SEARCH

David Kauchak
CS51A – Fall 2025

1

Admin

Assignment 8

2

What is AI?

Think like a human Cognitive Modeling	**Think rationally** Logic-based Systems
Act like a human Turing Test	**Act rationally** Rational Agents

3

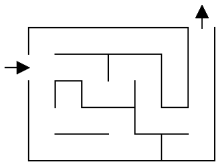
What is AI?

Think like a human Cognitive Modeling	**Think rationally** Logic-based Systems
Act like a human Turing Test	**Act rationally** Rational Agents

Next couple of weeks

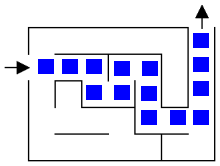
4

Solve the maze!



5

Solve the maze!



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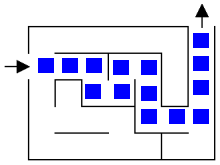
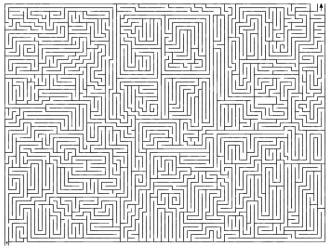
Solve the maze!



How did you figure it out?

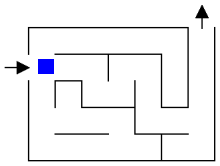
7

Solve the maze!



8

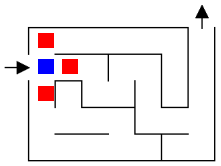
One approach



What now?

9

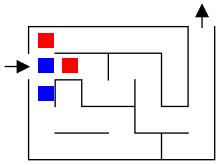
One approach



Three choices

10

One approach

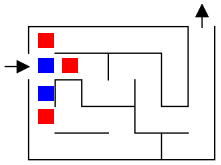


Pick one!

What now?

11

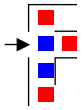
One approach



Still three options!

12

One approach

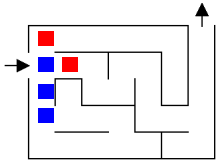


Still three options!

Which would you explore/pick?

13

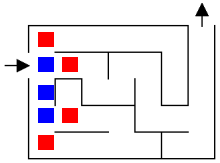
One approach



Most people go down a single path until they realize that it's wrong

14

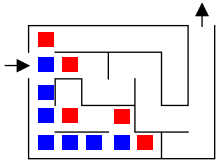
One approach



Keep exploring

15

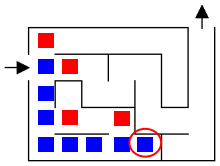
One approach



Keep exploring

16

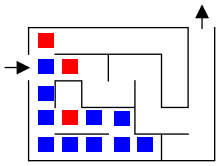
One approach



What now?

17

One approach

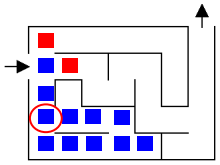


Are we stuck?

No. Red positions are just possible options we haven't explored

18

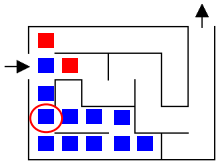
One approach



How do we know
not to go straight?

19

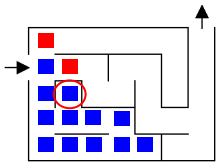
One approach



Have to be careful and keep track of
where we've been if we can loop

20

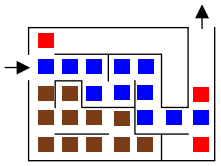
One approach



Now what?

21

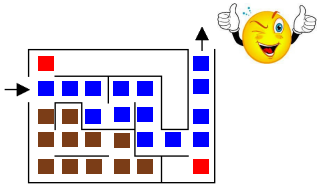
One approach



Now what?

22

One approach



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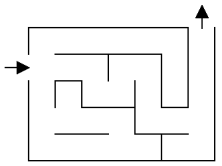
Search problems



What information do we need to figure out a solution?

