ICS 171, Summer 2000: Midterm Prepartion

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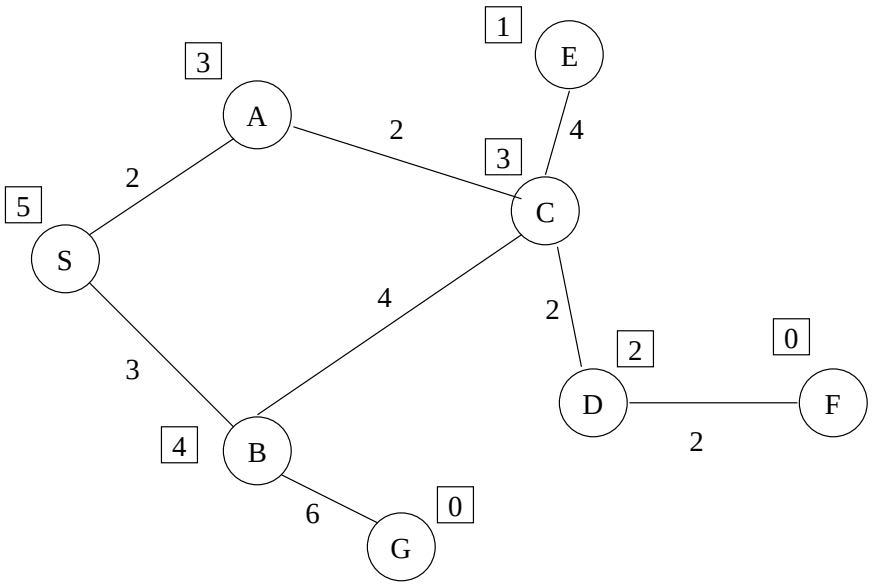
(1) Consider the following graph representing the state space and operators of a navigation problem:



The path cost is shown by the number on the links; the heuristic evaluation is shown by the number in the box.

- There are two goal states at G and F.
- When placing expanded child nodes on a queue, assume that the child nodes are placed in alphabetical order (i.e. if node S is expanded the queue will be: A B)
- Assume that we never generate child nodes that appear as ancestors of the current node in the search tree.

(a) What is the order that best first search will expand the nodes?

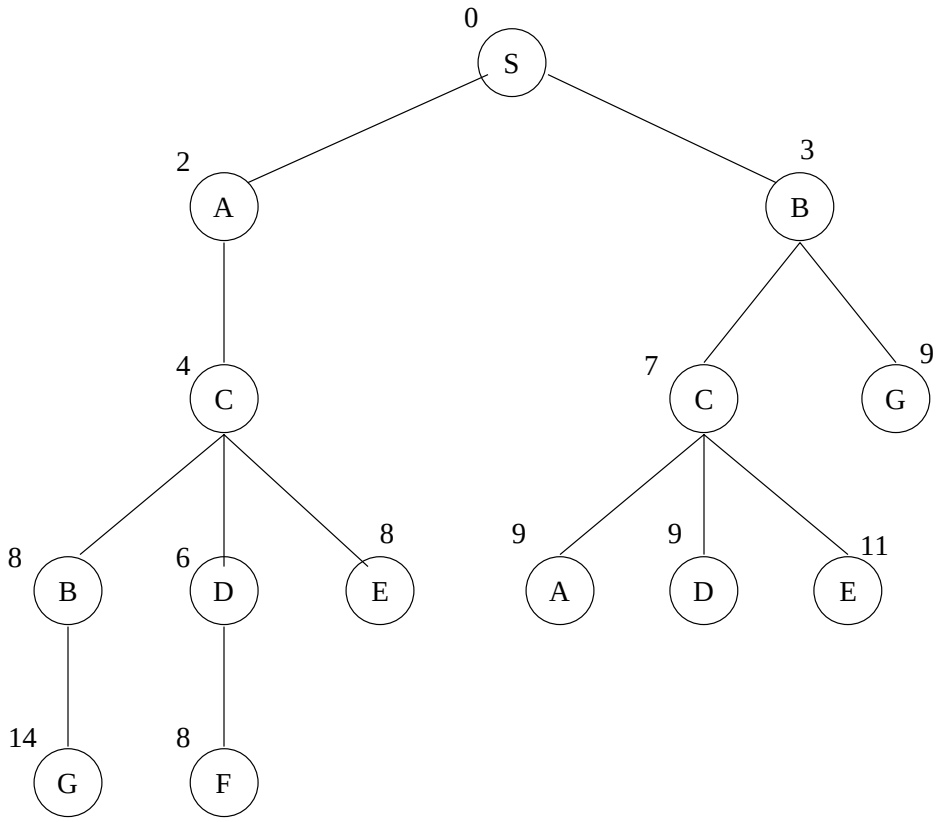
S A C E D F

(b) What is the order that hill-climbing search will expand the nodes?

