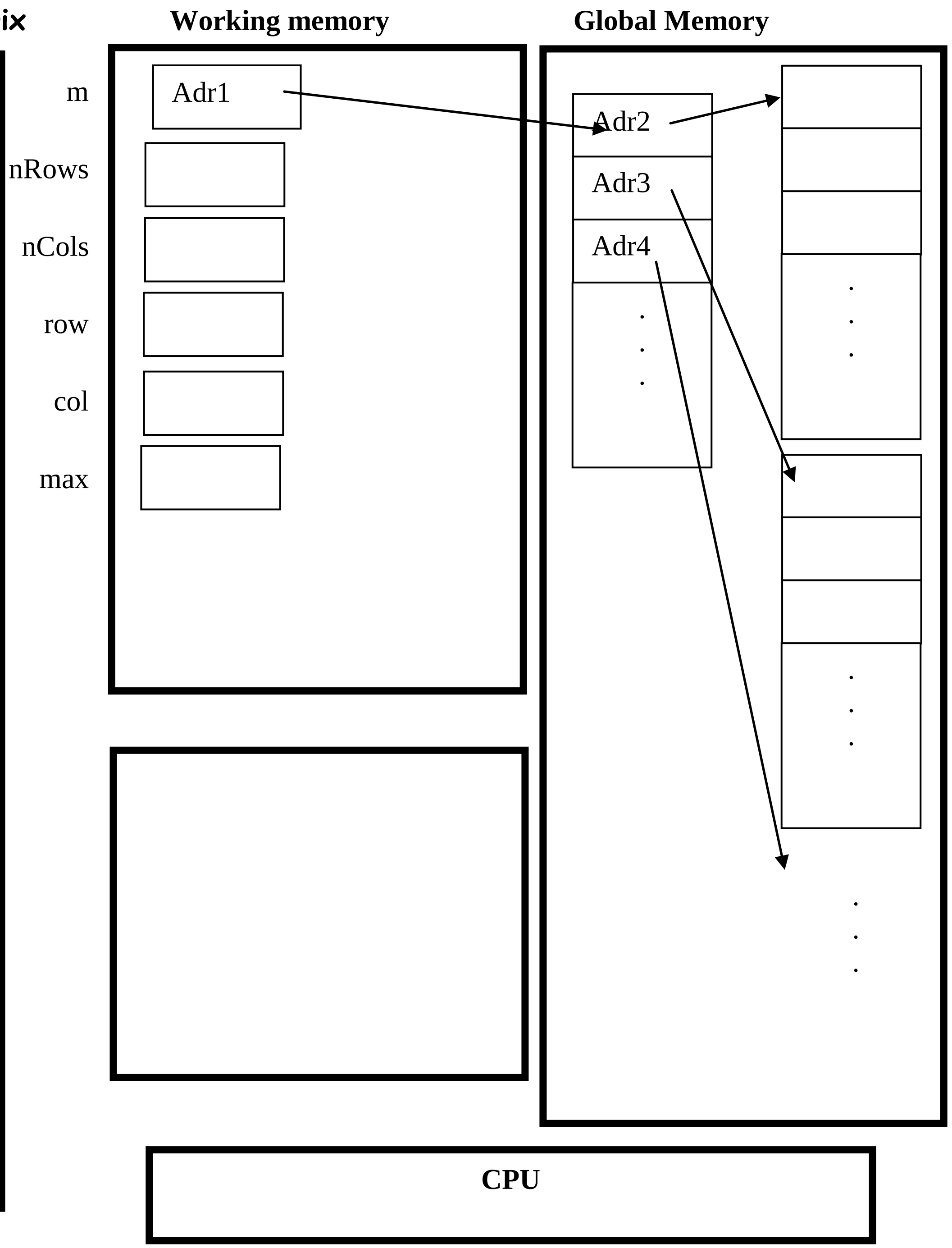
```
// Note:  Integer.MIN_VALUE is the most
// negative allowable integer for a Java
// int, and can be used for -∞.

public static int matrixMax (int[][] m,
                      int nRows, int nCols)
{
   max = Integer.MIN_VALUE;
           // m[0][0] is an alternate choice
   int max;  // if the matrix m is not empty
   int row; // INTERMEDIATE
   int col; // INTERMEDIATE
   for ( row = 0; row < nRows;
         row = row + 1 )
   {
      for ( col = 0; col < nCols;
            col = col + 1 )
      {
         if ( m[row][col] > max )
         {
              max = m[row][col];
         }
         else
         {
            /* do nothing */ ;
         }
      }
   }
   return max;
}
```



