Uninformed Search Strategies

CPSC 322 – Search 2

January 14, 2011

Textbook §3.5

Discussion of feedback

- Printed lecture slides

  30+, 2- (“waste of paper”)

  – Example for decision theory:
    - Utility = - (#sheets of paper used), want to maximize utility
    - Action A = “I print lecture notes”
    - Action B = “Student prints lecture notes at home”
    - Variable D = “Student has double-sided printer at home”, P(D) ≈ 0.4
    - U(A) = -3
    - U(B) = -3*P(D) + (-6)*P(not D) ≈ -0.4*(-3) + 0.6*(-6) = -4.8

  – Conclusion: A is much better than B
    - Only counting students who would o/w print themselves
    - But most others would otherwise print when studying for midterm/exam …

Discussion of feedback

- Examples: unanimous good

  25+, 10- “more examples”, 3- “more real-world examples”

- Videos: unanimous good

  Please send me any cool videos you find during the course

- Coloured cards: unanimous helpful

  23+, 3- “even more, please”

  2- “most of us have clickers”, 3+ “thanks for NOT using clickers”

Discussion of feedback

- Most negative point: definitions sometimes unclear (6-)
  - In the intro I was sometimes vague
    - Some concepts weren't too clear-cut
    - Trying to categorize AI research is not math
  - Starting with the search module, I hope definitions get more crisp
    - First crisp definitions, then examples …
- Similarly: "missing math and algorithmic parts" (3-)
  - Those should be coming up
- Pace:
  - 5: "too slow", 8: "good", 0: "too fast"
  - I'll speed up a tiny bit (should naturally happen after intro is over)
- Speaking: 1 "too slow", 1 "too fast", I'll keep it as is

Discussion of feedback

- Which concepts are the important ones?
  - First 3 lectures only to frame & organize rest of course
  - Last lecture was important (all search algos depend on it)
  - Learning goals cover the most important parts
- Extra slide with answer to m/c question:
  - Sorry, defies the purpose a bit
- Expectations & hints how the midterm will look like
  - I put a sample midterm in WebCT (just to see the type of questions)
  - Again, see learning goals
- “Watch for hands more” (1-)
  - Help me out if I’m blind, I really encourage questions!
- Powerpoint slides incompatible “.pptx”: now .ppt

Today's Lecture

- Lecture 4 Recap
- Uninformed search + criteria to compare search algorithms
  - Depth first
  - Breadth first

Recap

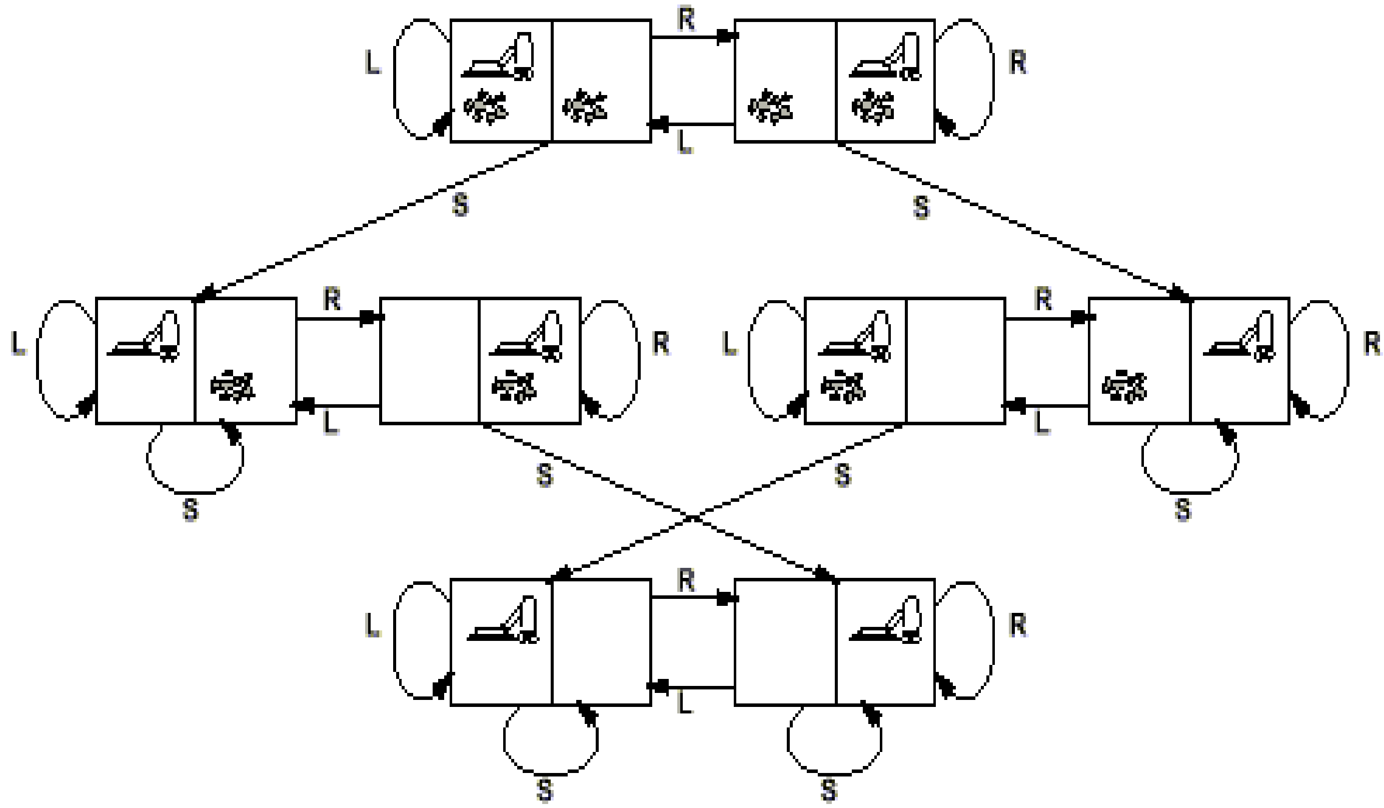
- Search is a key computational mechanism in many AI agents
- We will study the basic principles of search on the simple deterministic goal-driven search agent model