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Search problems

Where to start

Where to finish (goal)

What the "world" (in this case a maze) looks like

- We'll define the world as a collection of *discrete* states
- States are connected if we can get from one state to another by taking a particular action
- This is called the "state space"

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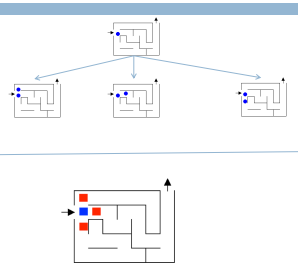
State space example



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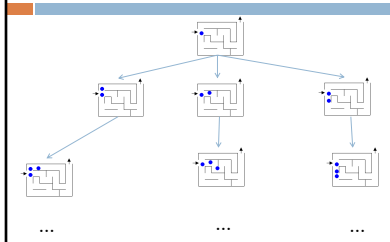
State space example



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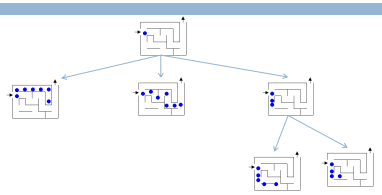
State space example



For a given problem, still could have different state-spaces

How many more states are there?

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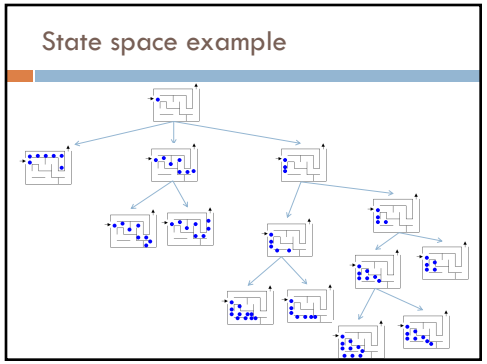
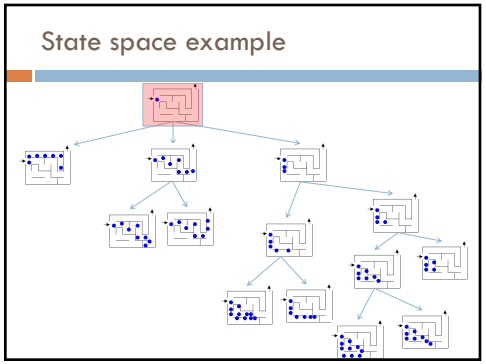
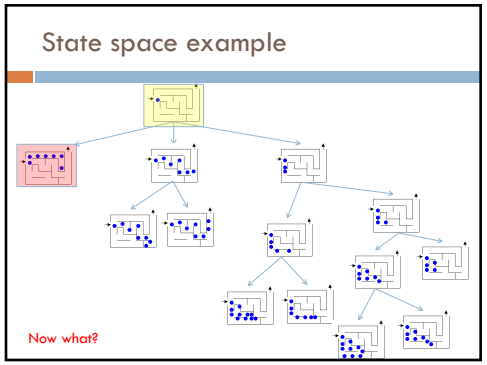

State space example

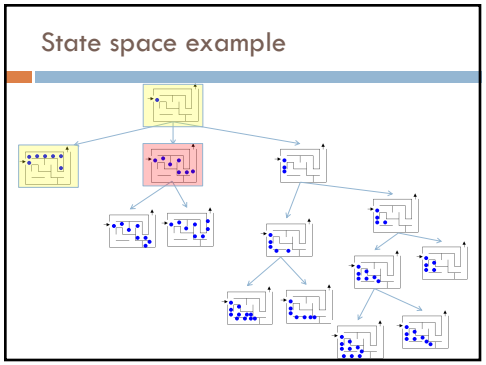
29


State space example

30

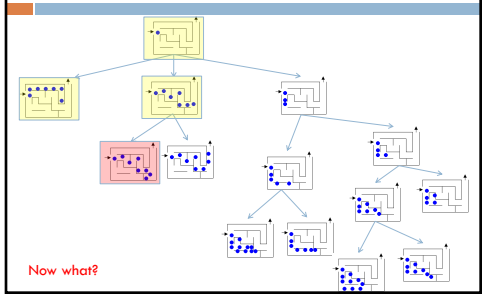

State space example
Now what?

