

Depth First Search

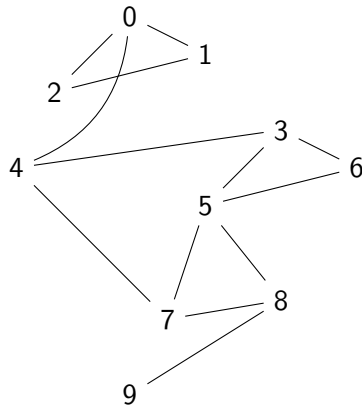
Madhavan Mukund

<https://www.cmi.ac.in/~madhavan>

Mathematics for Data Science 1
Week 10

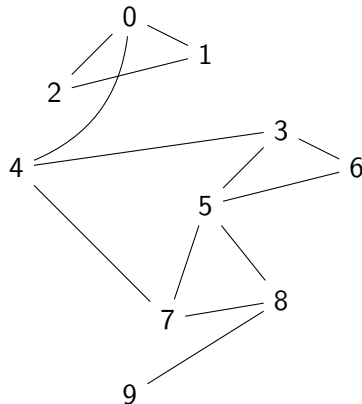
Depth first search (DFS)

- Start from i , visit an unexplored neighbour j



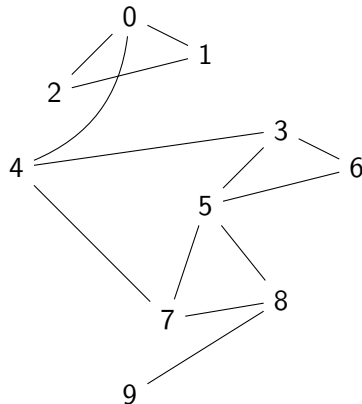
Depth first search (DFS)

- Start from i , visit an unexplored neighbour j
- Suspend the exploration of i and explore j instead



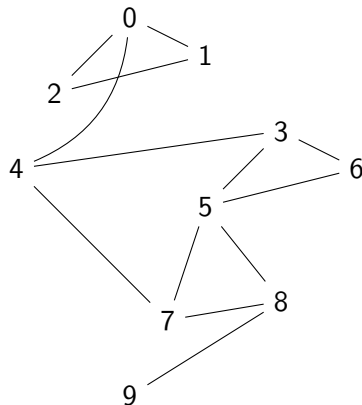
Depth first search (DFS)

- Start from i , visit an unexplored neighbour j
- Suspend the exploration of i and explore j instead
- Continue till you reach a vertex with no unexplored neighbours



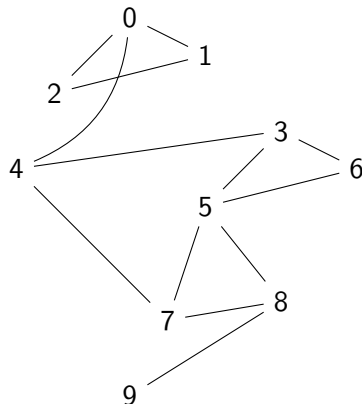
Depth first search (DFS)

- Start from i , visit an unexplored neighbour j
- Suspend the exploration of i and explore j instead
- Continue till you reach a vertex with no unexplored neighbours
- Backtrack to nearest suspended vertex that still has an unexplored neighbour



Depth first search (DFS)

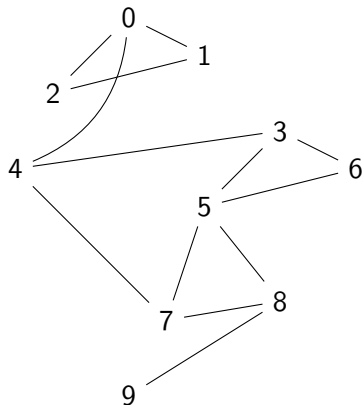
- Start from i , visit an unexplored neighbour j
- Suspend the exploration of i and explore j instead
- Continue till you reach a vertex with no unexplored neighbours
- Backtrack to nearest suspended vertex that still has an unexplored neighbour
- Suspended vertices are stored in a **stack**
 - Last in, first out
 - Most recently suspended is checked first



