Final Exam Presentation

Shortest Path Algorithm Analysis

Member Info

Department | CSE | 陳伯豪 | s1131525 | 黃博彥 | s1131406 | 黃以慈 | s1133313

Report Content

What is Shortest Path

Theory of BFS

Theory of DFS

Dijkstra

Bellman-Ford

Floyd-Warshall

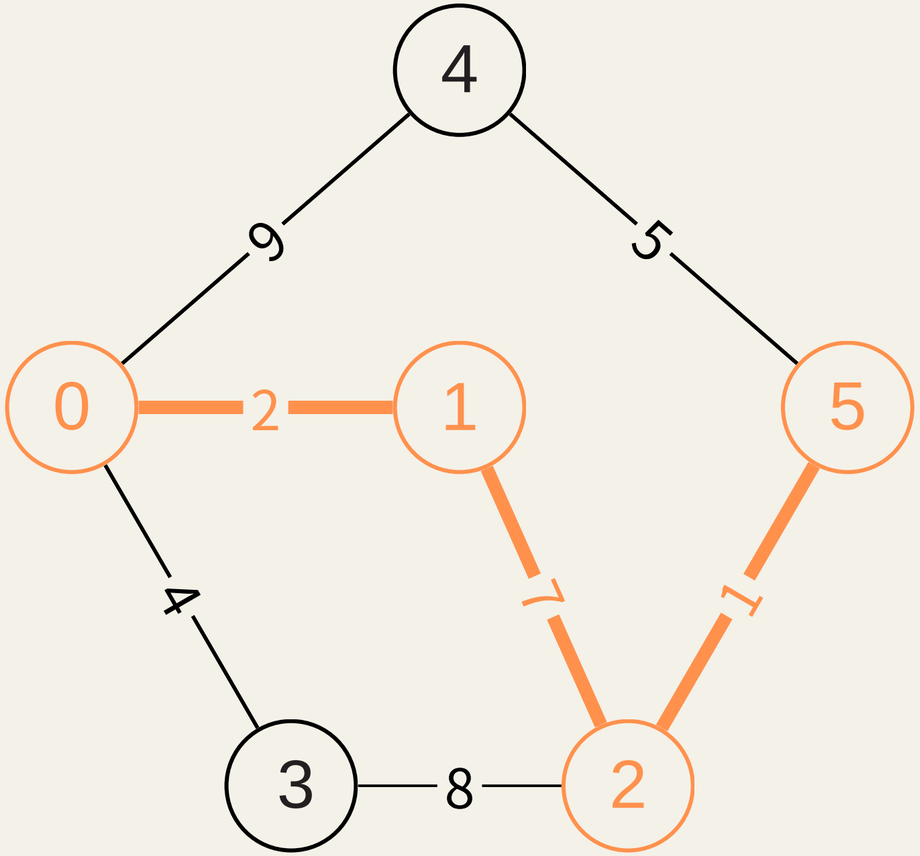
Comparison

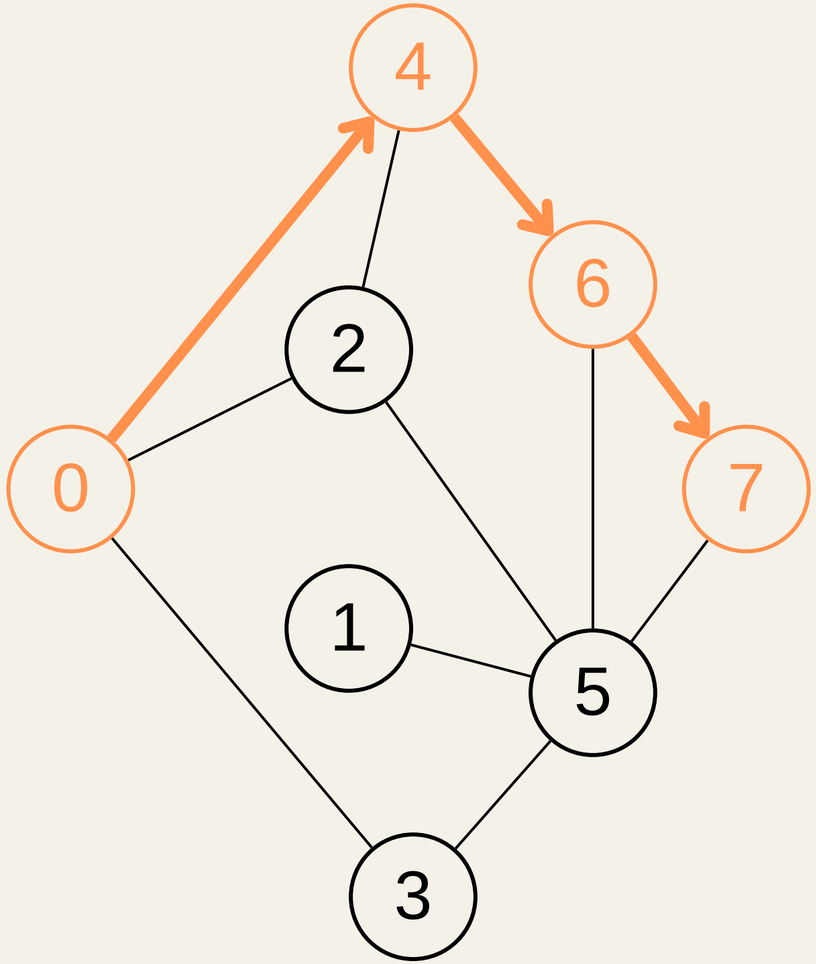
Implementation

Theory

Implementation

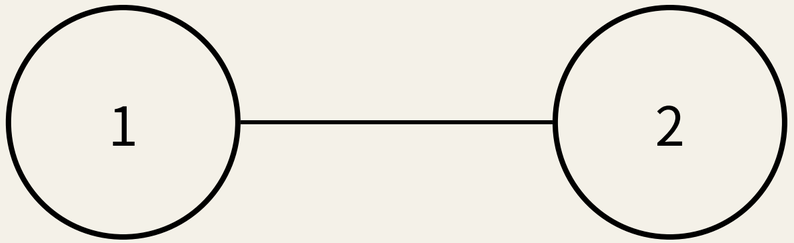
Shortest Path



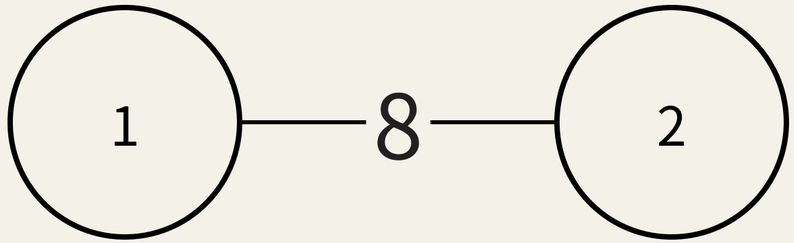


Graph Elements

Vertex

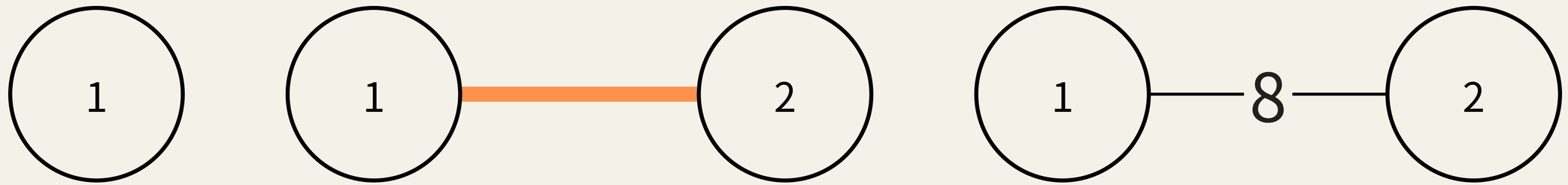


Edge



Weight

Graph Elements

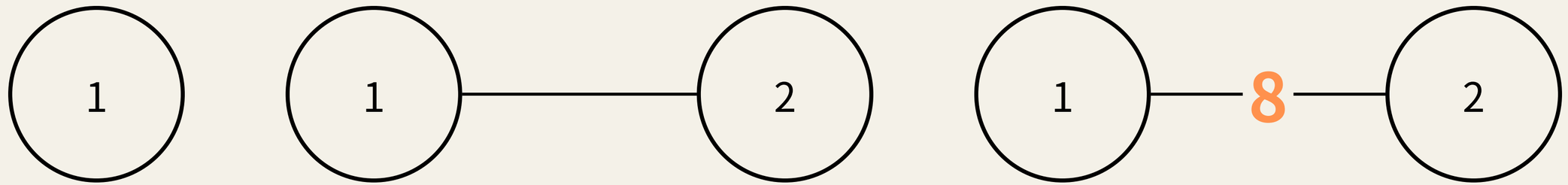


Vertex

Edge

Weight

Graph Elements



Vertex

Edge

Weight

Breadth First Search

廣度優先搜尋演算法

Initialize

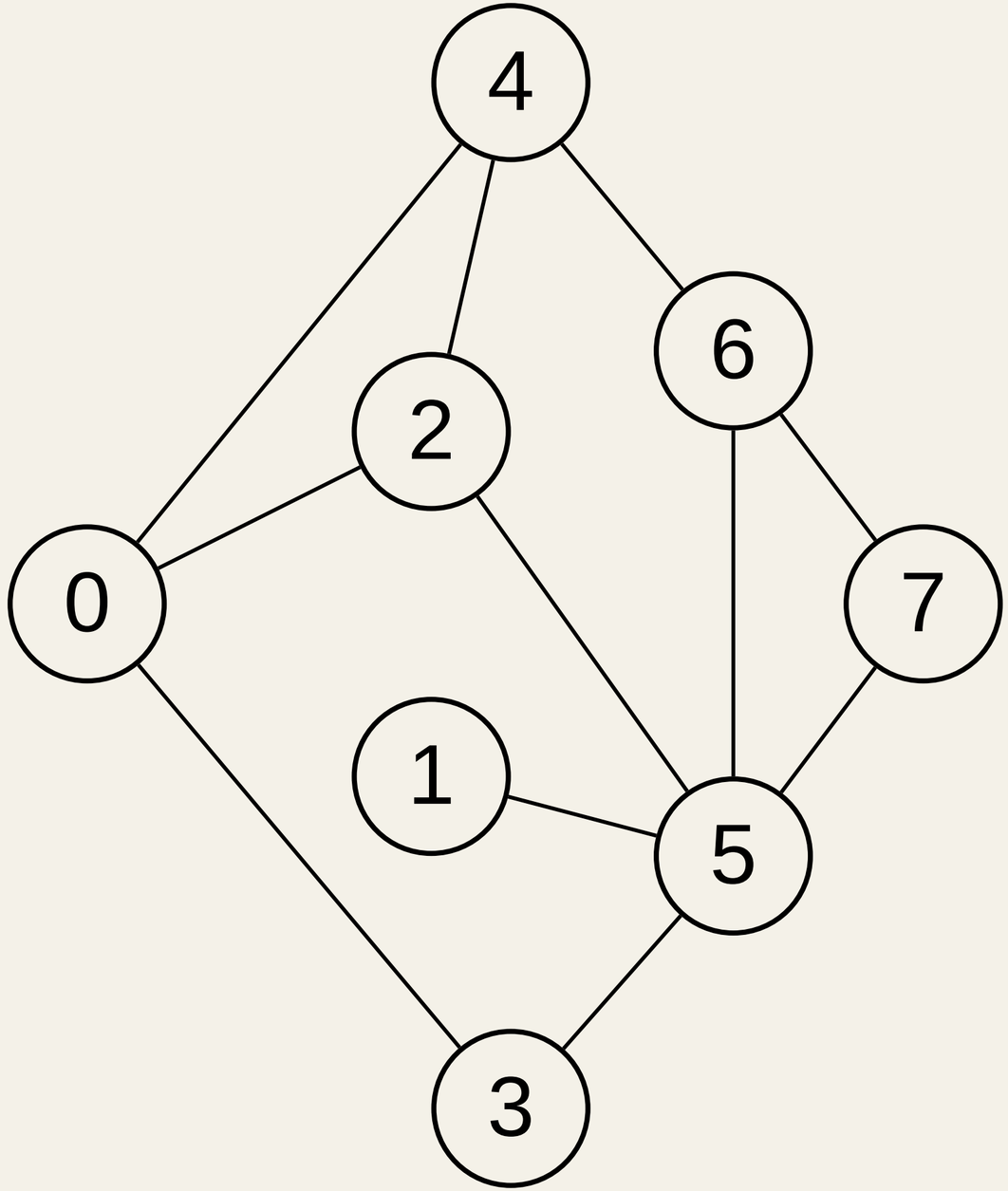
index	0	1	2	3	4	5	6	7
dis[ ]	-1	-1	-1	-1	-1	-1	-1	-1

❶ Set all of the value in distance array to default value which equivalent to the distance you will never reach → -1

queue<pair<int, int>> q

q.empty() = True

❷ Make sure the queue we are going to use is empty → declare a new queue



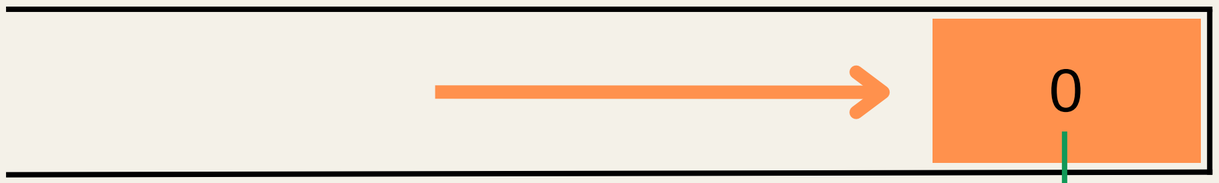
Initial Operation

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	-1	-1	-1	-1	-1	-1

❷ Set the distance of starting vertex to 0

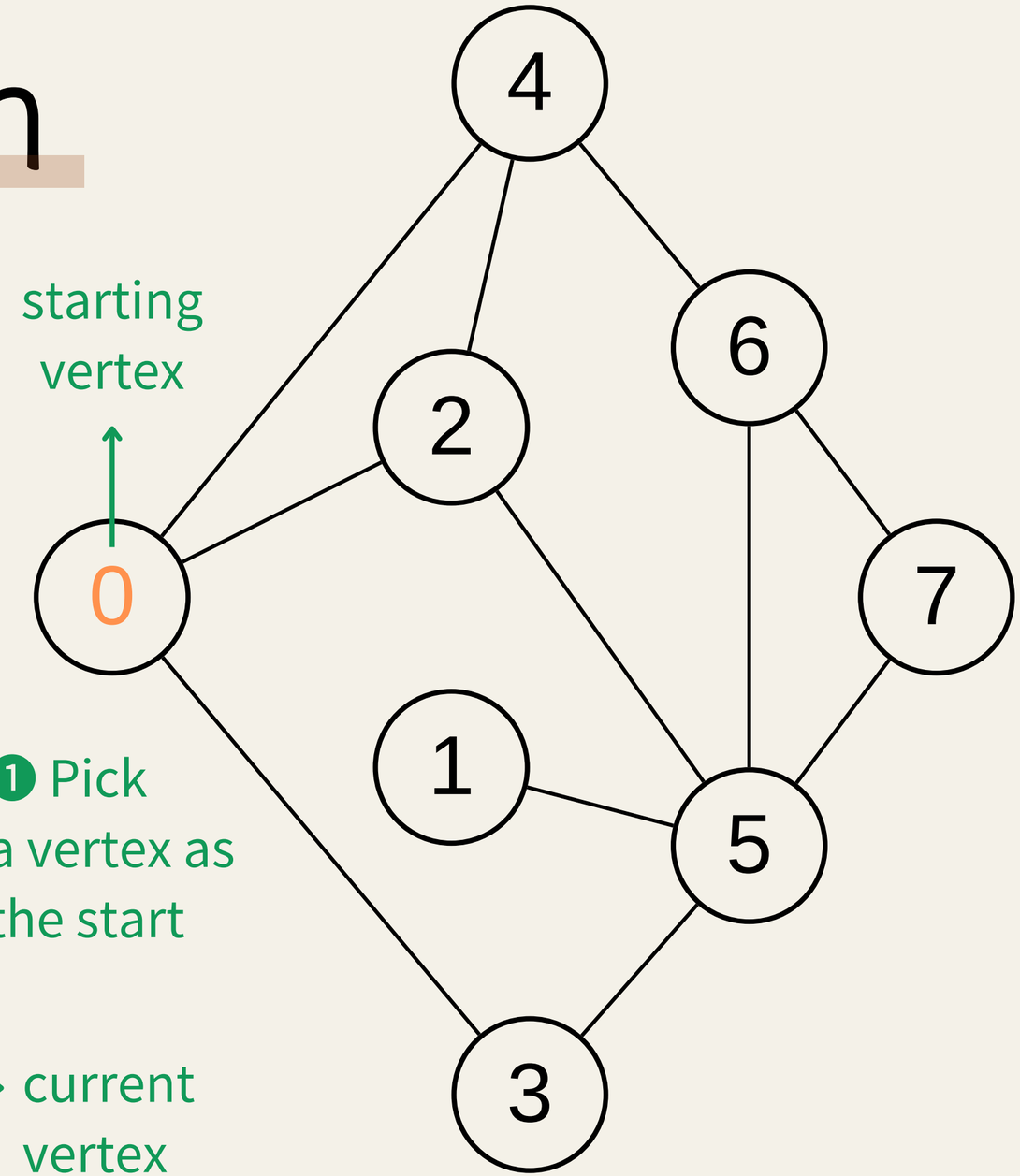
→ The distance from starting vertex to starting vertex will definitely be 0

queue<pair<int, int>> q



❸ Push starting vertex into queue

→ This means we are ready to deal with this vertex



starting vertex

❶ Pick a vertex as the start

current vertex

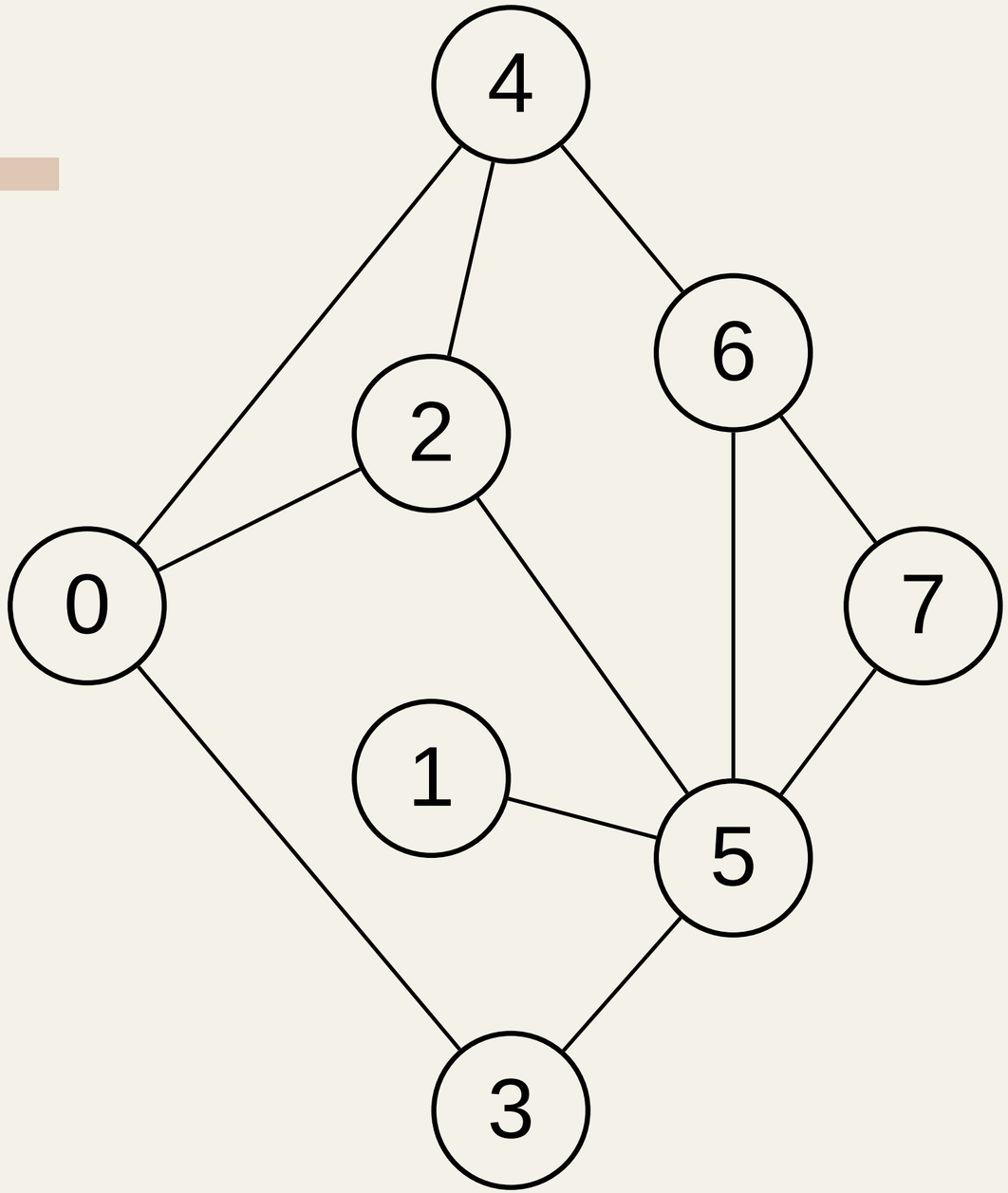
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	-1	-1	-1	-1	-1	-1

queue<pair<int, int>> q

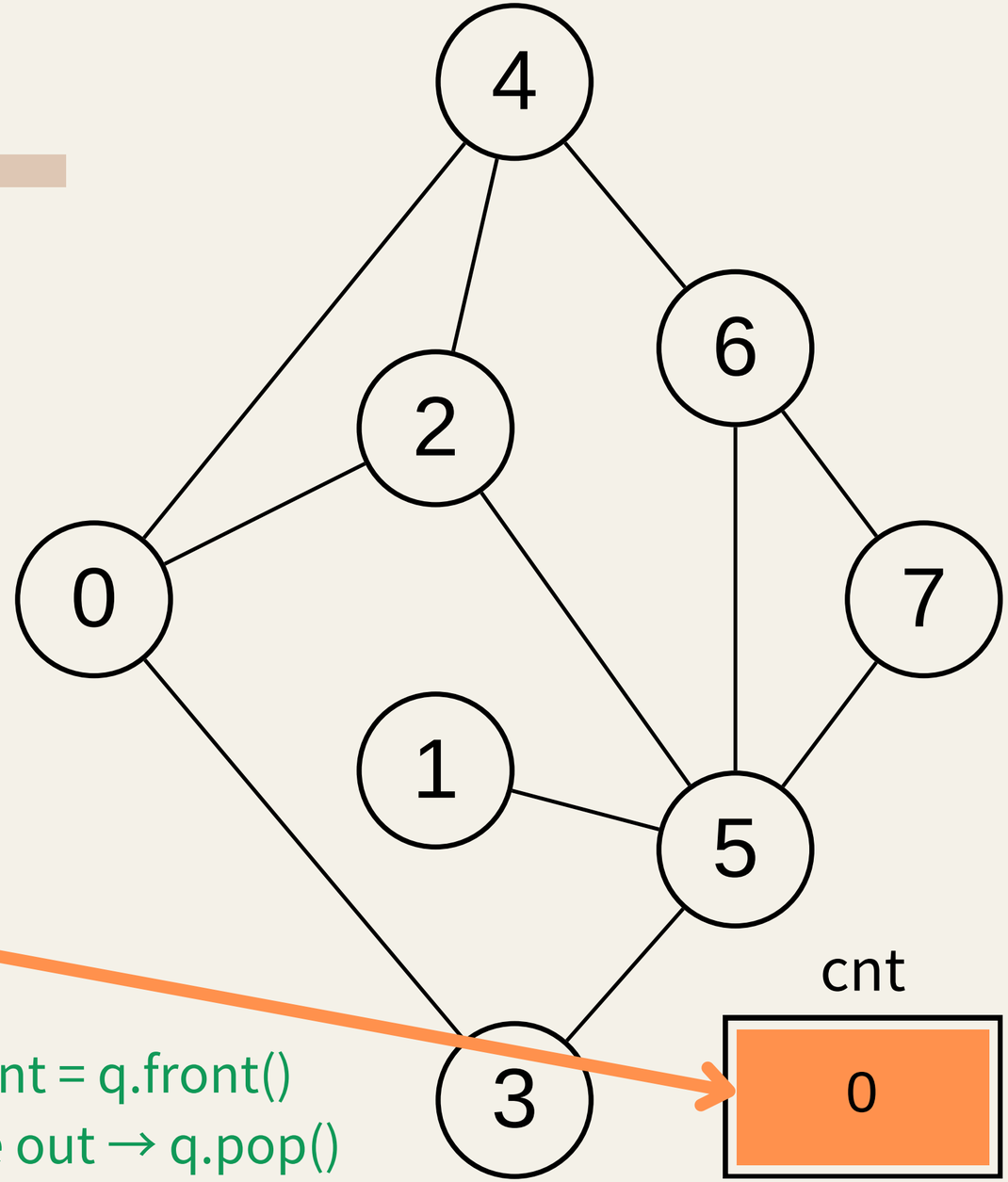
Once the queue is not empty

→ Keep going with the remaining vertices



Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	-1	-1	-1	-1	-1	-1



queue<pair<int, int>> q

❶ Put the front most element of queue into cnt → cnt = q.front()

❷ Pop out the old element which already been take out → q.pop()

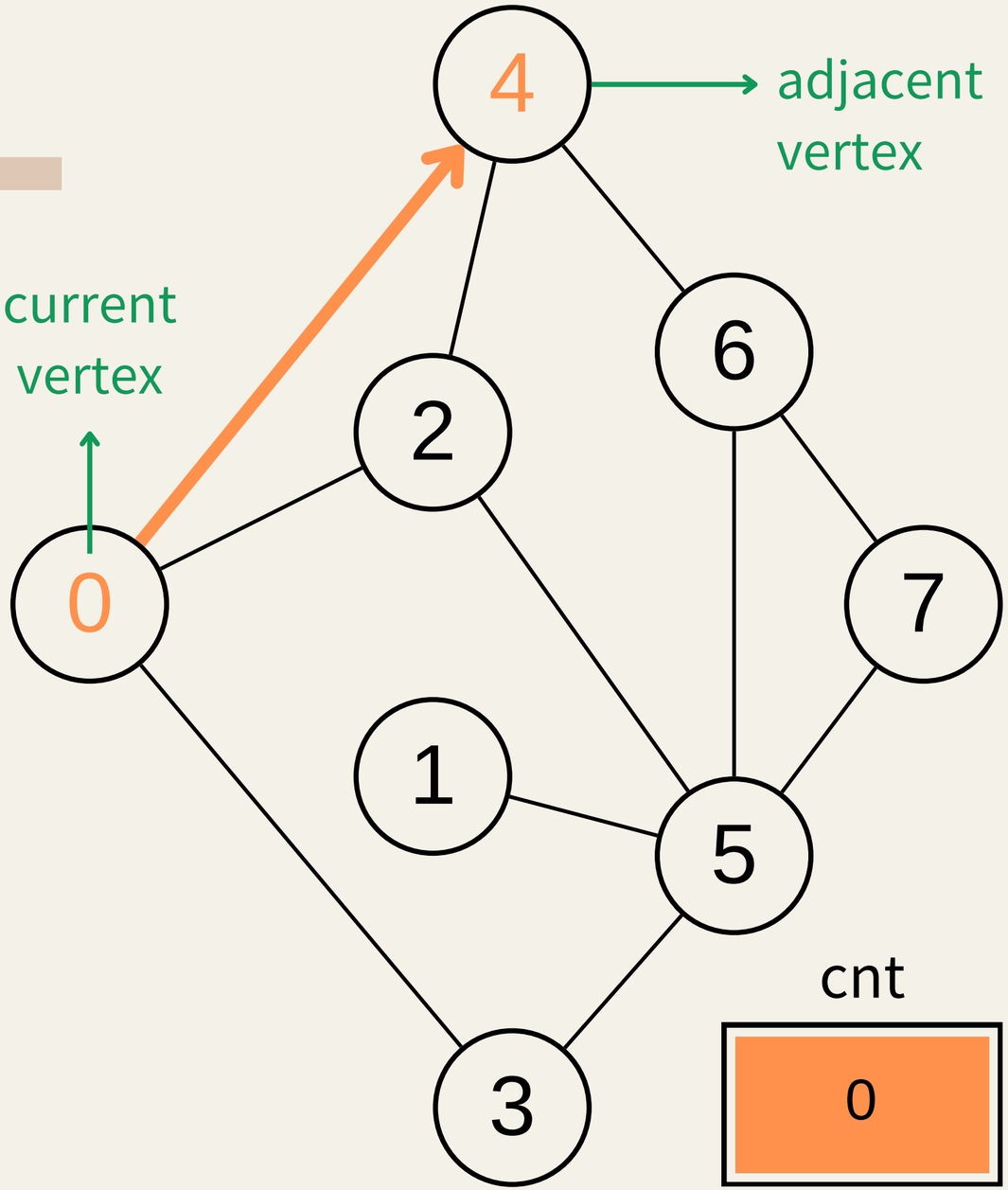
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	-1	-1	-1	-1	-1	-1

Available ✓

Check whether adjacent vertex is avaliable or not
→ dis[adjacent] equals to default value

queue<pair<int, int>> q



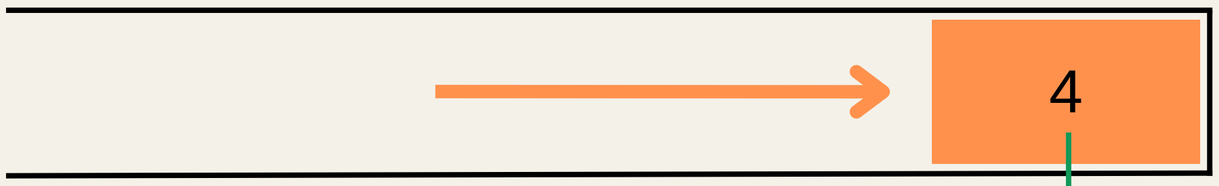
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	-1	-1	1	-1	-1	-1

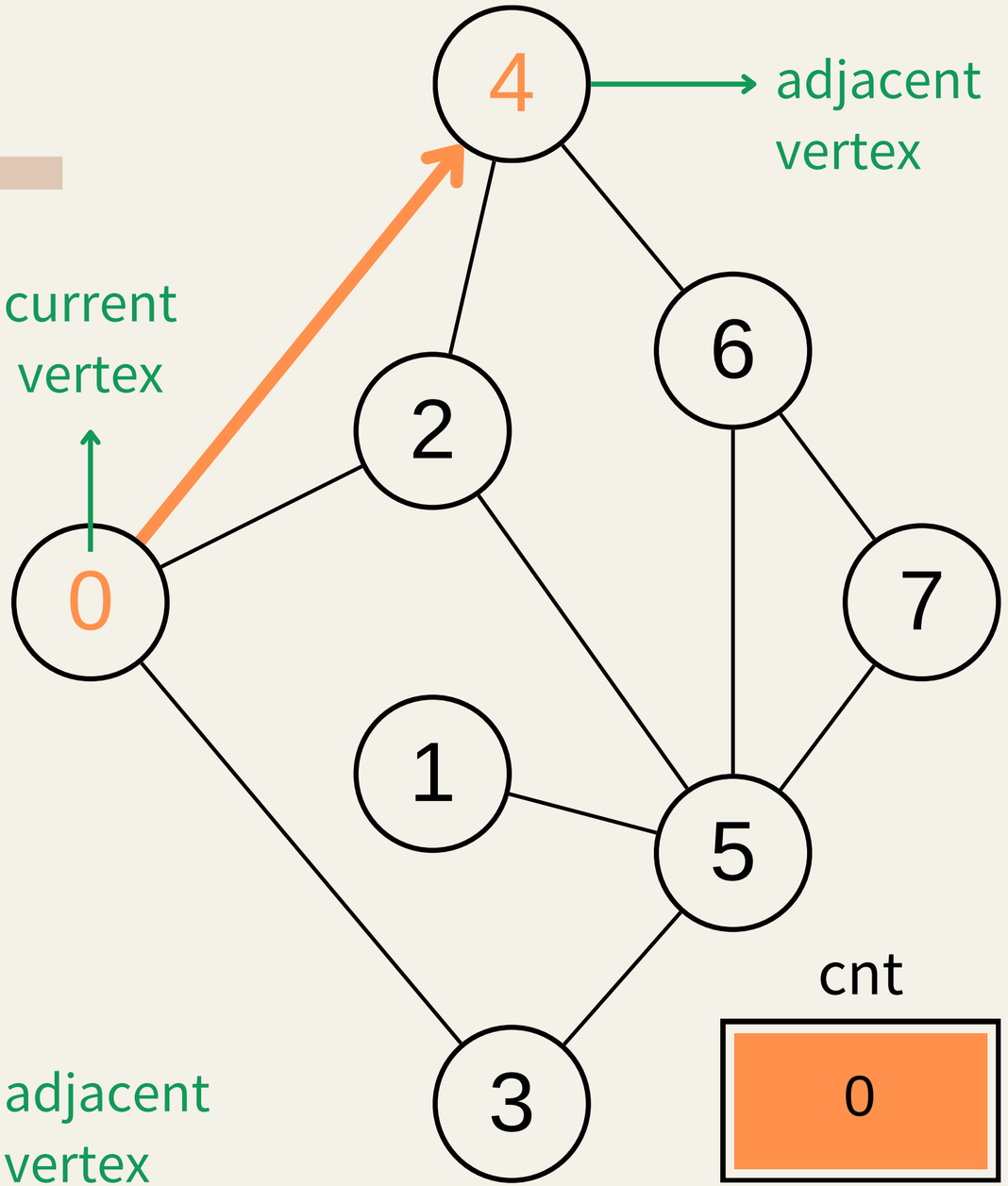
❶ If adjacent vertex is avaliable

→ Update dis[adjacent] to dis[cnt] + 1

queue<pair<int, int>> q



❷ Push adjacent vertex into queue



Operating BFS

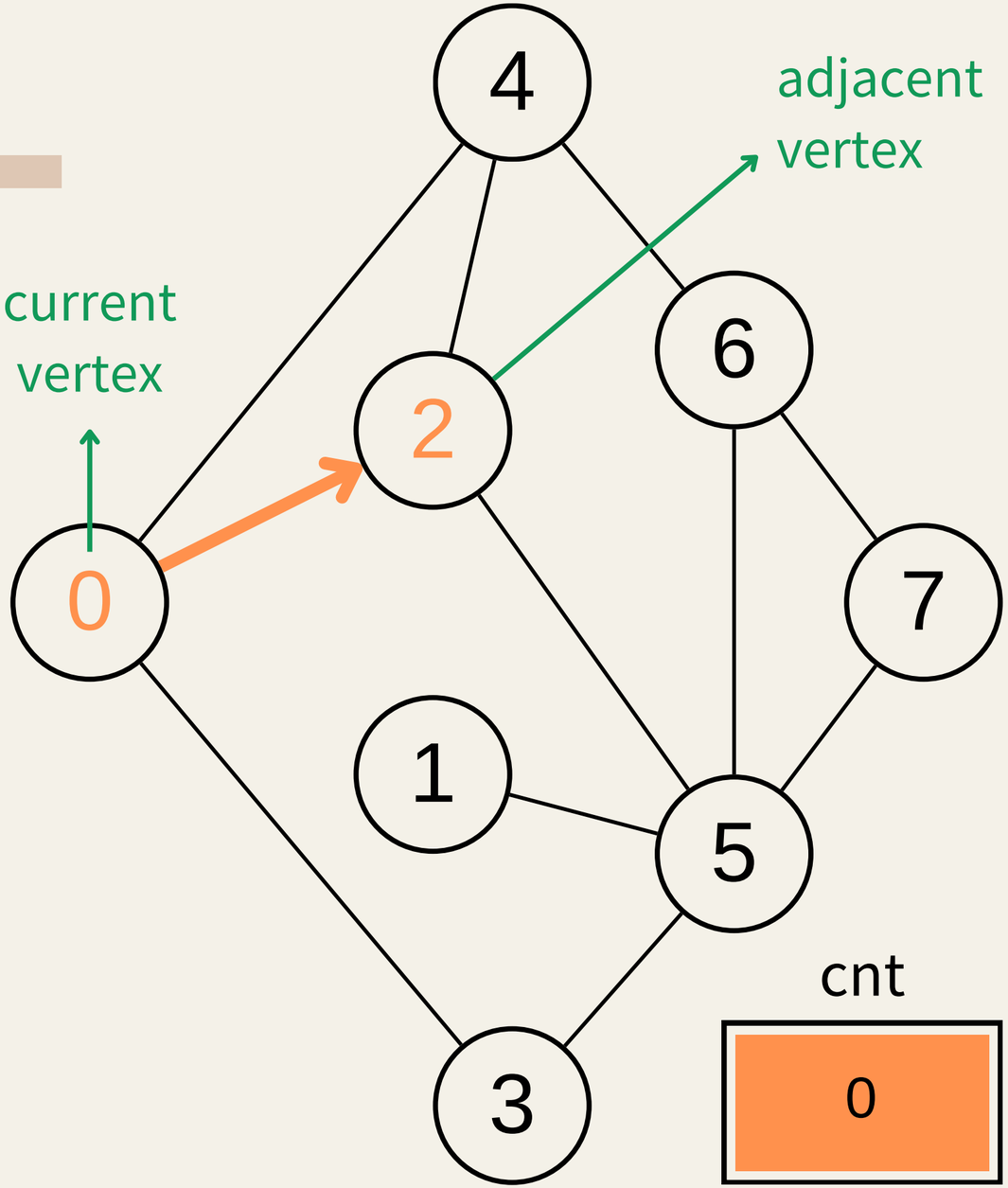
index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	-1	-1	1	-1	-1	-1

Available ✓

Check whether adjacent vertex is avaliable or not
→ dis[adjacent] equals to default value

queue<pair<int, int>> q

4



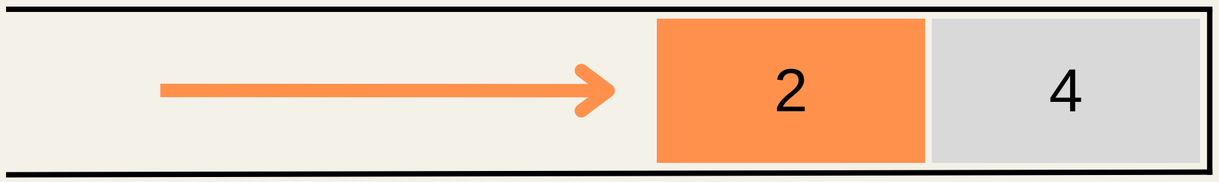
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	-1	1	-1	-1	-1

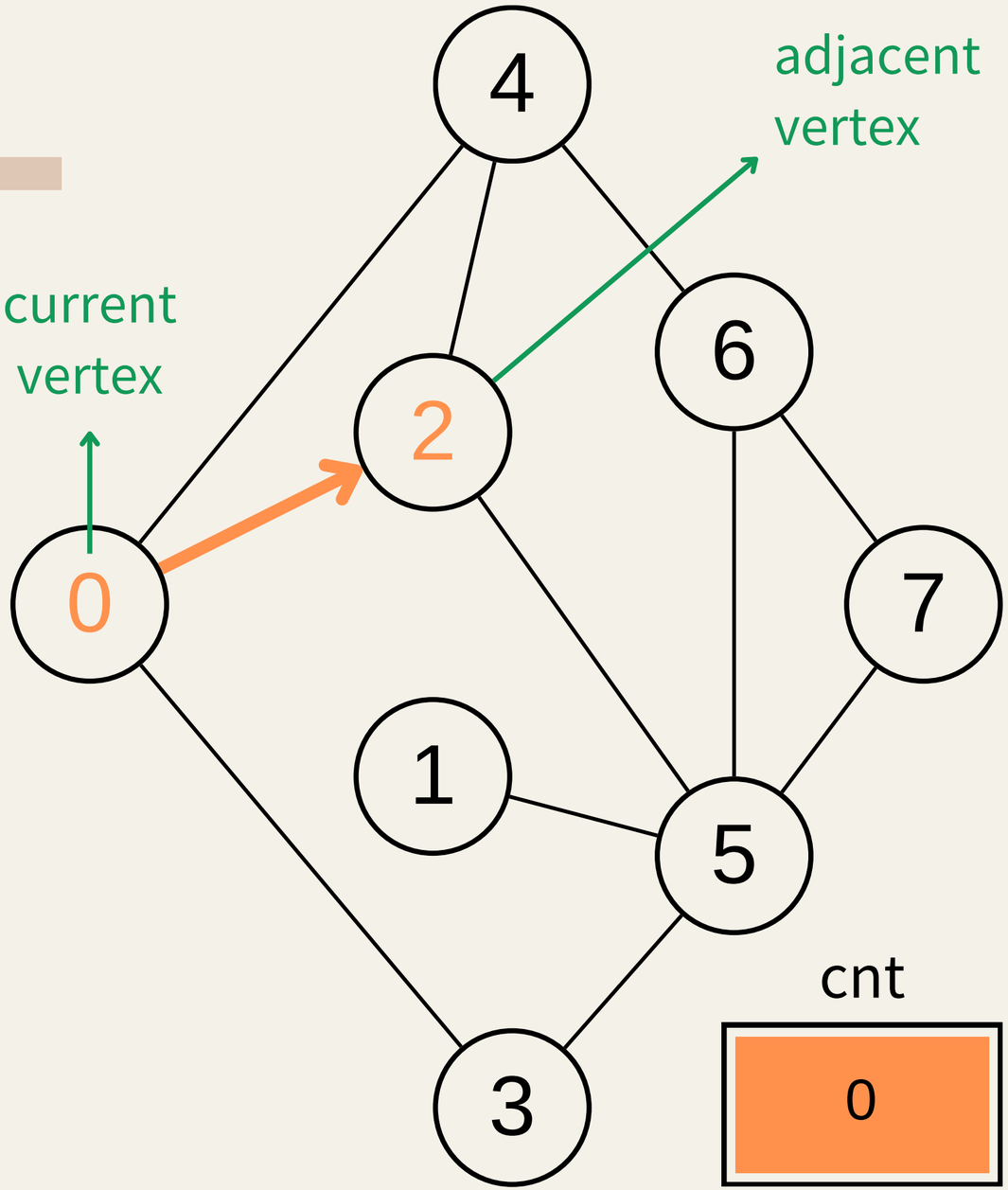
❶ If adjacent vertex is avaliable

→ Update dis[adjacent] to dis[cnt] + 1

queue<pair<int, int>> q



❷ Push adjacent vertex into queue



Operating BFS

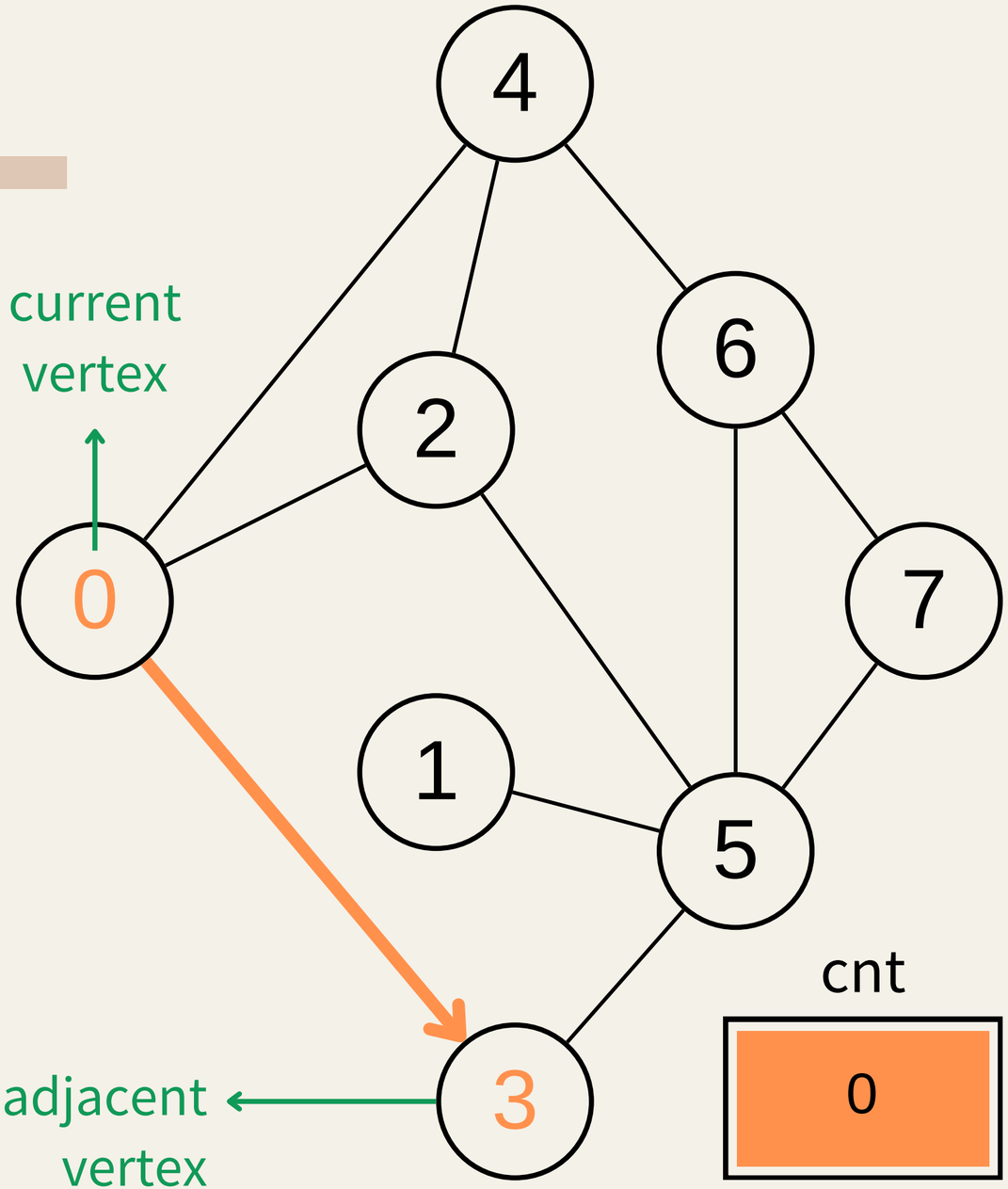
index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	-1	1	-1	-1	-1