Program Memory

Exercise 9-5 – Reading a Matrix

```
public static int readMatrix(int nRows, int nCols)
{
   int row, col;
   int nRows, nCols;
   int[][] m ;
   System.out.println("Enter number of rows and
                         number of columns: ") ;
   nRows = ITI1120.readInt() ;
   nCols = ITI1120.readInt() ;
   m = new int[nRows][nCols] ;
   for ( row = 0 ; row < nRows ; row = row+1 )
   {
      System.out.println("Enter the values for row "
                             + row );
      for ( col=0; col < nCols ; col = col+1)
      {
         m[row][col] = ITI1120.readInt() ;
      }
   }
```



Program Memory

Exercise 9-6 – Find Cheap Direct Flights

Working memory

Global Memory

GIVENS:

- home (the number of the city you live)
- cost (reference to the cost matrix)
- d (the amount you afford)
- n (the total number of cities)

RESULTS:

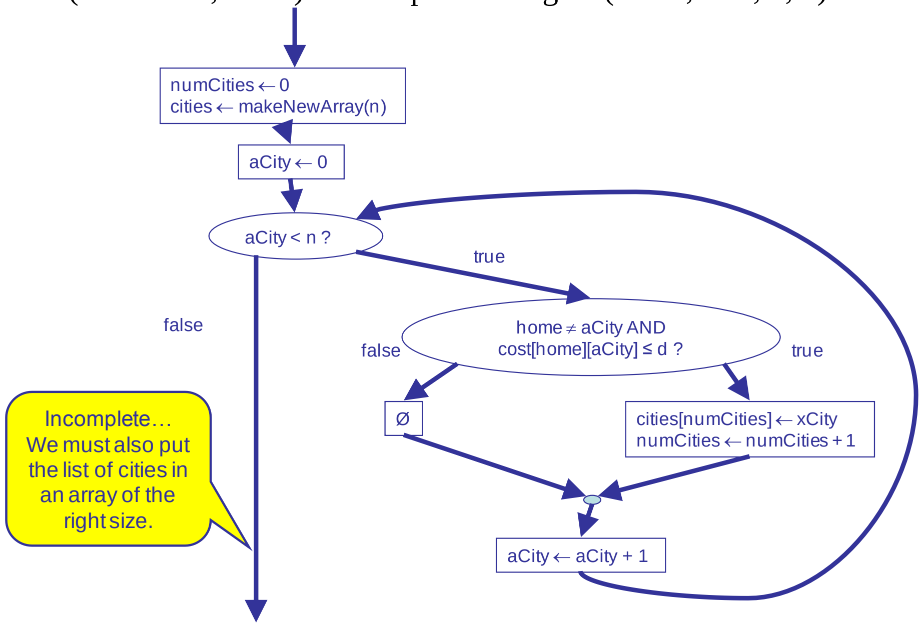
- cities (reference to an array of cities which you can visit)

INTERMEDIATE:

- aCity (the city we are currently checking)
- numCities (the number of cities to which you can go)

HEADER

(numCities, cities) ← cheapDirectFlights (home, cost, d, n)



numCities ← 0
cities ← makeNewArray(n)

aCity ← 0

aCity < n ?

true

false

home ≠ aCity AND cost[home][aCity] ≤ d ?