DFS from vertex 4

Visited	
0	False
1	False
2	False
3	False
4	False
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									

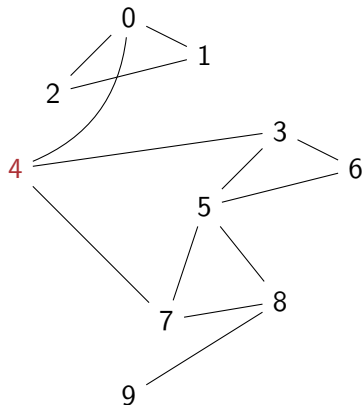


DFS from vertex 4

Visited	
0	False
1	False
2	False
3	False
4	True
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									

■ Mark 4,

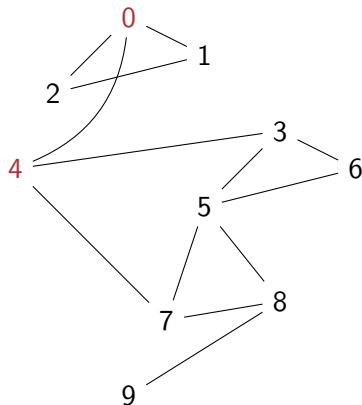


DFS from vertex 4

Visited	
0	True
1	False
2	False
3	False
4	True
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									
4									

■ Mark 4, Suspend 4, explore 0

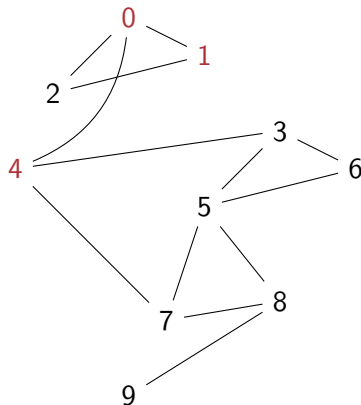


DFS from vertex 4

Visited	
0	True
1	True
2	False
3	False
4	True
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									
4	0								

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1

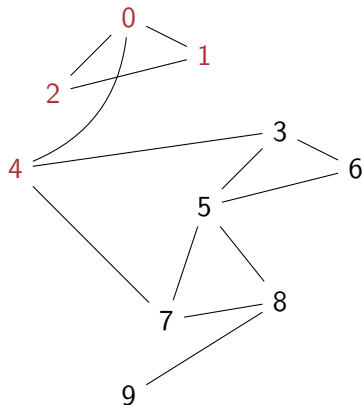


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	False
4	True
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									
4	0	1							

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2

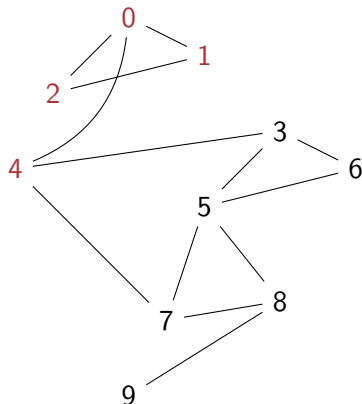


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	False
4	True
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									
4	0								

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1,

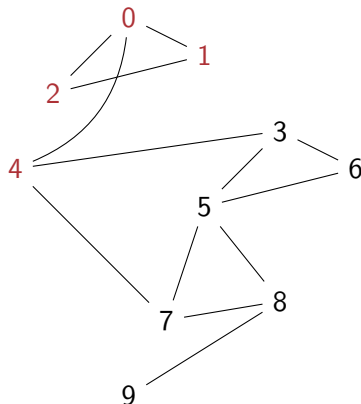


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	False
4	True
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									
4									