31


State space example

32

State space example



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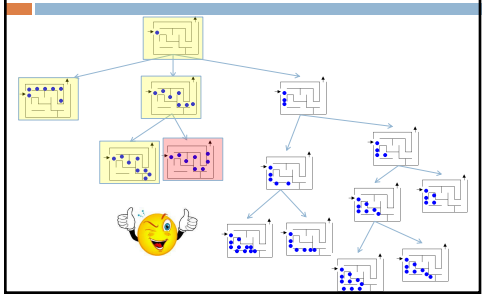
State space example



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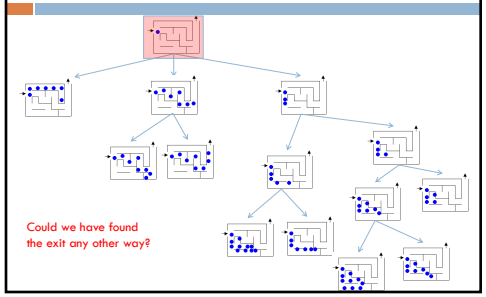
State space example



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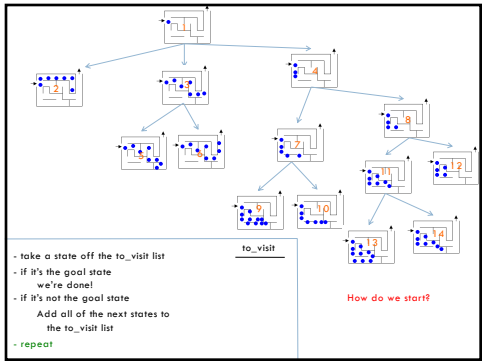
Search algorithm

Keep track of a list of states that we *could* visit, we'll call it "to_visit"

General idea:

- take a state off the to_visit list
- if it's the goal state
  - we're done!
- if it's not the goal state
  - Add all of the next states to the to_visit list
- repeat

36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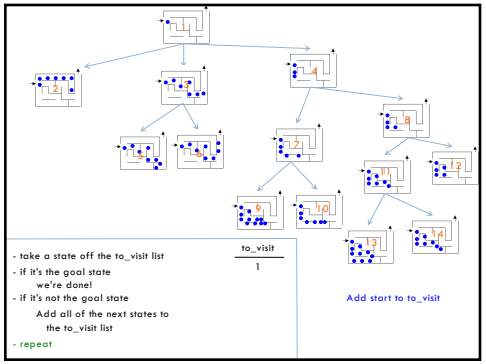
to_visit
How do we start?

37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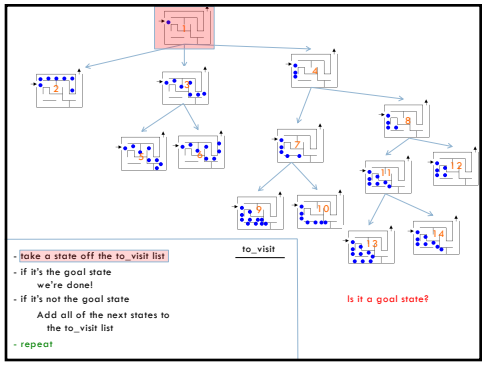
Add all of the next states to
the to_visit list
- repeat
to_visit
1
Add start to to_visit

38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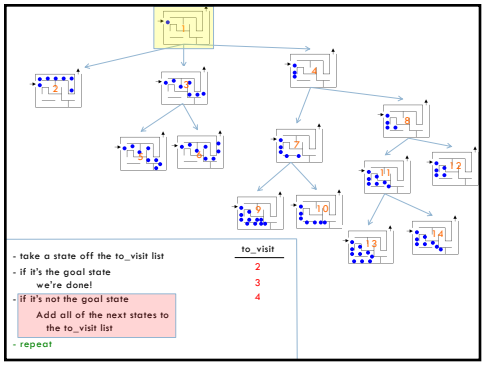
to_visit
Is it a goal state?

