CS-2001
DATA STRUCTURE

Dr. Hashim Yasin

National University of Computer and Emerging Sciences,

Faisalabad, Pakistan.

DEPTH FIRST SEARCH

Depth First Search

Go as deep as can visiting un-visited nodes

Choose any un-visited vertex when you have a choice

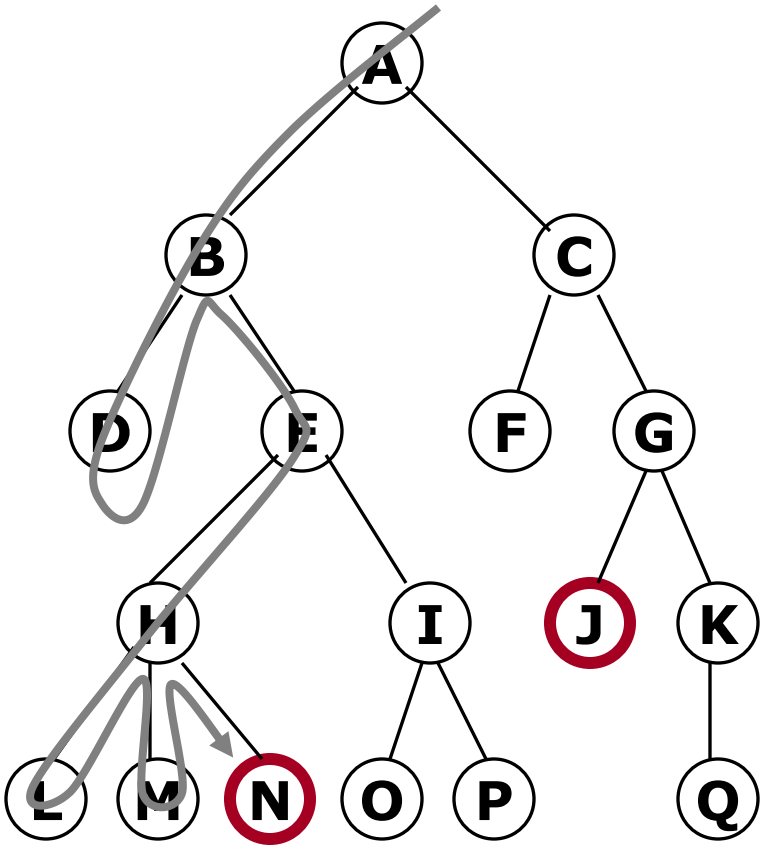
If stuck at a dead-end, backtrack as little as possible

Back up to where you could go to another unvisited vertex

Then continue to go on from that point

Eventually you'll return to where you started

Depth-first searching



A depth-first search (DFS) explores a path all the way to a leaf node before backtracking and exploring another path

For example, after searching A, then B, then D, the search backtracks and tries another path from B

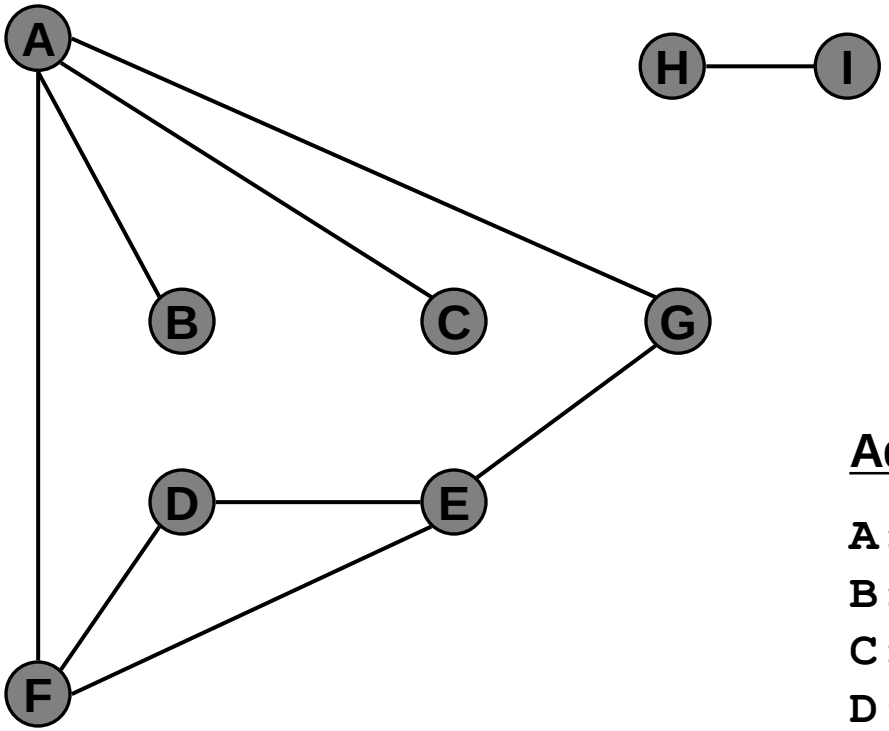
Nodes are explored in the order A B D E H L M N I O P C F G J K Q

N will be found before J

DFS Algorithm

```
create a stack S
mark v as visited and push v onto S
while S is non-empty
        pop at the top u of S
        if u has an (unvisited) neighbor w,
                mark w and push it onto S
        else
                pop S
```

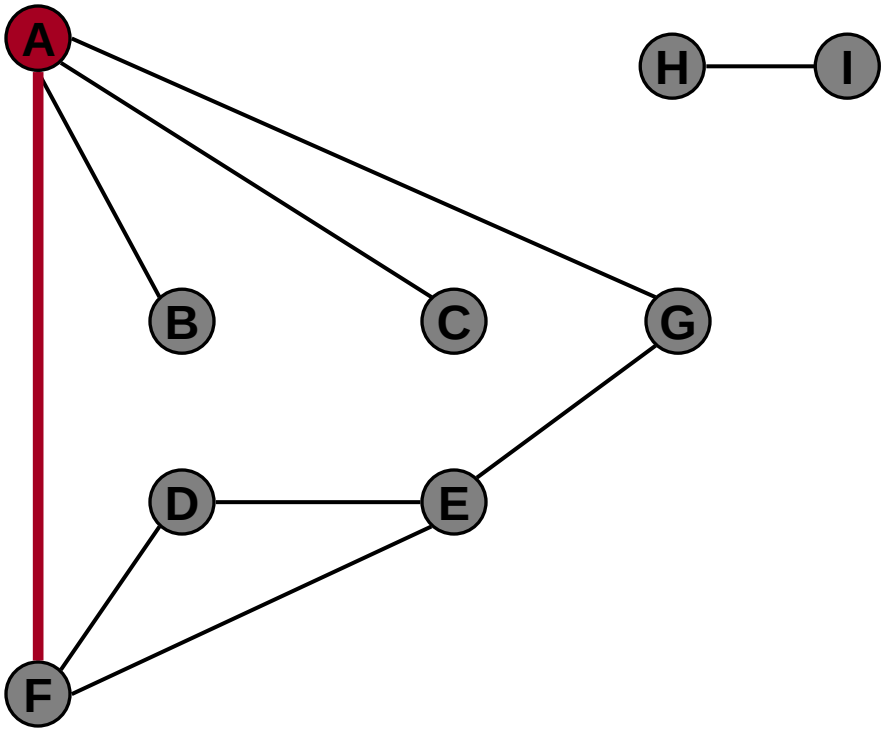
Undirected Depth First Search



Adjacency Lists

```
A:   F C B G
B:   A
C:   A
D:   F E
E:   G F D
F:   A E D:
G:   E A:
H:   I:
I:   H:
```