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0,

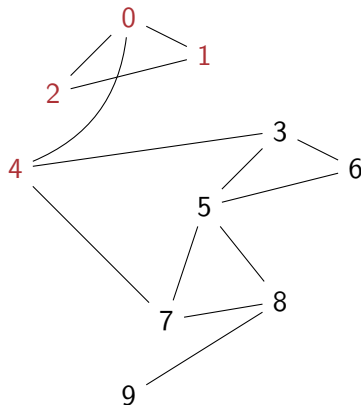


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4

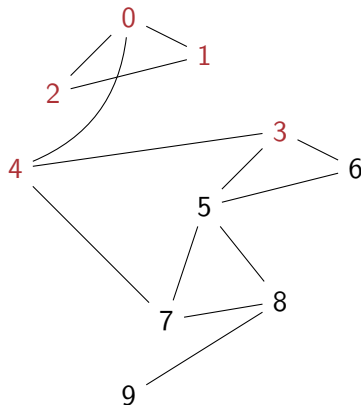


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	False
6	False
7	False
8	False
9	False

Stack of suspended vertices									
4									

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3

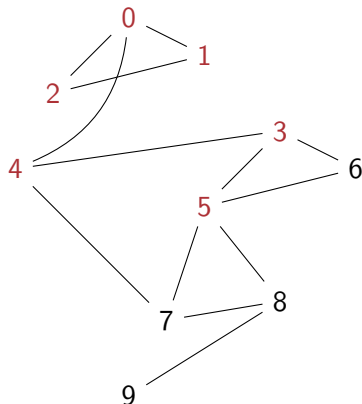


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	False
7	False
8	False
9	False

Stack of suspended vertices									
4	3								

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5

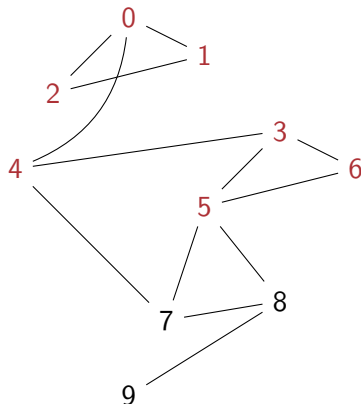


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	False
8	False
9	False

Stack of suspended vertices								
4	3	5						

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6

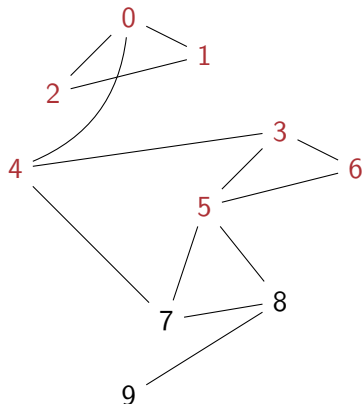


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	False
8	False
9	False

Stack of suspended vertices									
4	3								

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5,

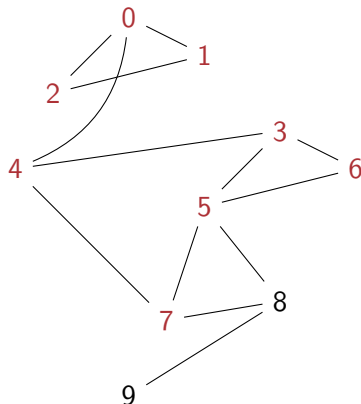


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	False
9	False

Stack of suspended vertices								
4	3	5						

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5, suspend 5, explore 7

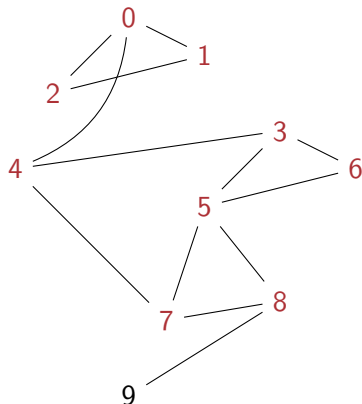


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	True
9	False

Stack of suspended vertices								
4	3	5	7					

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5, suspend 5, explore 7
- Suspend 7, explore 8

