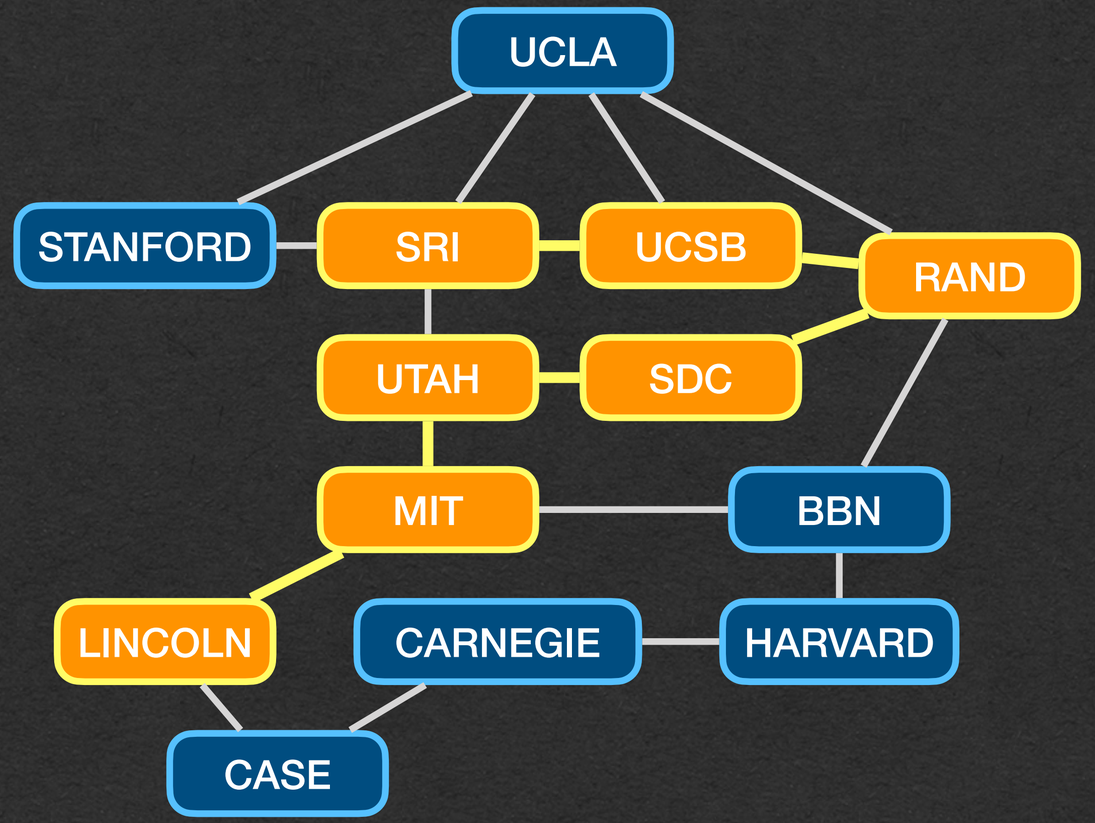
Pathfinding with BFS

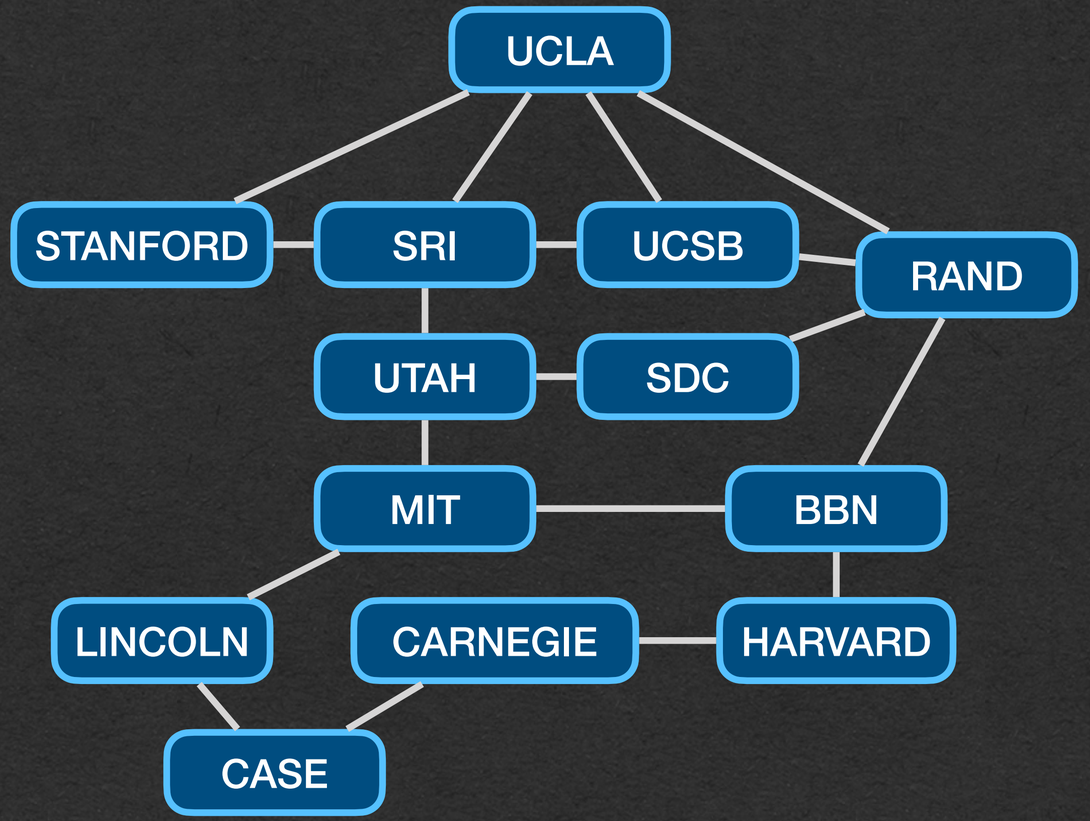
Paths

- Path: A sequence of nodes with each adjacent pair of nodes connected by an edge
- The length of a path is the number of edges it contains (number of nodes - 1)
- [LINCOLN, MIT, UTAH, SDC, RAND, UCSB, SRI] <-- Path of length 6



Distance

- Distance between two nodes: The length of a shortest path between the nodes
- Distance between LINCOLN and SRI == 3
- Distance between RAND and BBN == 1

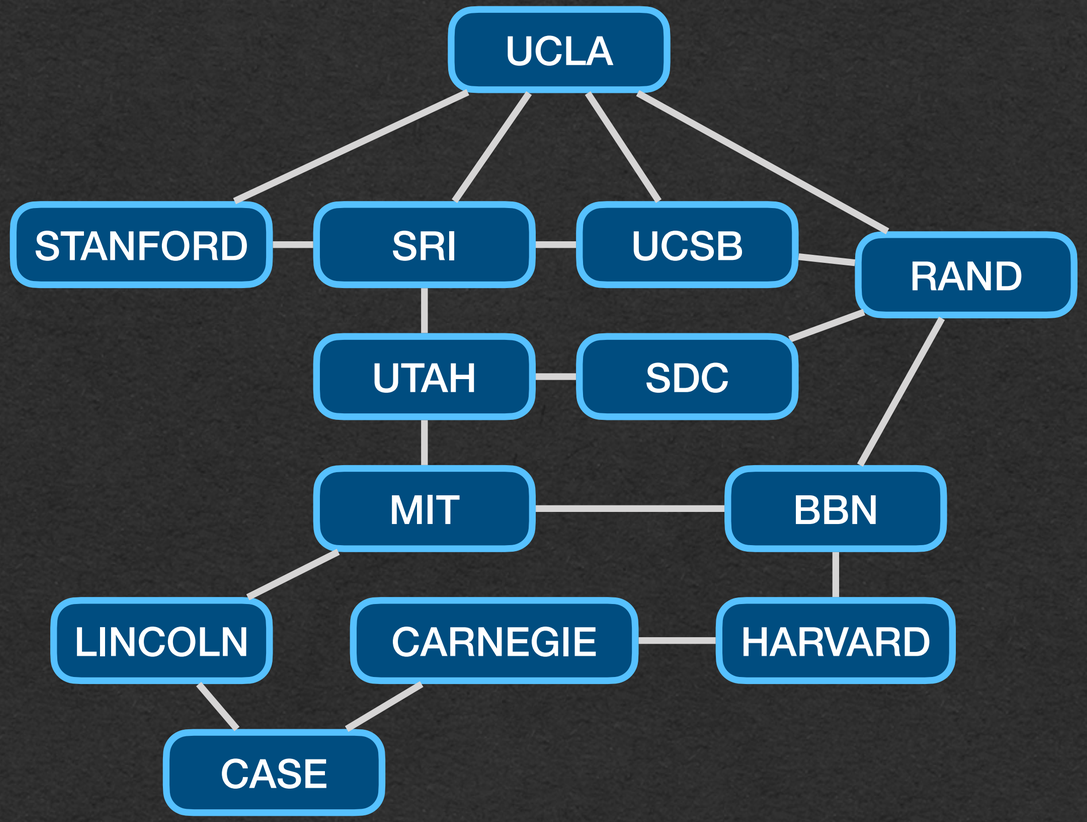


Use BFS to find the distance between nodes

Track the shortest path for pathfinding

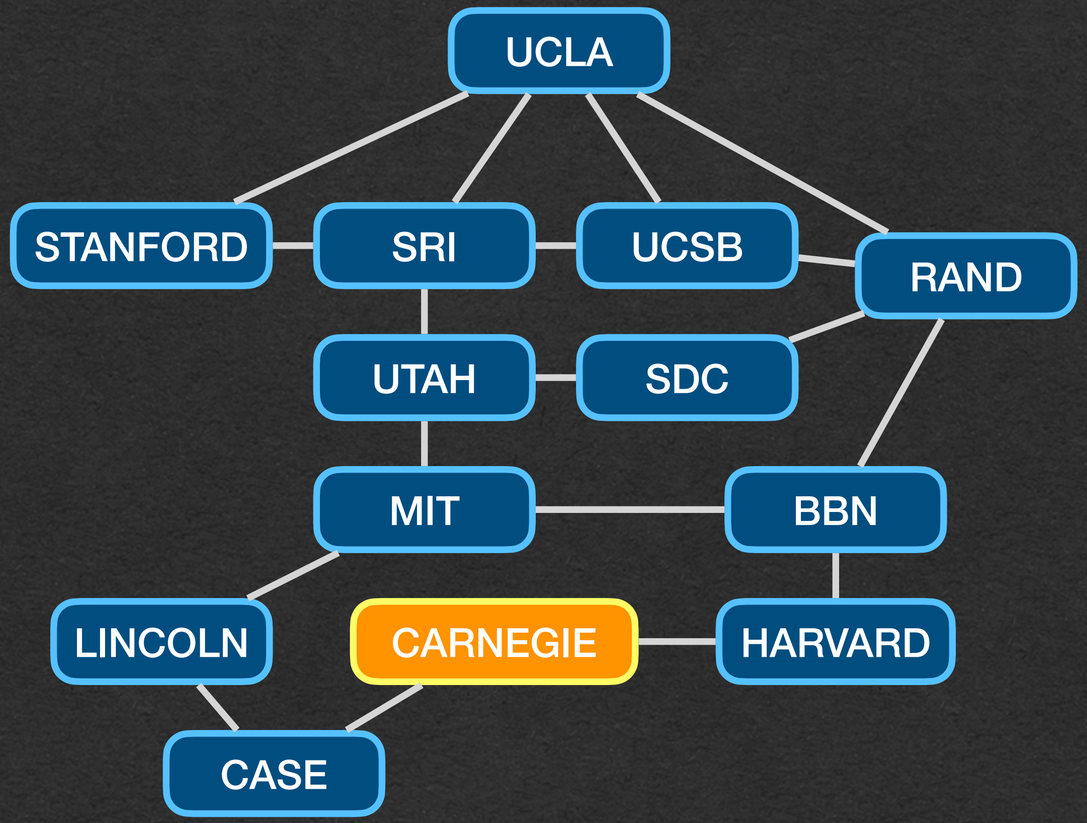
There's Levels to This

- Let's run through BFS again
  - Instead of just finding the connected component, let's track the paths taken to explore each node