S A C E

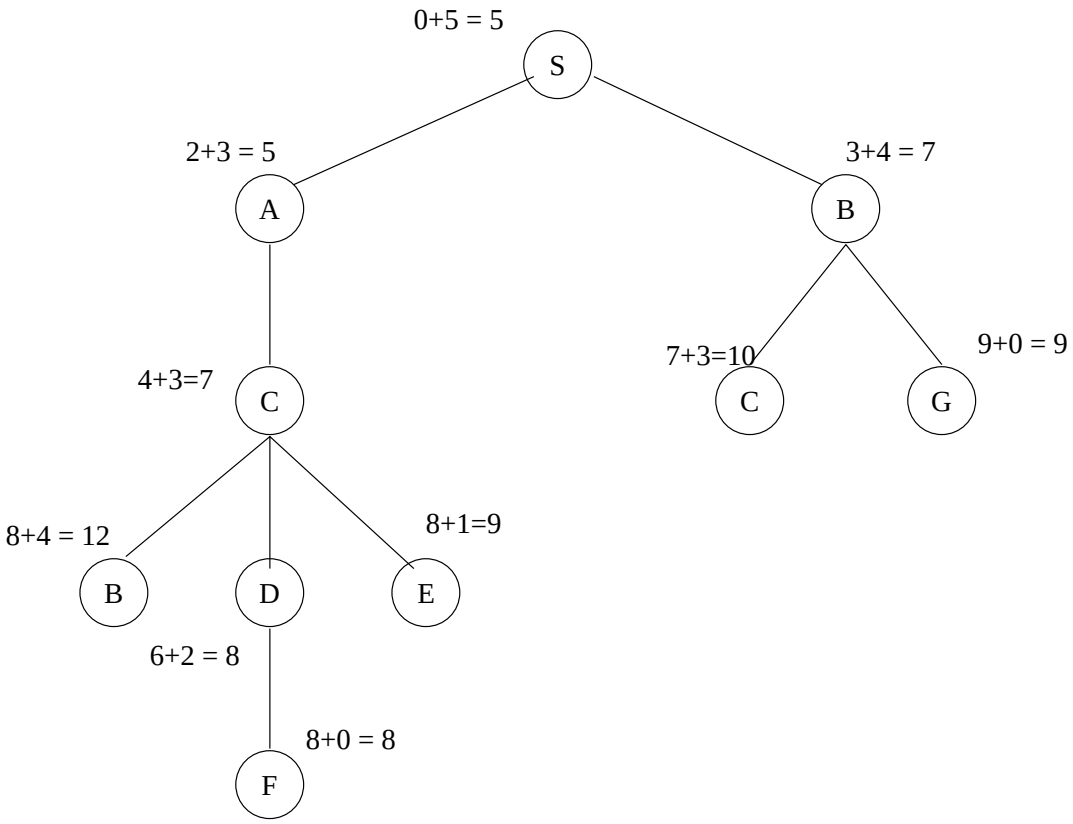
Hill climbing will get stuck at E.

(c) What is the order that uniform cost search will expand the nodes?



1. Q = {S}
2. pull S, test S for goal, expand S, add children A B to Q, Q = $\{A_2, B_3\}$
3. pull A, test A for goal, expand A, add child C to Q, Q = $\{B_3, C_4\}$
4. pull B, test B for goal, expand B, add children C G to Q, Q = $\{C_4, C_7, G_9\}$
5. pull C, test C for goal, expand C, add children B D E to Q, Q = $\{D_6, C_7, B_8, E_8, G_9\}$
6. pull D, test D for goal, expand D, add child F to Q, Q = $\{C_7, B_8, E_8, F_8, G_9\}$
7. pull C, test C for goal, expand C, add children A D E to Q, Q = $\{B_8, E_8, F_8, A_9, D_9, G_9, E_{11}\}$
8. pull B, test B for goal, expand B, add child G to Q, Q = $\{E_8, F_8, A_9, D_9, G_9, E_{11}, G_{14}\}$
9. pull E, test E for goal, expand E, E is deadend, Q = $\{F_8, A_9, D_9, G_9, E_{11}, G_{14}\}$
10. pull F, test F for goal – success

(d) What is the order that A* search will expand the nodes?

