

def Search ( $G, s, \text{goal}$ )

$F = \{ \langle s \rangle \}$

While  $F \neq \{\}$  do:

    select and remove  $\langle u_0, \dots, u_k \rangle$  from  $F$

    if goal( $u_k$ ) then:

        return  $\langle u_0, \dots, u_k \rangle$

$F = F \cup \{ \langle u_0, \dots, u_k, u \rangle : \langle u_k, u \rangle \in A \}$

return  $\perp$

\* Breadth first algorithm (BFS)

The frontier is a queue.

\* Depth first algorithm (DFS)

The frontier is a stack

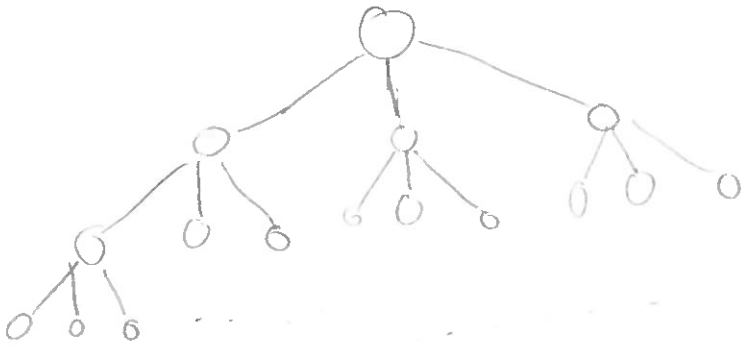
\* Lowest-cost first

- Priority queue using the path cost.

↳ Guaranteed optimal cost

# Search complexity

Breadth first



Basic operation:

Add element to the frontier.

$$1 \quad 3^0 \quad b^0$$

$$3 \quad 3^1 \quad b^1$$

$$9 \quad 3^2 \quad b^2$$

$$27 \quad 3^3 \quad b^3$$

$$\vdots$$

$$3^h \quad b^h$$

Time and space

$$C(b, h) = \sum_{i=0}^h b^i = \frac{1 - b^{h+1}}{1 - b} \in O(b^h)$$

$$S_r = ar^0 + ar^1 + \dots + ar^{h-1}$$

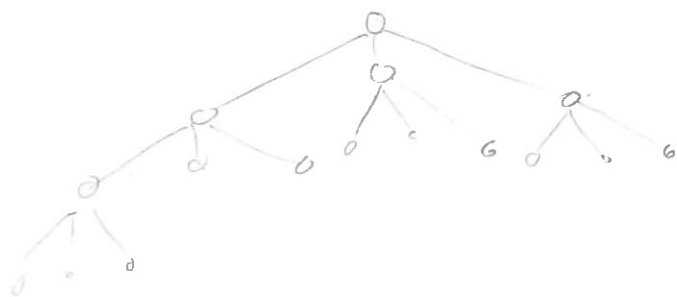
$$rS_r = ar^1 + ar^2 + \dots + ar^h$$

$$S_r - rS_r = ar^0 + ar^h$$

$$S_r(1 - r) = a(1 + r^h)$$

$$S_r = a \frac{(1 + r^h)}{(1 - r)}$$

Depth first



$$1 \quad 3 \times 0 = (-1)$$

$$3 \quad (3 \times 1) = 0$$

$$5 \quad (3 \times 2) = 1$$

$$7 \quad (3 \times 3) = 2$$

$$9 \quad (3 \times 4) = 3$$

$$11 \quad (3 \times 5) = 4$$

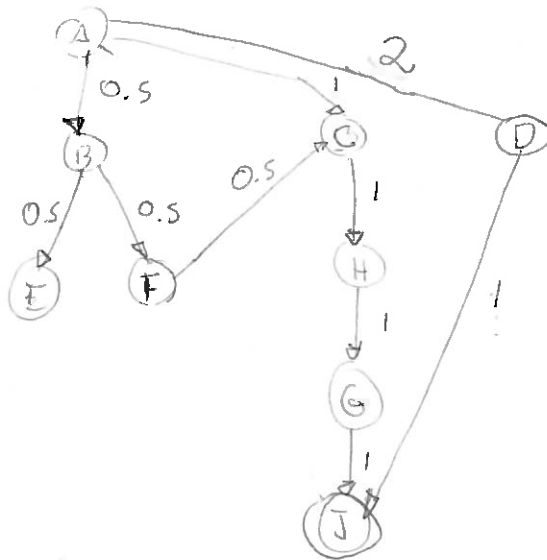
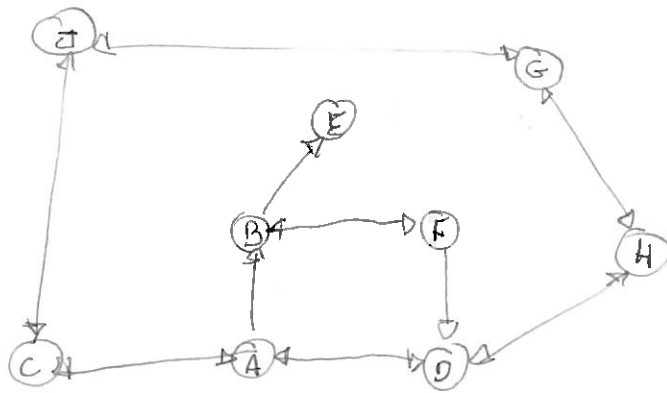
$$\frac{b^h - (h-1)}{b-1}$$

$$O(b^h)$$

Poda

↳ Poda de ciclos

↳ Poda de múltiplos caminhos

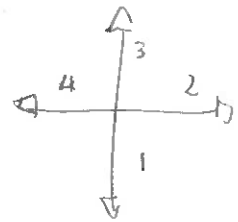
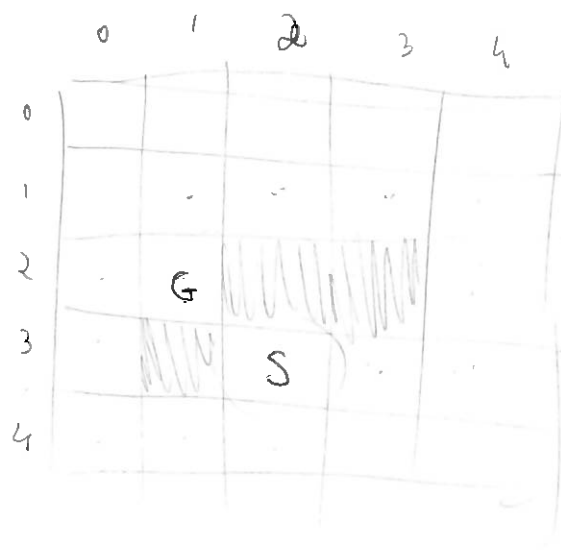


Exercício:

Fazer BFS

Fazer DFS

Fazer LCFS



Fazer DFS

Fazer BFS

$[0,0]$

$\{([2,3], [2,4]), ([2,3], [3,3])\}$