Available ✓

Check whether adjacent vertex is avaliable or not
→ dis[adjacent] equals to default value

queue<pair<int, int>> q

		2	4



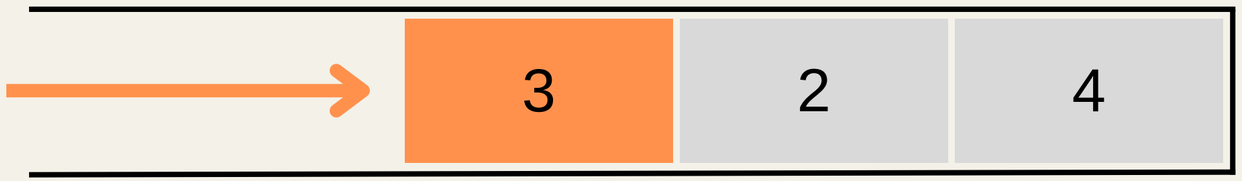
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	-1	-1

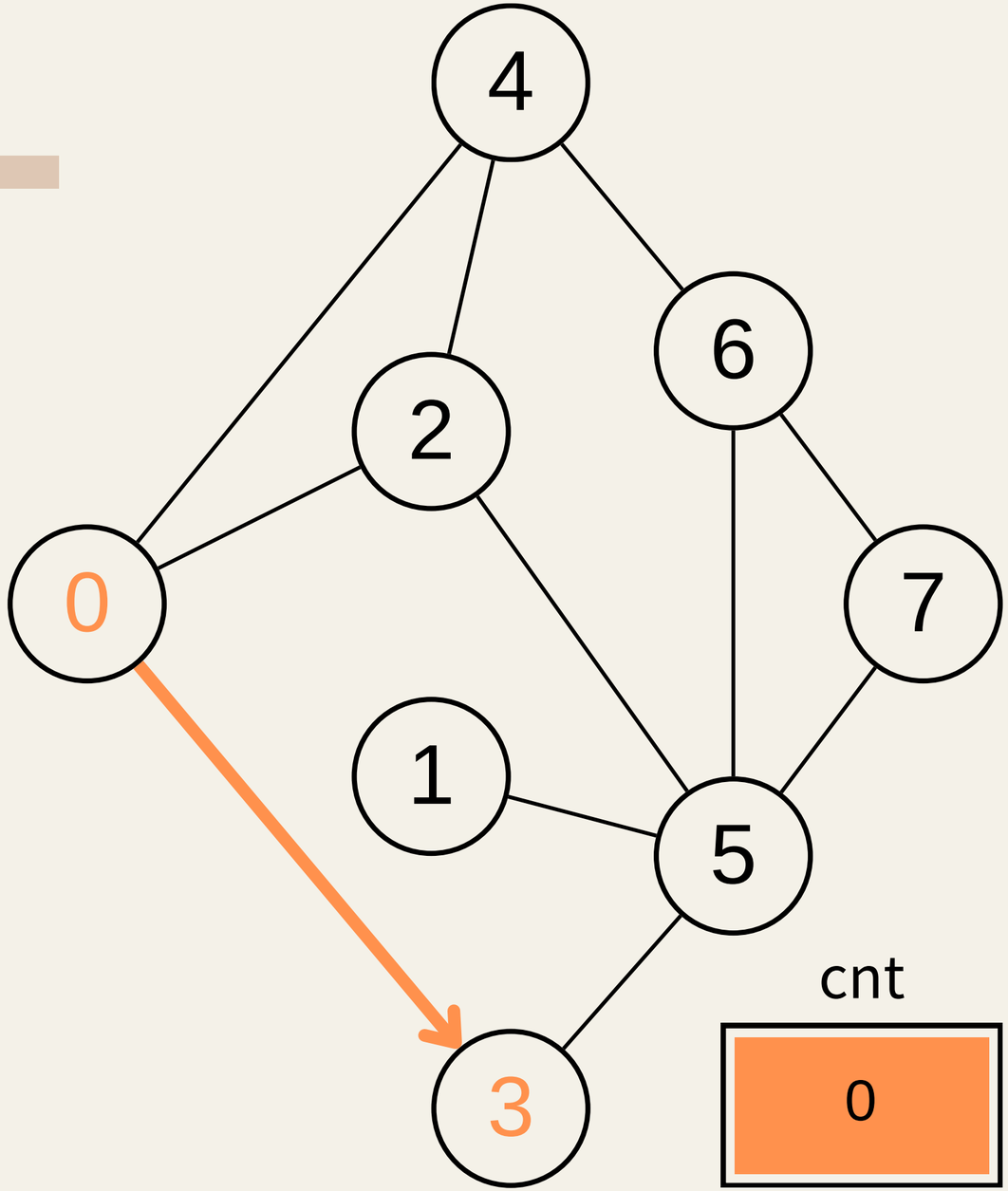
❶ If adjacent vertex is avaliable

→ Update dis[adjacent] to dis[cnt] + 1

queue<pair<int, int>> q



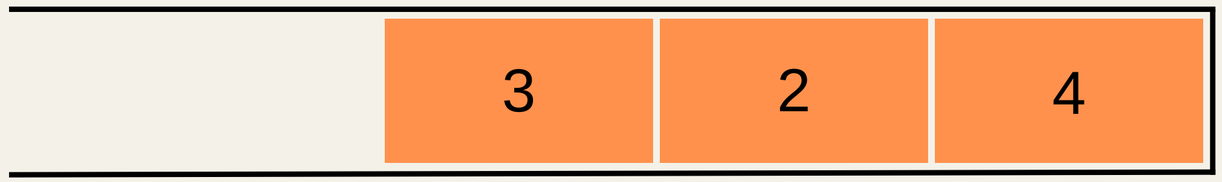
❷ Push adjacent vertex into queue

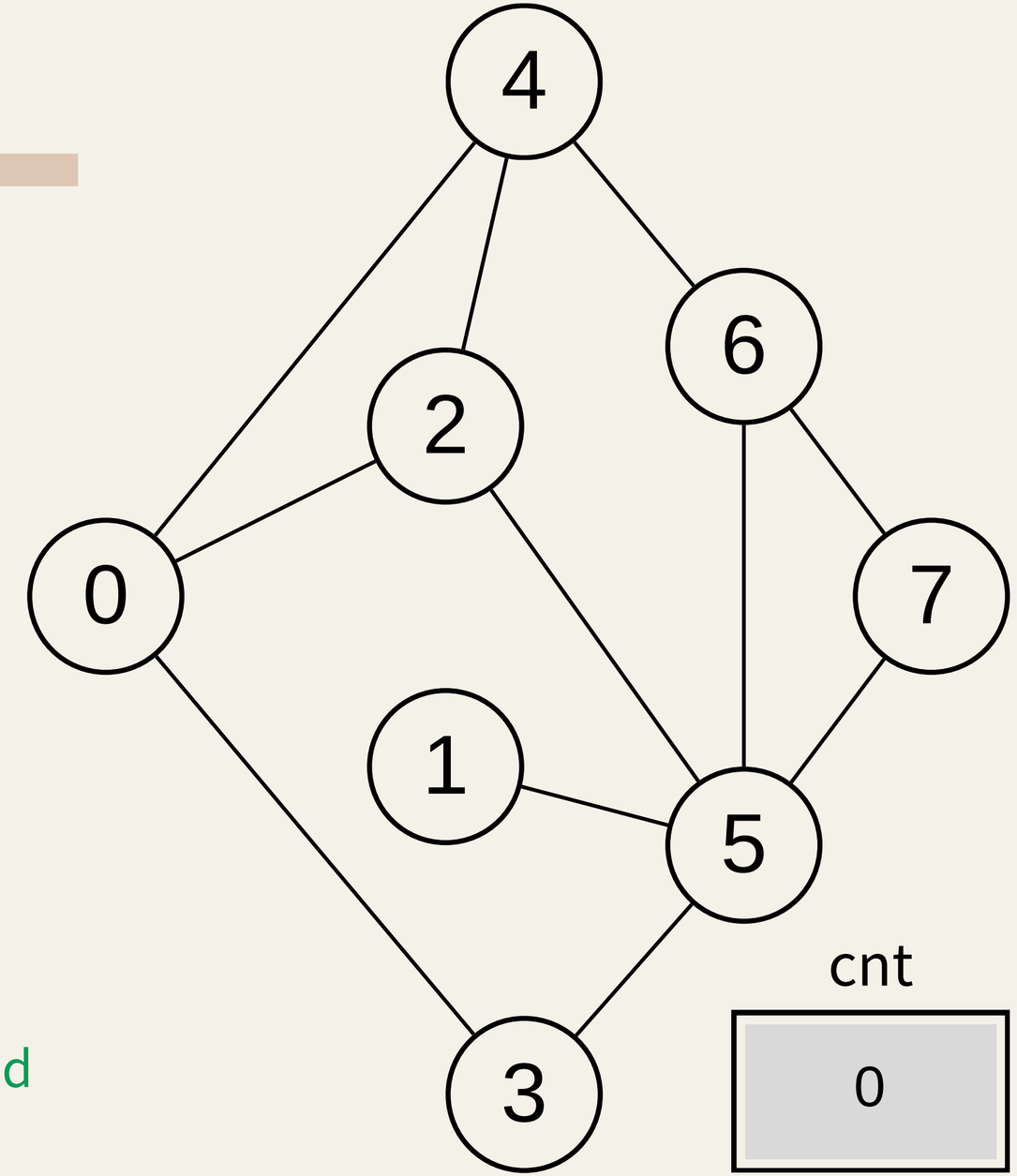


Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	-1	-1

queue<pair<int, int>> q

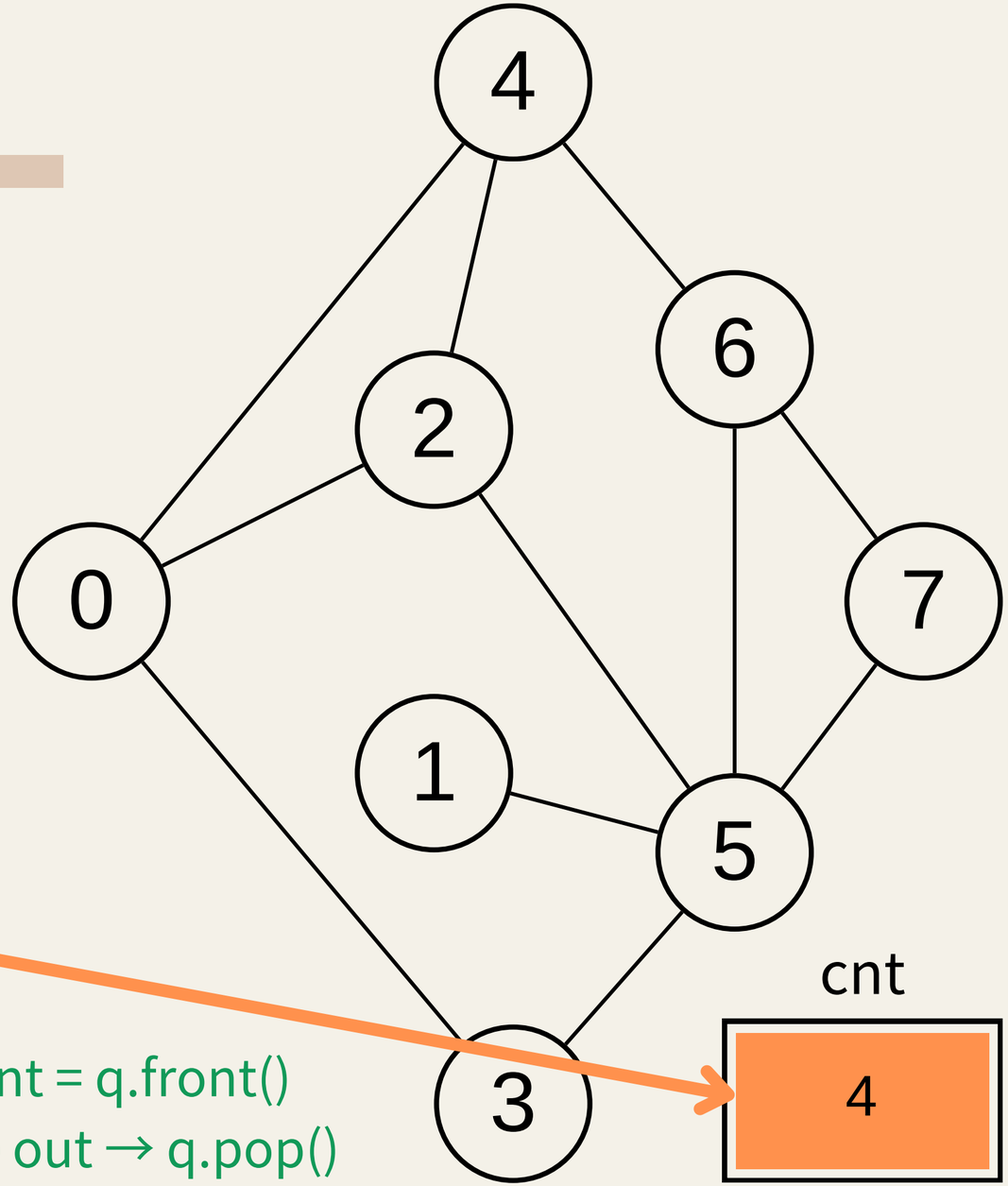




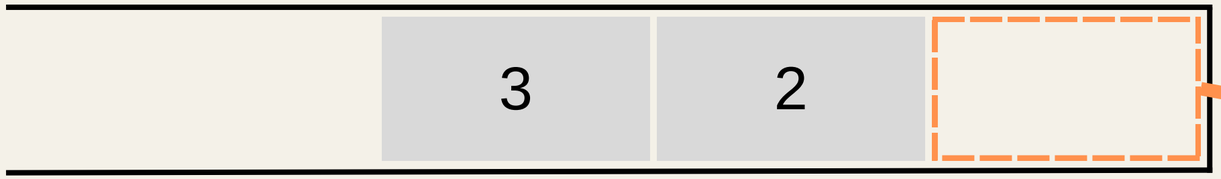
When all vertex adjacent to cnt have been processed
Then, Check the whether queue is empty or not
→ If true, keep going with the remaining vertices

Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	-1	-1



queue<pair<int, int>> q



cnt

❶ Put the front most element of queue into cnt → cnt = q.front()

❷ Pop out the old element which already been take out → q.pop()

Operating BFS

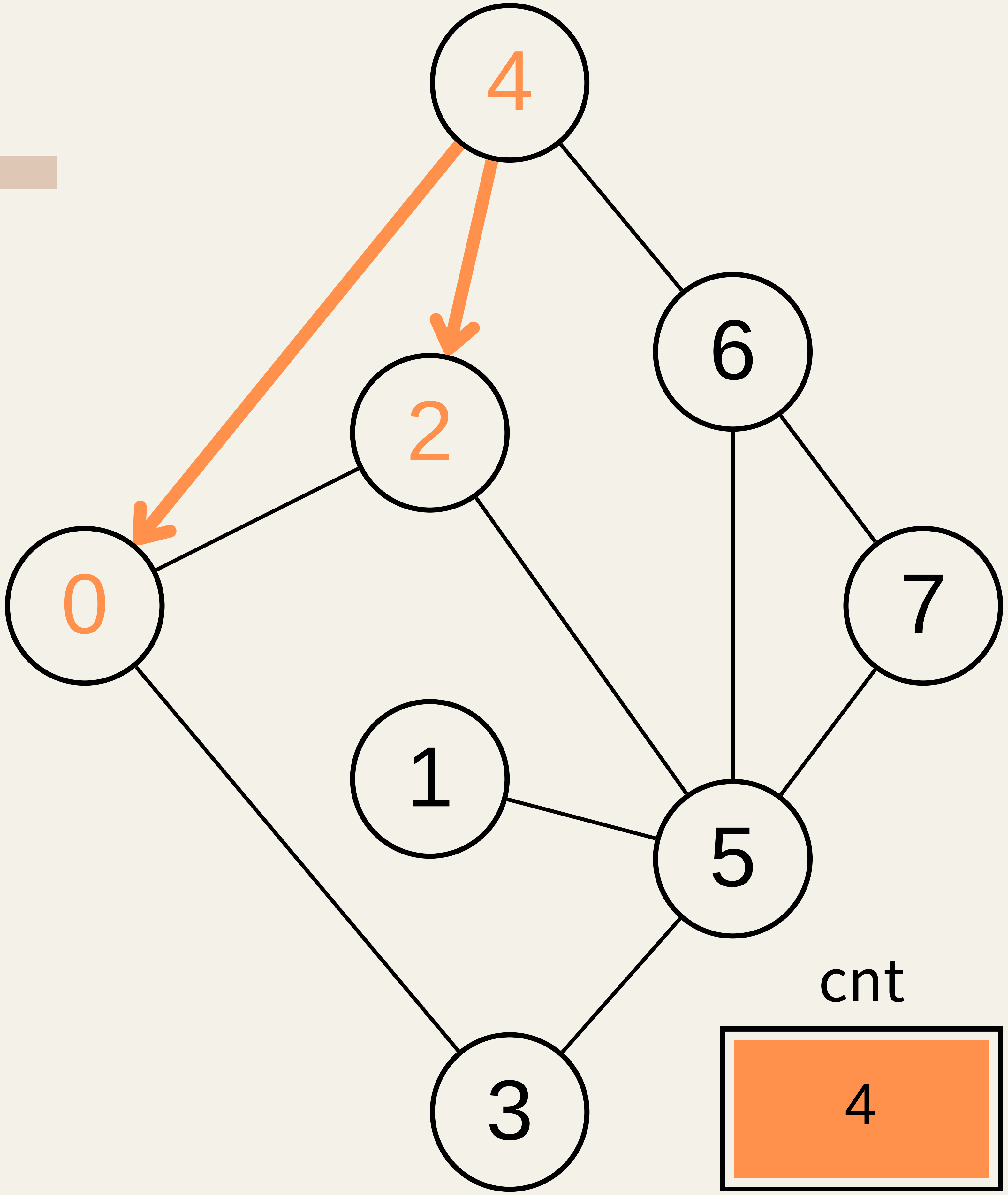
index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	-1	-1

Not Available ✗

Check whether adjacent vertex is avaliable or not
→ dis[adjacent] equals to default value

queue<pair<int, int>> q

3	2



Operating BFS

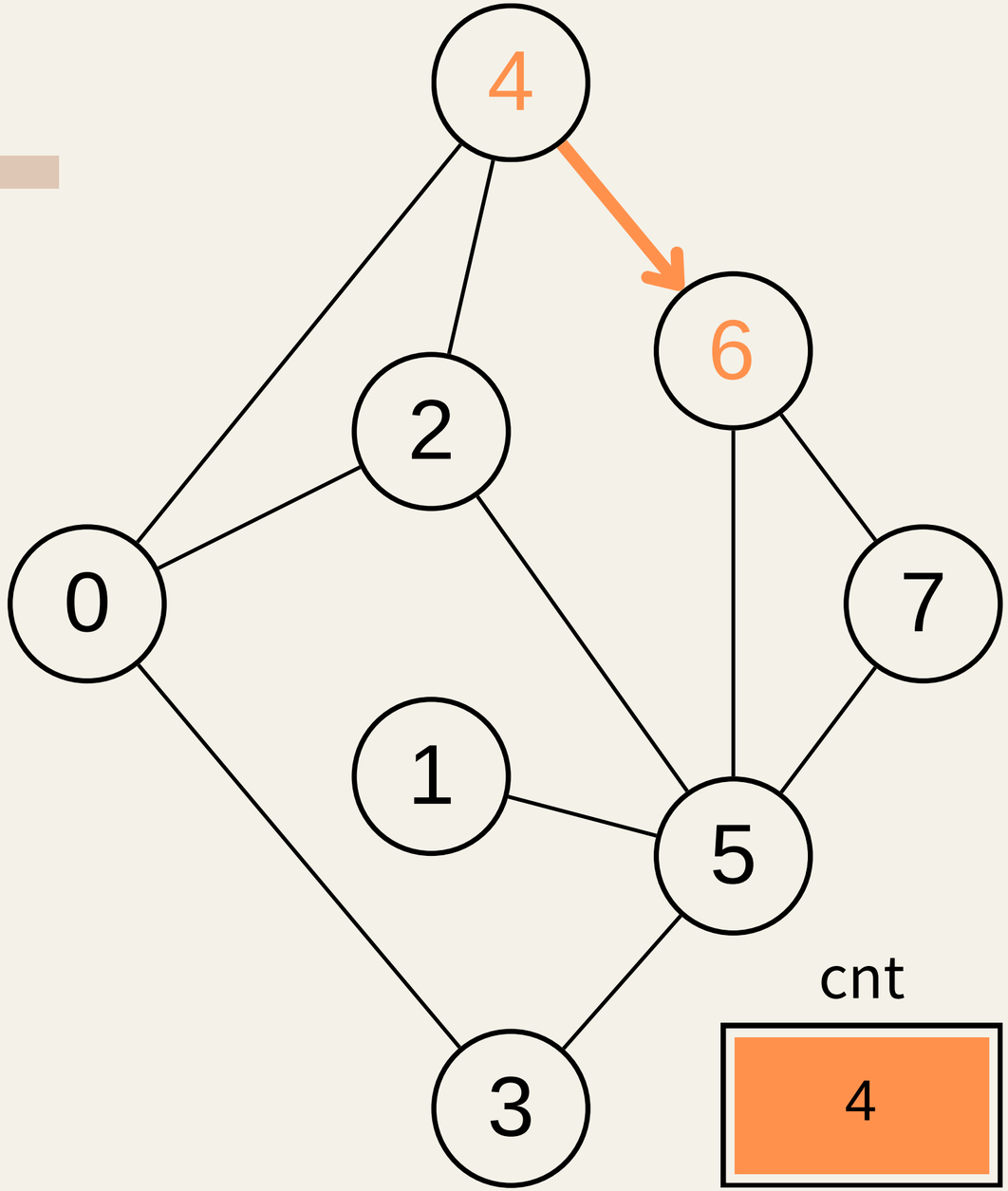
index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	-1	-1

Available ✓

Check whether adjacent vertex is avaliable or not
→ dis[adjacent] equals to default value

queue<pair<int, int>> q

								3	2



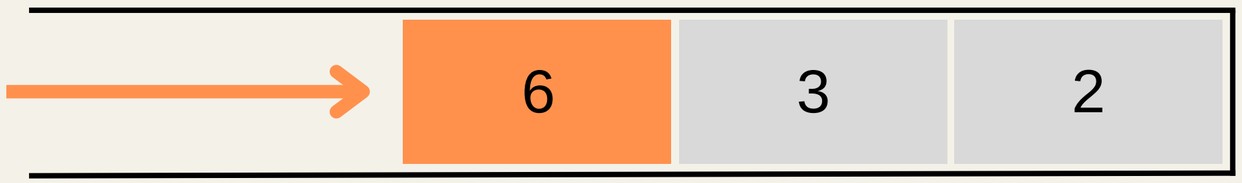
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	2	-1

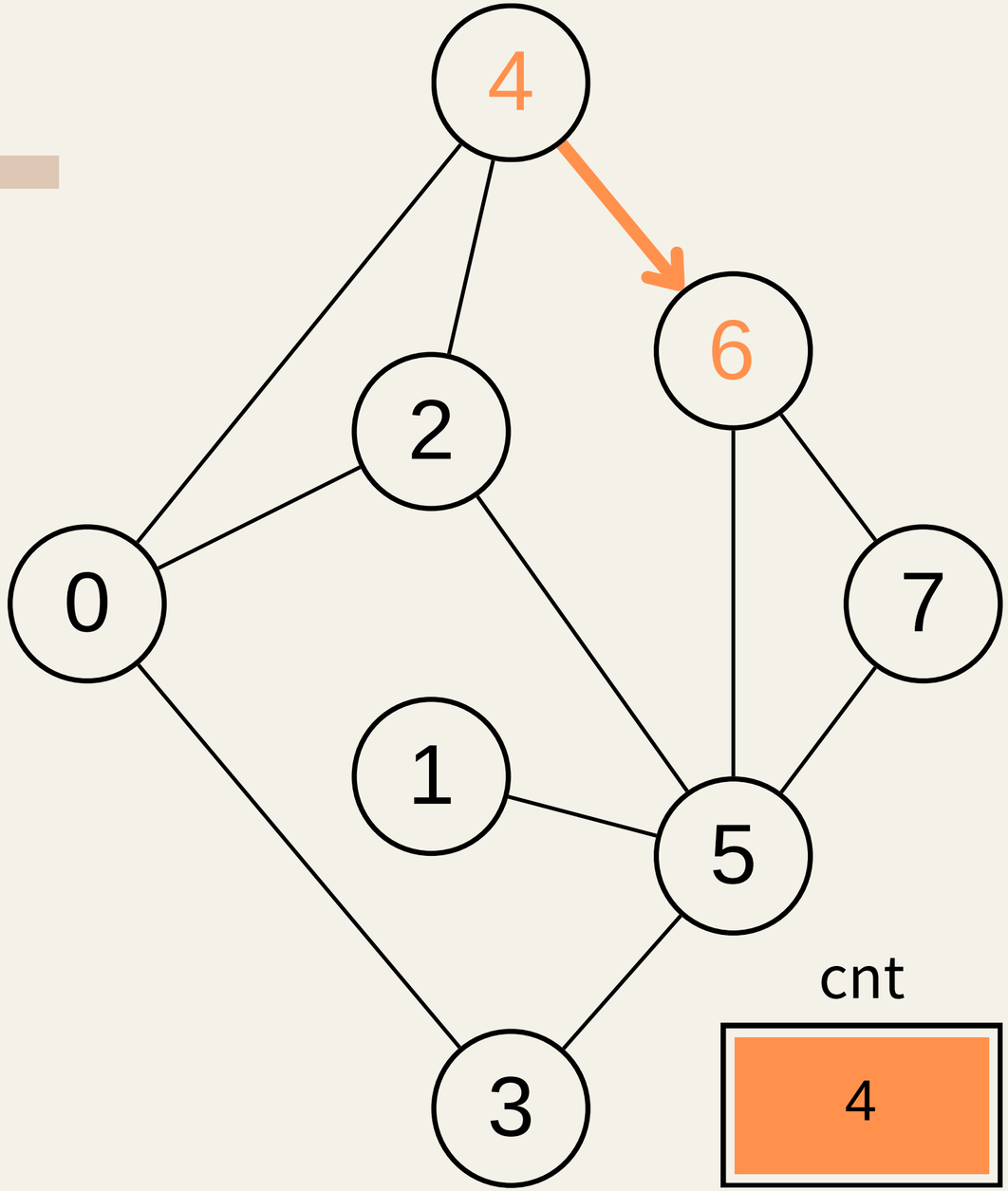
❶ If adjacent vertex is avaliable

→ Update dis[adjacent] to dis[cnt] + 1

queue<pair<int, int>> q



❷ Push adjacent vertex into queue

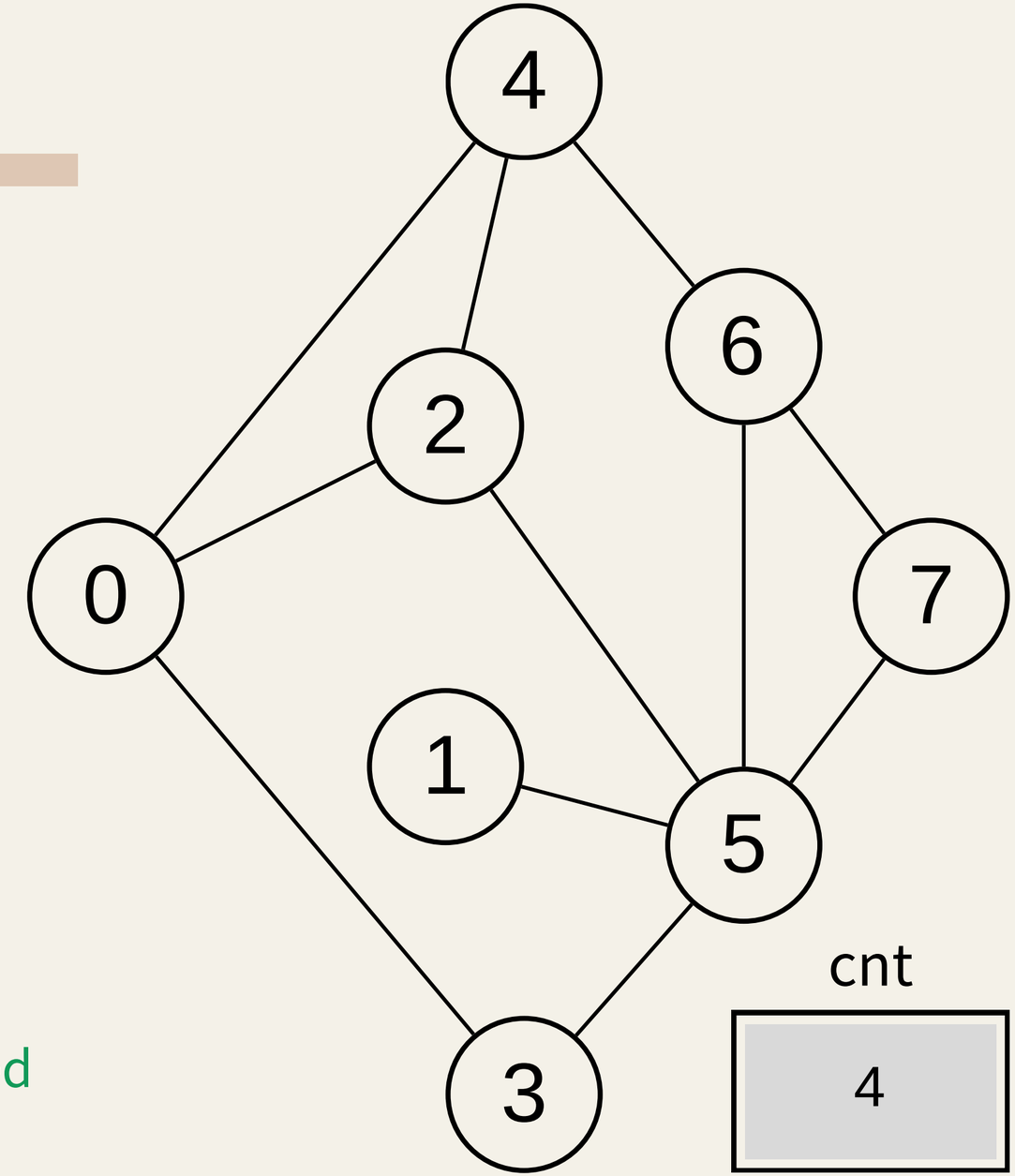


Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	2	-1

queue<pair<int, int>> q

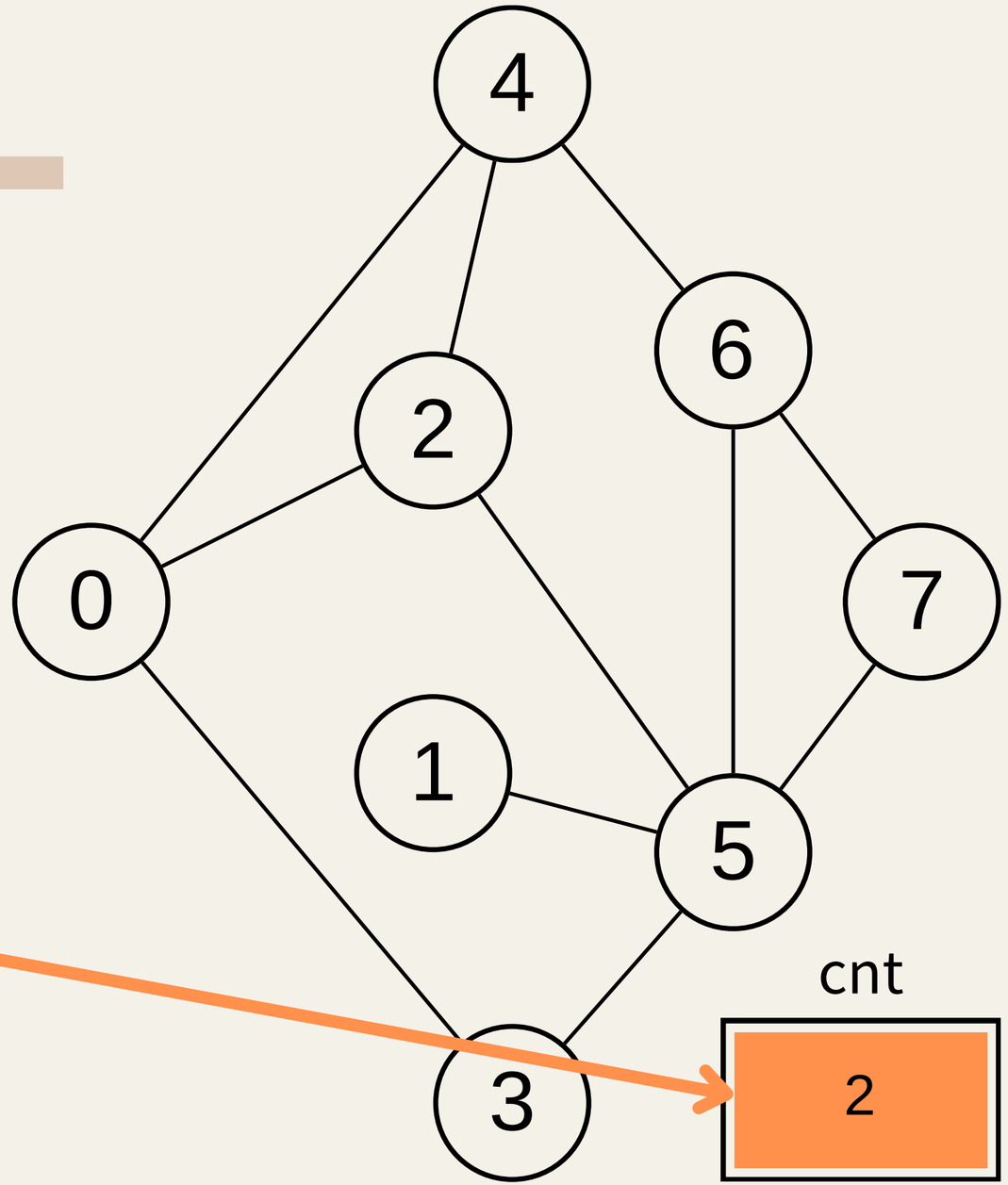
When all vertex adjacent to cnt have been processed
Then, Check the whether queue is empty or not
→ If true, keep going with the remaining vertices



Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	2	-1

queue<pair<int, int>> q



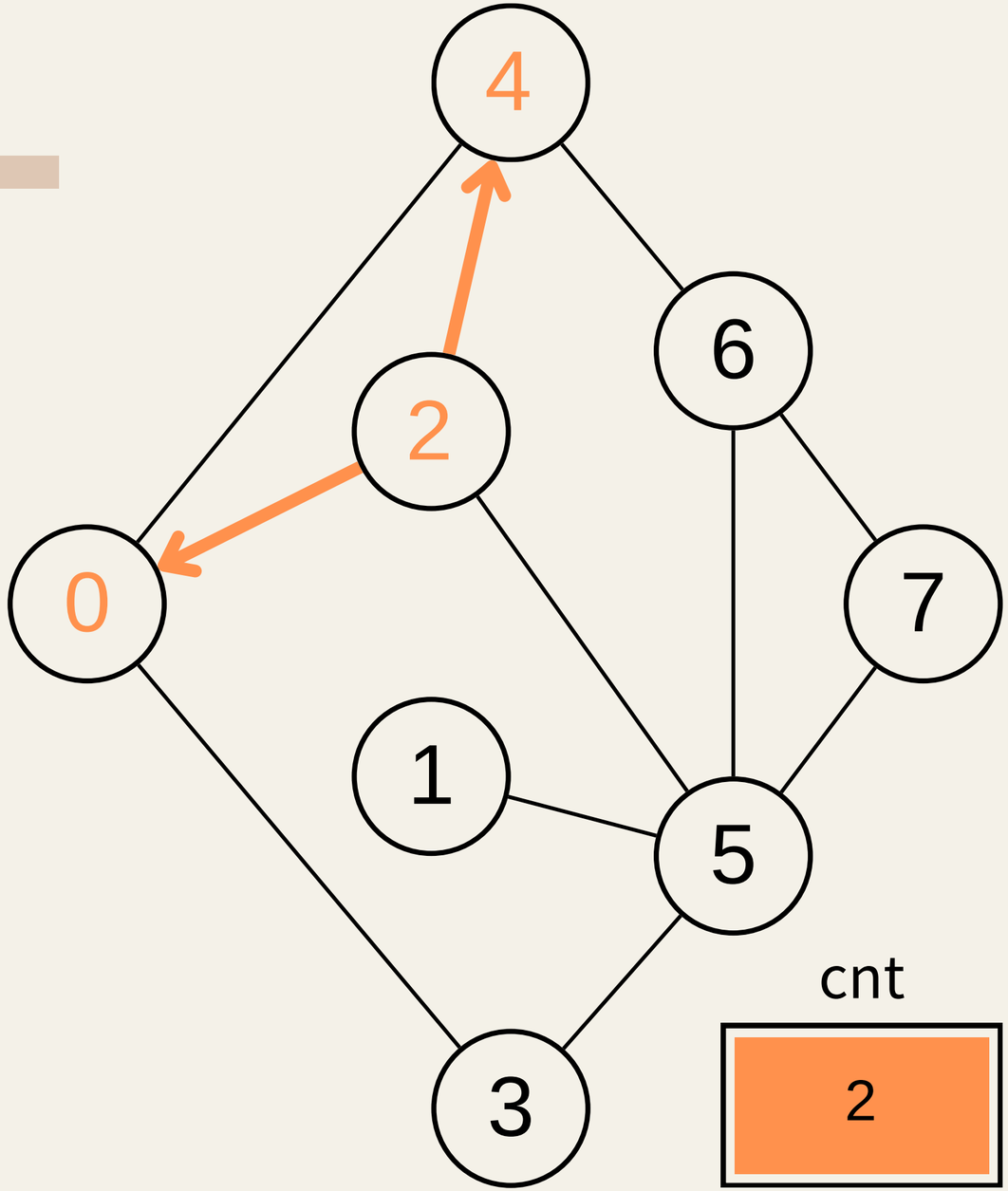
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	2	-1

