

Asymptotic Dominance in Action							
	O(lg n)	O(n)	O(n lg n)	n²	2 ⁿ	n!	
10	0.003 µs	0.01 µs	0.033 µs	0.1 µs	1 µs	3.63 ms	
20	0.004 µs	0.02 µs	0.086 µs	0.4 µs	1 ms	77.1 years	
30	0.005 µs	0.03 µs	0.147 µs	0.9 µs	1 sec	8.4*1015 yrs	
40	0.005 µs	0.04 µs	0.213 µs	1.6 µs	18.3 min		
50	0.006 µs	0.05 µs	0.282 µs	2.5 µs	13 days		
100	0.007 µs	0.1 µs	0.644 µs	10 µs	4*1013 yrs		
1,000	0.010 µs	1.00 µs	9.966 µs	1 ms			
10,000	0.013 µs	10 µs	130 µs	100 ms			
100,000	0.017 µs	0.10 ms	1.67 ms	10 sec			
1,000,000	0.020 µs	1 ms	19.93 ms	16.7 min			
10,000,000	0.023 µs	0.01 sec	0.23 sec	1.16 days			
100,000,000	0.027 µs	0.10 sec	2.66 sec	115.7 days			
1,000,000,000	0.030 µs	1 sec	29.90 sec	3.7 years			
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Divide and Conquer Algorithms

• Analysis of divide and conquer algorithms requires knowledge of:

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- Mathematical Induction
- Substitution/Iterative Method
- o Recurrences

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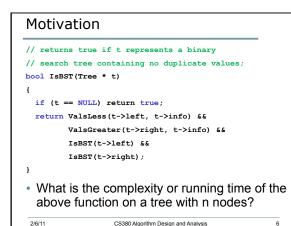
Motivation • The following structure and function exist: struct Tree { int info; Tree * left; Tree * right;

Tree(int value, Tree * lchild, Tree * rchild) : info
(value), left(lchild), right(rchild) { }
};

// return true if & only if all values in t are less than val bool ValsLess(Tree * t, int val)

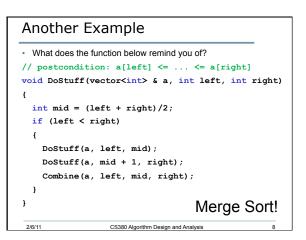
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Thank you Owen Astrachan

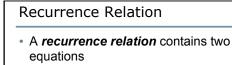


```
Another Example
• What is the asymptotic complexity of the
  function below? Assume Combine is O(n)
// postcondition: a[left] <= ... <= a[right]</pre>
void DoStuff(vector<int> & a, int left, int right)
{
 int mid = (left + right)/2;
 if (left < right)</pre>
 ł
   DoStuff(a, left, mid);
   DoStuff(a, mid + 1, right);
   Combine(a, left, mid, right);
 }
}
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```

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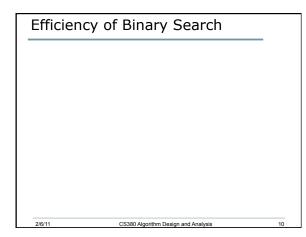
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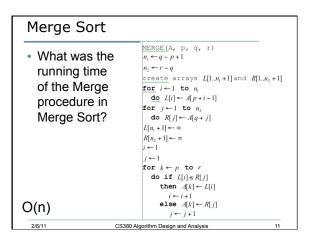


One for the general case

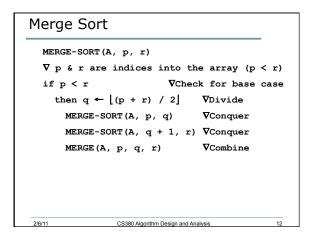
o One for the base case

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Recurrence Relation

- Let T(n) be the time for Merge-Sort to execute on an n element array.
- The time to execute on a one element array is O(1)
- Then we have the following relationship:

Merge Sort

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• To solve the recurrence relation we'll write n instead of O(n) as it makes the algebra simpler:

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• T(n) = 2 T(n/2) + n

- o T(1) = 1
- Solve the recurrence by iteration (substitution)

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• Use induction to prove the solution is correct

Recurrence Relations to Remember					
T(n) = T(n/2) + O(n/2)	(1)				
T(n) = T(n-1) + O((1)				
T(n) = 2 T(n/2) +	0(1)				
T(n) = T(n-1) + O(n-1)	(n)				
T(n) = 2 T(n/2) +	0 (n)				
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Your Turn

 Solve the following recurrence relation using the expansion (iteration) method

∘ T(n) = T(n-1) + 2n -1

• T(0) = 0

Approaches to Algorithm Design

Incremental

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Job is partly done – do a little more, repeat until done.

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- Divide-and-Conquer (recursive)
 - Divide problem into sub-problems of the same kind.
 - For small subproblems, solve, else, solve them recursively.

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Combine subproblem solutions to solve the whole thing.

For Next Time

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• So far we've covered chapters 1, 2, and 3.

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