- Generic search approach:
  - Define a search space graph
  - Initialize the frontier with an empty path
  - incrementally expand frontier until goal state is reached

- Frontier:
  - The set of paths which could be explored next

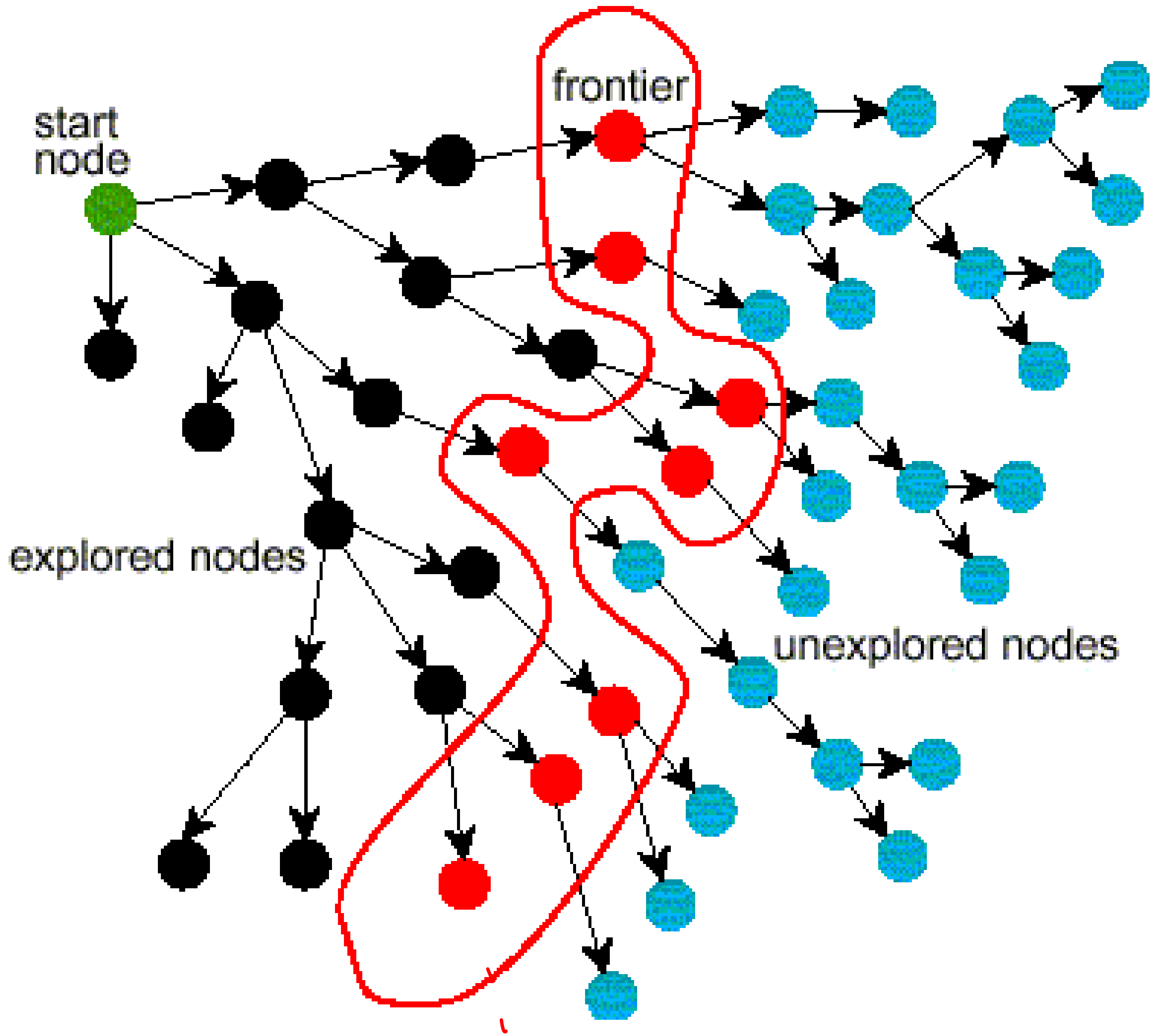
- The way in which the frontier is expanded defines the search strategy

Search Space Graph: example



- **Operators** –*left*, *right*, *suck*
  - Successor states in the graph describe the effect of each action applied to a given state
- **Possible Goal** – no dirt

Problem Solving by Graph Searching



Bogus version of Generic Search Algorithm

Input: a graph
a set of start nodes
Boolean procedure goal(n) that tests if n is a goal node
frontier:= [<g>: g is a goal node];
While frontier is not empty:
select and **remove** path $\langle n_o,\ldots,n_k \rangle$ from frontier;
If goal(n_k)
return $\langle n_o,\ldots,n_k \rangle$;
Find a neighbor n of n_k
add <n> to frontier;
end

- There are a couple of bugs in this version here: help me find them!

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- Start at the start node(s)
- Add all neighbours of n_k to the frontier
- Add path(s) to frontier, NOT just the node(s)