39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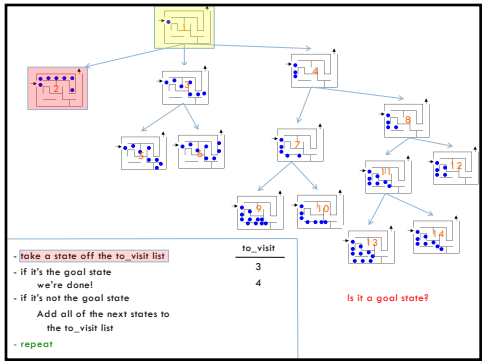
the to_visit list
- repeat
to_visit
2
3
4

40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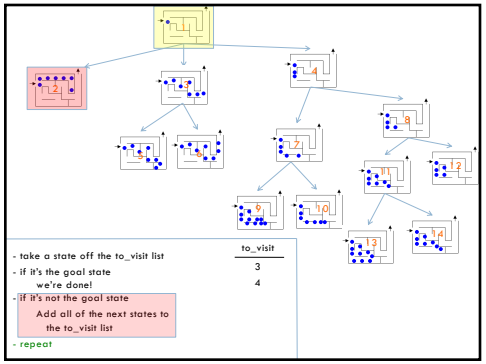
to_visit
3
4
Is it a goal state?

41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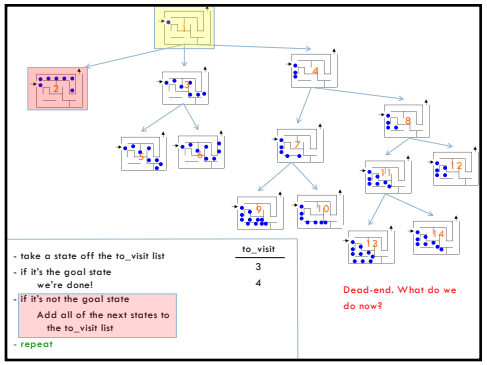
42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3
4
Dead-end. What do we
do now?

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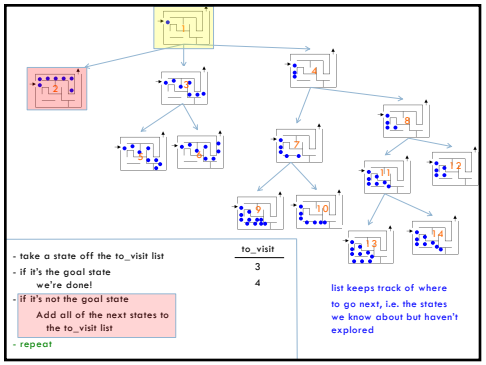
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Add all of the next states to
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to_visit
3
4
list keeps track of where
to go next, i.e. the states
we know about but haven't
explored

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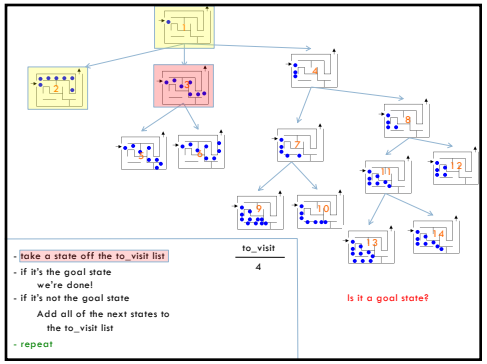
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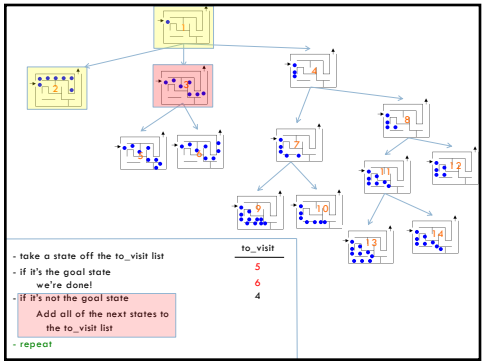
Is it a goal state?

45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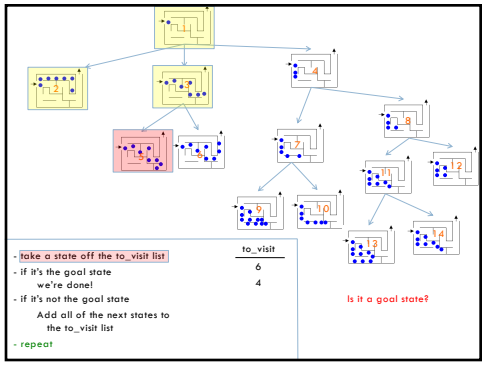
6
4

46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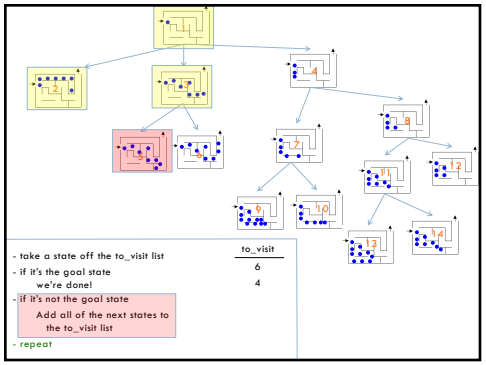
Is it a goal state?

