Announcements for This Lecture

Material

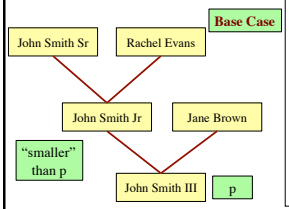
- Section 9.1
  - Last new material for final!
- Section 12.1 next time
  - Relevant to assignment
  - But not on the exam
- Next week: wrapping up
- Review sessions in 2 weeks
  - Will announce next week

Assignments

- A6 still being graded
  - Having to "eyeball it"
  - Will take us this week
- Assignment A7 now posted
  - Last assignment of semester
  - Please meet suggested dates
    - Makes it manageable
  - Due Saturday after classes

Prelim II: How I Lowered the Mean

- **Progress to Termination**
  - Arguments of recursive calls must somehow get "smaller"
  - Each call closer to base case




```
/** Yields: number of family members
 *  (including profile p and his/her
 *  ancestors) with given first name */
public int withName(String s) {
  int count =
     (getName().equals(s) ? 1 : 0);

  if (father != null)
     count = count+father.withName(s);

  if (mother != null)
     count = count+mother.withName(s);
  return count;
}
```

Instance Method

What is Up with reveall in A6?

Try it Yourself

```
/** Extract and return ... */
public String reveal() {
  ...
  int p= 4;
  String result= "";

  // inv: All hidden chars before
  // pixel p are in result[0..k-1]
  for (int k= 0; k < len; k= k+1) {
     result= result +
           (char) (getHidden(p));
     p= p+1;
  }
  return result;
}
```

n^2 algorithm (n is the length of message)

```
/** Extract and return ... */
public String reveal() {
  ...
  int p= 4;
  char[] result= new char[len];

  // inv: All hidden chars before
  // pixel p are in result[0..k-1]
  for (int k= 0; k < len; k= k+1) {
     result[k]=
           (char) (getHidden(p));
     p= p+1;
  }
  return new String(result);
}
```

linear algorithm (n time steps)

Overview of Two-Dimensional Arrays

- Type of d is **int**[][]
  ("**int** array array"/ "an array of **int** arrays")
- To declare variable d:
  int d[][];
- Create a new array and assign to d:
  d = **new int**[5][4];
- Initializer for two-dimensional array:
  int[][] d = {{5,4,7,3},{4,8,9,7},{5,1,2,3},{4,1,2,9},{6,7,8,0}};

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

Overview of Two-Dimensional Arrays

- Access value in position at row 3, col 2:
  d[3][4]
- Access value in position at row 3, col 2:
  d[3][2] = 8;

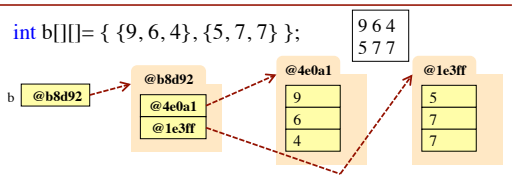
Some Mysterious Features

- An odd symmetry
  - Number of rows of d: d.length
  - Number of columns in row r of d: d[r].length
- Also, try toString(int[]) in the demo

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

How Multidimensial Arrays are Stored

- int b[][]= { {9, 6, 4}, {5, 7, 7} };



- b holds name of a one-dimensional array object
  - Has b.length elements
  - Its elements are the names of 1D arrays
- b[i] holds the name of a one-dimensional array of **int**s
  - Has length b[i].length

Ragged Arrays: Rows w/ Different Length

- Declare variable b of type **int**[][]

  int[][] b;
- Create a 1-D array of length 2 and store name in b

  b= **new int**[2][] // Elements have **int**[] (and start as **null**)
- Create **int** array, store its name in b[0]

  b[0]= **new int**[] {17, 13, 19};
- Create **int** array, store its name in b[1]

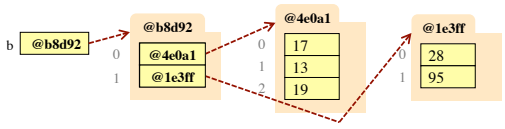
  b[1]= **new int**[] {28, 95};

Ragged Arrays: Rows w/ Different Length

- Create **int** array, store its name in b[0]

  b[0]= **new int**[] {17, 13, 19};
- Create **int** array, store its name in b[1]

  b[1]= **new int**[] {28, 95};



Aside: Image Array

- ImageArray used 1D array
  - Flattened version of 2D array
  - Simulated with p = r*length+c
- Uses less memory
  - Each row a folder in 2D array
  - ImageArray uses one folder
- Faster to access
  - 2D array needs 2 memory look-ups
  - 1D array is math+memory look-up
  - Computation faster than memory
- But 1D is harder to use

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

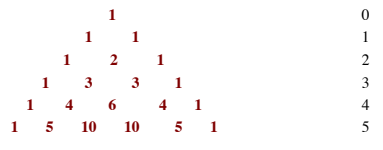
b	5	4	7	3	4	8	9	7 …

Pascal's Triangle

- Entry p[i][j] = number of ways i elements can be chosen from a set of size j !
- p[i][j] = "i choose j" = $\binom{i}{j}$

Recursive formula:
for 0 < i < j, p[i][j] = p[i–1][j–1] + p[i–1][j]

Pascal's Triangle



- **Binomial Theorem**: Row r gives the coefficients of $(x + y)^r$
  - $(x + y)^2 = 1x^2 + 2xy + 1y^2$
  - $(x + y)^3 = 1x^3 + 3x^2y + 3xy^2 + 1y^3$
  - $(x + y)^r = \sum_{0 \le k \le r} (k \text{ choose } r)\, x^k y^{r-k}$

Ragged Arrays for Pascal's Triangle

```
/** Yields: ragged array of first n rows of Pascal's triangle. Precondition: 0 ≤ n */
public static int[][] pascalTriangle(int n) {
    int[][] b= new int[n][];    // First n rows of Pascal's triangle
    // invariant: rows 0..i-1 have been created
    for (int i = 0; i != b.length; i= i+1) {
        b[i]= new int[i+1];     // Create row i of Pascal's triangle
        b[i][0]= 1;             // Calculate row i of Pascal's triangle
        // invariant b[i][0..j-1] have been created
        for (int j= 1; j < i; j= j+1) {
            b[i][j]= b[i-1][j-1] + b[i-1][j];
        }
        b[i][i]= 1;
    }
    return b;
}
```