false

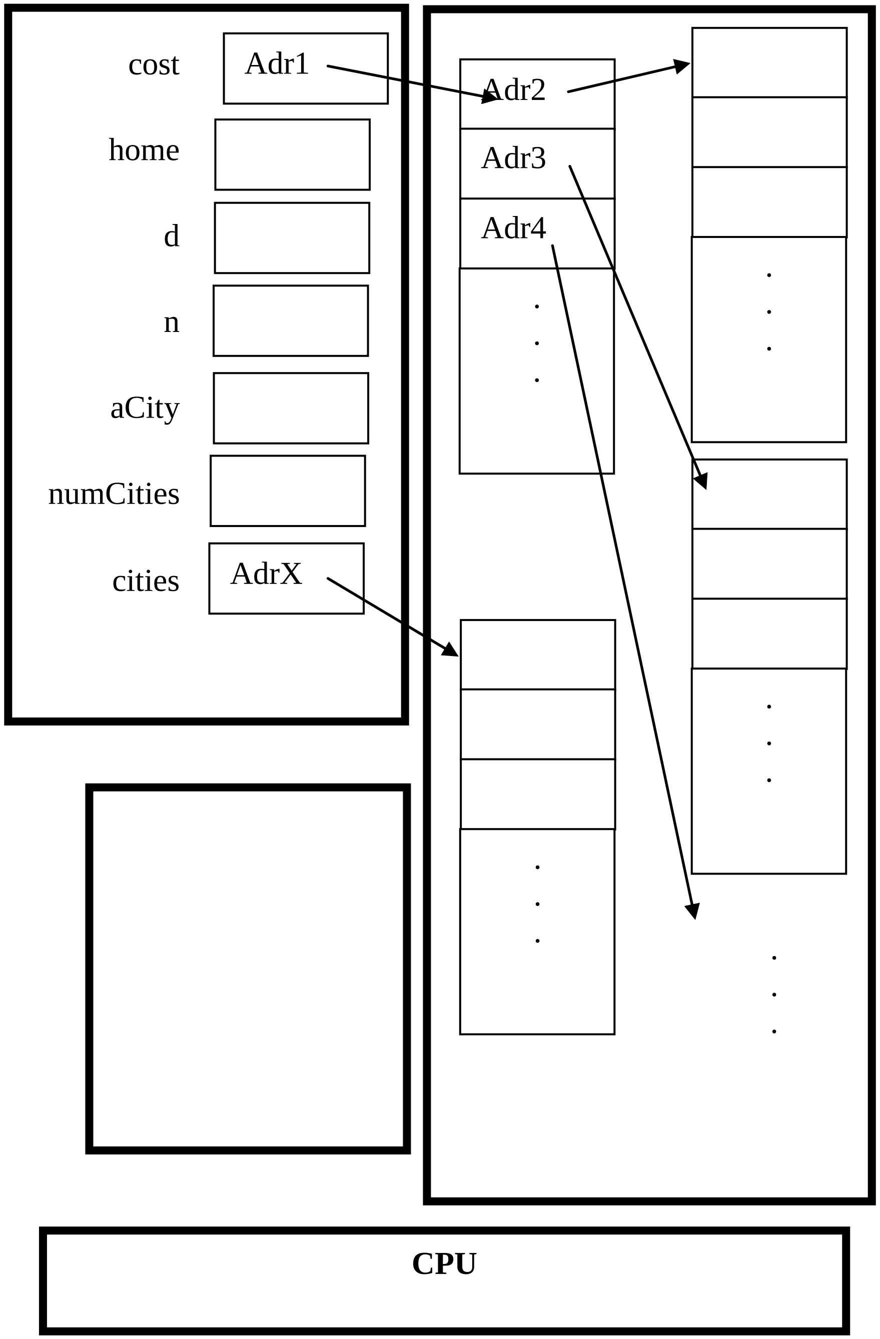
true

Ø

cities[numCities] ← xCity
numCities ← numCities + 1