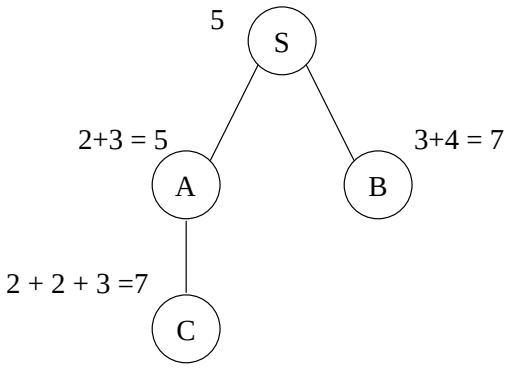


1. Q = {S}
2. pull S, test S for goal, expand S, add children A B to Q, Q = {A_5, B_7}
3. pull A, test A for goal, expand A, add child C to Q, Q = {B_7,C_7}
4. pull B, test B for goal, expand B, add children C G to Q, Q = {C_7, G_9, C_{10}}
5. pull C, test C for goal, expand C, add children B D E to Q, Q = {D_8, E_9, G_9, C_{10}, B_{12}}
6. pull D, test D for goal, expand D, add child F to Q, Q = {F_8, E_9, G_9, C_{10}, B_{12}}
7. pull F, test F for goal – success

(e) What is the order that IDA* search will expand the nodes?

With IDA* we search with DFS up to an fcost limit. Note that in the Q we recorded the fcost for each of the nodes but we do not sort the Q by fcost. We operate the Q as in DFS, which is LIFO (last in first out).

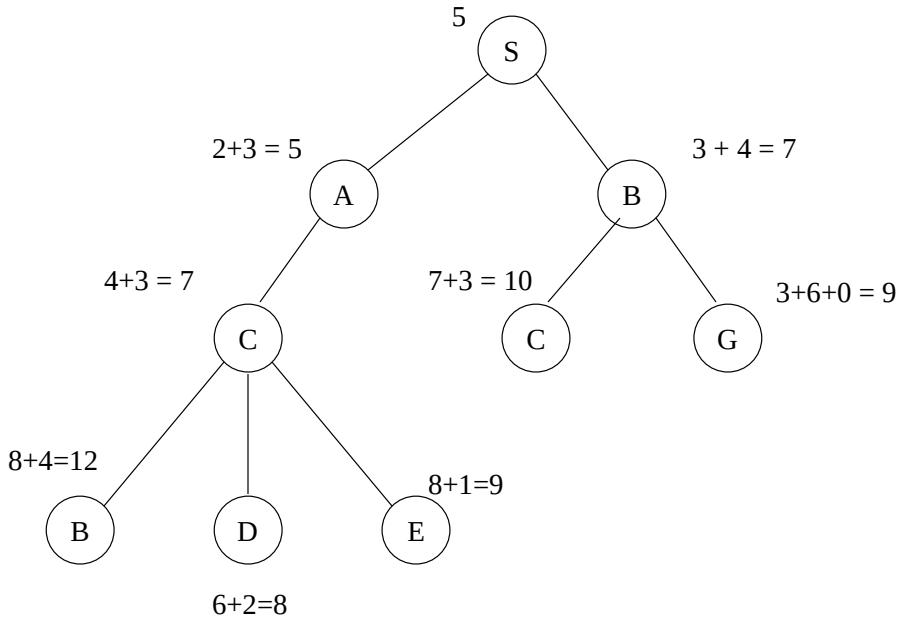
Iteration 1: fcost limit is 5



1. Q = {S}
2. pull S, test S for goal, expand S, add children A B to Q, Q = $\{A_5, B_7\}$
3. pull A, test A for goal, expand A, add child C to Q, Q = $\{C_7, B_7\}$
4. drop C, since fcost(C) is greater than 5, Q = $\{B_7\}$
5. drop B, since fcost(B) is greater than 5, Q = { }

We set the fcost limit for the next iteration to 7, because that was the next value on the Q greater than our current limit of 5.