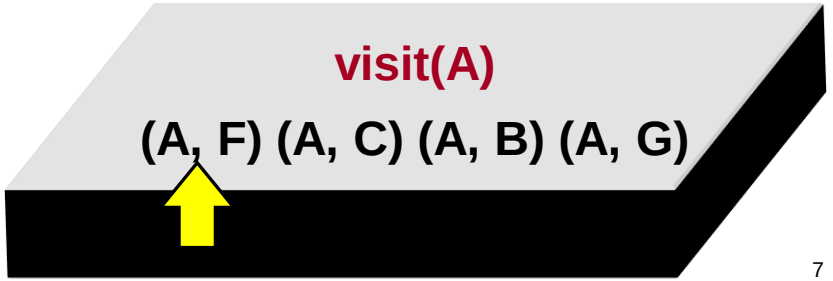
Undirected Depth First Search



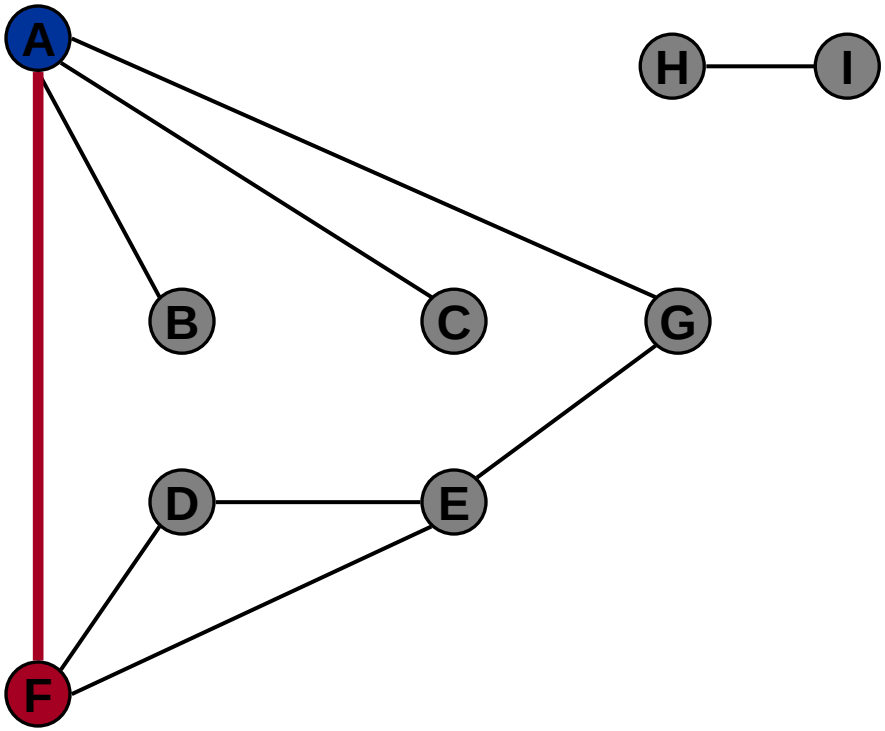
F newly discovered

Undiscovered
Marked
Active
Finished

Stack

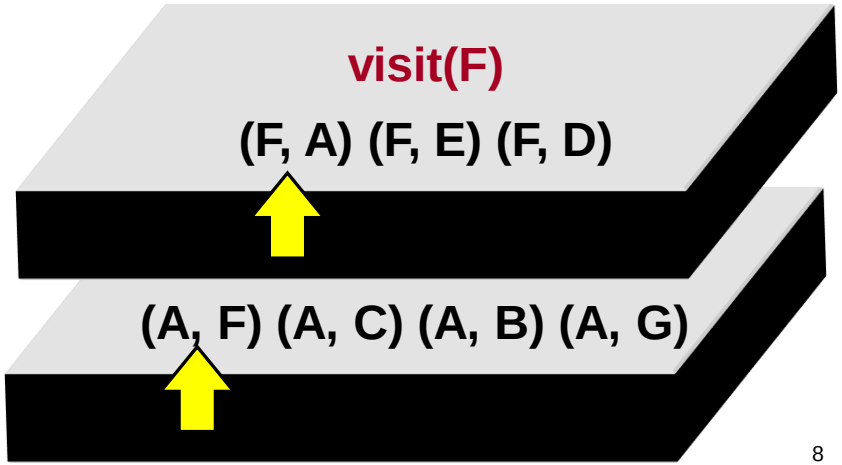


Undirected Depth First Search



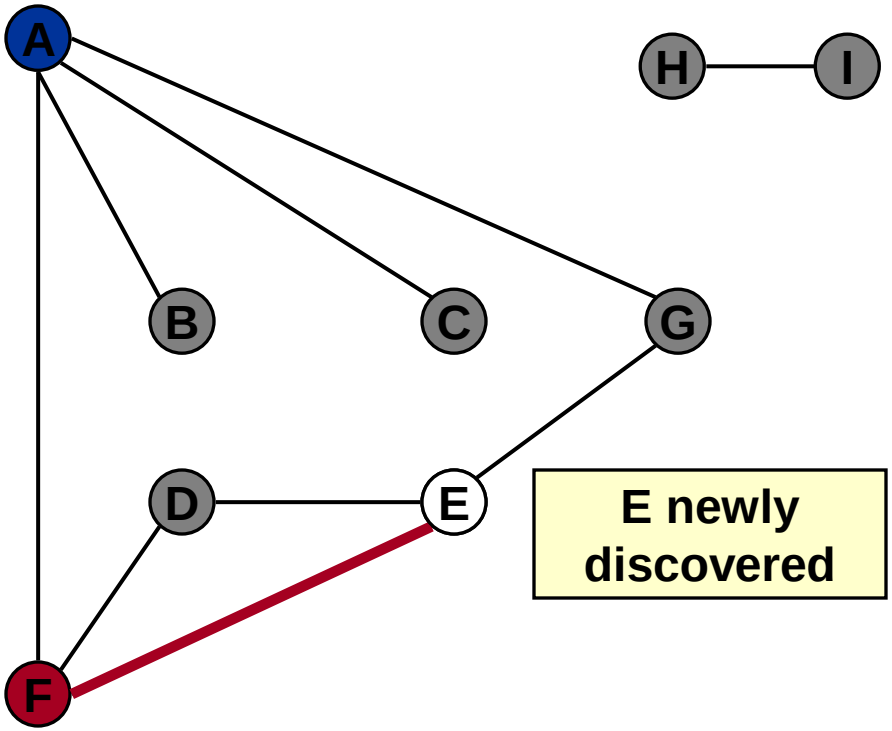
A already marked

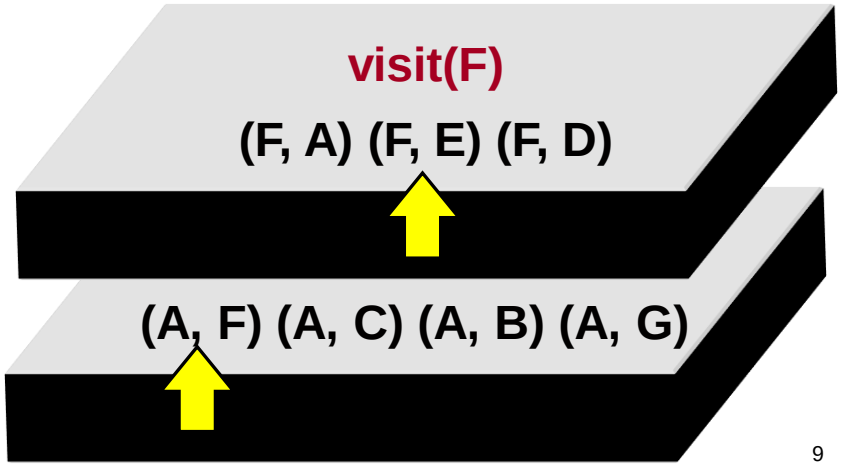
Undiscovered
Marked
Active
Finished



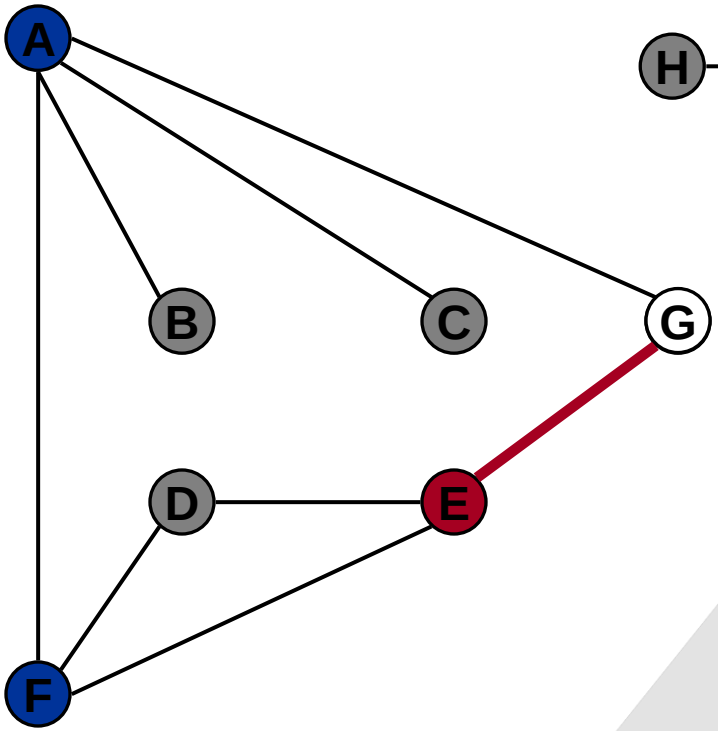
Stack

Undirected Depth First Search

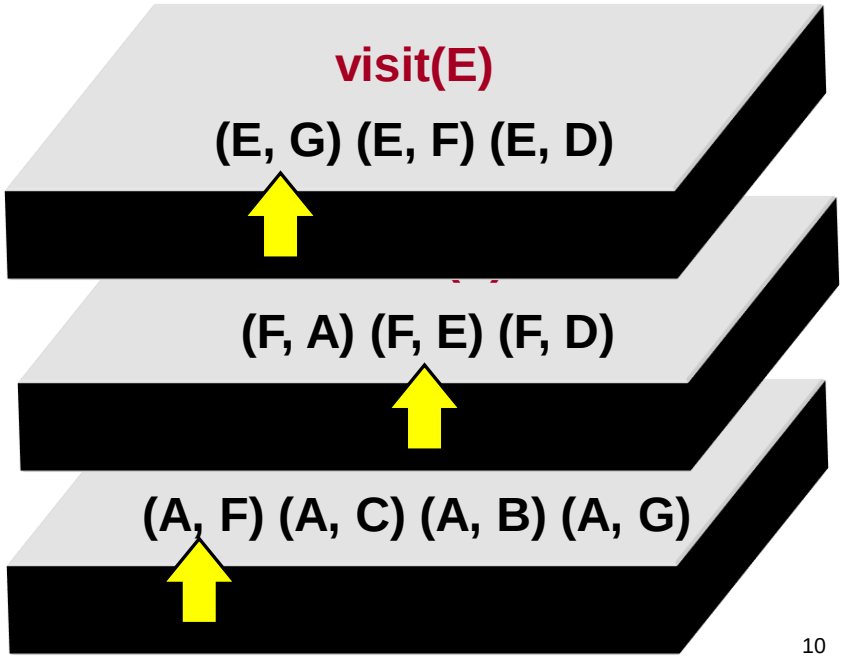




Undirected Depth First Search

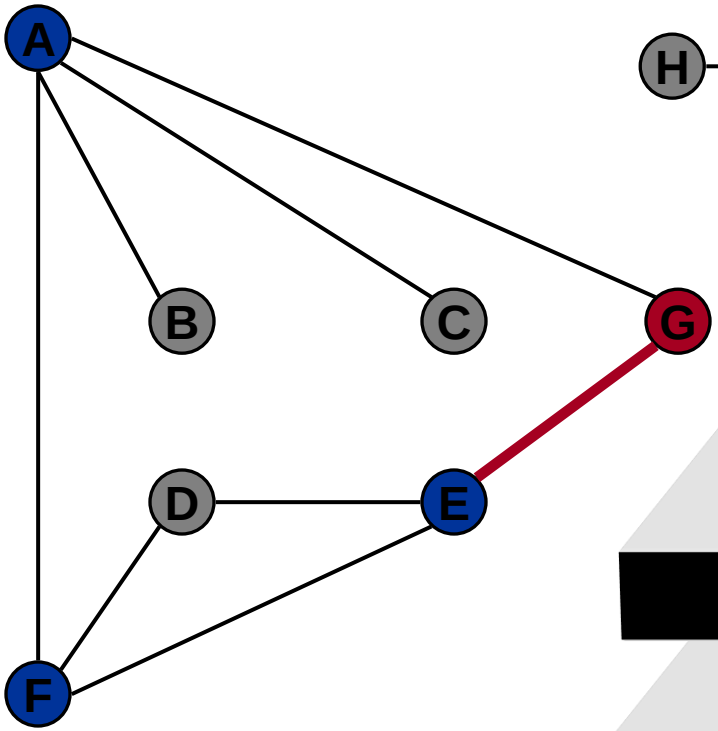


G newly discovered

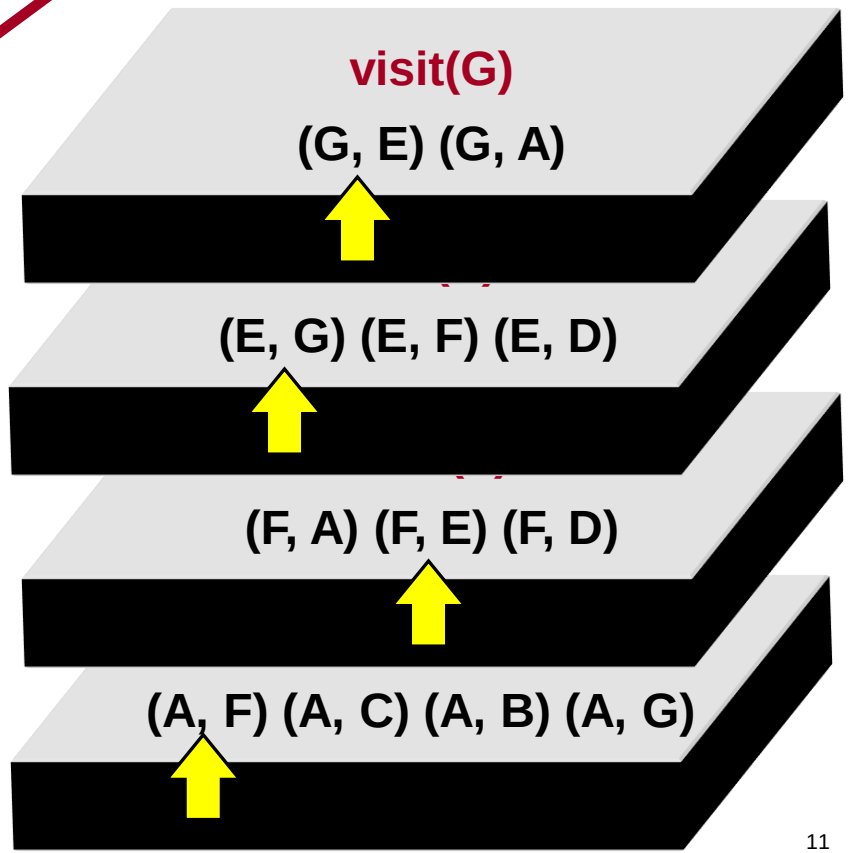


Stack

Undirected Depth First Search