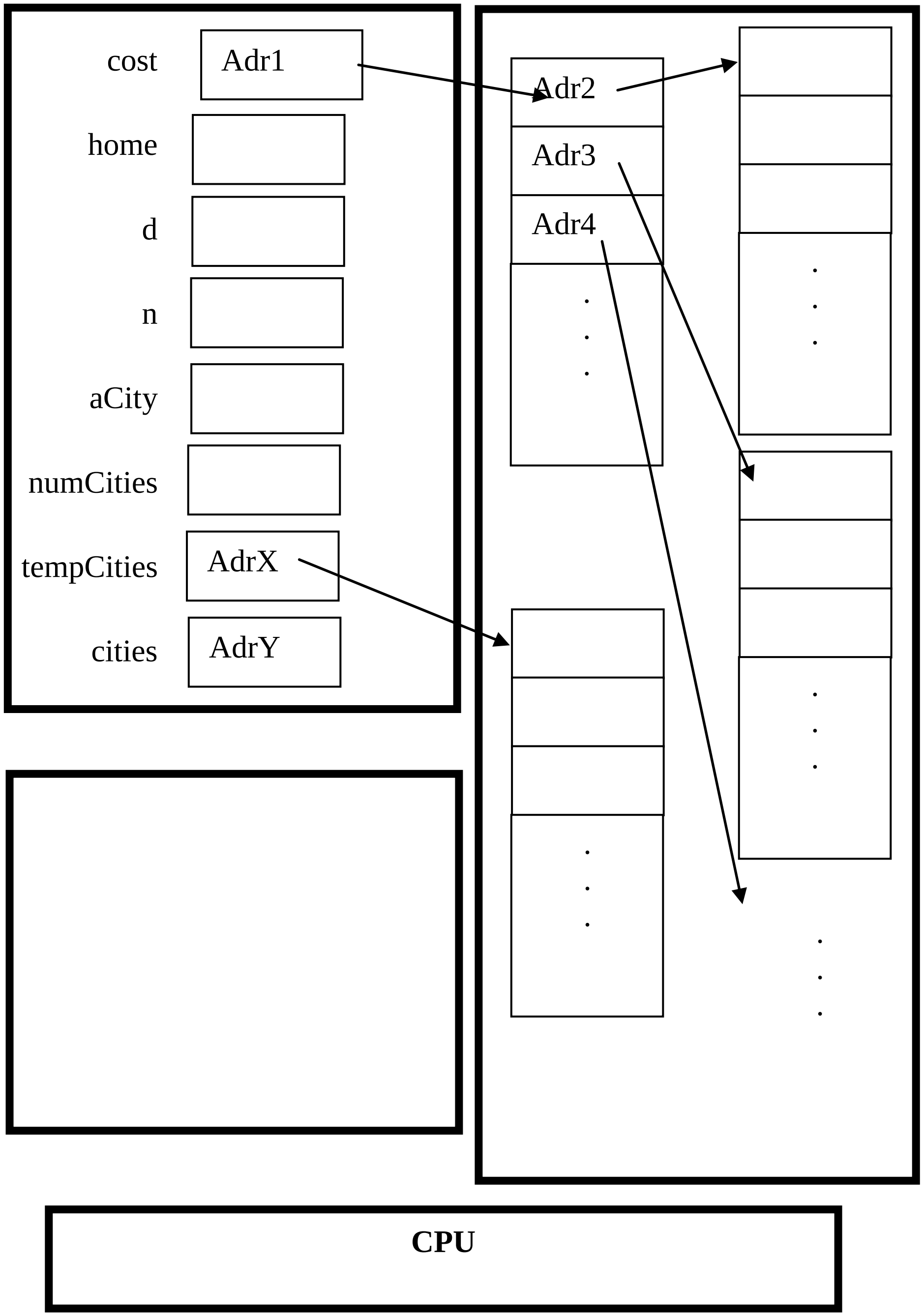
aCity ← aCity + 1

Incomplete… We must also put the list of cities in an array of the right size.