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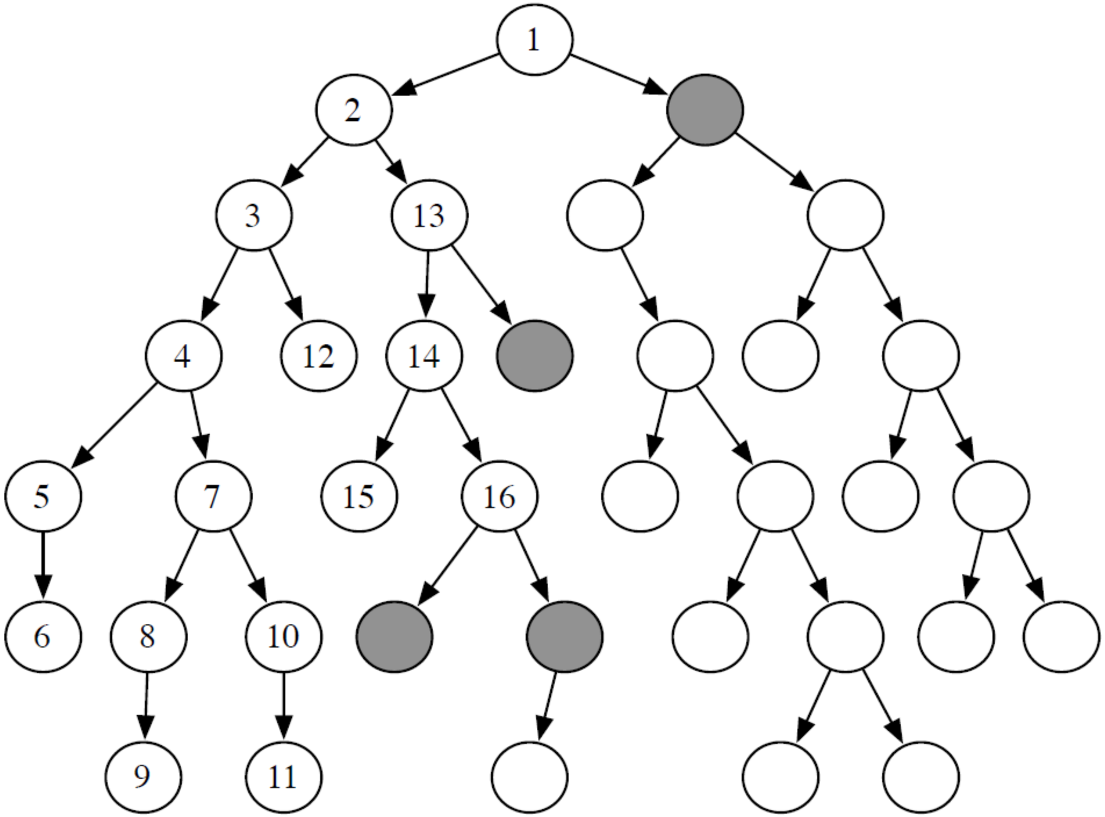
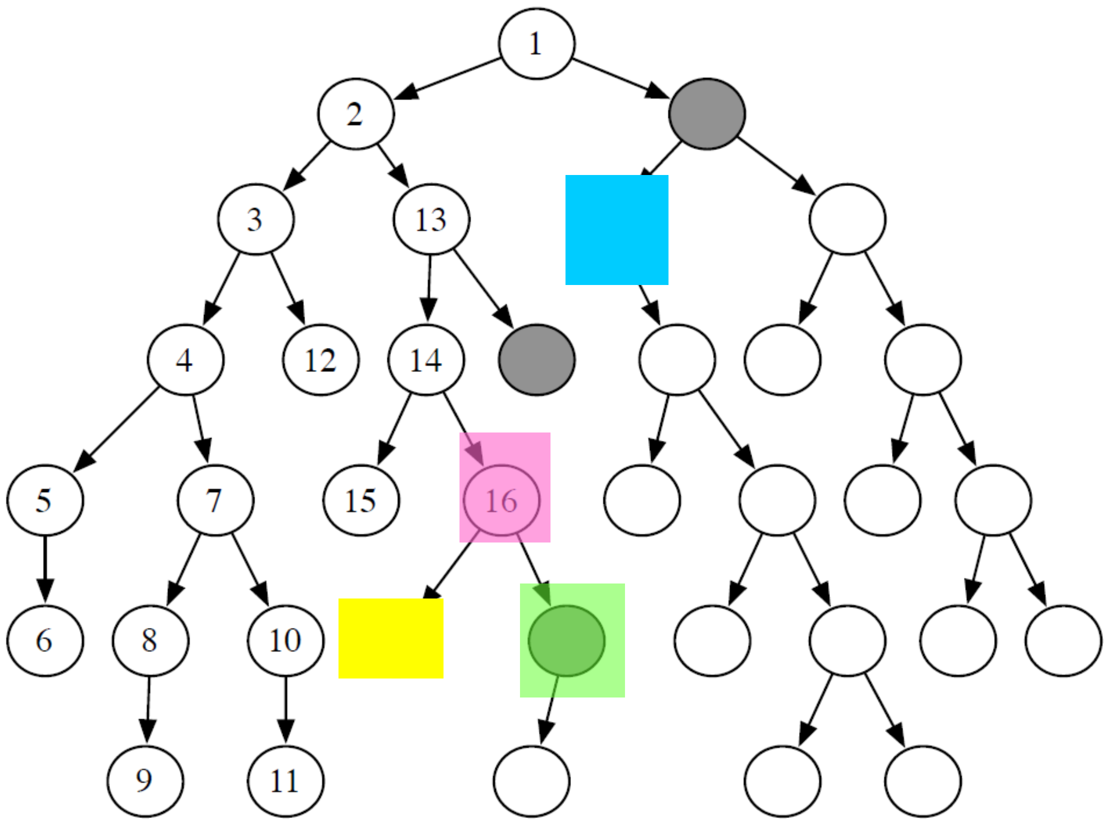
Depth first search (DFS)