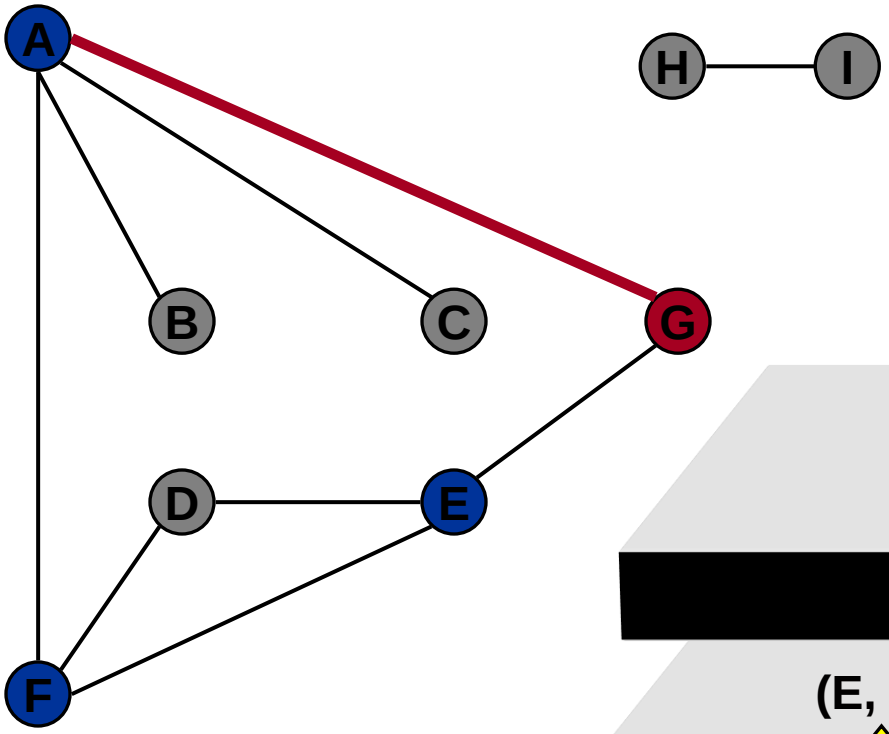


E already marked



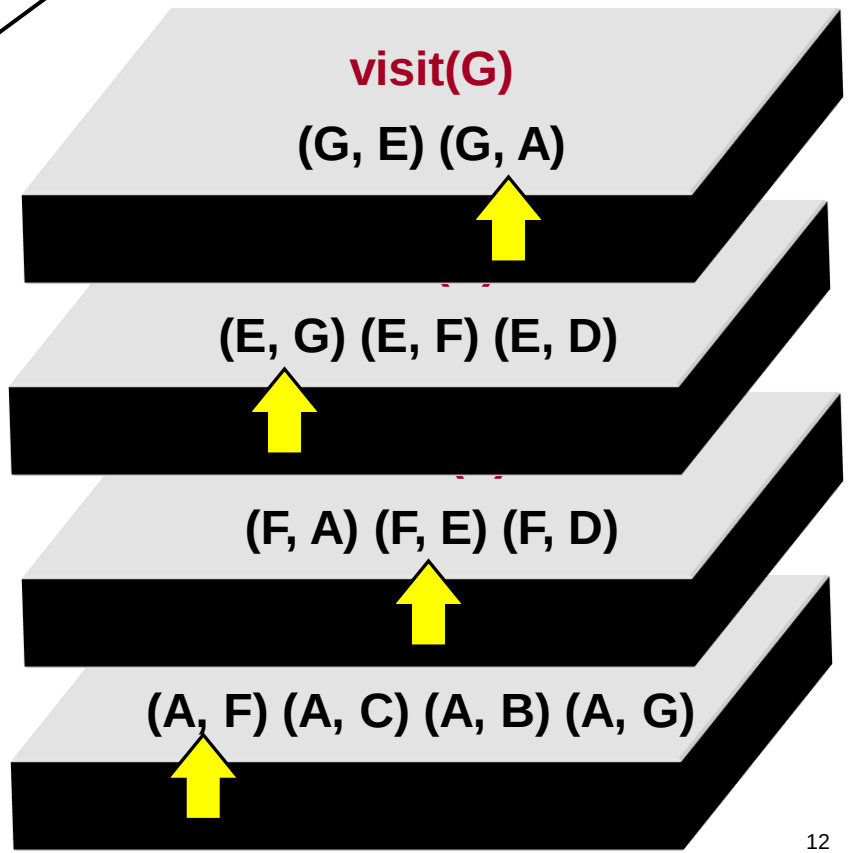
Stack

Undirected Depth First Search



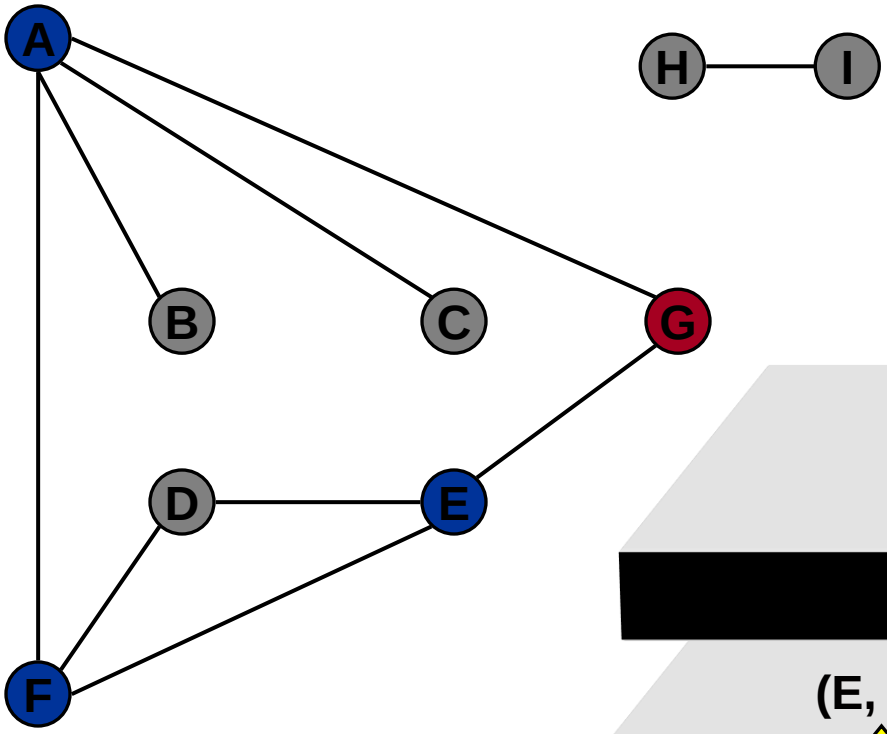
A already marked

Undiscovered
Marked
Active
Finished

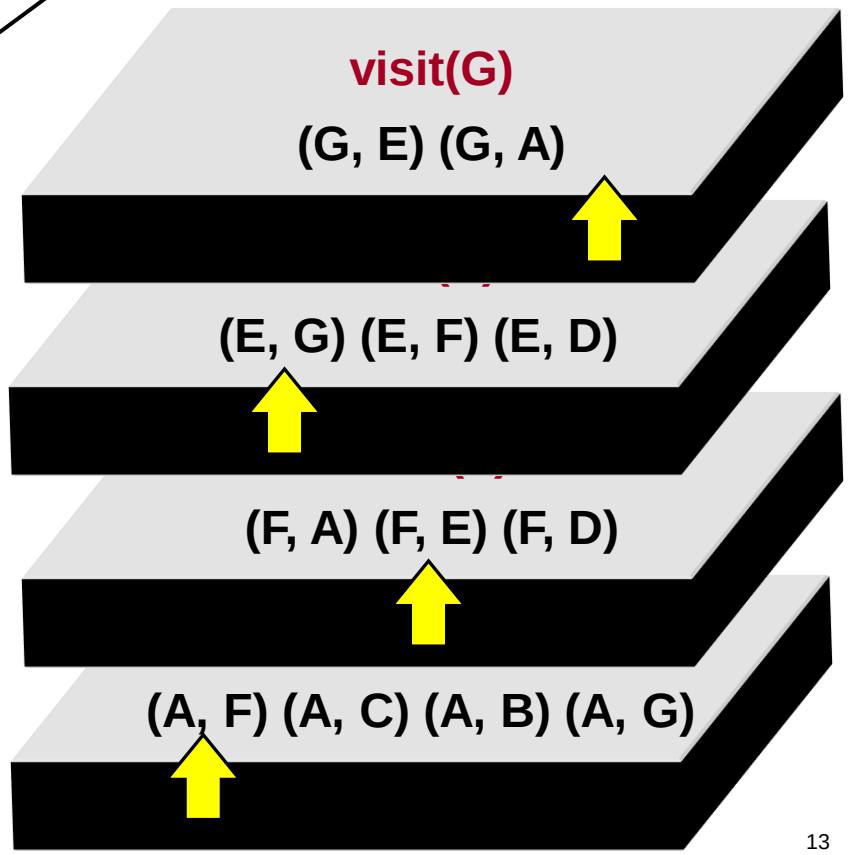


Stack

Undirected Depth First Search



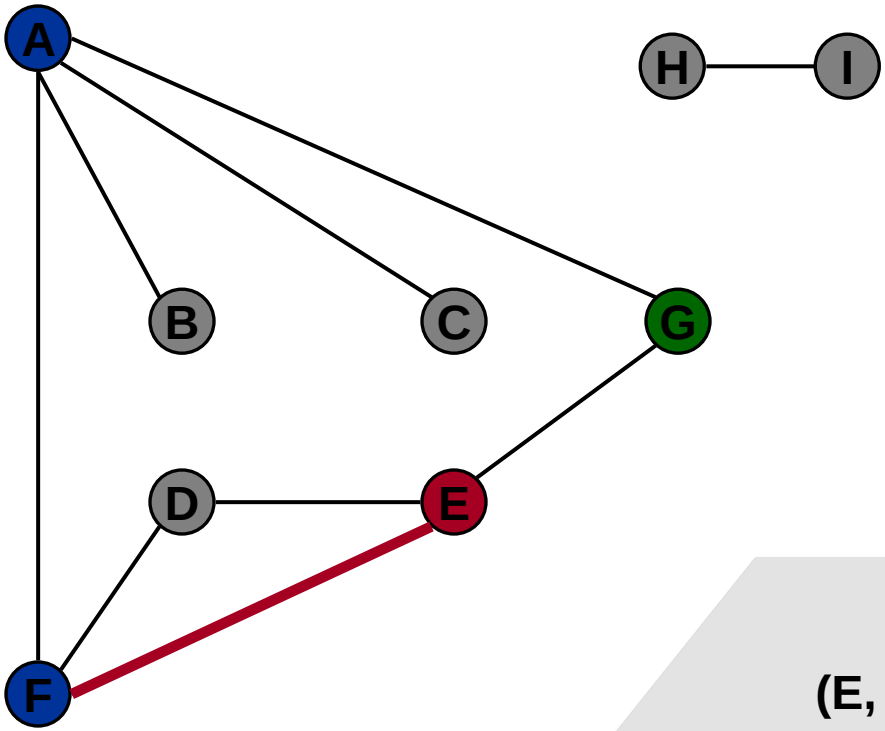
Finished G



Undiscovered
Marked
Active
Finished

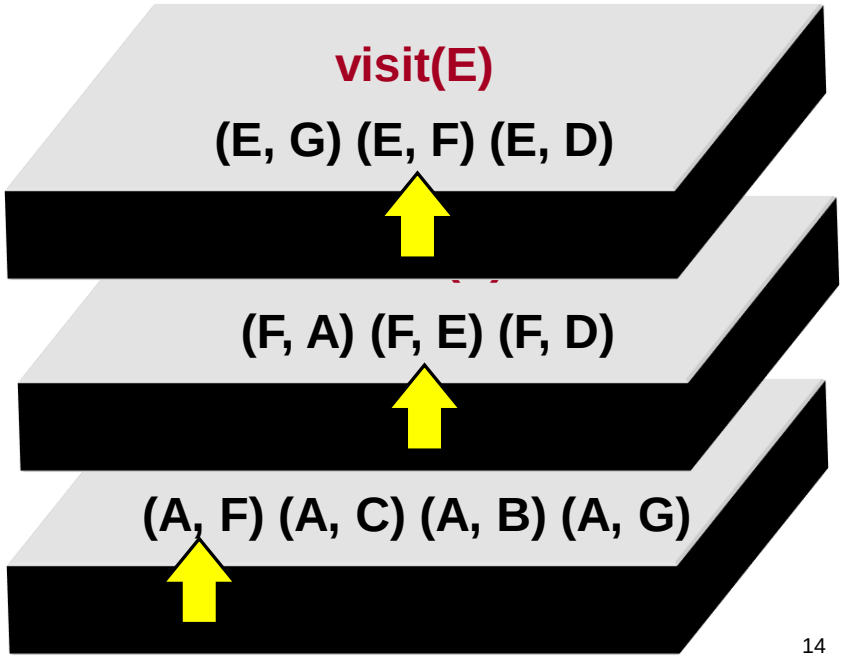
Stack

Undirected Depth First Search



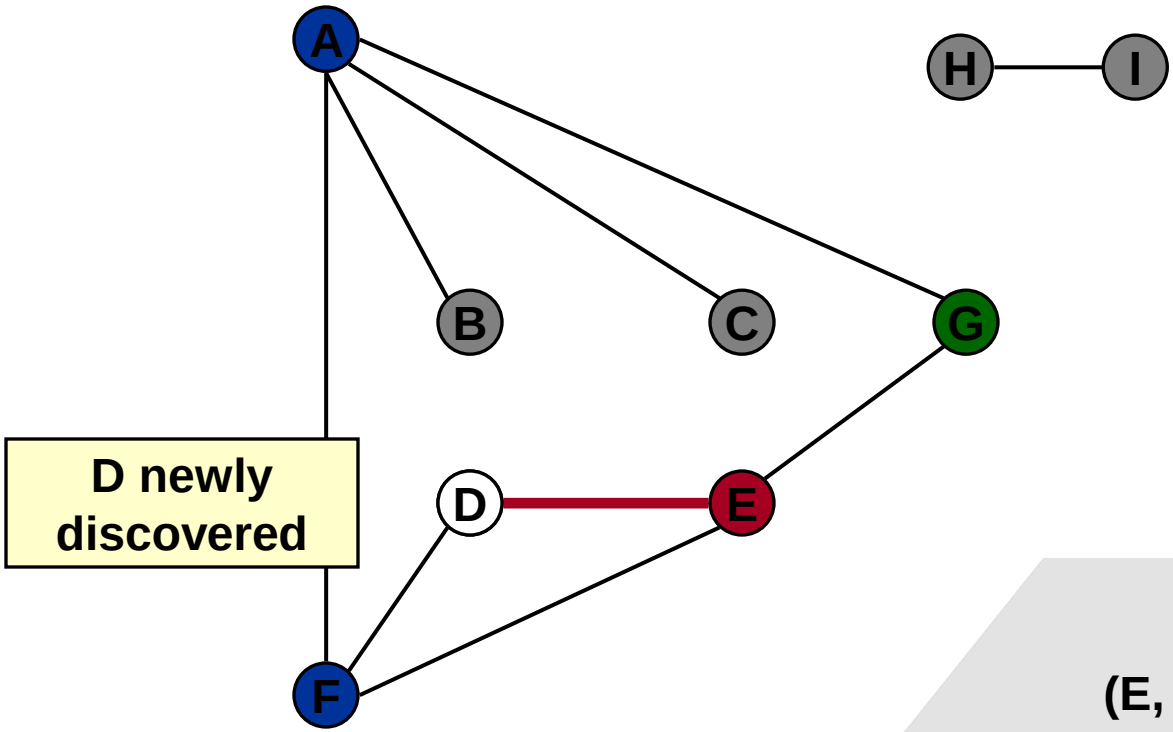
F already marked

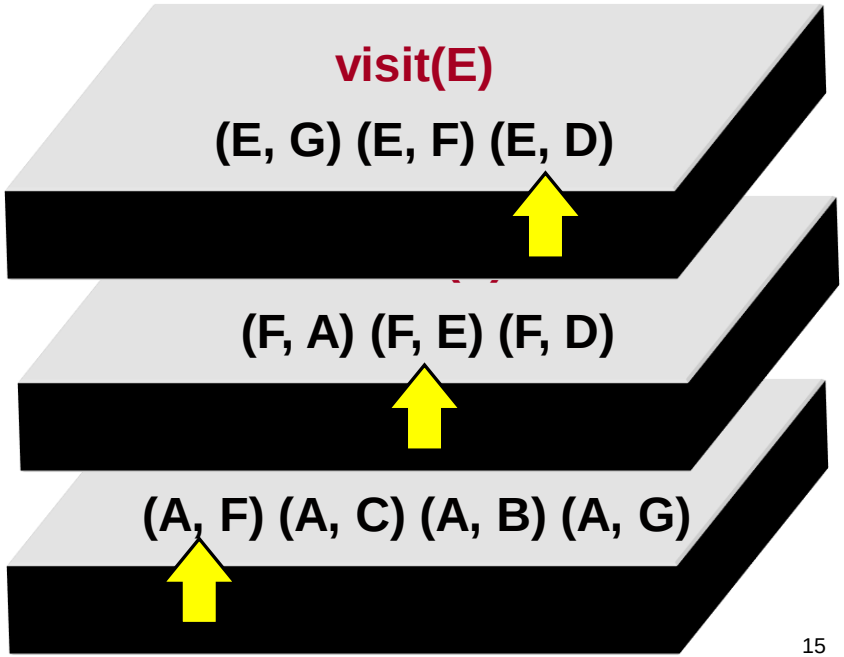
Undiscovered
Marked
Active
Finished



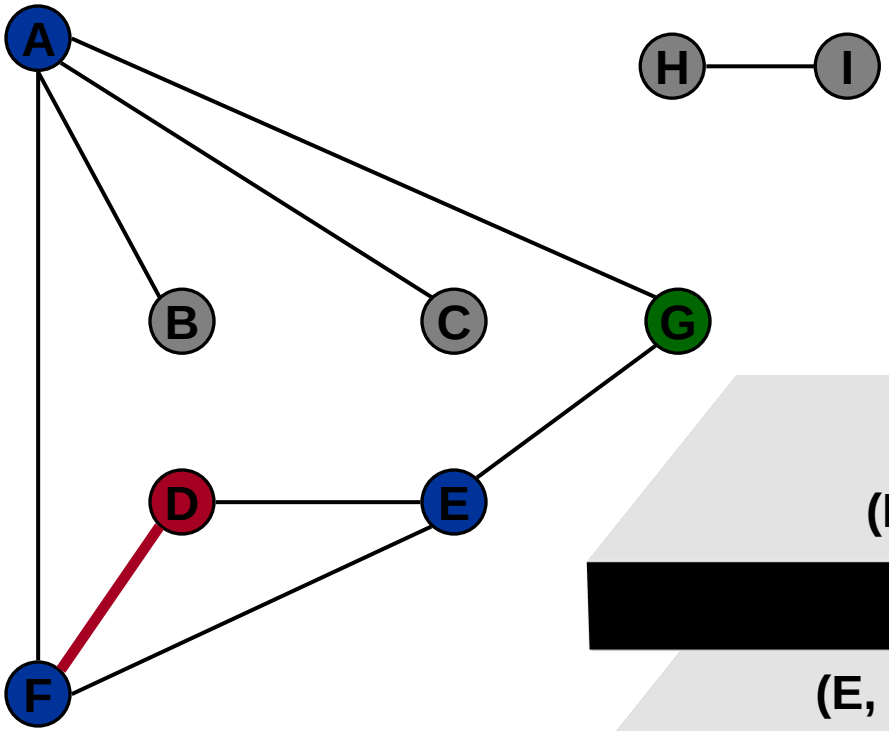