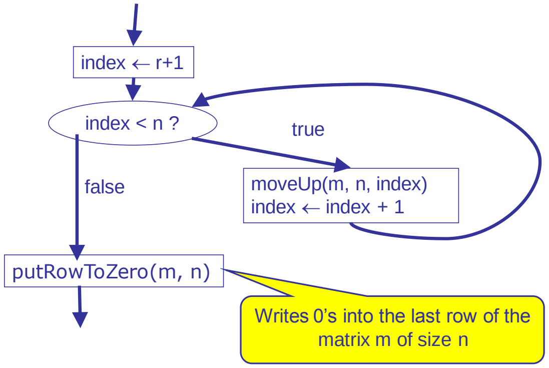
Program Memory **Exercise 9-6 (cont.) – Find Cheap Direct Flights in Java** **Working memory** **Global Memory**

```
public static int[] cheapDirectFlights(int home,
                        int[][] cost, int d, int n )
{
   int[] cities; // RESULT:  an array of cities we
                 // can afford to visit
   // INTERMEDIATES:
   int aCity ;    // The city currently checking
   int numCities ; // Number of cities we can visit
   int[] tempCities; // Temporary array for cities
   // BODY
   tempCities = new int[n-1];
   numCities = 0 ;
   for (aCity = 0; aCity < n ; aCity = aCity + 1 )
   {
      if(( aCity != home ) &&
         (cost[home][aCity ] <= d) )
      {
         tempCities[numCities] = aCity;
         numCities = numCities + 1;
      }
      else
      {
         /* do nothing */ ;
      }
   }
   // At this point we have to get around Java's
   // inability to return more than one  value.
   // Create a new array of the correct length. The
   // caller can obtain the number of cities by the
   // length of the array.
   cities = new int[numCities];
   for ( aCity = 0; aCity <  numCities;
         aCity  = aCity + 1 )
   {
      cities[aCity] = tempCities[aCity];
   }

   // Now return the array of cities with correct length
   return cities;
}
```



Program Memory **Exercise 9-7 - Delete a Row** **Working mem** **Global Mem**

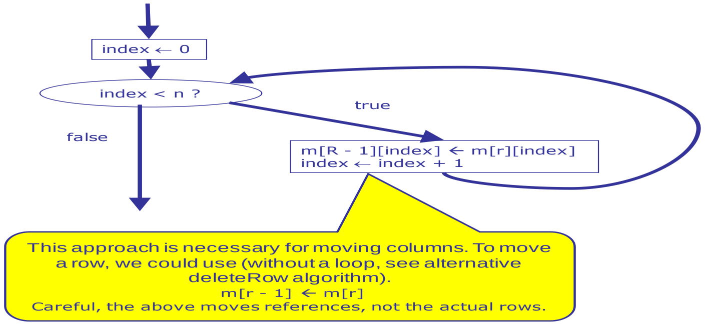
GIVENS: M (a square matrix)
N (number of rows and columns in M)
R (row number to be removed)
RESULTS: (none)
MODIFIEDS: M (the original matrix with row R removed, and all rows moved up by one)
INTERMEDIATES: Index (index of row being moved)
HEADER: DeleteRow(M, N, R)
BODY:



Writes 0's into the last row of the matrix m of size n

```
public static void deleteRow(int [ ][ ]m,
                             int n, int r)
{
  int index; // INTERMEDIATE
  for (index = r + 1; index < n;
       index = index + 1)
  {
     moveUp(m, n, index);
  }
  putRowToZero(m, n);
}
```

GIVENS: m *(a square matrix)*
n *(size of m)*
r *(number of row to move, r > 0)*
RESULT: (none)
MODIFIED: m *(row r copied to row r-1)*
INTERMEDIATE: index *(column index)*
HEADER: moveUp(m, n, r)
BODY:



This approach is necessary for moving columns. To move a row, we could use (without a loop, see alternative deleteRow algorithm).
m[r - 1] ← m[r]
Careful, the above moves references, not the actual rows.

```
private static void moveUp(int [ ][ ]m,
                           int n, int r)
{
  int index; // INTERMEDIATE
  for (index = 0; index < n;
       index = index + 1)
  {
     m[r - 1][index] = m[r][index];
  }
}
```