Not Available ✗ Not Available ✗

queue<pair<int, int>> q

						6	3



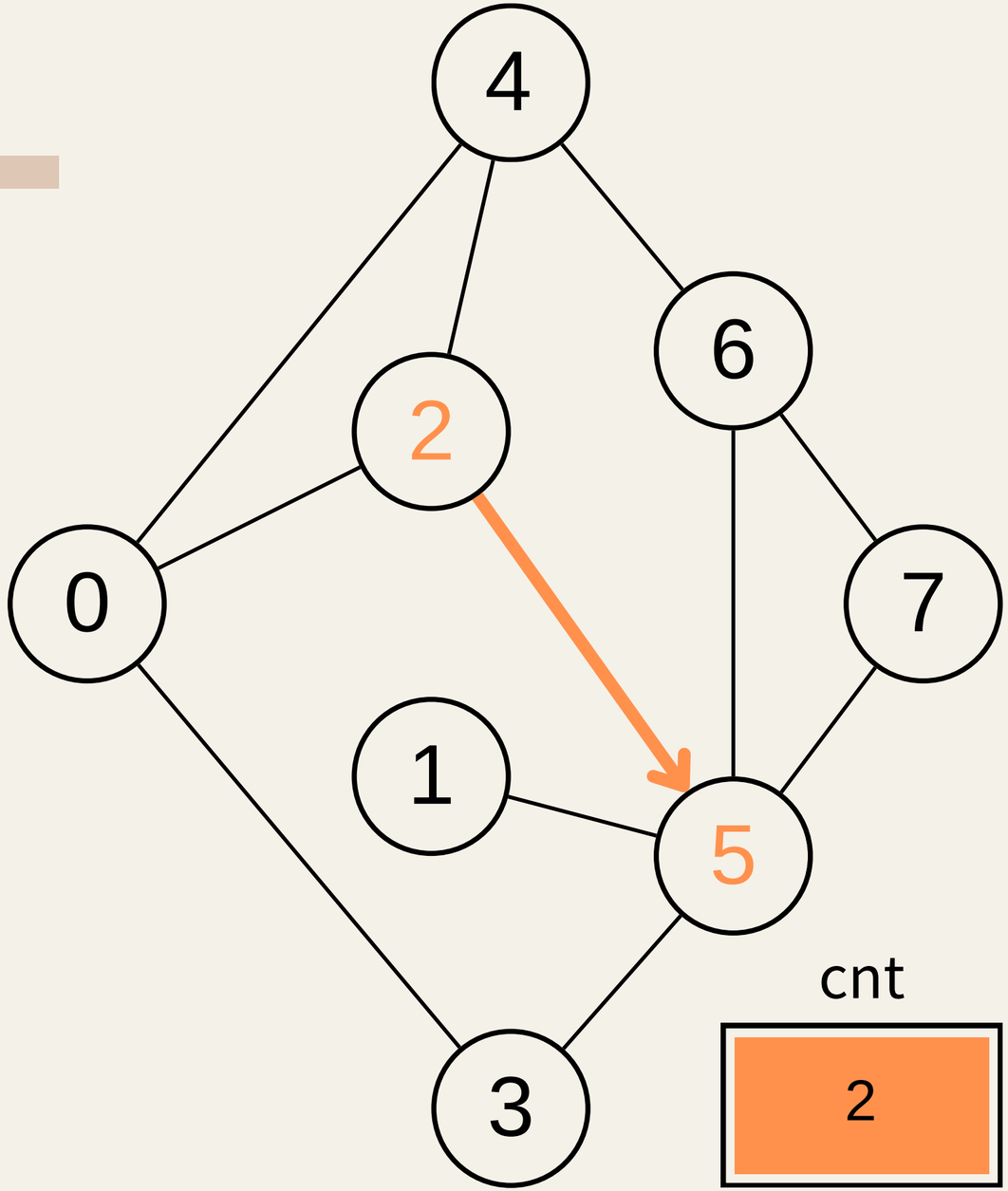
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	-1	2	-1

Available ✓

queue<pair<int, int>> q

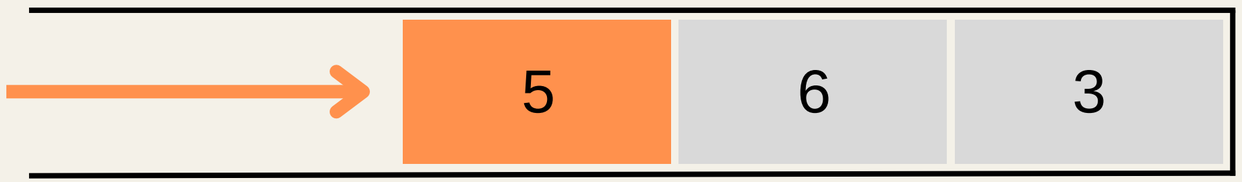
6	3

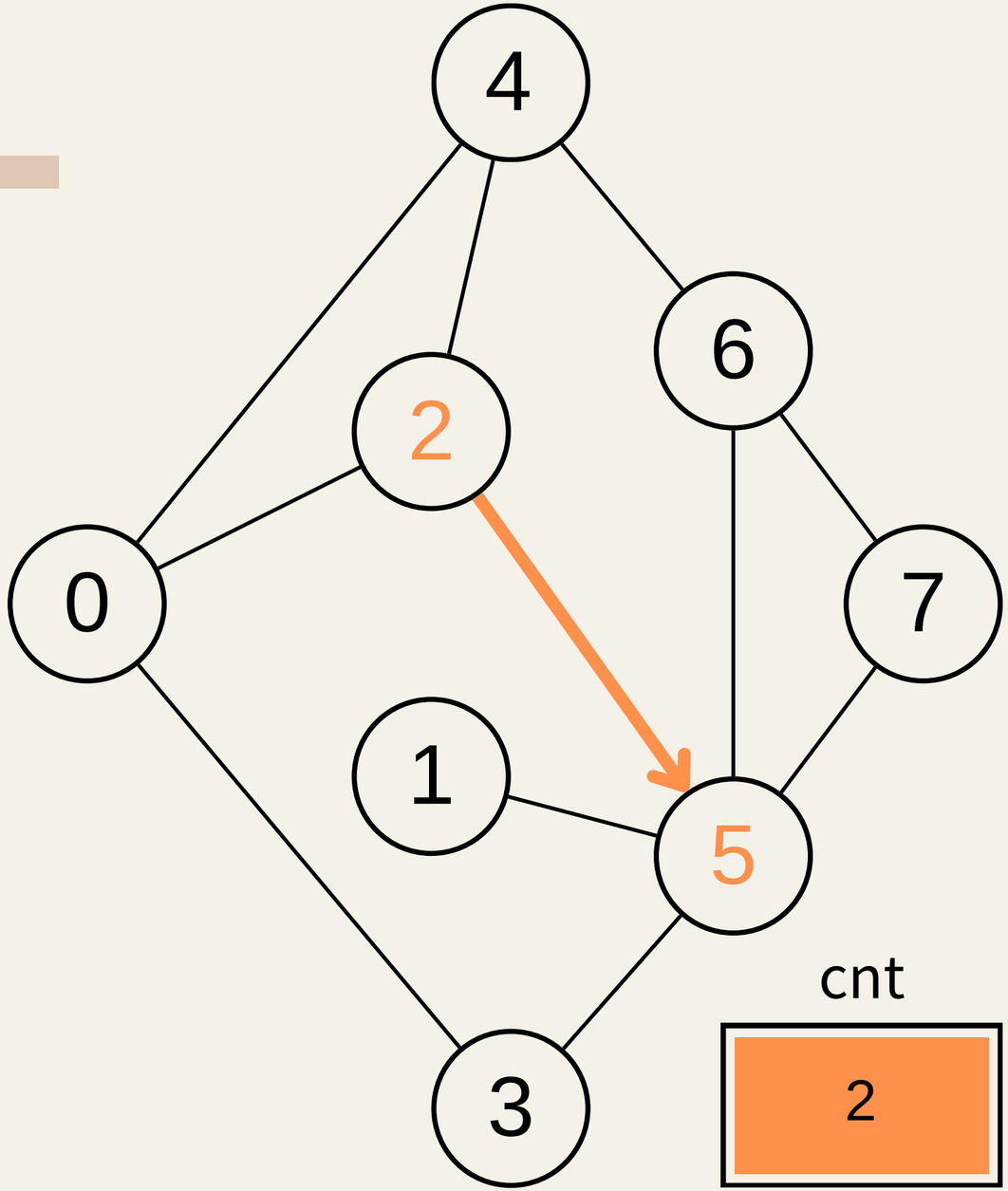


Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	-1

queue<pair<int, int>> q



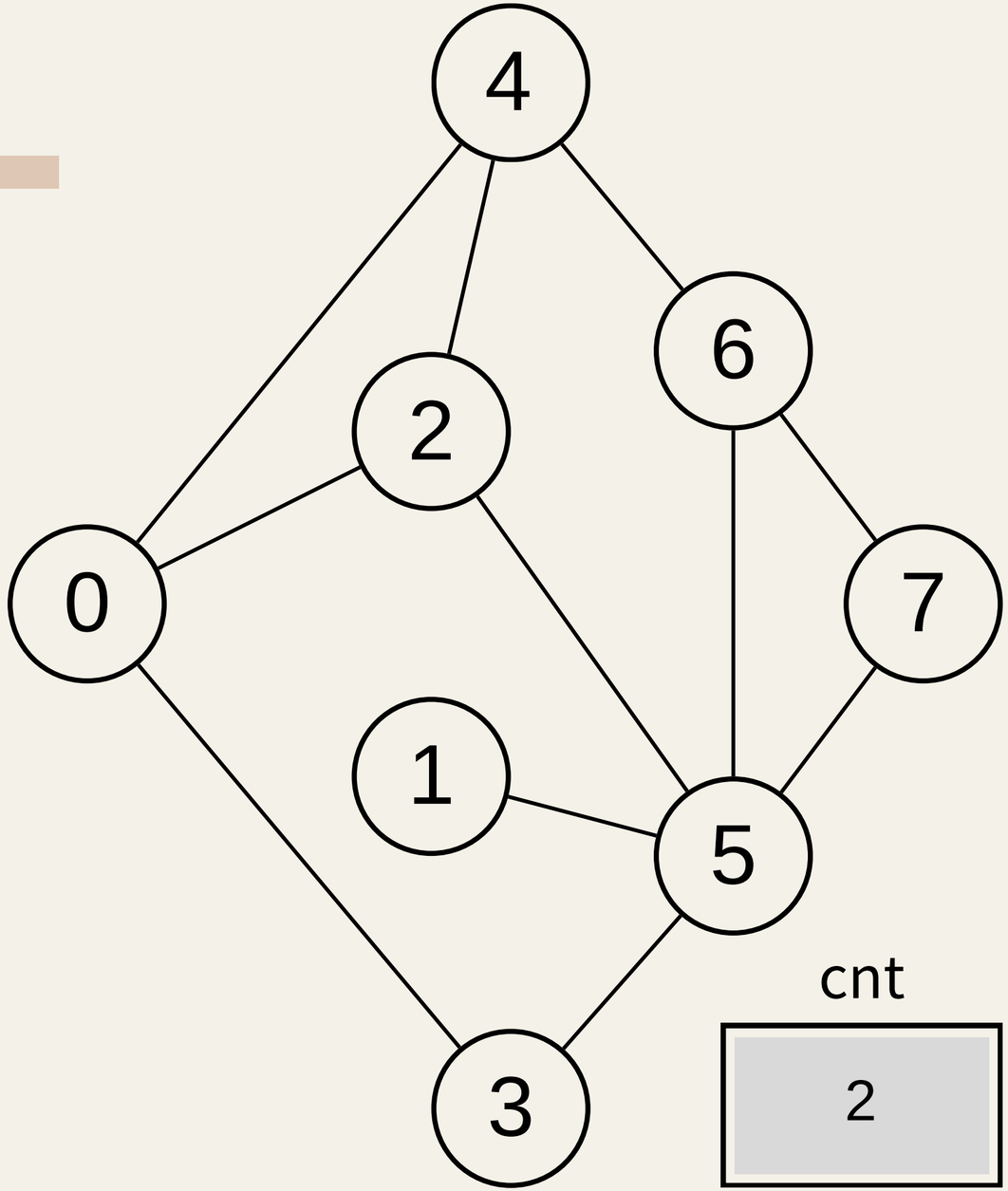


Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	-1

queue<pair<int, int>> q

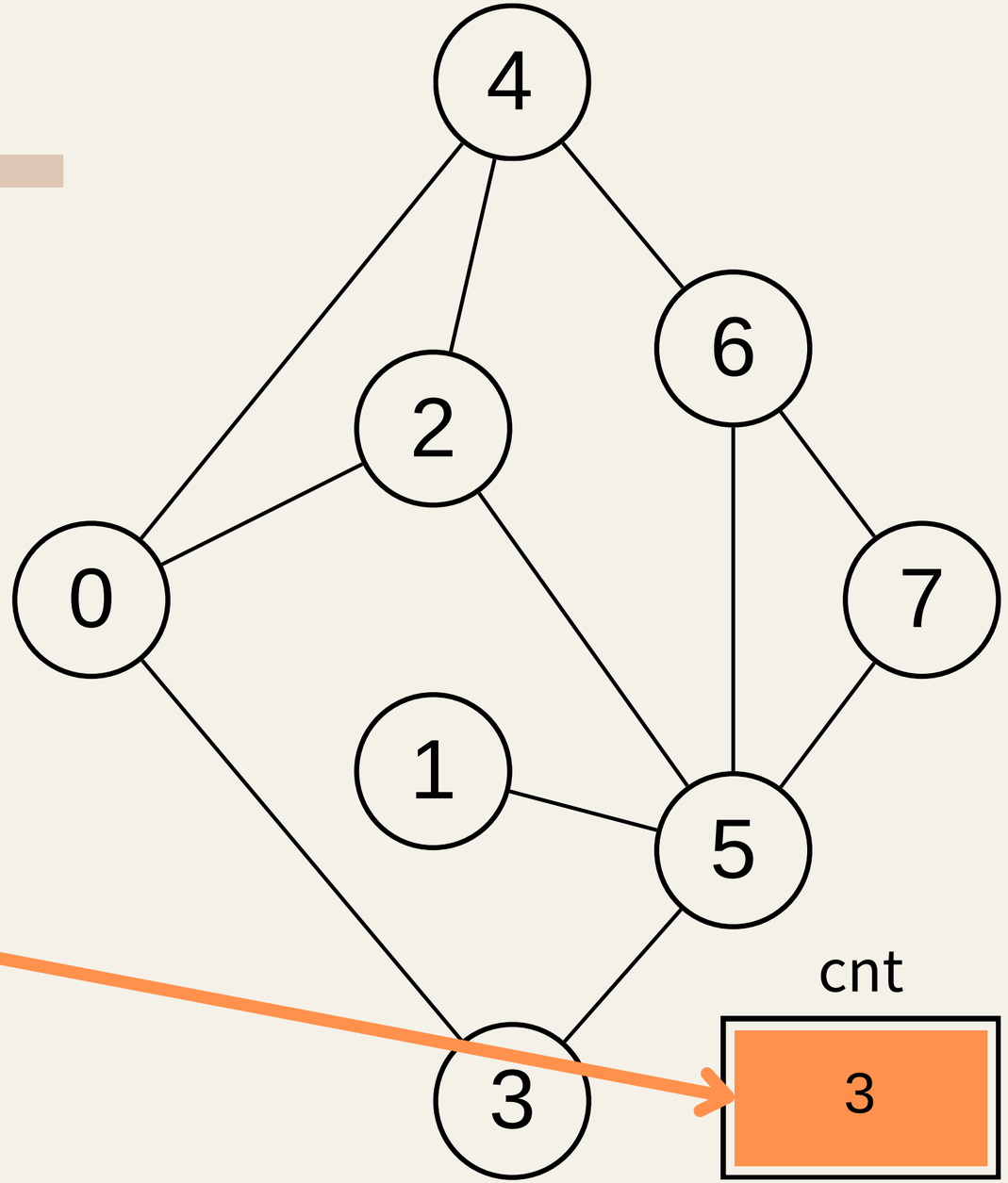
5	6	3



Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	-1

queue<pair<int, int>> q



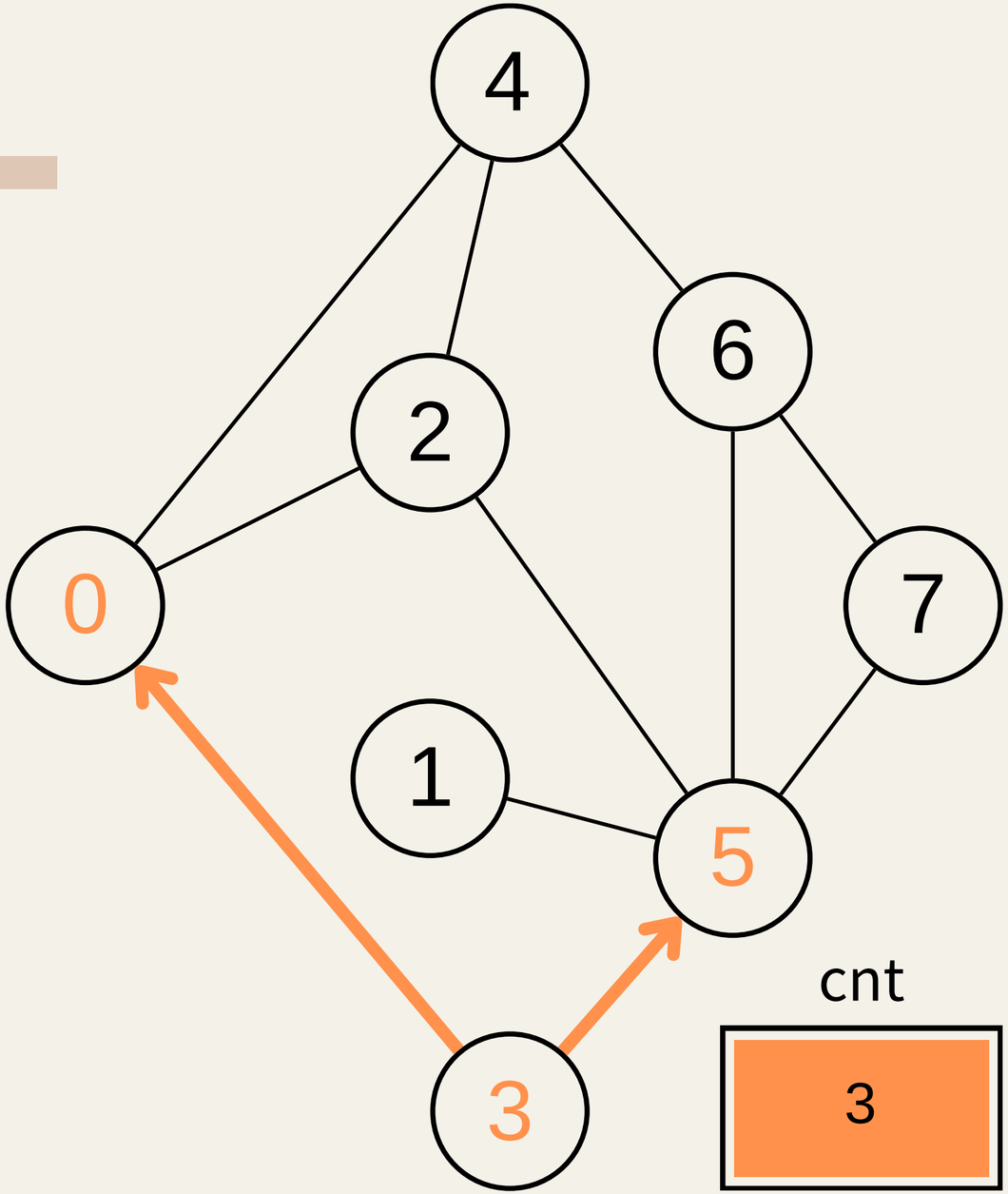
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	-1

Not Available ✗

queue<pair<int, int>> q

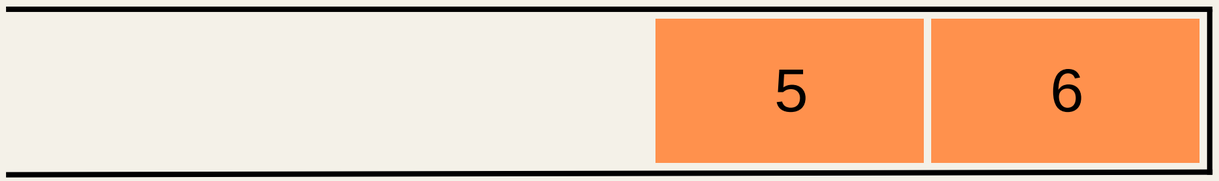
5	6

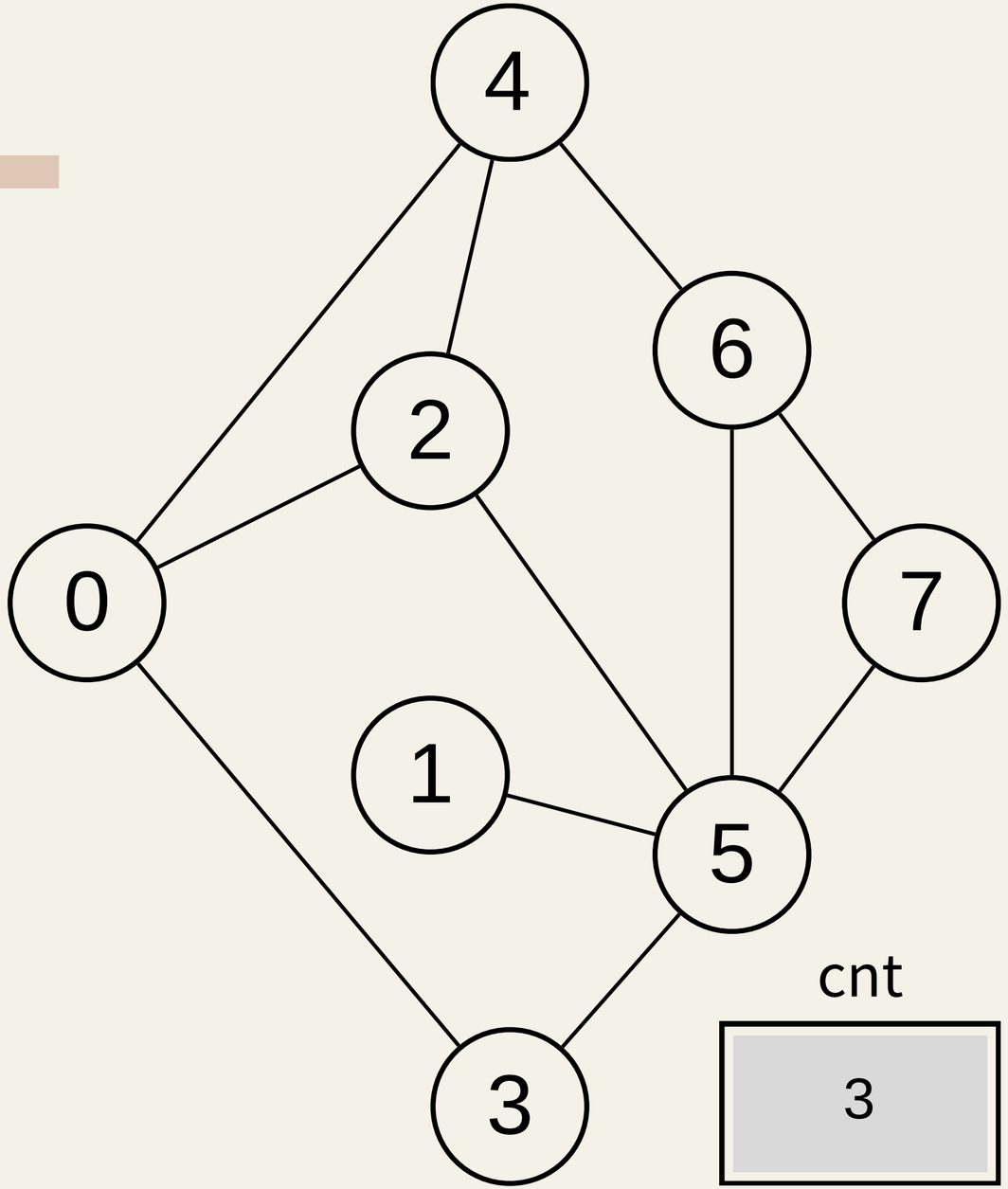


Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	-1

queue<pair<int, int>> q

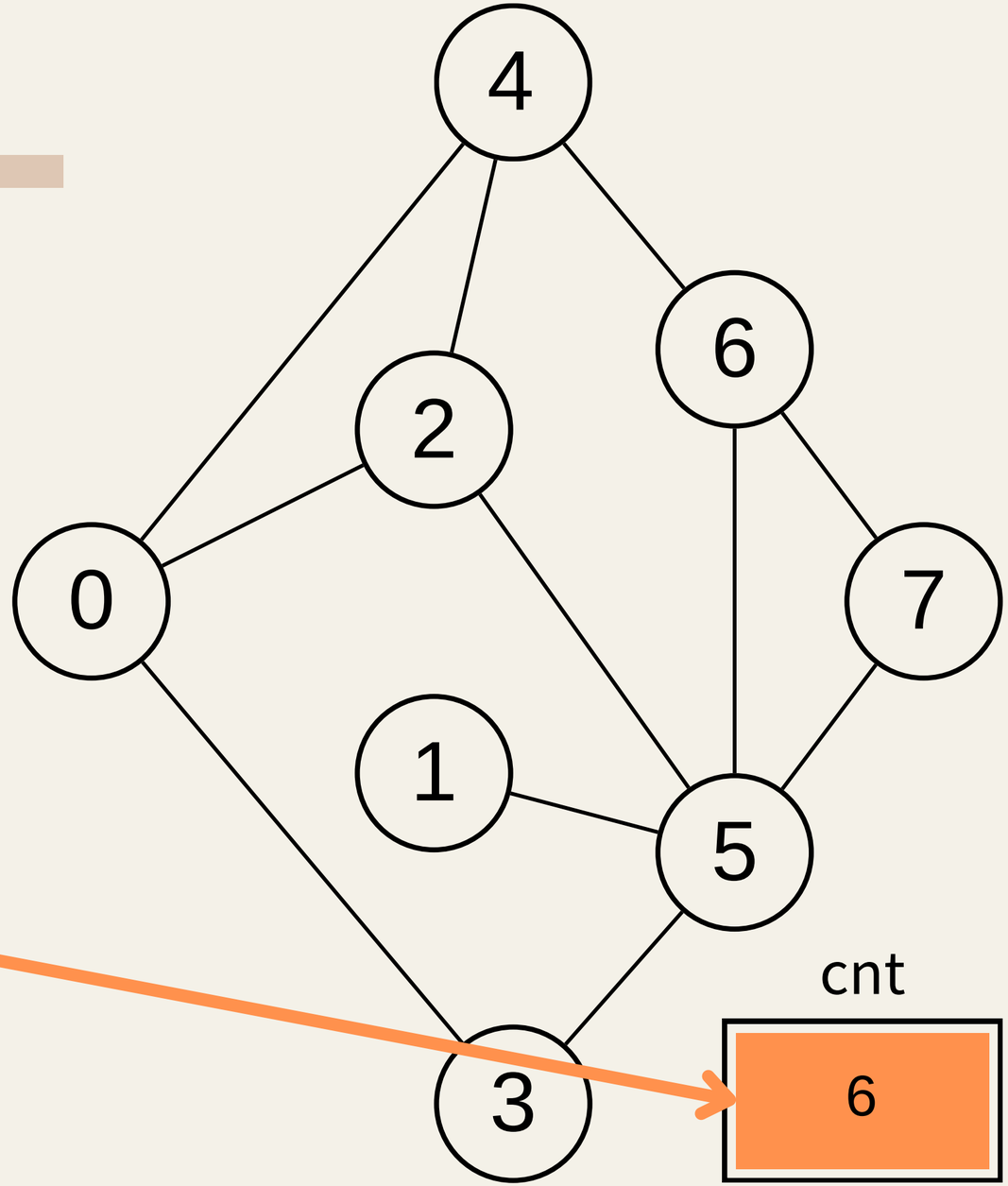




Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	-1

queue<pair<int, int>> q

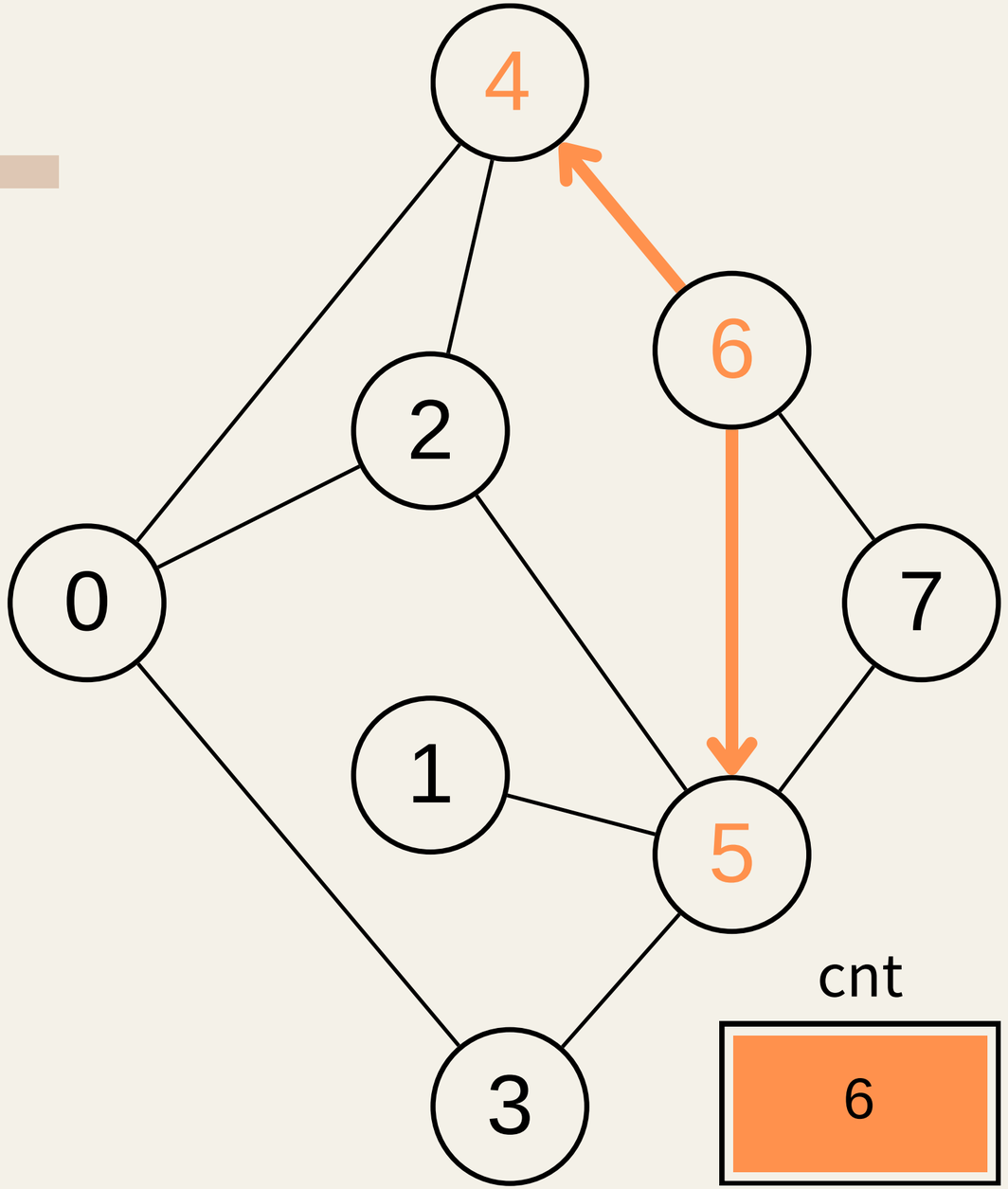


Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	-1

Not Available ✗

queue<pair<int, int>> q



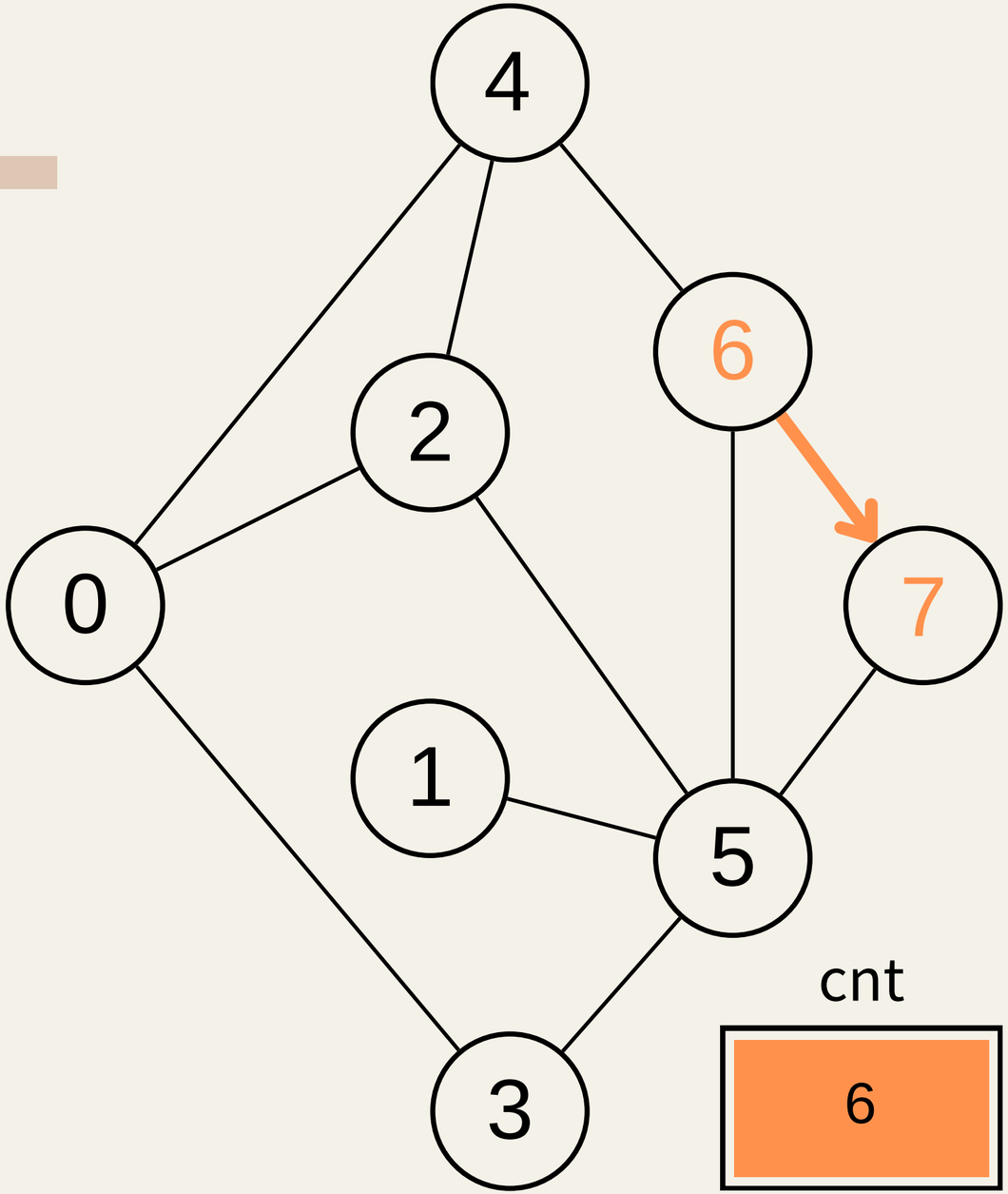
Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	-1

Available ✓

queue<pair<int, int>> q

5

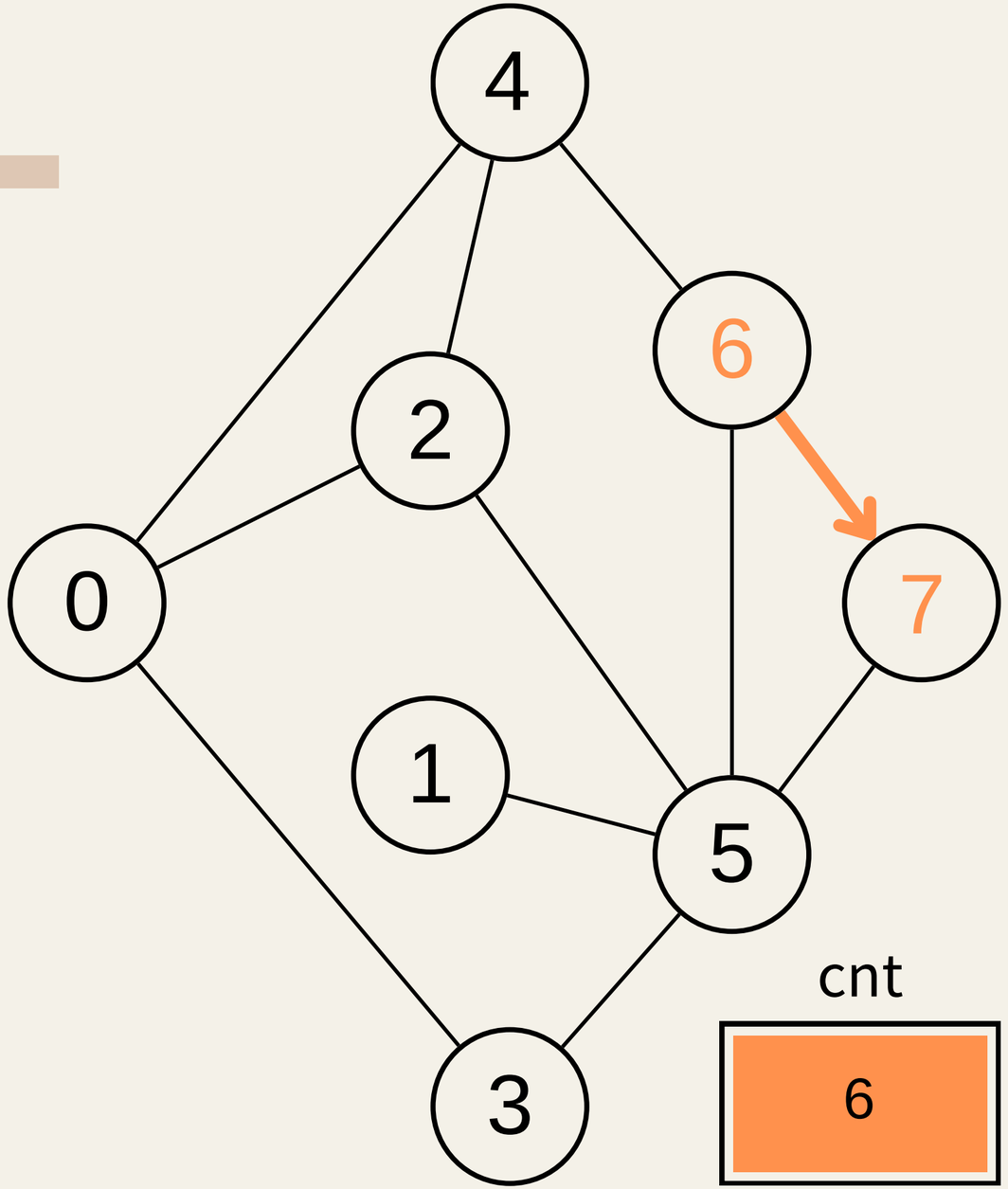


Operating BFS

index	0	1	2	3	4	5	6	7
dis[ ]	0	-1	1	1	1	2	2	3

This is the shortest path !

queue<pair<int, int>> q



Depth First Search

深度優先搜尋演算法

Initialize

index	0	1	2	3	4	5	6	7
used[ ]	False	False	False	False	False	False	False	False

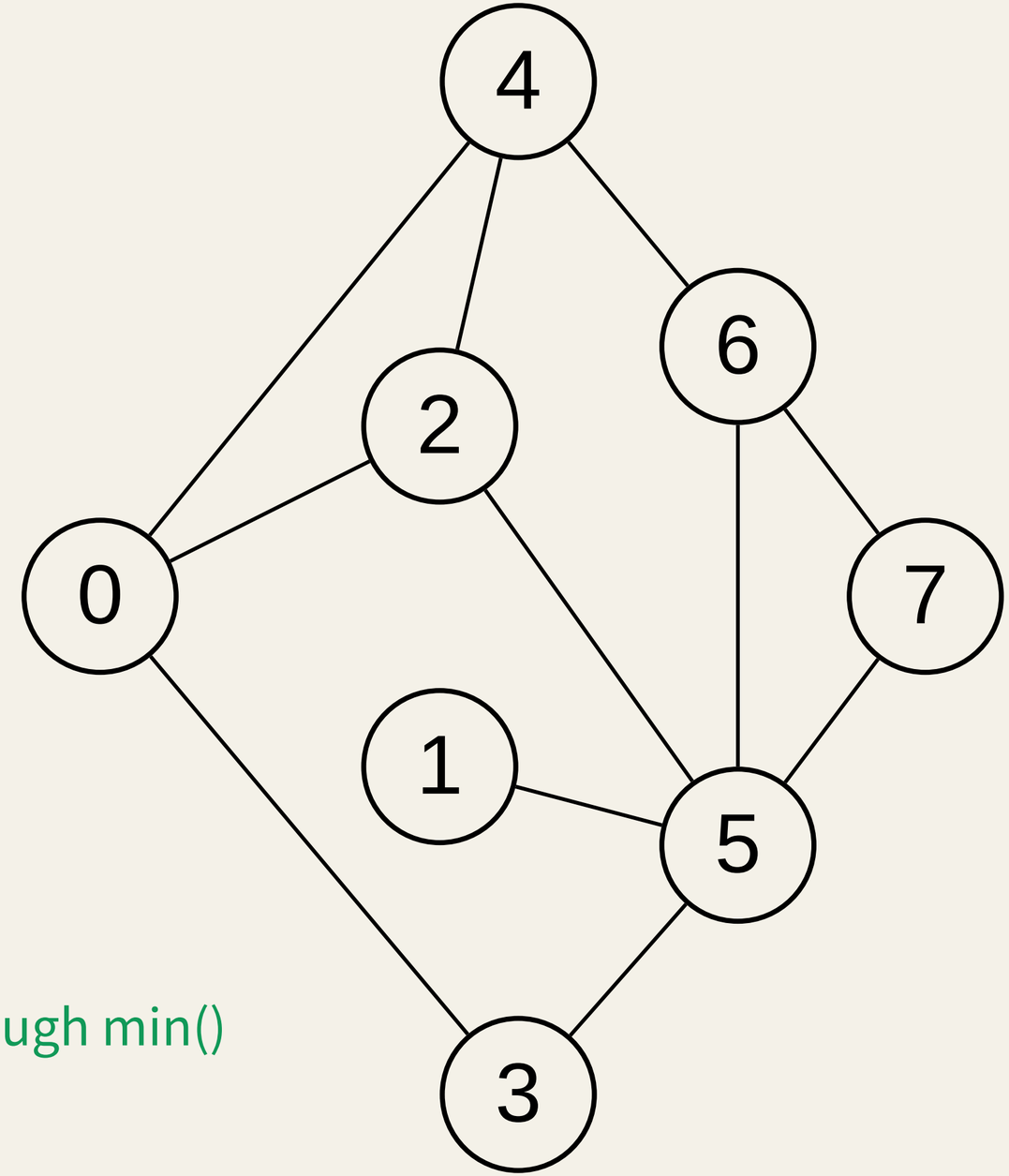
❶ Set all of the value in used array to default value → Define false for not been processed

res

INF

❷ Set res to a large enough value

→ Because we have to constantly reduce it through min()



Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	False	False	False	False

❷ Set the statement of starting vertex to true

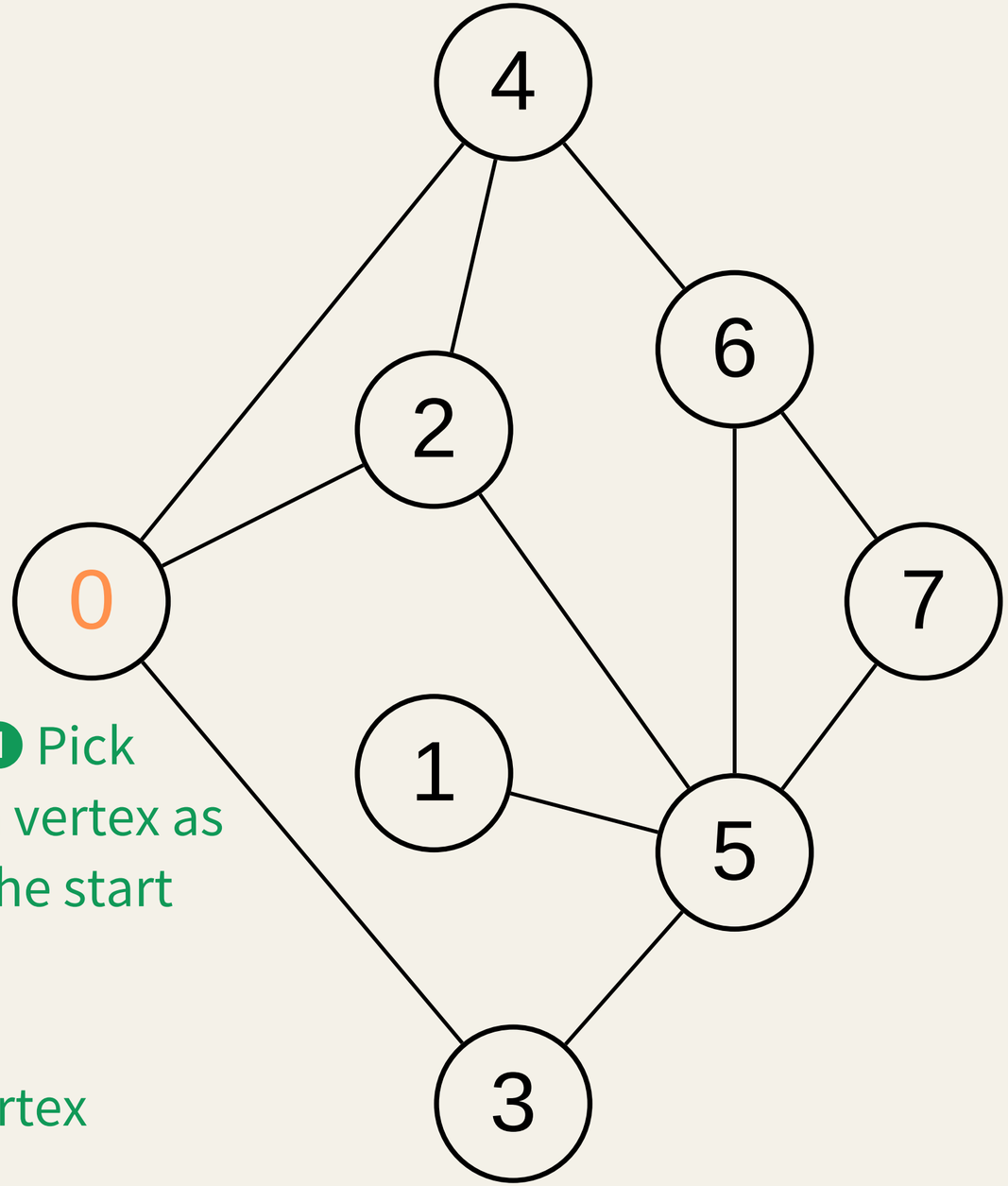
res	cnt	dis
INF	0	0

❶ Pick a vertex as the start

❸ Declare two variable cnt and dis to store the data

cnt → current vertex

dis → distance from starting vertex to current vertex



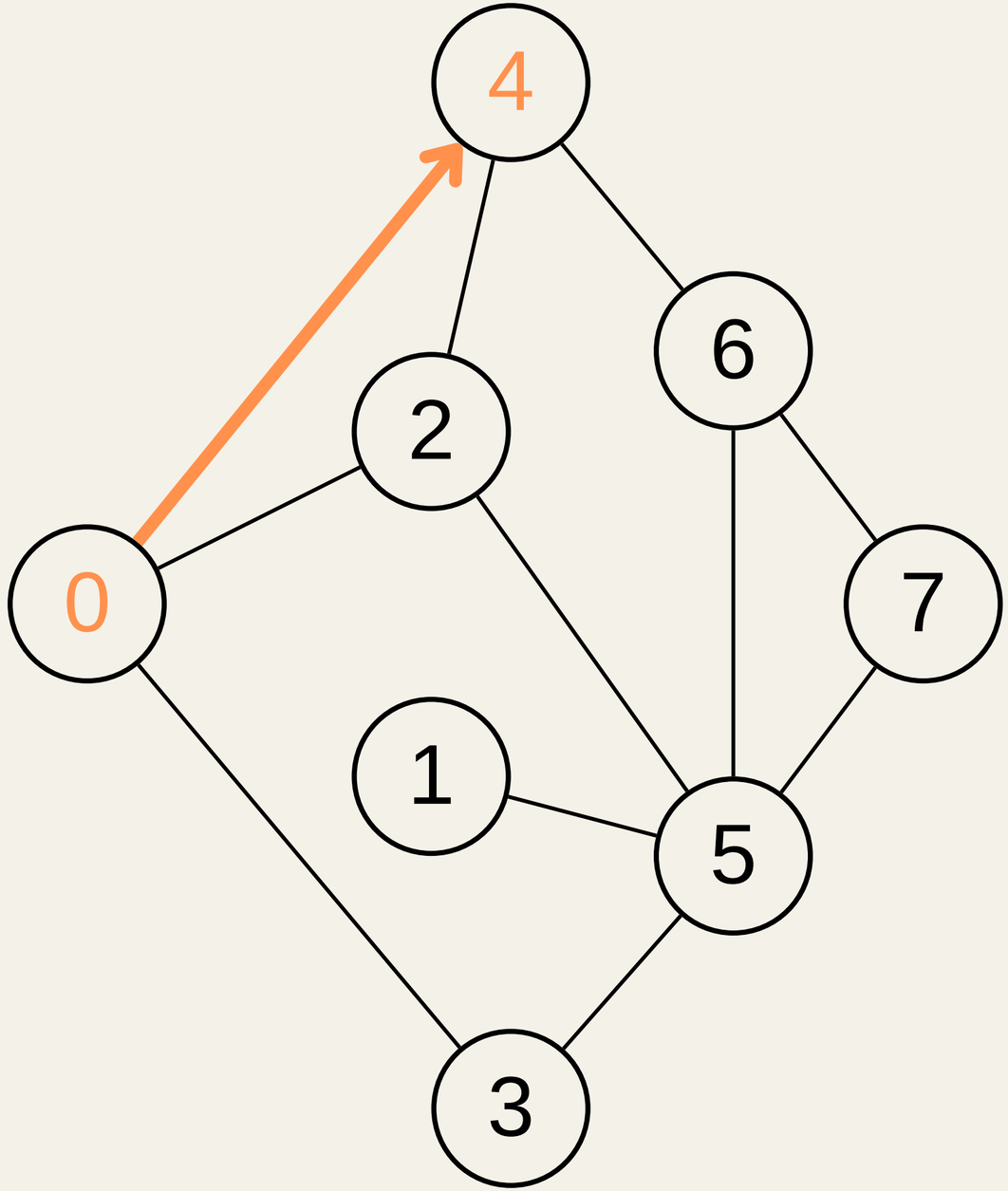
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	False	False	False	False

Available ✓

Check whether adjacent vertex already been used

res	cnt	dis
INF	0	0



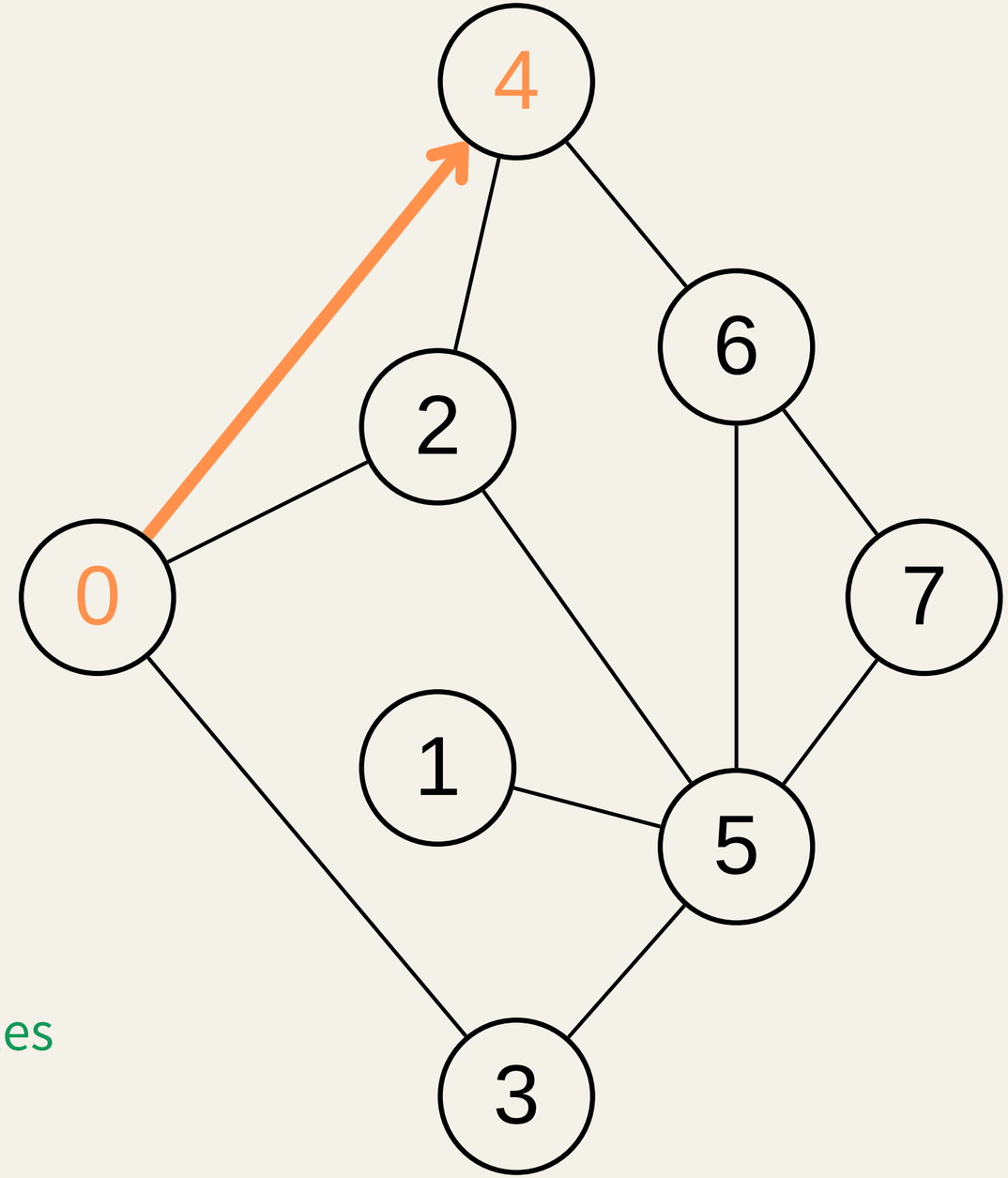
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	False	False

❶ If cnt vertex hadn't been used
→ Update its statement

res	cnt	dis
INF	4	1

❷ If cnt vertex hadn't been used
→ Update cnt and dis variables



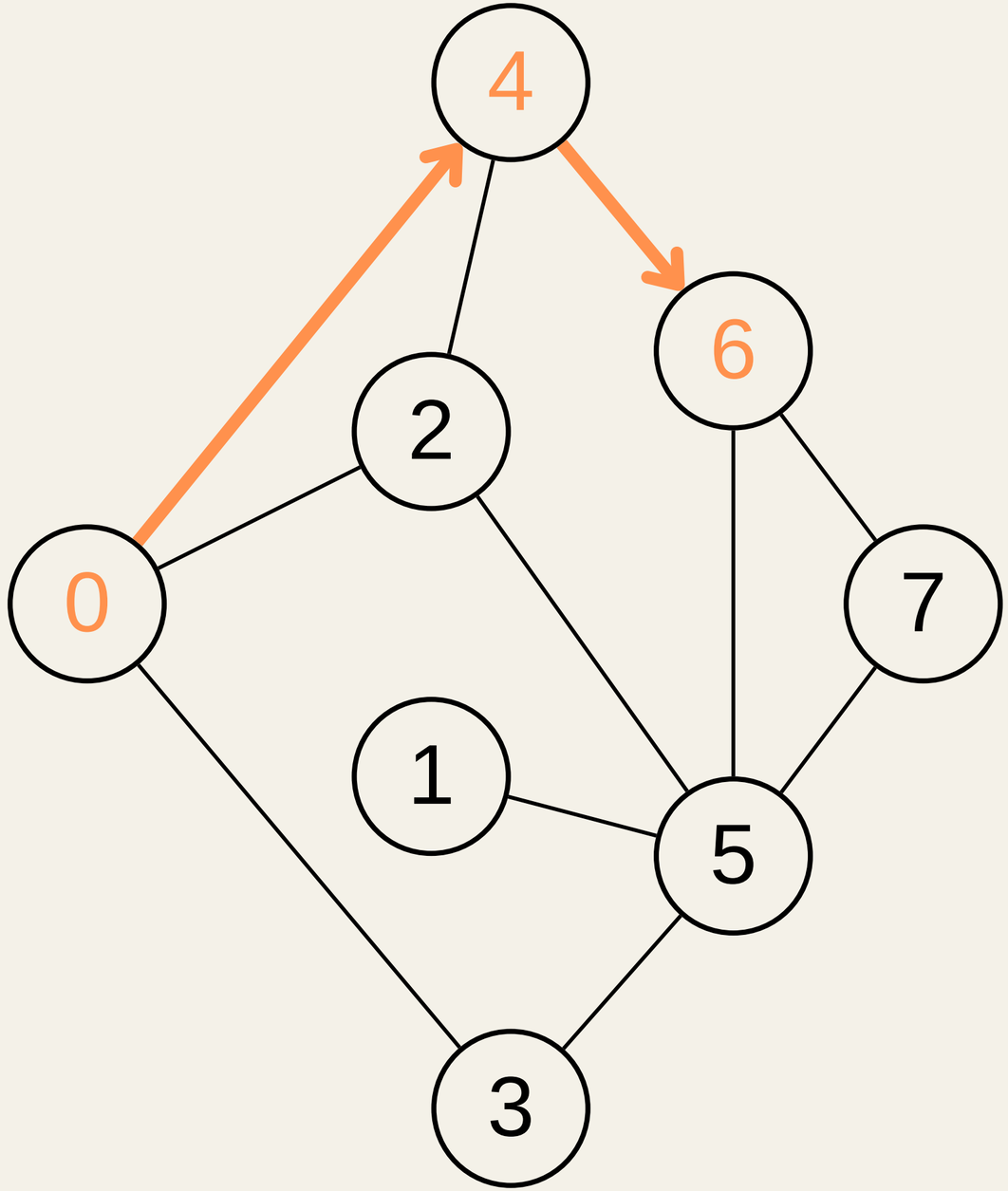
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	False	False

Available ✓

Check whether adjacent vertex already been used

res	cnt	dis
INF	4	1



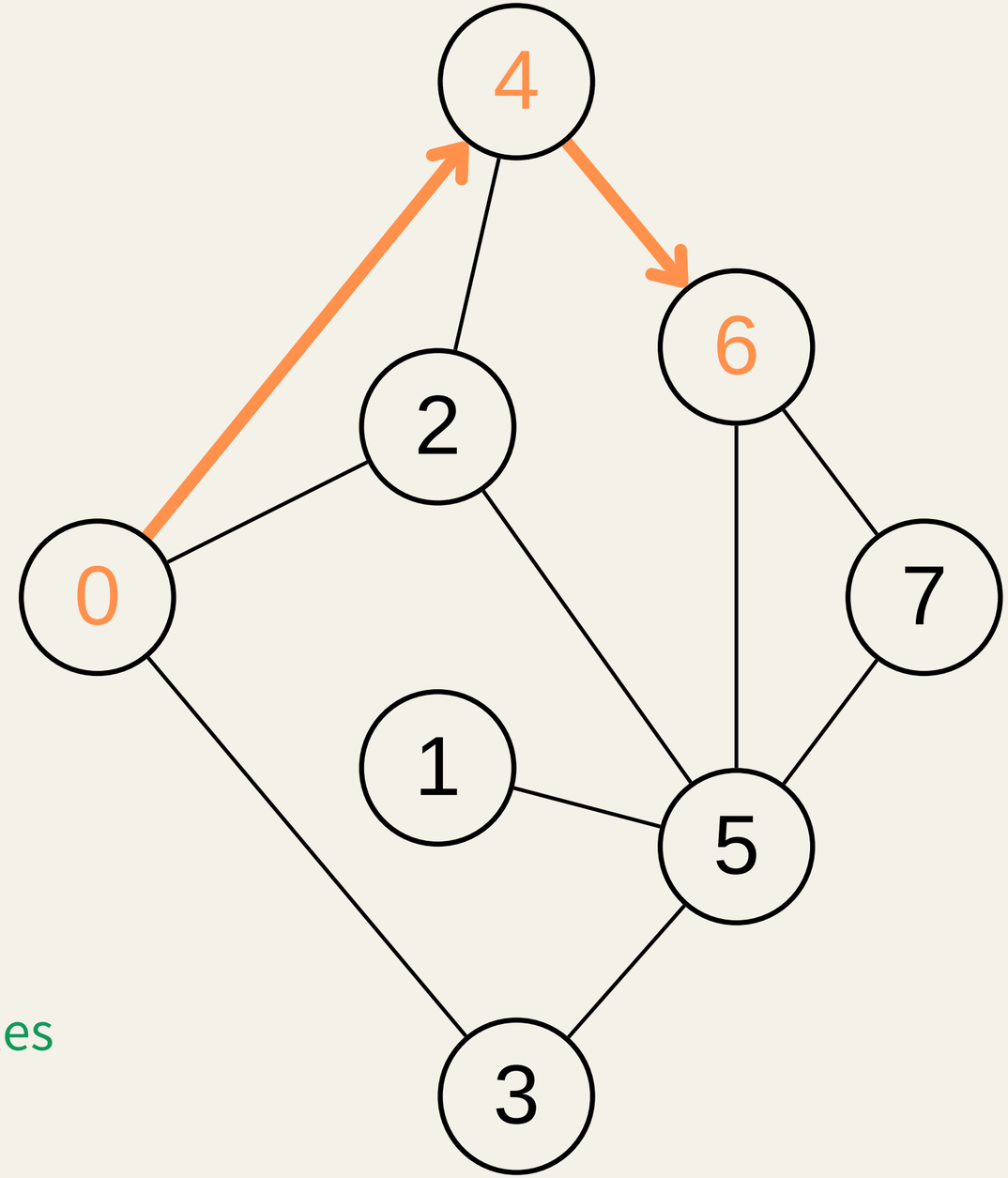
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	True	False

❶ If cnt vertex hadn't been used
→ Update its statement

res	cnt	dis
INF	6	2

❷ If cnt vertex hadn't been used
→ Update cnt and dis variables



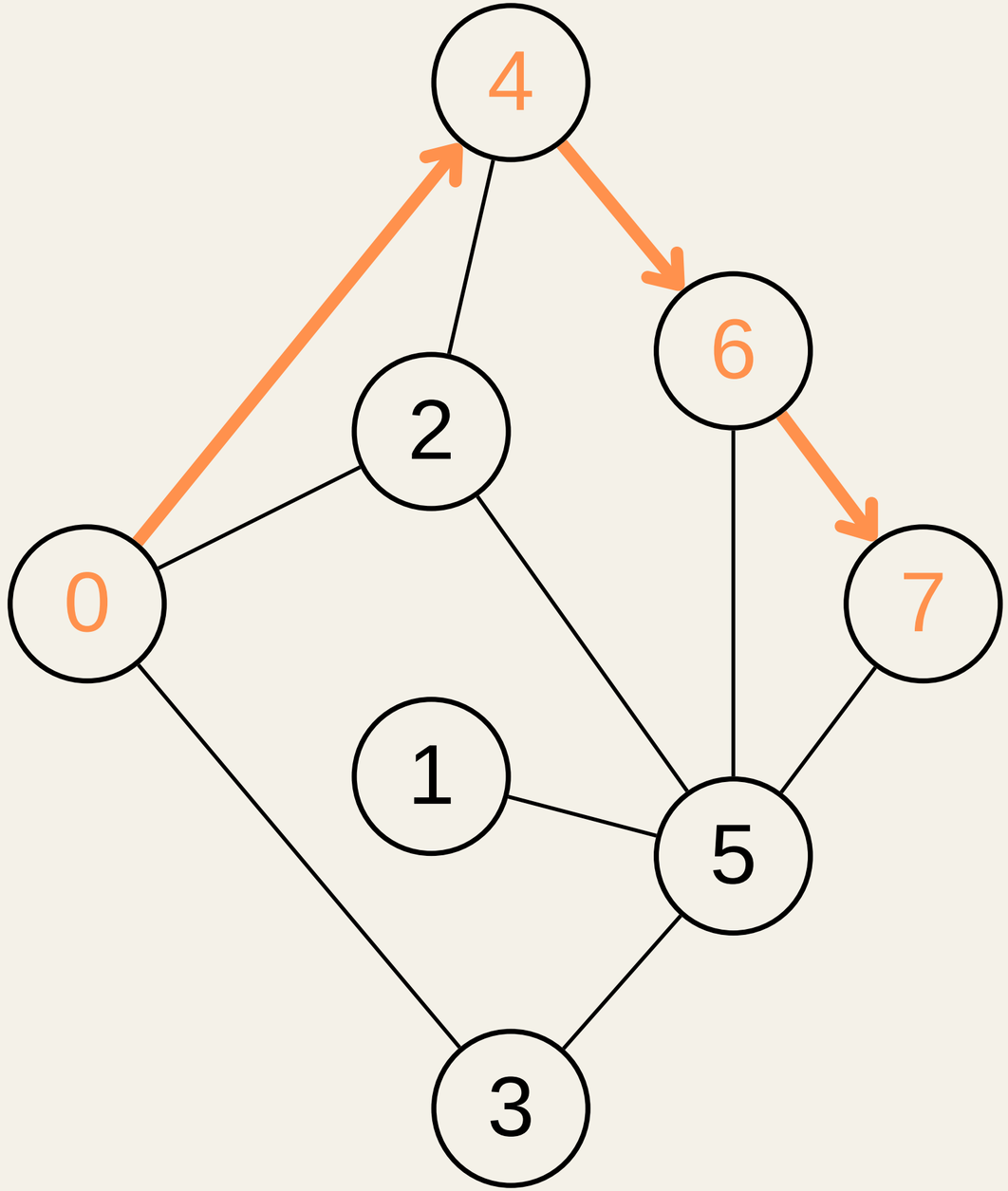
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	True	False

Available ✓

Check whether adjacent vertex already been used

res	cnt	dis
INF	6	2



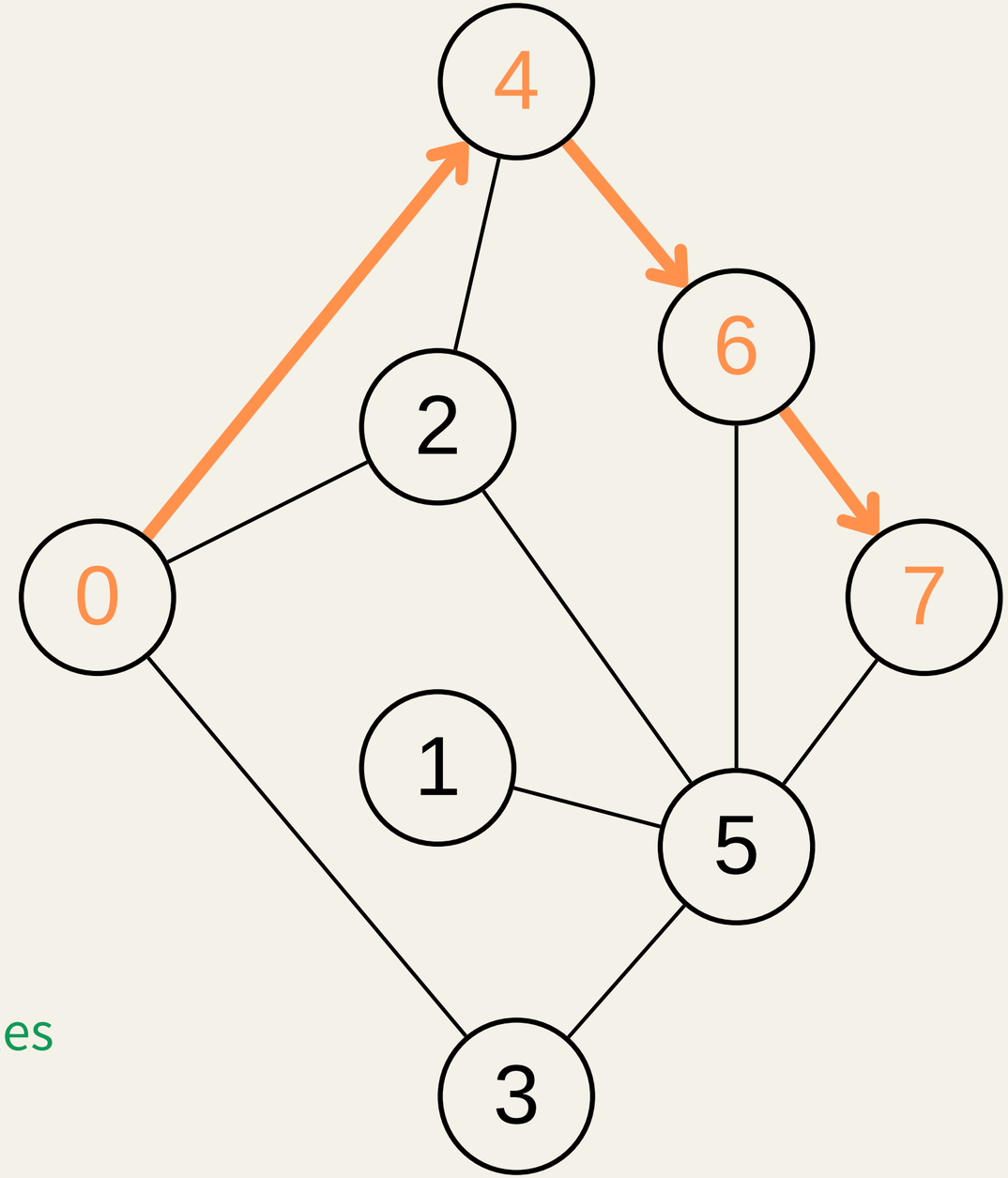
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	True	True

❶ If cnt vertex hadn't been used
→ Update its statement

res	cnt	dis
INF	7	3

❷ If cnt vertex hadn't been used
→ Update cnt and dis variables



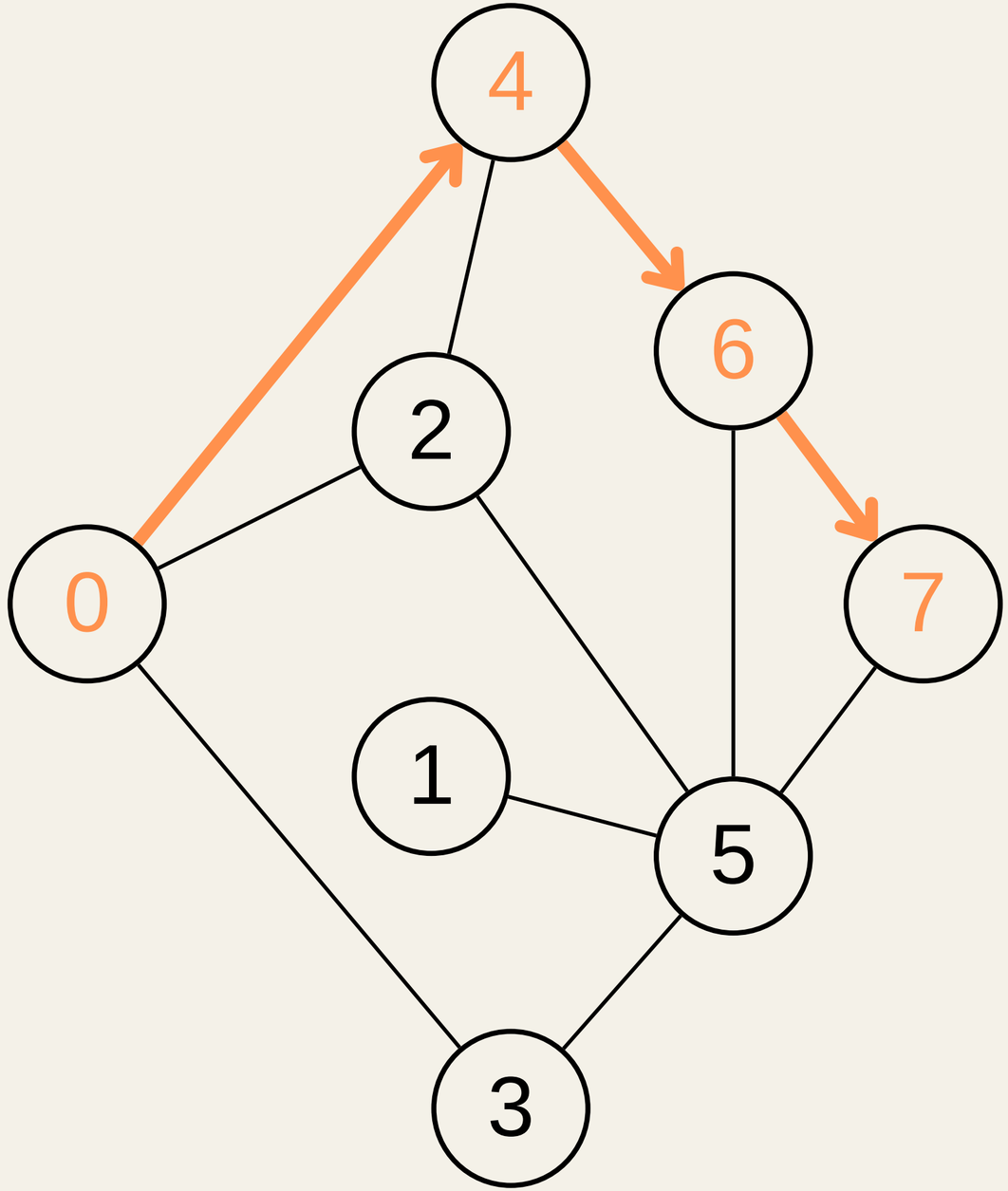
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	True	True

res	cnt	dis
3	7	3

If cnt equals to the ending vertex

→ Update res value through min(res, dis)



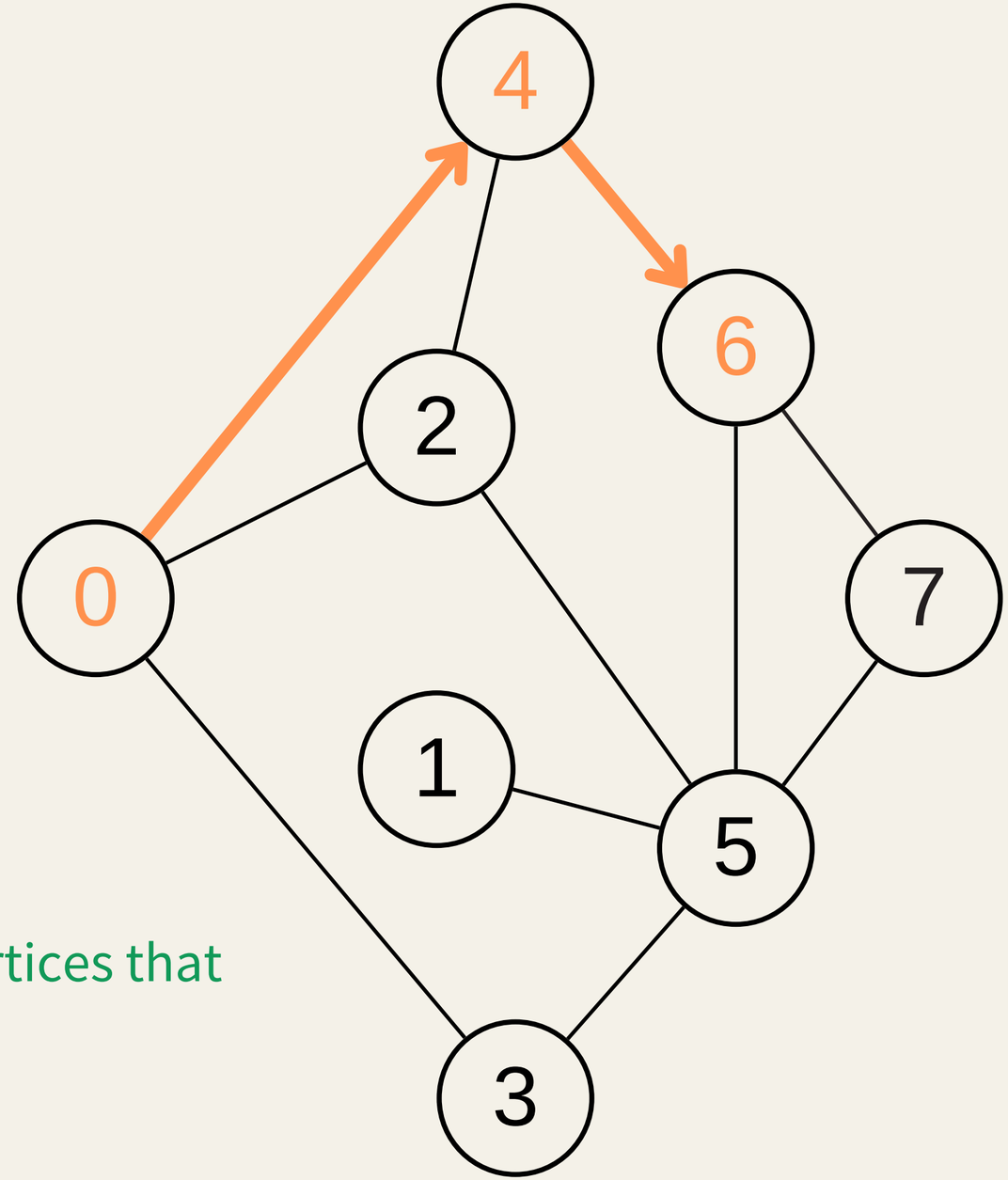
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	True	False

❶ If cnt has no other adjacent vertices that haven't been visited → Trace back

res	cnt	dis
3	6	2

❷ If cnt has no other adjacent vertices that haven't been visited → Trace back cnt and dis



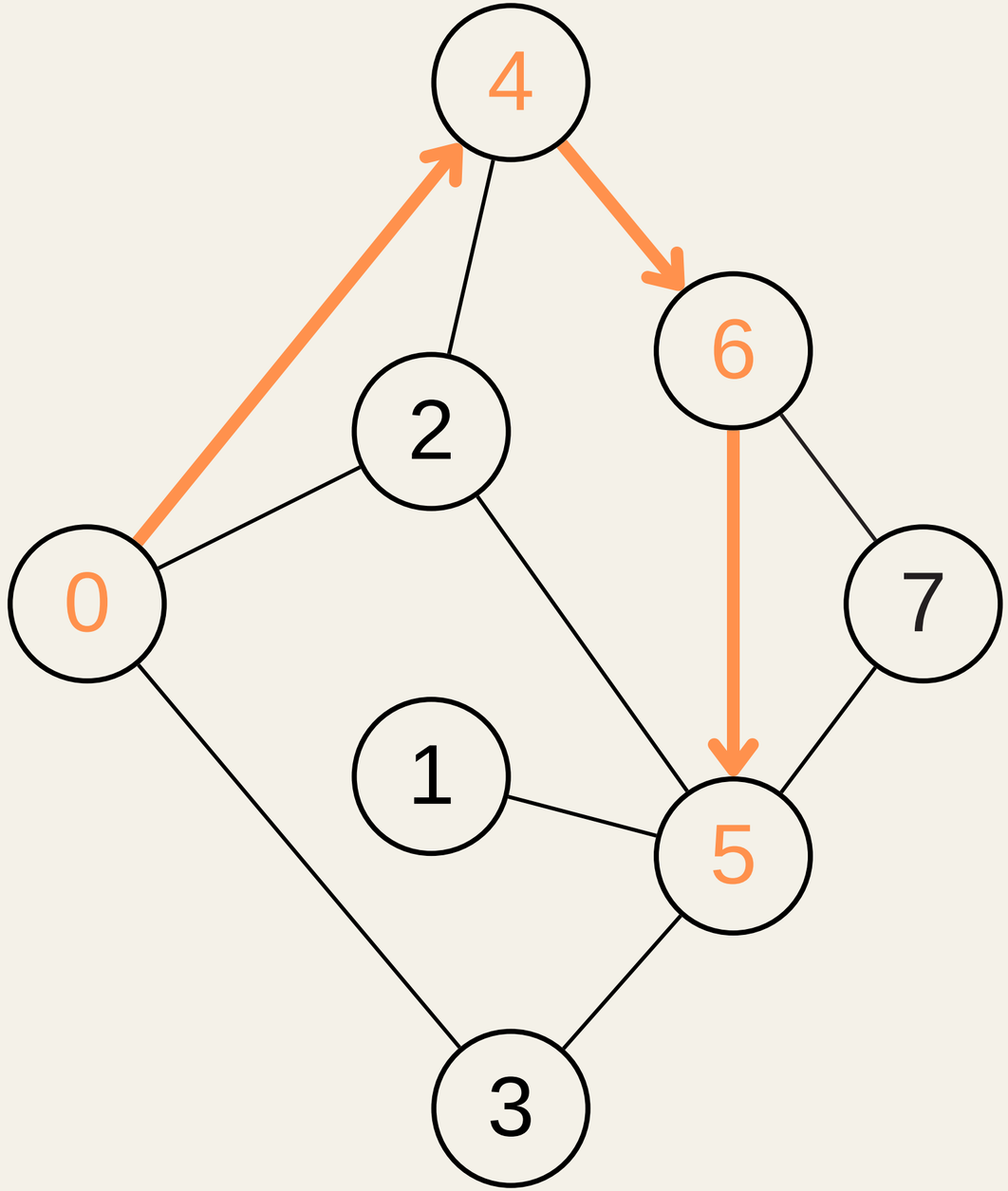
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	True	False

Available ✓

Keep checking the statement of adjacent vertex

res	cnt	dis
3	6	2



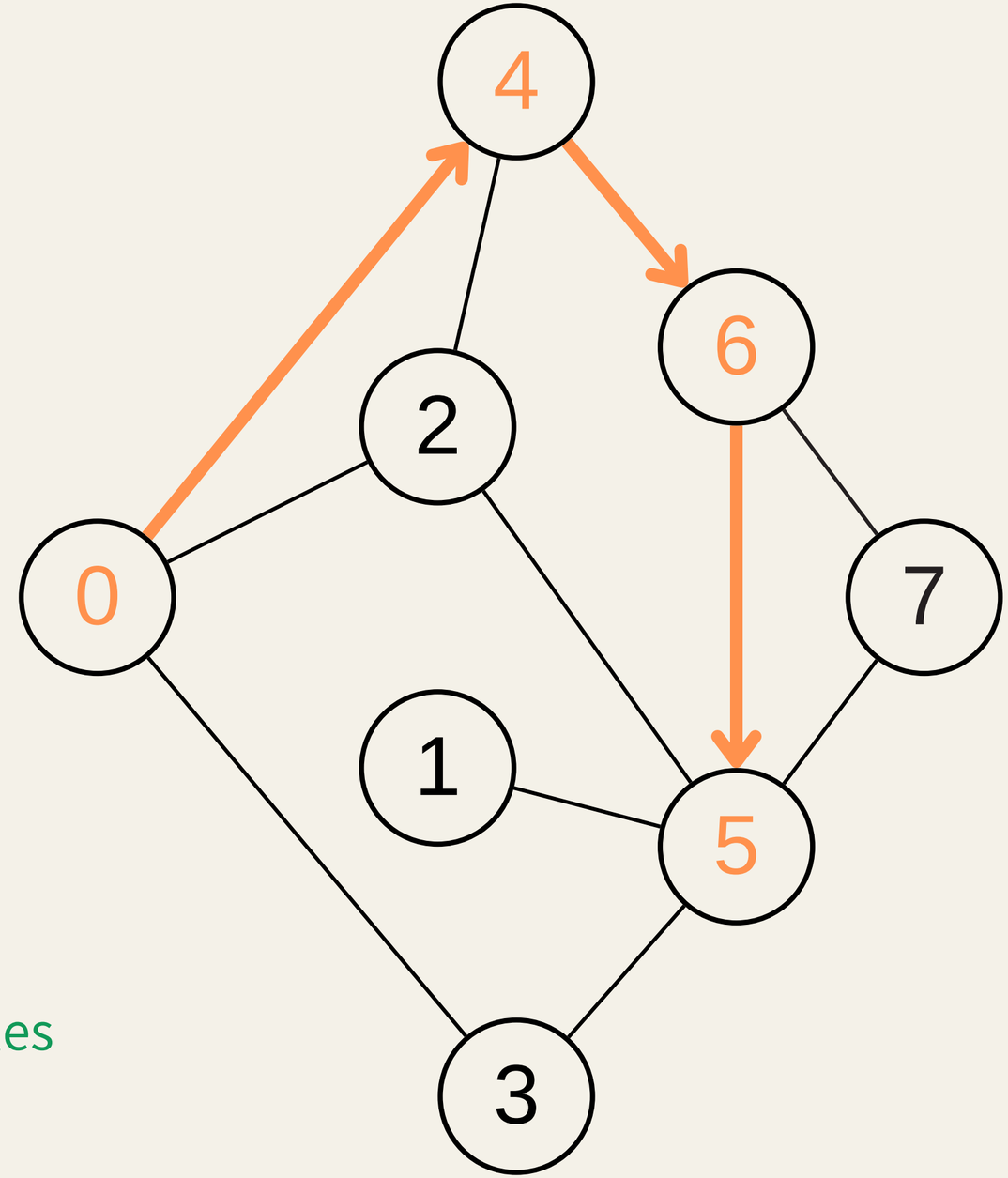
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	True	True	False