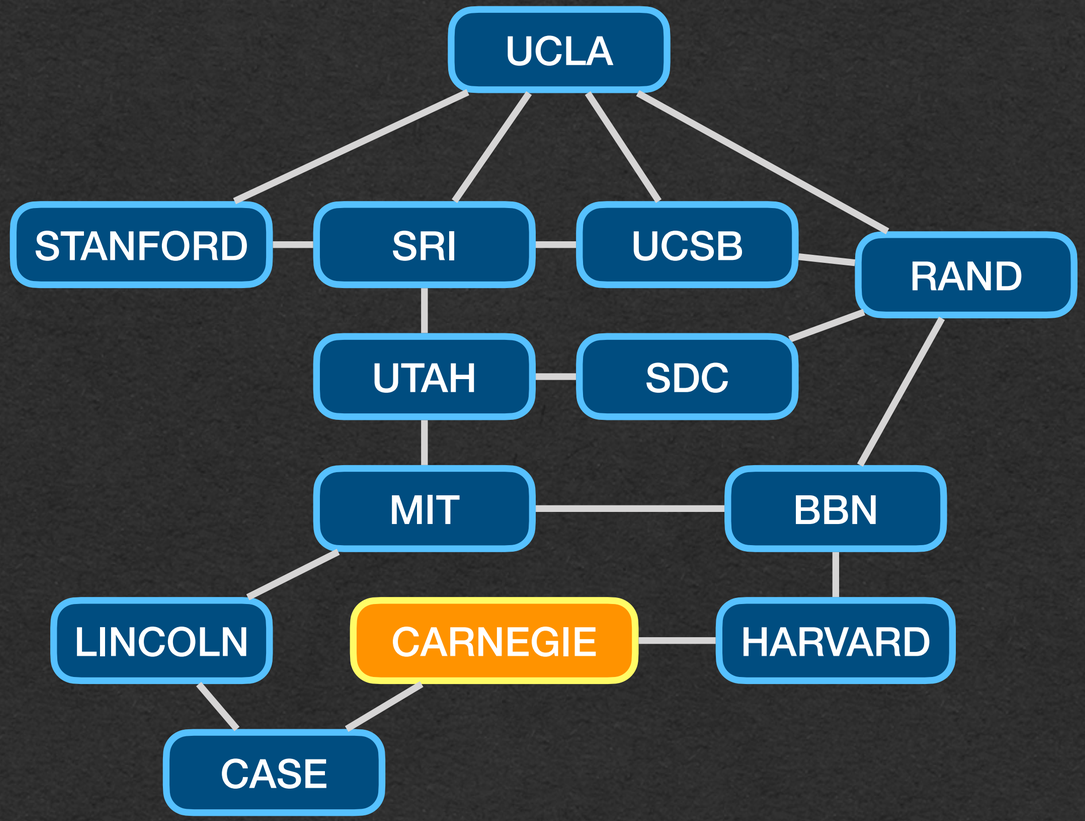
There's Levels to This

- Let's start at CARNEGIE this time



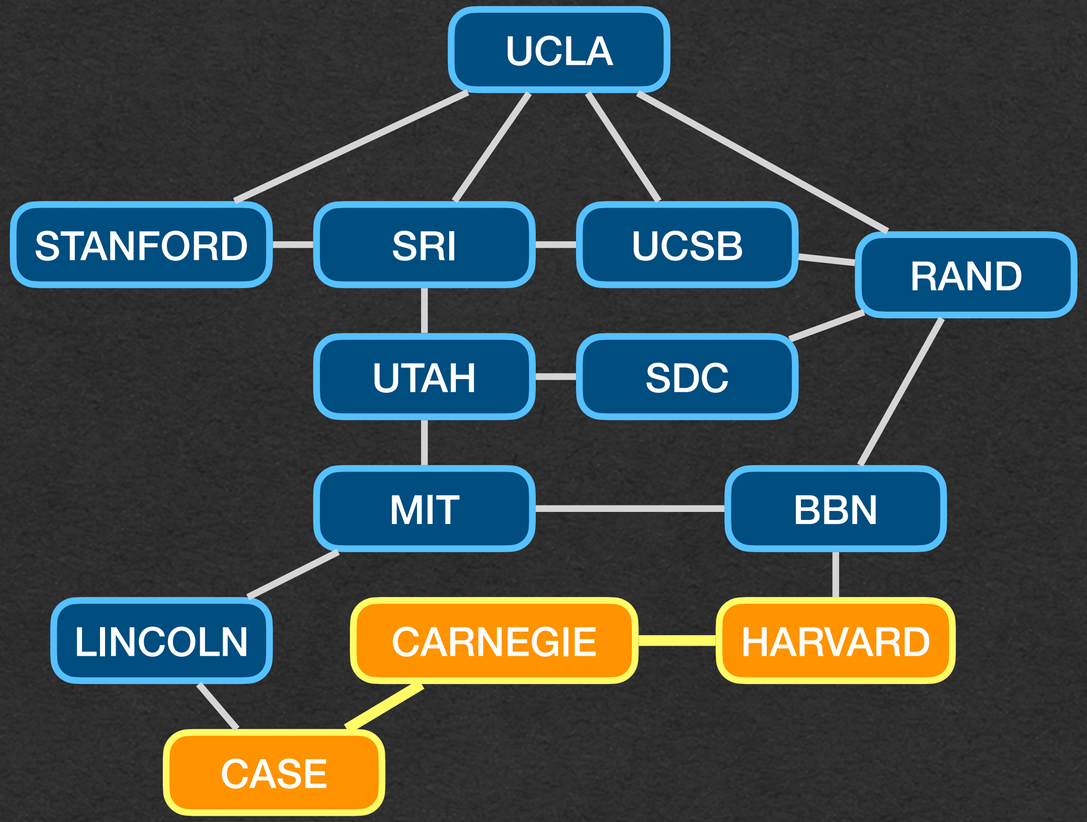
There's Levels to This

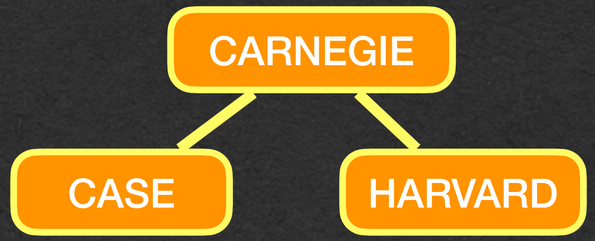
- Keep track of all edges used to explore new nodes
- Redraw the graph with only these edges



There's Levels to This

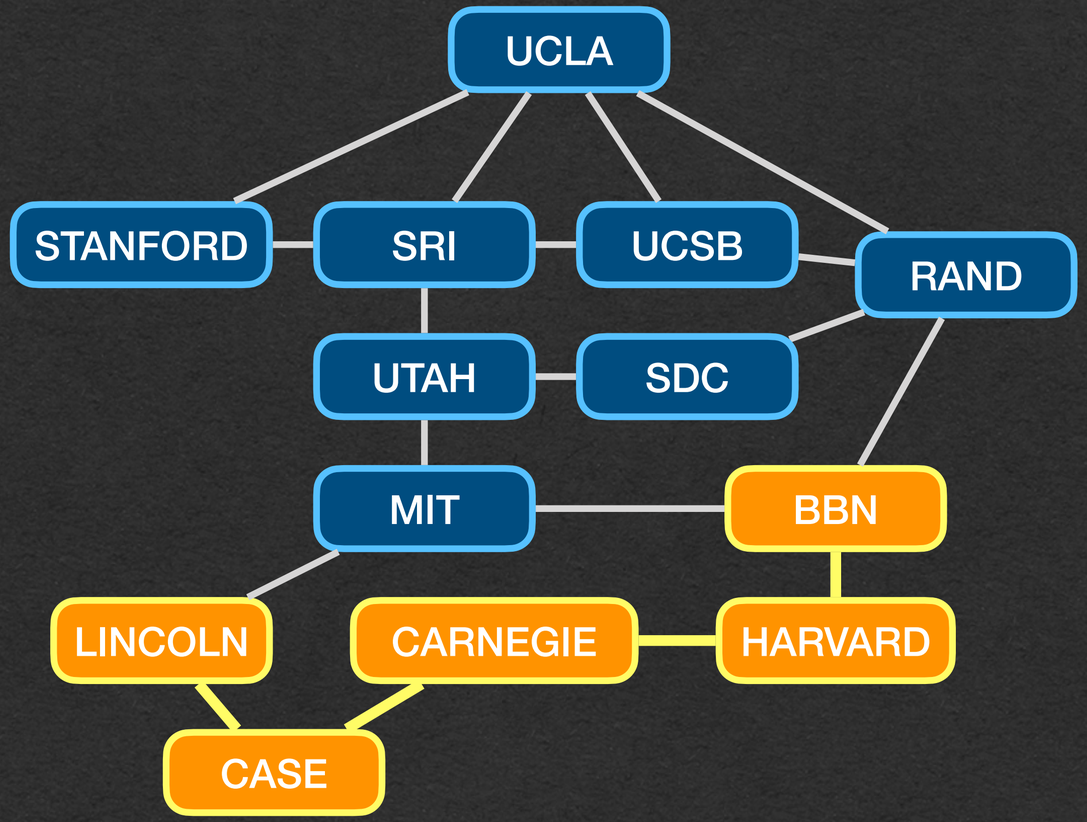
- Explore all neighbors of the starting node

