CSE 326: Data Structures
Sorting by Comparison

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Sorting by Comparison algorithms

- Simple: Selection Sort
  - (Insertion Sort, Bubble Sort, Shell Sort)
- Good worst case: HeapSort, AVLSort, MergeSort
- Quick: QuickSort
- Imaginary: StrawSort (aka, BrianSort)
- Can we do better?

Selection Sort idea

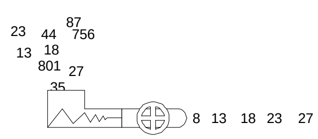
- Find the smallest element, put it first
- Find the next smallest element, put it second
- Find the next smallest, put it next
- etc.

Selection Sort

```
void SelectionSort (Array a[1..n]) {
      for (i=0, i<n; ++i) {
            Find the smallest entry in Array.
            Let j be the index of that entry.
            Swap(a[i],a[j])'
      }

      while (other people are coding QuickSort/MergeSort)
      {
            Twiddle thumbs
      }
}
```

HeapSort: sorting with a priority queue ADT (heap)



Shove everything into a queue, take them out smallest to largest.

AVL Sort?

MergeSort

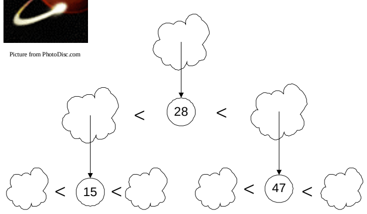
```
MergeSort (Array [1..n])
Split Array in half
Recursively sort each half
Merge two halves together
```

```
Merge (a1[1..n],a2[1..n])
i1=1, i2=1
While (i1<n, i2<n) {
      if (a1[i1] < a2[i2]) {
            Next is a1[i1]
            i1++
      } else {
            Next is a2[i2]
            i2++
      }
}
```

MergeSort Running Time

QuickSort

Picture from PhotoDisc.com



Pick a “pivot”. Divide into less-than & greater-than pivot.
Sort each side recursively.

QuickSort Partition

Pick pivot:

7	2	8	3	5	9	6

Partition
with cursors

7	2	8	3	5	9	6

< >

2 goes to
less-than

7	2	8	3	5	9	6

< >

QuickSort Partition (cont’d)

6, 8 swap
less/greater-than

7	2	6	3	5	9	8

< >

3,5 less-than
9 greater-than

7	2	6	3	5	9	8

Partition done.
Recursively
sort each side.

7	2	6	3	5	9	8

QuickSort
Worst case

Dealing with Slow QuickSorts

- Randomly permute input
  - Bad cases more common than simple probability would suggest. So, make it truly random.
- Pick pivot cleverly
  - “Median-of-3” rule takes Median(first, middle, last) element.
- Choose pivot point randomly!

QuickSelect

- What if we want to find the k^{th} biggest element in an array?
- What if k = N/2 (i.e., we want to find the median)?

QuickSelect

Pick pivot:

7	2	8	3	5	9	6

Partition array:

7	2	6	3	5	9	8

If (k == partition_index + 1), we are done!
else recursively call QuickSelect on **one** subarray.

StrawSort (aka BrianSort)

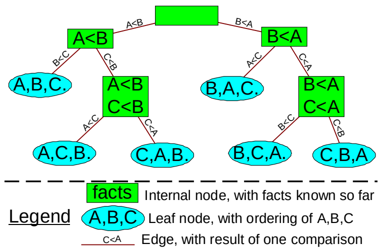
Could we do better?*

* (no. sorry.)

Worst case time Lower Bound

- How many comparisons does it take before we can be sure of the order?
- This is the minimum # of comparisons that any algorithm could do.

Decision tree to sort list A,B,C



Max depth of the decision tree

- What's the most leaves a binary tree of height *h* could have?
- What's the shallowest tree with *L* leaves?

- A decision tree to sort N elements must have N! leaves.
- Any sorting algorithm that uses only comparisons between elements requires at least log(N!) comparisons in the worst case!