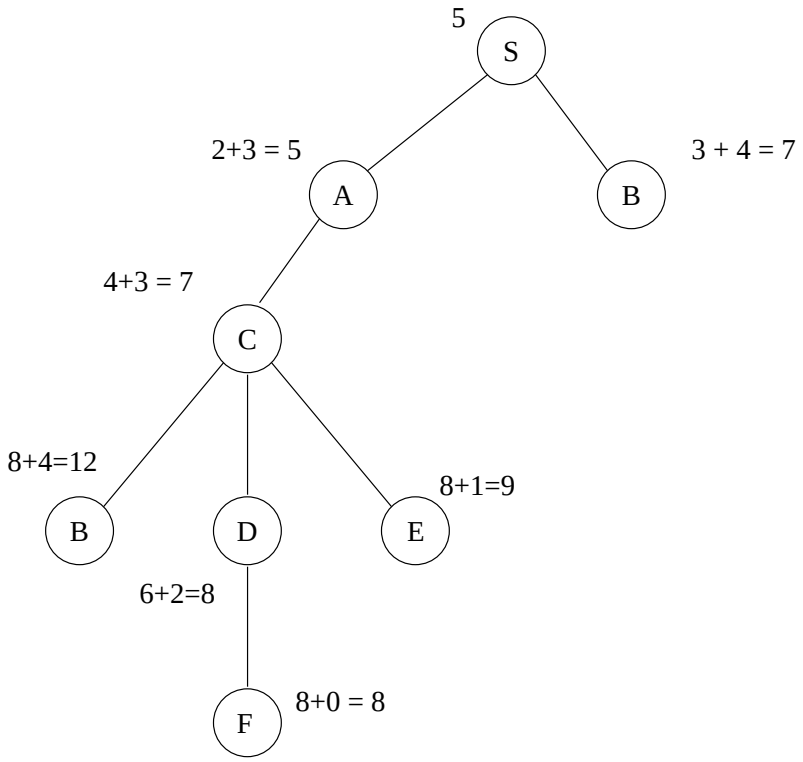
Iteration 2: fcost limit is 7



1. Q = {S}
2. pull S, test S for goal, expand S, add children A B to Q, Q = $\{A_5, B_7\}$
3. pull A, test A for goal, expand A, add child C to Q, Q = $\{C_7, B_7\}$
4. pull C, test C for goal, expand C, add children B D E to Q, Q = $\{B_{12}, D_8, E_9, B_7\}$
5. drop B, since fcost(B) is greater than 7, Q = $\{D_8, E_9, B_7\}$
6. drop D, since fcost(D) is greater than 7, Q = $\{E_9, B_7\}$
7. drop E, since fcost(E) is greater than 7, Q = $\{B_7\}$
8. pull B, test B for goal, expand B, add children C G to Q, Q = $\{C_{10}, G_9\}$
9. drop C, since fcost(C) is greater than 7, Q = $\{G_9\}$
10. drop G, since fcost(G) is greater than 7, Q = { }

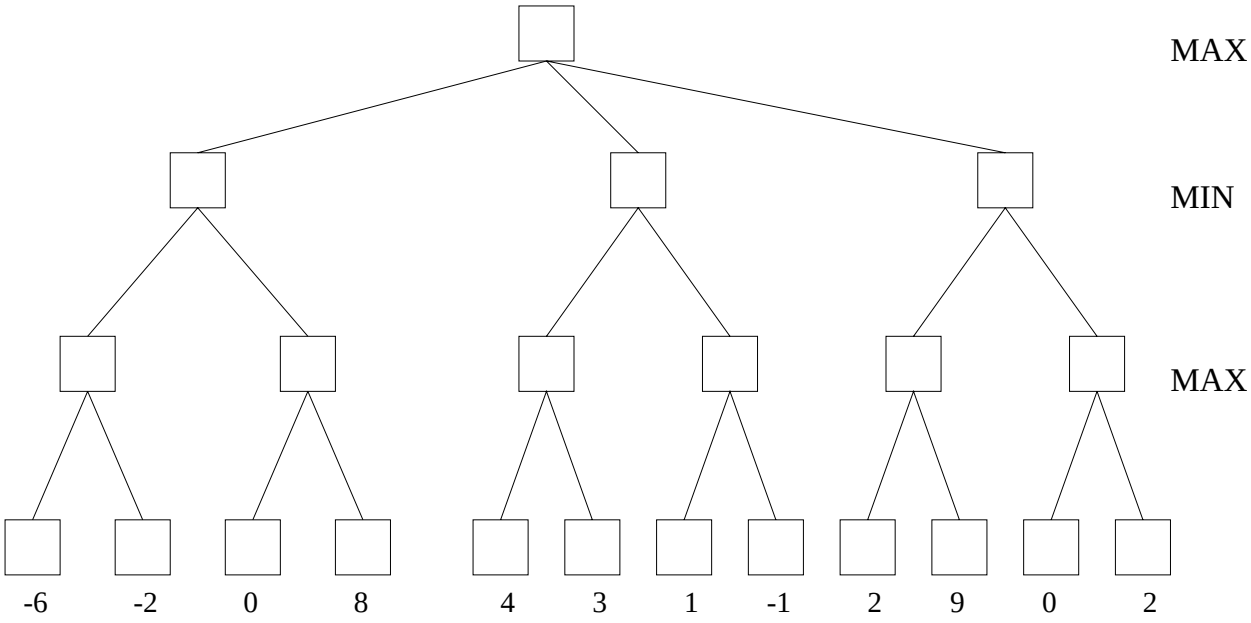
Set the fcost limit for the next iteration to 8.