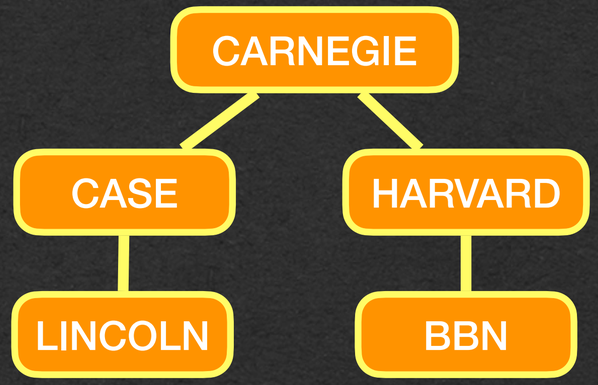




There's Levels to This

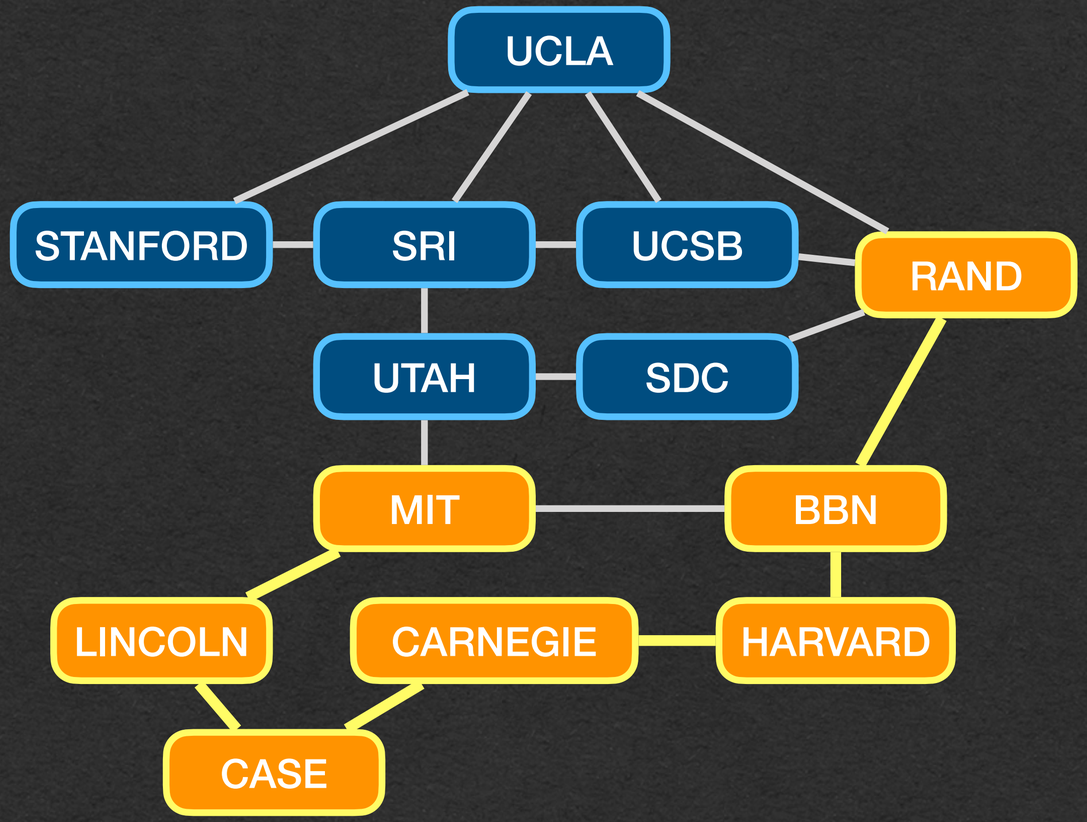
- Explore all neighbors of the nodes explored in the last step

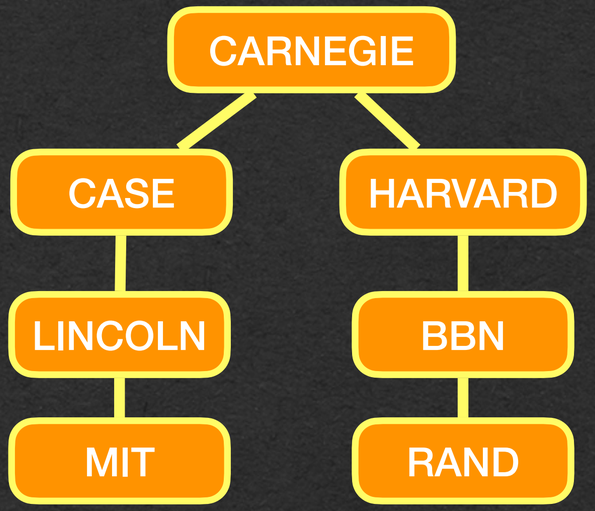




There's Levels to This

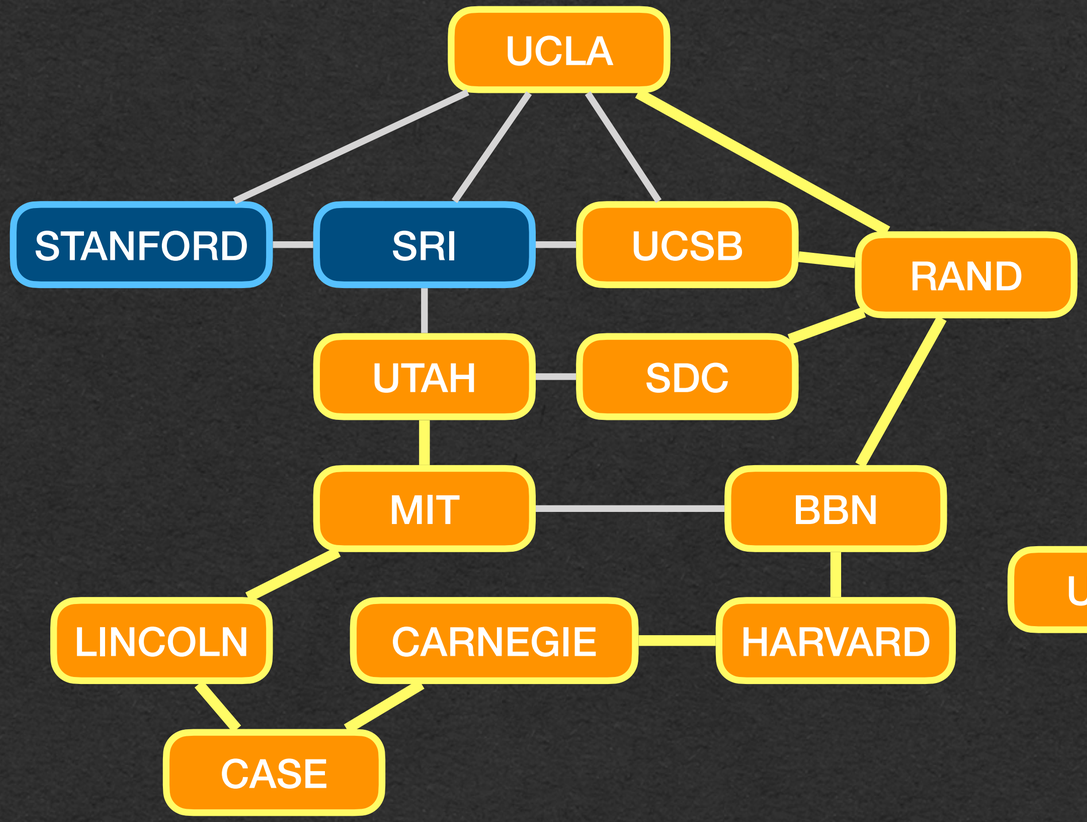
- Repeat
- Choose edge to use for MIT arbitrarily

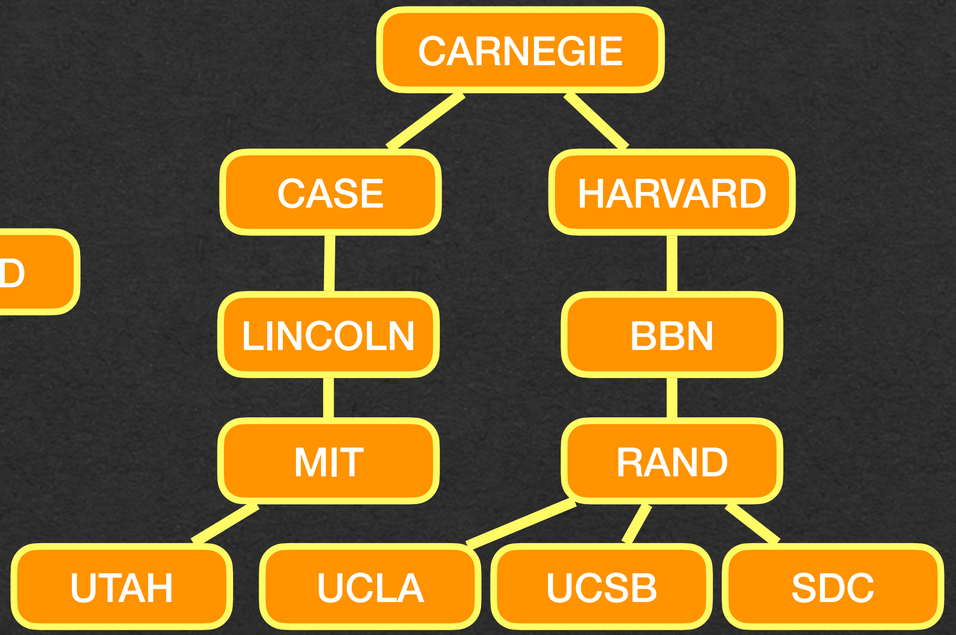




There's Levels to This

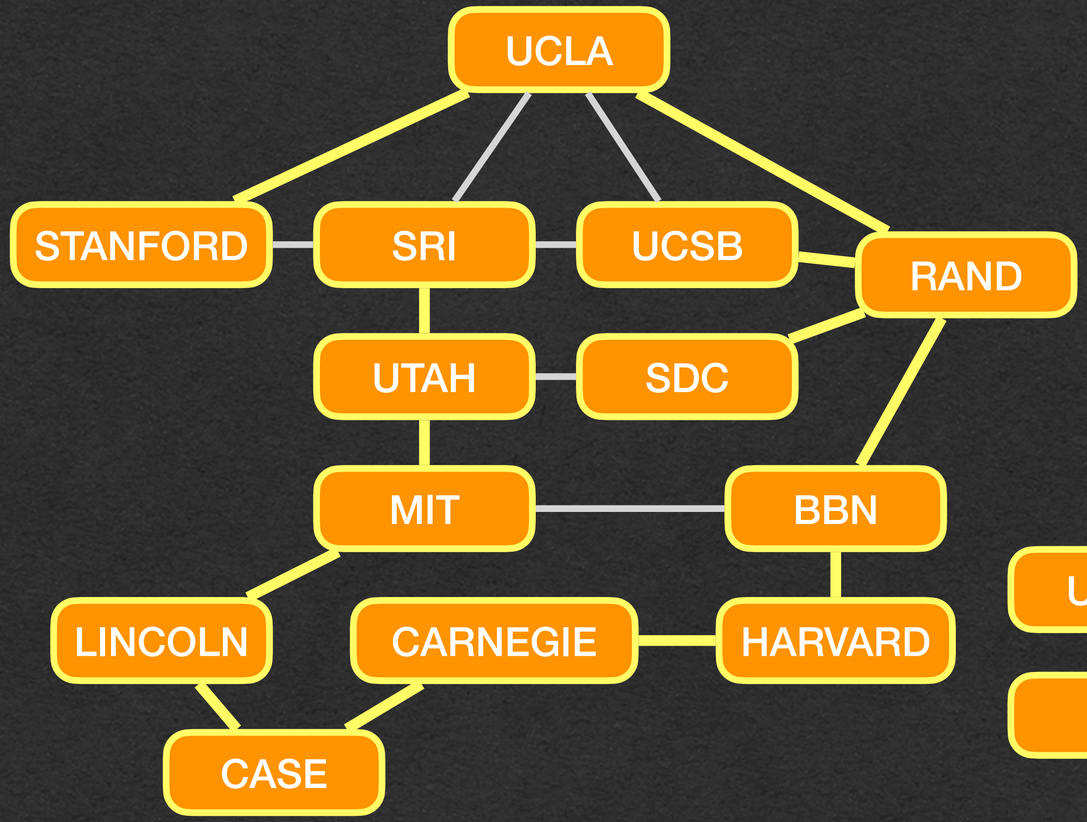
- Each step we explore all nodes that can be reached from the nodes added in the previous step

