2D Arrays
(Savitch, Chapter 7.5)

TOPICS

- Multidimensional Arrays
- 2D Array Allocation
- 2D Array Initialization
- TicTacToe Game

Learning objectives

- Using 2D arrays
- Decomposition of a solution into objects and methods

Declaring and initializing 2D arrays

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```
// setting up a 2D array
final int M=3, N=4;
int [][] matrix = new int [M][N];
for(int i=0; i<M; i++) {
    for (int j=0; j<N; j++) {
        matrix[i][j] = fileScanner.nextInt();
    }
}
```

3

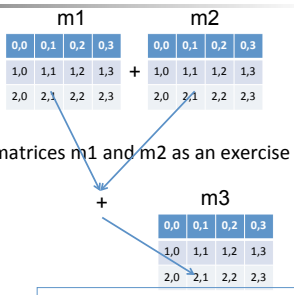
0,0	0,1	0,2	0,3
1,0	1,1	1,2	1,3
2,0	2,1	2,2	2,3

Printing 2D arrays

```
// printing from a 2D array
final int M=100, N=200;
int [][] matrix = new int [M][N];
for(int i=0; i<M; i++) {
    for (int j=0; j<N; j++) {
        System.out.print(matrix[i][j] + " ");
    }
    System.out.println();
}
```

Adding two matrices

```
// setting up a 2D array
final int M=100, N=200;
int [][] m1 = new int [M][N];
int [][] m2 = new int [M][N];
// First write code to initialize the matrices m1 and m2 as an exercise
int [][] m3 = new int[M][N];
for(int i=0; i<M; i++) {
    for (int j=0; j<N; j++) {
        m3[i][j] = m1[i][j] + m2[i][j];
    }
}
```



The numbers in each cell represent the indices

More on 2D arrays

- int[][] matrix = new int[3][4];
- What is matrix.length? It is 3
- What is matrix[0].length? It is 4
  - So is matrix[1].length, matrix[2].length, and matrix[3].length
- You can access a particular row using matrix[i] where i refers to the row number between 0 and 2
- Each row is a one-dimensional array
- You cannot access a column like that ☹
- Exercises:
  - Write code that subtracts one matrix from another
  - Write code that transposes the given matrix

Review (Java)

- Assignments & expressions
- Sequential control: if & switch
- Looping control: while, for, do
- Organization: classes & methods
- Tools: Eclipse & debugging

Why? So you can program…

Programming

- … but programming isn't about syntax
  - You can program in many languages
- Programming is about problem solving
  - Problem definition/refinement
  - Problem decomposition
  - Managing complexity

Challenge Problem

- So here is a problem to be worked through together:
  - *Write a person versus computer TicTacToe game.*

Challenge Problem

- Write a TicTacToe game
  - Machine goes first, plays 'X'
  - Print the board before every user move
  - User plays 'O', specifies moves by coordinate
    - 0..2, 0..2.
  - Machine selects random, legal moves
  - Program knows when game is over

Decomposition

- Game board
  - State
- Player moves
  - User I/O
- Computer moves
  - Select random, legal moves
- Manage game
  - Alternate turns until end

Further Decomposition

- Game board
  - Maintain board state
    - *2D array makes sense*
  - Mark board square
    - *Add an 'X' or 'O' at row, col*
    - *Check that row, col are empty*
  - Print entire board
    - *Show the state of the board*
  - Detect game over

Code (Part 1a)

- Focusing on the game state:
  - Board state needed by multiple subtasks
  - Good candidate for an instance variable
- Initialize the board : method
- Mark a square : method
- Print the board : method
- Detect game over : methods

Public vs Private

- What is the difference between *public* & *private* variables/methods?
- If something is public, it can be accessed by other objects
  - Think of the String object
  - If it's length() method weren't public, you couldn't use it!
- If something is private, only methods of the same class can access it
  - Note that if something is public, it can be changed at any point (more error checking!)
- General rule: top-level methods should be public, everything else should be private

Code (Part 1b)

- markSquare() & printBoard() are straightforward
  - Note error checking, only valid moves allowed
  - print just iterates the 2D array
- What about gameOver()?
  - When is a game of tic-tac-toe over?
    - When there is a row of X's or O's…
    - … or a column
    - … or a diagonal
    - … or the board is full (tie game)
  - So may require decomposition
    - Leading to more methods…

Stop!
Do not pass go or collect $200…

- DO NOT write the whole program at all once
  - Too hard to debug that way
  - Test each piece separately
- Write a temporary main function
  - Have it initialize the board, mark a square, print the result. Does it work?
  - Have it test end of game scenarios too.
  - Then comment out the test code
  - It's not part of the final product.
    - Think of it like scaffolding…

Code (Part 2)

- OK, now we need to get moves from the user
  - Print a prompt
  - Read in coordinates
  - Call markSquare()
- Probably doesn't need further decomposition
- But does need to be tested!

Code (Part 3)

- Machine move: picked at random
  - Java has a Random class
    - Generates a stream of pseudo-random numbers
  - Pick a row and col at random
    - Between 0 and 2
  - Check if legal. If not, pick another
  - What will happen if board is full?
- Don't forget testing….

Initialization

- Problem: which method allocates the board?
  - How about Scanner and Random?
- We want instance variables initialized before any other method is called
  - But we haven't decided which method will be called first
  - Even if we had, might change when the code is modified
- Solution: A *constructor* is a method that is called by new when an object is created.

Constructors

- The syntax for constructors is unique
  - Constructors take parameters, but they never return a value
  - The constructor name is always the same as the class name
  - The default constructor has no parameters, but we can add them
  - The constructor is generally used to initialize class instance variables

Code (Part 4)

- Now we've done everything but play the game!
- The game is the main function
  - What should happen when the class is executed
  - Hence, public static void main(String[] args)
- The game depends on instance variables, so main needs to instantiate TicTacToe

Eclipse Demo

- Write the program for TicTacToe
- Will be posted on the course website