Stack

Undirected Depth First Search

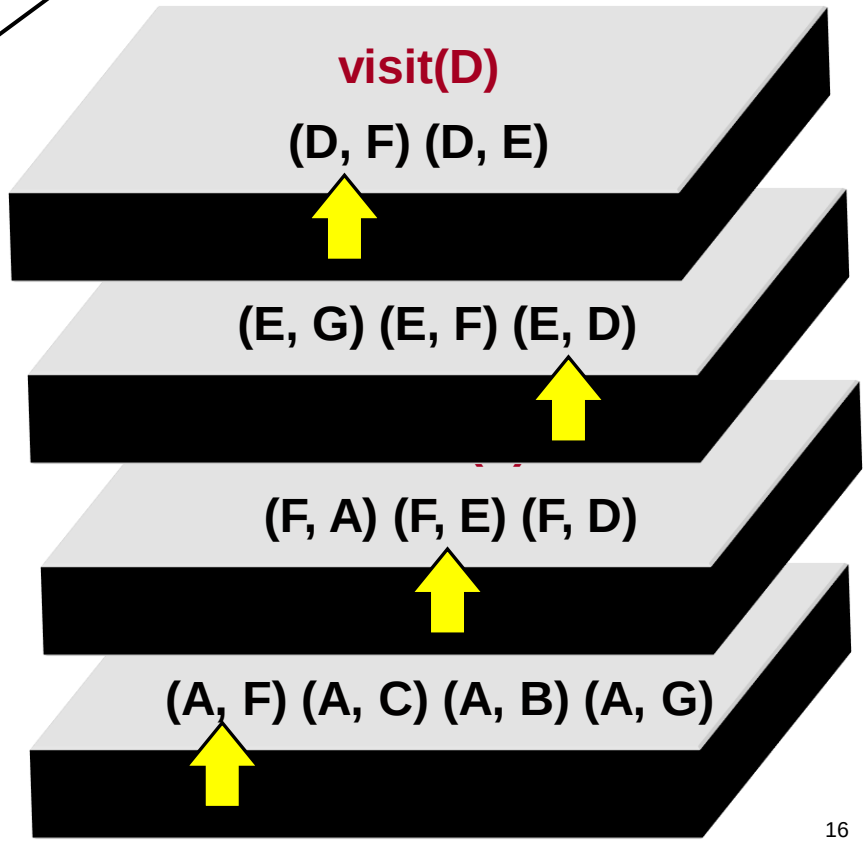




Undirected Depth First Search



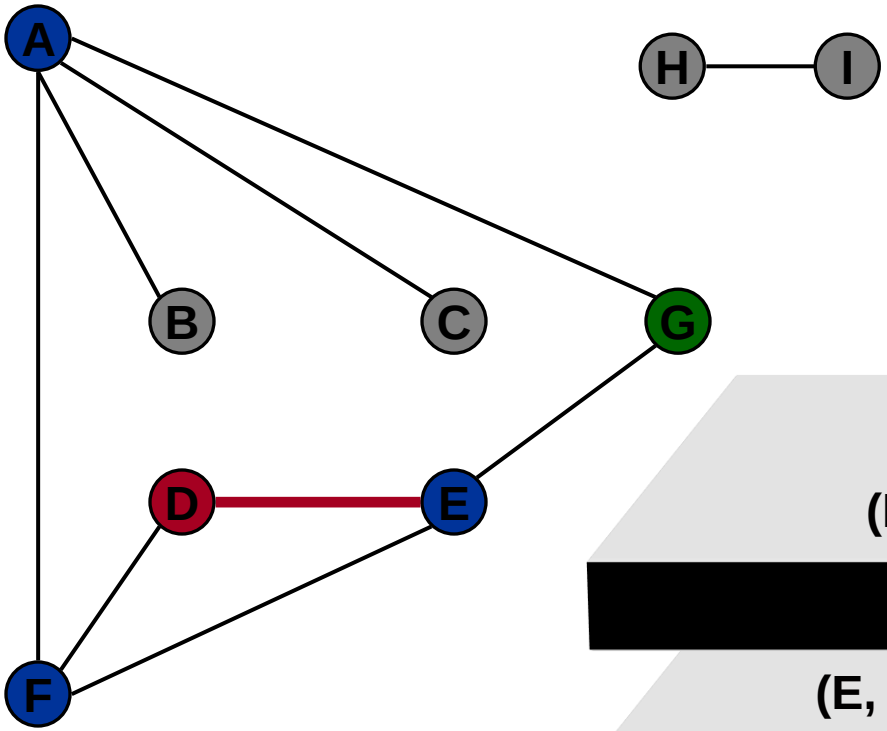
F already marked



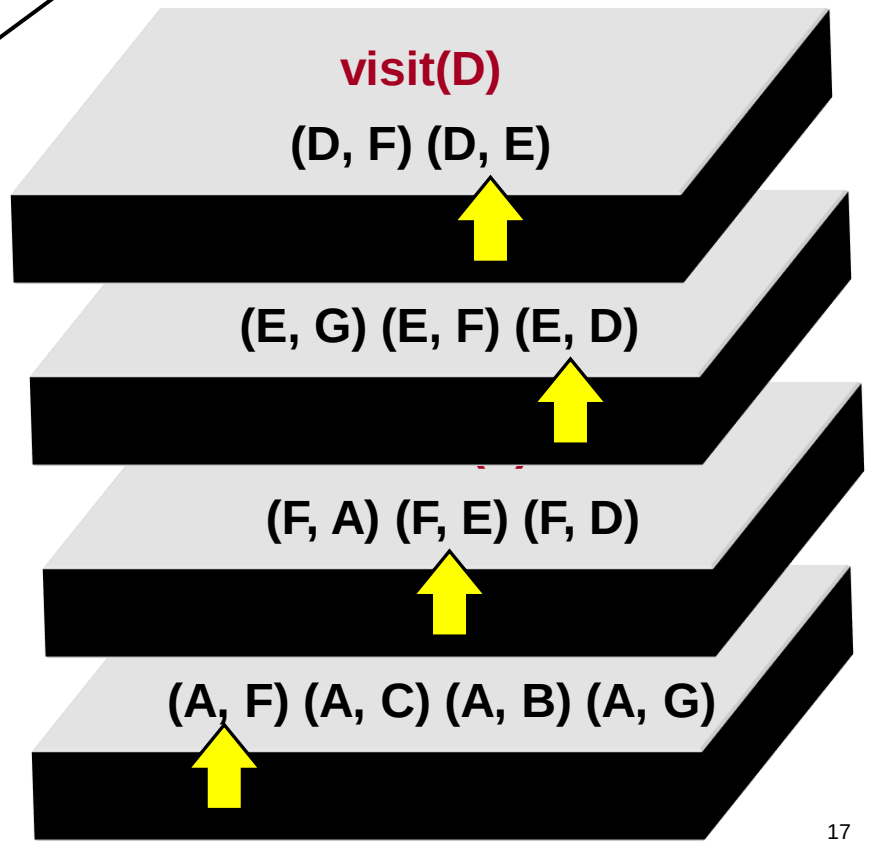
Undiscovered
Marked
Active
Finished

Stack

Undirected Depth First Search

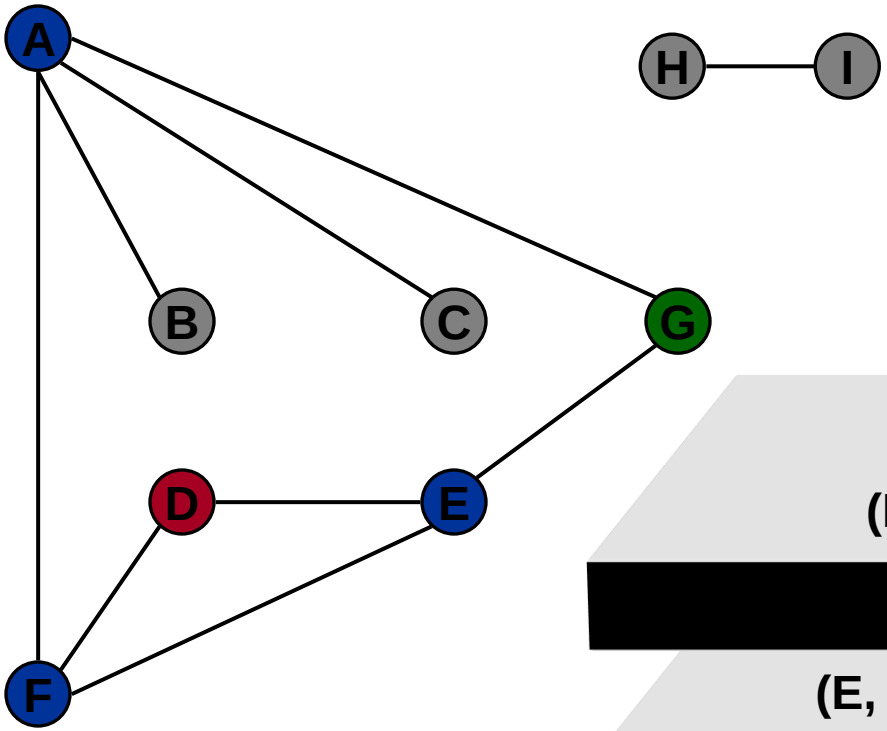


E already marked

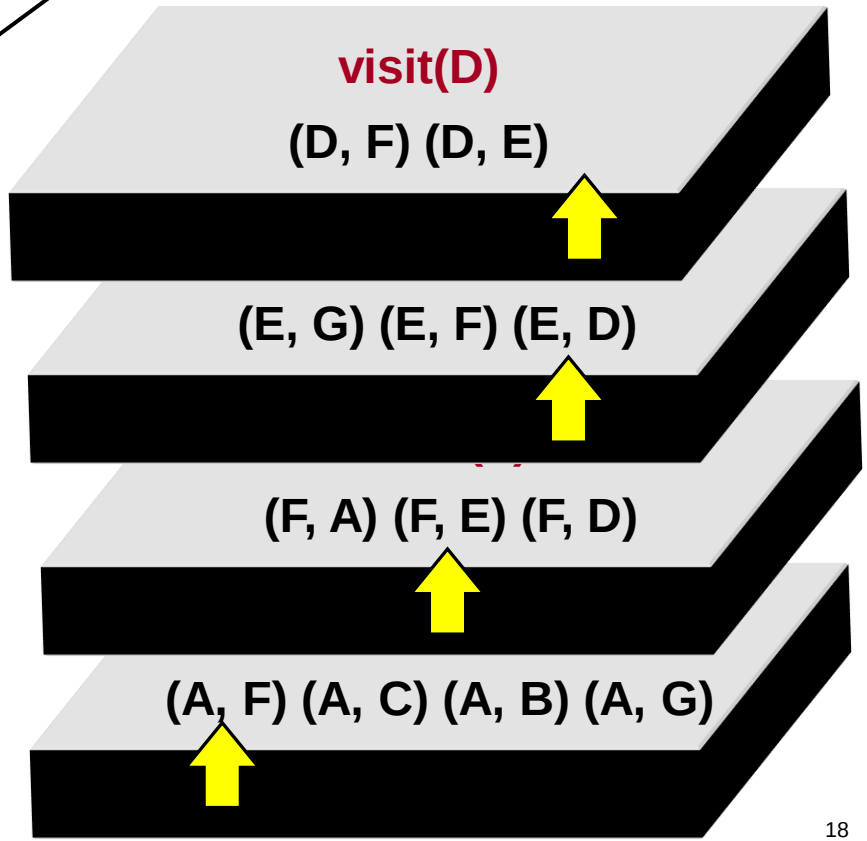


Stack

Undirected Depth First Search



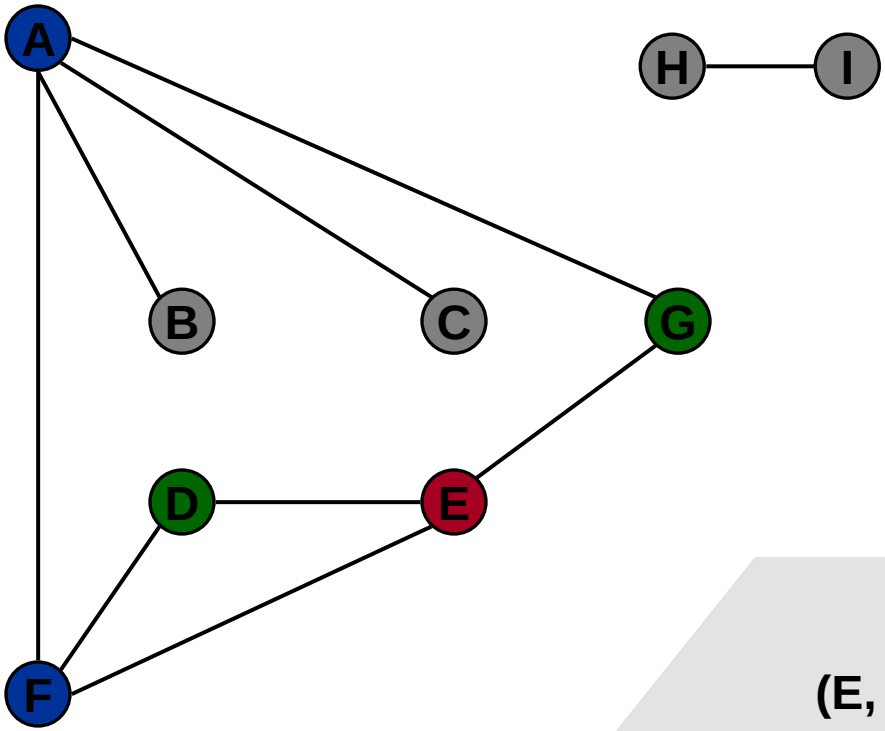
Finished D



Undiscovered
Marked
Active
Finished

Stack

Undirected Depth First Search



Finished E

visit(E)

(E, G) (E, F) (E, D)

(F, A) (F, E) (F, D)

(A, F) (A, C) (A, B) (A, G)