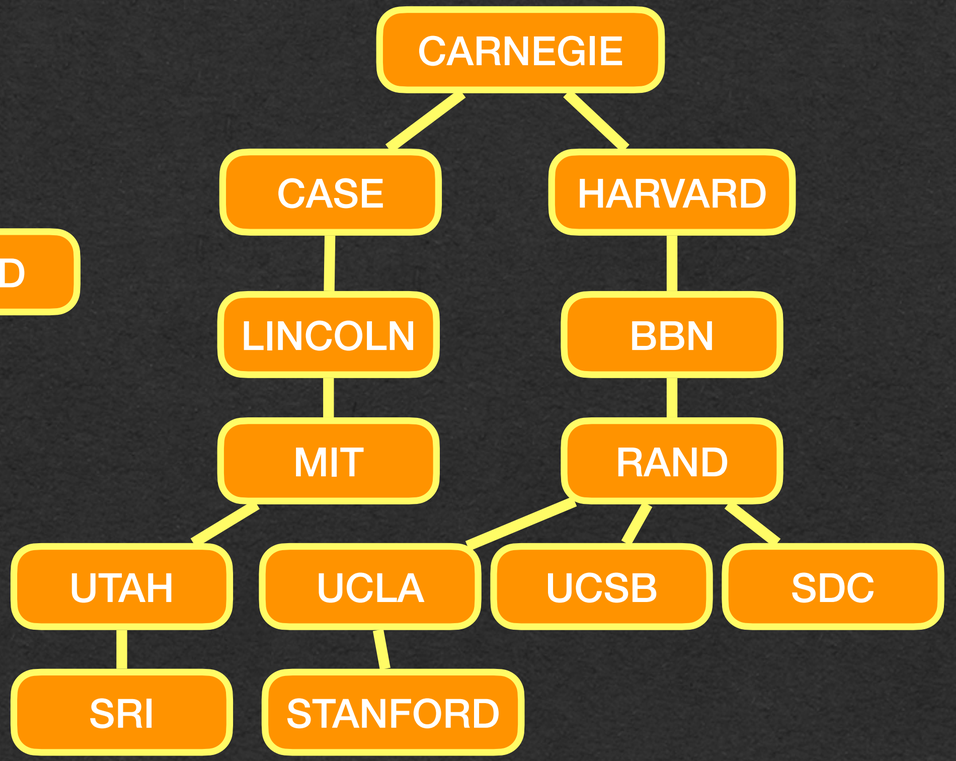




There's Levels to This

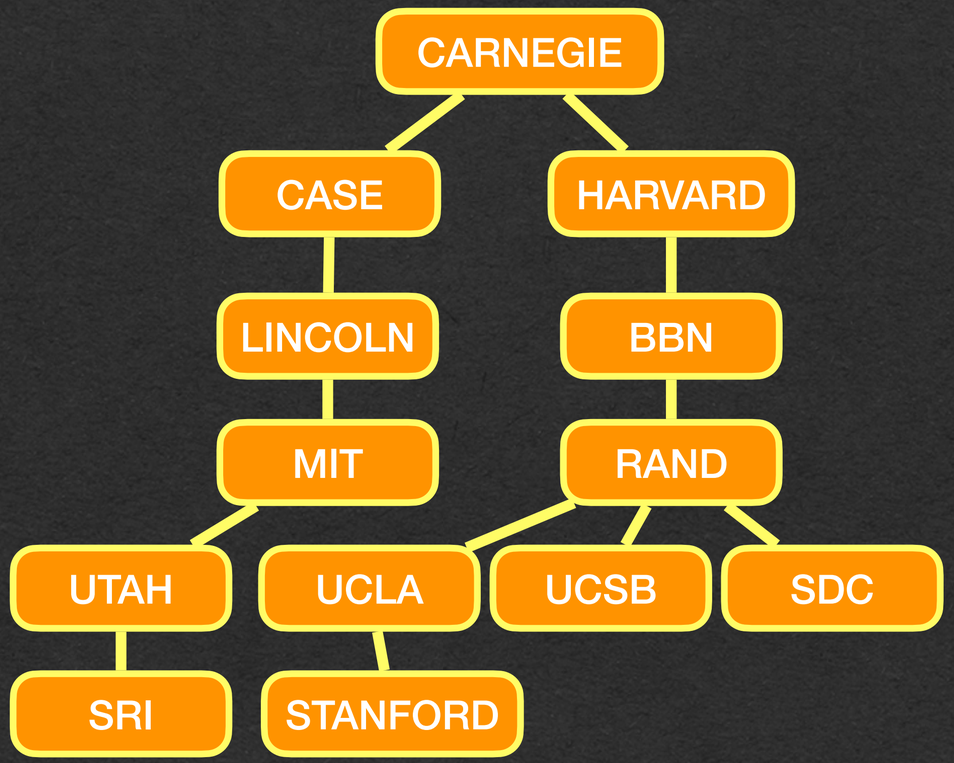
- Each step we explore all nodes that can be reached from the nodes added in the previous step





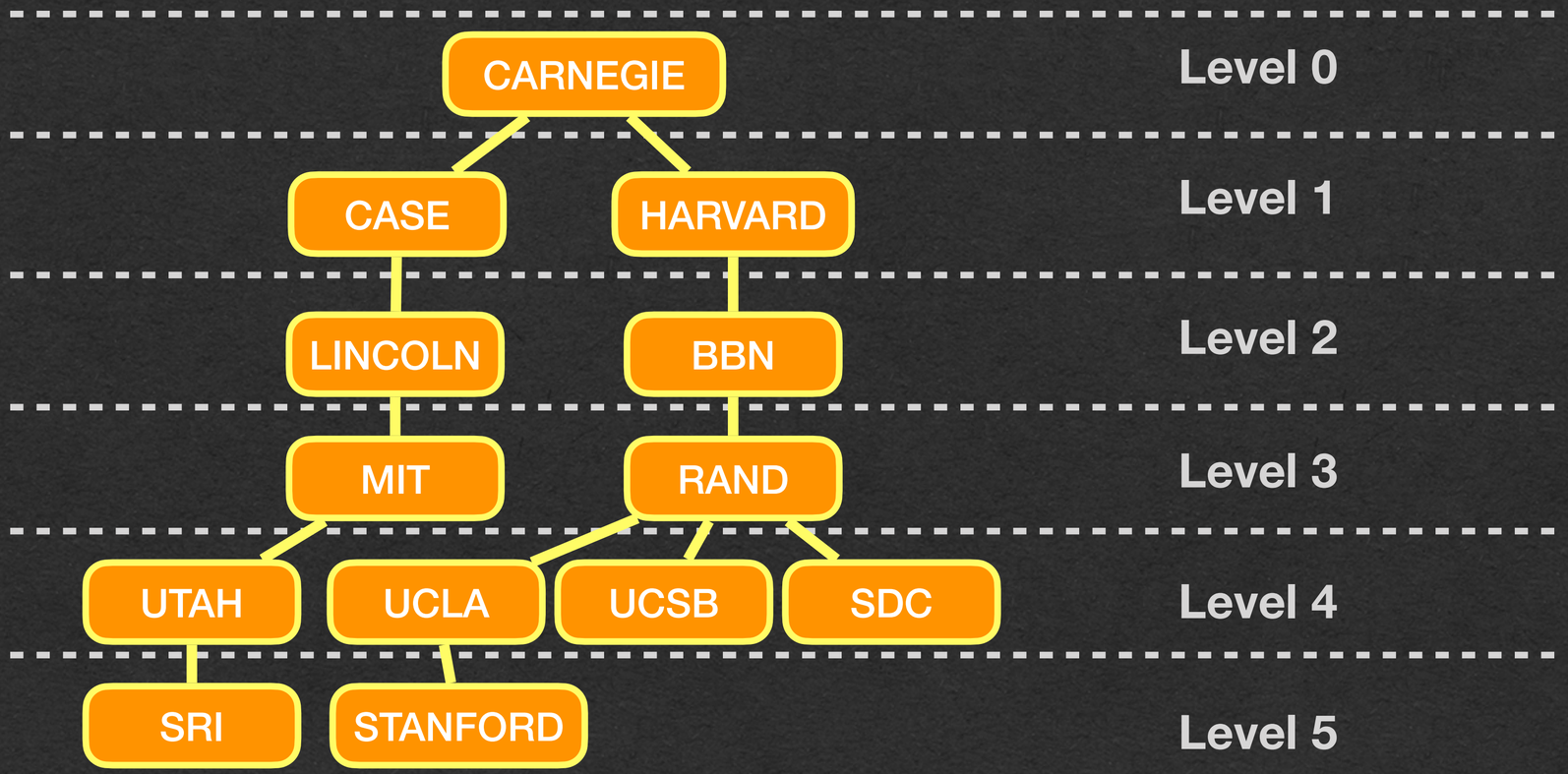
There's Levels to This

- We have a new graph with a few edges removed
- This graph is a tree (no cycles)



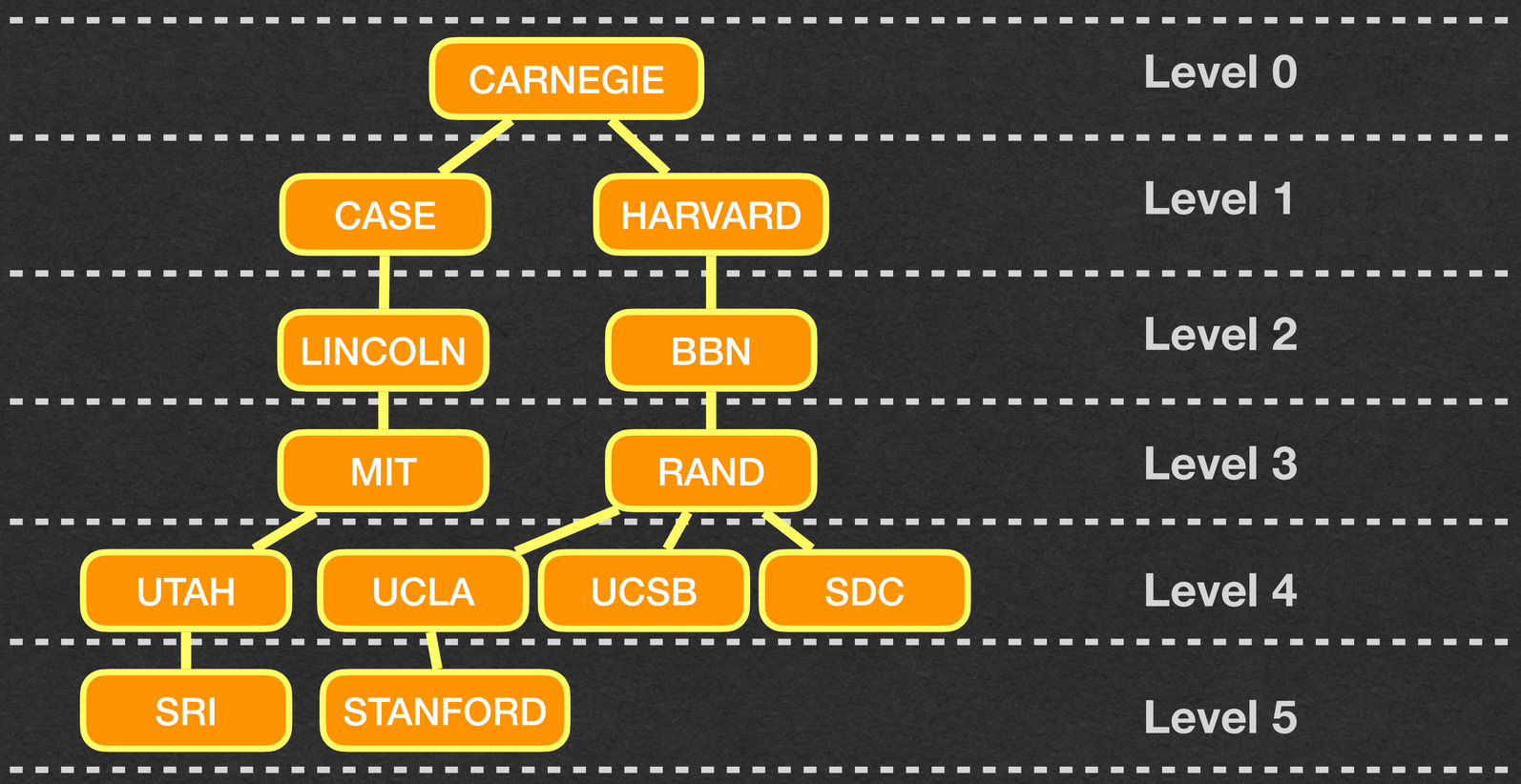
There's Levels to This

- And it has levels!



