CS 180 - Basic Linked Lists

Note Title 9/19/2011

Announcements

- HW - up after class
  due next Sunday
- Tutoring starts this week

Recap of arrays (Ch 3.1 of text)

Limits

- not very flexible
  - size is fixed at creation
  - 1 kind of data
  - inserting + moving can be difficult

Q: How would we insert an element in the middle of an array?

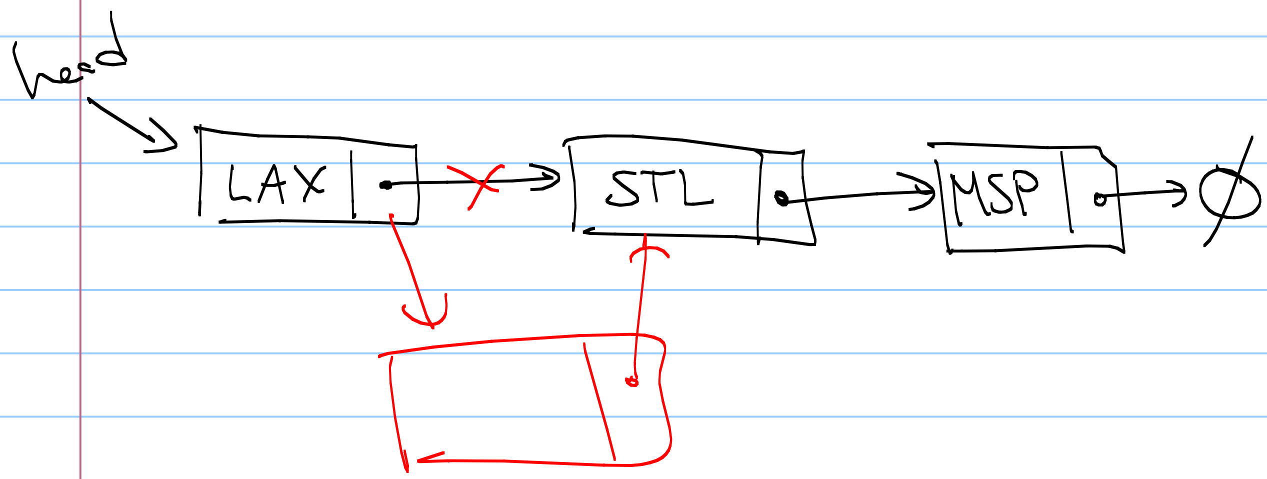
ex: insert(20) in sorted order

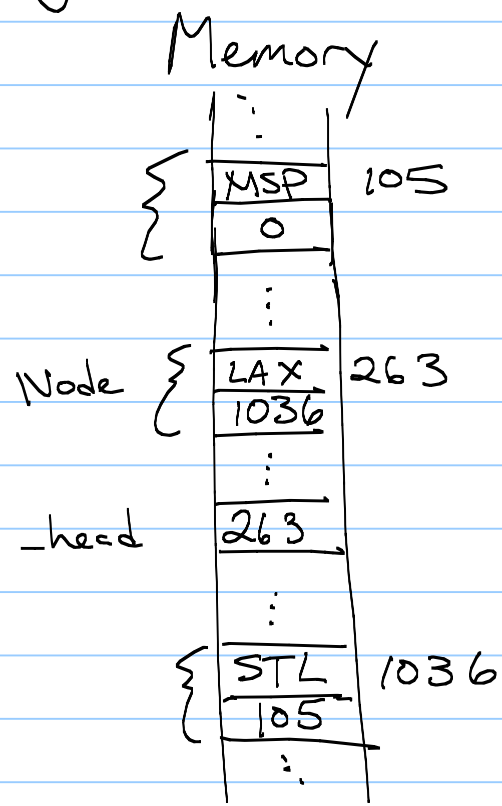
2	5	6	11	25	26	31				
0	1	2	3	4						

20

Singly Linked Lists

A collection of nodes that together form a linear ordering.





Code

See SLinkedList.h & SLinkedList.tcc

templated

Algorithm Analysis (Ch. 4)

How do we compare two programs?

- speed
- space (or memory usage)
- maintainability
- portability
- readability

Speed

How fast an algorithm runs can be very dependent on variables in the system.