CPU

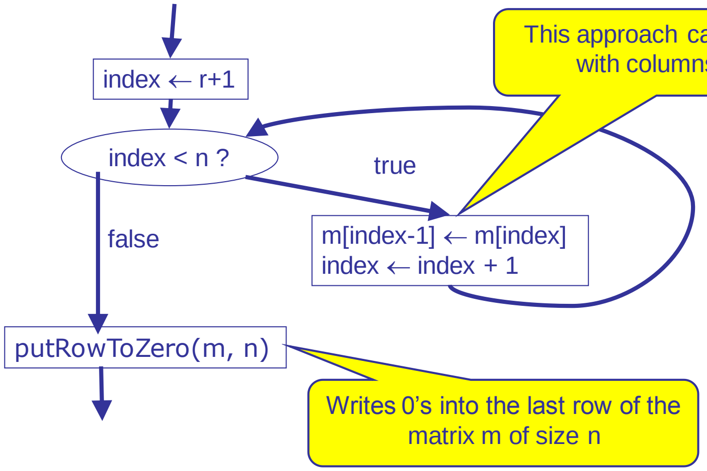
Program Memory

Exercise 9-7 – Delete a Row

Working mem

Global Mem

GIVENS: m (a square matrix)
n (number of rows and columns in m)
r (row number to be removed)
RESULTS: (none)
MODIFIEDS: m (the original matrix with row r removed, and all rows moved up by one)
INTERMEDIATES: index (index of row being moved)
HEADER: deleteRow(m, n, r) *(Alternative algorithm using the array of references)*
BODY:



This approach cannot be used with columns. Why?

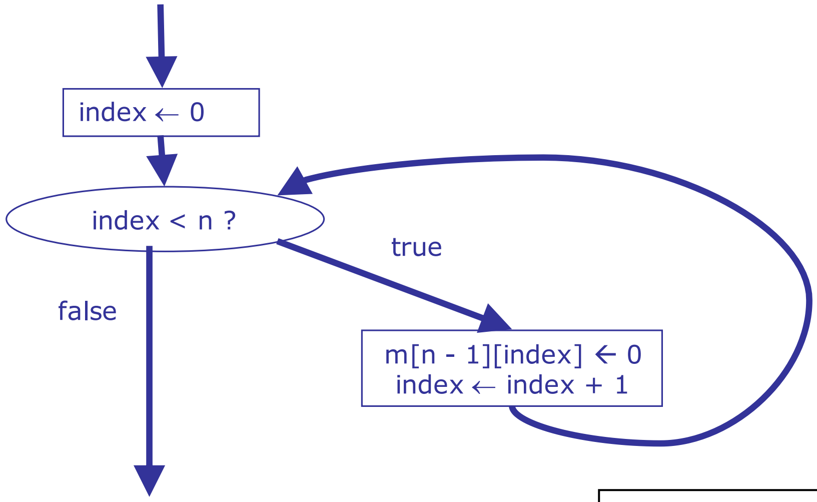
Writes 0's into the last row of the matrix m of size n

```
public static void deleteRow(int [ ][ ]m,
                             int n, int r)
{
  int index; // INTERMEDIATE
  for (index = r + 1; index < n;
       index = index + 1)
  {
     m[index-1] = m[index];
  }
  putRowToZero(m, n);
}
```

CPU

Program Memory **Exercise 9-7 (continued) – Delete a Row** **Working mem** **Global Mem**

GIVENS: m *(a square matrix)*
n *(size of m)*
RESULTS: (none)
MODIFIED: m *(last row put to 0)*
INTERMEDIATE: index *(index of the column)*
HEADER: putRowToZero(m, n)



index ← 0

index < n ?

true

false

m[n - 1][index] ← 0
index ← index + 1

```
private static void putRowToZero(int [ ][ ]m,
                                 int n)
{
  int index; // INTERMEDIATE
  for (index = 0; index < n;
       index = index + 1)
  {
       m[n - 1][index] = 0;
  }
}
```

CPU