❶ If cnt vertex hadn't been used
→ Update its statement

res	cnt	dis
3	5	3

❷ If cnt vertex hadn't been used
→ Update cnt and dis variables



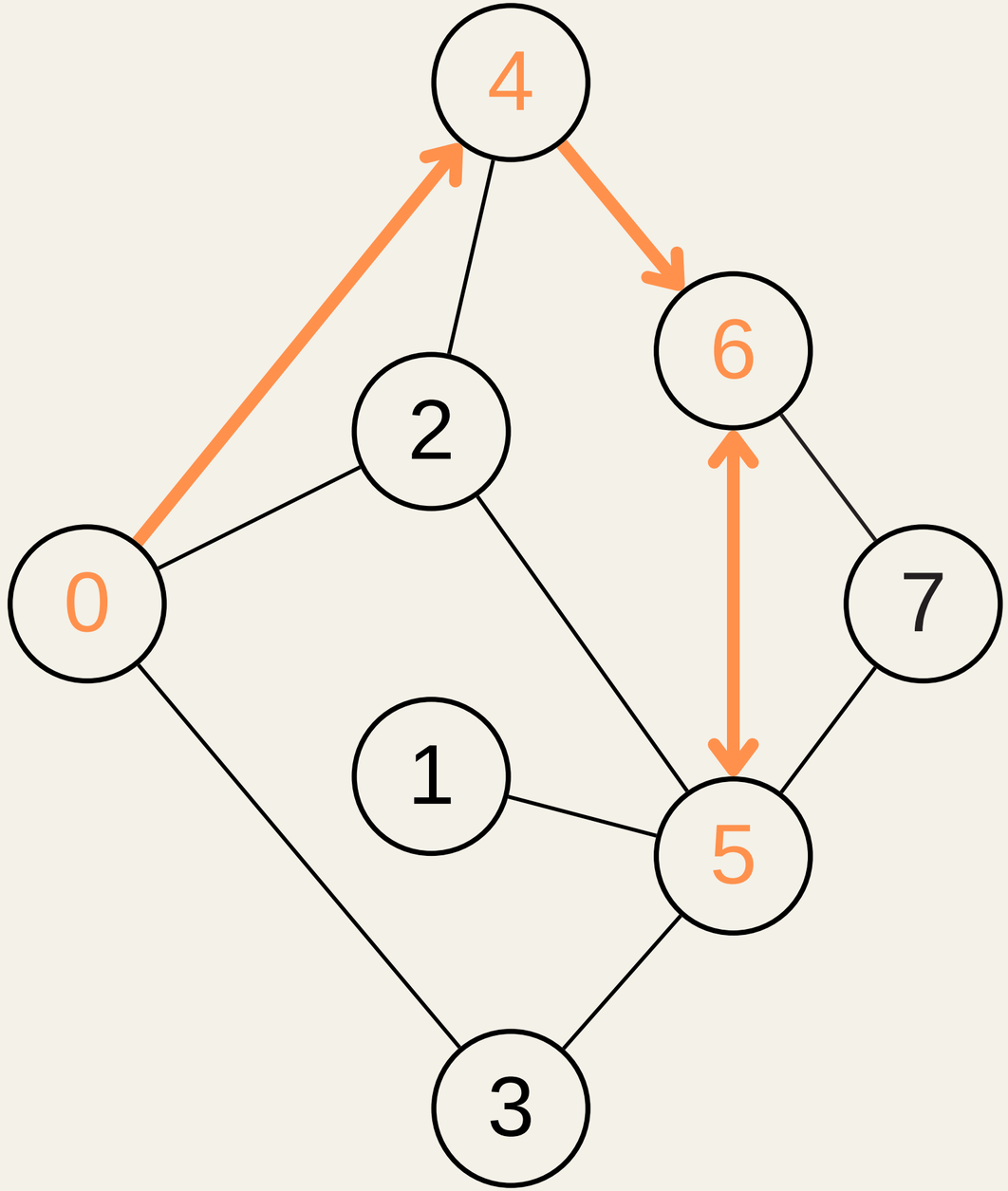
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	True	True	False

Not Available ✗

Check whether adjacent vertex already been used

res	cnt	dis
3	5	3



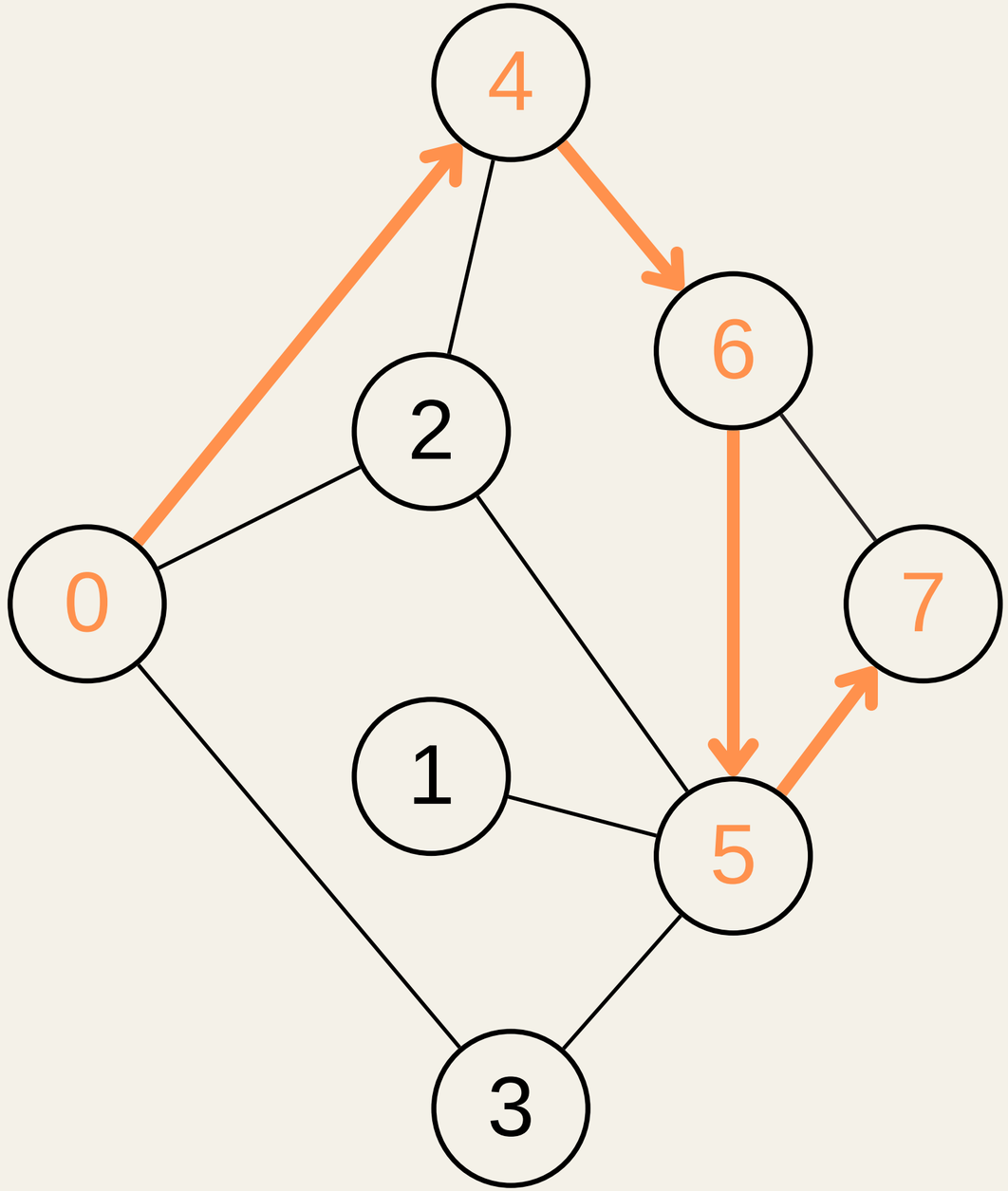
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	True	True	False

Available ✓

Check whether adjacent vertex already been used

res	cnt	dis
3	7	4



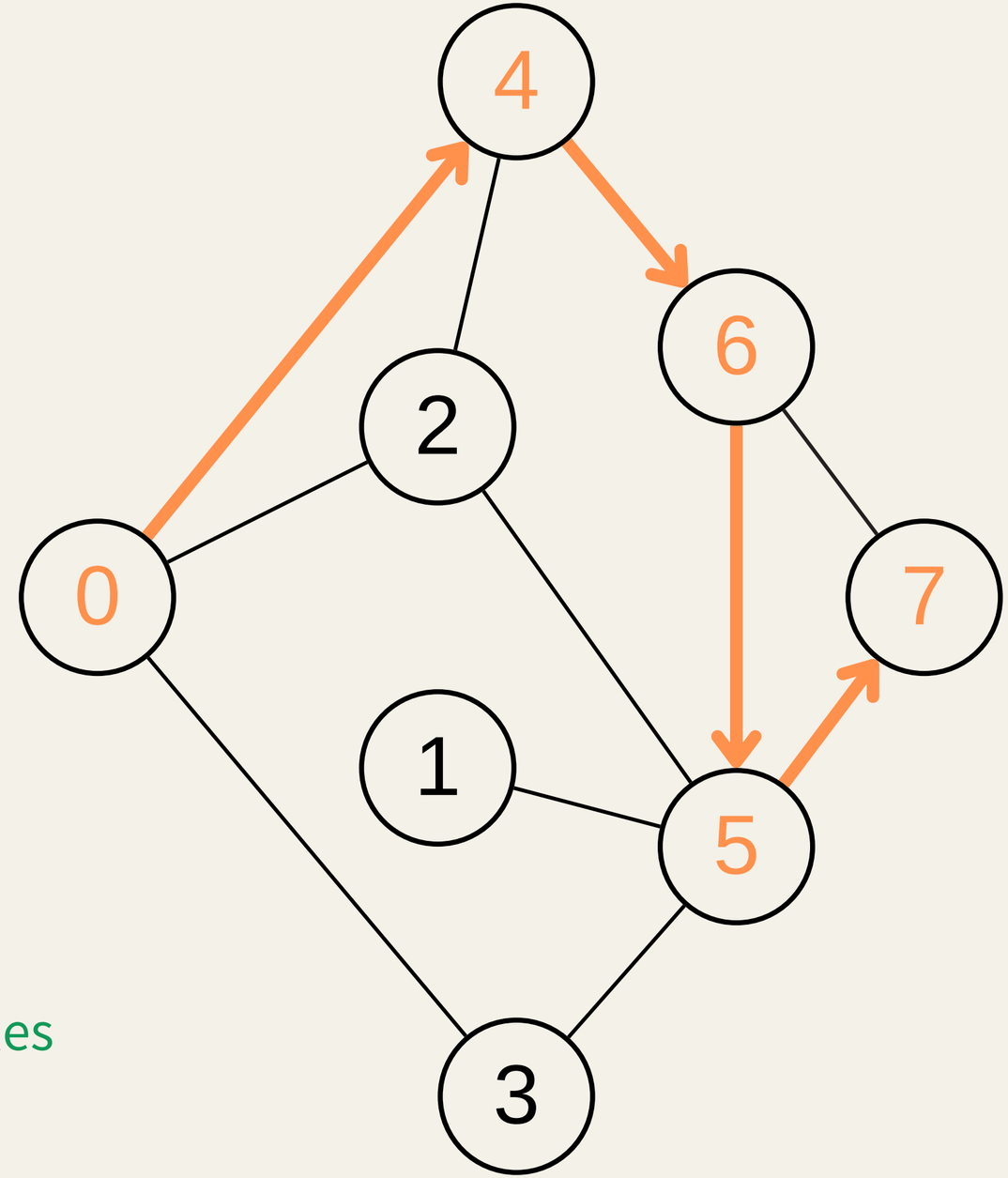
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	True	True	True

❶ If cnt vertex hadn't been used
→ Update its statement

res	cnt	dis
3	7	4

❷ If cnt vertex hadn't been used
→ Update cnt and dis variables



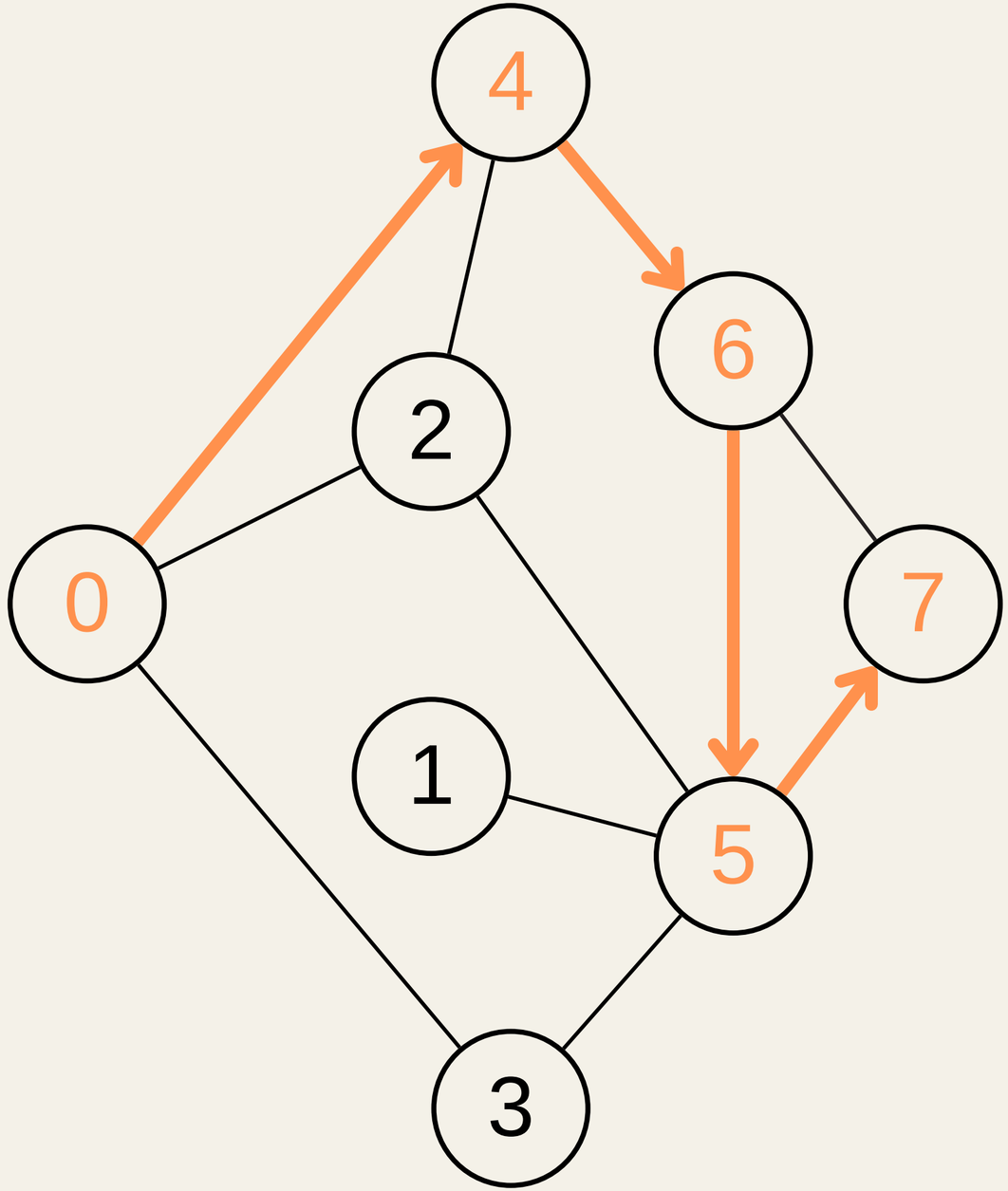
Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	True	True	True

res	cnt	dis
3	7	4

If cnt equals to the ending vertex

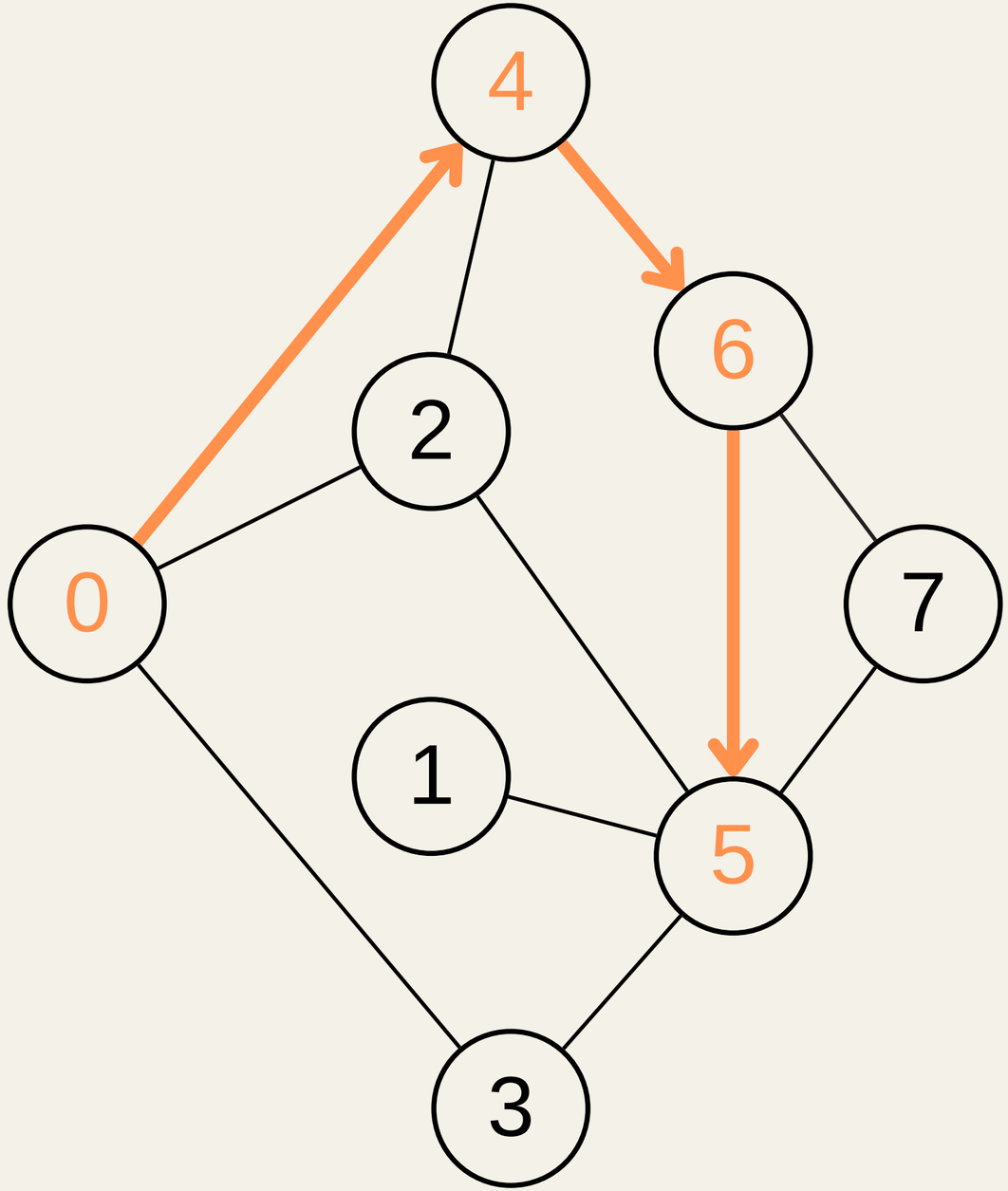
→ Update res value through min(res, dis)



Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	True	True	False

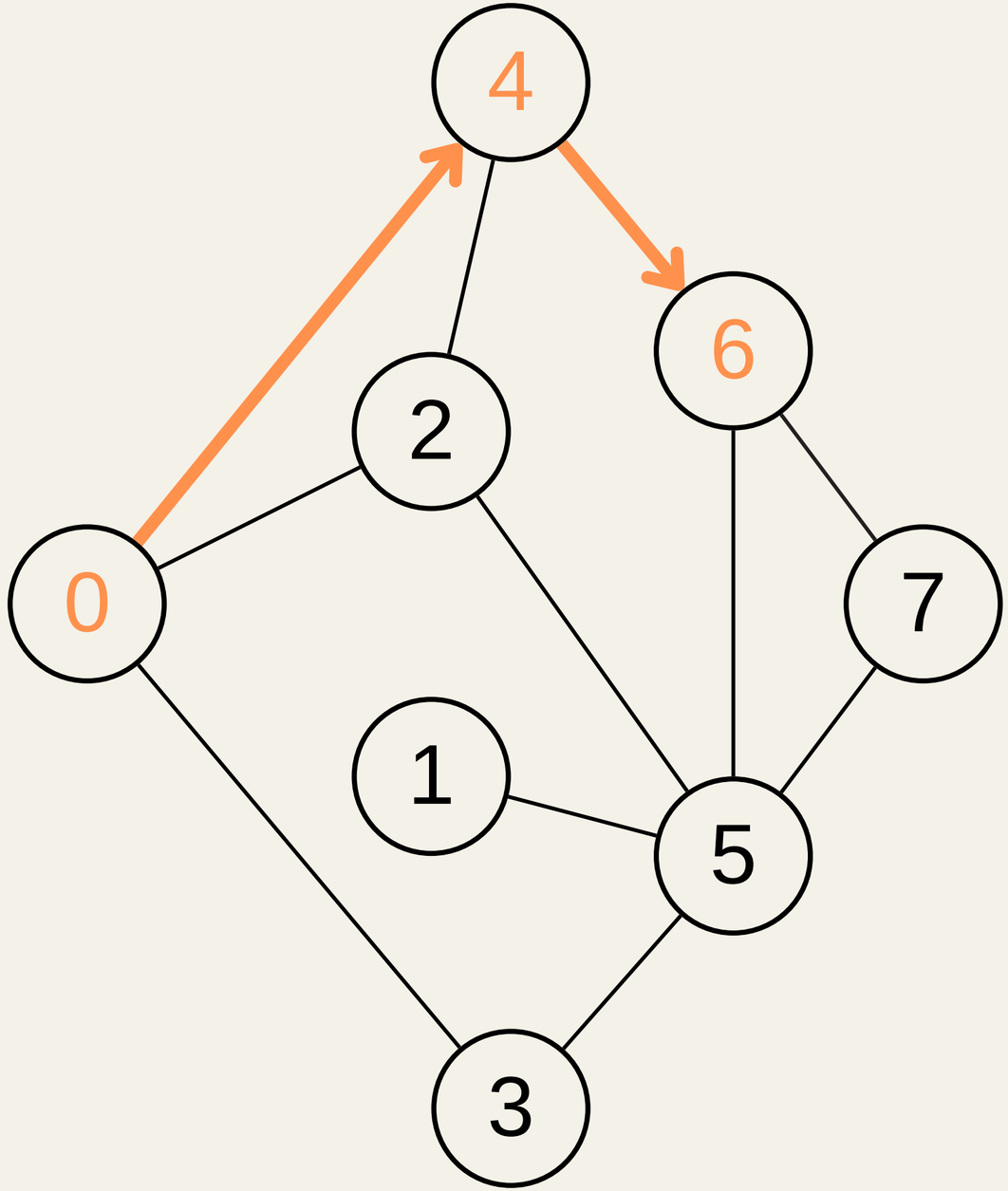
res	cnt	dis
3	7	4



Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	True	False

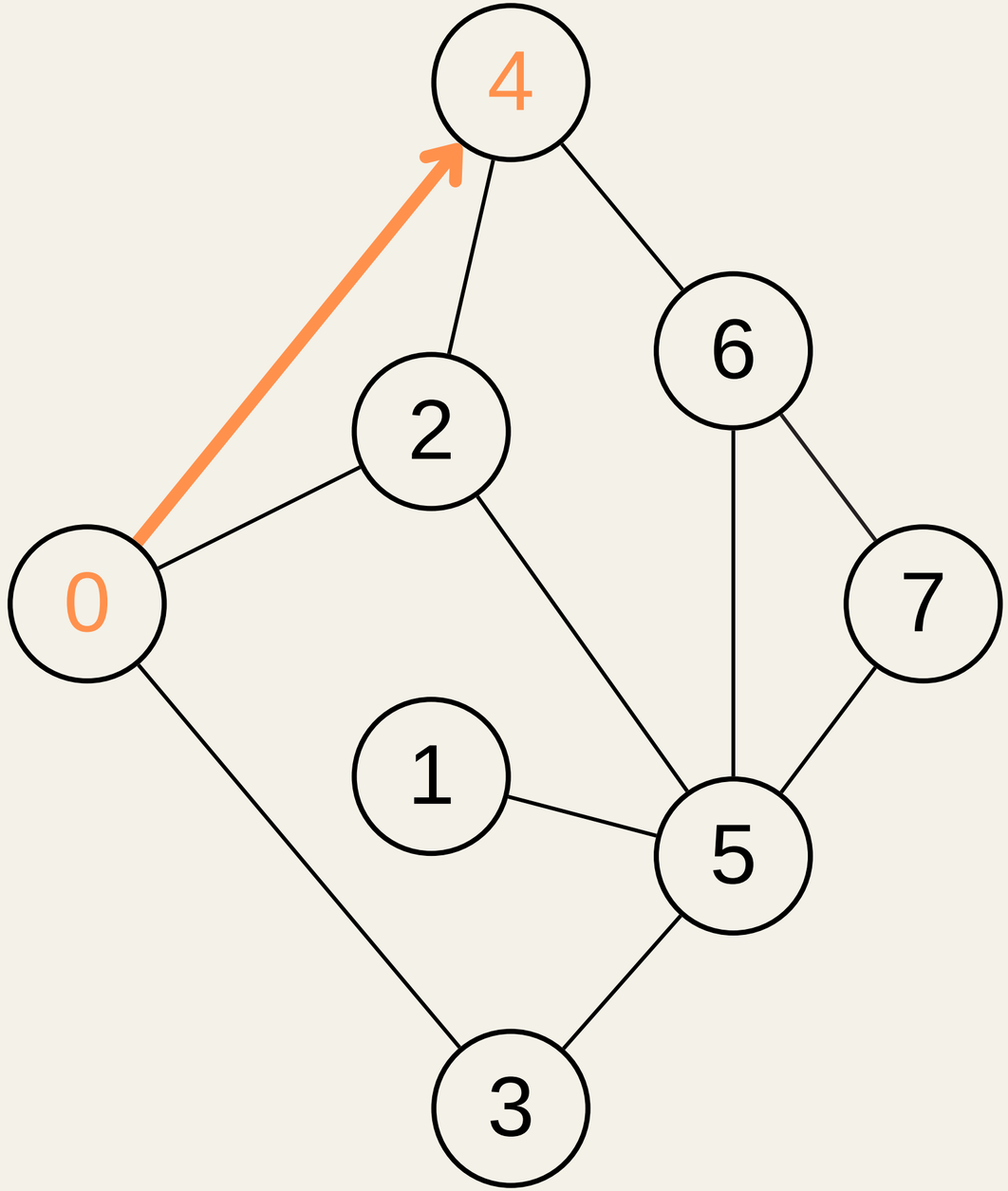
res	cnt	dis
3	7	4



Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	False	False

res	cnt	dis
3	7	4

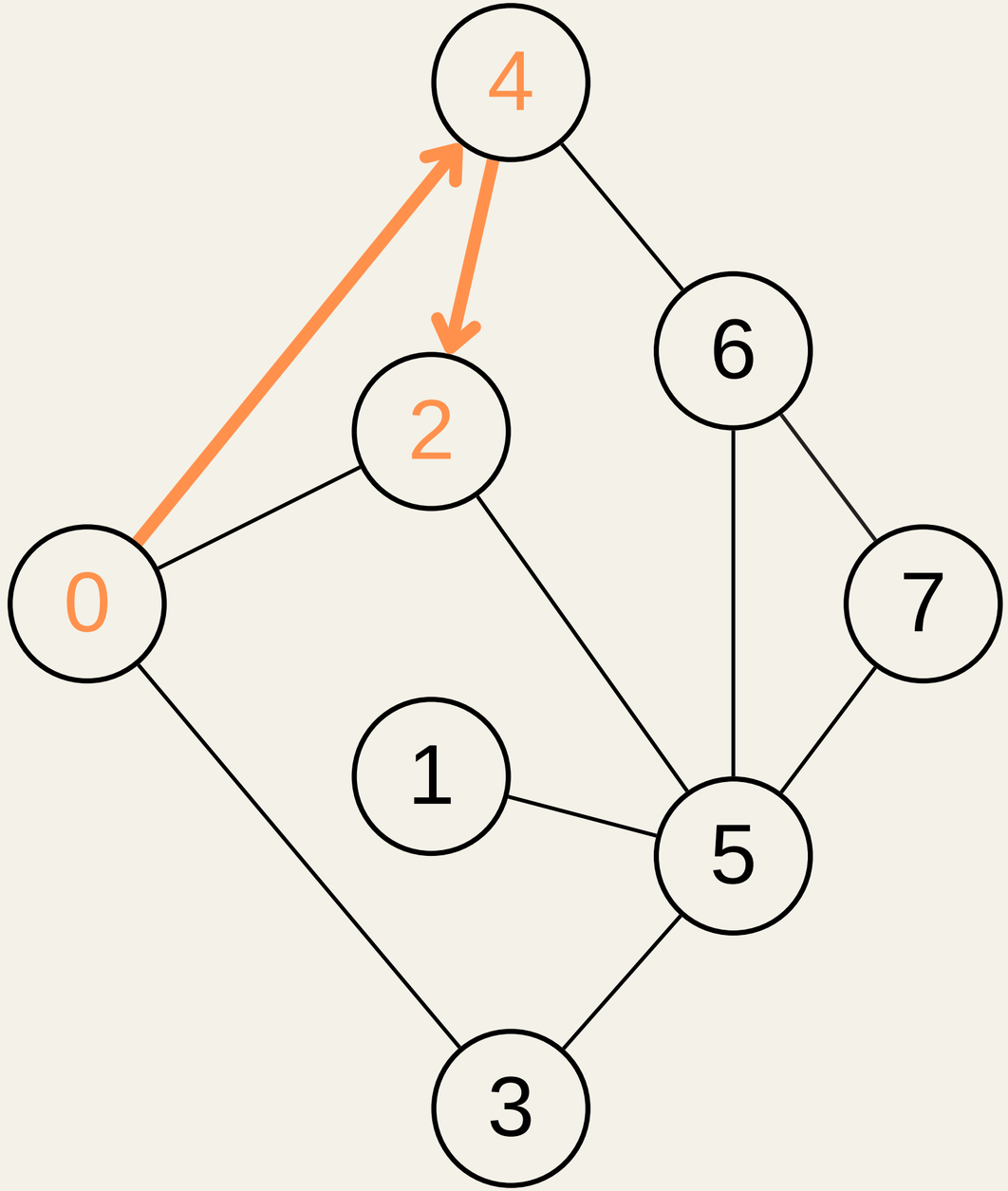


Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	False	False	True	False	False	False

Available ✓

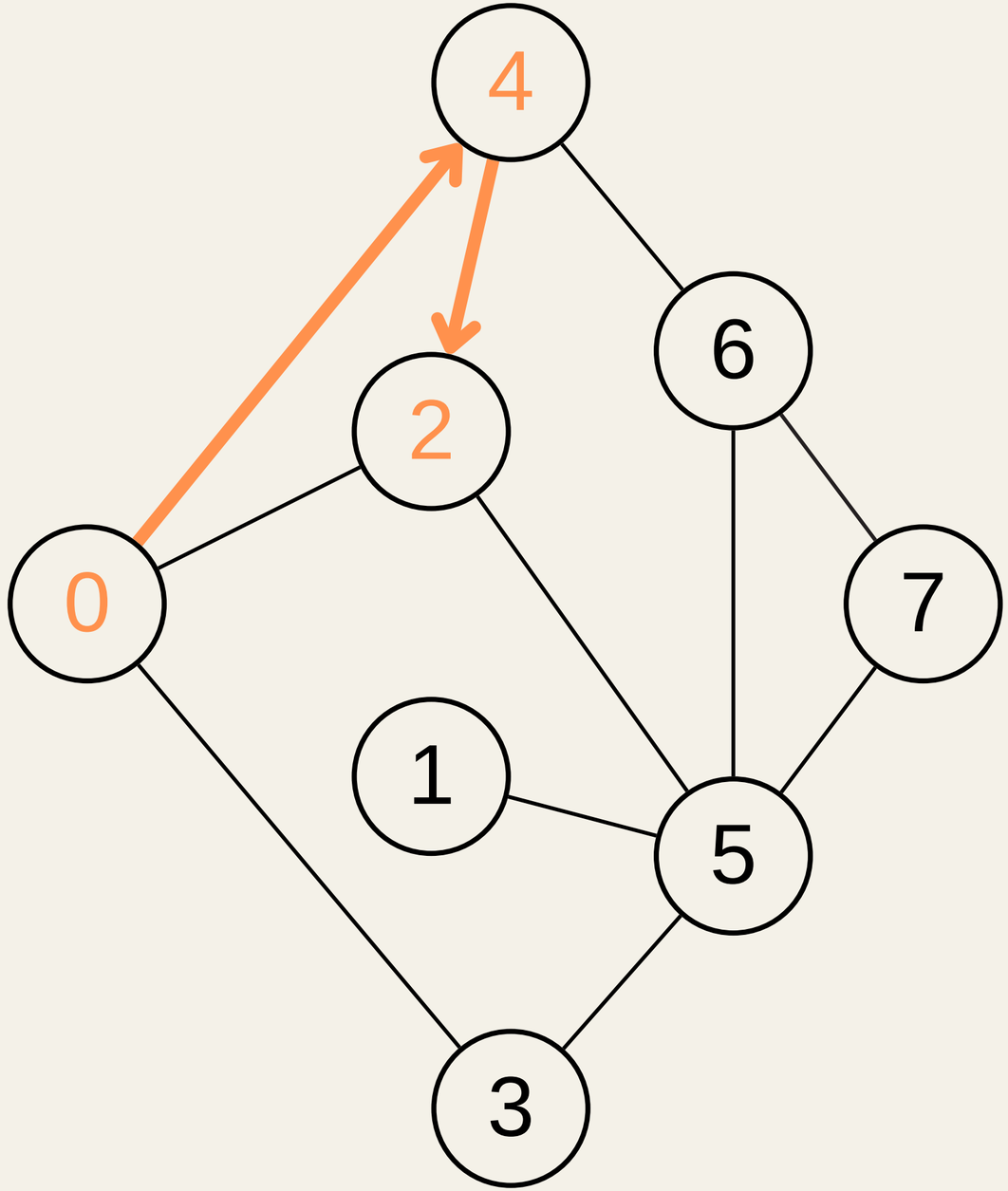
res	cnt	dis
3	7	4



Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	True	False	True	False	False	False

res	cnt	dis
3	2	2

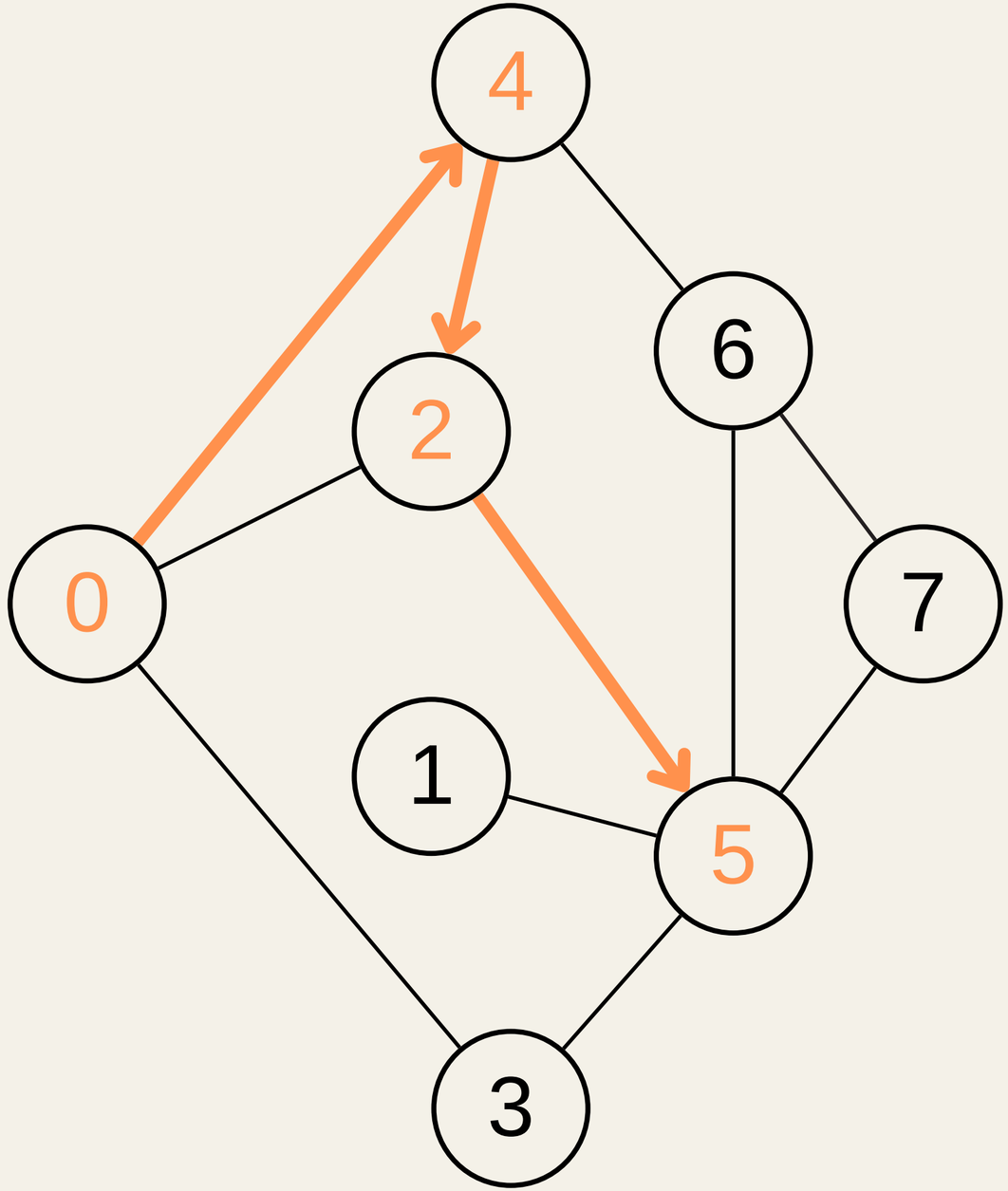


Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	True	False	True	False	False	False

Available ✓

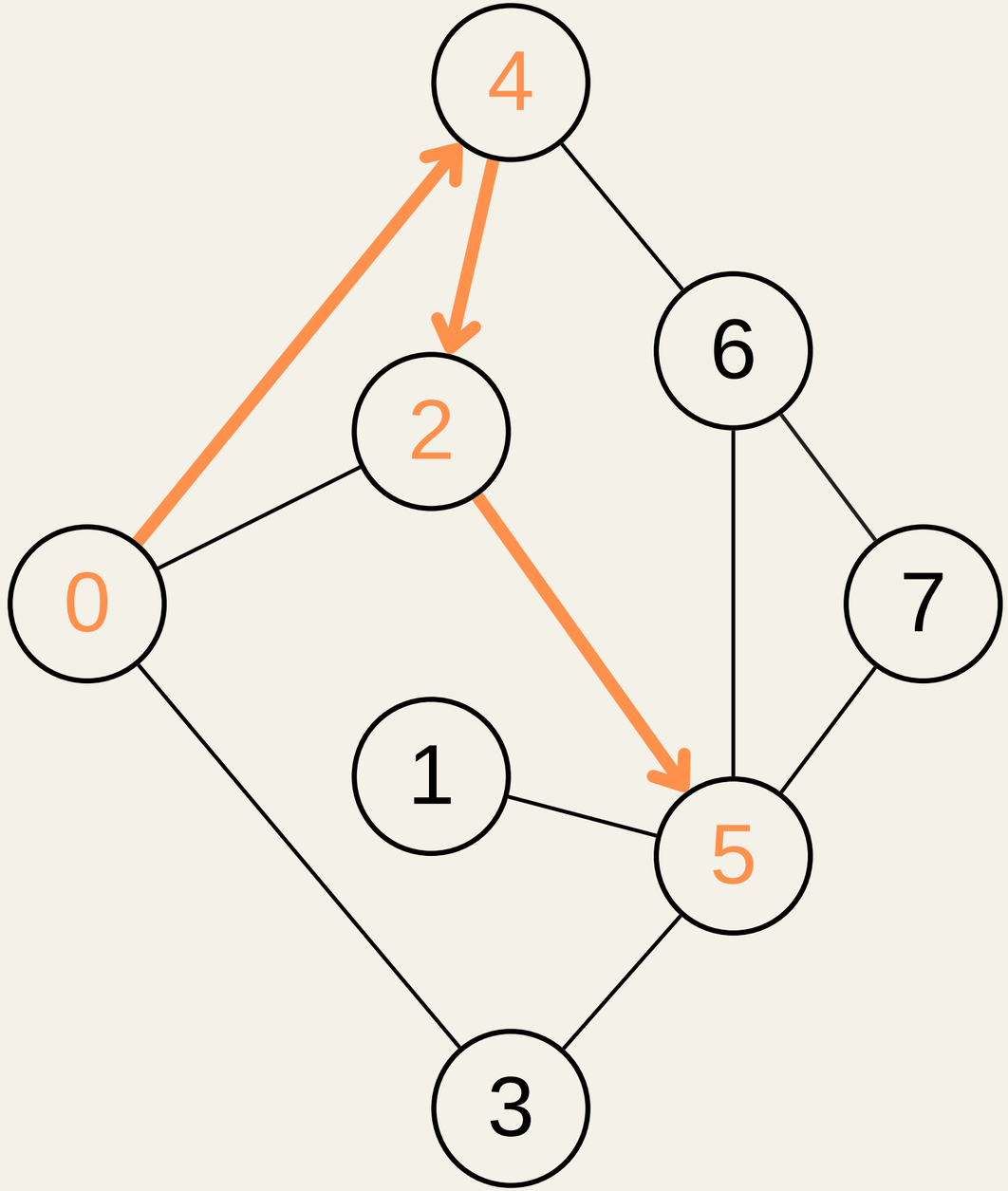
res	cnt	dis
3	2	2



Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	True	False	True	True	False	False

res	cnt	dis
3	5	3

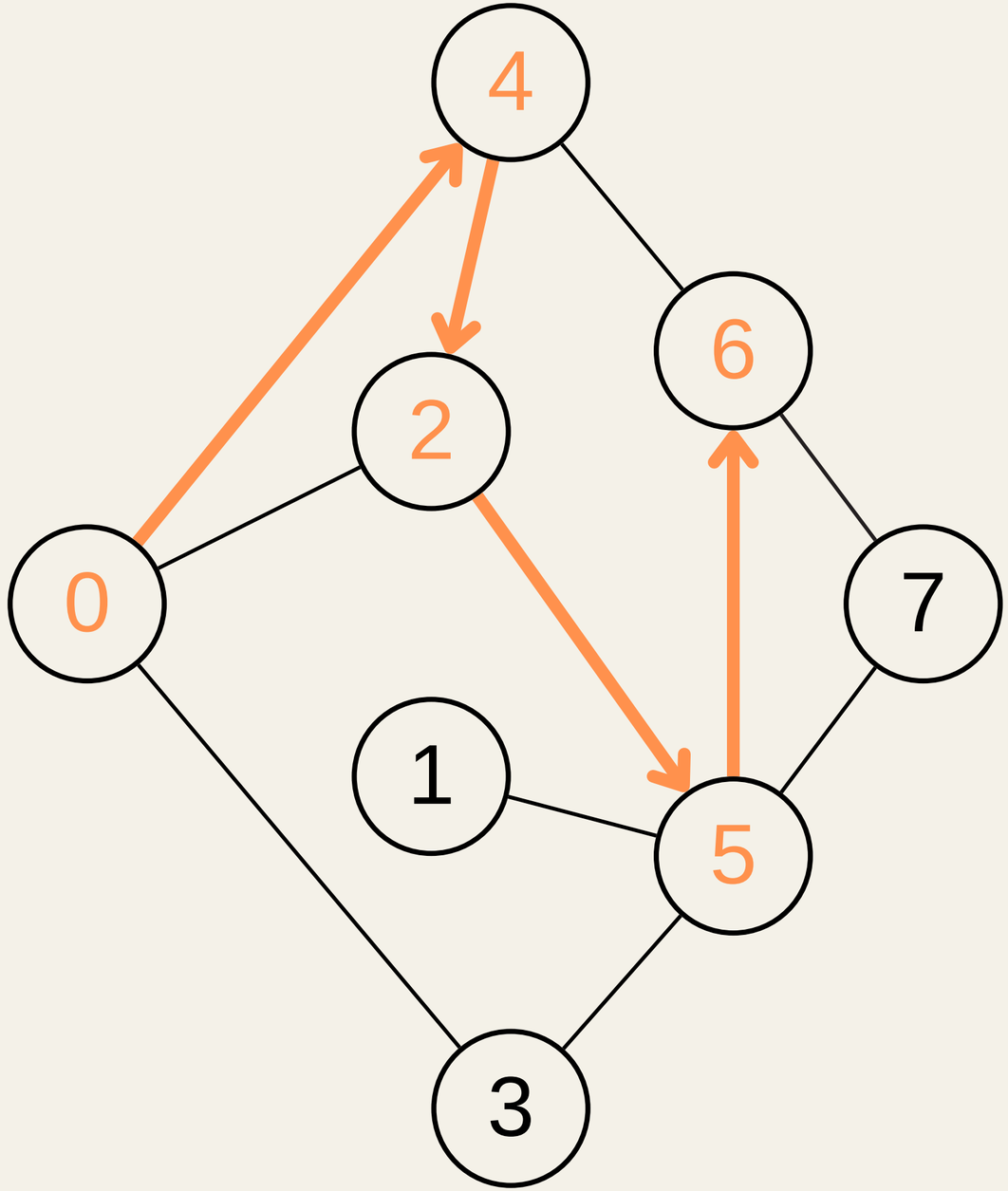


Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	True	False	True	True	False	False

Available ✓

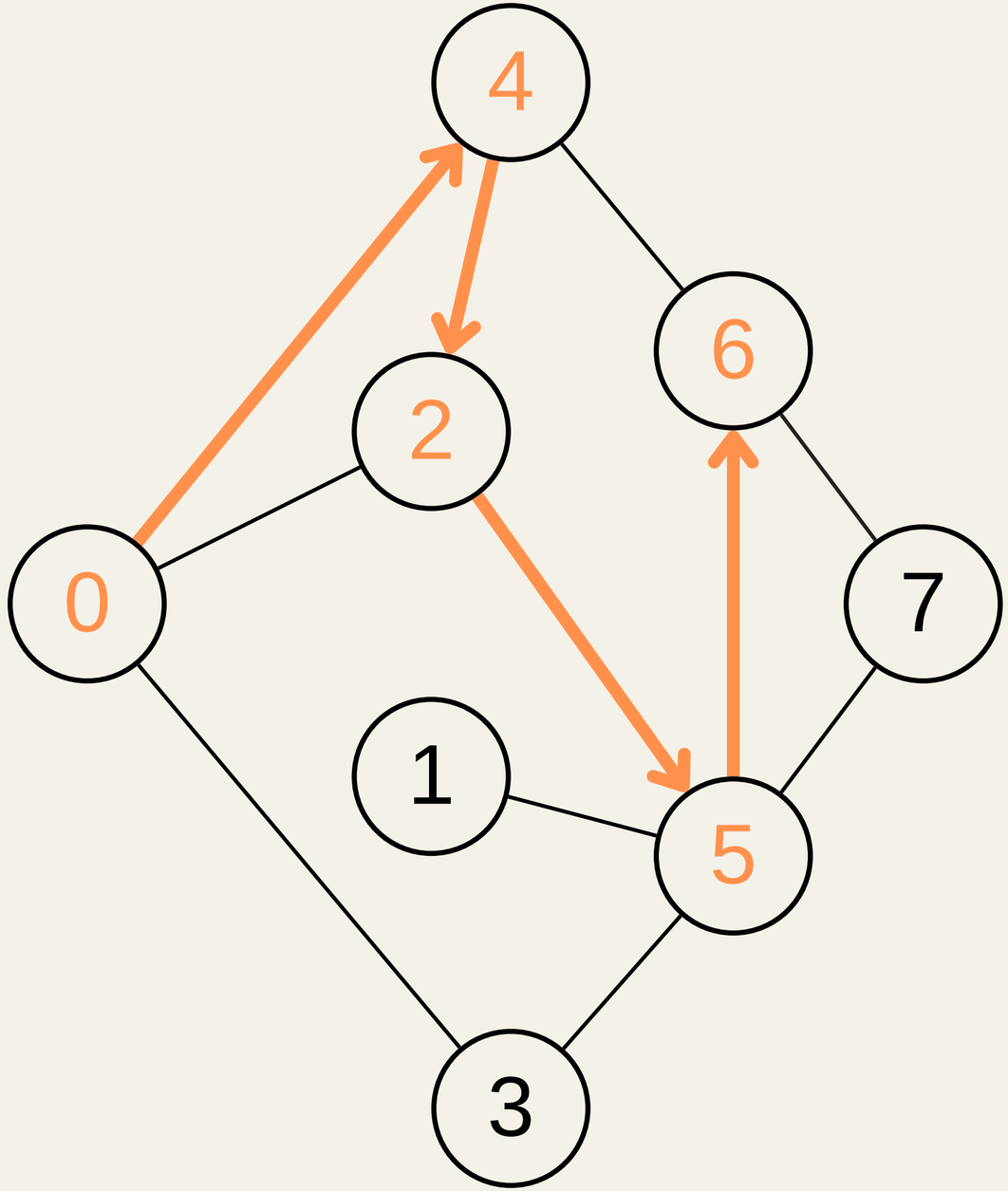
res	cnt	dis
3	5	3



Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	True	False	True	True	True	False

res	cnt	dis
3	6	4

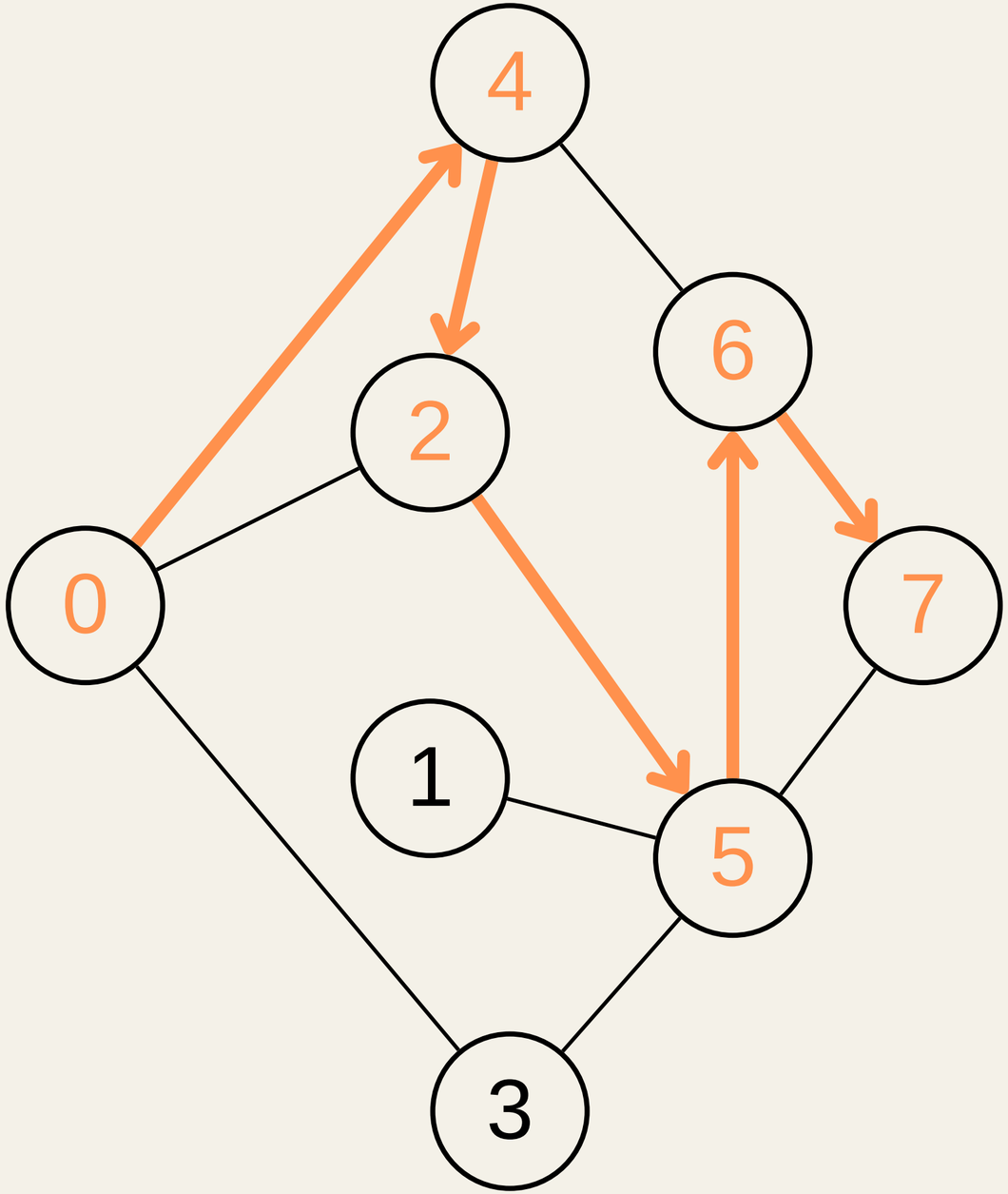


Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	True	False	True	True	True	False

Available ✓

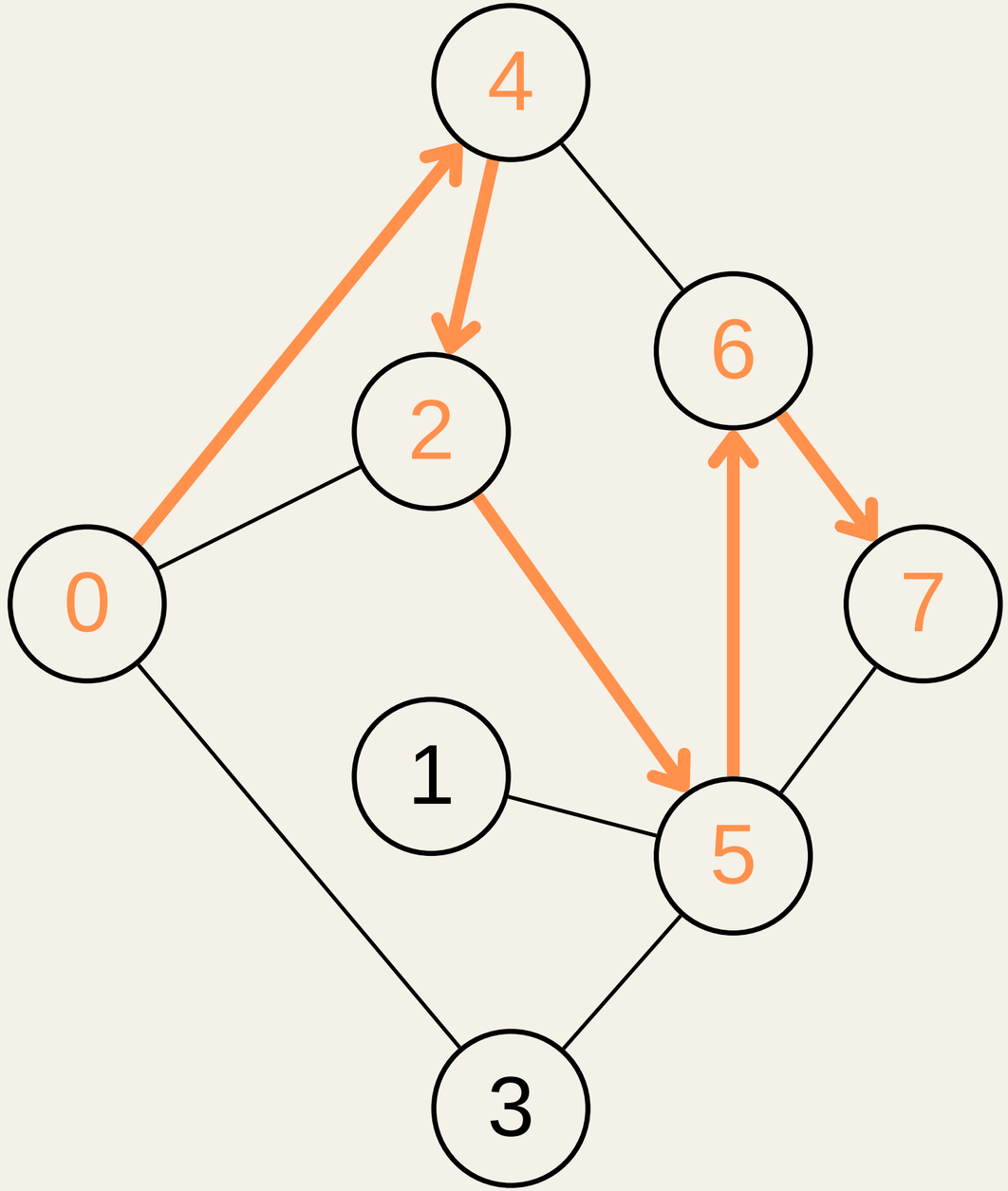
res	cnt	dis
3	6	4



Operating DFS

index	0	1	2	3	4	5	6	7
used[ ]	True	False	True	False	True	True	True	True

res	cnt	dis
3	7	5



Operating DFS

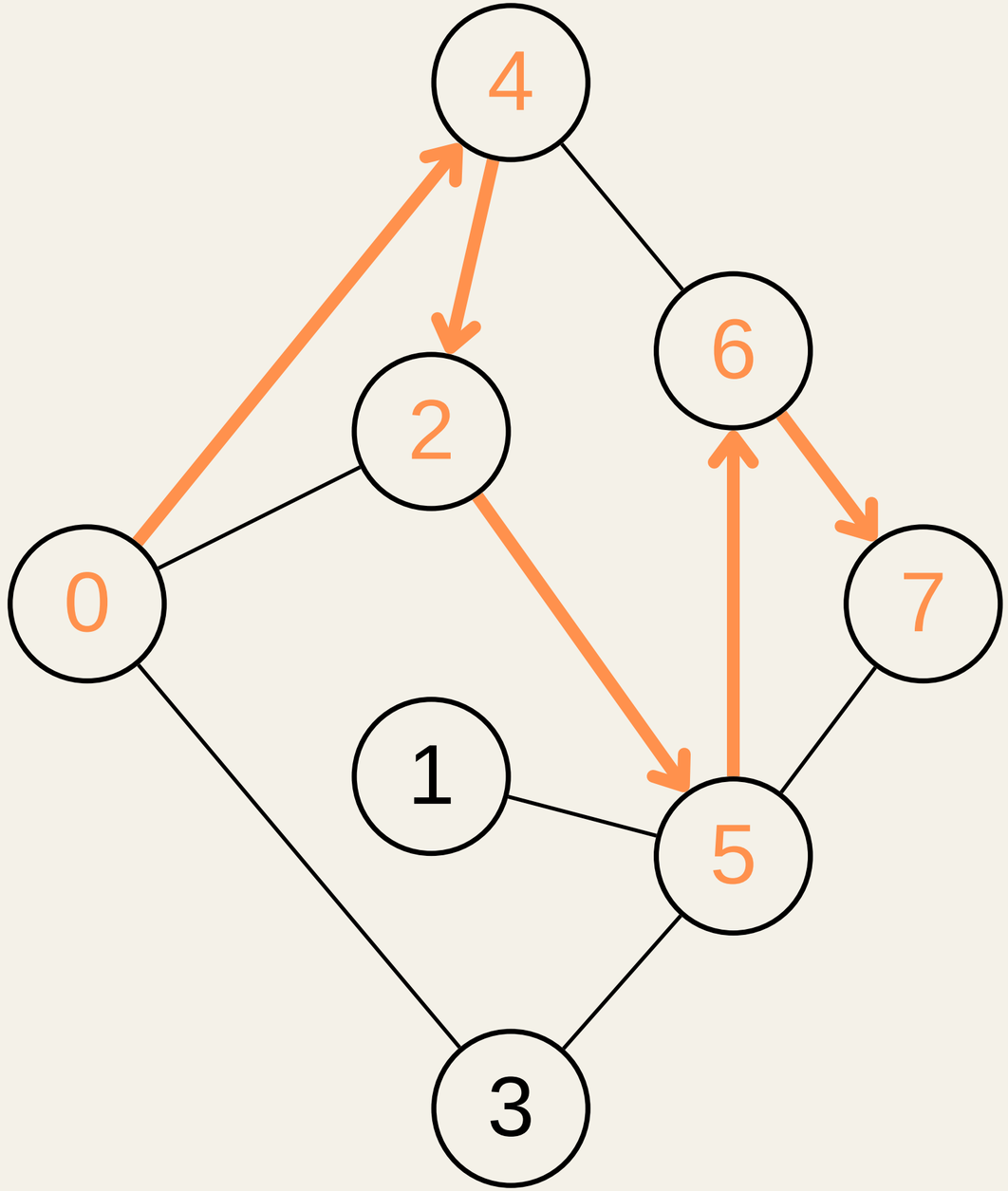
index	0	1	2	3	4	5	6	7
used[ ]	True	False	True	False	True	True	True	True

res	cnt	dis
3	7	5

If cnt equals to the ending vertex

→ Update res value through min(res, dis)

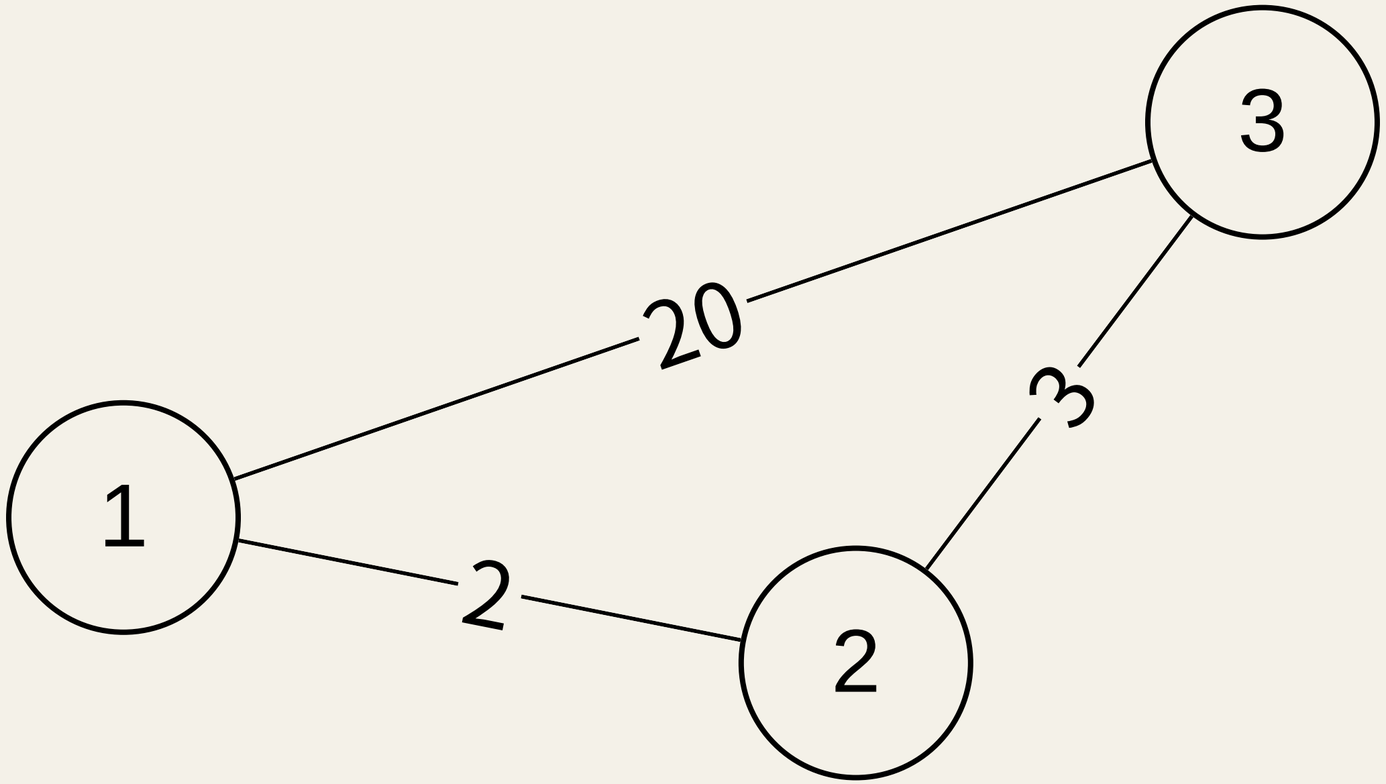
This is the shortest path !



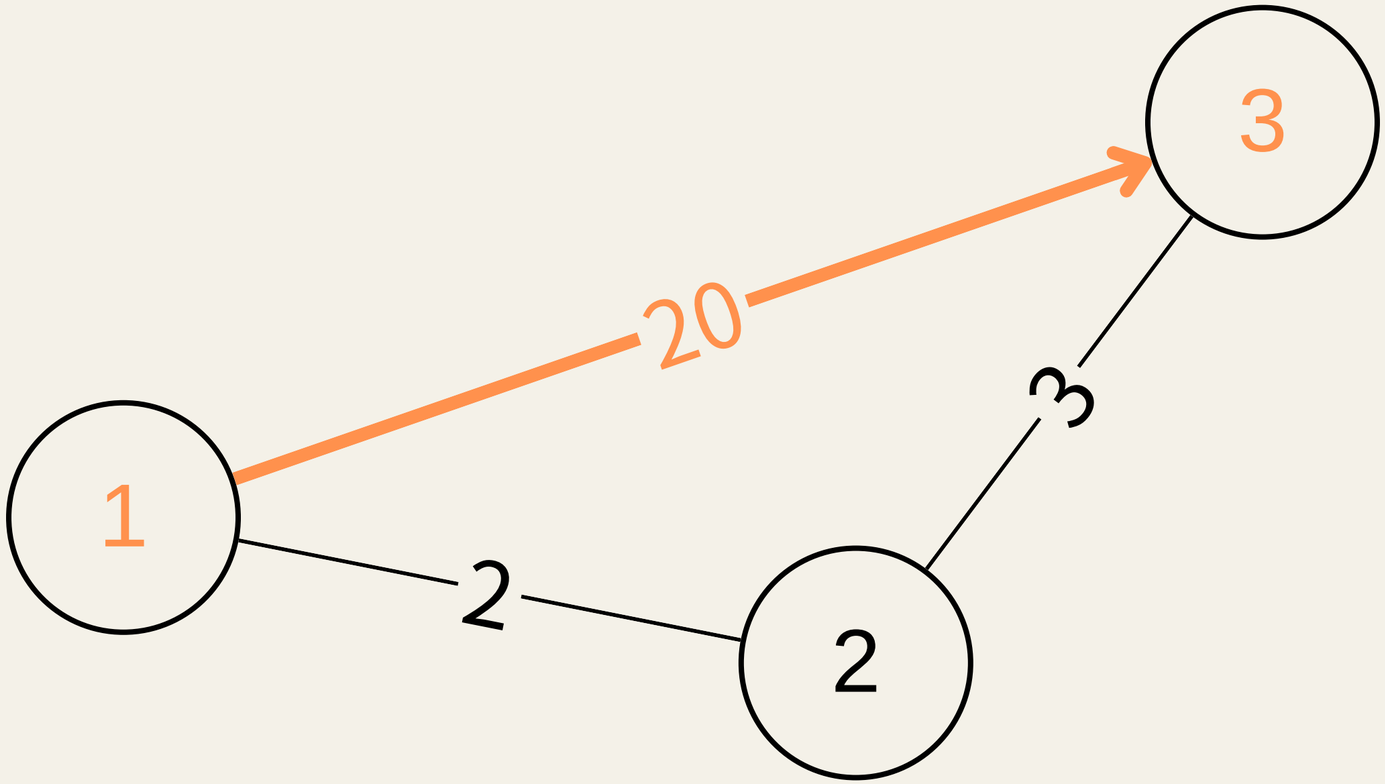
Dijkstra

戴克斯特拉演算法

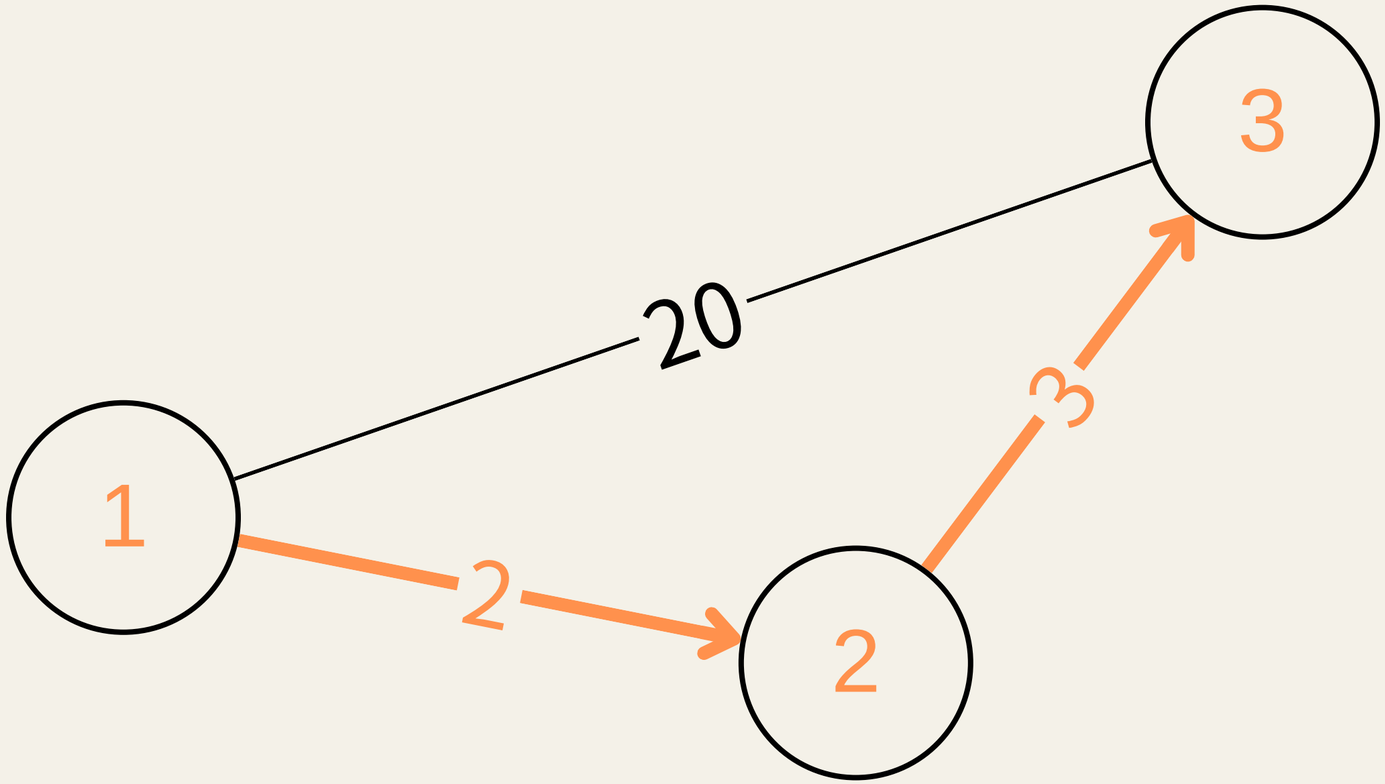
Relax Operation



Relax Operation



Relax Operation



Relax Operation

Initialize

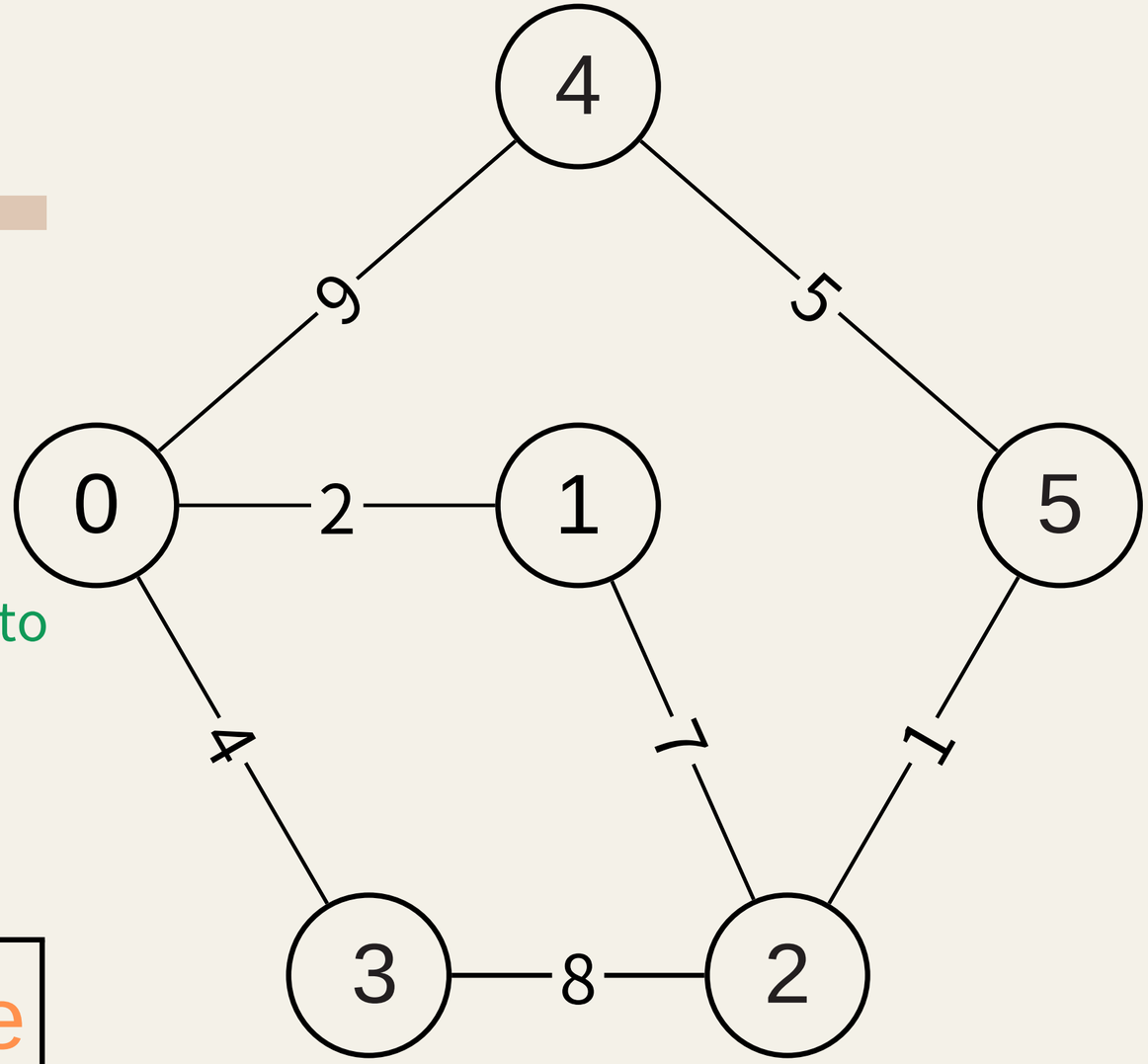
index	0	1	2	3	4	5
dis[ ]	INF	INF	INF	INF	INF	INF

❶ Set all of the value in distance array to default value → Infinite

priority queue<pair<int, int>> pq

pq.empty() = True

❷ Make sure the priority queue we are going to use is empty → declare a new one

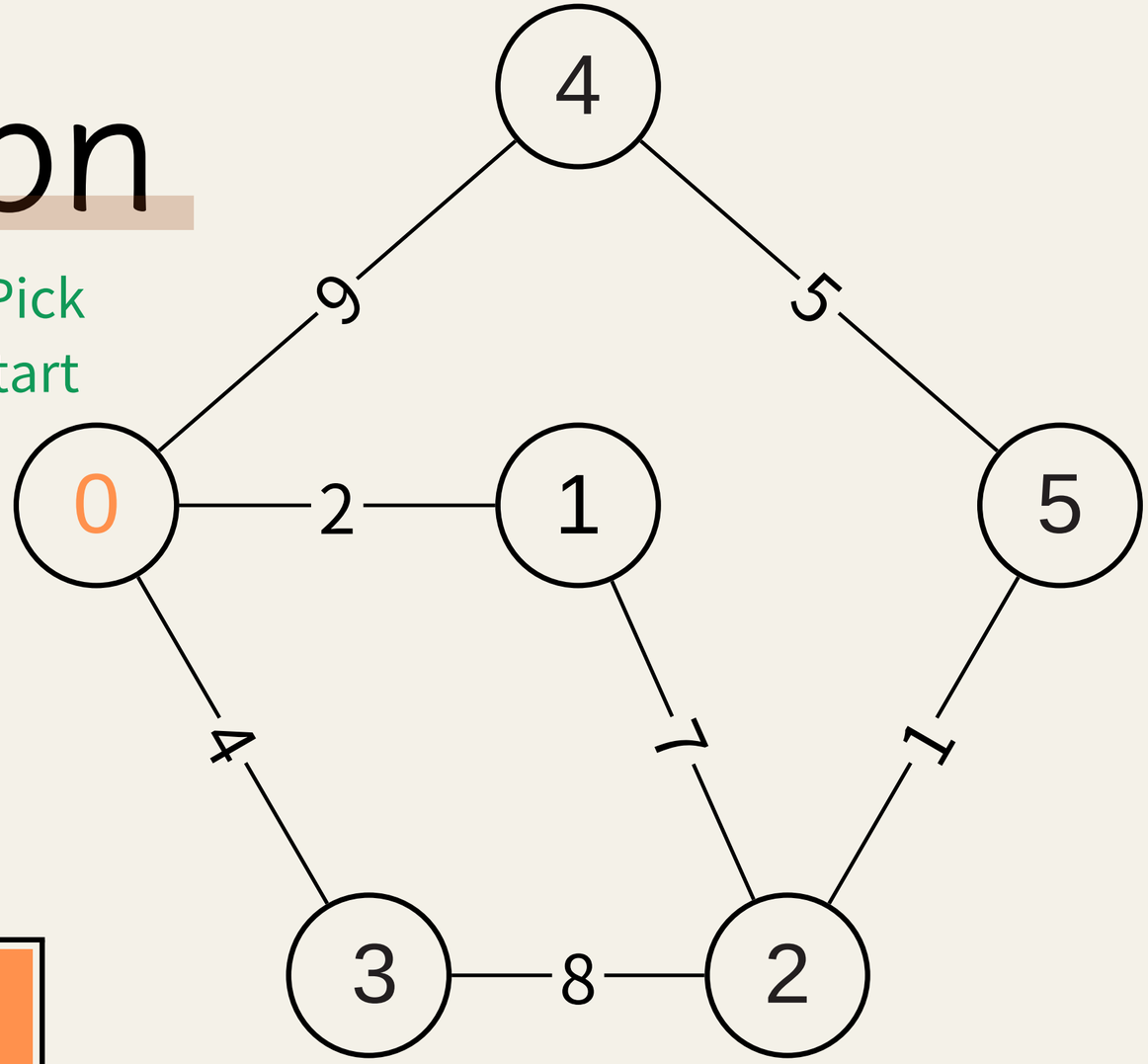


Initial Operation

index 0 1 2 3 4 5

dis[ ]	0	INF	INF	INF	INF	INF

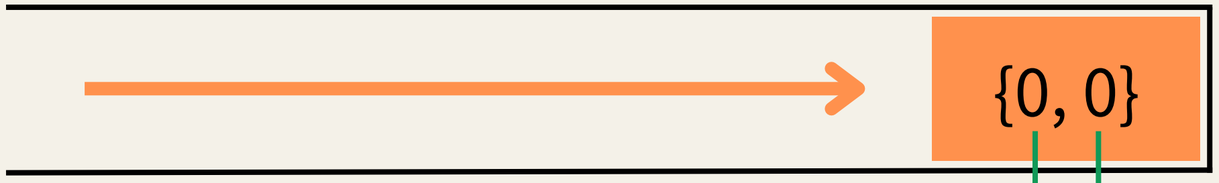
❶ Pick a start



❷ Set the distance of starting vertex to 0

→ The distance from starting vertex to starting vertex will definitely be 0

priority queue<pair<int, int>> q



❸ Push starting vertex into priority queue

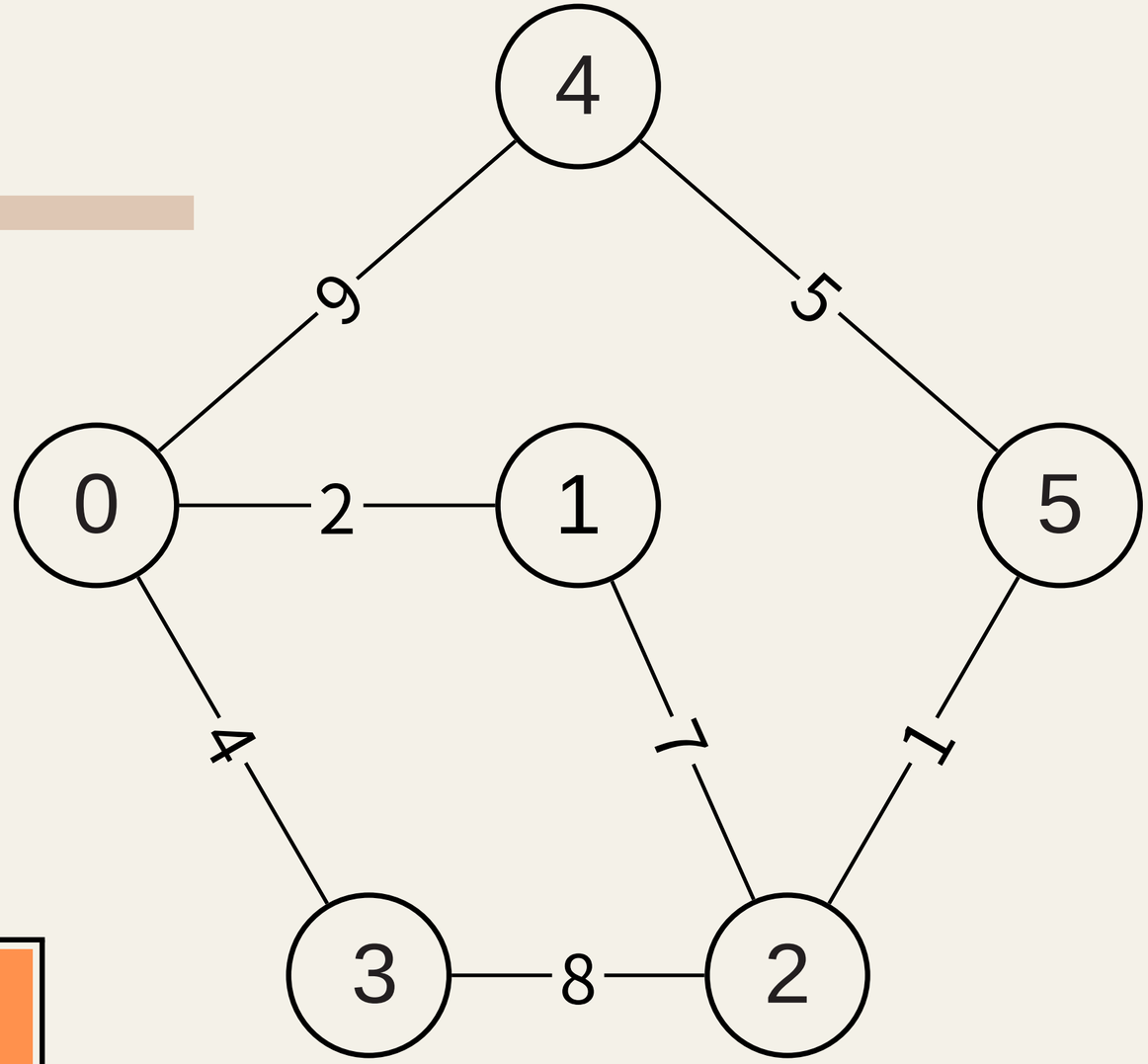
→ This means we are ready to deal with this vertex

current vertex

distance from starting vertex to current vertex

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	INF	INF	INF	INF	INF



priority queue<pair<int, int>> q

{0, 0}

Once the priority queue is not empty

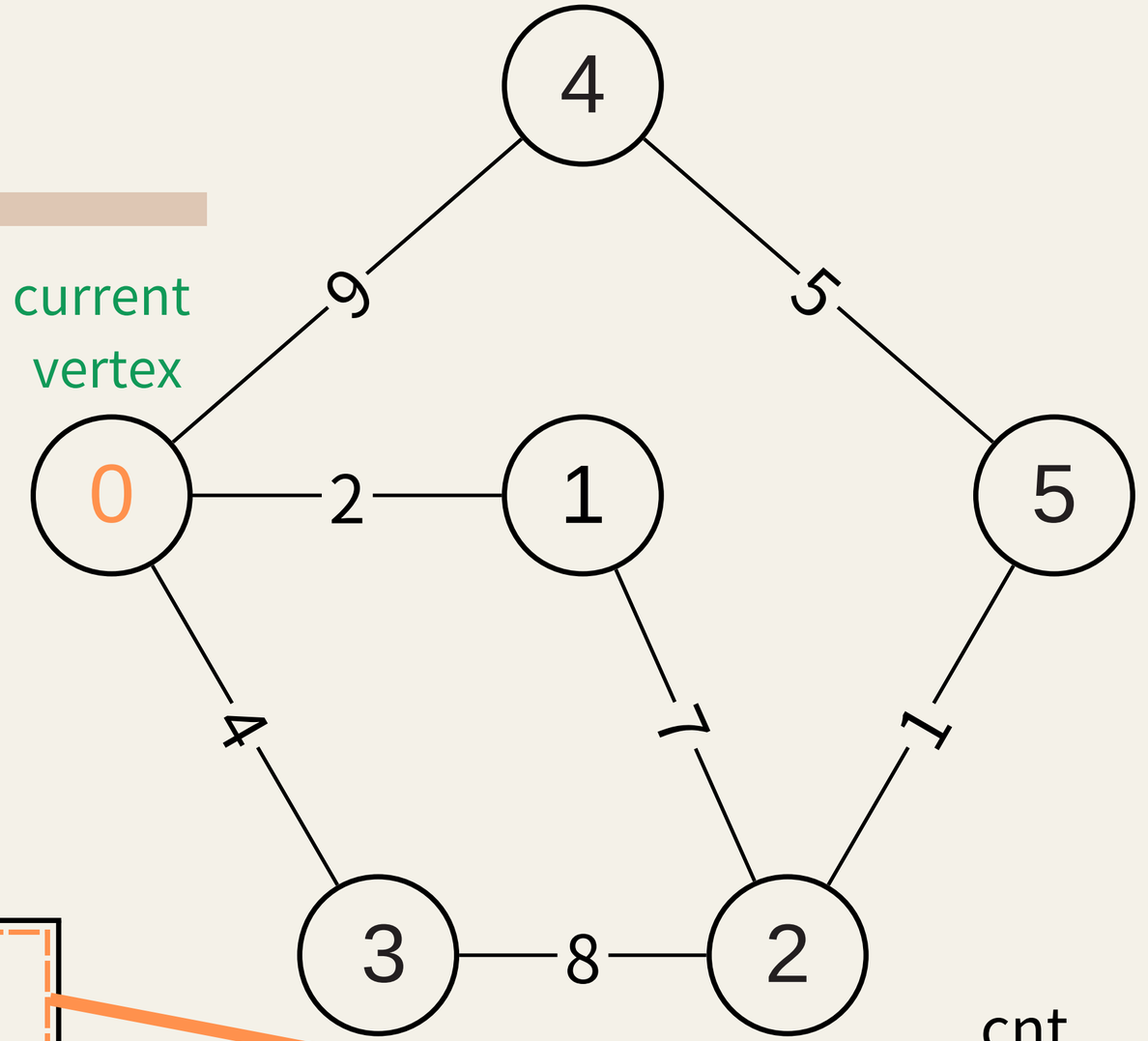
→ Keep going with the remaining vertices

Dijkstra

index 0 1 2 3 4 5

dis[ ]

0	INF	INF	INF	INF	INF



priority queue<pair<int, int>> q

cnt

{0, 0}

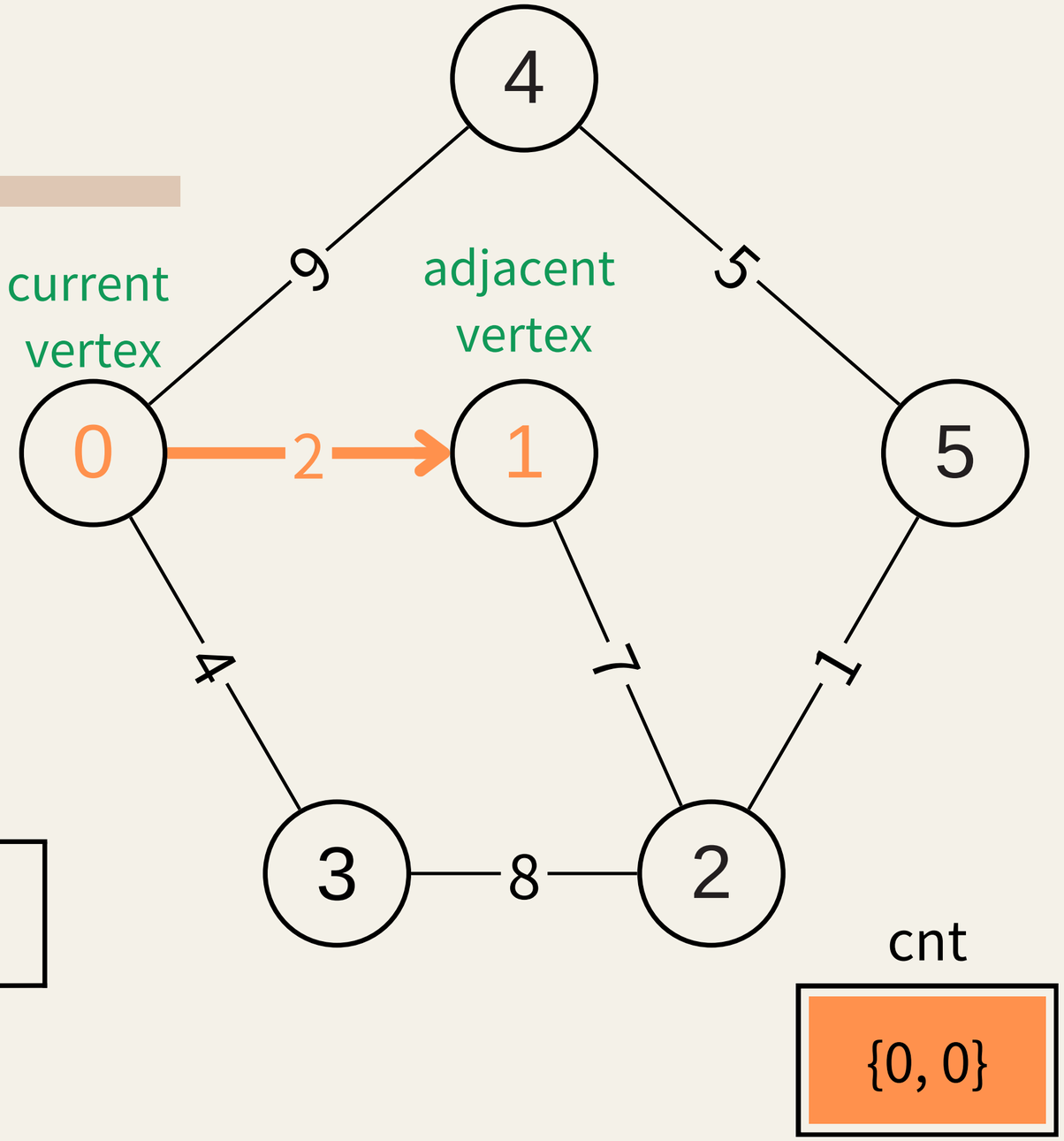
Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	INF	INF	INF	INF	INF

Available ✓

Check the adjacent vertax
if can be relaxed or not

priority queue<pair<int, int>> q



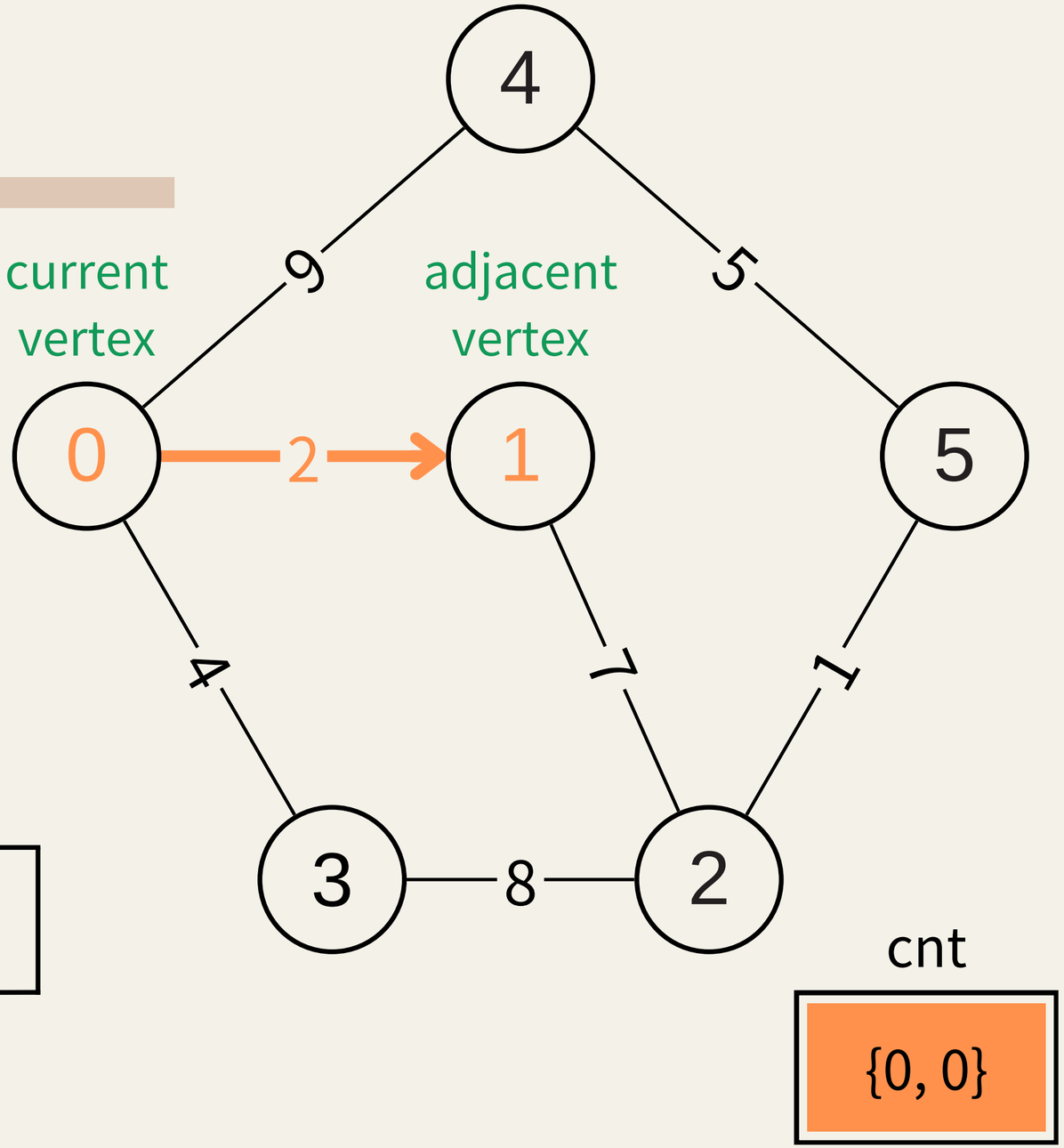
cnt

{0, 0}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	INF	INF	INF

priority queue<pair<int, int>> q



cnt

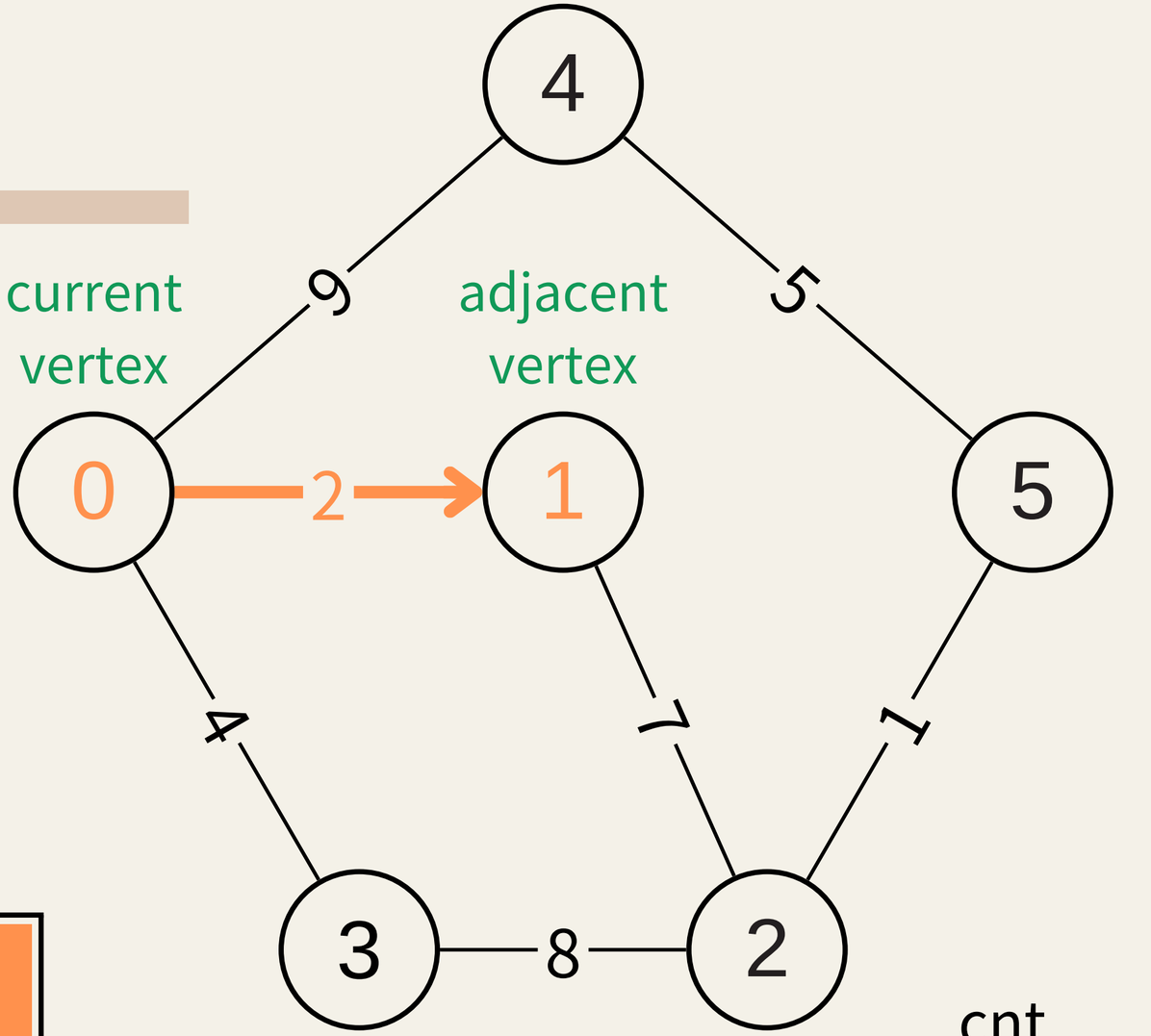
{0, 0}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	INF	INF	INF

priority queue<pair<int, int>> q

{2, 1}



cnt

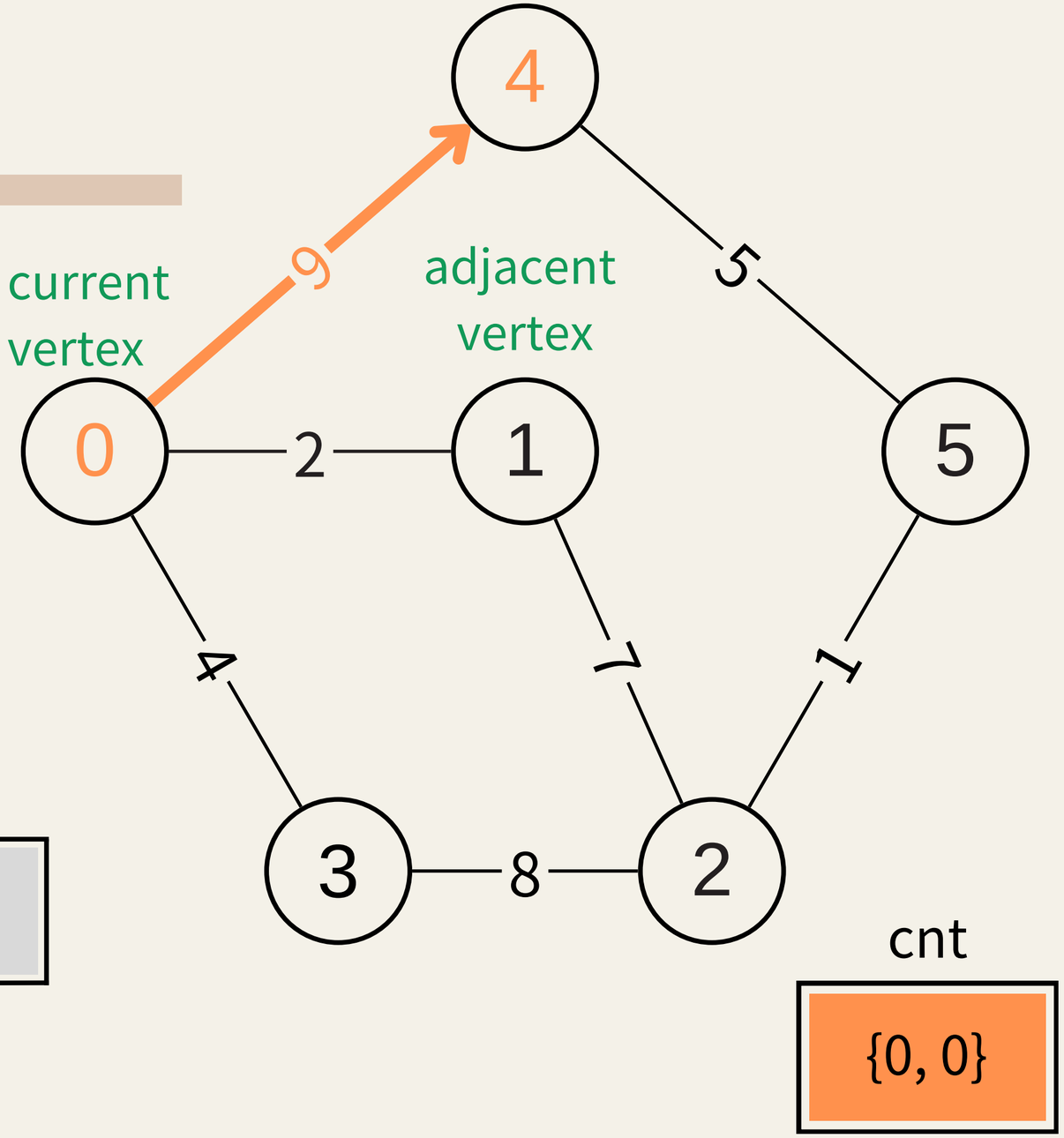
{0, 0}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	INF	INF	INF

priority queue<pair<int, int>> q

{2, 1}



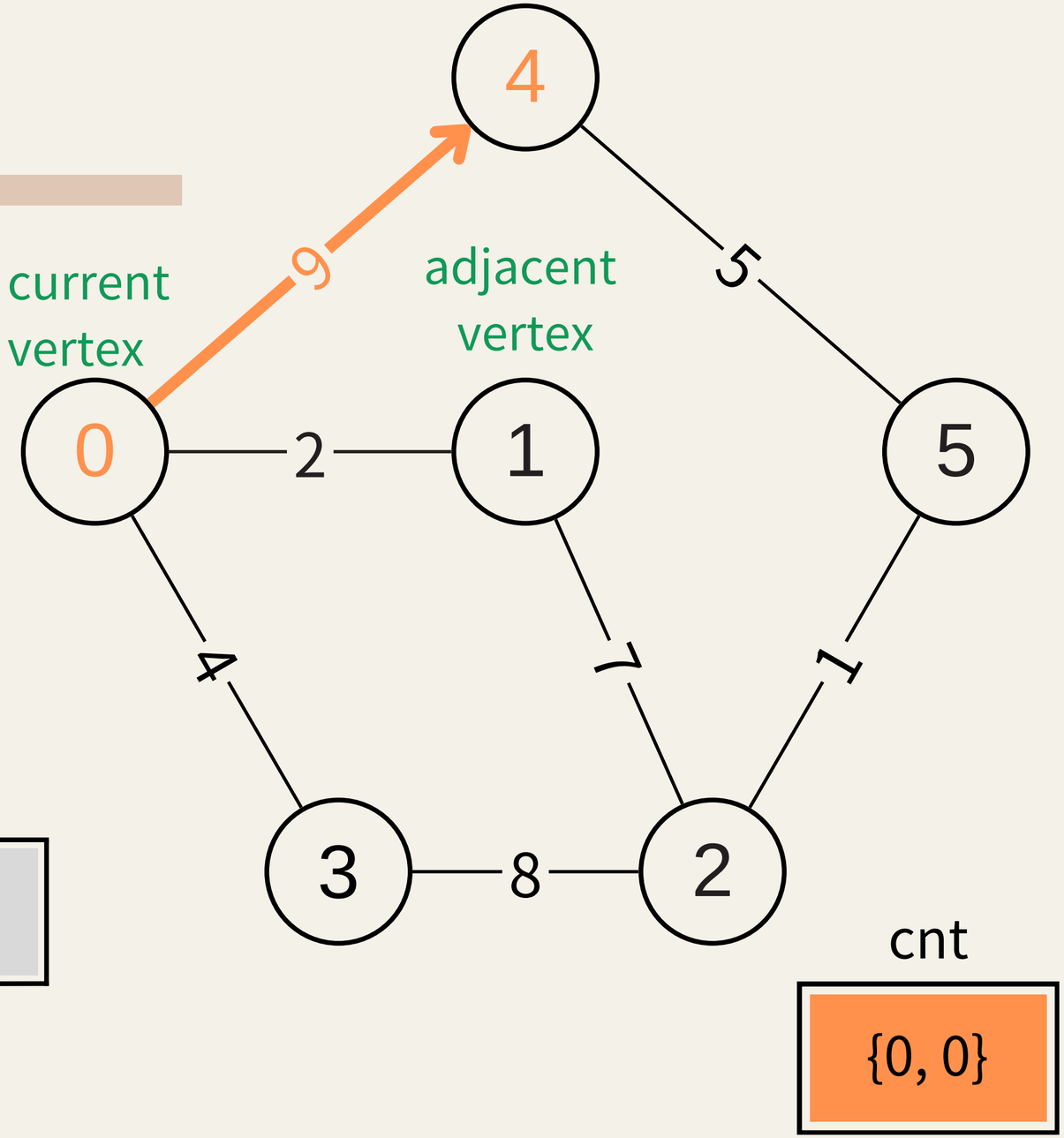
cnt

{0, 0}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	INF	INF	INF

Available ✓



priority queue<pair<int, int>> q

{2, 1}

cnt

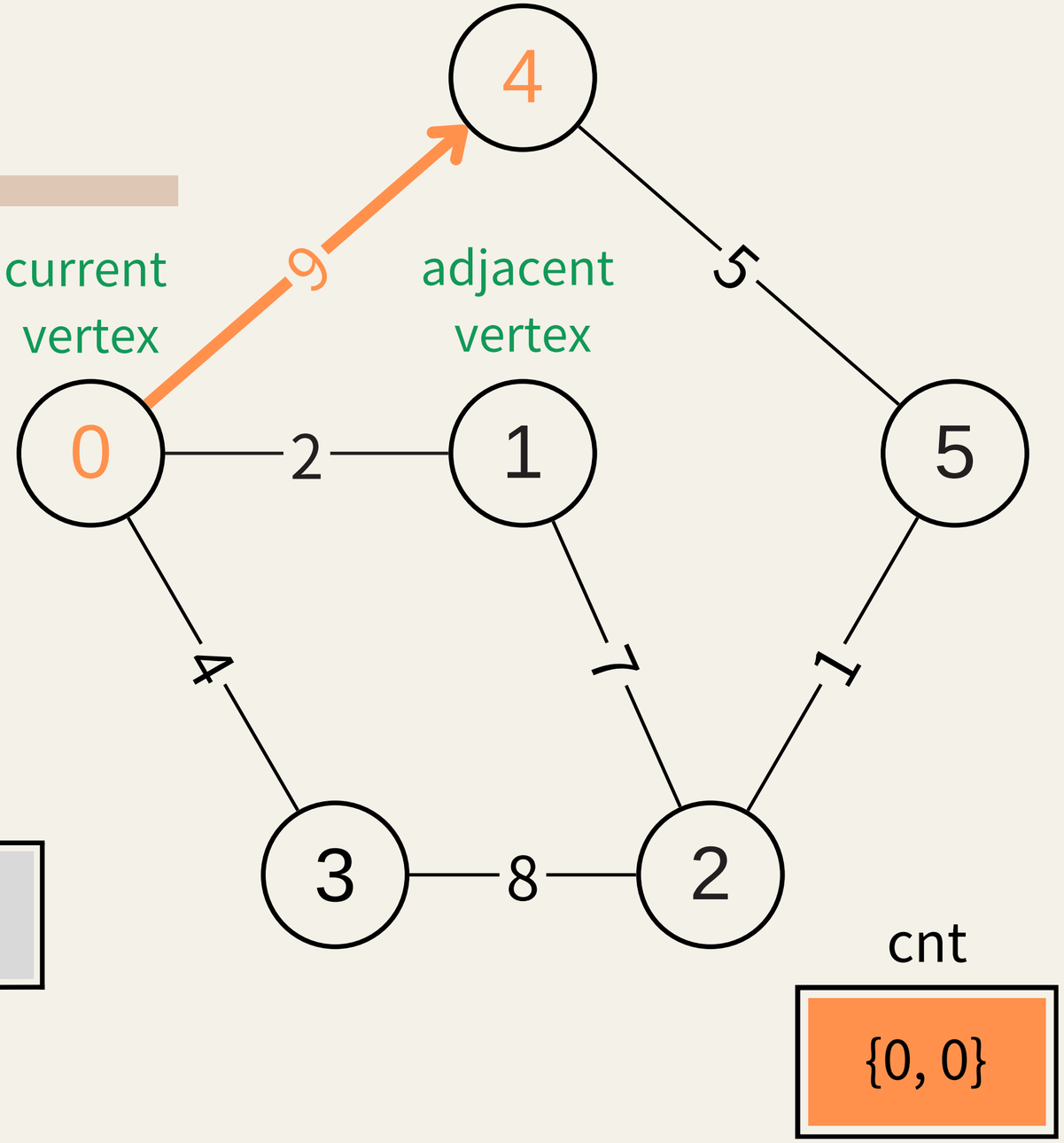
{0, 0}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	INF	9	INF

priority queue<pair<int, int>> q

{2, 1}



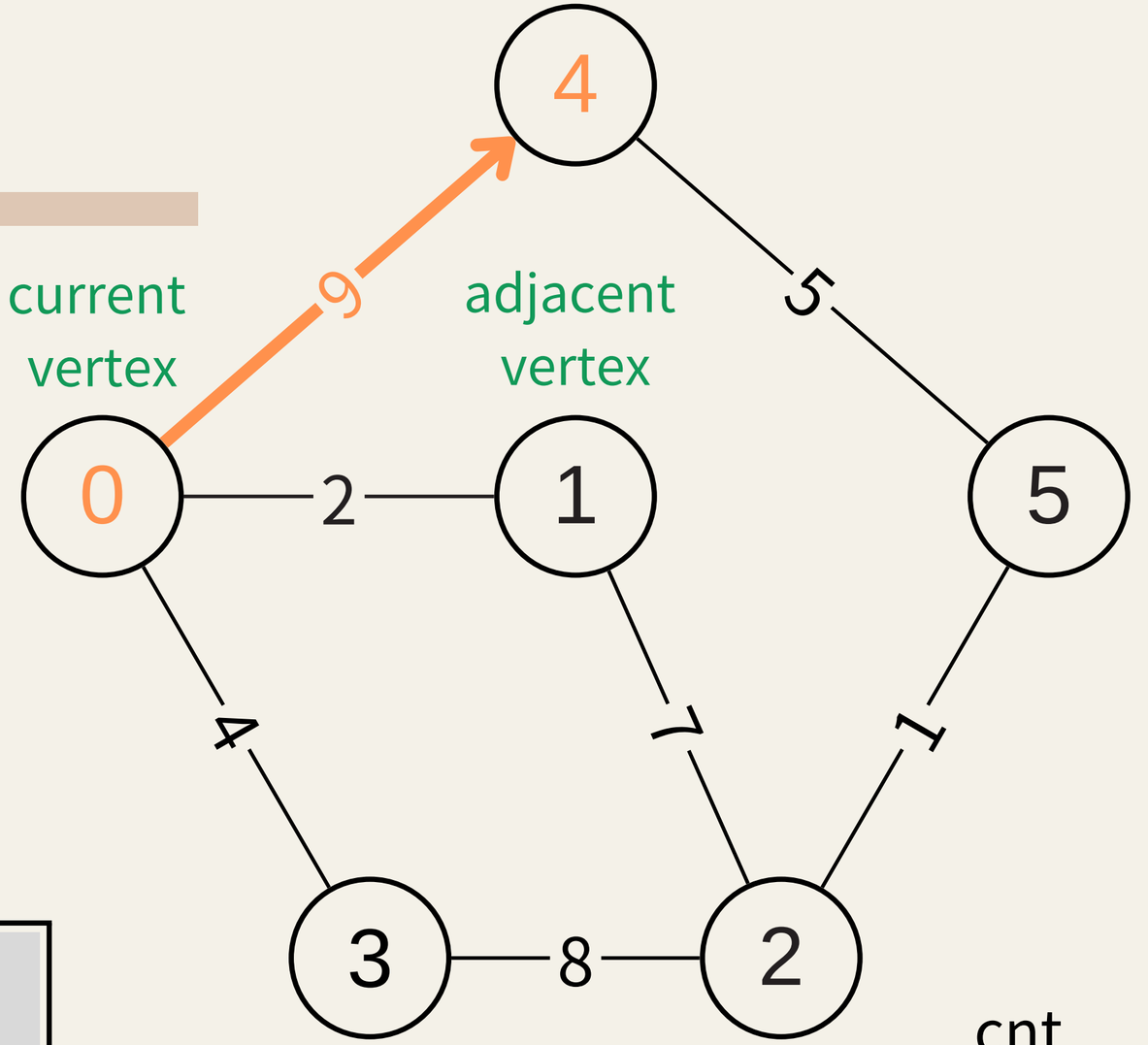
cnt

{0, 0}

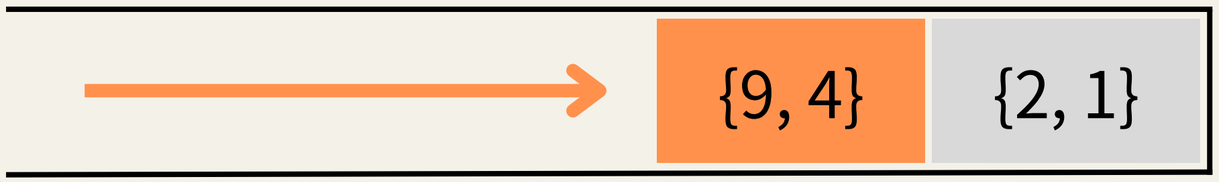
Dijkstra

index 0 1 2 3 4 5

dis[ ]	0	2	INF	INF	9	INF



priority queue<pair<int, int>> q



cnt

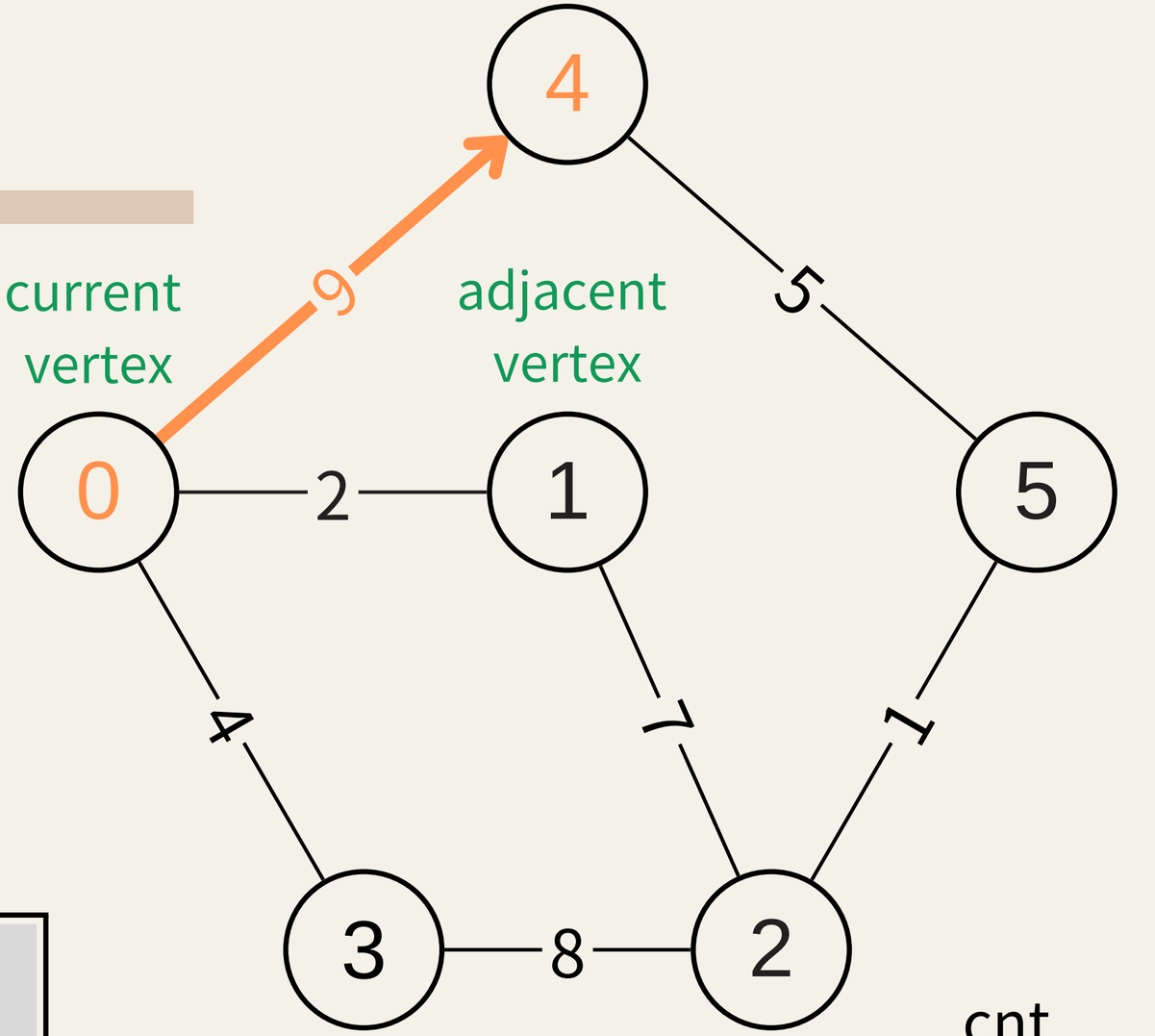
{0, 0}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	INF	9	INF

priority queue<pair<int, int>> q

{9, 4}	{2, 1}



cnt

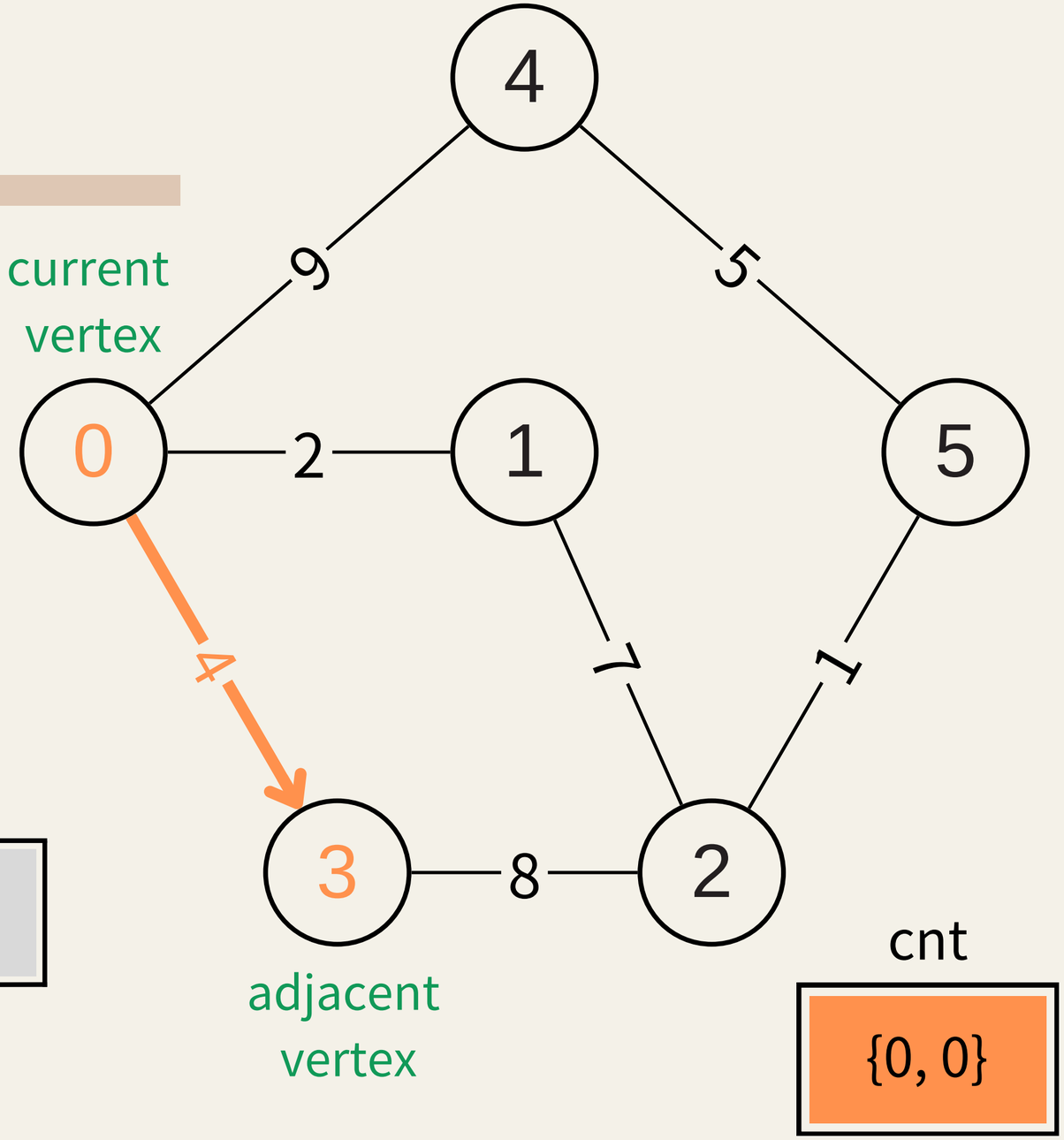
{0, 0}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	INF	9	INF

priority queue<pair<int, int>> q

	{9, 4}	{2, 1}



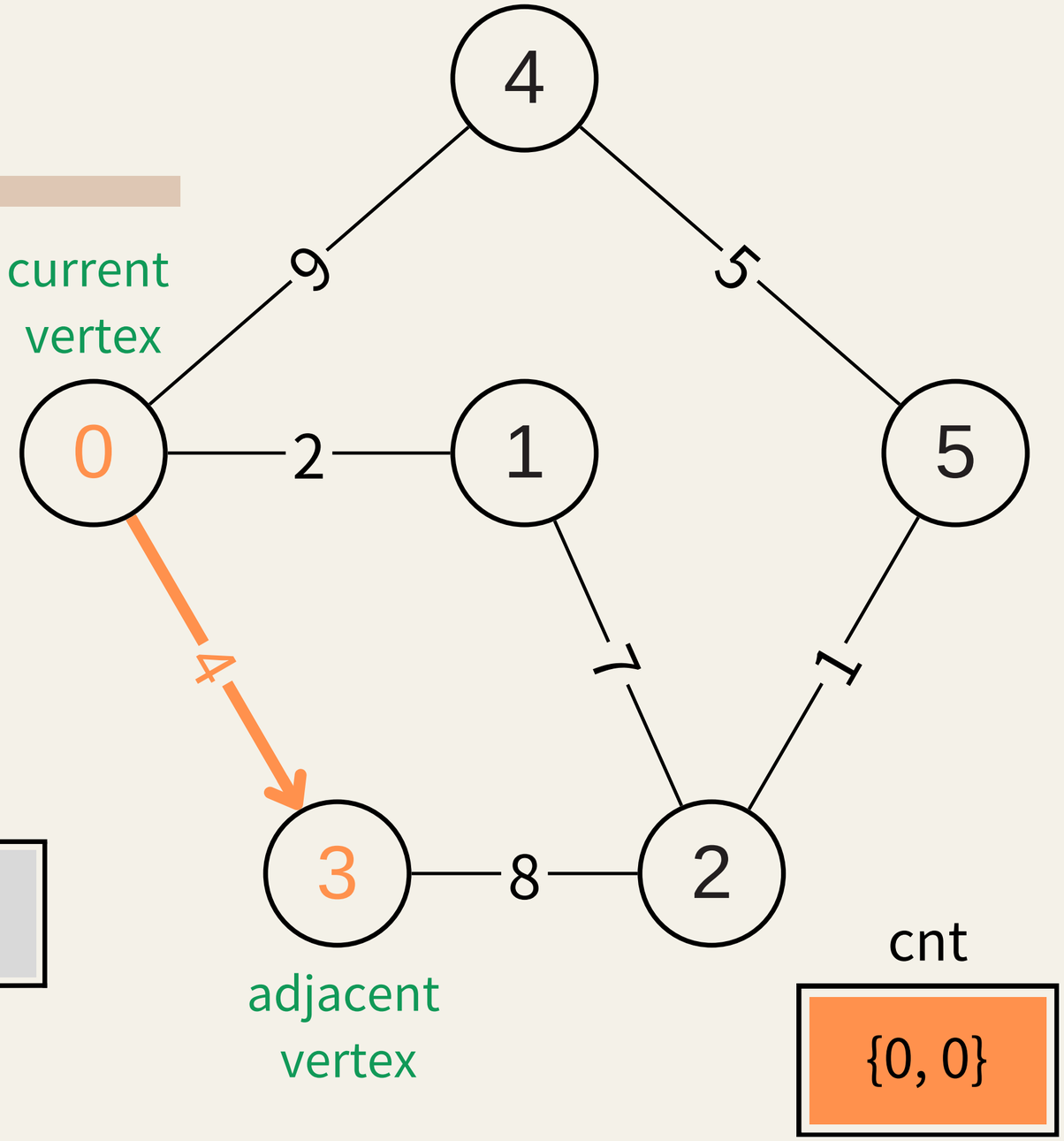
Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	INF	9	INF