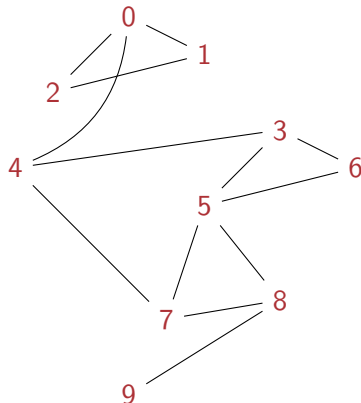


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	True
9	True

Stack of suspended vertices									
4	3	5	7	8					

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5, suspend 5, explore 7
- Suspend 7, explore 8
- Suspend 8, explore 9

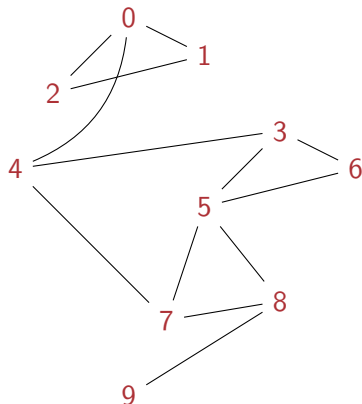


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	True
9	True

Stack of suspended vertices									
4	3	5	7						

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5, suspend 5, explore 7
- Suspend 7, explore 8
- Suspend 8, explore 9
- Backtrack to 8,

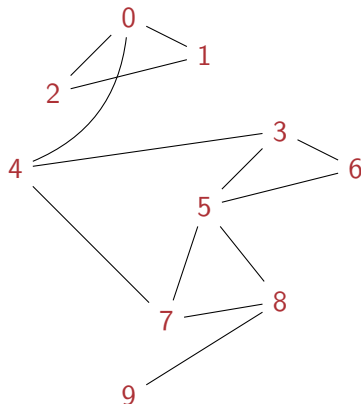


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	True
9	True

Stack of suspended vertices								
4	3	5						

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5, suspend 5, explore 7
- Suspend 7, explore 8
- Suspend 8, explore 9
- Backtrack to 8, 7,

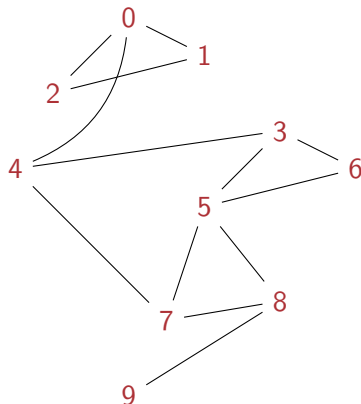


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	True
9	True

Stack of suspended vertices								
4	3							

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5, suspend 5, explore 7
- Suspend 7, explore 8
- Suspend 8, explore 9
- Backtrack to 8, 7, 5,

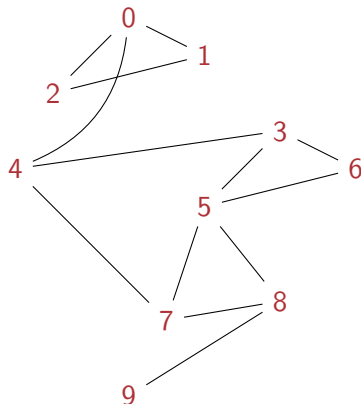


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	True
9	True

Stack of suspended vertices									
4									

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5, suspend 5, explore 7
- Suspend 7, explore 8
- Suspend 8, explore 9
- Backtrack to 8, 7, 5, 3,

