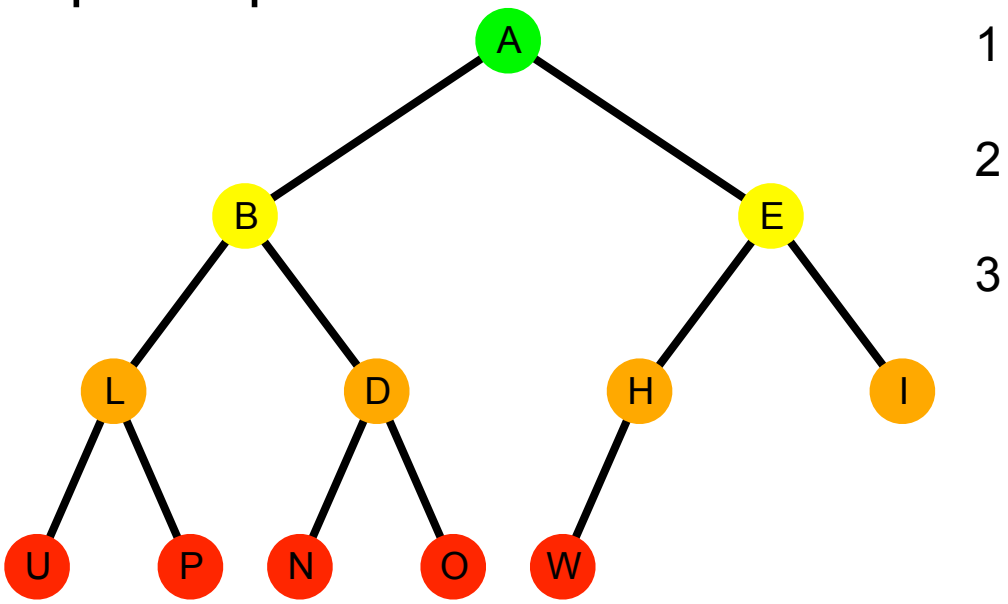
Today's announcements:

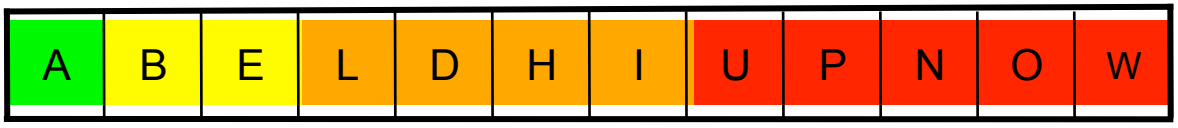
MP7 available, due 4/30, 11:59p. EC due 4/19.

Code Challenge #4, 4/17, 9p, Siebel 0224.

This image reminds us of a _____,
which is one way we can implement ADT _____,
whose functions include _____ and _____,
whose running times are _____.
This structure can be built in time _____.

(min)Heap: heapSort





Running time?

Why do we need another sorting algorithm?

An example:

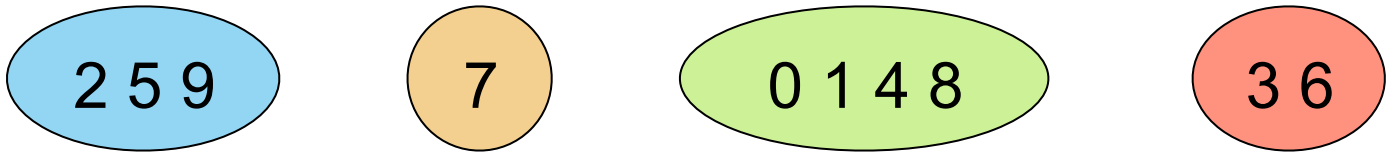
Let R be an equivalence relation on the set of students in this room, where $(s,t) \in R$ if s and t have the same favorite among {AB, FN, DJ, ZH, _____}.

Notation from math: $[\ \_\_\_\ ]_R = \{x : xR\_\_\_\}$

One big goal for us: Given s and t we want to determine if sRt.

A Disjoint Sets example:

Let *R* be an equivalence relation on the set of students in this room, where *(s,t)* ∈ *R* if *s* and *t* have the same favorite among {AB, FN, DJ, ZH, ____}.



1. Find(4)
2. Find(4)==Find(8)
3. If (!(Find(7)==Find(2)) then Union(Find(7),Find(2))

Disjoint Sets ADT

We will implement a data structure in support of “Disjoint Sets”:

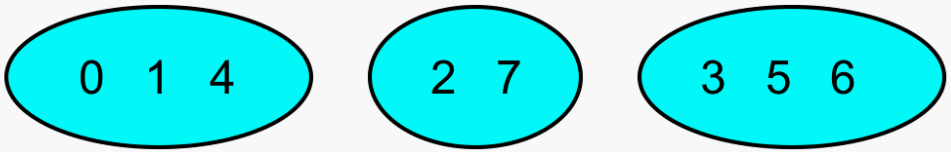
- Maintains a collection S = $\{s_0, s_1, \ldots s_k\}$ of disjoint sets.
- Each set has a representative member.
- Supports functions:

```
void MakeSet(const T & k);

void Union(const T & k1, const T & k2);

T & Find(const T & k);
```

A first data structure for Disjoint Sets:



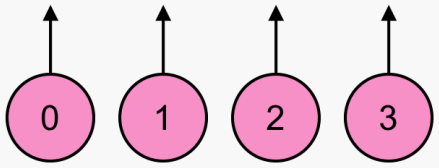
0	1	2	3	4	5	6	7
A	A	B	C	A	C	C	B

Find:

Union:

A better data structure for Disjoint Sets: UpTrees

- if array value is -1, then we've found a root, o/w value is index of parent.
- x and y are in the same tree iff they are in the same set.