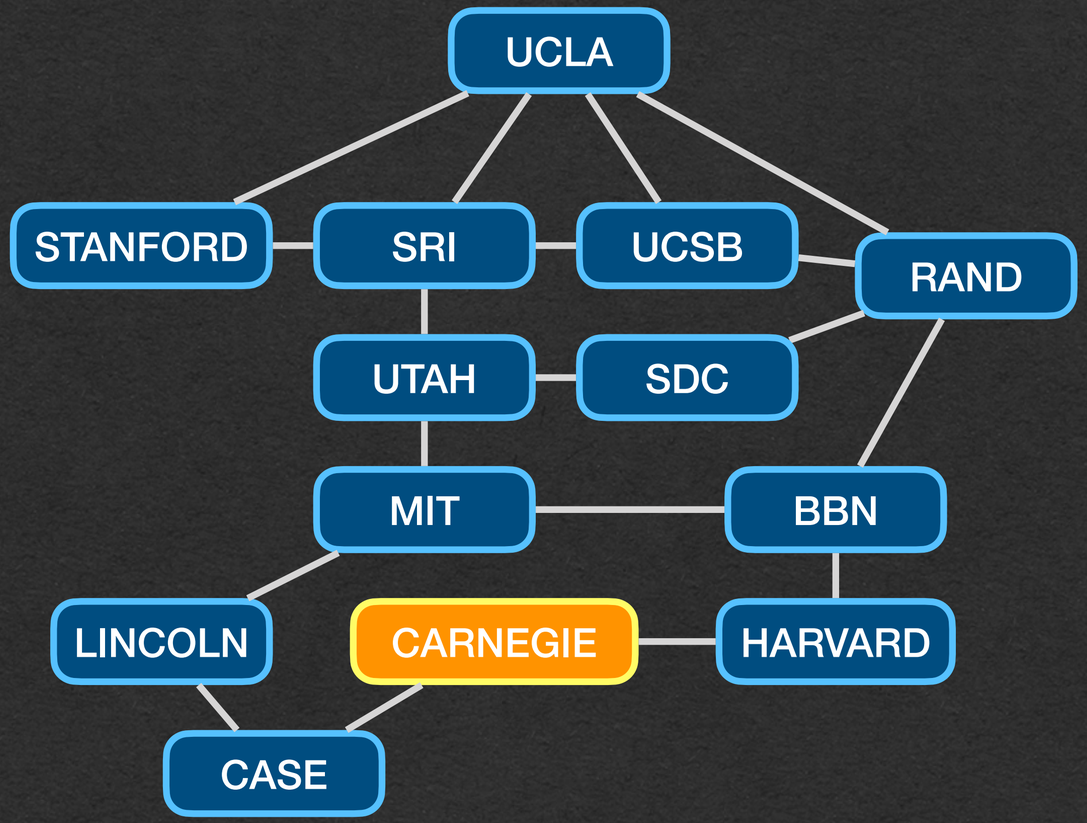
There's Levels to This

- Number the levels starting with 0
- The level number == the distance from the starting node to any node in that level



BFS and Distance

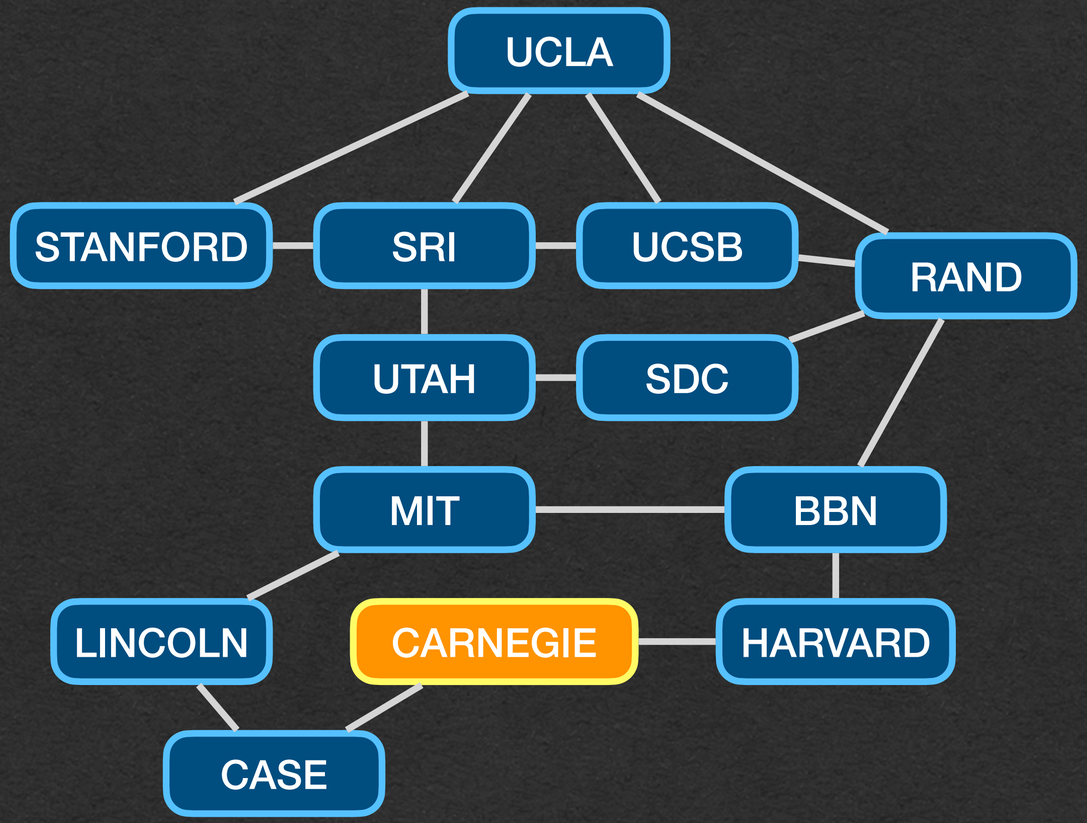
- But how do we track the levels?
- Track levels in a data structure



