# CSCI561 FALL 2018
# Week 3 Discussion

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# A New Mailing List

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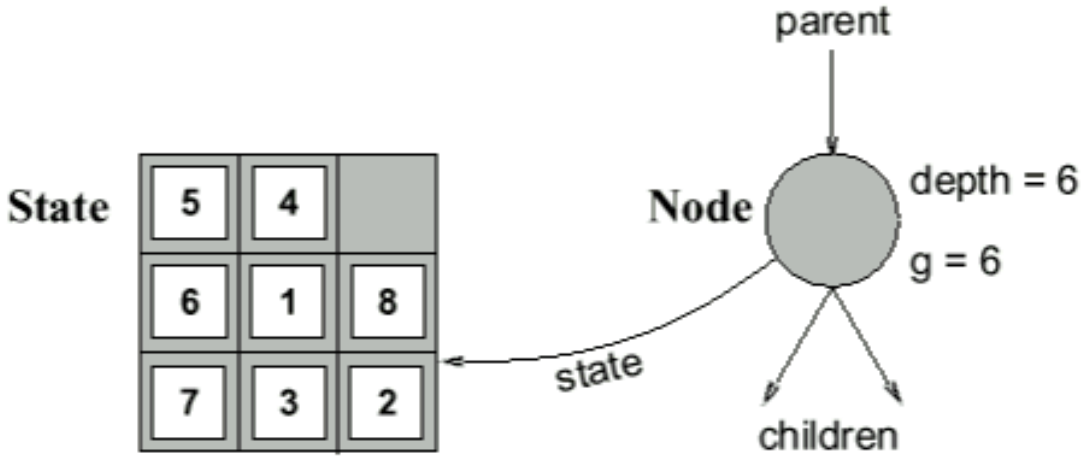
**This is our new mail address for students to use to contact the class admin**

# Graph Search

```
function GRAPH-SEARCH(problem) returns a solution or failure
    frontier ← MAKE-LIST(MAKE-NODE(problem.INITIAL-STATE))
   explored_set ← empty
    loop do
          if EMPTY?(frontier) then return failure
          node ← REMOVE-FIRST(frontier)
          if problem.GOAL-TEST applied to node.STATE succeeds
                then return SOLUTION(node)
          explored_set ← INSERT(node)
          for each new_node in EXPAND(node, problem) do
                if NOT(MEMBER?(new_node, frontier)) and
                  NOT(MEMBER?(new_node, explored_set))
                  then frontier ← INSERT(new_node)
```