Undiscovered

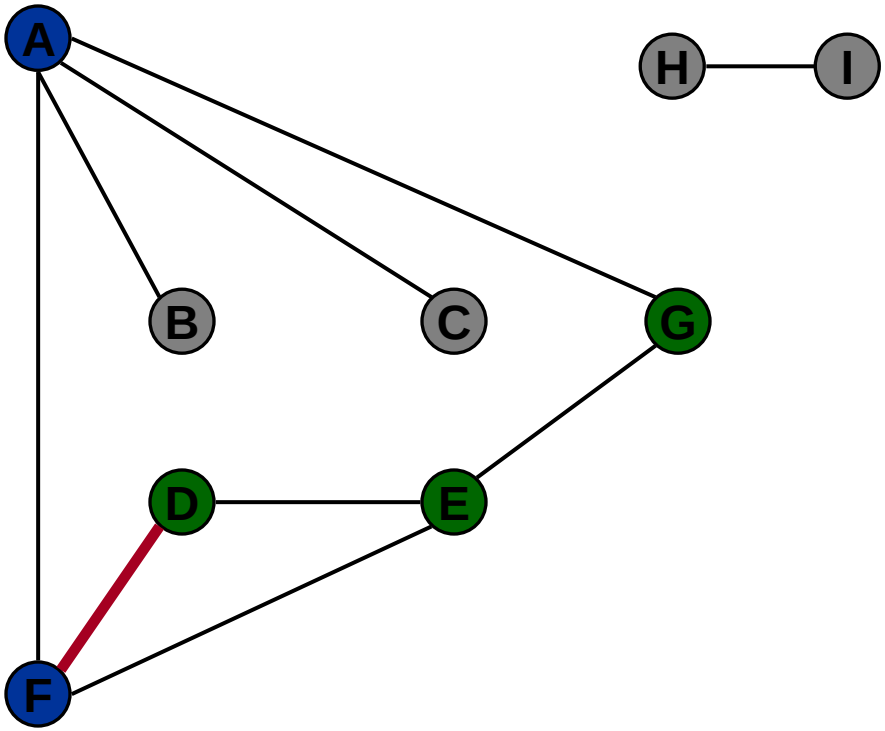
Marked

Active

Finished

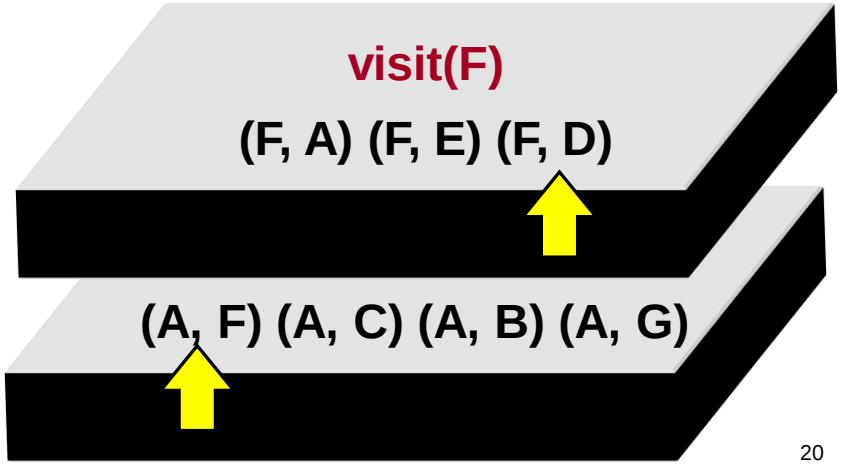
Stack

Undirected Depth First Search



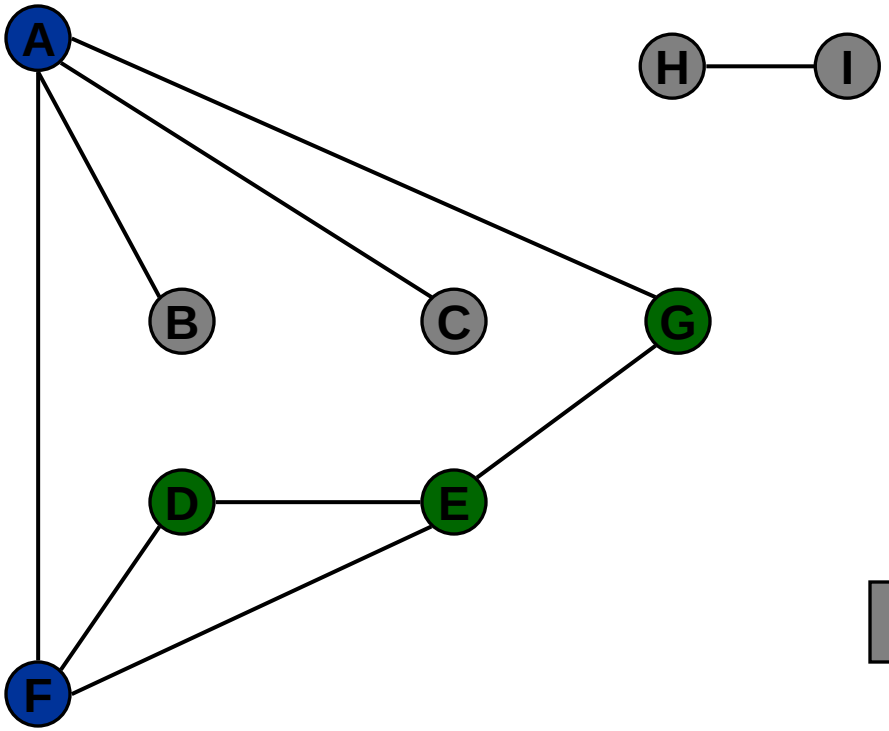
D already marked

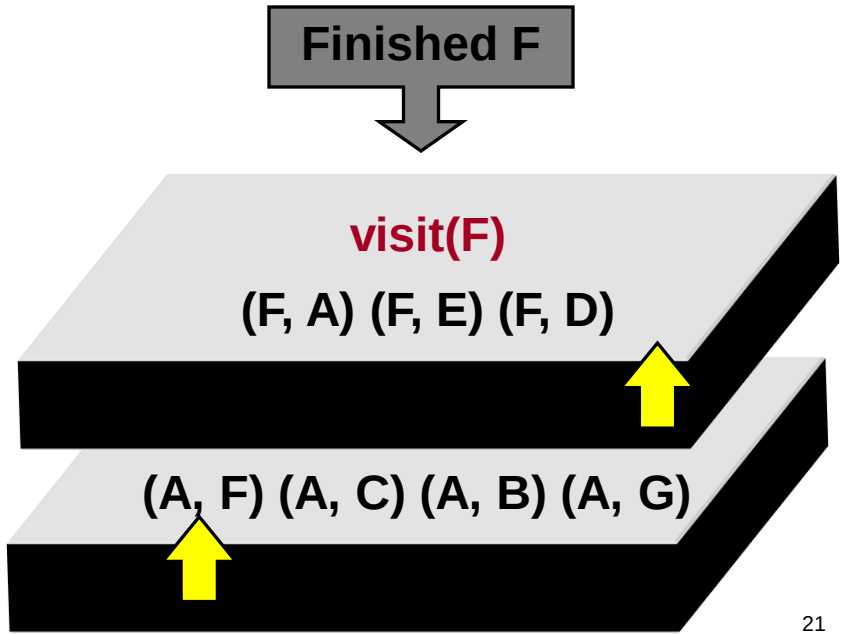
Undiscovered
Marked
Active
Finished



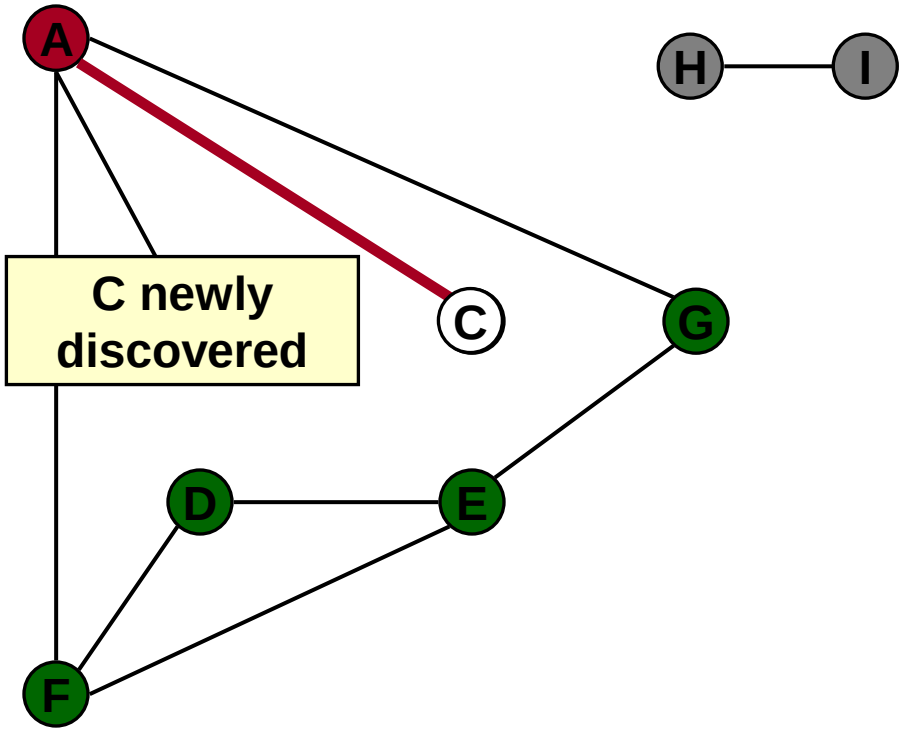
Stack

Undirected Depth First Search



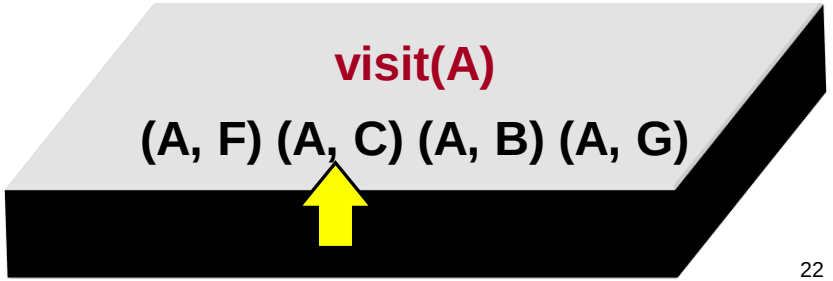


Undirected Depth First Search

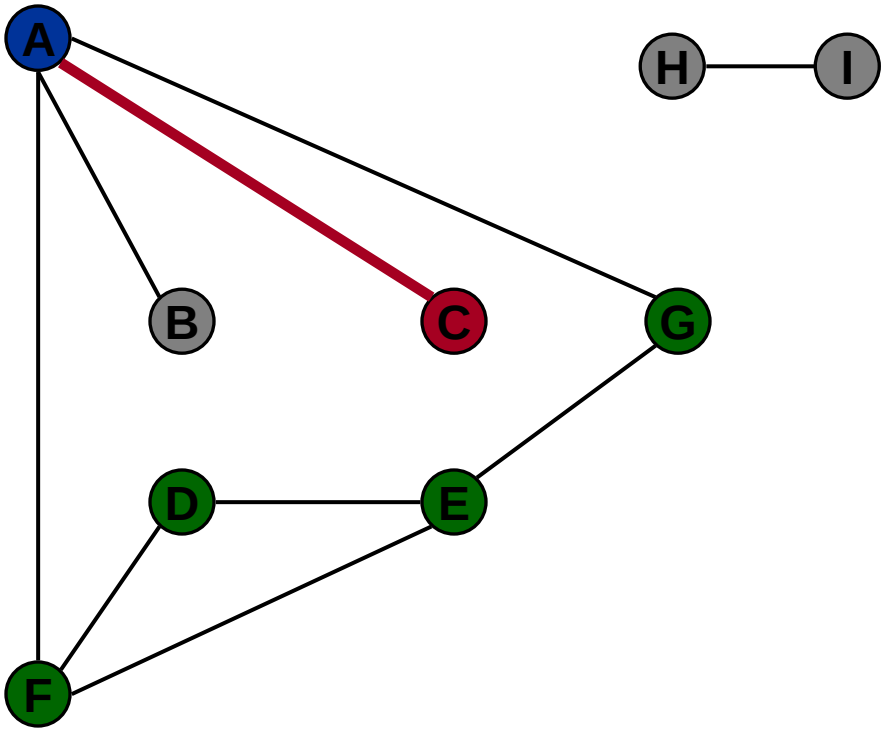


Undiscovered
Marked
Active
Finished

Stack

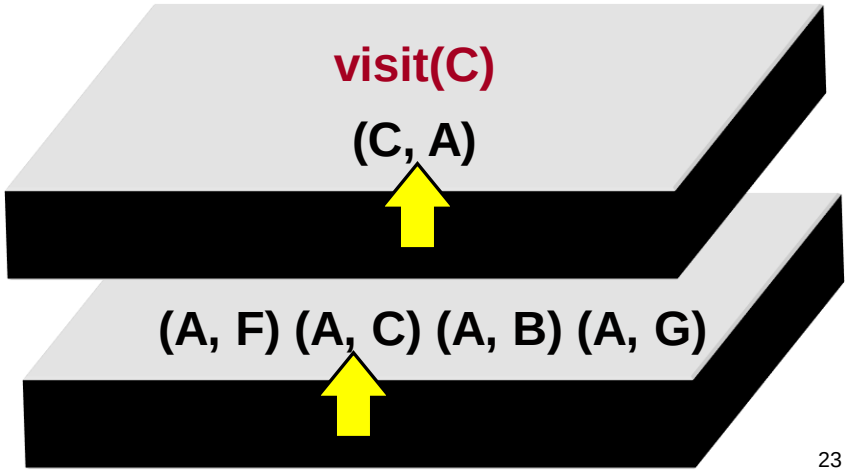


Undirected Depth First Search



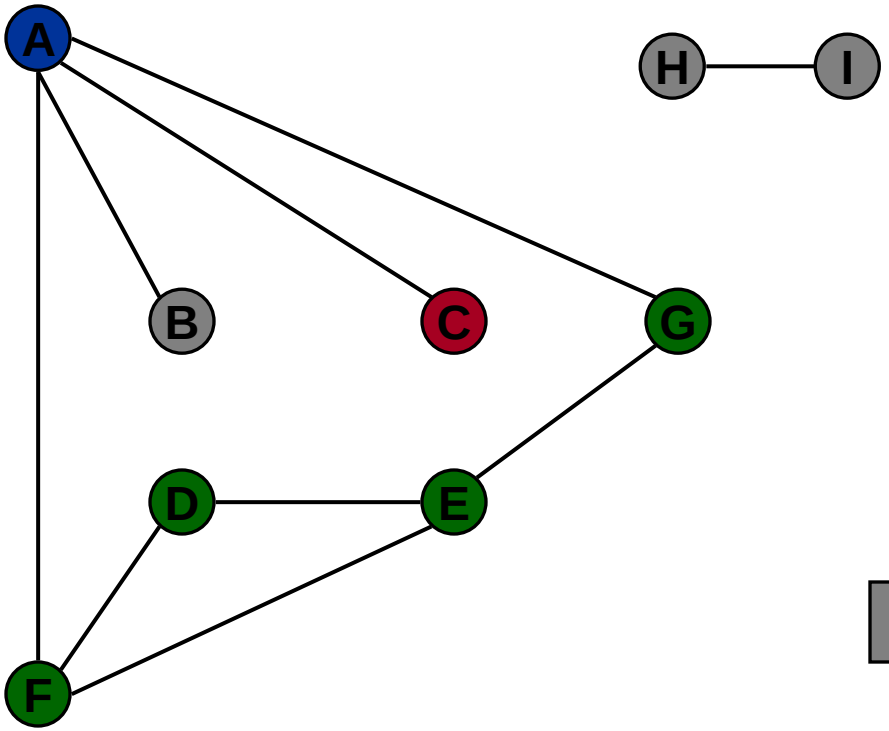
A already marked

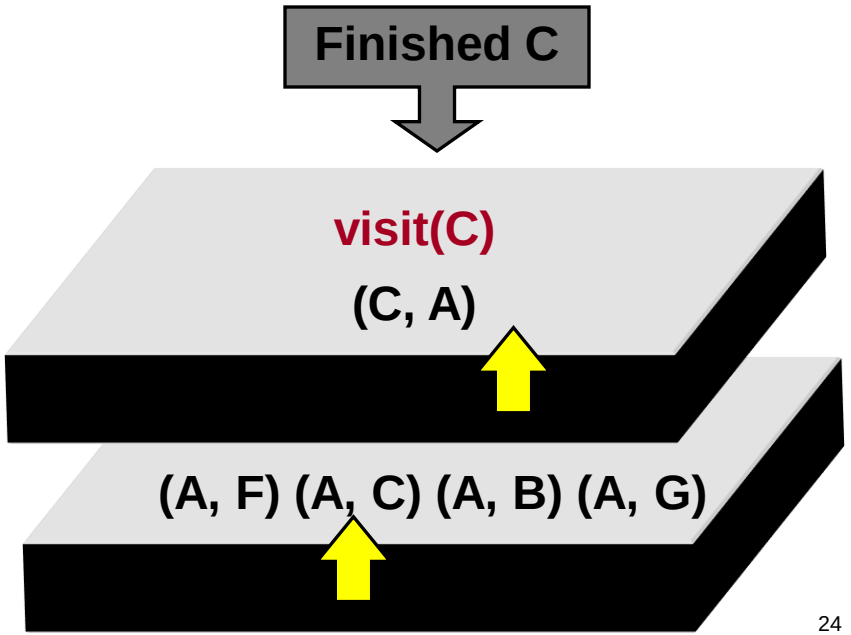
Undiscovered
Marked
Active
Finished



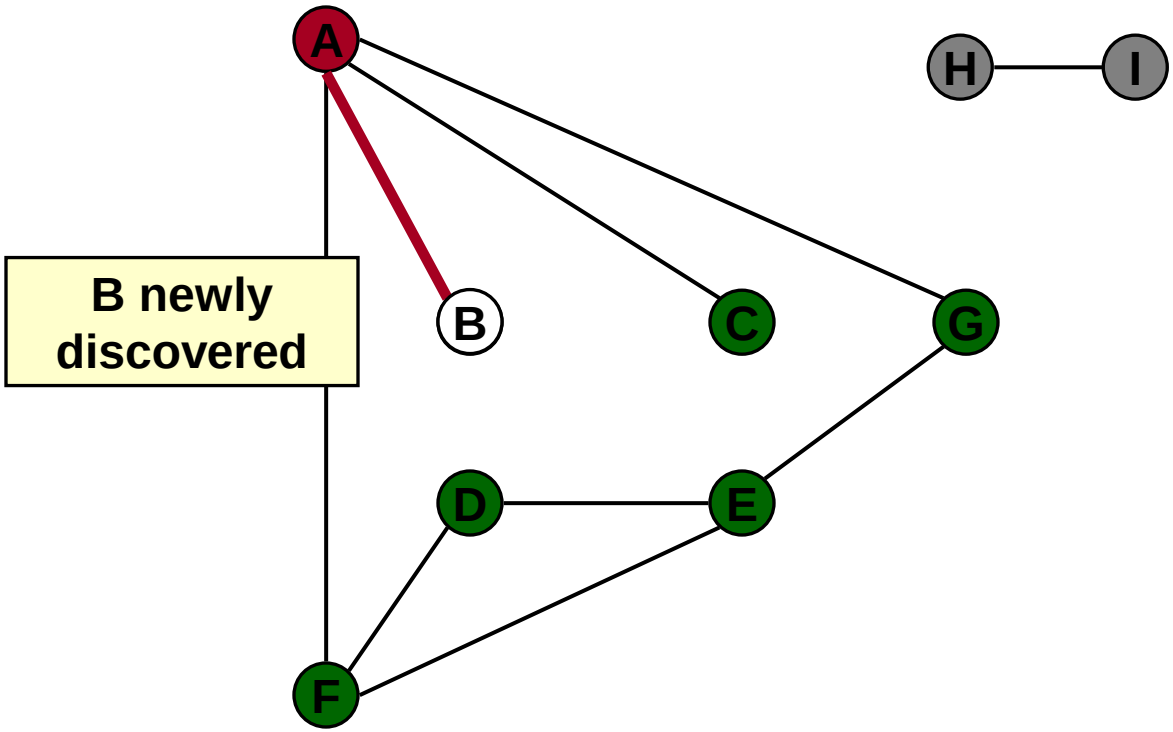