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	∞
CASE	∞

- To find distance in your code
  - You can use 3 data structures

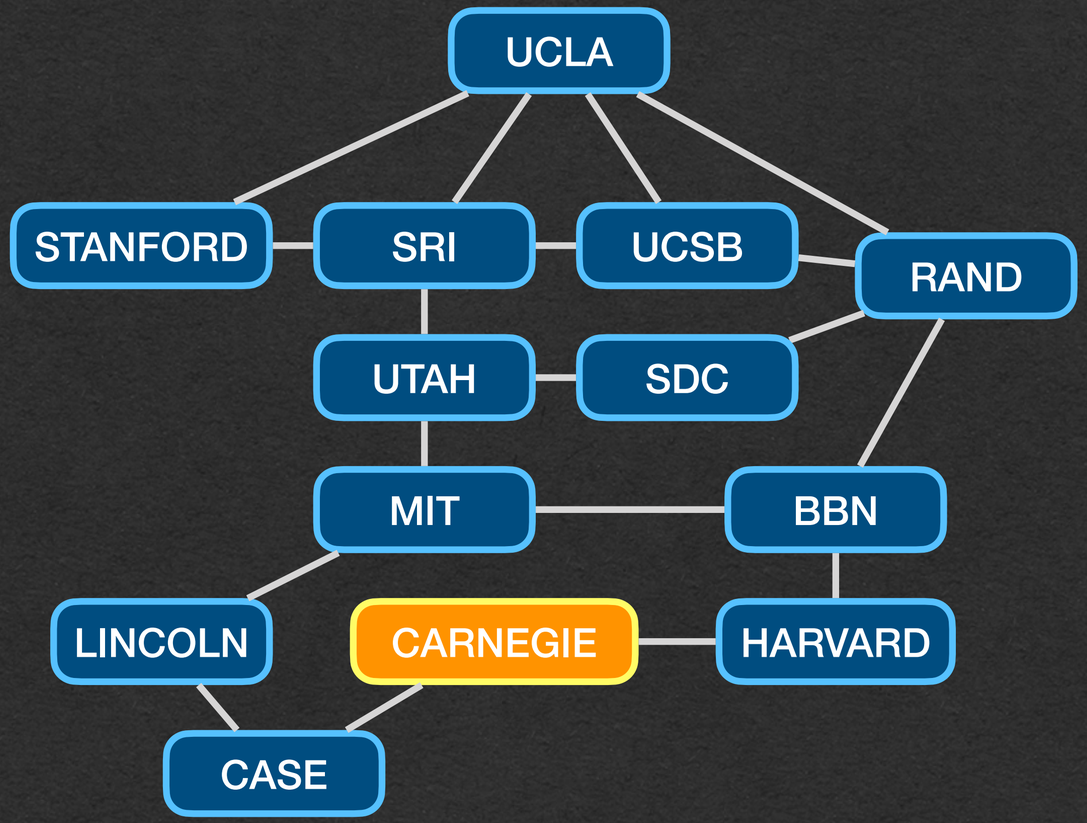
CARNEGIE



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	∞
CASE	∞

- A Queue
  - Track the nodes that need to be visited

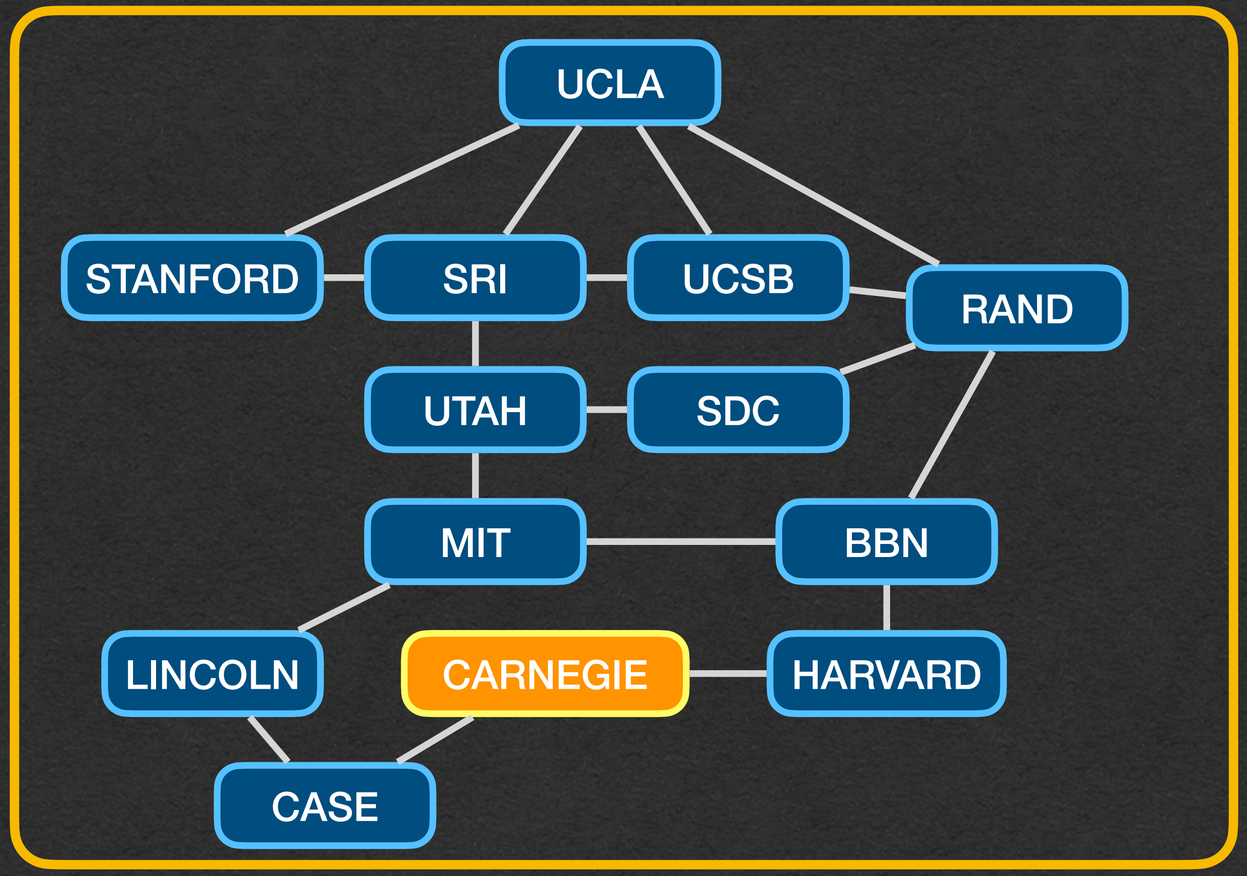
CARNEGIE



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	∞
CASE	∞

- A List/Array/Set/Tree
  - Track the nodes have already been explored

CARNEGIE



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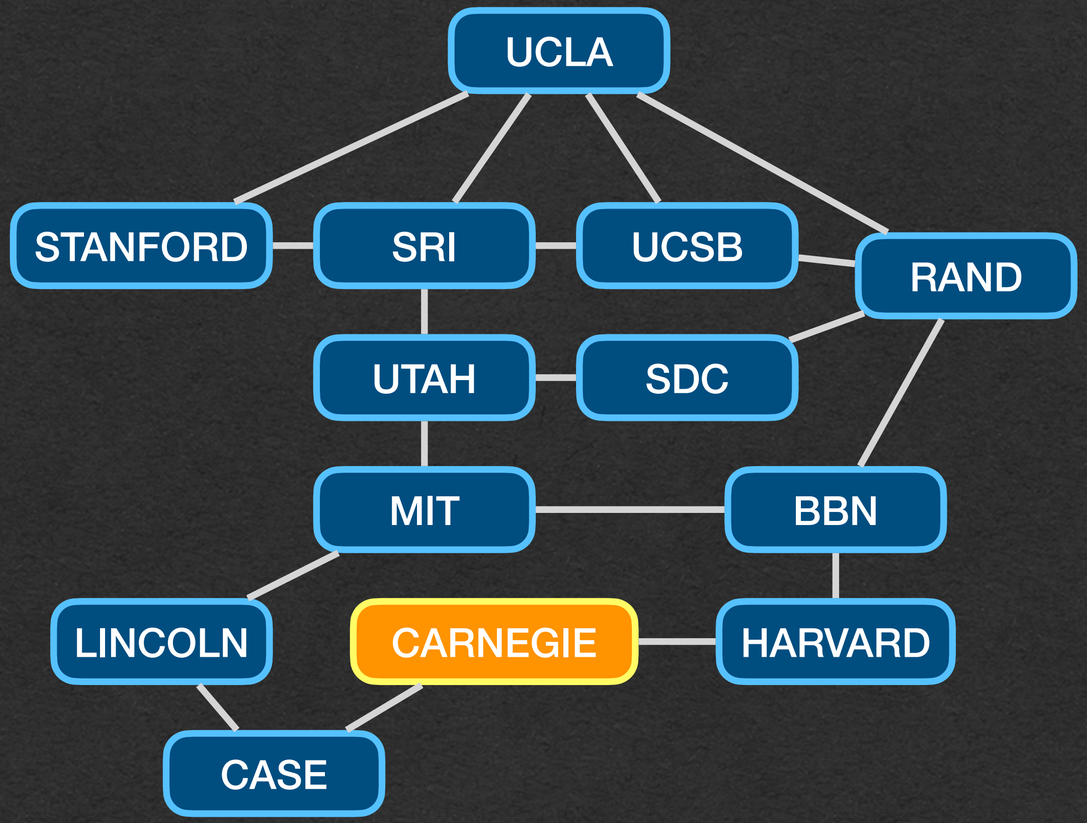
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	∞
CASE	∞

- A Map
  - Store the distances/levels for every node

CARNEGIE



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	∞
CASE	∞

- To write your code
  - Create and update these data structures as you explore the graph

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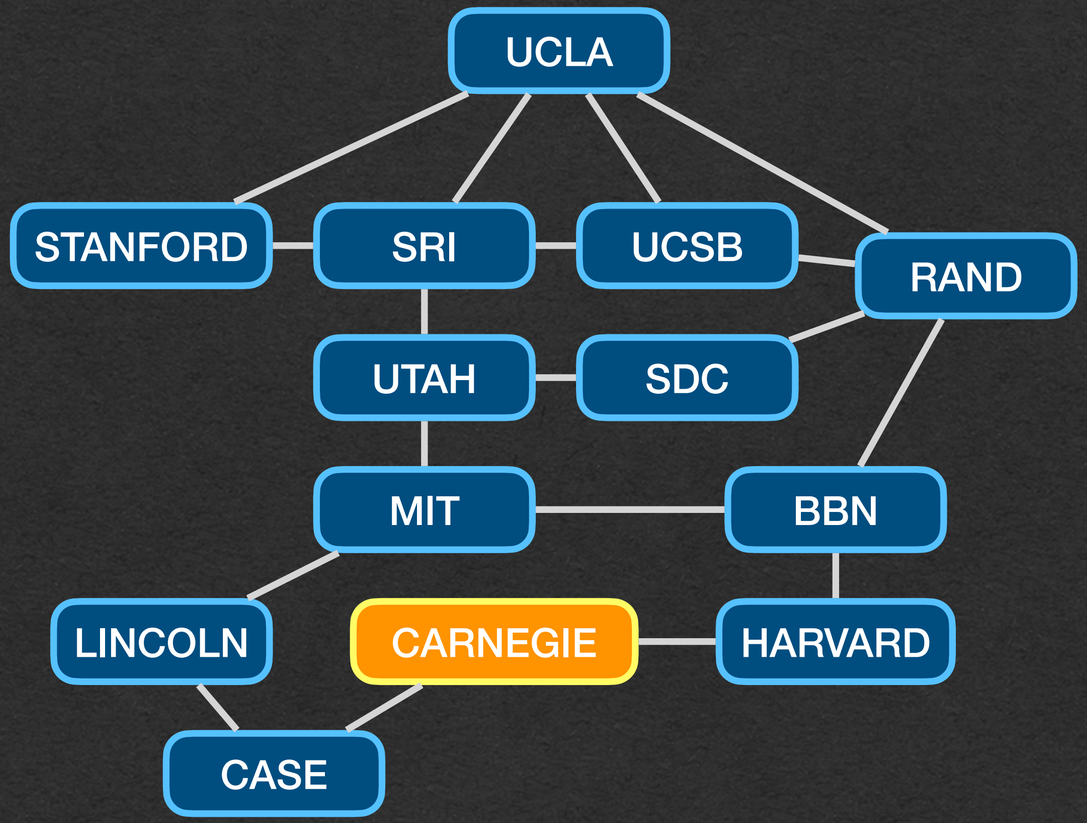
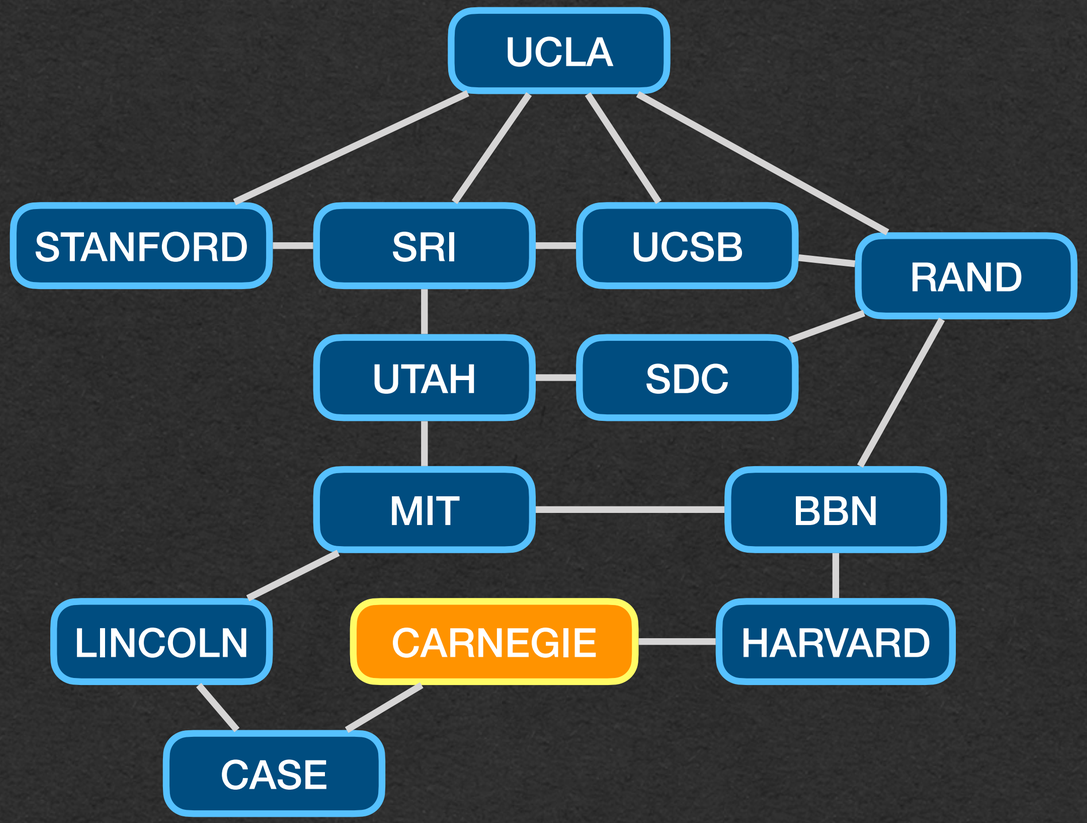
CARNEGIE



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	∞
CASE	∞

BFS and Distance

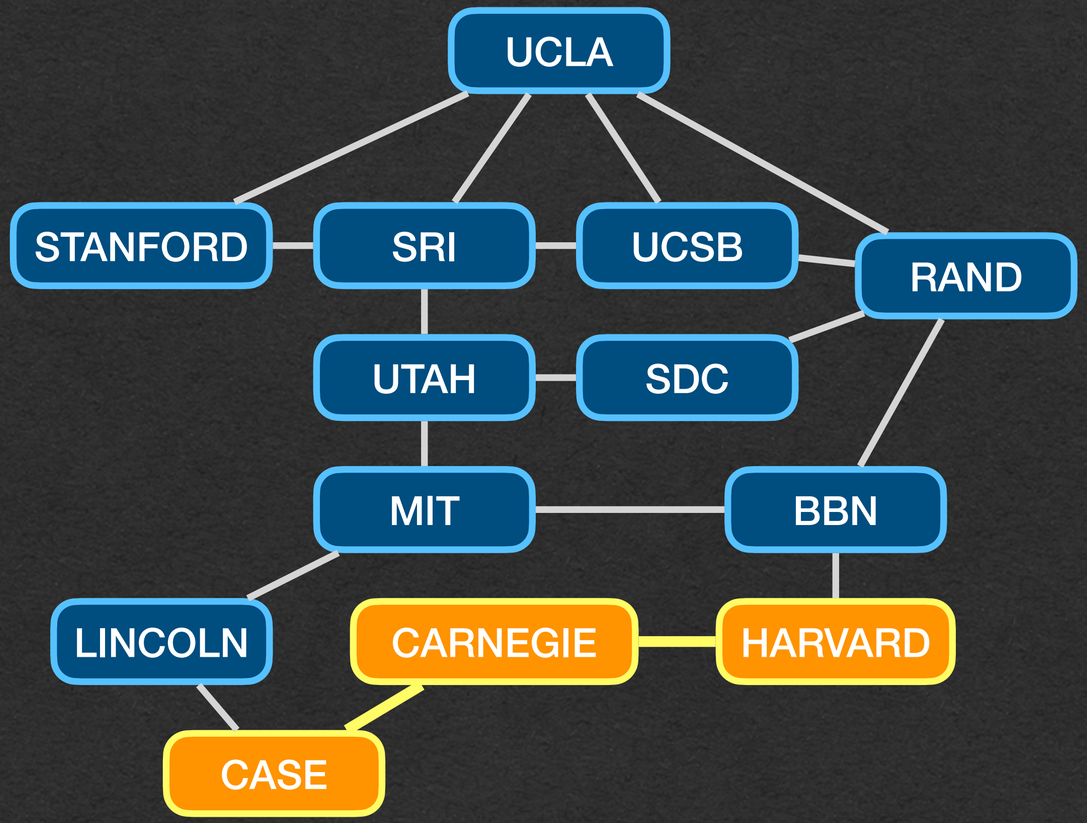
CARNEGIE



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	∞
CASE	∞

BFS and Distance

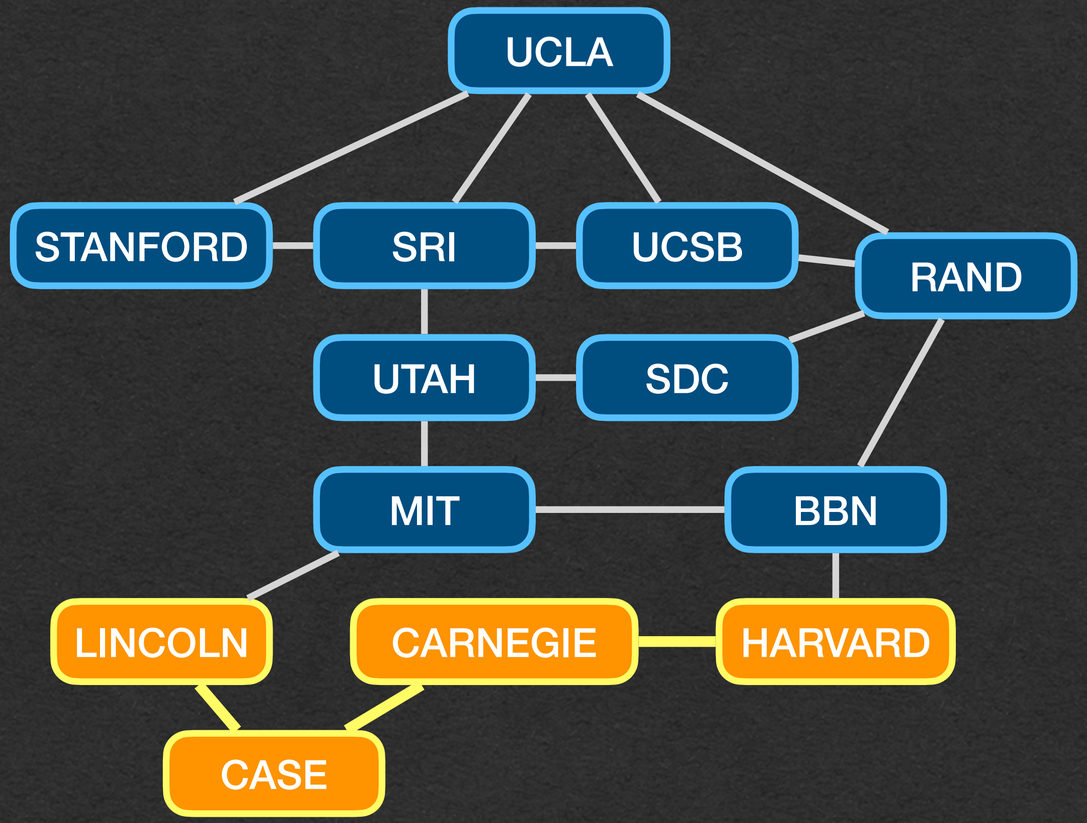
CASE | HARVARD



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

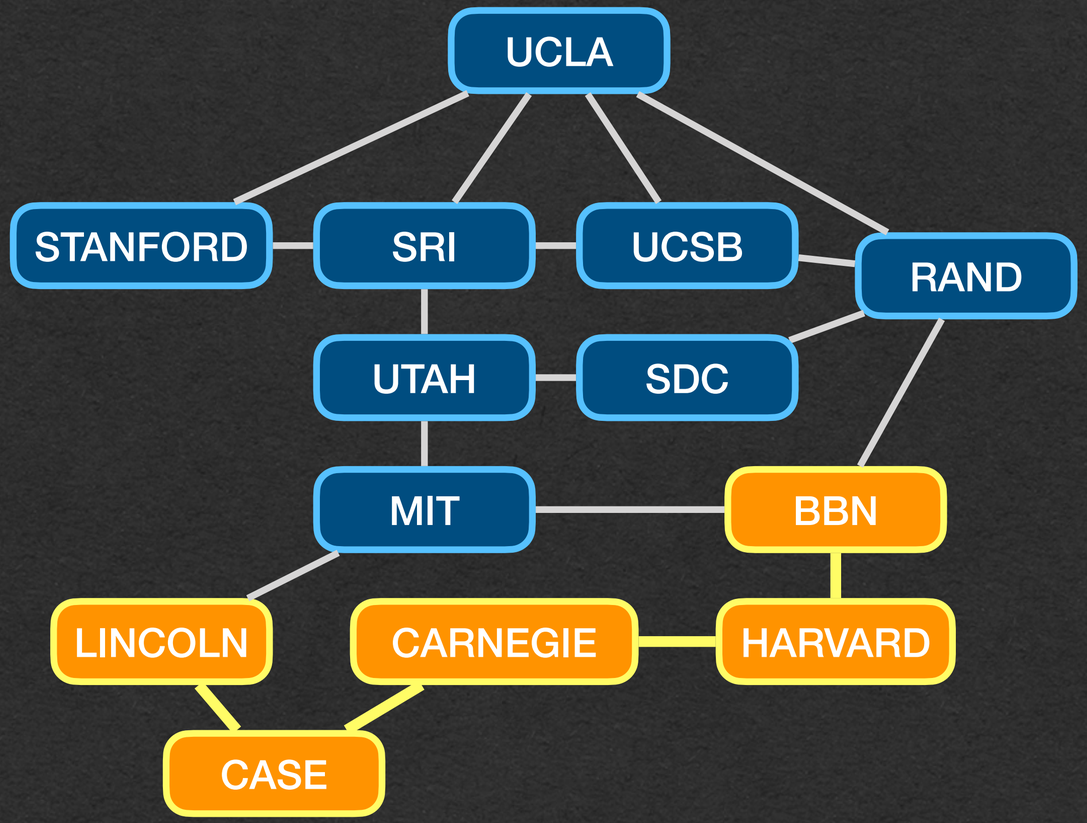
HARVARD | LINCOLN



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

LINCOLN | BBN



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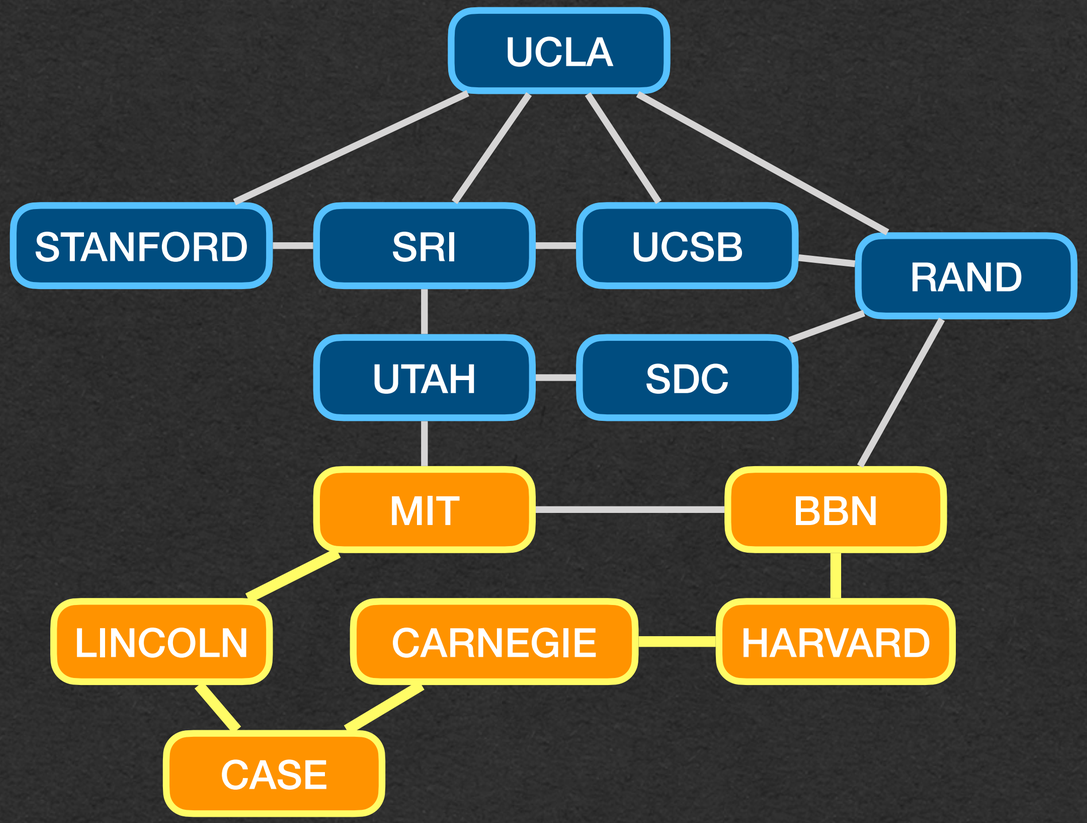
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