- Frontier: shaded nodes

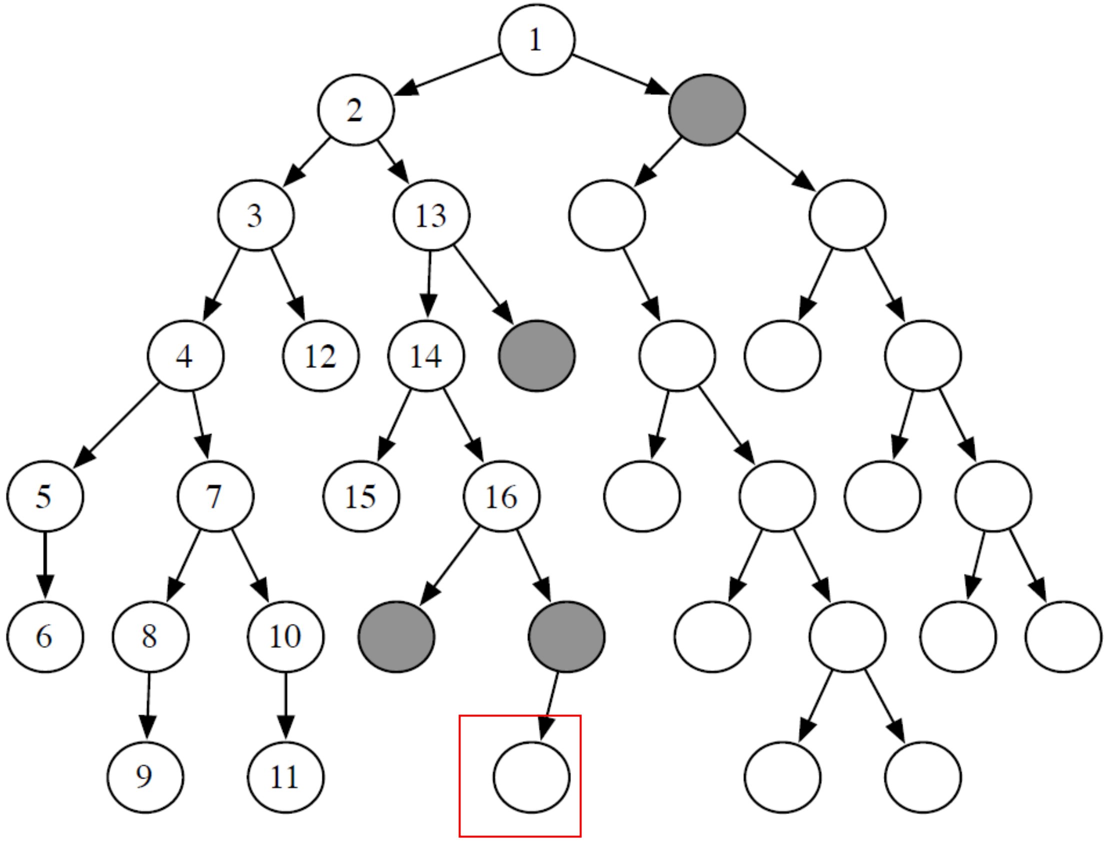
Depth first search (DFS)



- Frontier: shaded nodes
- Which node will be expanded next?

  (expand = "remove node from frontier & put its successors on")

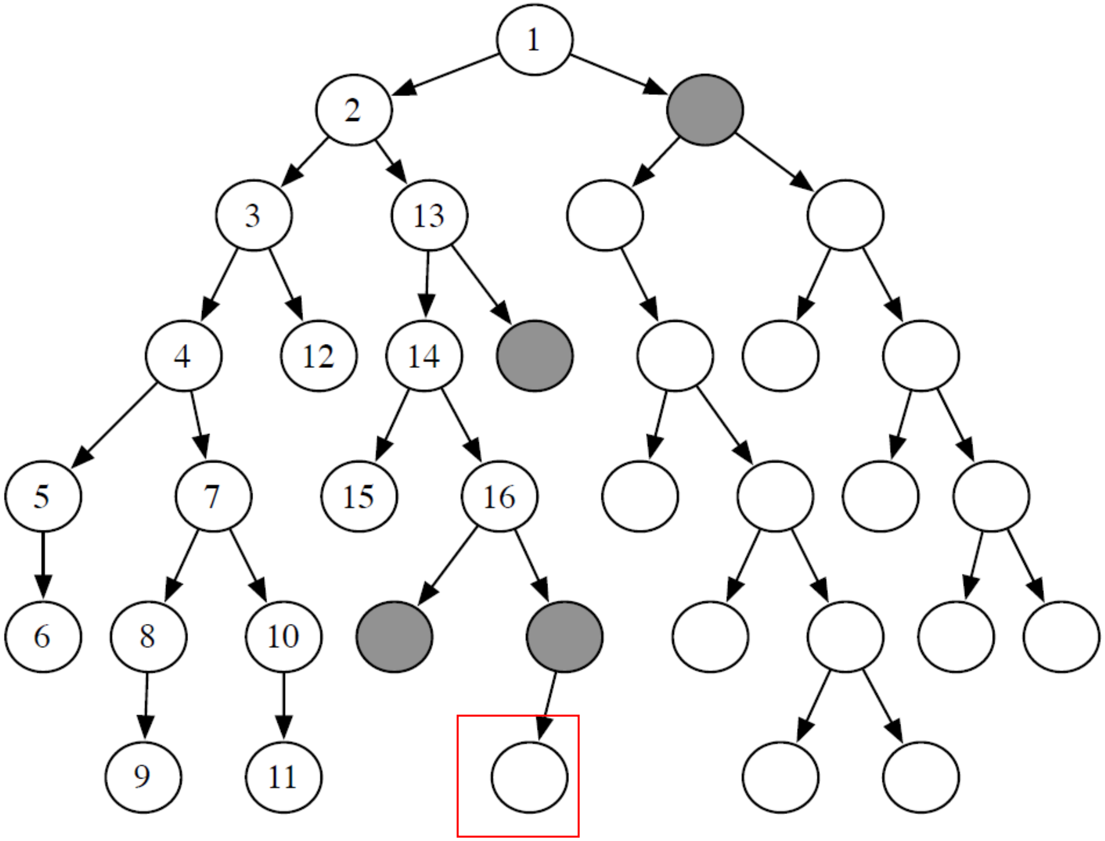
Depth first search (DFS)



- Say, node in red box is a goal
- How many more nodes will be expanded?

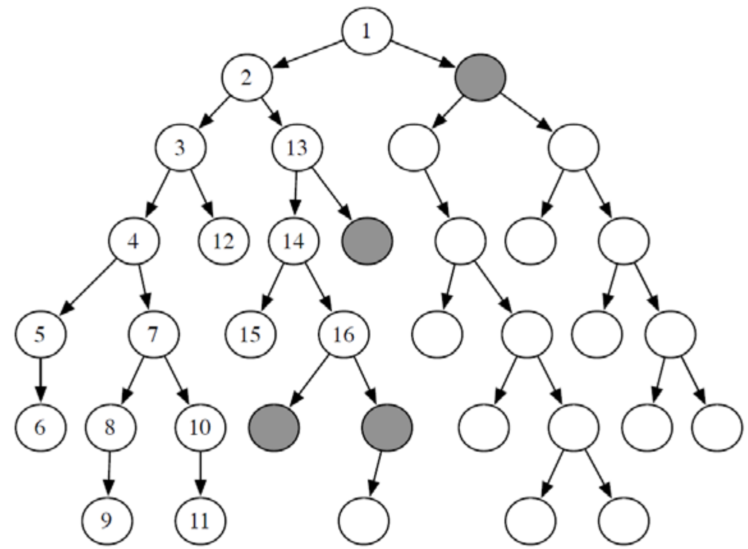
1 2 3 4

Depth first search (DFS)



- Say, node in red box is a goal
- How many more nodes will be expanded?
  - 3: you only return once the goal is being expanded!
  - Not once a goal is put onto the frontier!