Stack

Undirected Depth First Search

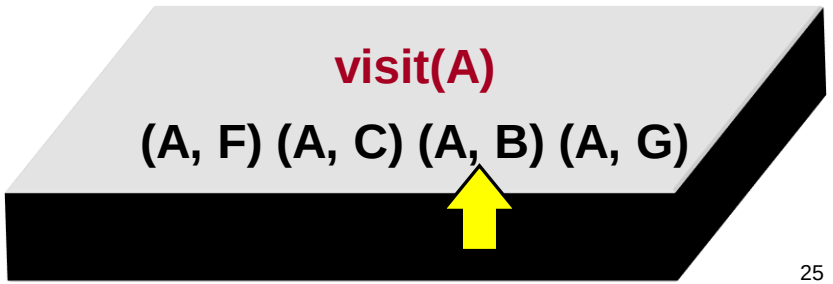




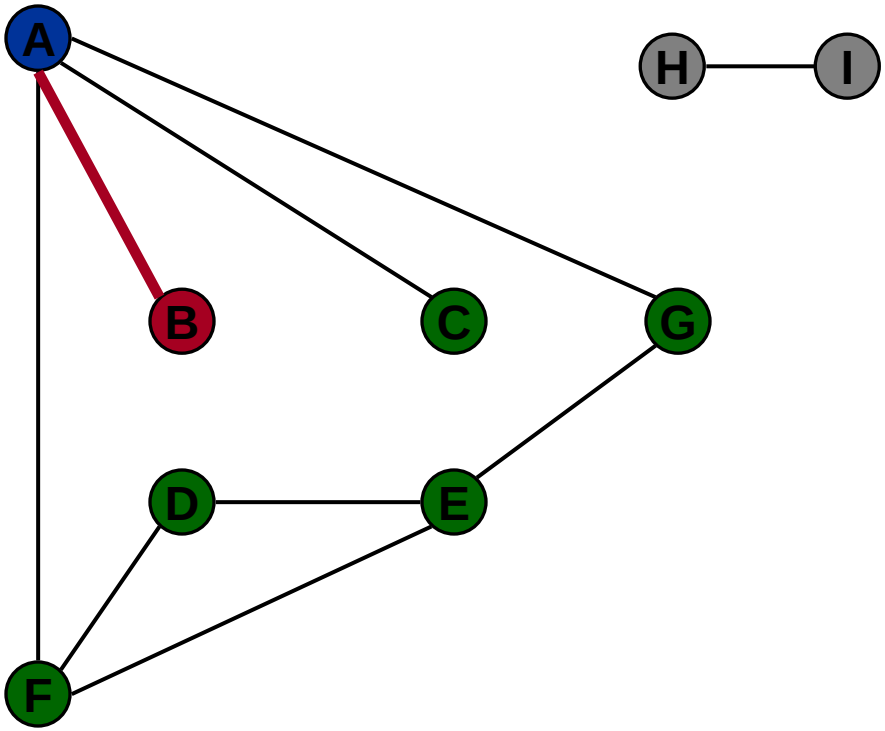
Undirected Depth First Search



Stack

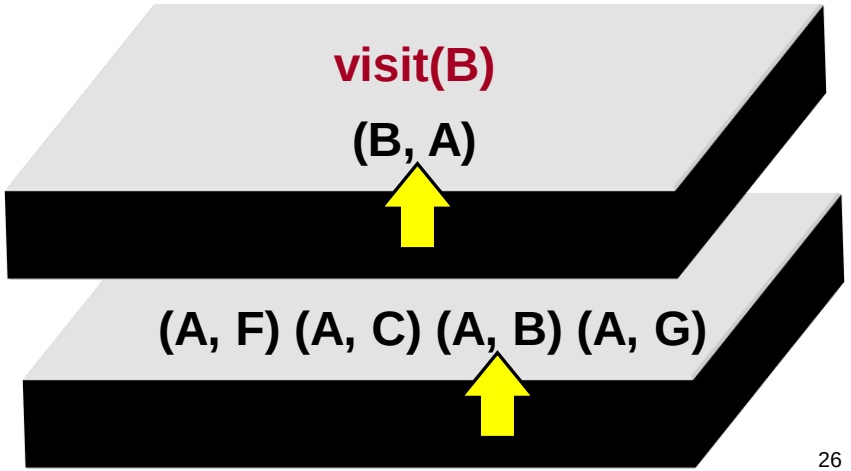


Undirected Depth First Search



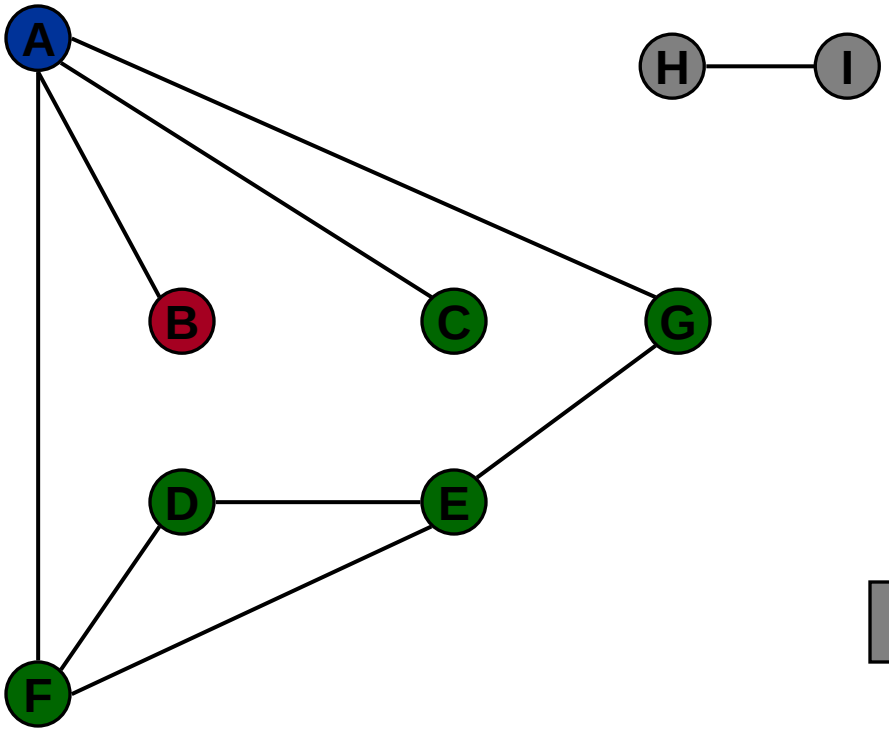
A already marked

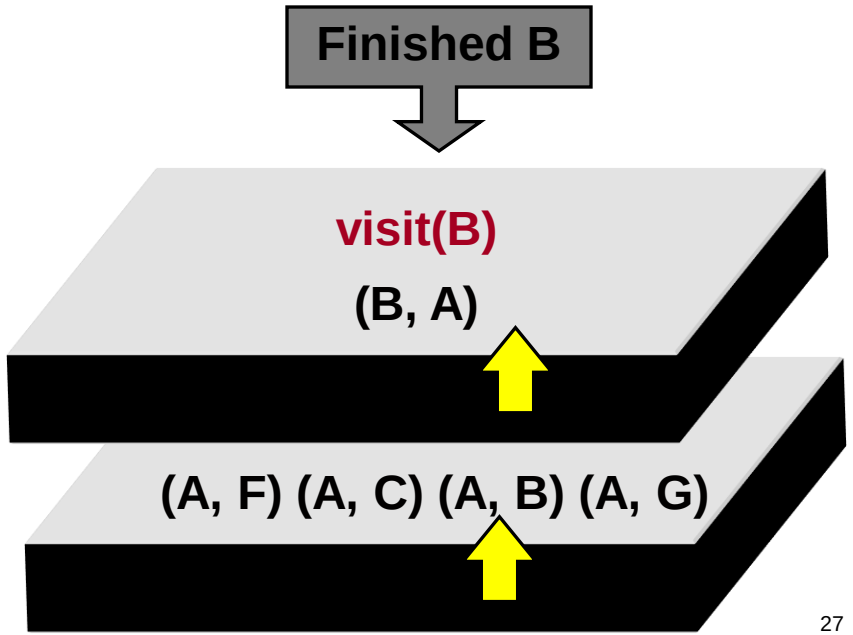
Undiscovered
Marked
Active
Finished



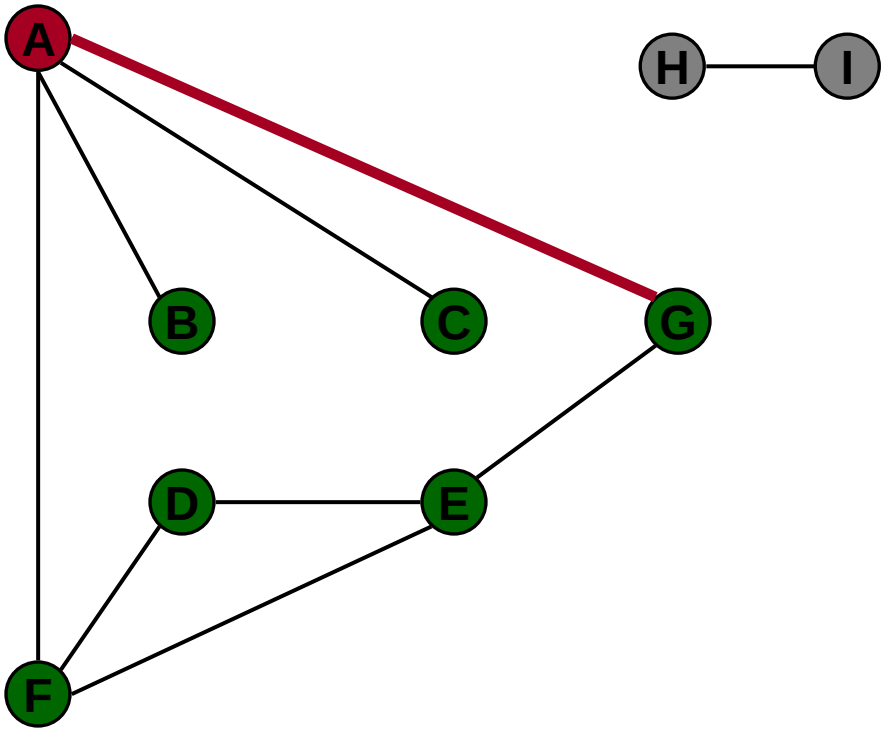
Stack

Undirected Depth First Search





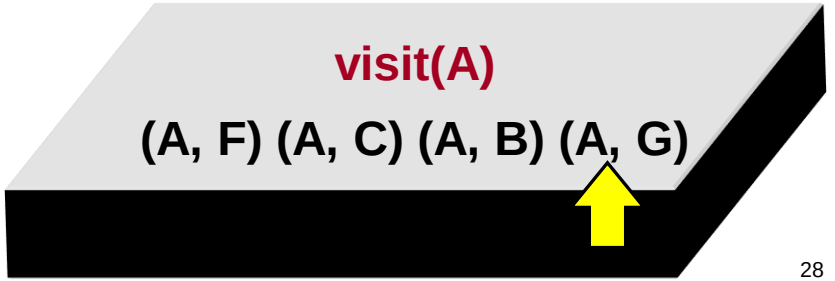
Undirected Depth First Search



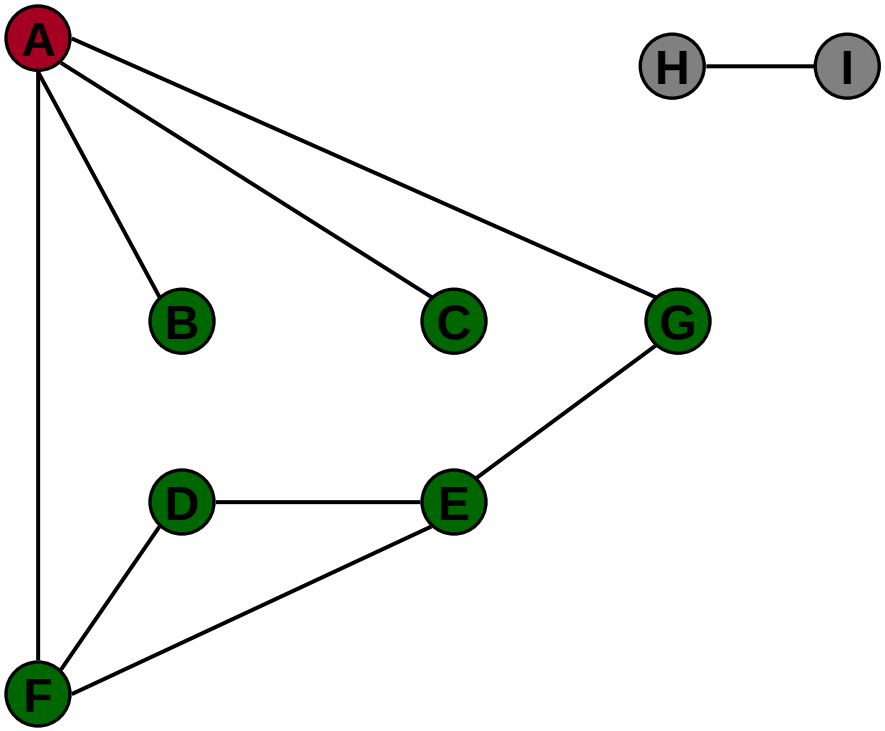
G already finished

Undiscovered
Marked
Active
Finished

Stack



Undirected Depth First Search



Undiscovered
Marked
Active
Finished

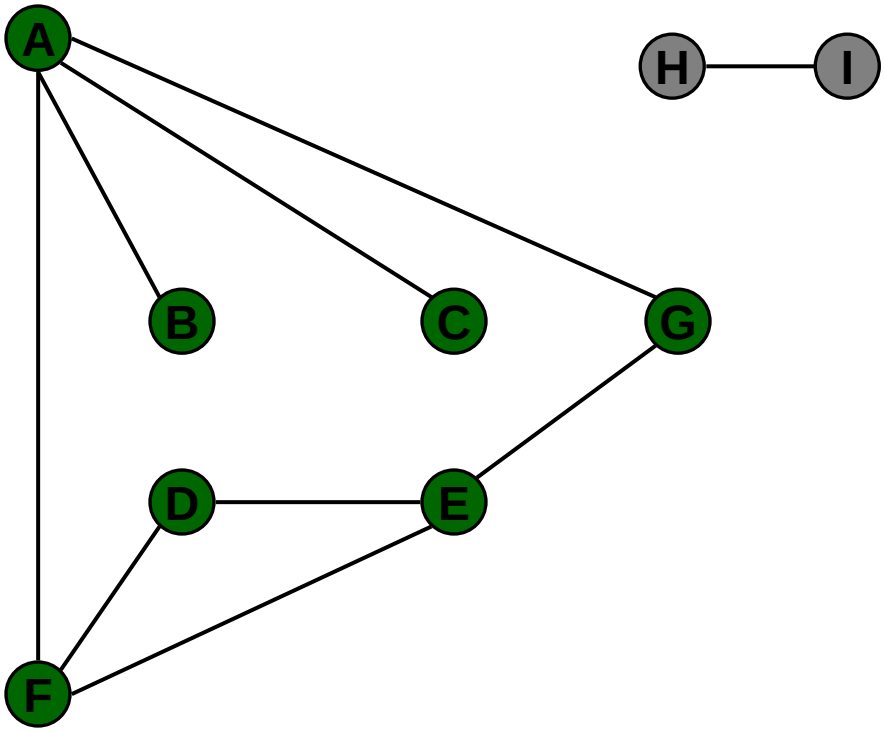
Finished A

visit(A)

(A, F) (A, C) (A, B) (A, G)

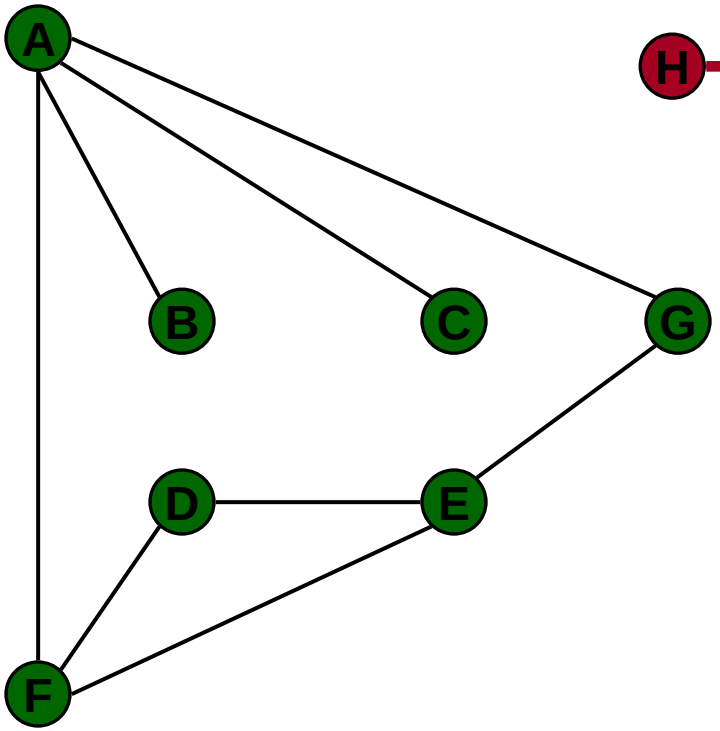
Stack

Undirected Depth First Search



Stack

Undirected Depth First Search



I newly discovered

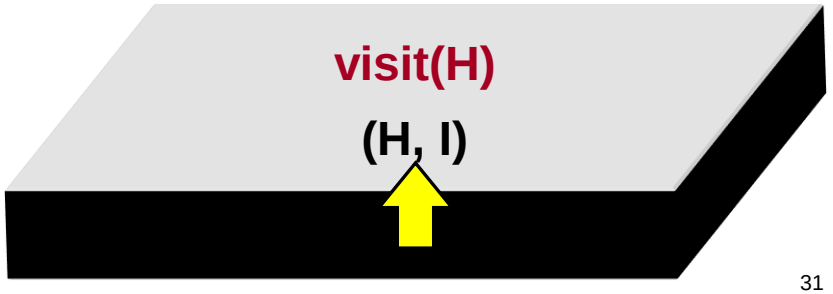
Undiscovered

Marked

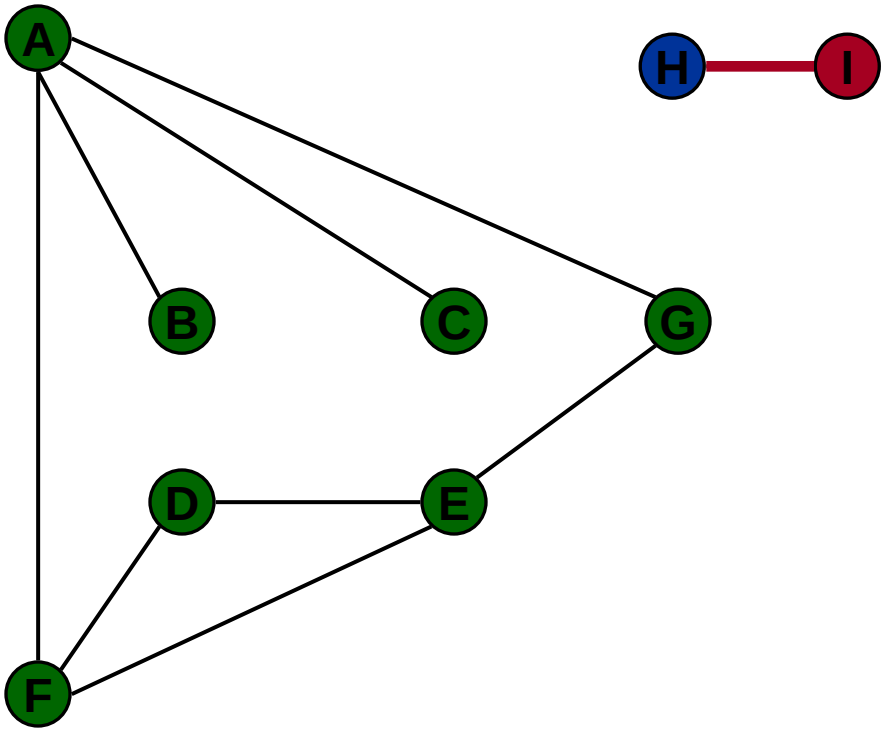
Active

Finished

Stack



Undirected Depth First Search

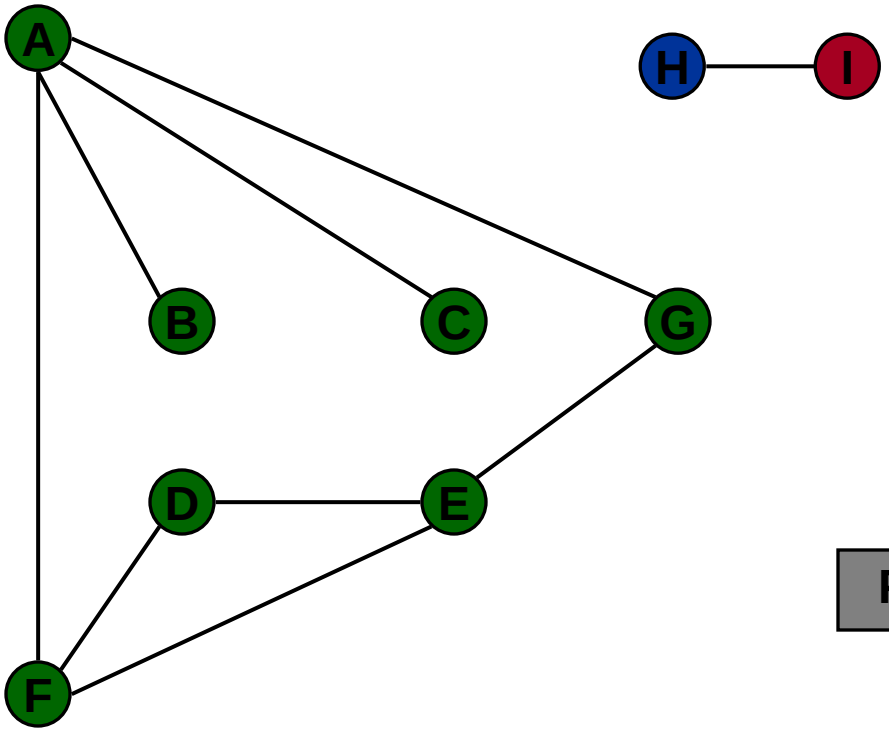


H already marked

Undiscovered
Marked
Active
Finished

Stack

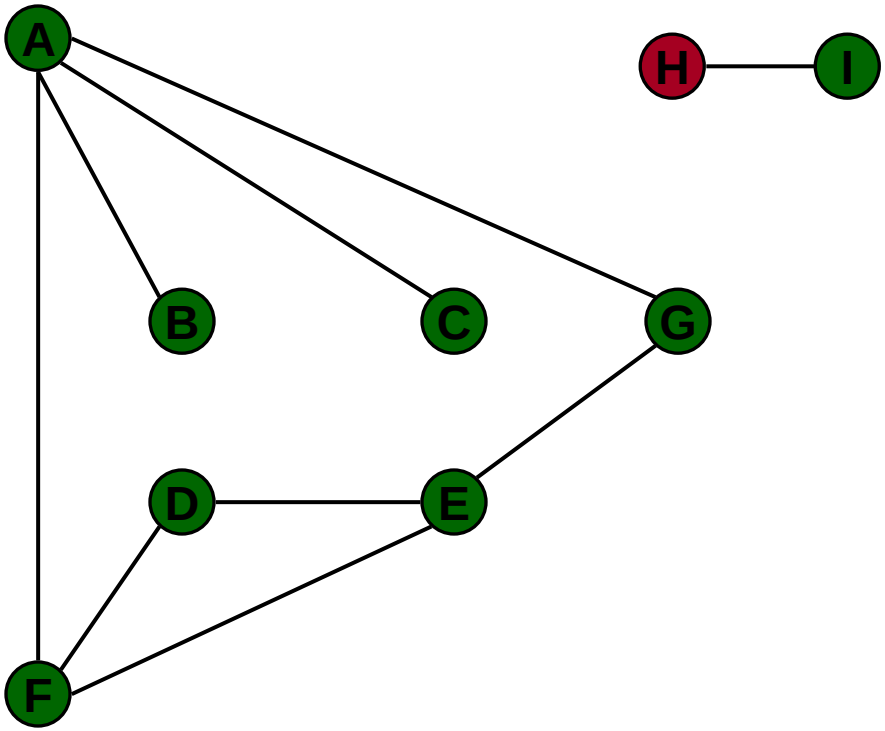
Undirected Depth First Search

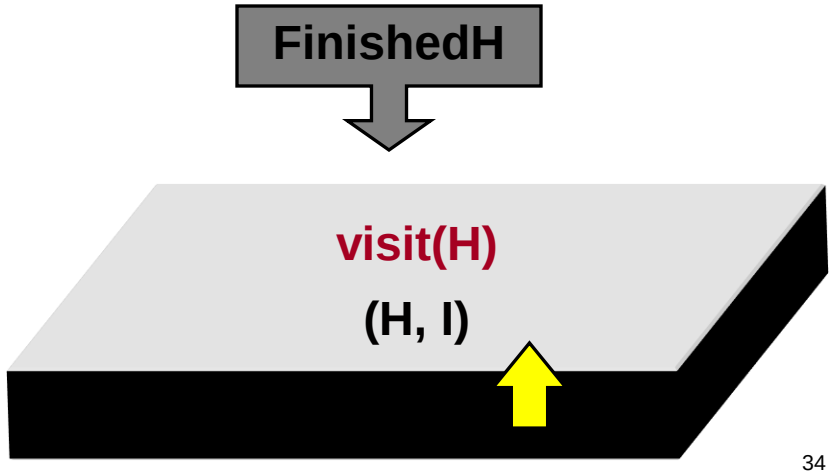


Finished I

Stack

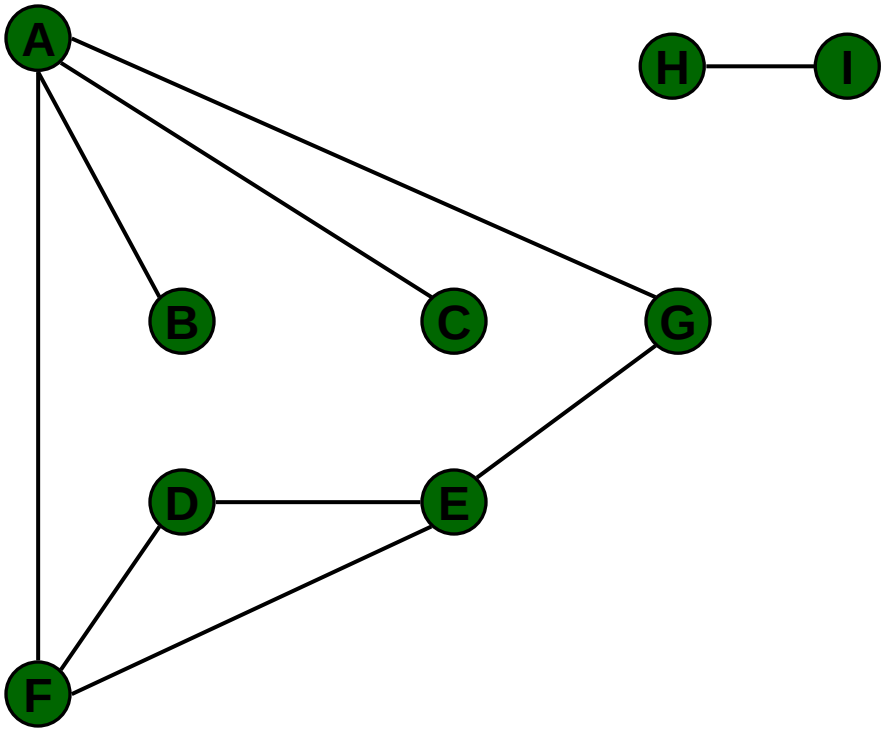
Undirected Depth First Search





Stack

Undirected Depth First Search



Stack

DFS IMPLEMENTATION

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

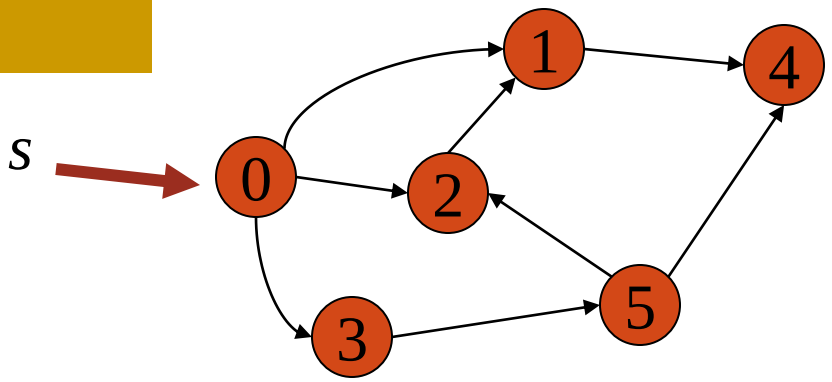
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S = \varnothing$

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

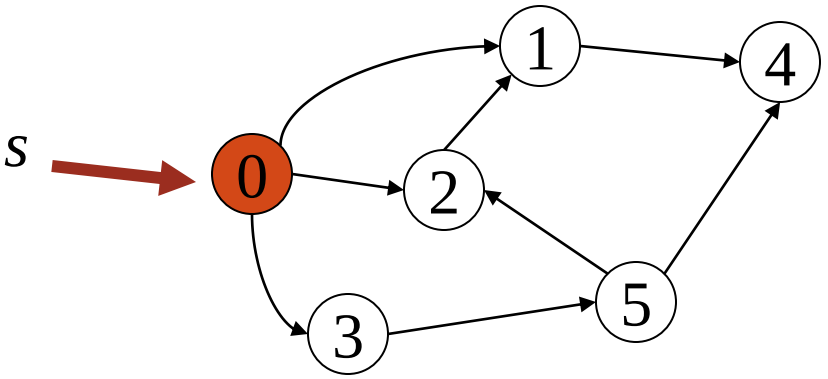
            $color[v] \leftarrow gray$

            Push(S, v)

        }

    $color[u] \leftarrow black;$

}



$S = \varnothing$

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

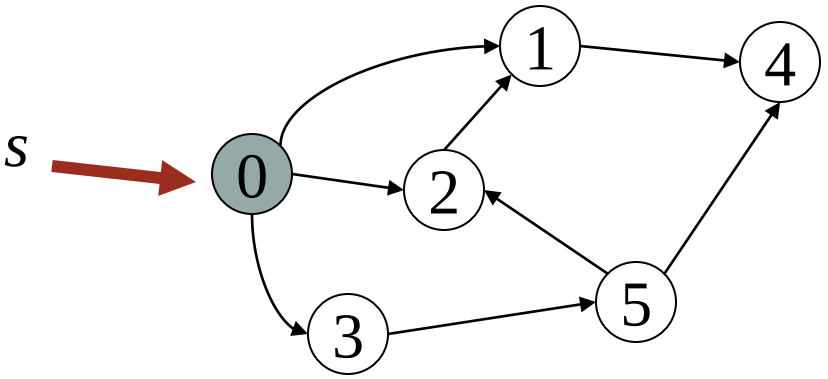
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S =$ 0

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

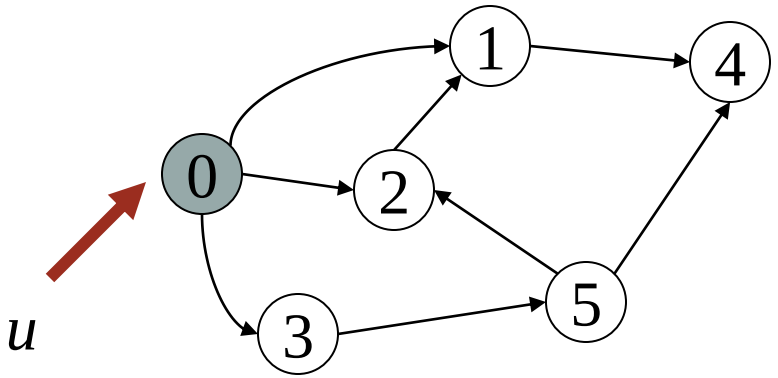
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S = \varnothing$