Examples:

- CPU
- RAM
- Hard drive + buses
- Network
- Language
- Design decisions
- Compiler
- Input

Primitive Operations

As a way to compare algorithms in a generic way, we instead count primitive operations.

- addition, storing a value, subtraction, multiplication, allocating space, ...

In addition, we (generally) only analyze the worst possible running time.

Why? Generally, worst case is what causes problems!

Comparing

OK, so we have the worst case # of operations – usually a function of n. ← size of input

How to compare?

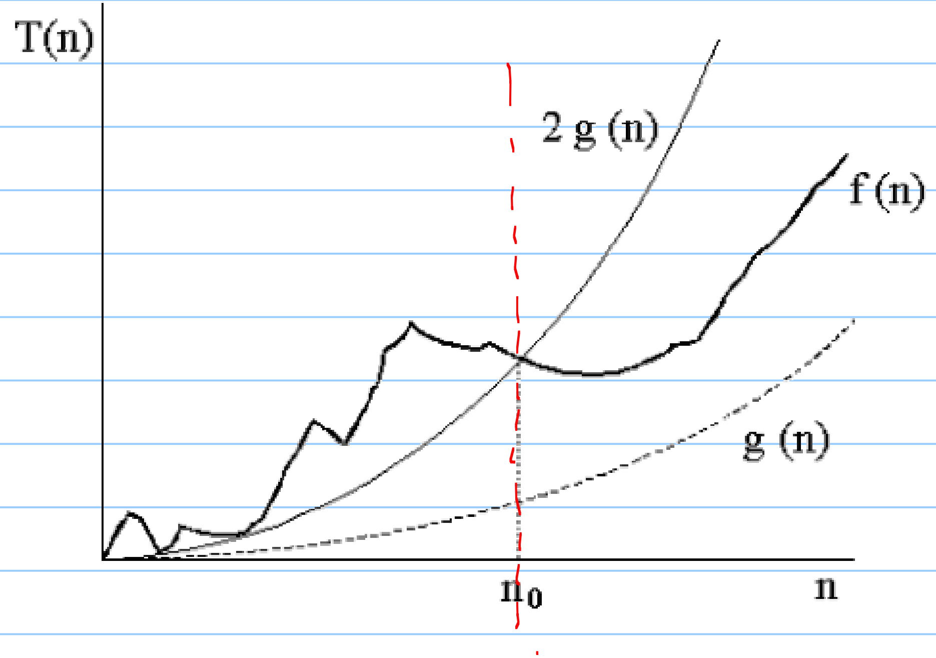
big-O notation

Big-O

We say $f(n)$ is $O(g(n))$ if $\forall n > n_0$,
$\exists\ c > 0$ such that $f(n) \le c \cdot g(n)$.

for all

there exists



Ex: $5n$ is $O(n^2)$

if $n > 5$, $n \cdot n = n^2 > 5n$

$\Rightarrow n_0 = 5$, $c = 1$

Ex: $5 \cdot n$ is $O(n)$

Let $n_0 = 1$, $c = 6$

$f(n) = 5 \cdot n < c \cdot n = 6n$

Ex: $16n^2 + 52$ is $O(n^2)$

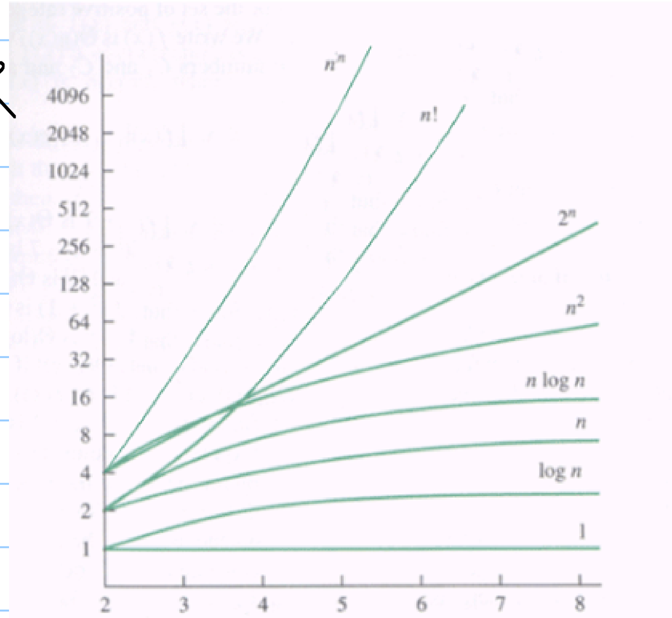
$n_0 = 52$, $c = 17$

$\vdots$

In polynomials, largest degree matters.