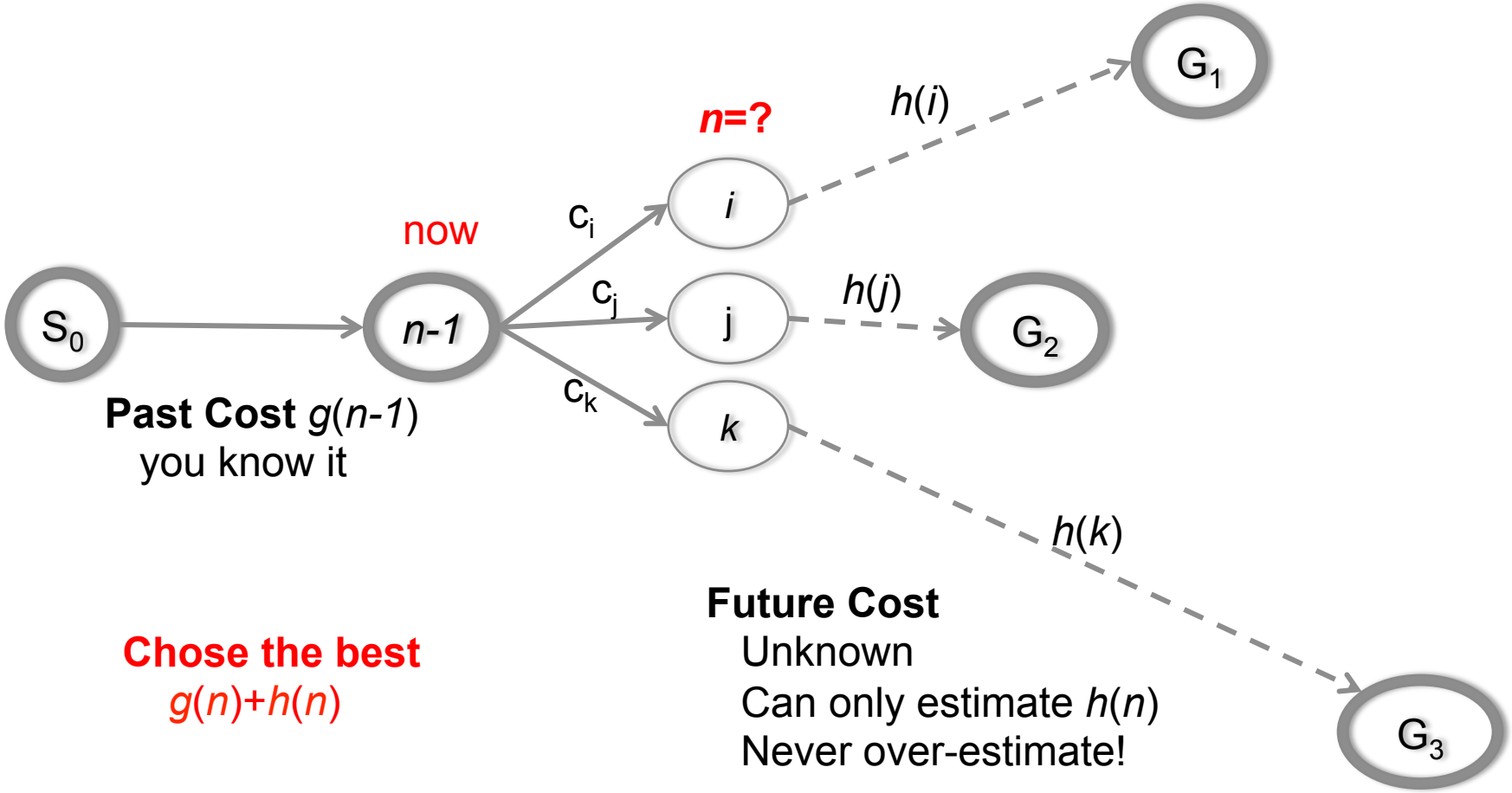
# Encapsulating *state* in *nodes*

A *state* is a (representation of) a physical configuration
A *node* is a data structure constituting part of a search tree
includes *parent*, *children*, *depth*, *path cost* $g(x)$
*States* do not have parents, children, depth, or path cost!




The EXPAND function creates new nodes, filling in the various fields and using the OPERATORS (or SUCCESSORFN) of the problem to create the corresponding states.