DFS as an instantiation of the Generic Search Algorithm



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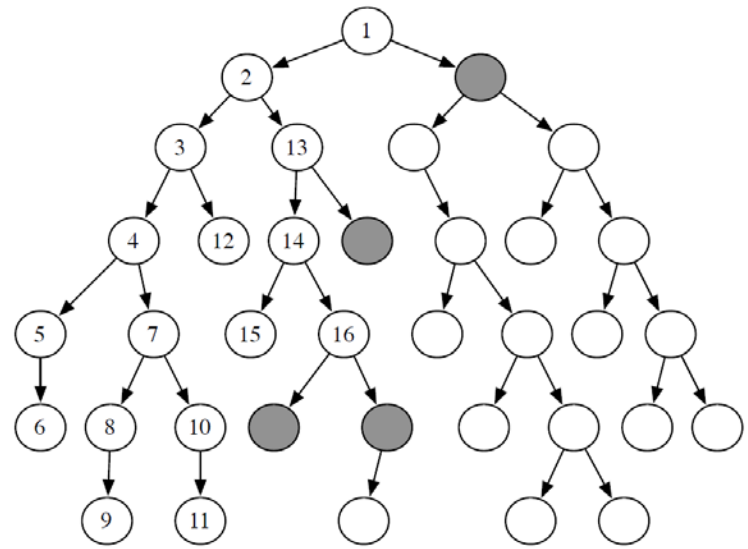

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end

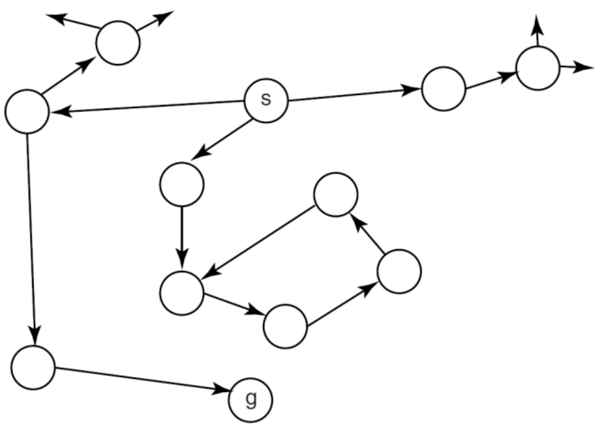
In DFS, the frontier is a last-in-first-out stack

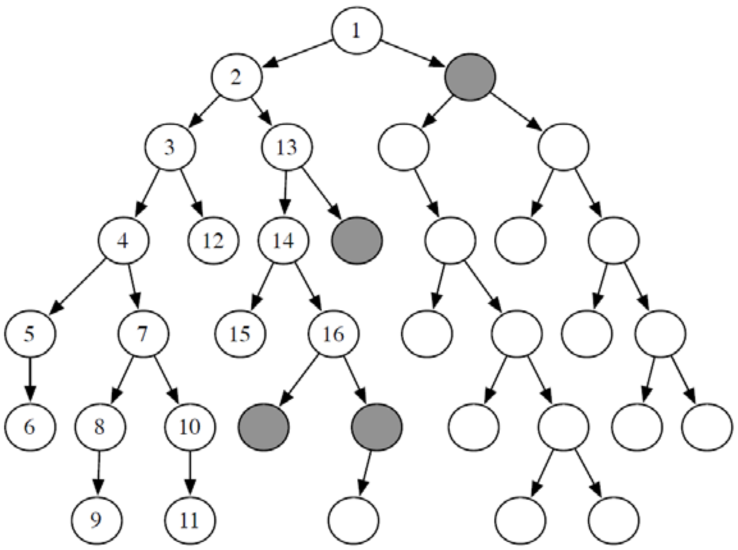
Analysis of DFS

Def. : A search algorithm is complete if

whenever there is at least one solution, the algorithm is guaranteed to find it within a finite amount of time.

Is DFS complete? Yes No





Analysis of DFS

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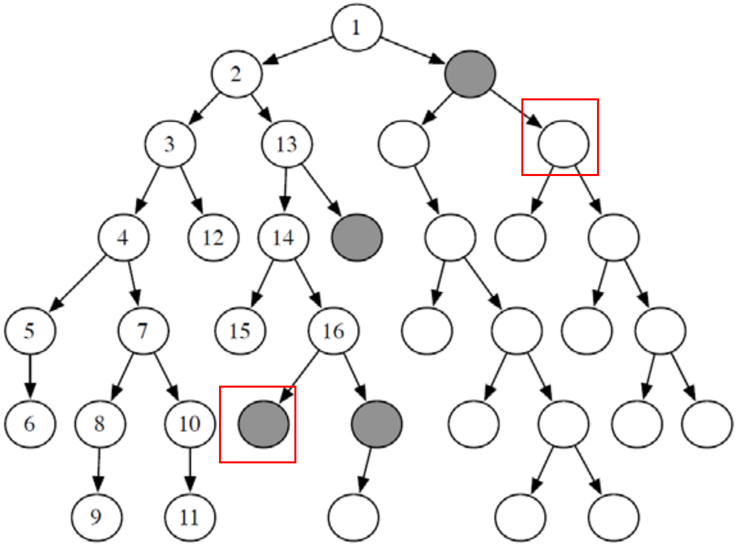
Is DFS optimal? Yes No