Functions we will use

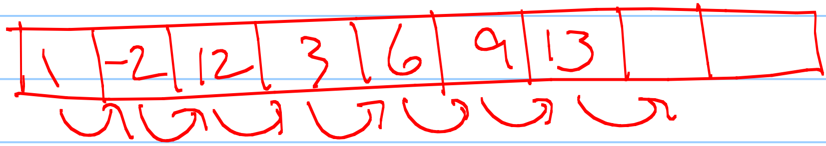
1. $O(1)$ – constant time
2. $O(\log n)$ – logarthmic time
   binary search
3. $O(n)$ – linear time
4. $O(n \log n)$
5. $O(n^2)$ – quadratic time
6. $O(n^3)$ – cubic time
7. $O(2^n)$ – exponential time



Algorithms

Claim: Inserting an element into the first spot in an array is $O(n)$ time.

put 5 here

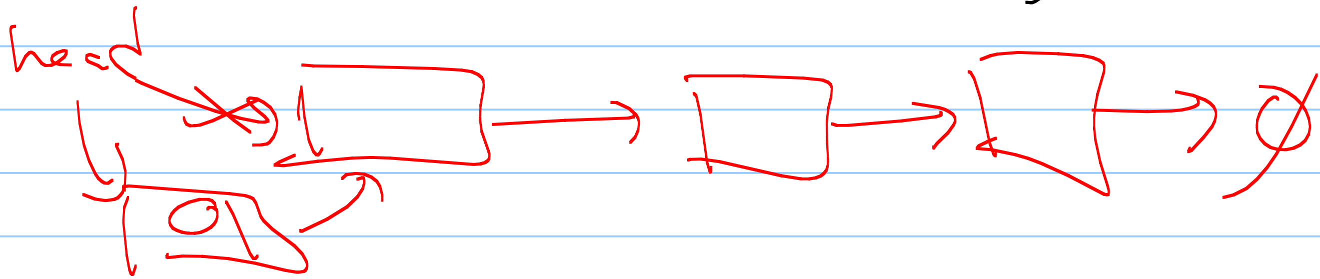


for loop

$A[i+1] = A[i]$

$$\sum_{i=1}^{n-1} 3 = 3n$$

Claim: Inserting at the beginning of a list is $O(1)$ time.



Common running times

- A for loop which goes from $i=0$ to $n-1$ and reads ~~in~~to an array

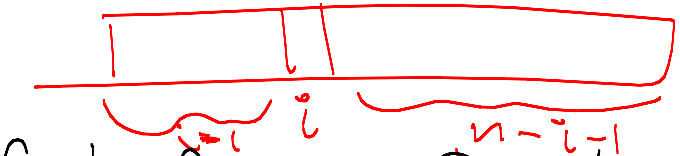
```
for (int i=0; i<n; i++)
    cin << array[i];
```

Analyze:

$$\sum_{i=0}^{n-1} (1+1+1+1) = 4n = O(n)$$

lazy: $$\sum_{i=0}^{n-1} 1 = \overbrace{(1+1+\dots+1)}^{n} = n$$

Nested For loops : find if any 2 elements are identical




```
for (int i=0; i<n; i++)
    for (int j=i+1; j<n; j++)
        if (A[i]==A[j])
            cout<<"Two items are the same"<<endl;
```

Analyze:

$$\sum_{i=0}^{n-1}\left(\sum_{j=i+1}^{n-1} 1\right) = \sum_{i=0}^{n-1}\left(1+1+\dots+1\right)$$

$$= \sum_{i=1}^{n-1}(n-i) = (n-1)+(n-2)+(n-3)+\dots 1$$

$$= \sum_{i=1}^{n-1} i = \frac{n(n-1)}{2} = \frac{n^2}{2}-\frac{n}{2} = O(n^2)$$