47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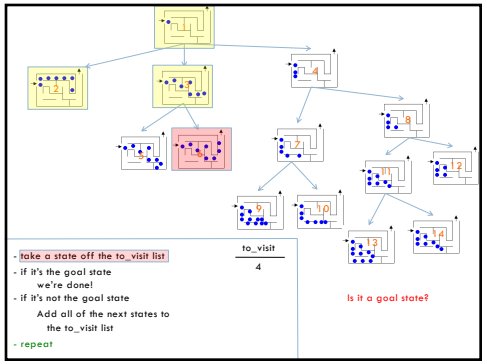
48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to_visit
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Is it a goal state?

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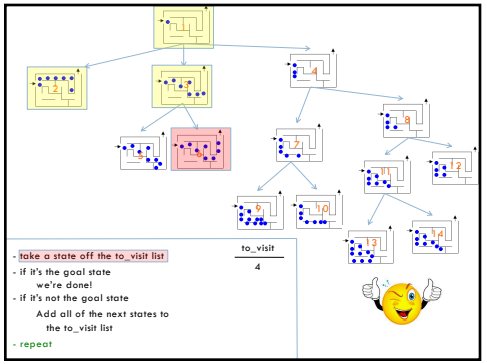
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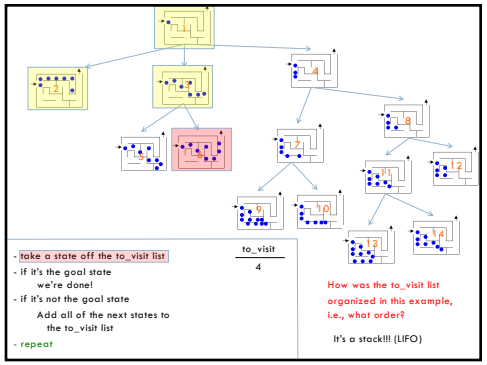
50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Add all of the next states to
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- repeat
to_visit
4
How was the to_visit list
organized in this example,
i.e., what order?
It's a stack!!! (LIFO)

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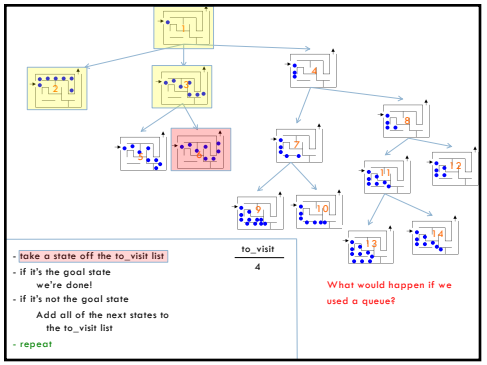
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Add all of the next states to
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to_visit
4
What would happen if we
used a queue?

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Search algorithms

add the start state to to_visit

Repeat
- take a state off the to_visit list
- if it's the goal state
  - we're done!
- if it's not the goal state
  - Add all of the next states to the to_visit list

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Search algorithms

add the start state to to_visit

Repeat
- take a state off the to_visit list
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  - we're done!
- if it's not the goal state
  - Add all of the next states to the to_visit list

Depth first search (DFS): to_visit is a stack
Breadth first search (BFS): to_visit is a queue

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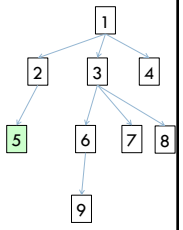
What order will BFS and DFS visit the states assuming states are added to to_visit left to right?

add the start state to to_visit

Repeat
- take a state off the to_visit list
- if it's the goal state
  - we're done!
- if it's not the goal state
  - Add all of the successive states to the to_visit list



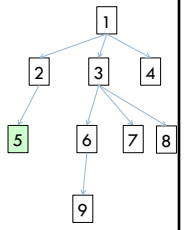
Depth first search (DFS): to_visit is a stack
Breadth first search (BFS): to_visit is a queue

55

What order will BFS and DFS visit the states?