- E.g., goal nodes: red boxes

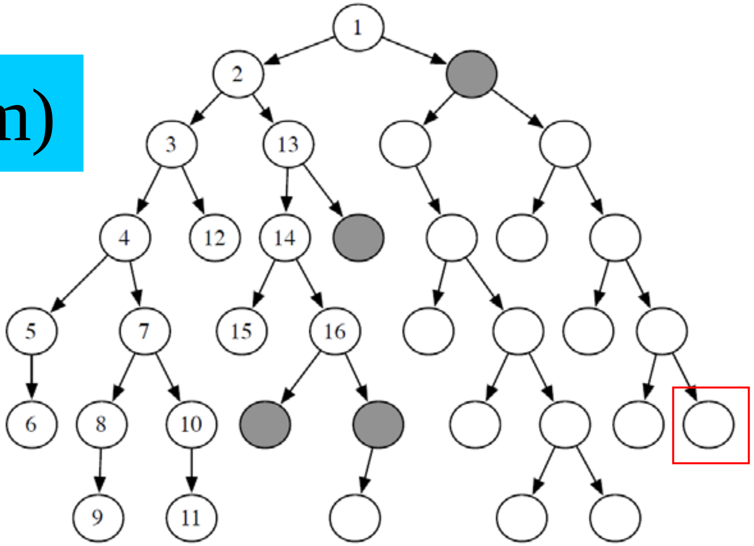
Analysis of DFS

Def.: The time complexity of a search algorithm is
the worst-case amount of time it will take to run, expressed in terms of
- maximum path length *m*
- maximum forward branching factor *b*.

- What is DFS's time complexity, in terms of m and b ?

$O(b^m)$	$O(m^b)$	$O(bm)$	$O(b+m)$

- E.g., single goal node: red box



Analysis of DFS

Def.: The space complexity of a search algorithm is the worst-case amount of memory that the algorithm will use (i.e., the maxmial number of nodes on the frontier), expressed in terms of

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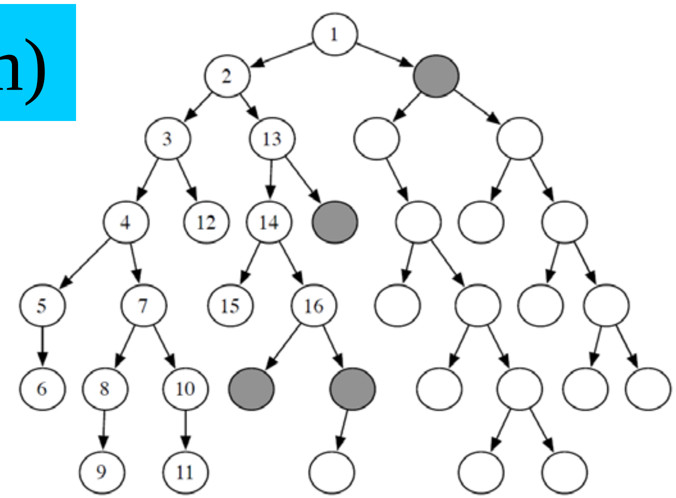
- O(bm)
- The longest possible path is m, and for every node in that path must maintain a fringe of size b



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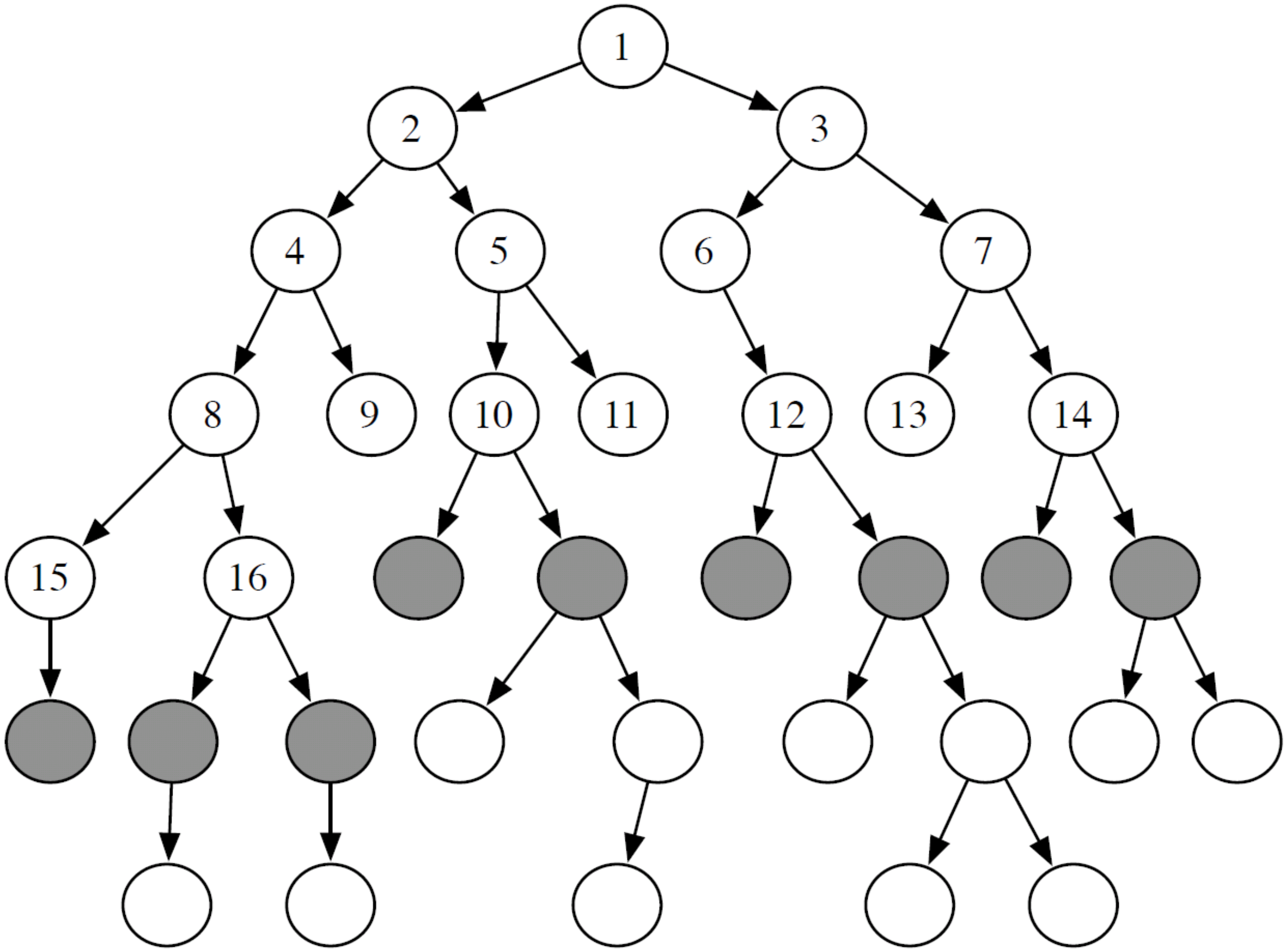
  - ⇨ Breadth first

