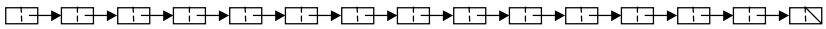
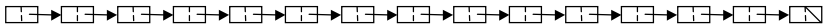


CSE 373: Trees

Chapter 4

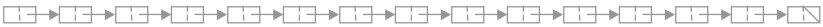


Summary of Last Week

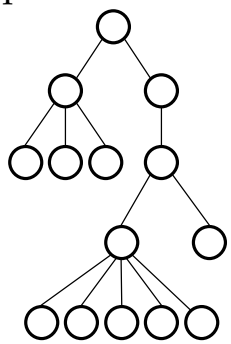
Lists, Stacks, and Queues…

- are composed of elements in a *sequential* order
  - Lists – arbitrary order
  - Stacks – LIFO
  - Queues – FIFO
- implementations are usually array- or link-based
- operations add, remove, find elements
- usually, searching for a specific element is O(n)
  - counterexample?

Trees



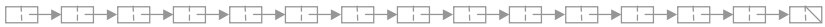
Trees allow the expression of non-sequential relationships



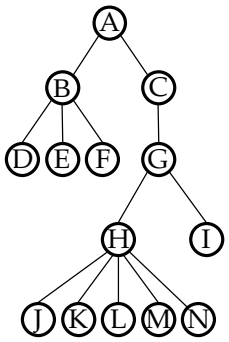
Real-life Instances of Trees

- Family trees
- Organization Charts
- Classification trees
  - what kind of flower is this?
  - what's wrong with my car?
- File directory structure
  - folders, subfolders in Windows
  - directories, subdirectories in UNIX
- Procedure call chains

Tree Terminology



root:
leaf:
child:
parent:
sibling:
grandparent
grandchild:
ancestor:
descendent:



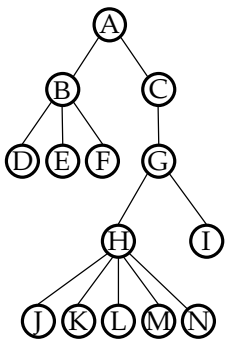
More Tree Terminology

path:

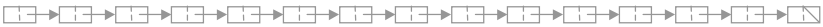
depth:

height:

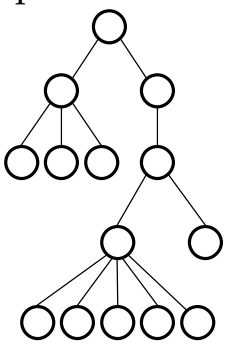
degree:



Implementation of Trees



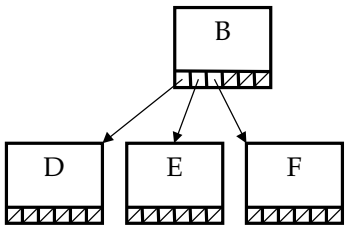
- Trees can't be implemented with lists (easily)
- Why not?



Naive Tree Implementation

If we can bound the degree of a tree's nodes, it has a simple implementation:

```
typedef struct _TreeNode {
  NodeType data;
  struct _TreeNode *child[MAX_DEGREE];
} TreeNode;
```

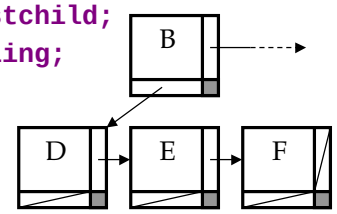


General Tree Implementation

Since a tree can have any number of children…

- Parent links to first child
- Siblings link to one another

```
typedef struct _TreeNode {
  NodeType data;
  struct _TreeNode *firstchild;
  struct _TreeNode *sibling;
} TreeNode;
```

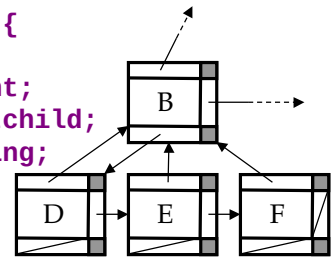


Design Decision: Parent Pointer

For most operations, only pointers to children are needed

Some implementations may also store a pointer to a node's parent:

```
typedef struct _TreeNode {
  NodeType data;
  struct _TreeNode *parent;
  struct _TreeNode *firstchild;
  struct _TreeNode *sibling;
} TreeNode;
```



Tree Operations

- Not a well-defined ADT…
- Possible Operations
  - Tree operations:

```
TreeNode *Root(Tree);
TreeNode *Find(Tree,NodeType);
```

  - Node operations:

```
void AddChild(TreeNode *,NodeType);
int NumChildren(TreeNode *);
TreeNode *GetKthChild(TreeNode *);
void DeleteKthChild(TreeNode *,int);
```

  - Also traversal operations…

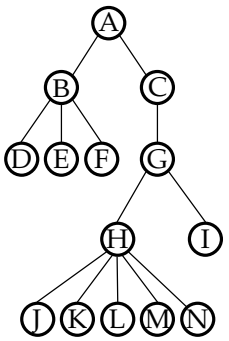
Well-defined Traversals

pre-order:

1) process node
2) process children

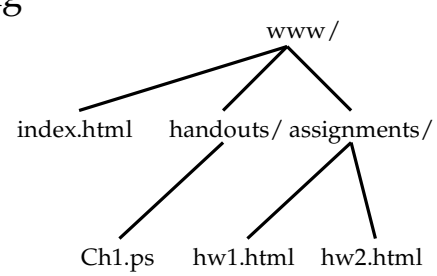
post-order:

1) process children
2) process node



Traversal Applications

- Print Directory Listing



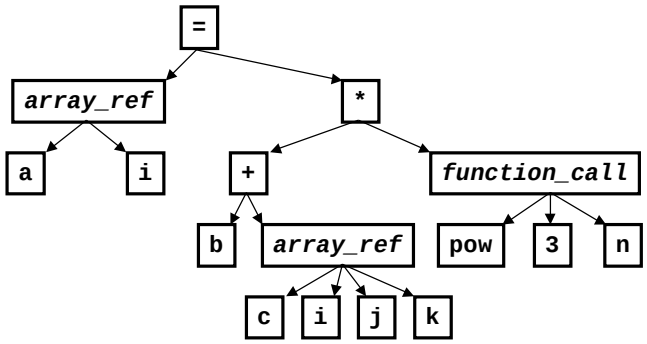
- Print Disk Usage

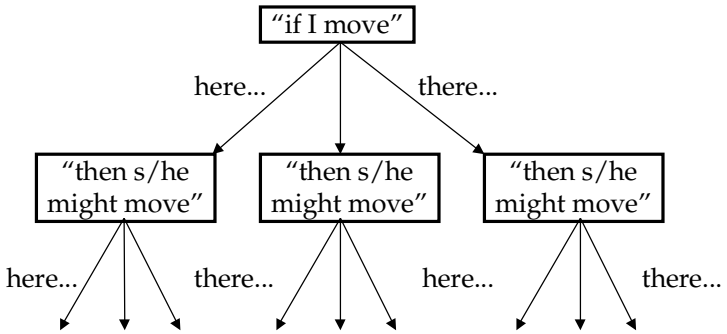
Tree Applications

- Storing data for the "real life applications"
- **CAD/drawing:** Storing hierarchies of objects
  (a wheel is made of a tire and spokes; a car is made…)
- **graphics:** Storing a scene's geometry/structure
- **languages:** Storing a class hierarchy (*e.g.*, C++)

Application: Storing Expressions


```
a[i] = (b + c[i,j,k]) * pow(3,n);
```



Application: AI programs

Decision Trees: