INT404 ARTIFICIAL INTELLIGENCE

UNINFORMED SEARCH
-BFS
-DFS

Lecture 7

State – space search

State-space search is the process of searching through a state space for a solution by making explicit a sufficient portion of an implicit state-space graph to include a goal node.

–Hence, initially V={S}, where S is the start node;

–when S is expanded, its successors are generated and those nodes are added to V and the associated arcs are added to E.

–This process continues until a goal node is generated (included in V) and identified (by goal test)

States of a Node

During search, a node can be in one of the three categories:

–Not generated yet (has not been made explicit yet)

–**OPEN**: generated but not expanded

–**CLOSED**: expanded

–Search strategies differ mainly on how to select an OPEN node for expansion at each step of search

A General State-Space Search Algorithm


```
open := {S}; closed :={};
repeat
   n := select(open)  /* select one node from open for expansion */
        if n is a goal
            then exit with success;  /* delayed goal testing */
        expand(n)
                /* generate all children of n put these newly generated
        nodes in open (check duplicates) put n in closed (check
        duplicates) */
until open = {};
exit with failure
```

Some Issues

Search process constructs a search tree, where

–**root** is the initial state S, and

–**leaf nodes** are nodes

•not yet been expanded (i.e., they are in OPEN list) or

•having no successors (i.e., they're "dead ends“)

Some Issues

Some important issue that arises

- The direction in which conduct the search(forward vs. backward reasoning)
- How to select applicable rules(matching).
- How to represent each node of search process(the knowledge representation problem)
- Search tree vs. search graph

Evaluating Search Strategies

- **Completeness**
  - Guarantees finding a solution whenever one exists
- **Time Complexity**
  - How long (worst or average case) does it take to find a solution? Usually measured in terms of the **number of nodes expanded**
- **Space Complexity**
  - How much space is used by the algorithm? Usually measured in terms of the **maximum size that the "OPEN" list** becomes during the search
- **Optimality/Admissibility**
  - If a solution is found, is it guaranteed to be an optimal one? For example, is it the one with minimum cost?

Algorithm : Breadth-First Search

1. Create a variable called *NODE-LIST* and set it to the initial state.

2. Until a goal state is found or *NODE-LIST* is empty:

(a) Remove the first element from *NODE-LIST* and call it *E.* If *NODE-LIST* was empty, quit.

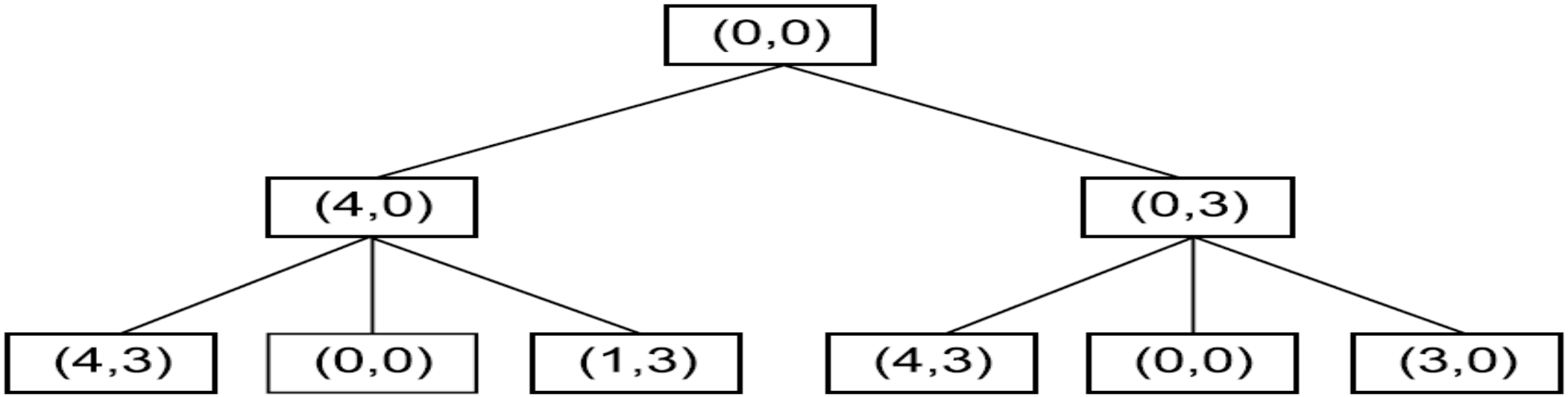
(b) For each way that each rule can match the state described in *E* do:

(i) Apply the rule to generate a new state,

(ii) If the new state is a goal state, quit and return this state.

(iii) Otherwise, add the new state to the end of NODE-LIST.

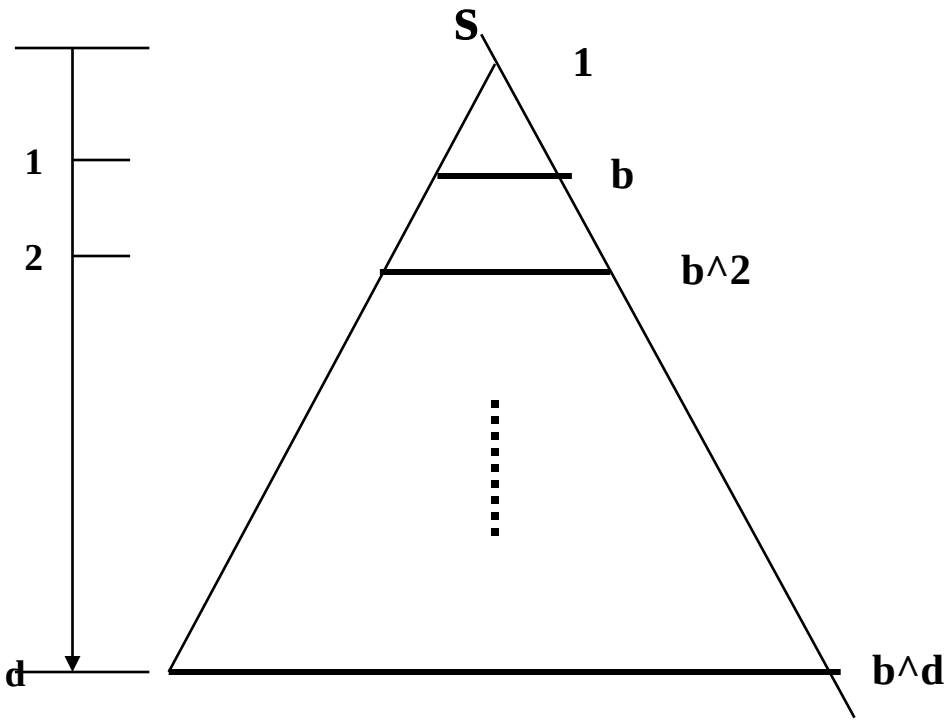
Two Levels of a Breadth-First Search Tree



Breadth-First Search Tree

Breadth-First Complexity

- A complete search tree of depth d where each non-leaf node has b children, has a total of 1 + b + b^2 + ... + b^d = (b^(d+1) - 1)/(b-1) nodes
- Time complexity (# of nodes generated): O(b^d)
- Space complexity (maximum length of OPEN): O(b^d)



– BFS is suitable for problems with shallow solutions

Algorithm : Depth-First Search

1. If the initial state is a goal state, quit and return success.

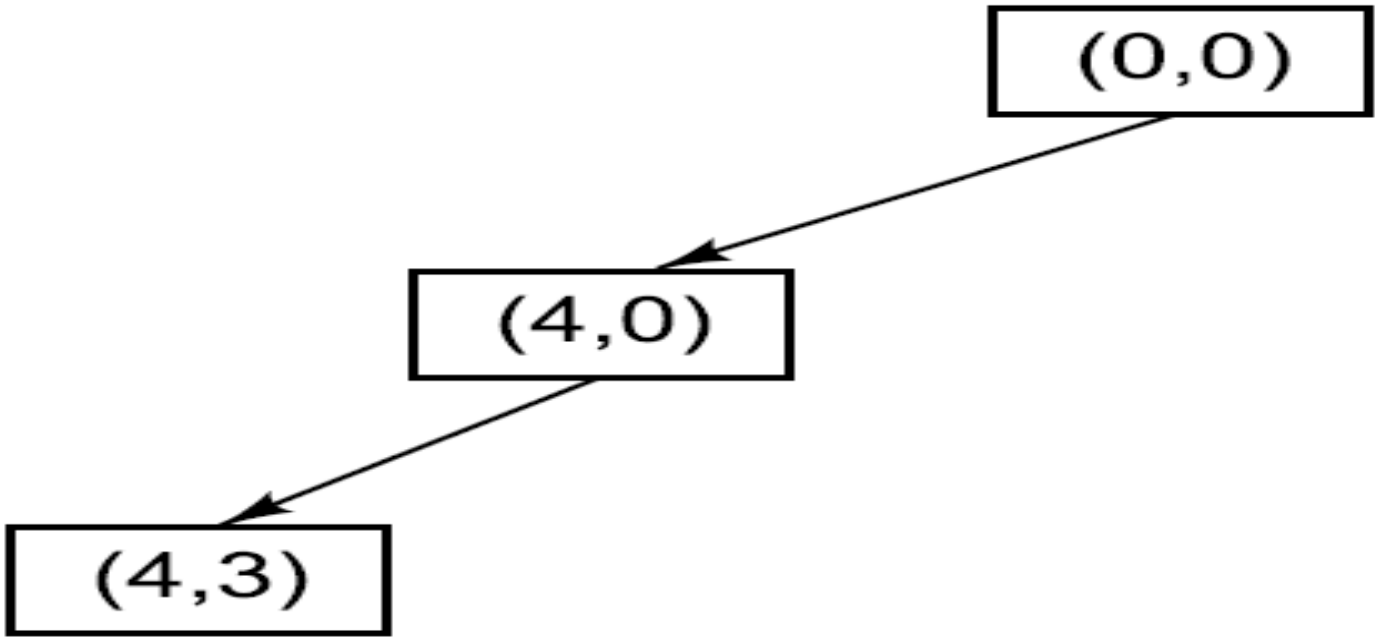
2. Otherwise, do the following until success or failure is signaled:

(a) Generate a successor, *E,* of the initial state. If there are no more successors, signal failure.

(b) Call Depth-First Search with *E* as the initial state.

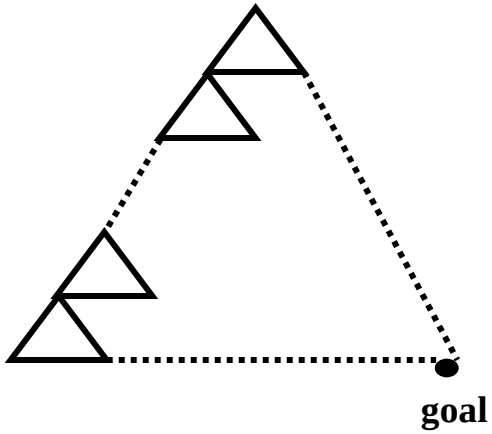
(c) If success is returned, signal success. Otherwise continue in this loop.

A Depth-First Search Tree



A Depth-First Search Tree

Depth-First (DFS)



Algorithm outline:

- Always select from the OPEN the node with the greatest depth for expansion, and put all newly generated nodes into OPEN
- OPEN is organized as **LIFO** (last-in, first-out) list.
- Terminate if a node selected for expansion is a goal

Depth-First (DFS)

- **May not terminate** without a "depth bound," i.e., cutting off search below a fixed depth D (How to determine the depth bound?)
- **Not complete** (with or without cycle detection, and with or without a cutoff depth)
- **Exponential time**, O(b^d), but only **linear space**, O(bd), required
- Can find **deep solutions quickly** if lucky
- When search hits a deadend, can only back up one level at a time even if the "problem" occurs because of a bad operator choice near the top of the tree. Hence, only does "chronological backtracking"