Introduction to Trees

Lecture 20

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- Tree Ordering
- Trees and Recursion
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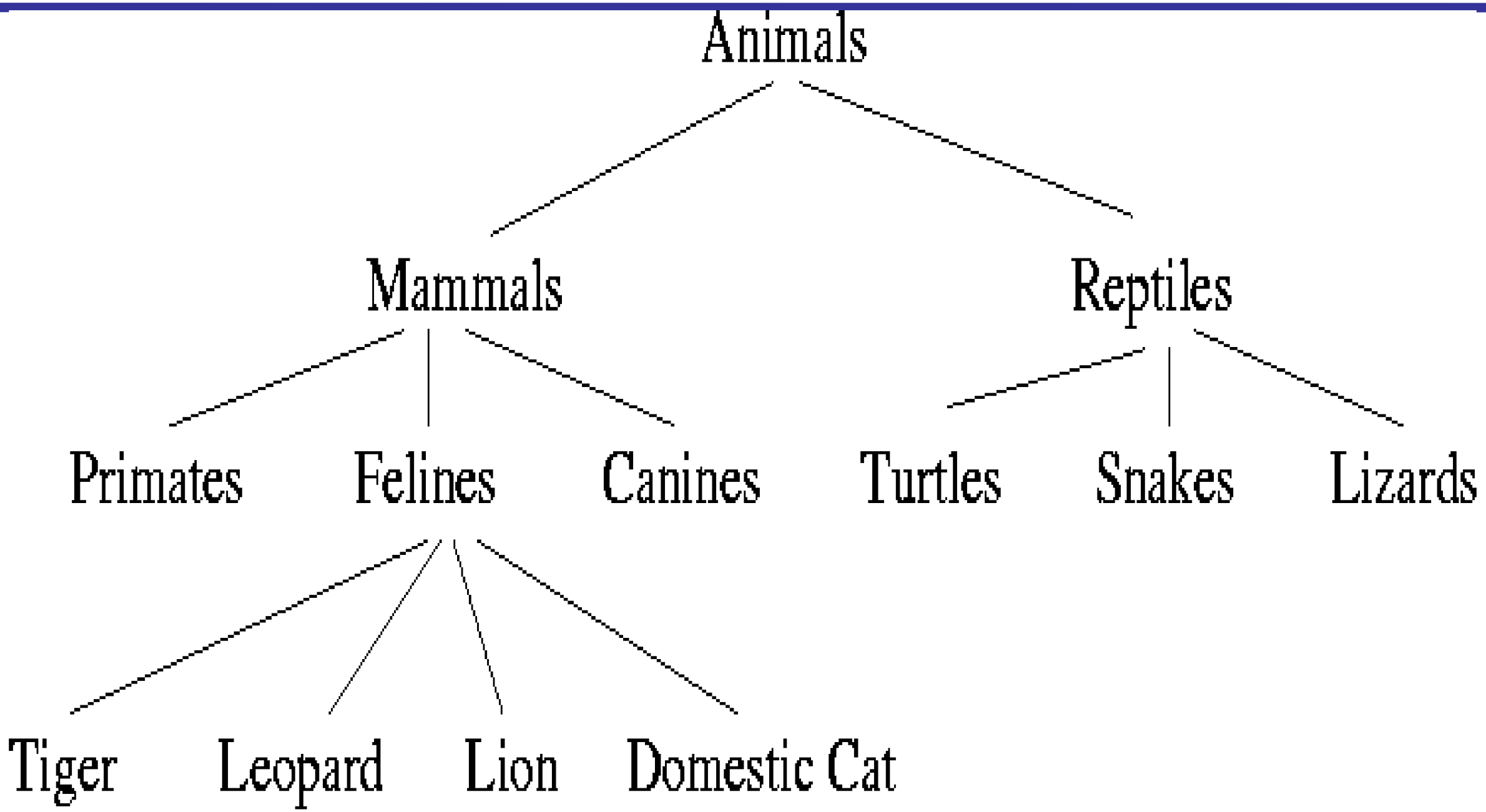
  - Chess
  - Taxonomy Tree
  - Decision Tree

Trees

- Some data are not linear (it has more structure!)
  - Family trees
  - Organisational charts
  - …
- Linear implementations are sometimes inefficient
  - Linked lists don’t store such structure information
- Trees offer an alternative
  - Representation
  - Implementation strategy
  - Set of algorithms