Breadth-first search (BFS)



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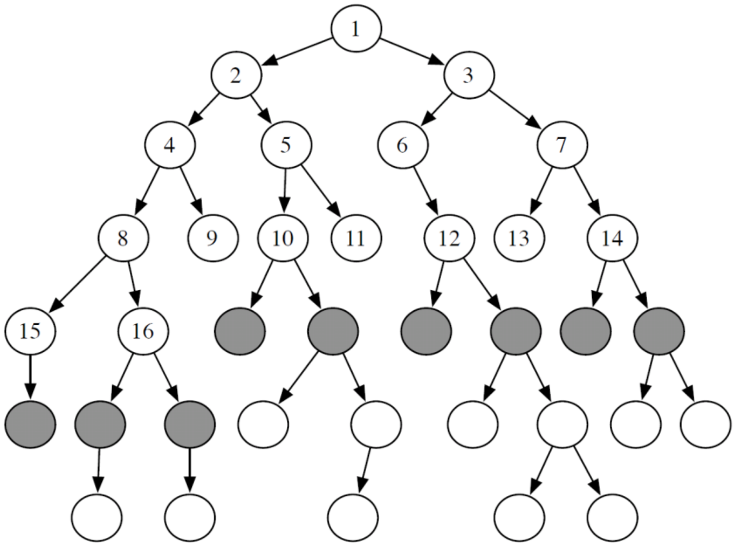

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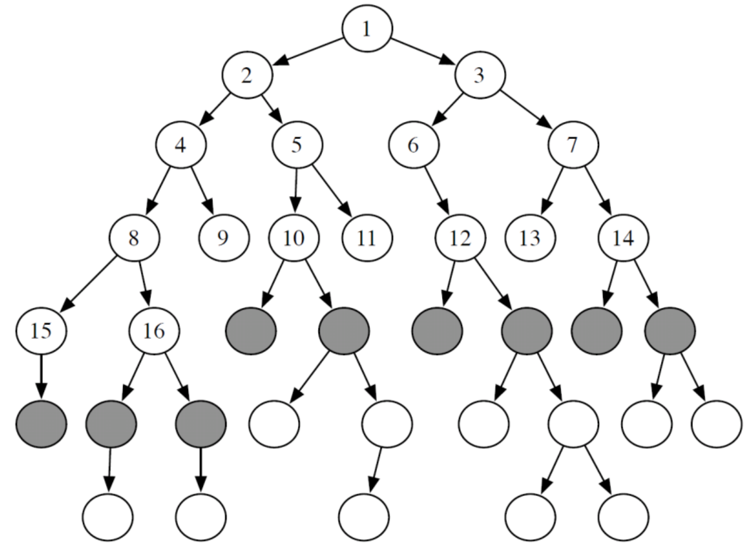

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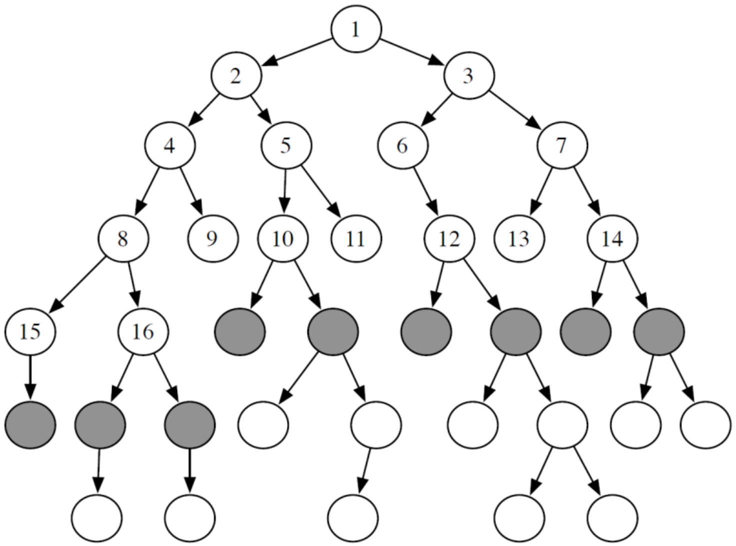

- Proof sketch?

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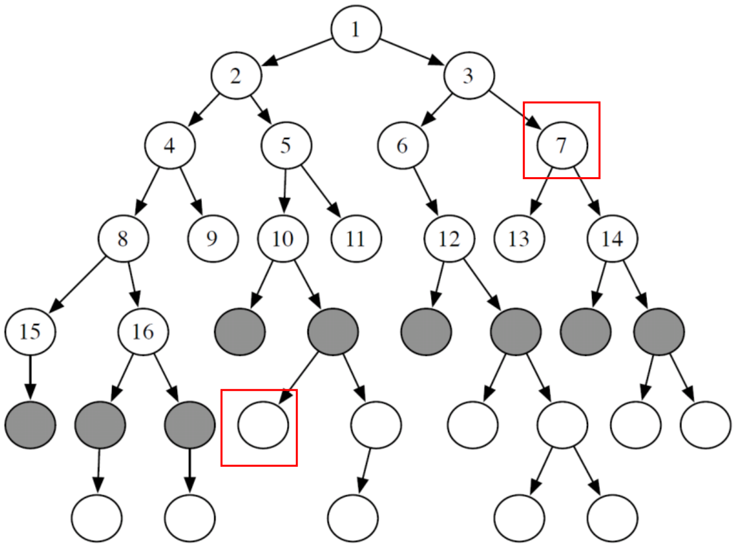