DFS: 1, 4, 3, 8, 7, 6, 9, 2, 5

Why not 1, 2, 5?



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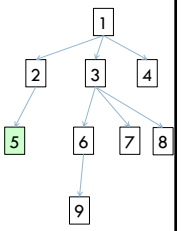

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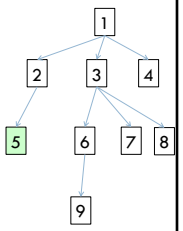

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58

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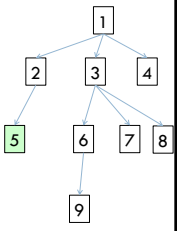

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59

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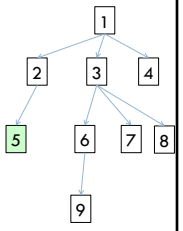
DFS: 1, 4, 3, 8, 7, 6, 9, 2, 5

BFS: 1, 2, 3, 4, 5



Depth first search (DFS): to_visit is a stack
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Implementing state space

What the "world" (in this case a maze) looks like

- We'll define the world as a collection of *discrete* states
- States are connected if we can get from one state to another by taking a particular action
- This is called the "state space"

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Implementing state space

What the "world" (in this case a maze) looks like

- We'll define the world as a collection of *discrete* states
- States are connected if we can get from one state to another by taking a particular action
- This is called the "state space"

State:

- Is this the goal state? (is_goal)
- What states are connected to this state? (next_states)

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Search variants implemented

add the start state to to_visit

Repeat

- take a state off the to_visit list
- if it's the goal state
  - we're done!
- if it's not the goal state
  - Add all of the successive states to the to_visit list

```
def dfs(start_state):
    s = Stack()
    return search(start_state, s)

def bfs(start_state):
    q = Queue()
    return search(start_state, q)

def search(start_state, to_visit):
    to_visit.add(start_state)

    while not to_visit.is_empty():
        current = to_visit.remove()

        if current.is_goal():
            return current
        else:
            for s in current.next_states():
                to_visit.add(s)

    return None
```

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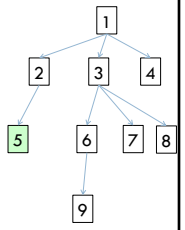
What order would this variant visit the states?

```
def search(state):
    if state.is_goal():
        return state
    else:
        for s in state.next_states():
            result = search(s)
            if result != None:
                return result

        return None
```



1, 2, 5

64

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def search(state):
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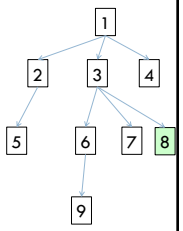

1, 2, 5, 3, 6, 9, 7, 8

What search algorithm is this?

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What order would this variant visit the states?

```
def search(state):
    if state.is_goal():
        return state
    else:
        for s in state.next_states():
            result = search(s)
            if result != None:
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        return None
```

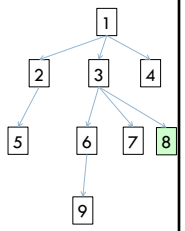

1, 2, 5, 3, 6, 9, 7, 8

DFS!

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One last DFS variant

```
def search(state):
    if state.is_goal():
        return state
    else:
        for s in state.next_states():
            result = search(s)
            if result != None:
                return result

        return None
```

```
def dfs(state):
    if state.is_goal():
        return [state]
    else:
        result = []

        for s in state.next_states():
            result += dfs(s)

        return result
```

How is this different?

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One last DFS variant

```
def search(state):
    if state.is_goal():
        return state
    else:
        for s in state.next_states():
            result = search(s)
            if result != None:
                return result

        return None
```

```
def dfs(state):
    if state.is_goal():
        return [state]
    else:
        result = []

        for s in state.next_states():
            result += dfs(s)

        return result
```

Returns ALL solutions found, not just one

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Matrices!

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