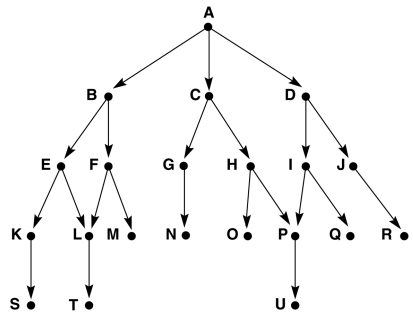
COMP 6721 Applied Artificial Intelligence (Winter 2021)

Worksheet #1: Solving Problems by Searching

Breadth-First Search. Let's apply the BFS algorithm discussed in the lecture on an example:

```
begin
  open := [Start];                                              % initialize
  closed := [ ];
  while open ≠ [ ] do                                           % states remain
    begin
      remove leftmost state from open, call it X;
        if X is a goal then return SUCCESS                      % goal found
          else begin
            generate children of X;
            put X on closed;
            discard children of X if already on open or closed; % loop check
            put remaining children on right end of open         % queue
          end
    end
  return FAIL                                                   % no states left
end.
```



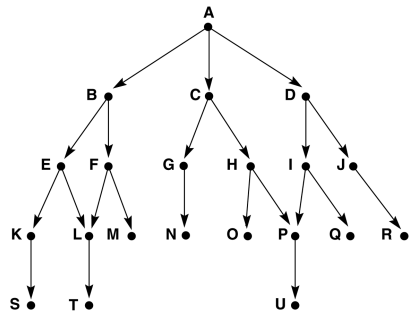
Assume **U** is the **goal state**. Note that **open** is a **queue**:

1. open $= [A_{\text{null}}]$, closed $= [\ ]$
2. open $= [B_A\ C_A\ D_A]$, closed $= [A]$
3. open $= [C_A\ D_A\ E_B\ F_B]$, closed $= [B\ A]$
4. open $= [$ ..... $]$, closed $= [$ ..... $]$
5. open $= [$ ..... $]$, closed $= [$ ..... $]$
6. open $= [$ ..... $]$, closed $= [$ ..... $]$
7. open $= [$ ..... $]$, closed $= [$ ..... $]$

Depth-First Search. Now we do the same for the DFS algorithm:

Function depth_first_search algorithm

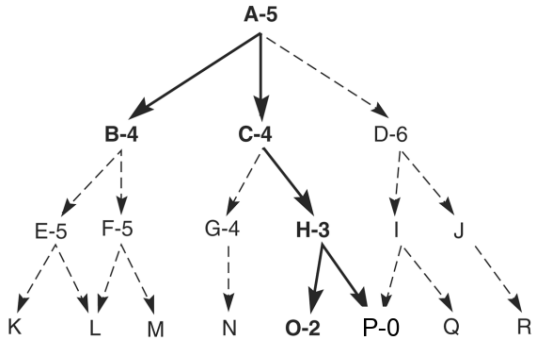
```
begin
  open := [Start];                                              % initialize
  closed := [ ];
  while open ≠ [ ] do                                           % states remain
    begin
      remove leftmost state from open, call it X;
      if X is a goal then return SUCCESS                        % goal found
        else begin
          generate children of X;
          put X on closed;
          discard children of X if already on open or closed;   % loop check
          put remaining children on left end of open            % stack
        end
    end;
  return FAIL                                                   % no states left
end.
```



Again, assume **U** is the **goal state**. Note that **open** is a **stack**:

1. open $= [A_{\text{null}}]$, closed $= [\ ]$
2. open $= [B_A\ C_A\ D_A]$, closed $= [A]$
3. open $= [E_B\ F_B\ C_A\ D_A]$, closed $= [B\ A]$
4. open $= [K_E\ L_E\ F_B\ C_A\ D_A]$, closed $= [E\ B\ A]$
5. open $= [S_K\ L_E\ F_B\ C_A\ D_A]$, closed $= [K\ E\ B\ A]$
6. open $= [$ ..... $]$, closed $= [$ ..... $]$
7. open $= [$ ..... $]$, closed $= [$ ..... $]$
8. open $= [$ ..... $]$, closed $= [$ ..... $]$
9. open $= [$ ..... $]$, closed $= [$ ..... $]$
10. open $= [$ ..... $]$, closed $= [$ ..... $]$

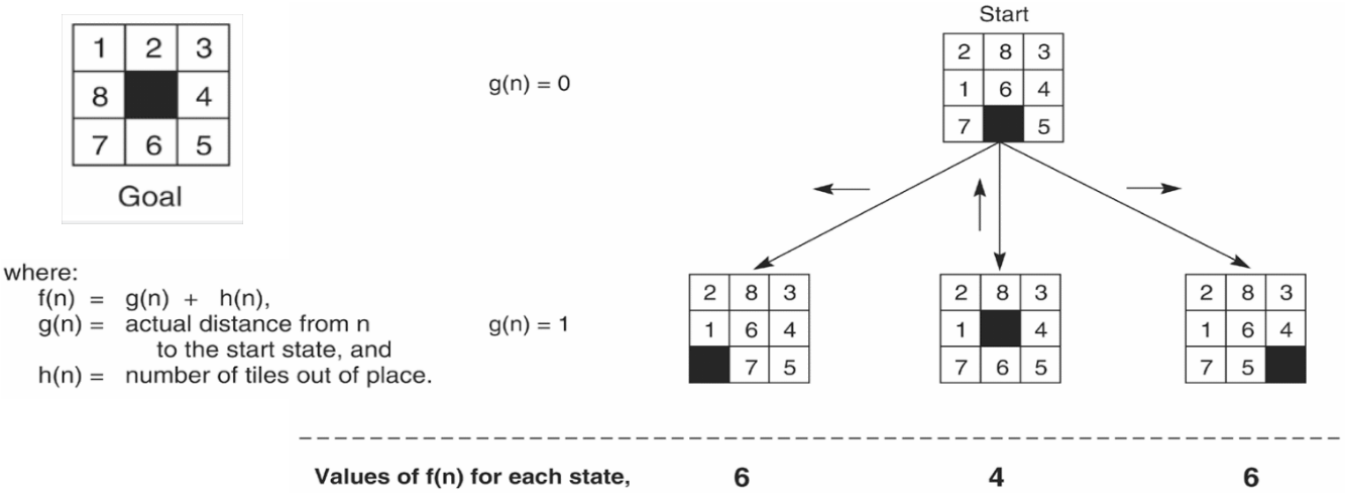
Best-First Search. Next, we try a best-first (greedy) search. We have a heuristic $h(n)$ that estimates the cost for each path. The goal is **P**. At each step, expand the node with the *lowest* cost (as predicted by the heuristic):



1. open = $[A^5_{\text{null}}]$, closed = [ ]
2. open = $[B^4_A\ C^4_A\ D^6_A]$ *(random choice)*, closed = $[A]$
3. open = $[C^4_A\ E^5_B\ F^5_B\ D^6_A]$, closed = $[B\ A]$
4. open = [.....], closed = [.....]
5. open = [.....], closed = [.....]
6. ..... ???

Finally, *extract the path to the solution* from the search result: .....

Algorithm A. Compute the next step of the Algorithm A on the 8-puzzle:



1. Pick the state with the *lowest* total cost $f(n)$
2. and compute the next possible search states, including the new values of $f(n)$, $g(n)$ and $h(n)$.