

CS4811  
 Jan 23, 2017  
 Monday (1)

Previous class

Search algorithms

Problem --- class

different problem instances in the same domain

initial state

goal test  
 (multiple states)  
 possible



describes domain

actions 4 actions u, d, l, r

transition model  
 result (s, a)



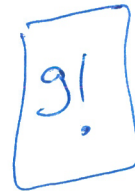
, d



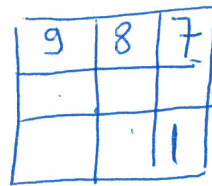
path cost

$P(g)$

$\pi$



3



1 2  
 9 8

g!

362 K

16!

1	2	3
4	5	6
7	8	///

start

3	2	1
4	5	6
7	8	///

goal

breadth first

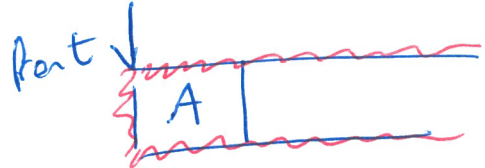
aima

frontier is a queue

frontier of the search

(A)

1	2	3
4	5	6
7	8	///



node contains the state

u, l

u

l

(B)

1	2	3
4	5	///
7	8	6

(C)

1	2	3
4	5	6
7	///	8

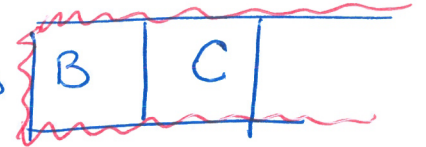
pick up: expansion

expansion generates children

(0 to b)

branching factor

write



maximum # of children  
 = maximum branching factor  
 = 4 for the 8-puzzle

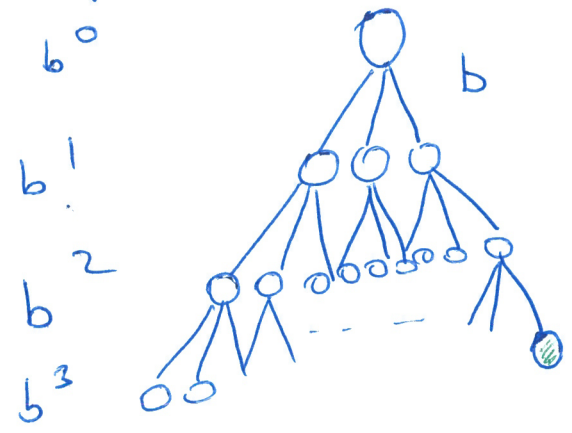
D E F



put children to the back of the queue = BFS

put children to the front = DFS  
depth-first-search

breadth-first search



we have a tree with branching factor  $b$ , we expand it to level  $d$ .

But we cut and the solution

How many nodes will we have looked at?

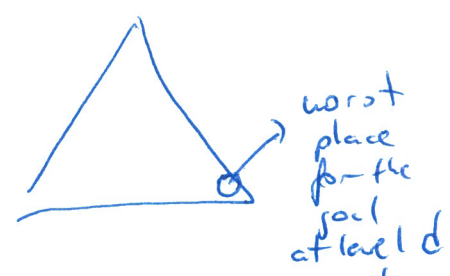
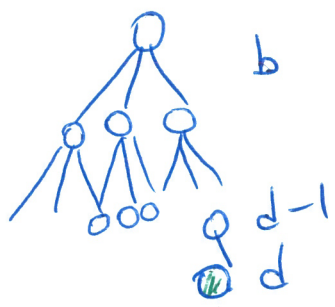
$$\sum_{i=1}^d b^{d-i}$$

$$\sum_{i=0}^{d-1} b^i = b^0 + b^1 + b^2 + \dots + b^{d-1}$$

For a search with  
branching factor  $b$   
and goal at depth  $d$   
the number of nodes expanded  
(generated)