Example: Taxonomy Tree

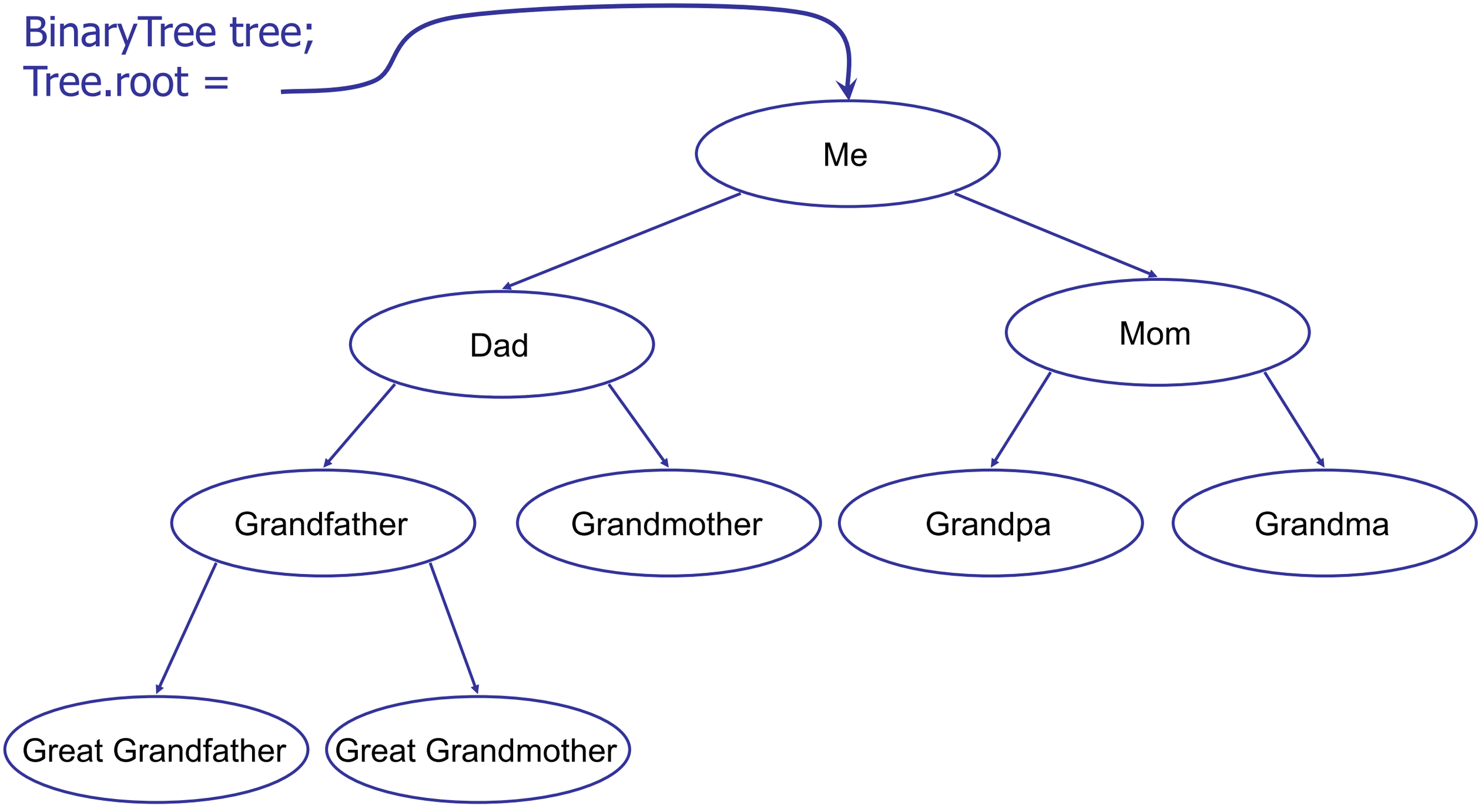


Trees

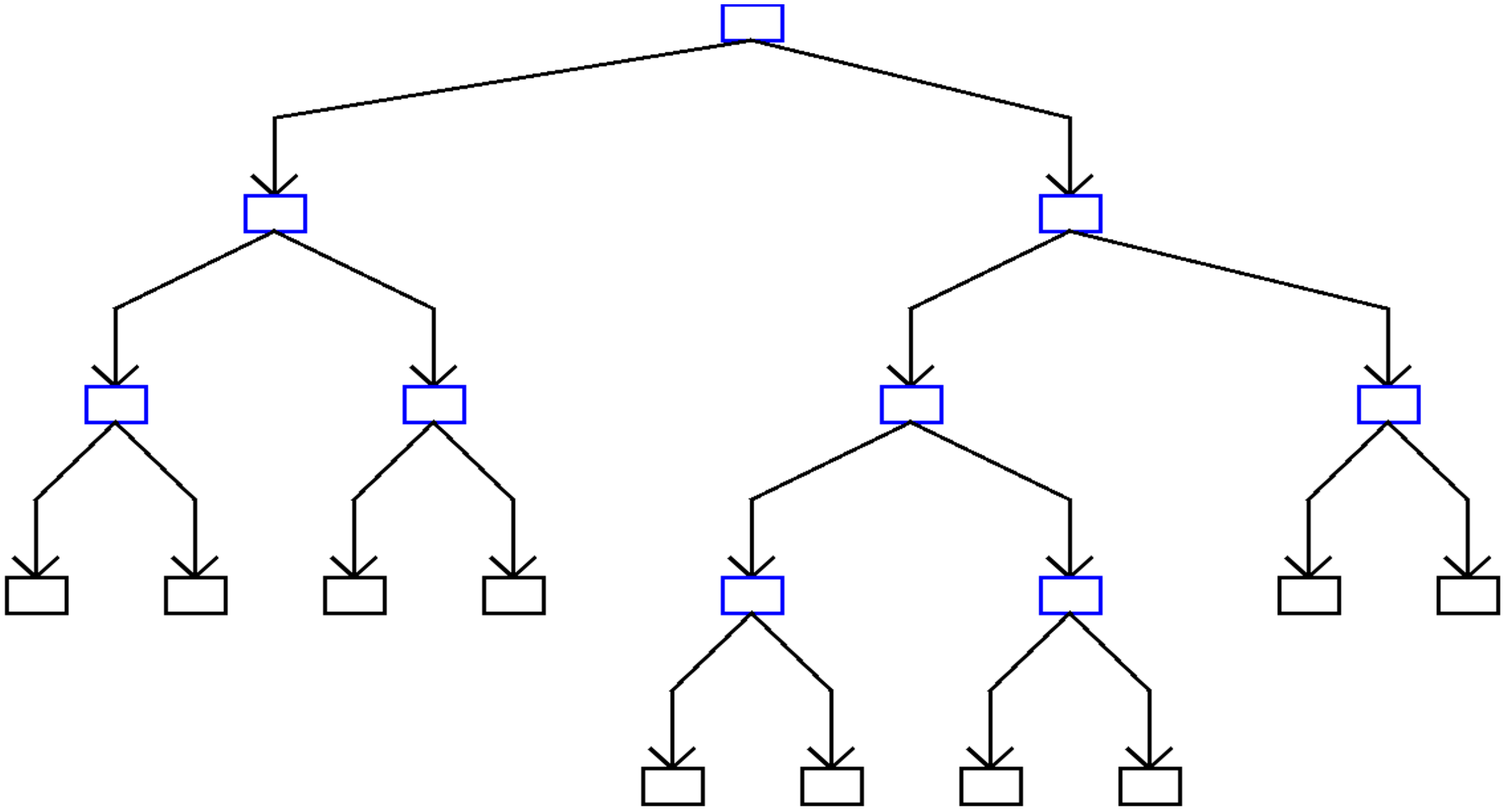
- linear data structures: lists, stacks, queues
- non-linear data structures: trees

Binary Tree

BinaryTree tree;
Tree.root =



Binary Tree

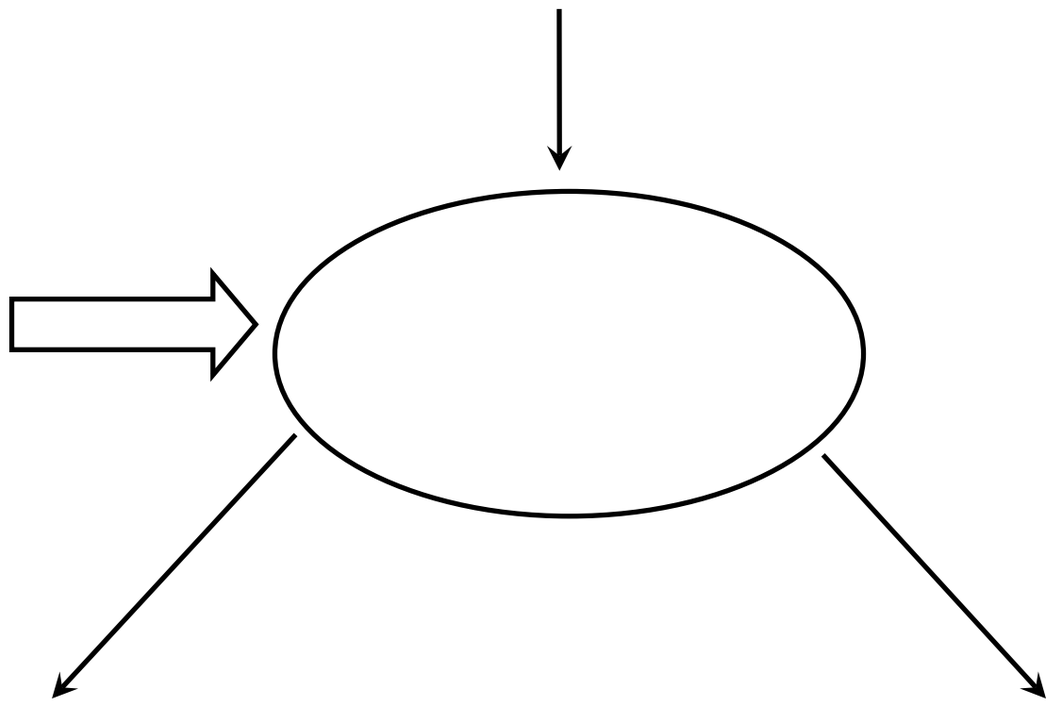


Size is limited by the depth of the tree.

Binary Tree

- Every node in the tree has a left child (or null)
- Every node in the tree has a right child (or null)
- The root of the tree is just another node

This is what you
Make a class for:



Binary tree

- A binary tree is either:
  - –empty or
  - –a root node together with two binary trees - left subtree & right subtree of the root

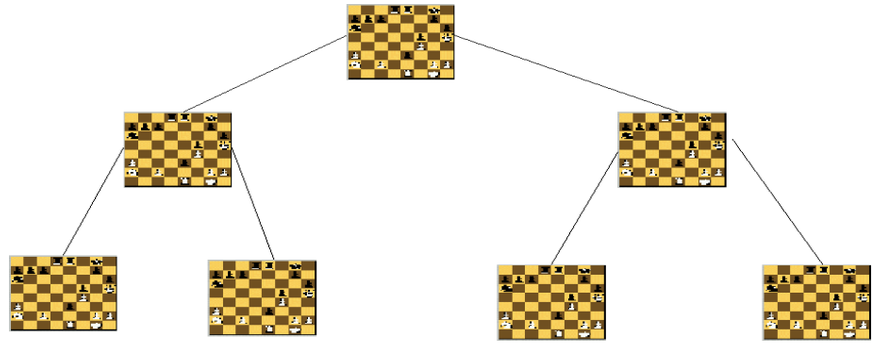
What is a tree exactly?

- Models the parent/child relationship between different elements
  - –Each child only has one parent
  - –Each parent has ? children
- From mathematics:
  - –A “directed acyclic graph” (DAG)
  - –At most one path from any one node to any other node
- Different kinds of trees exist
- Trees can be used for different purposes

- In what order do we visit elements in a tree?

Terminology

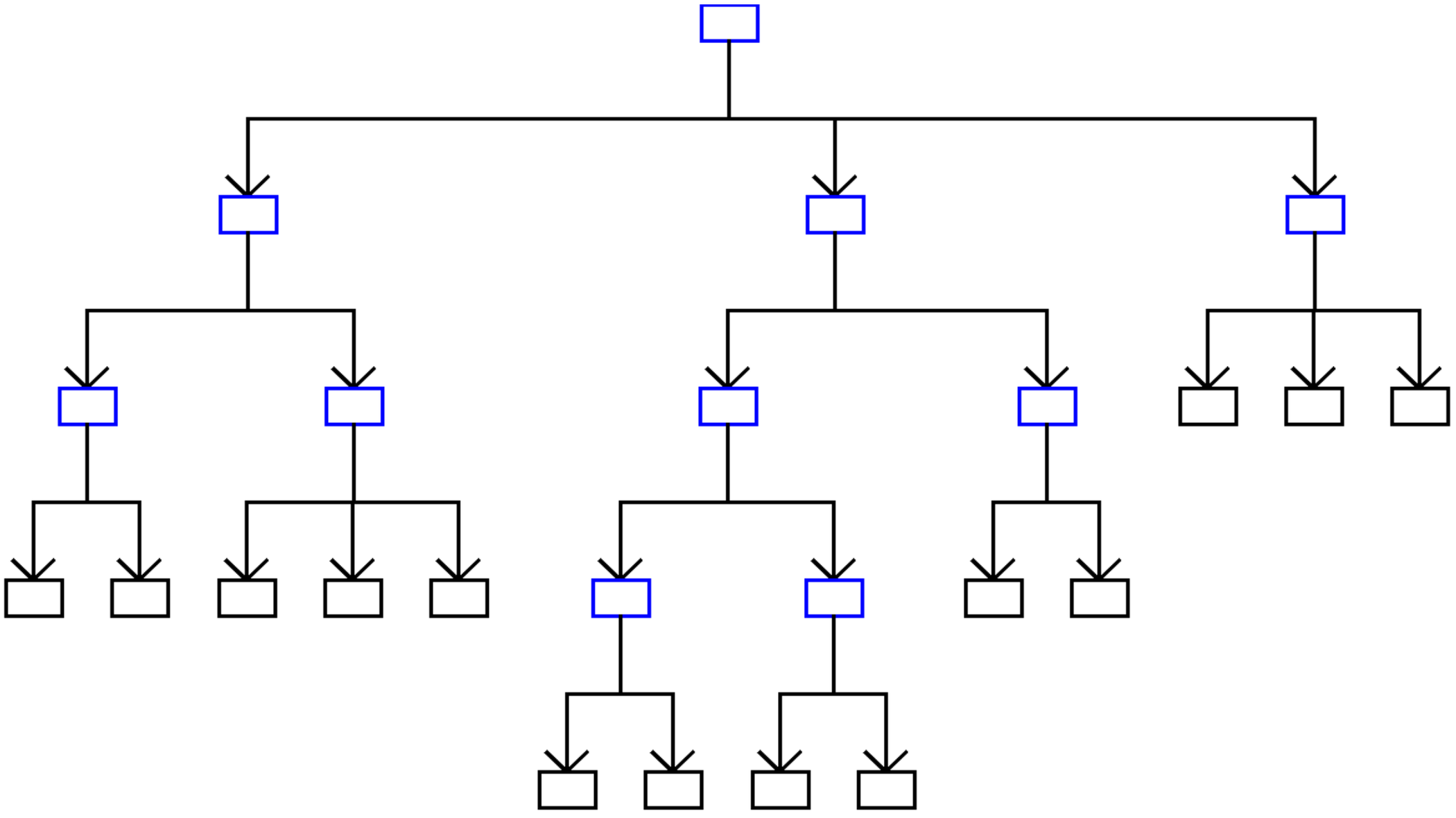
- Level:
  - –Equivalent to the “row” that a value is in
- Depth:
  - –The number of levels in the tree
- Leaf Nodes
  - –A node with no children
- Non-leaf Nodes
- Balanced:
  - –All leaf nodes are on levels n and (n+1), for some value of n (*and are grouped on the bottom level “to the left”*)



How many types of tree are there?

- Far too many:
  - –Red-Black Tree
  - –AVL Tree
  - –…
- Different types are used for different things
  - –To improve speed
  - –To improve the use of available memory
  - –To suit particular problems
- But we'll look at three:
  - –Binary Tree
  - –General Tree (n-ary tree)
  - –AVL Tree

General Trees



Question: Why is this *not* a Binary Tree?

Design Issue - Ordering of Values

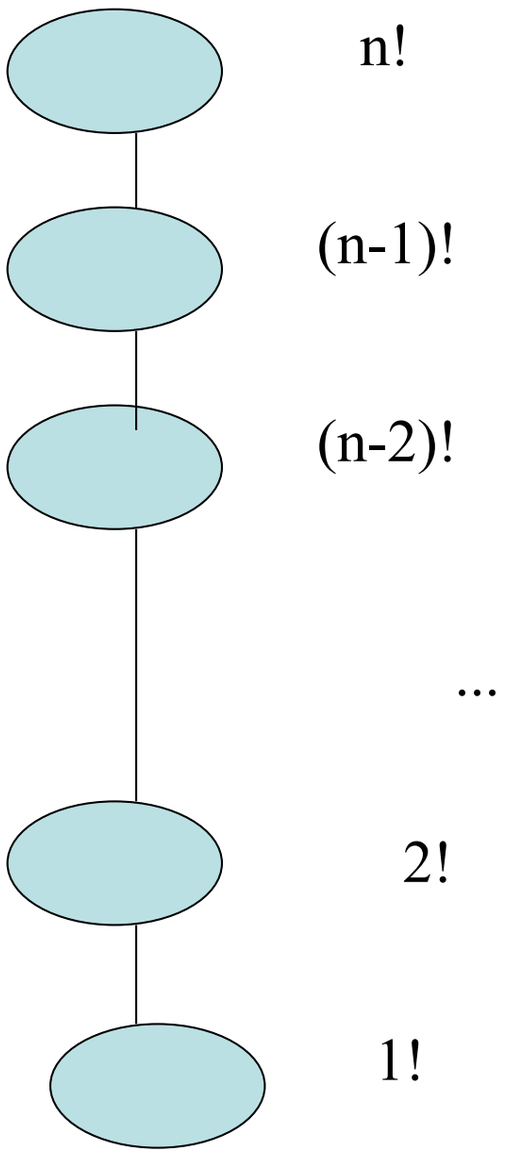
- Do the children of a parent have a particular order?
  - Does it matter which is the “first”, “second”, or “third” child?
  - Is there an inherent ordering there?

- Are the values of the children comparable with the values of the parent?

Trees and Recursion

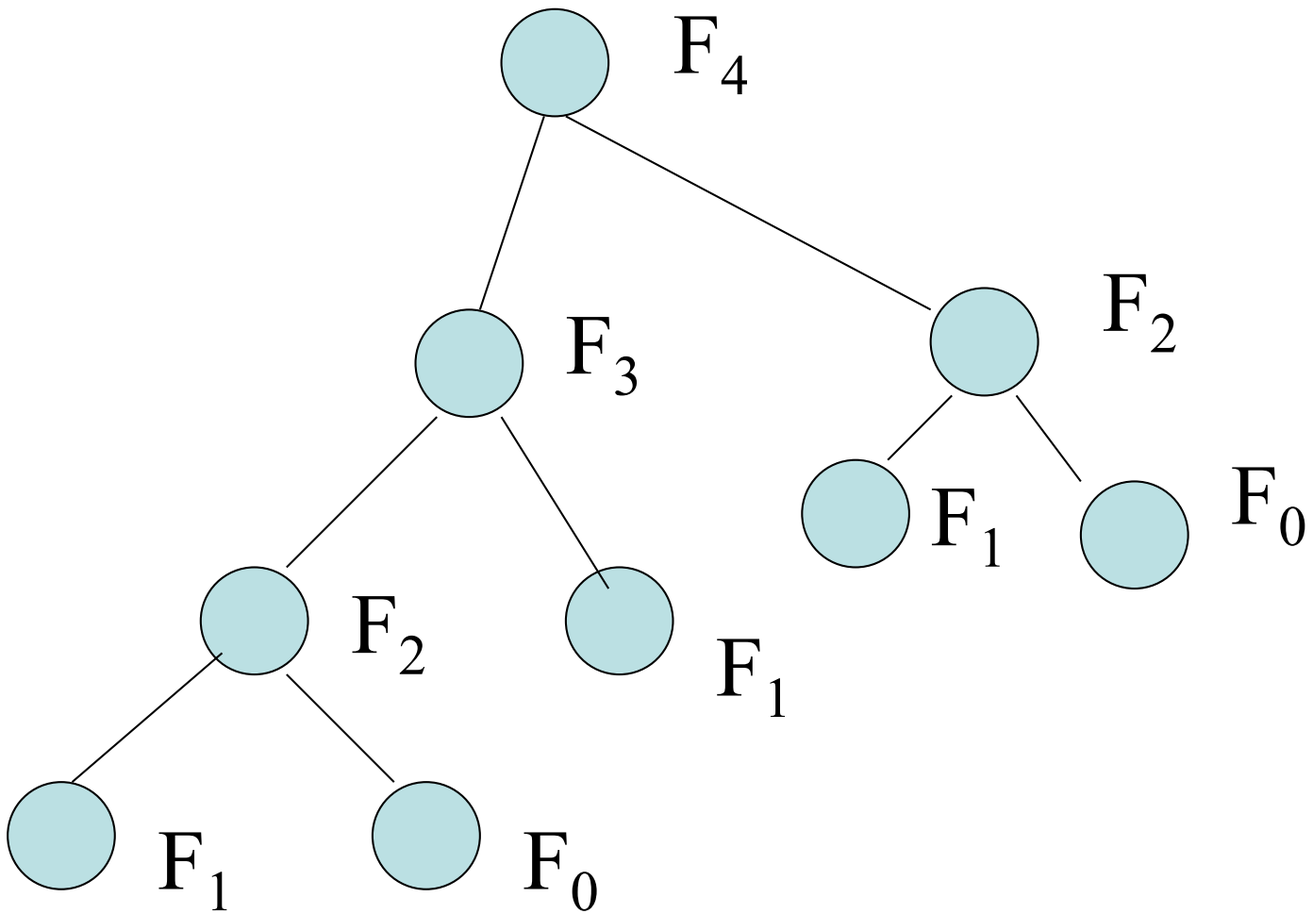
- Recursively defined data structure
- Recursion is very natural for trees – important!
- Recursion tree
- If you don’t use recursion then use iteration

Recursion tree for n!



recursion tree for n!

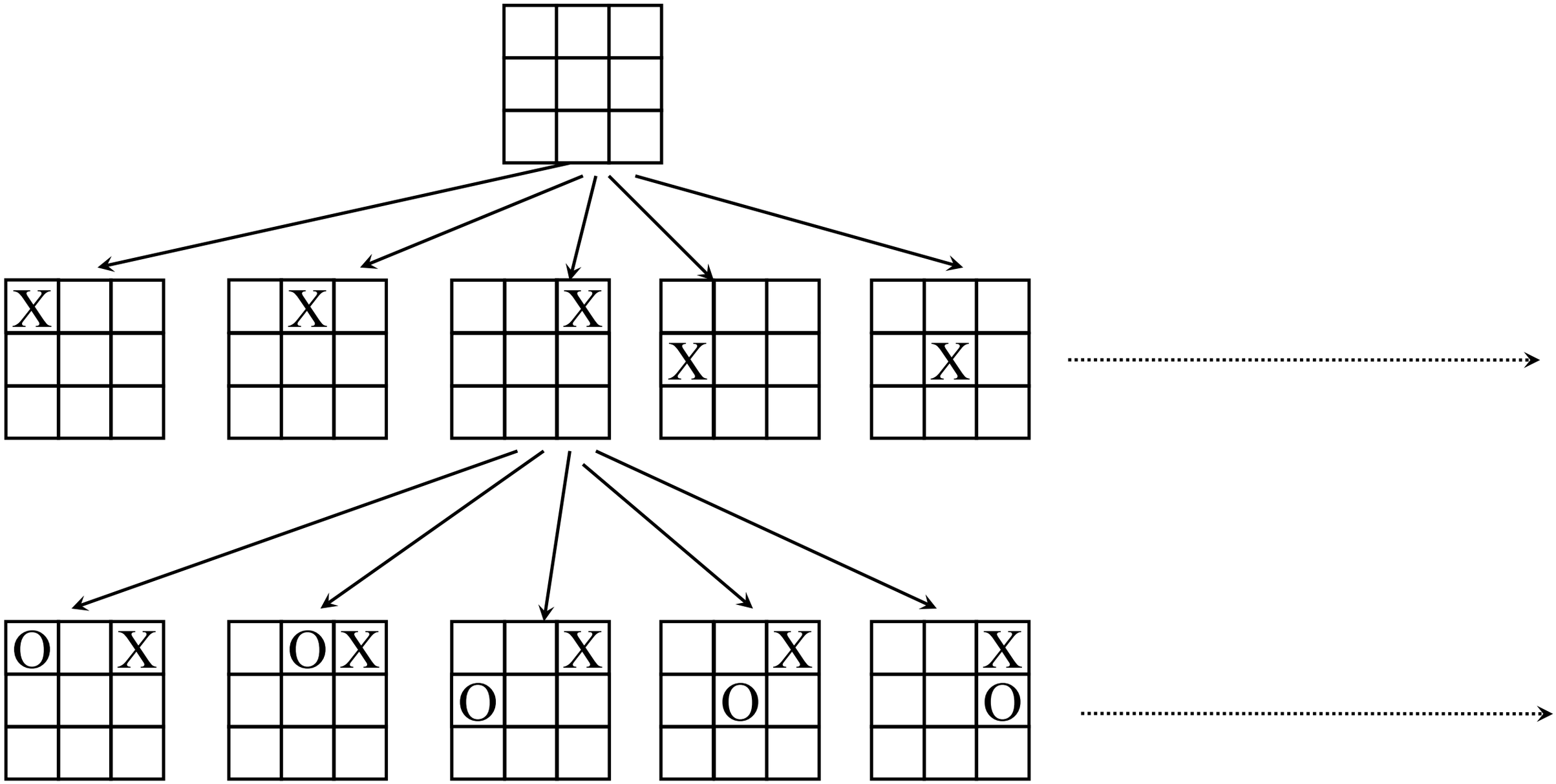
Recursion tree for fibonacci(4)