Available ✓

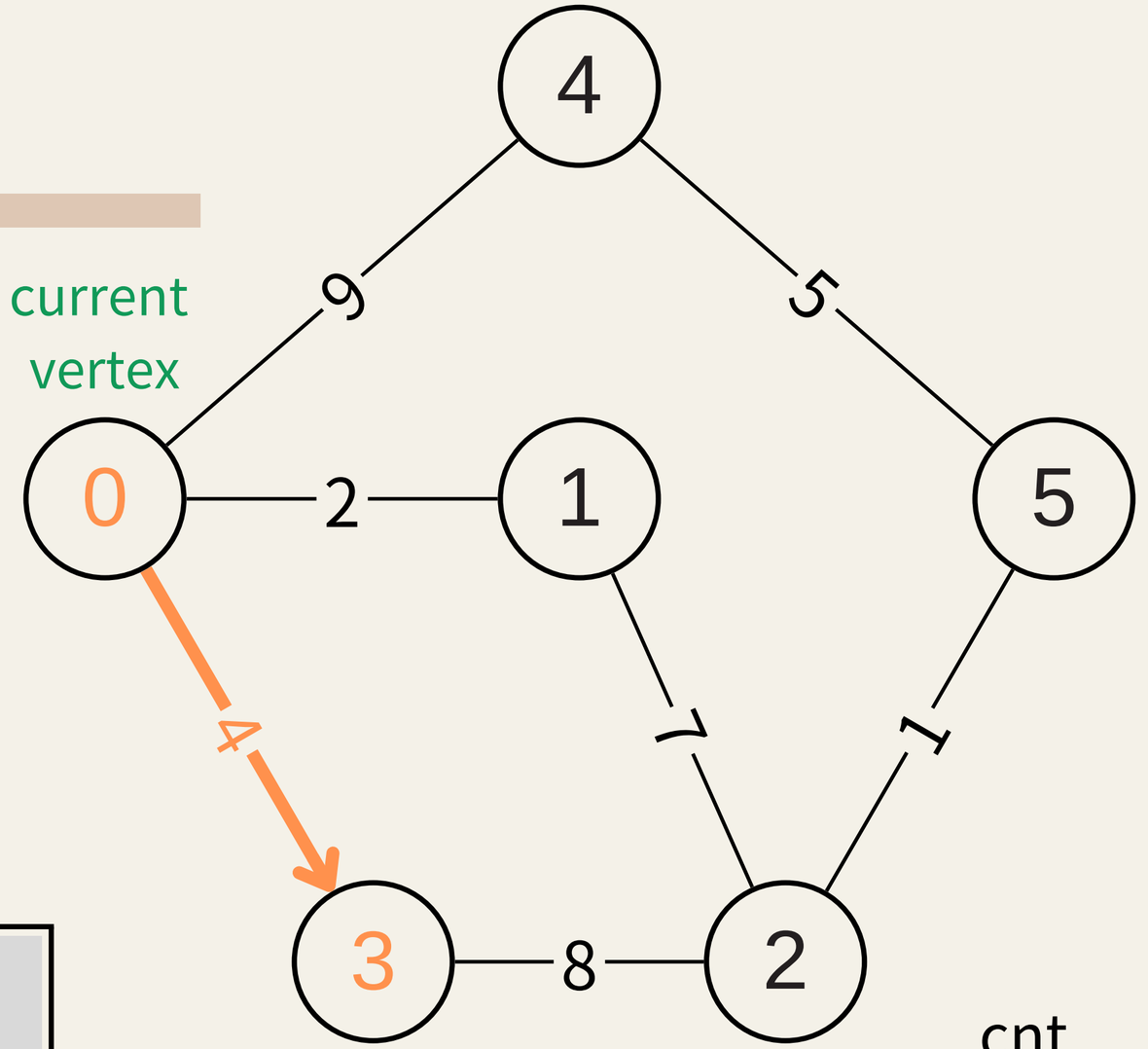
priority queue<pair<int, int>> q

{9, 4}	{2, 1}

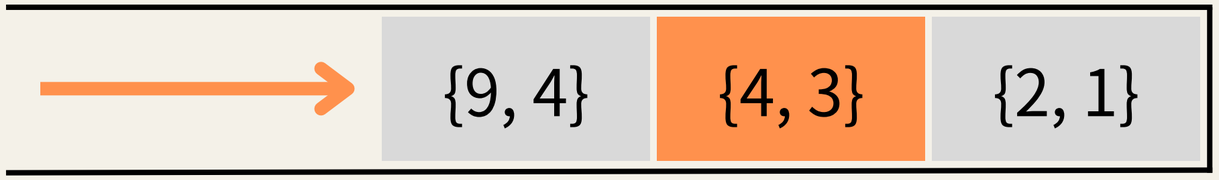


Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	4	9	INF



priority queue<pair<int, int>> q



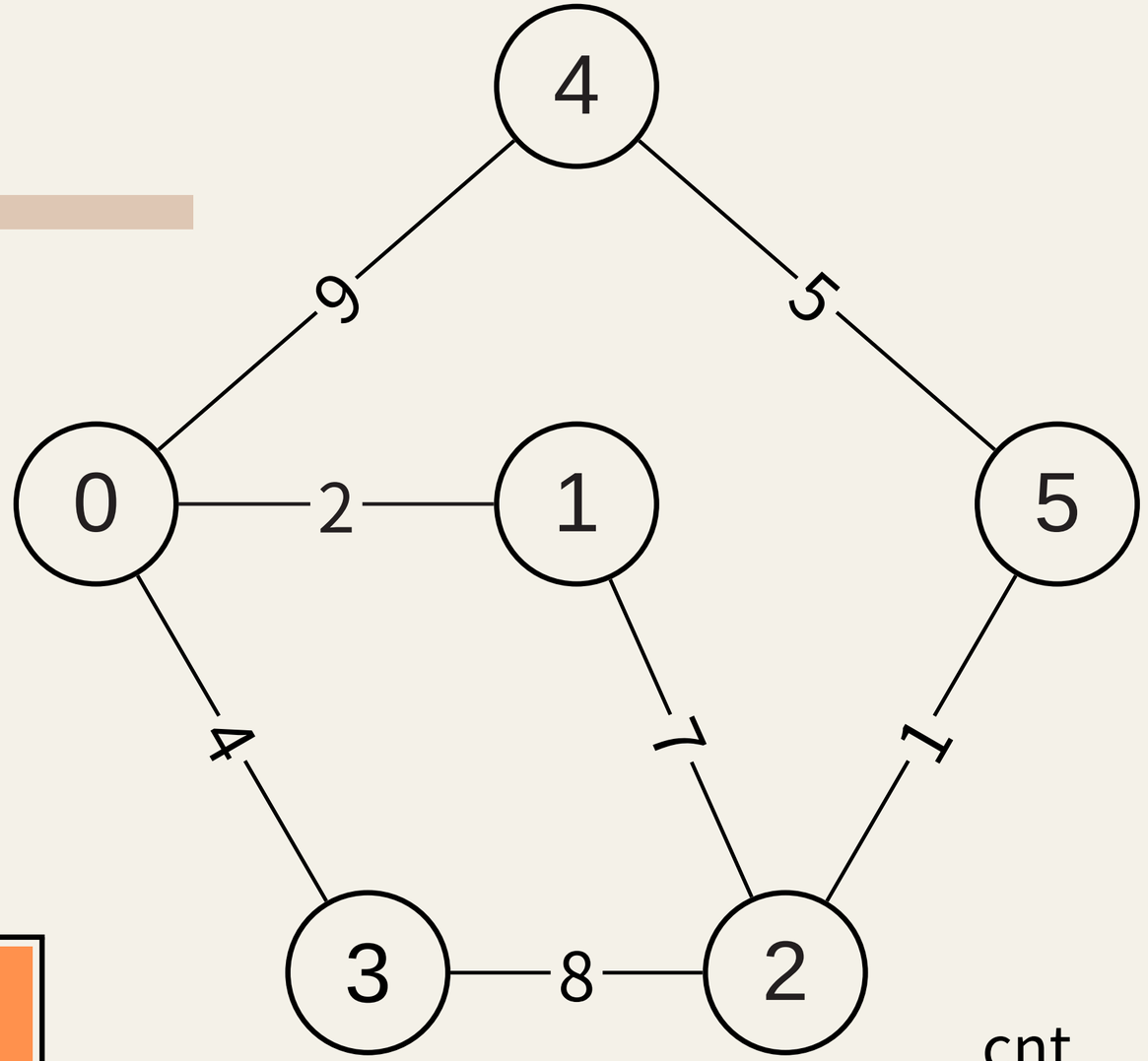
It is worth noting that priority queue will automatically sort

cnt

{0, 0}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	INF	4	9	INF



priority queue<pair<int, int>> q

{9, 4}	{4, 3}	{2, 1}

cnt

{0, 0}

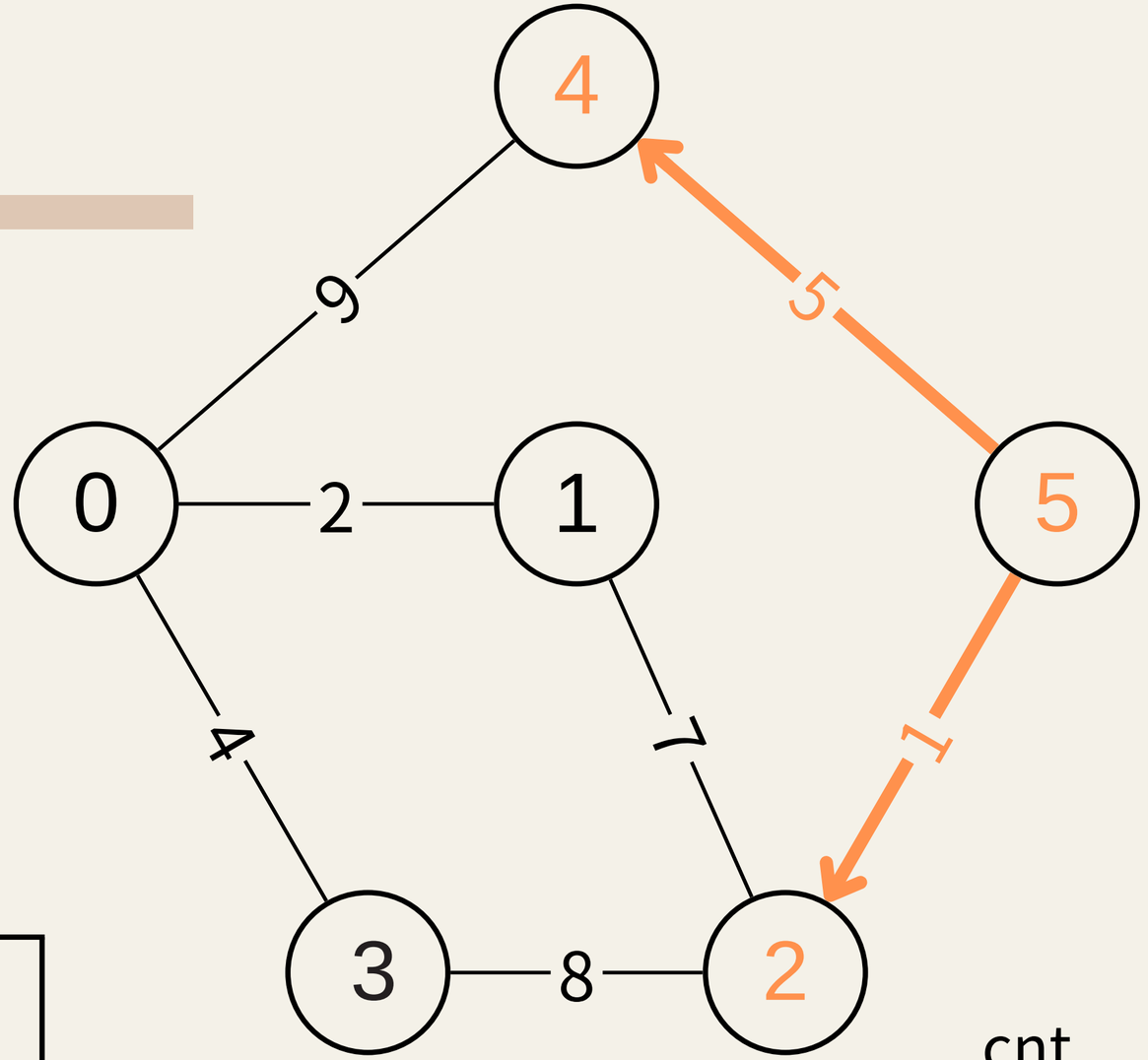
When all vertex adjacent to cnt have been processed
Then, Check the whether queue is empty or not
→ If true, keep going with the remaining vertices

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	9	4	9	10

This is the shortest path !

priority queue<pair<int, int>> q



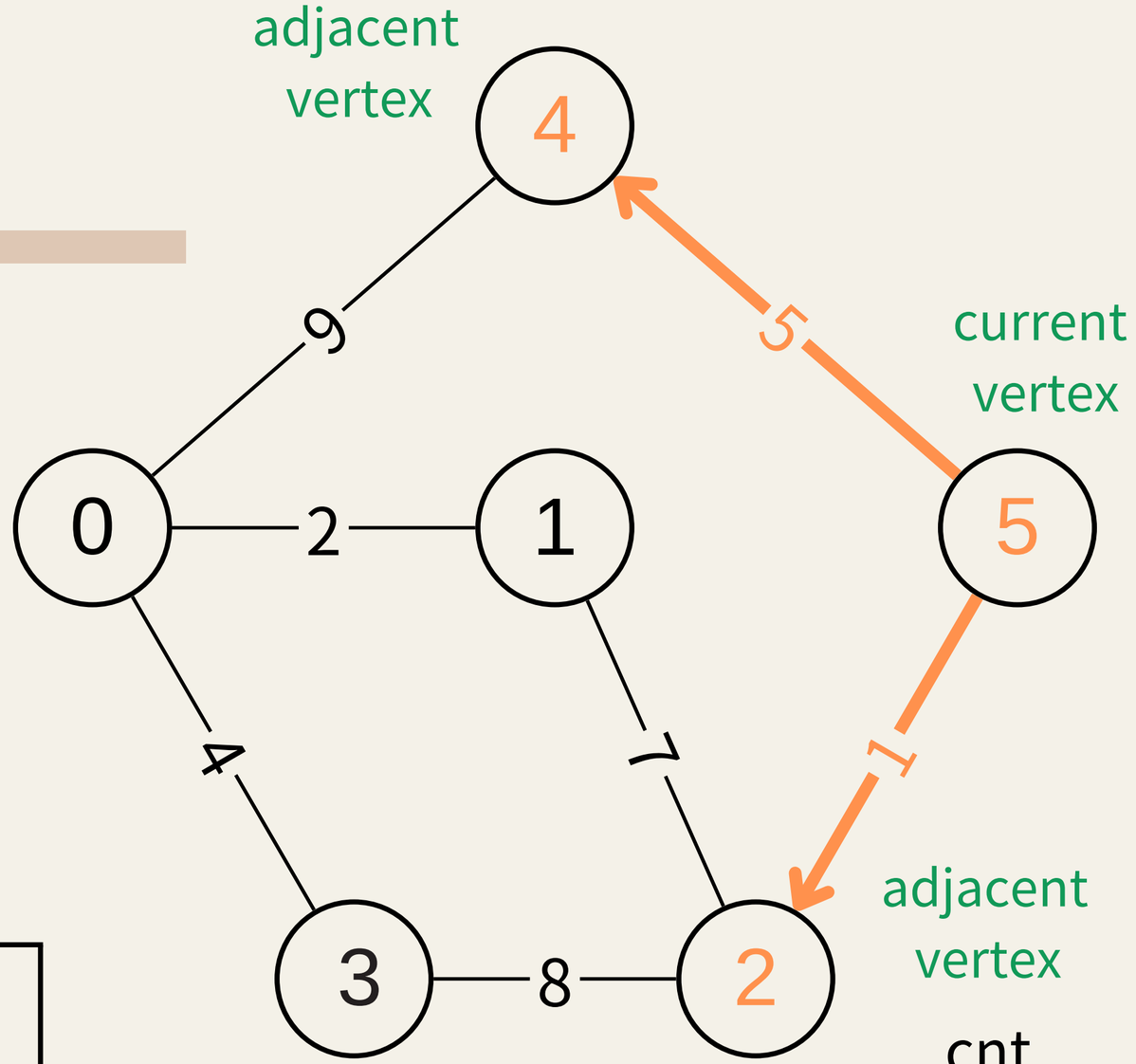
cnt

{10, 5}

Dijkstra

index	0	1	2	3	4	5
dis[ ]	0	2	9	4	9	10

Not Available ✗



priority queue<pair<int, int>> q

When all vertex adjacent to cnt have been processed
Then, Check the whether queue is empty or not
→ If true, keep going with the remaining vertices

Bellman-Ford

貝爾曼-福特演算法

Initialize

index	0	1	2	3
dis[ ]	0	INF	INF	INF

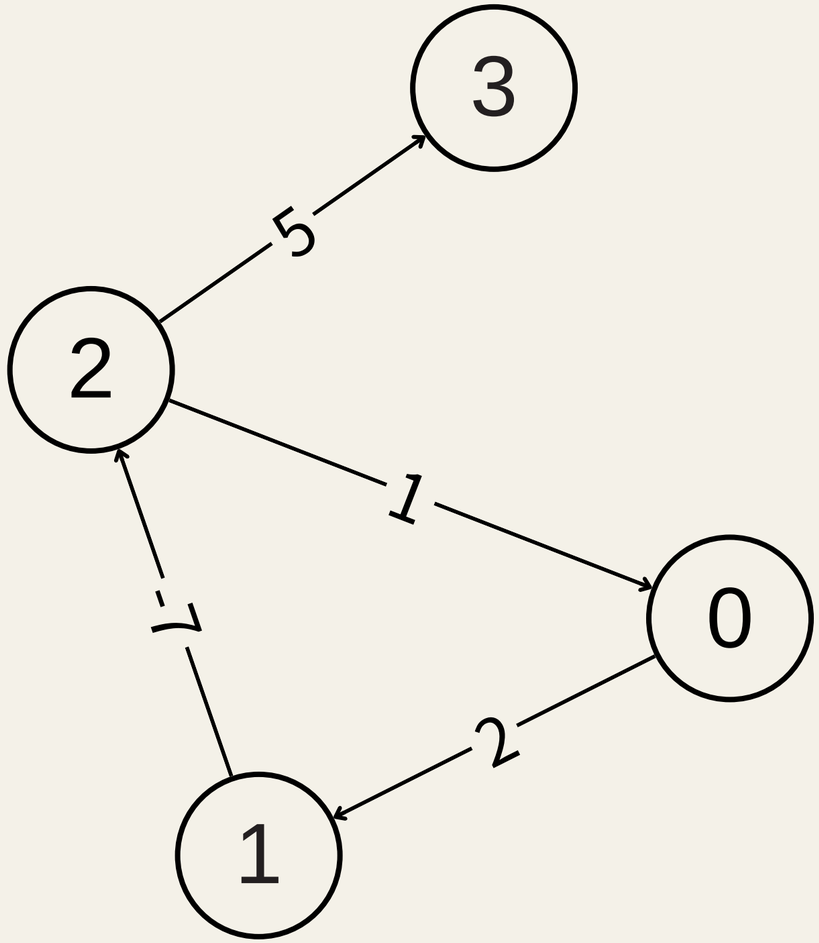
❶ Set all of the value distance array to default value → Infinite

❷ Set dis[start] → 0

vector<vector<int>> edge

edge[3]	edge[2]	edge[1]	edge[0]
{-7, 1, 2}	{1, 2, 0}	{5, 2, 3}	{2, 0, 1}

❸ Push all of the edge into vector



❹ Define ∀edge[i] ∈ edge

edge[i][0] → weight

edge[i][1] → vertex u

edge[i][2] → vertex v

Bellman-ford

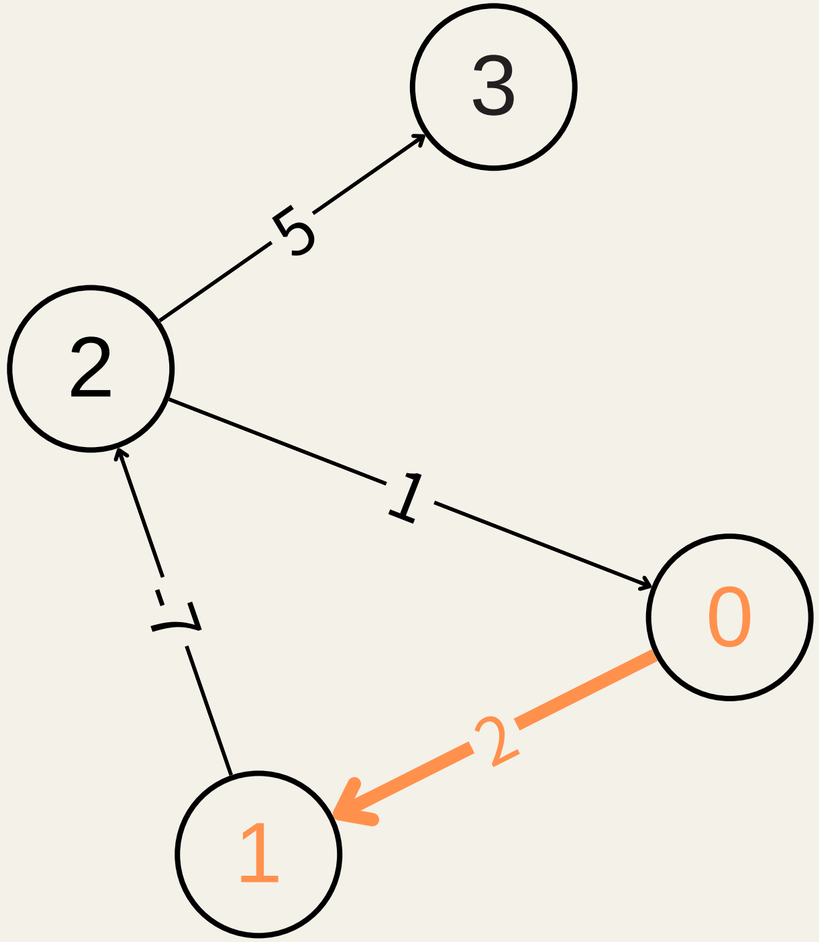
index	0	1	2	3
dis[ ]	0	2	INF	INF

❷ If edge[i] is relaxable → relax the edge

vector<vector<int>> edge

edge[3]	edge[2]	edge[1]	edge[0]
{-7, 1, 2}	{1, 2, 0}	{5, 2, 3}	{2, 0, 1}

w u v

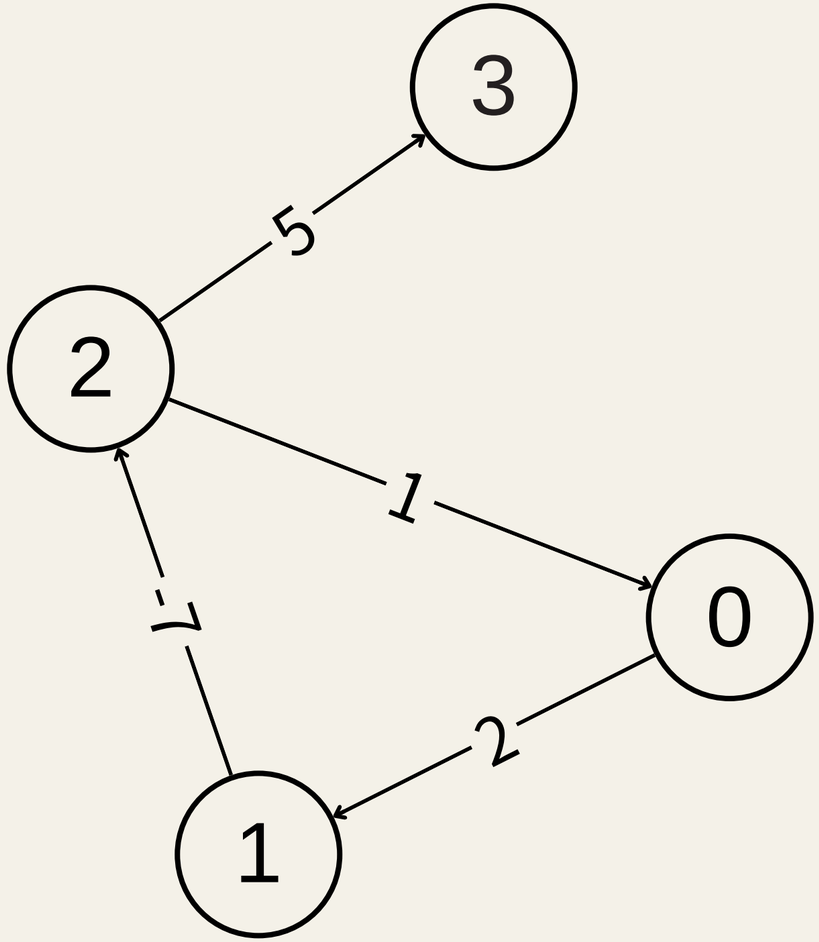


❶ Check If edge[i] is relaxable
→ dis[u] + w < dis[v]

Bellman-ford

index	0	1	2	3
dis[ ]	0	2	-5	INF

→ After 1 round of relax operation



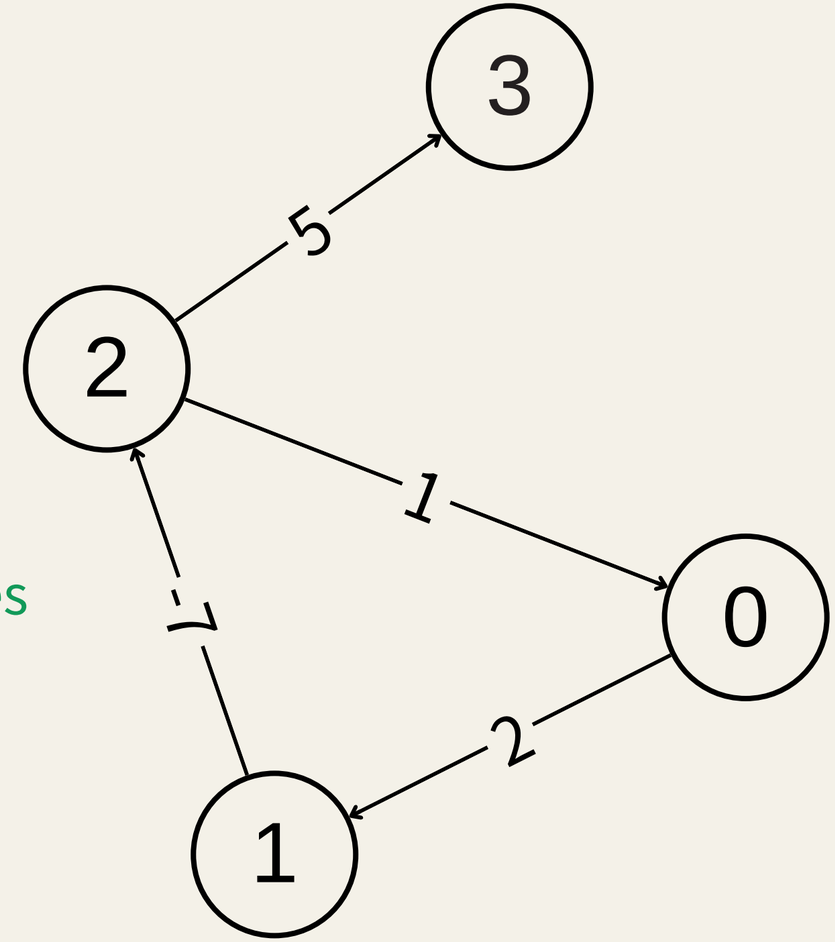
vector<vector<int>> edge

{-7, 1, 2}	{1, 2, 0}	{5, 2, 3}	{2, 0, 1}
edge[3]	edge[2]	edge[1]	edge[0]

Bellman-ford

index	0	1	2	3
dis[ ]	-8	-2	-9	-4

After N-1 rounds of relax operation. If there are edges that are still relaxable → The graph contains a cycle



vector<vector<int>> edge

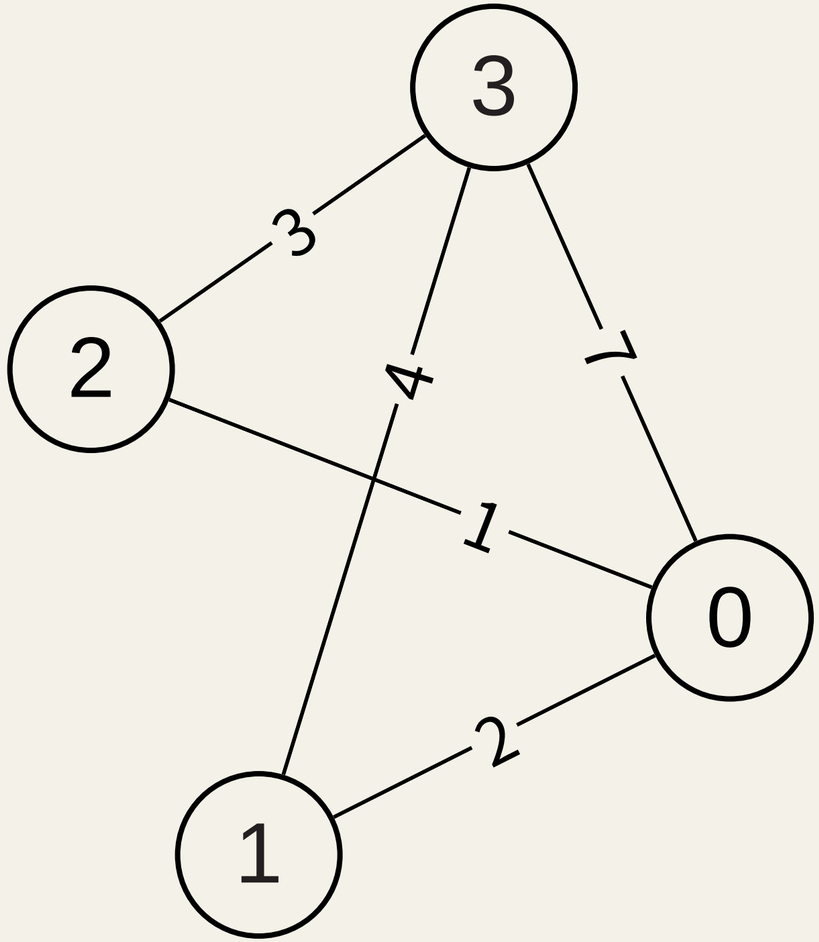
{-7, 1, 2}	{1, 2, 0}	{5, 2, 3}	{2, 0, 1}
edge[3]	edge[2]	edge[1]	edge[0]

Floyd-Warshall

佛洛依德演算法

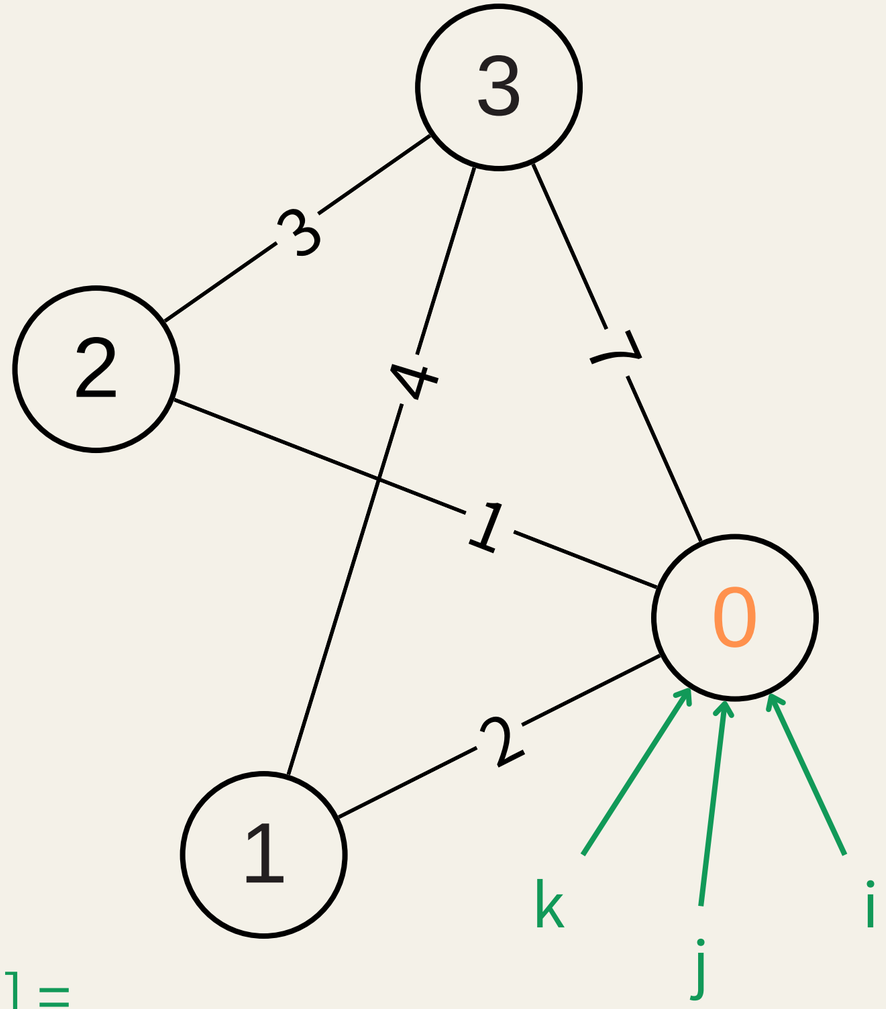
Initialize

index	0	1	2	3	
dis[ ][ ]	0	2	1	7	0
	2	0	INF	4	1
	1	INF	0	3	2
	7	4	3	0	3



Floyd-Washall

index	0	1	2	3	
dis[ ][ ]	0	2	1	7	0
	2	0	INF	4	1
	1	INF	0	3	2
	7	4	3	0	3

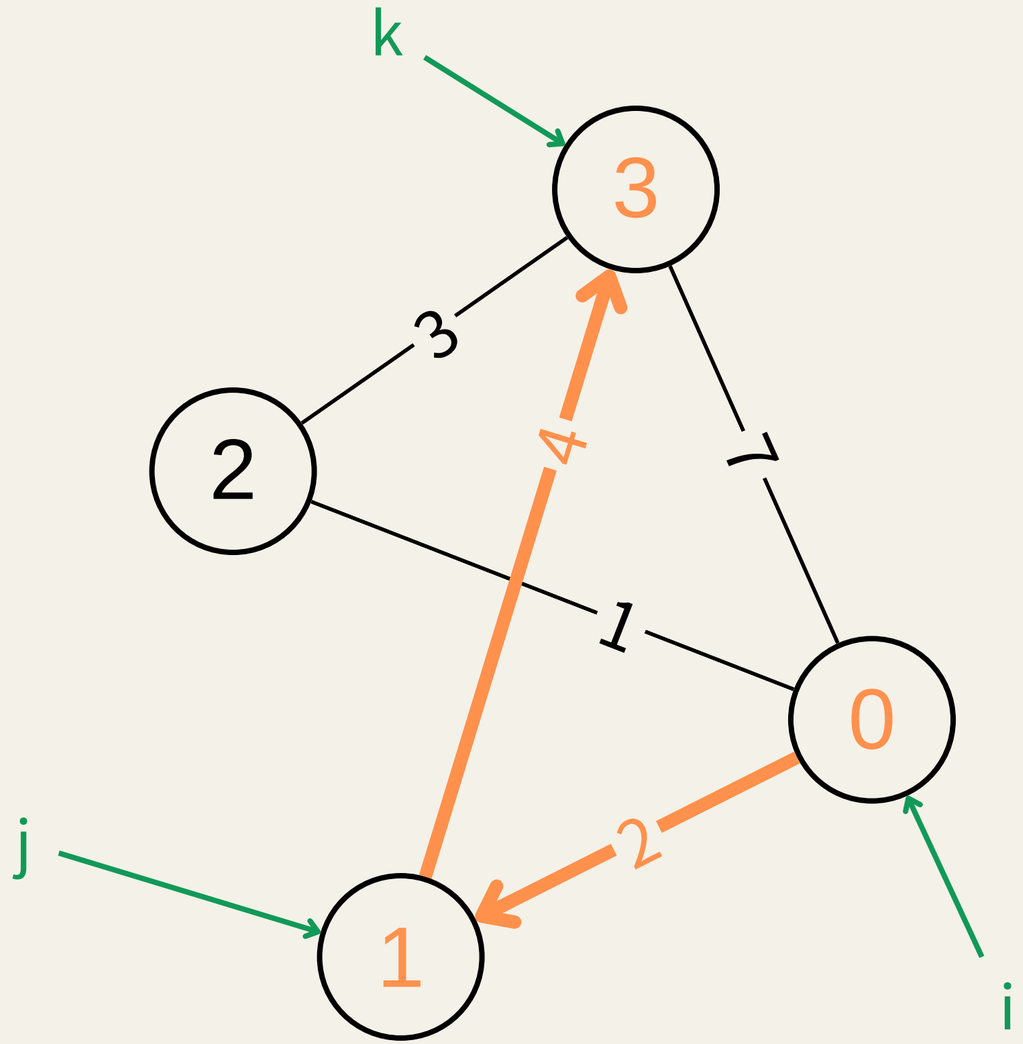


dis[i][j] =

min(dis[i][j], dis[i][k] + dis[k][j])

Floyd-Washall

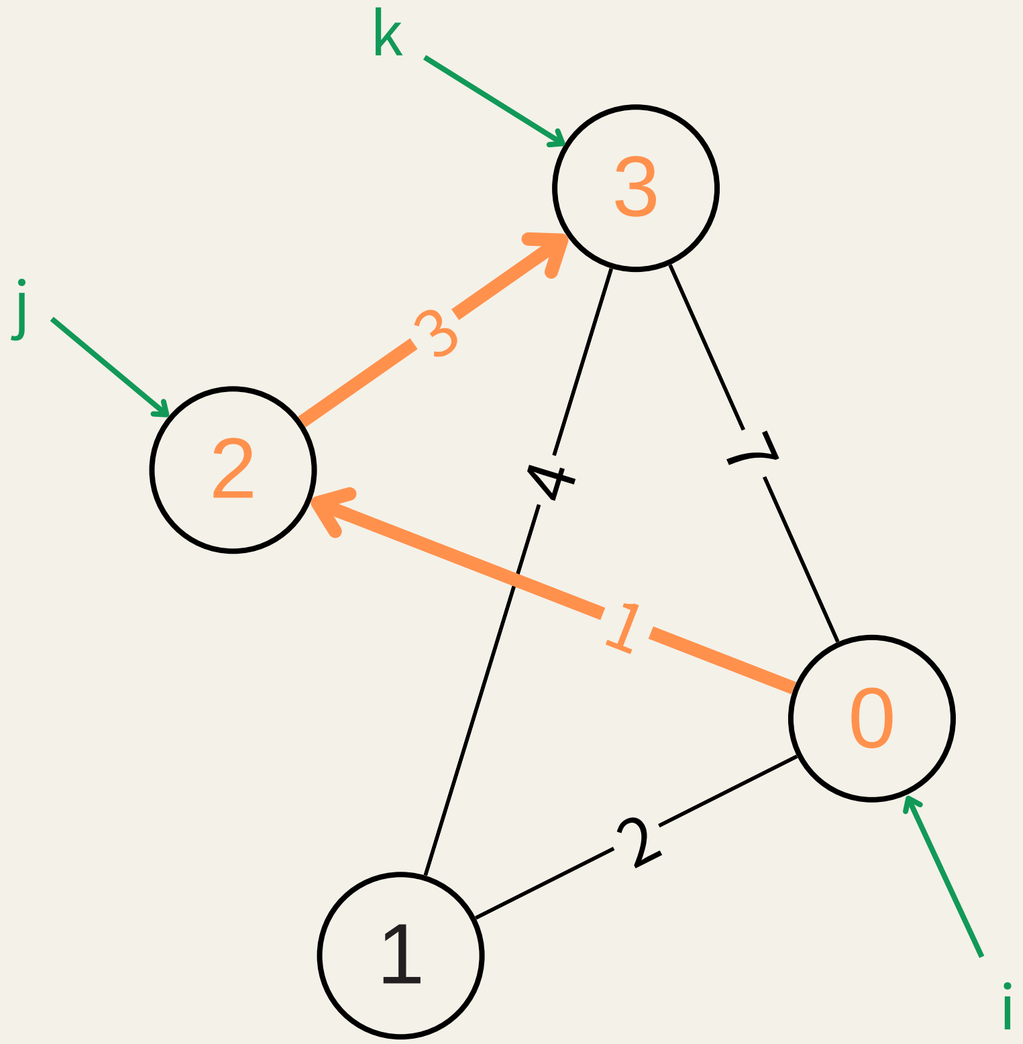
index	0	1	2	3	
dis[ ][ ]	0	2	1	6	0
	2	0	INF	4	1
	1	INF	0	3	2
	6	4	3	0	3



dis[i][j] =
min(dis[i][j], dis[i][k] + dis[k][j])

Floyd-Washall

index	0	1	2	3	
dis[ ][ ]	0	2	1	4	0
	2	0	INF	4	1
	1	INF	0	3	2
	4	4	3	0	3

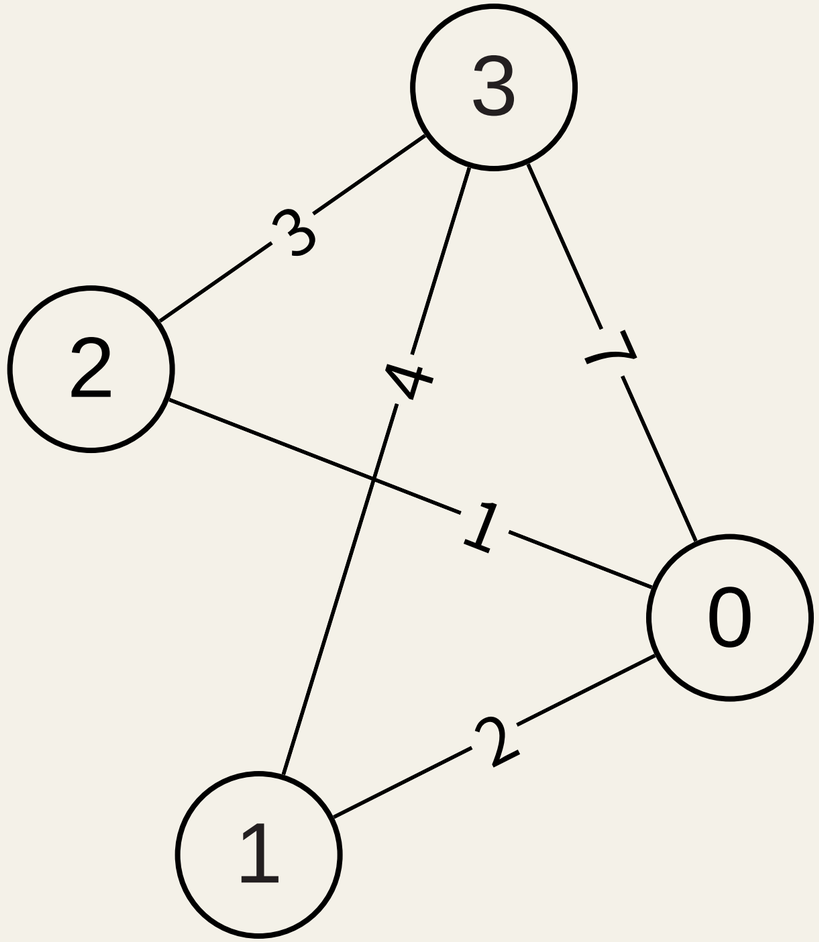


dis[i][j] =

min(dis[i][j], dis[i][k] + dis[k][j])

Floyd-Washall

index	0	1	2	3	
dis[ ][ ]	0	2	1	4	0
	2	0	INF	4	1
	1	INF	0	3	2
	4	4	3	0	3



COMPARISON

	Time Complexity	Shortest Path Type
BFS	$O(V+E)$ or $O(V^2)$	Single Source
DFS	$O(V+E)$ or $O(V^2)$	Single Source
Bellman-Ford	$O(VE)$	Single Source
Dijkstra	$O(E\log_2 E)$	Single Source
Floyd-Warshall	$O(V^3)$	Mutiple Source

	Detect Negative Cycle	Data Structure Used
BFS	Not Avaliable	Queue、Vector / Array
DFS	Not Avaliable	Vector / Array
Bellman-Ford	Avaliable	Vector / Array
Dijkstra	Not Avaliable	PQueue、Vector / Array
Floyd-Warshall	Avaliable	Vector / Array

Implementation

BFS

```
create a queue Q
mark v as visited and put v into Q
while Q is non-empty
    remove the head u of Q
    mark all (unvisited) neighbours of u
    enqueue all (unvisited) neighbours of u
```

DFS

```
DFS(G, u)
    u.visited = true
    for each v ∈ G.Adj[u]
        if v.visited == false
            DFS(G,v)

init() {
    For each u ∈ G
        u.visited = false
     For each u ∈ G
       DFS(G, u)
}
```

Dijkstra

```
function Dijkstra ( Graph, source )

    for each vertex v in Graph.Vertices
        dist[v] ← INFINITY
        prev[v] ← UNDEFINED
        add v to Q
    dist[source] ← 0

    while Q is not empty
        u ← vertex in Q with min dist[u]
        remove u from Q

        for each neighbor v of u still in Q:
            alt ← dist[u] + Graph.Edges(u, v)
            if alt < dist[v]:
                dist[v] ← alt
                prev[v] ← u

    return dist[], prev[]
```

Bellman-Ford

```
function bellmanFord(G, S)
   for each vertex V in G
      distance[V] <- infinite
      previous[V] <- NULL
   distance[S] <- 0

   for each vertex V in G
      for each edge (U,V) in G
         tempDistance <- distance[U] + edge_weight(U, V)
         if tempDistance < distance[V]
            distance[V] <- tempDistance
            previous[V] <- U

   for each edge (U,V) in G
      if distance[U] + edge_weight(U, V) < distance[V]
         Error: Negative Cycle Exists

   return distance[], previous[]
```

Floyd-Warshall

```
n = no of vertices
A = matrix of dimension n*n
for k = 1 to n
    for i = 1 to n
        for j = 1 to n
            A[i, j] = min (A[i, j], A[i, k] + A[k, j])
return A
```


Thank You
For Tunning In