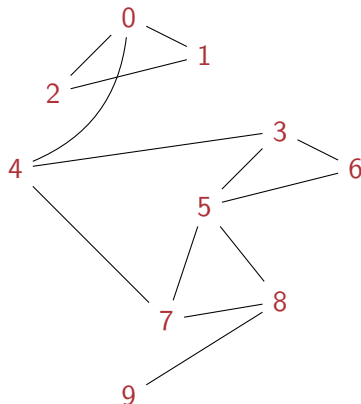


DFS from vertex 4

Visited	
0	True
1	True
2	True
3	True
4	True
5	True
6	True
7	True
8	True
9	True

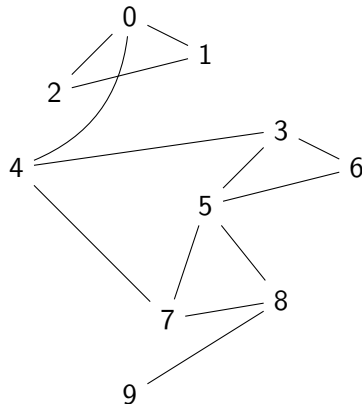
Stack of suspended vertices									

- Mark 4, Suspend 4, explore 0
- suspend 0, explore 1
- Suspend 1, explore 2
- Backtrack to 1, 0, 4
- Suspend 4, explore 3
- Suspend 3, explore 5
- Suspend 5, explore 6
- Backtrack to 5, suspend 5, explore 7
- Suspend 7, explore 8
- Suspend 8, explore 9
- Backtrack to 8, 7, 5, 3, 4



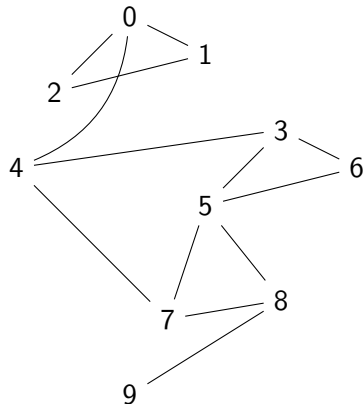
Depth first search (DFS)

- Paths discovered by BFS are not shortest paths, unlike BFS



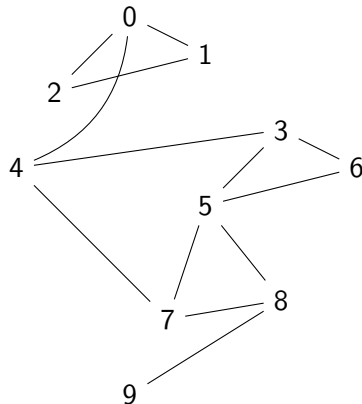
Depth first search (DFS)

- Paths discovered by BFS are not shortest paths, unlike BFS
- Useful features can be found by recording the order in which DFS visits vertices



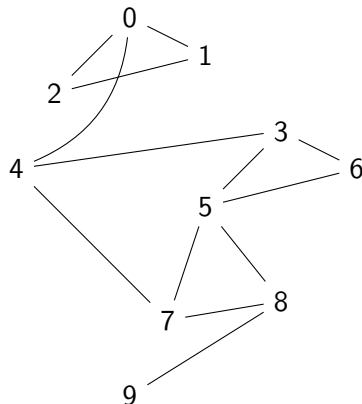
Depth first search (DFS)

- Paths discovered by BFS are not shortest paths, unlike BFS
- Useful features can be found by recording the order in which DFS visits vertices
- DFS numbering — maintain a counter
 - Increment and record counter value each time you start and finish exploring a vertex



Depth first search (DFS)

- Paths discovered by BFS are not shortest paths, unlike BFS
- Useful features can be found by recording the order in which DFS visits vertices
- DFS numbering — maintain a counter
 - Increment and record counter value each time you start and finish exploring a vertex
- DFS numbering can be used to
 - Find cut vertices (deleting vertex disconnects graph)
 - Find bridges (deleting edge disconnects graph)



Summary

- DFS is another systematic strategy to explore a graph

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- DFS uses a stack to suspend exploration and move to unexplored neighbours

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- DFS is another systematic strategy to explore a graph
- DFS uses a stack to suspend exploration and move to unexplored neighbours
- DFS numbering can be used to discover many facts about graphs