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    $u = \text{Pop}(S)$

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

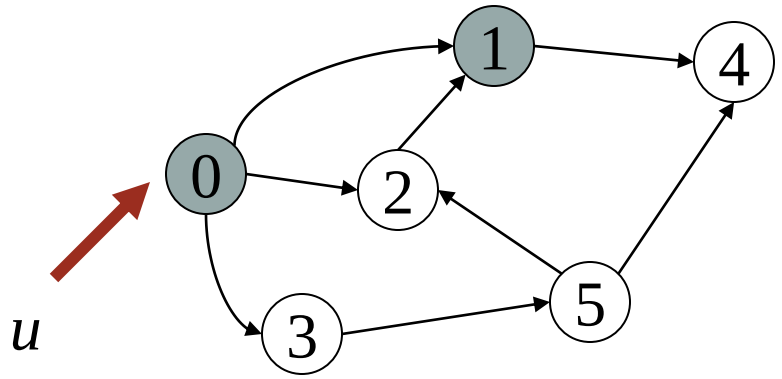
            $color[v] \leftarrow gray$

            $\text{Push}(S,v)$

        }

    $color[u] \leftarrow black;$

}



$S = \boxed{1}$

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

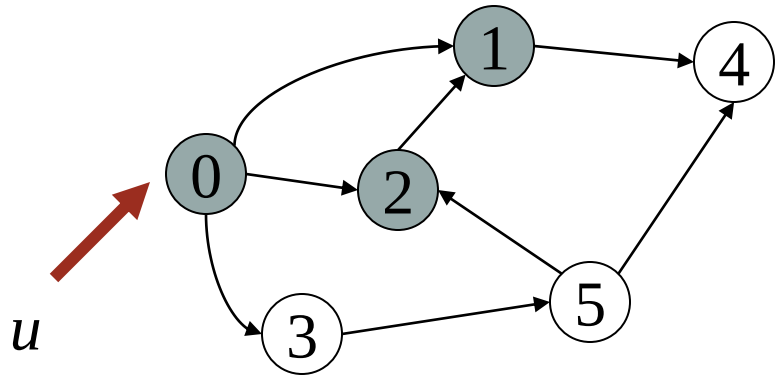
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S =$ | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

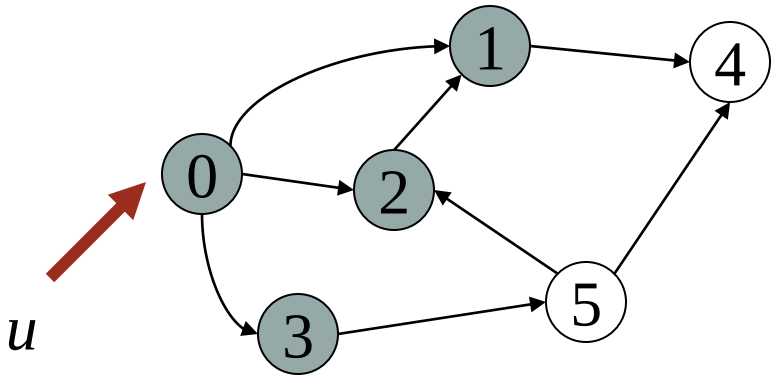
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S =$ | 3 | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

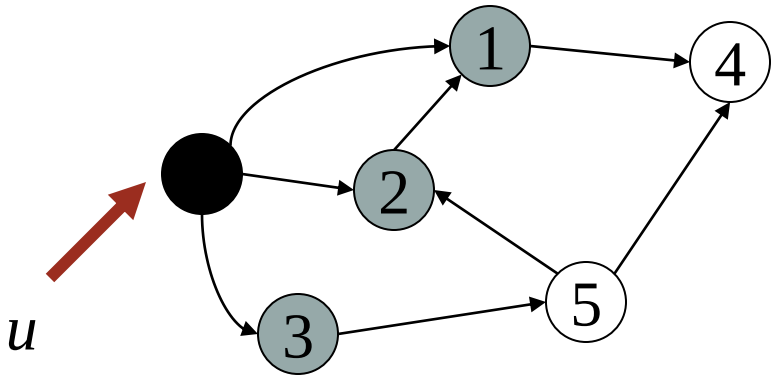
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S =$ | 3 | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

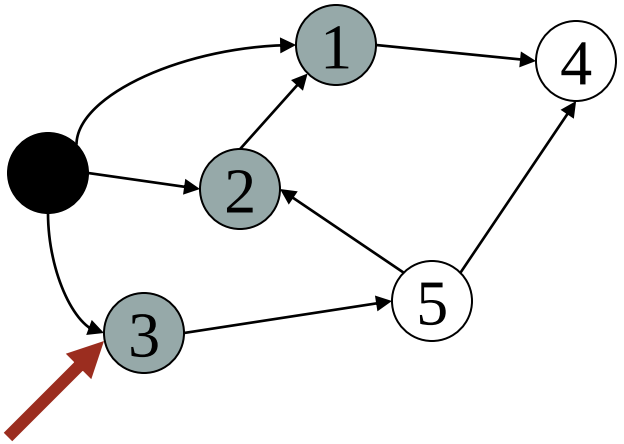
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



u

$S =$ | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

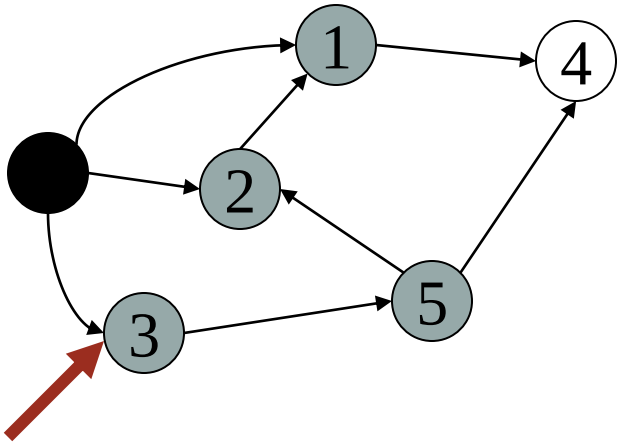
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



u

$S =$ | 5 | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

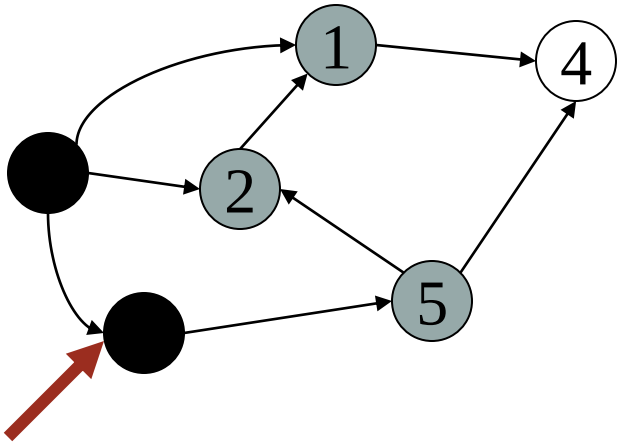
            $color[v] \leftarrow gray$

            Push(S, v)

        }

    $color[u] \leftarrow black;$

}



u

$S =$ | 5 | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

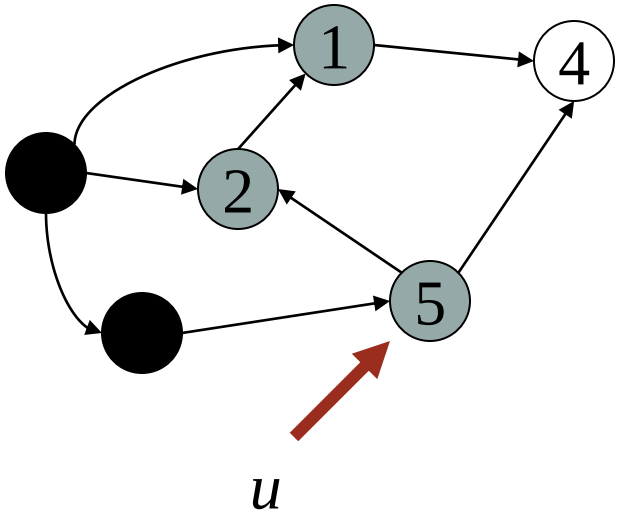
            $color[v] \leftarrow gray$

            Push(S, v)

        }

    $color[u] \leftarrow black;$

}



$S =$ | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

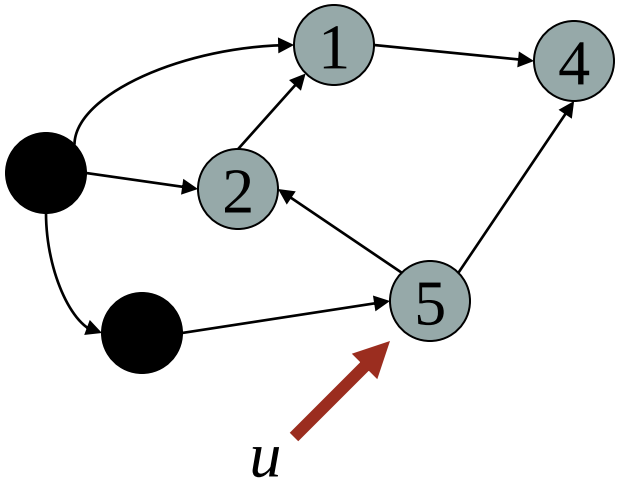
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S =$ | 4 | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

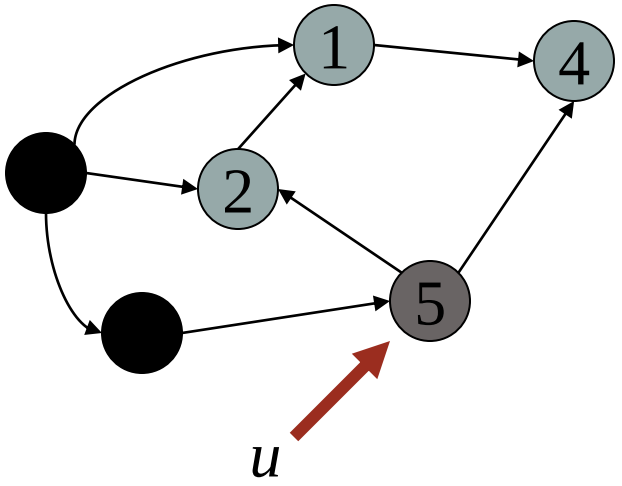
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S =$ | 4 | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

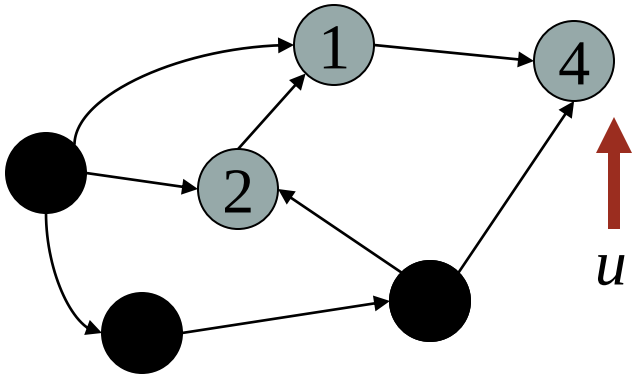
            $color[v] \leftarrow gray$

            Push(S, v)

        }

    $color[u] \leftarrow black;$

}



$S =$ | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

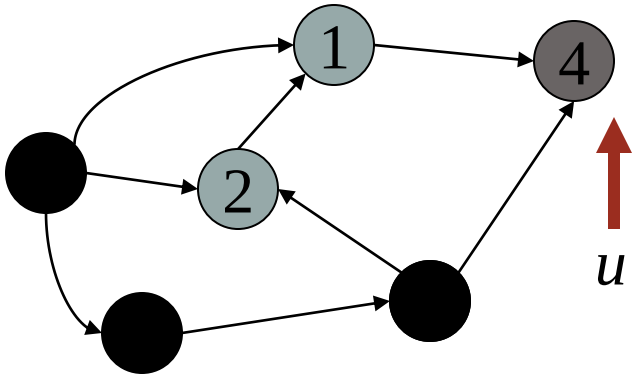
            $color[v] \leftarrow gray$

            Push(S, v)

        }

    $color[u] \leftarrow black;$

}



$S =$ | 2 | 1 |

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

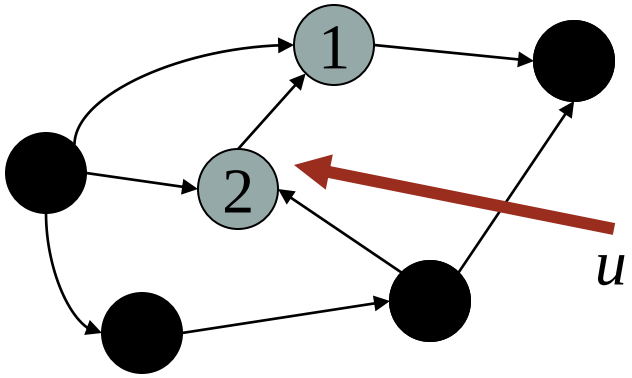
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S =$ 1

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

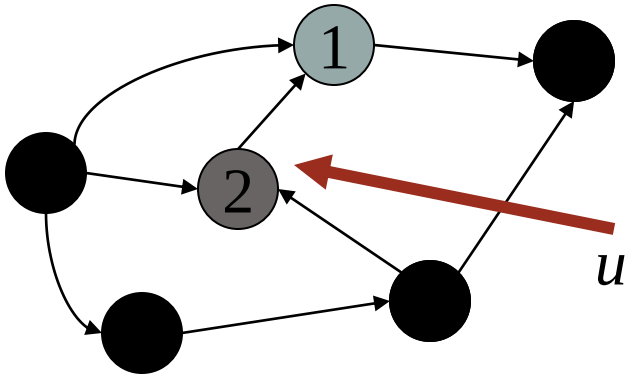
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S =$ 1

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

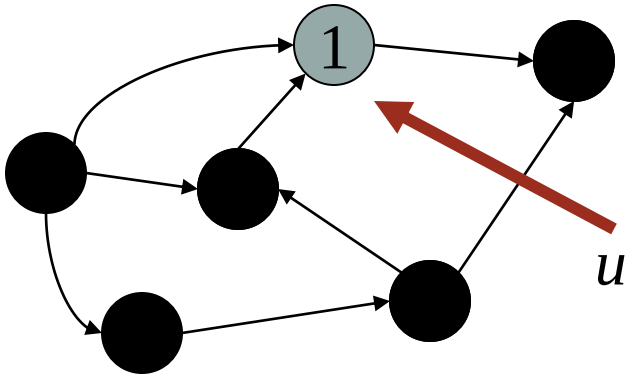
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S = \varnothing$

Depth First Search Algorithm

Given graph $G=(V,E)$ and source vertex $s \in V$

Create a stack S

For each vertex $u \in V - \{s\}$

    $color[u] \leftarrow white$

$color[s] \leftarrow gray$

$S \leftarrow \{s\}$

While $S \neq \varnothing$

{

    u = Pop(S)

    for each $v \in Adjacent[u]$

        if $color[v] = white$

        {

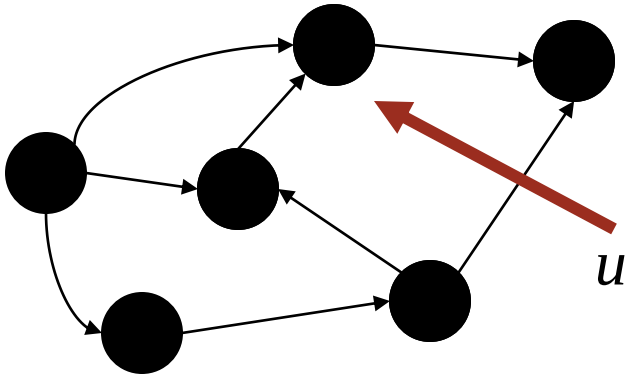
            $color[v] \leftarrow gray$

            Push(S,v)

        }

    $color[u] \leftarrow black;$

}



$S = \varnothing$