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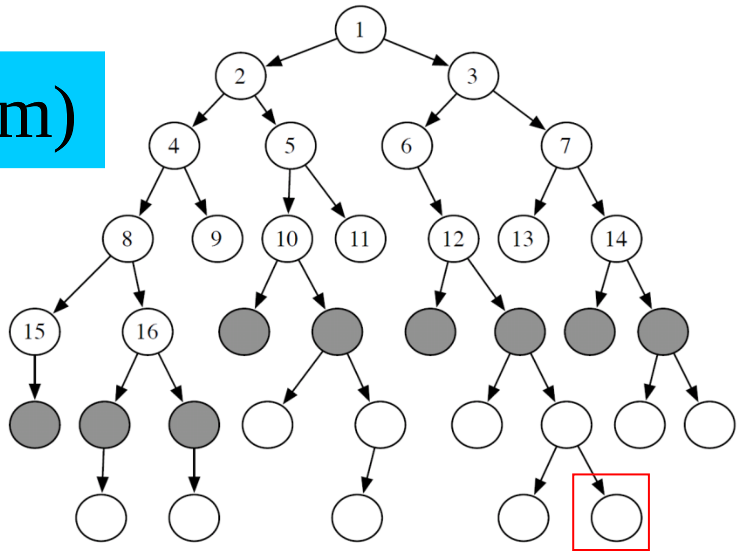

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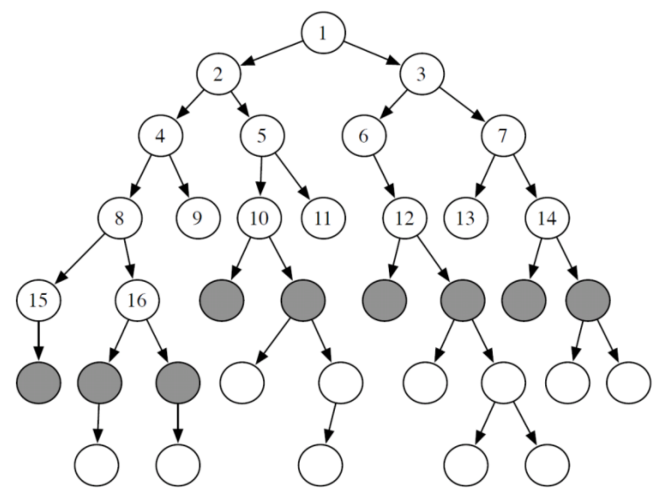


- How many nodes at depth m?

When to use BFS vs. DFS?

- The search graph has cycles or is infinite

  BFS DFS

- We need the shortest path to a solution

  BFS DFS

- There are only solutions at great depth

  BFS DFS

- There are some solutions at shallow depth: the other one

- No way the search graph will fit into memory

  BFS DFS

Real Example: Solving Sudoku

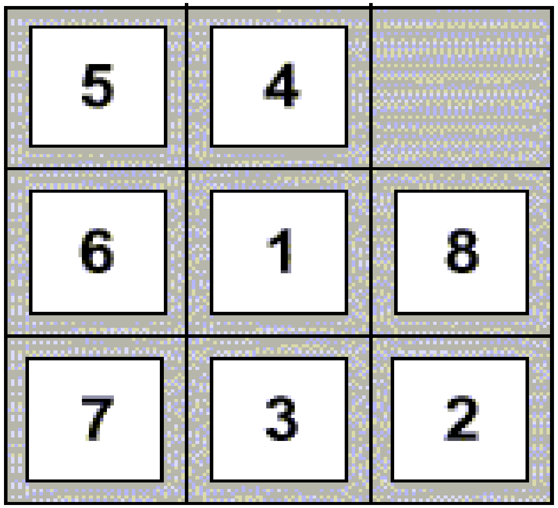
Sudoku Puzzle

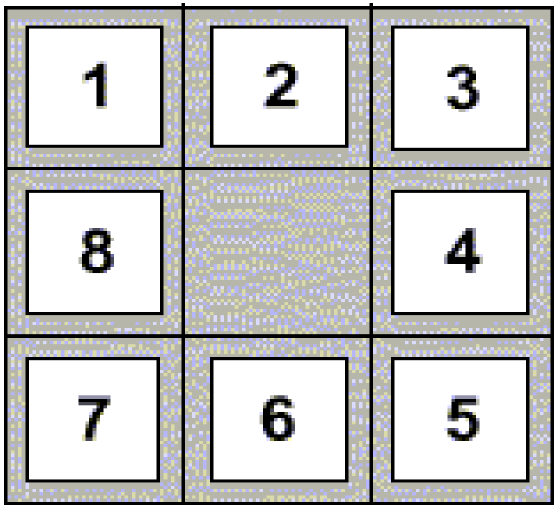
	9	3	6	2	8	1	4	
	6						5	
	3			1			9	
	5		8		2		7	
	4			7			6	
	8						3	
	1	7	5	9	3	4	2	

- E.g. start state on the left
- Operators:
  fill in an allowed number
- Solution: all numbers filled in, with constraints satisfied
- Which method would you rather use?

BFS DFS

Real Example: Eight Puzzle. DFS or BFS?





- Which method would you rather use?

BFS DFS

Learning Goals for today's class

- Apply basic properties of search algorithms:
  - completeness
  - optimality
  - time and space complexity of search algorithms

- Select the most appropriate search algorithms for specific problems.
  – Depth-First Search vs. Breadth-First Search

Coming up …

- I am away all next week
  - AI conference in Rome: Learning and Intelligent Optimization
  - I will check email regularly
- All classes will happen. TAs will teach:
  - Monday: Mike (including demo of AIspace search applet)
  - Wednesday: Vasanth (including lots more Infinite Mario)
  - Friday: Mike (including a proof of the optimal search algorithm)
- First practice exercise online – see assessments from WebCT Vista
  - Covers paths, frontier, BFS and DFS
  - Tracing algorithms as in there is the first question in assignment 1
- Read section 3.6