# A* = Best-First (past + estimated future)



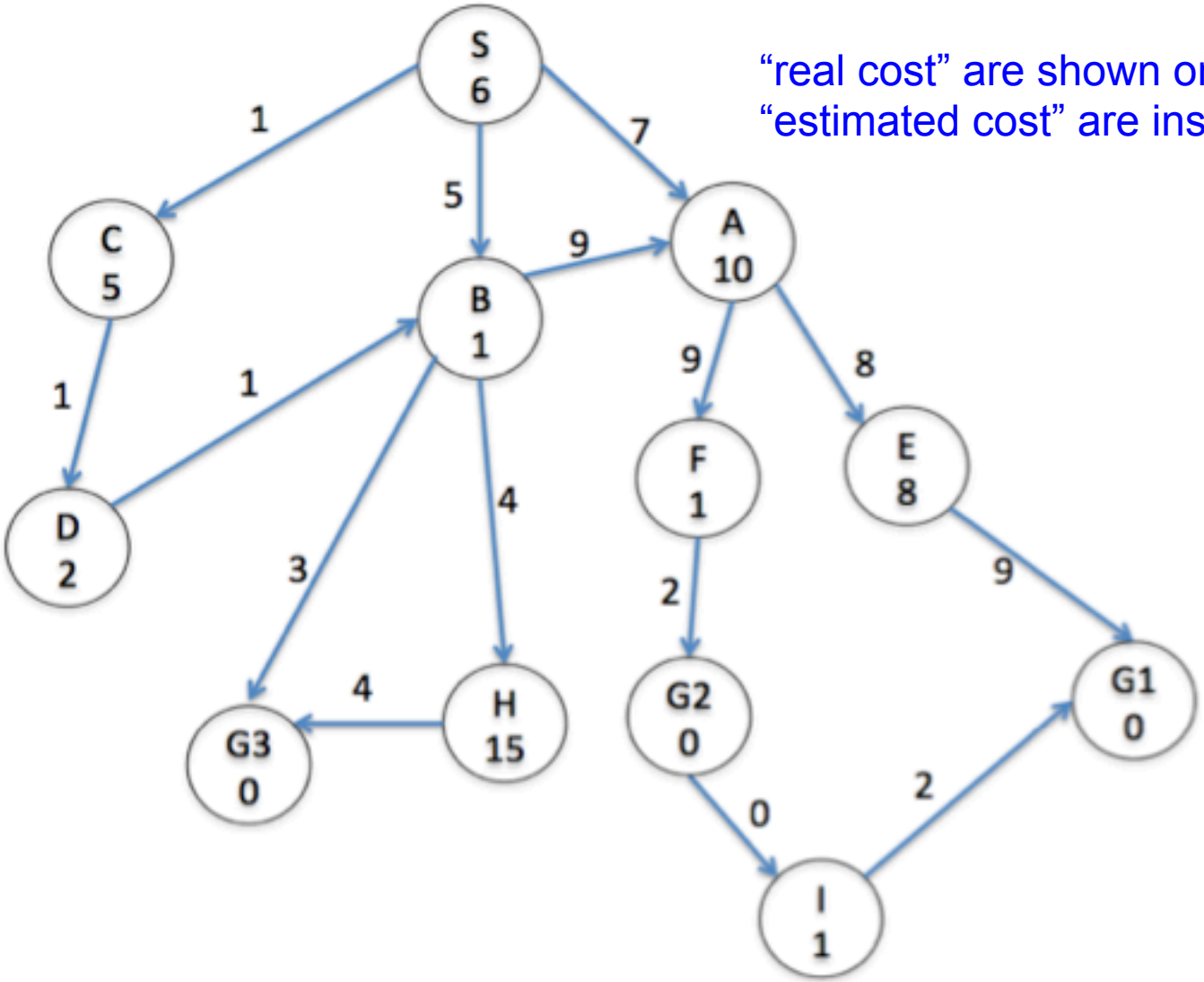

**Past Cost** *g*(*n-1*)
you know it

**Chose the best**
*g*(*n*)+*h*(*n*)

**Future Cost**
Unknown
Can only estimate *h*(*n*)
Never over-estimate!

Is it good to have h(*x*)=0 for all *x*?

# Search with “estimated future cost”




“real cost” are shown on edge
“estimated cost” are inside circle

# Exercise 3.14

**Which of the following are true and which are false? Explain your answers.**

1. **Depth-first search always expands at least as many nodes as A∗ search with an admissible heuristic.**
2. **h(n) = 0 is an admissible heuristic for the 8-puzzle.**
3. **A∗ is of no use in robotics because percepts, states, and actions are continuous.**
4. **Breadth-first search is complete even if zero step costs are allowed.**
5. **Assume that a rook can move on a chessboard any number of squares in a straight line, vertically or horizontally, but cannot jump over other pieces. Manhattan distance is an admissible heuristic for the problem of moving the rook from square A to square B in the smallest number of moves**
6. **If h(n)=1 everywhere except the goals, A* behaves like breath-first.**

# What you should know

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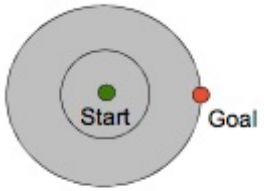
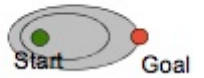



A*




- What is the difference between uninformed and informed search? Which ones are optimal
- What are the advantages and disadvantages of depth-first search?
- Why does a search heuristic need to be "admissible"?
- Be familiar with the differences between search strategies shown in Figure 3.21, and also all informed search

| Criterion | Breadth-First | Uniform-Cost | Depth-First | Depth-Limited | Iterative Deepening | Bidirectional (if applicable) |
|---|---|---|---|---|---|---|
| Complete? | Yes[a] | Yes[a,b] | No | No | Yes[a] | Yes[a,d] |
| Time | $O(b^d)$ | $O(b^{1+\lfloor C^*/\epsilon \rfloor})$ | $O(b^m)$ | $O(b^\ell)$ | $O(b^d)$ | $O(b^{d/2})$ |
| Space | $O(b^d)$ | $O(b^{1+\lfloor C^*/\epsilon \rfloor})$ | $O(bm)$ | $O(b\ell)$ | $O(bd)$ | $O(b^{d/2})$ |
| Optimal? | Yes[c] | Yes | No | No | Yes[c] | Yes[c,d] |

# Want more?

**Check out these search comparison demos:**

http://cse.unl.edu/~choueiry/S03-476-876/searchapplet/

https://courses.cs.washington.edu/courses/cse473/06sp/MazeRunnerDemo/search/applet.html

**A* and heuristics:**

http://www.briangrinstead.com/files/astar/

http://www.cs.rmit.edu.au/AI-Search/Product/

**Practice Exercises:**

**Chapter 4: # 4.1**

**Chapter 6: # 6.1, 6.5**