time complexity = how long  
for the search to run. does it take

BFS



goal is at level  $d$   
how many nodes  
will be expanded  
in the worst case

$$b^0 + b^1 + b^2 + \dots + b^d$$

goal test: when a node is expanded  
 $O(x^4 + 3x^2 + 8)$  big-oh

$$O(x^4)$$

of the running time

$$O(2^x + x^4 + 1,000,000)$$

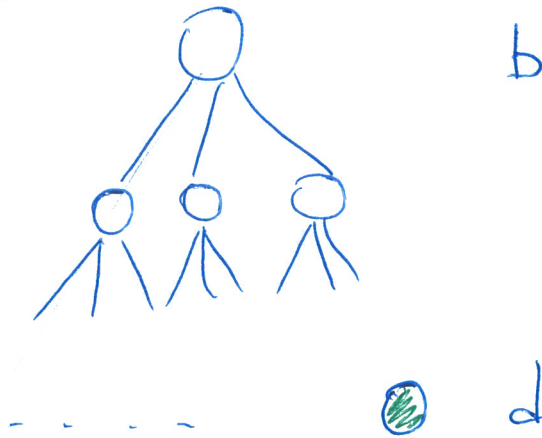
$$O(2^x)$$

input size

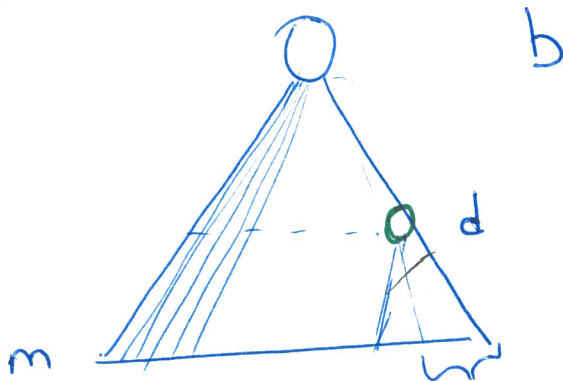
$$O(b^d)$$

depth - first search

5



How many nodes would DFS ~~generate~~ expand?  
maximum depth of my search



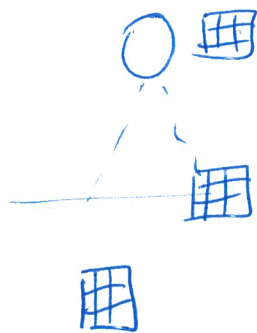
$$O(b^m)$$

optimality

6

not how fast the search runs  
but rather is the optimal goal found?

↓  
least cost



□ G

best solution level d  
optimal goal

d+x

worse solution  
suboptimal goal

will the search always find the optimal  
(guarantee)

solution?

BFS

yes

DFS

no (guarantee)

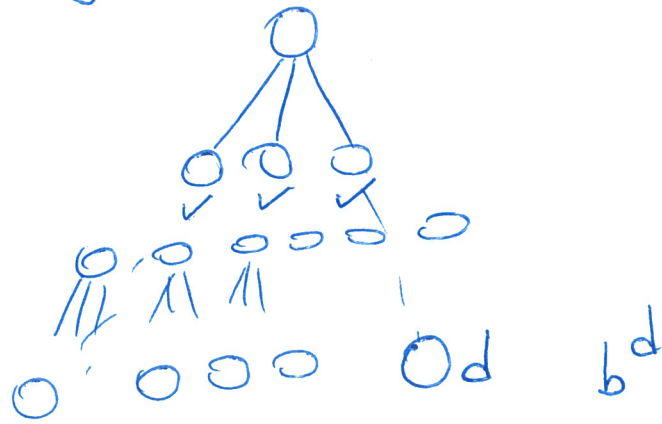
○

□

□

space complexity  
 maximum amount of space used  
 at any point in the search

(7)



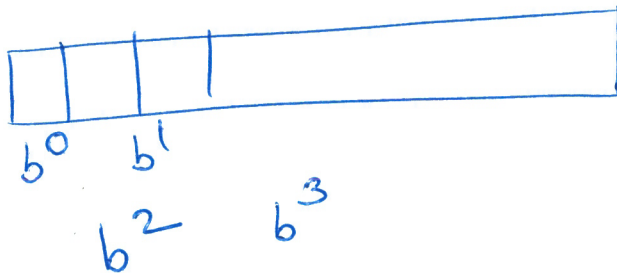
our primary  
 storage is  
 the frontier

m 0

~~$b^{d+1}$~~

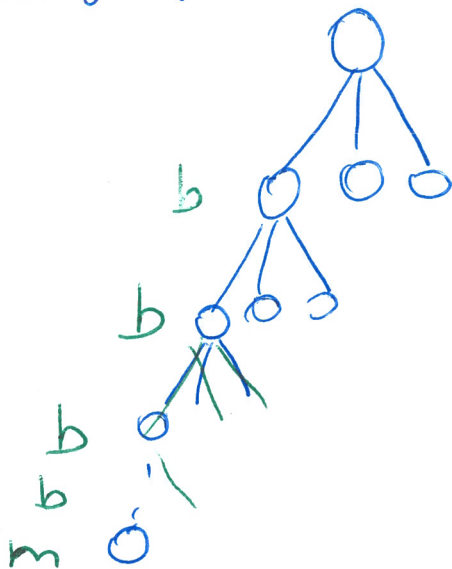
$O(b^{d+1})$

BFS



$10^{30}$   
 $10^{40}$

storage for DFS



b  
 b  
 b

$b \times m$

4 100  
 10 100 1000