Iteration 3: fcost limit is 8



1. Q = {S}
2. pull S, test S for goal, expand S, add children A B to Q, Q = $\{A_5, B_7\}$
3. pull A, test A for goal, expand A, add child C to Q, Q = $\{C_7, B_7\}$
4. pull C, test C for goal, expand C, add children B D E to Q, Q = $\{B_{12}, D_8, E_9, B_7\}$
5. drop B, since fcost(B) is greater than 8, Q = $\{D_8, E_9, B_7\}$
6. pull D, test D for goal, expand D, add child F to Q, Q = $\{F_8, E_9, B_7\}$
7. pull F, test F for goal – success

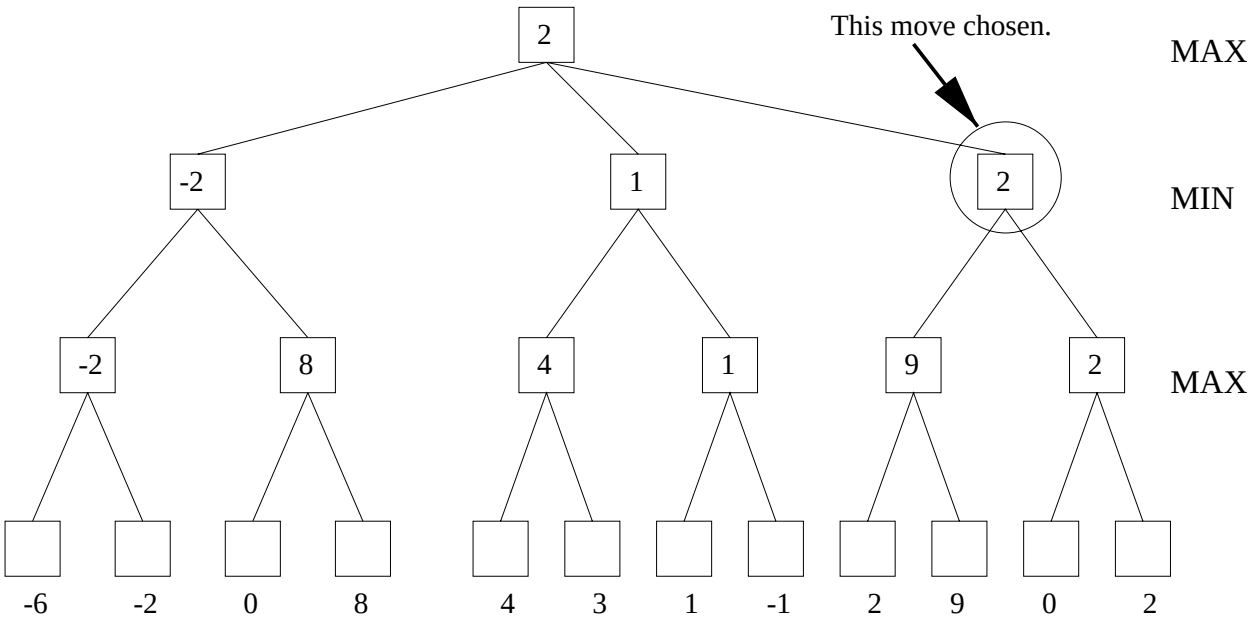
(2) Shown below is a game tree where the root node is a MAX node.



Assume that:

- the tree is explored by minimax in a left to right manner
- the tree is explored to depth 3 and no further
- the numbers beneath the leaves of the tree are the evaluation function values for the corresponding states

Write in the boxes the minimax values for each state. Indicate the move chosen by MAX (the computer) as its first move.


2
This move chosen.
MAX
-2
1
2
MIN
-2
8
4
1
9
2
MAX
-6
-2
0
8
4
3
1
-1
2
9
0
2