0	1	2	3
-1	-1	-1	-1

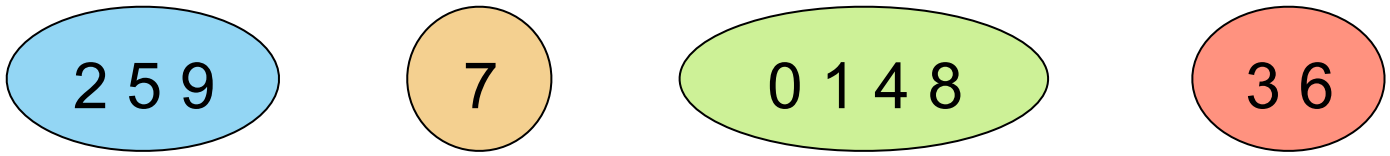
0	1	2	3

0	1	2	3

0	1	2	3

A Disjoint Sets example:

Let *R* be an equivalence relation on the set of students in this room, where *(s,t)* ∈ *R* if *s* and *t* have the same favorite among {AB, FN, DJ, ZH, PvZ}.



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

1. Find(4)
2. Find(4)==Find(8)
3. If (!(Find(7)==Find(2)) then Union(Find(7),Find(2))

A better data structure for Disjoint Sets:

```
int DS::Find(int i) {
   if (s[i] < 0) return i;
   else return Find(s[i]);
}
```

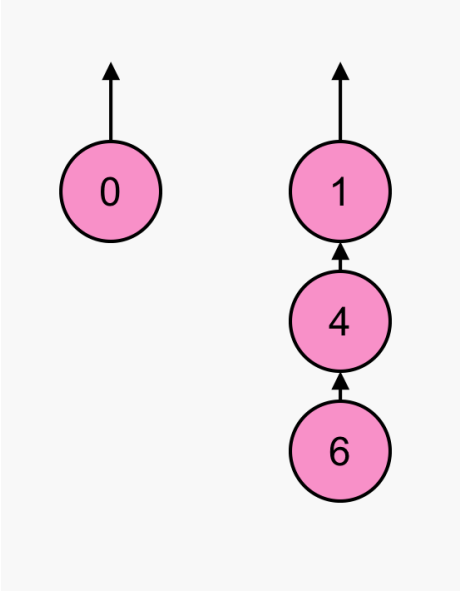
Running time depends on _____.

Worst case?

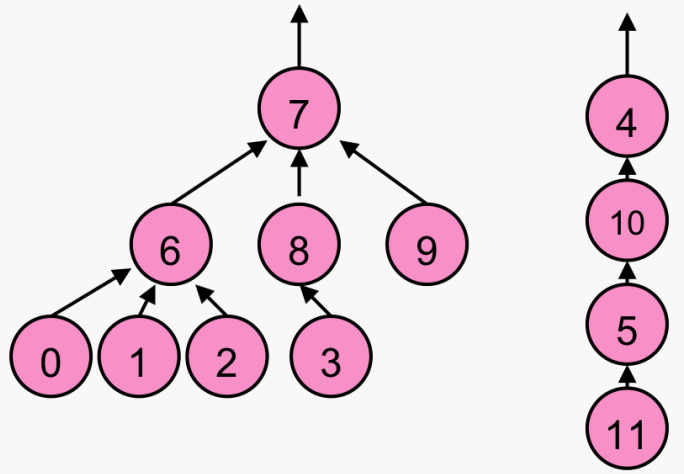
What's an ideal tree?

```
void DS::Union(int root1, int root2) {
   _____________________________;
}
```

something to consider…



Smart unions:



Union by height:

0	1	2	3	4	5	6	7	8	9	10	11
6	6	6	8		10	7		7	7	4	5

Keeps overall height of tree as small as possible.

Union by size:

0	1	2	3	4	5	6	7	8	9	10	11
6	6	6	8		10	7		7	7	4	5

Increases distance to root for fewest nodes.

Both of these schemes for Union guarantee the height of the tree is _____.

Smart unions:

```
int DS::Find(int i) {
   if (s[i] < 0) return i;
   else return Find(s[i]);
}
```

```
void DS::UnionBySize(int root1, int root2) {
   int newSize = s[root1]+s[root2];
   if (isBigger(root1,root2)) {
      s[root2]= root1;
      s[root1]= newSize;
   }
   else {
      s[root1] = root2;
      s[root2]= newSize;
   }
}
```