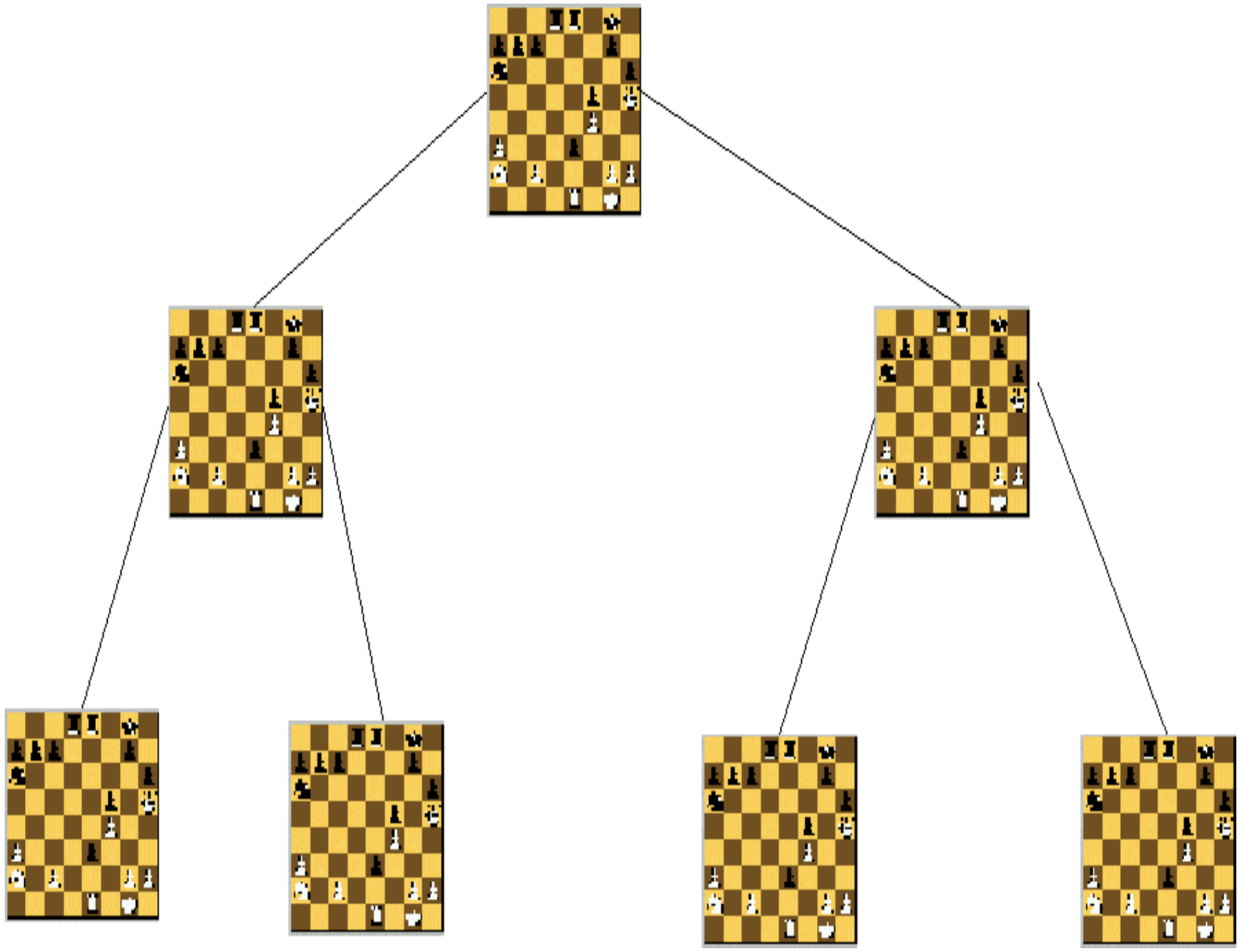
What is a tree useful for?

- Artificial Intelligence – planning, navigating, games
- Representing things:
  - –Simple file systems
  - –Class inheritance and composition
  - –Classification, e.g. taxonomy (the is-a relationship)
  - –HTML pages
  - –Parse trees for languages
  - –Essential in compilers like Java, C# etc.
  - –3D graphics (e.g. BSP trees)

