Week 10
Pointers and the Heap

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CS 212 – Spring 2004

Announcements

- Part 3 updates
  - Due date has been delayed by one week
    - Now due: Monday, April 19,11pm
  - Be sure you handle *all* parts of the Part 3 grammar!
- Sections are meeting
  - Today
  - Next week, too
- Make use of Office Hours!
- If your Part 2 did not compile or if it failed many tests
  - The graders are not expected to determine the exact nature of any problems with your code
  - If there is some small error, you can request a regrade
    - Describe the problem
    - Describe the fix
    - Provide working code
  - *Do not* use this as a coding strategy --- penalties increase for Parts 3 and 4

Pointers

- Java hides pointers (but they're there)
- Pointers are used explicitly in C (and many other languages)
- A pointer is basically an *address* (of a cell in memory)
  - In Java, these addresses refer only to cells in the Heap
  - In C, these addresses can refer to *any* cell
- Pointer operations
  - Dereferencing: identify the thing that is pointed to
  - Assignment: copy pointer values
  - Comparison: equality/inequality of pointers
  - Dynamic allocation: a "new" block of memory
  - Deallocation: return a block of memory to the system
  - Arithmetic: used in C (mostly for arrays)

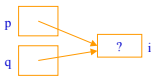
Pointers in C

- The code
  ```
  int *p;
  ```
  declares a variable p that can point to an integer
  - Immediately after declaration, it doesn't point at anything in particular
- This code
  ```
  int i, j, *p;
  p = &i;
  ```
  causes p to point at i

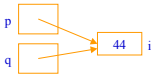
- * is the *indirection* operator
- & is the *address* operator
- These assignments are the same
  ```
  j = *&i;
  j = i;
  ```
- These are the same, too
  ```
  i = 4;
  *p = 4;
  ```

C Pointer Examples

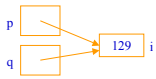
```
int i, j, *p, *q;
p = &i;
q = p;
```



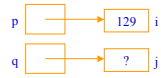

```
*p = 44;
```




```
*q = 129;
```



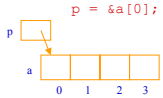

```
q = &j;
```



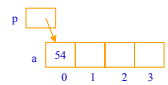
What about
`*q = *p;` vs. `q = p;` ?

Pointers and Arrays in C

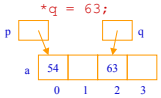
- A pointer can point at an array
  ```
  int a[4], *p, *q;
  p = &a[0];
  ```



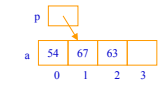
- You can use pointer arithmetic to access array elements
  ```
  *p = 54;
  ```



- Addition works
  ```
  q = p + 2;
  *q = 63;
  ```



- So does subtraction
  ```
  p = &a[3];
  p = p - 2;
  *p = 67;
  ```



Oddities of Pointers and Arrays in C

- An array name can be used as a pointer

```
int a[4];
*a = 7;
*(a+1) = 77;
```

- A common way to sum the elements of an array

```
for (p = a; p < a+N; p++)
    sum += *p;
```

- These two references are the same:

```
a[i]
*(a + i)
```

- Also, strangely, these two are the same

```
a[i]
i[a]
```

because both are equivalent to `*(a + i)`

- Arrays and pointer are nearly equivalent, but you can't assign to an array name

Pointers in Java

- Java doesn't use pointers in an explicit way
  - Java implicitly uses pointers (called *references* in Java)
  - Every variable that does not hold a primitive type holds a reference (a pointer) to an Object
- There is no Java equivalent to the pointer arithmetic typically done in C
- In Java

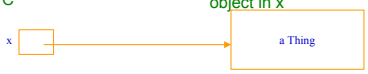
```
Thing x;
```

declares that x holds a reference to an Object of type Thing

- The code

```
x = new Thing(...);
```

reserves space for an Object of type Thing in the Heap, initializes the Object, and places a reference to the object in x



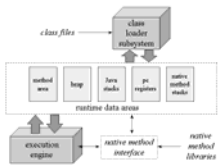
Allocating/Deallocating Heap Memory

- In C
  - Allocating memory
    - malloc: allocates a block of memory (no initialization)
    - calloc: allocates a block of memory and clears it
    - realloc: resizes a previously allocated block of memory
  - Deallocating memory
    - free(p): deallocates block of memory that p points to
    - Beware of *dangling pointers*!
- In Java
  - Allocating memory
    - The *new* operator
      - allocates a block of memory
      - calls the specified *constructor*
  - Deallocating memory
    - Java uses an automatic *garbage collector*
      - frees any allocated memory that is no longer in use
    - Can choose to run it using the System.gc method

Runtime Data Areas

- for SaM
  - Code
  - Stack
  - Heap
  - Registers

- for Java
  - Method area
  - Java stacks
  - Heap
  - PC registers
  - Native method stacks



from: http://www.artima.com/insidejvm/ed2/jvm2.html

JVM Runtime Data Areas

- Method area (stores data for each type)
  - Information about the type (e.g., name, modifiers, superclass, etc.)
  - *Constant pool* for the type
    - Any constant used in the type's code (e.g., 5 or 'x' or 1.414)
  - Field & method information for the type (including the *code* for each method)
  - *Class variables* (i.e., *static* fields)
- Java stacks
  - Stores *stack frames*
  - But keeps *multiple* stacks because Java is *multithreaded*
- Heap
  - Stores objects (including *instance variables*)
- PC registers
  - One PC register for each *thread*
- Native method stacks
  - A work area for methods written in a language other than Java