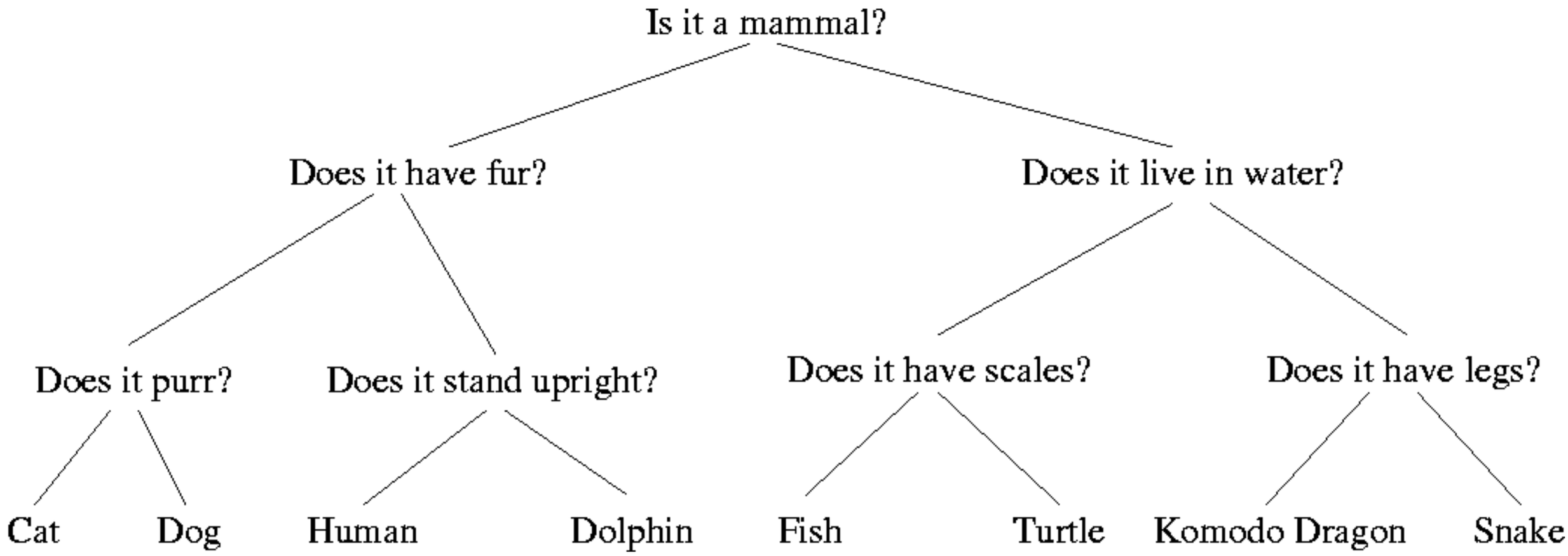
Example: Tic Tac Toe



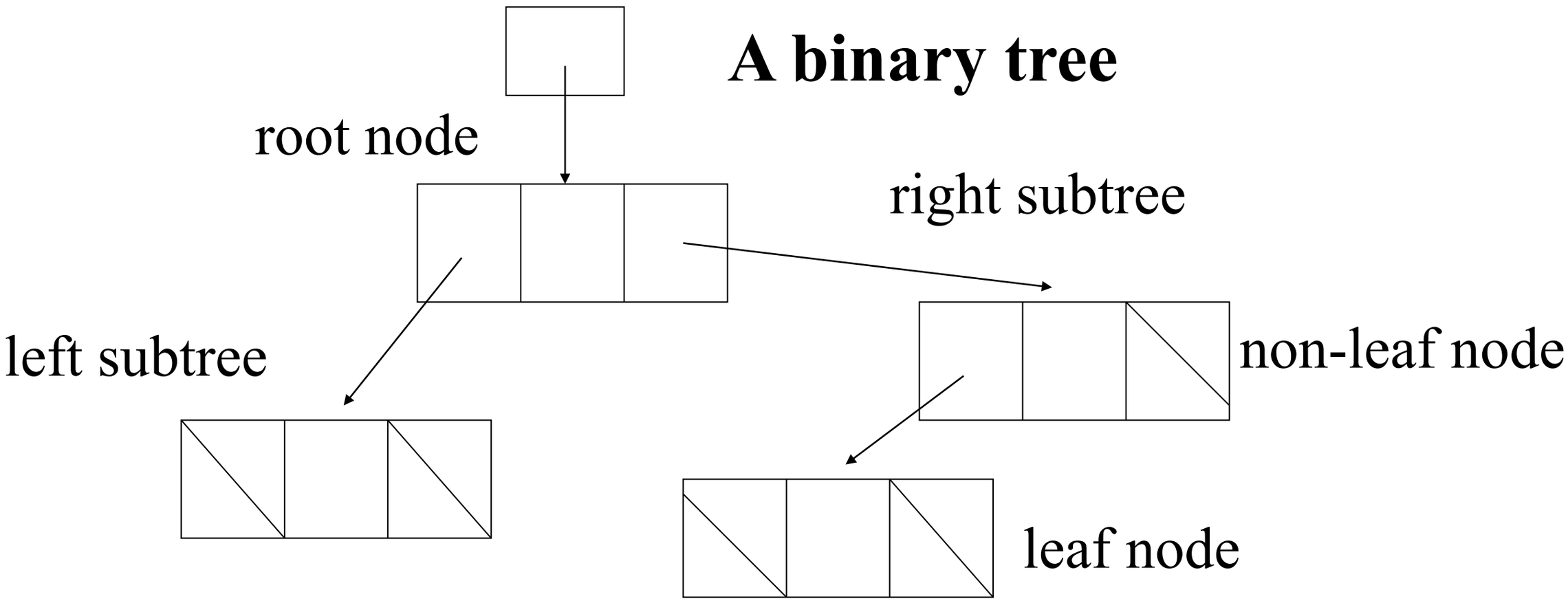
Example: Chess



Example: Decision Tree



Binary tree implementation



In brief

- Data representation of tree is important
- Efficiently adding, accessing and removing data from a tree is important
- Trees can be made efficient and help you organise data
- Trees are useful in:
  - Computer graphics
  - Artificial Intelligence
  - Databases
  - …

Q&A

- Tree represents an efficient 1-dimensional data structure. (T or F?)
- A leaf node in a tree has no children. (T or F?)
- Binary tree has no ordering upon its sibling nodes. (T or F?)
- Name 3 applications for tree.
- Relationship among recursive calls can be expressed in what type of tree?

Summary

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Readings

- [Mar07] Read 4.1, 4.2, 4.6
- [Mar13] Read 4.1, 4.2, 4.6