BBN MIT



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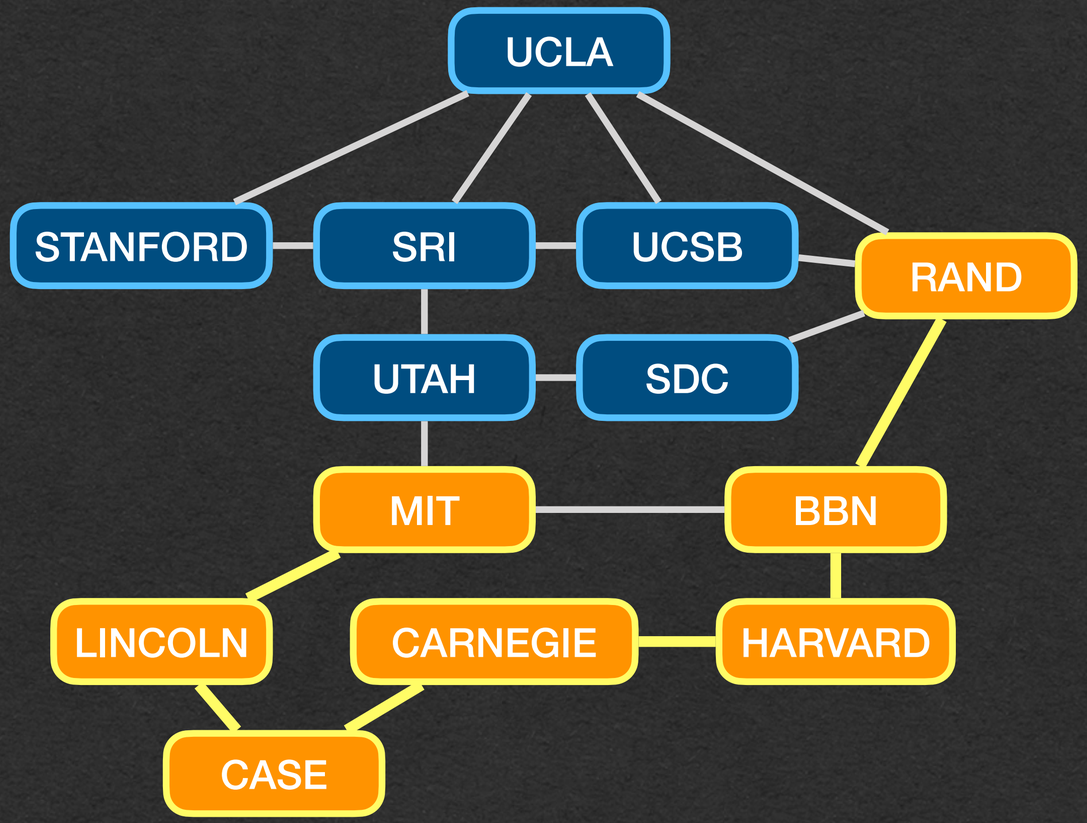
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

MIT RAND



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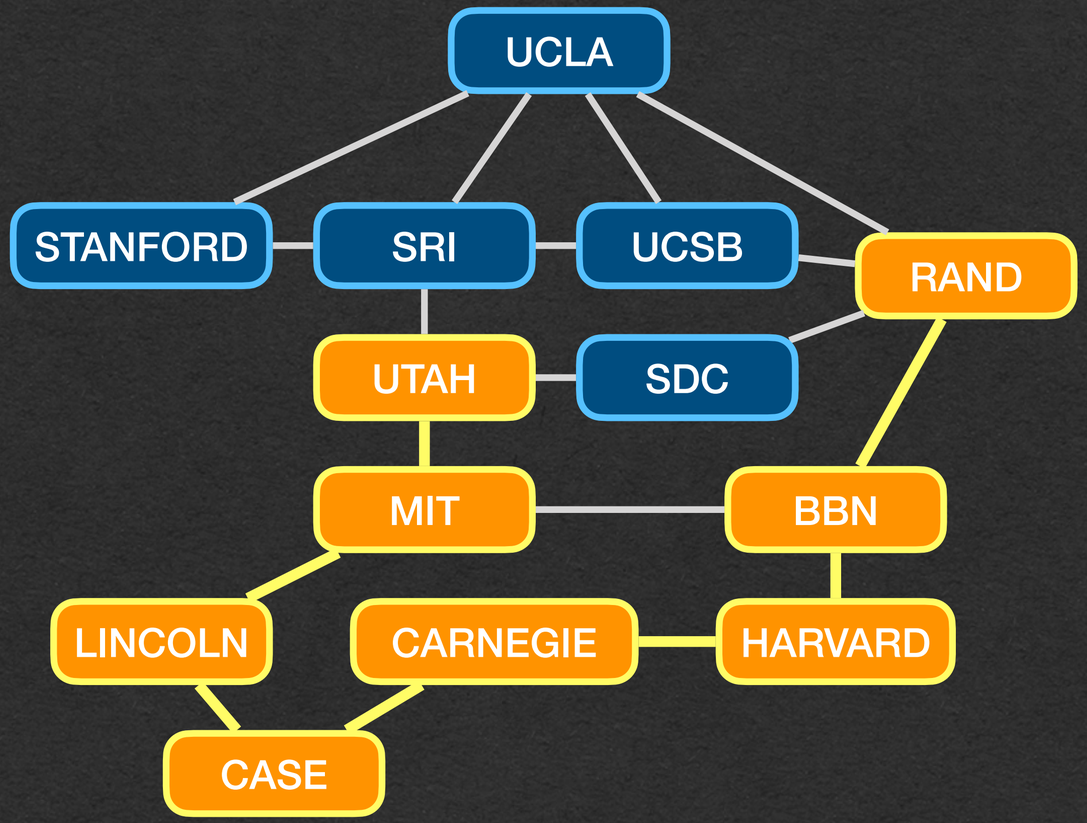
STANFORD	∞
SRI	∞
UCSB	∞
RAND	3
UTAH	∞
SDC	∞
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

RAND | UTAH



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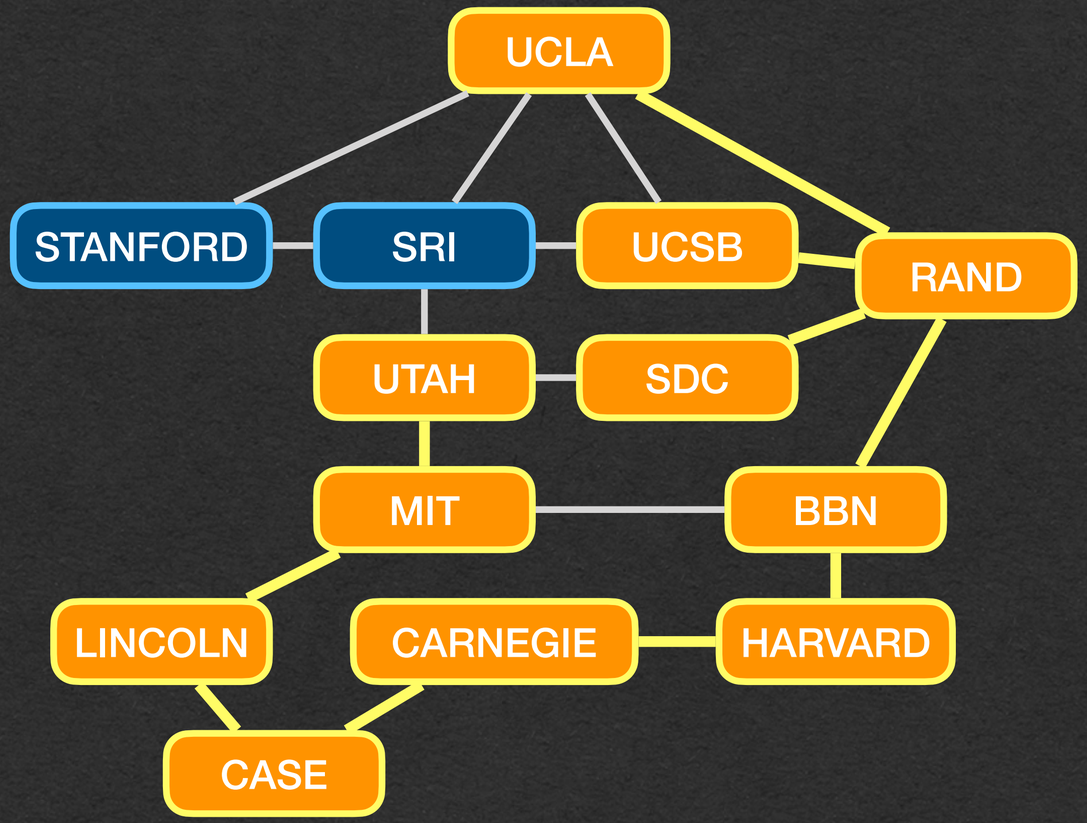
STANFORD	∞
SRI	∞
UCSB	∞
RAND	3
UTAH	4
SDC	∞
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

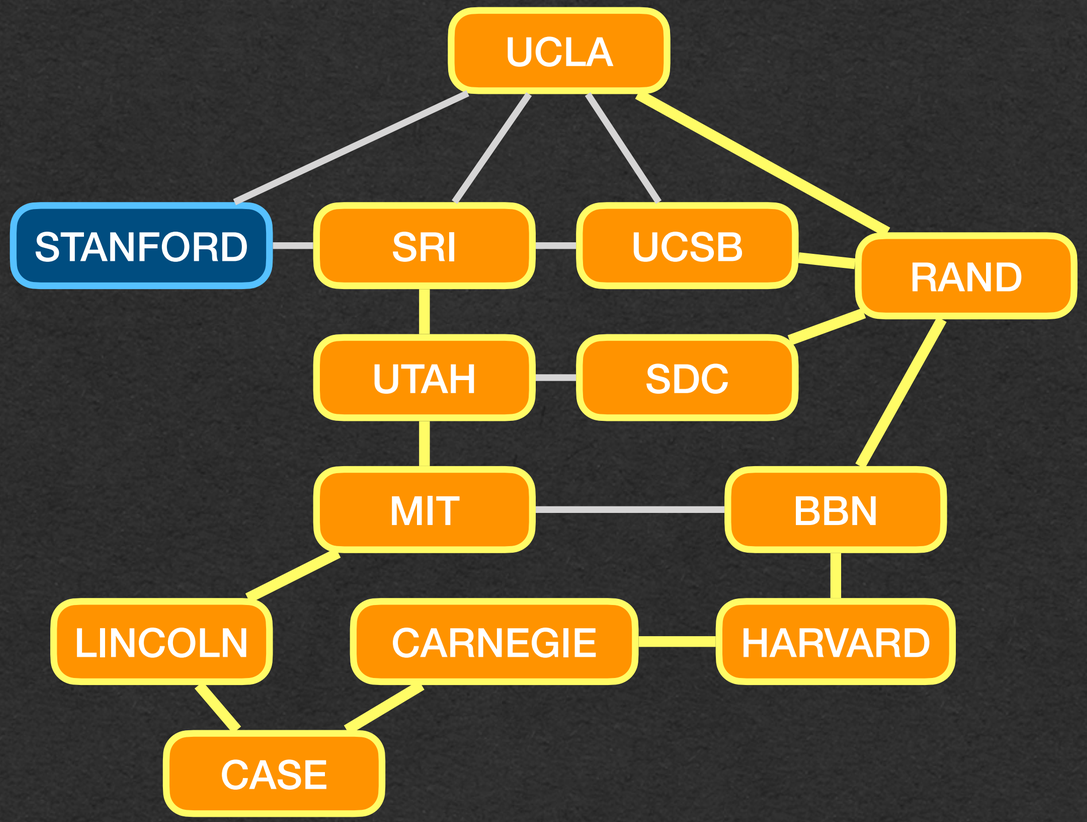
BFS and Distance

UTAH | UCLA | UCSB | SDC



UCLA	4
STANFORD	∞
SRI	∞
UCSB	4
RAND	3
UTAH	4
SDC	4
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

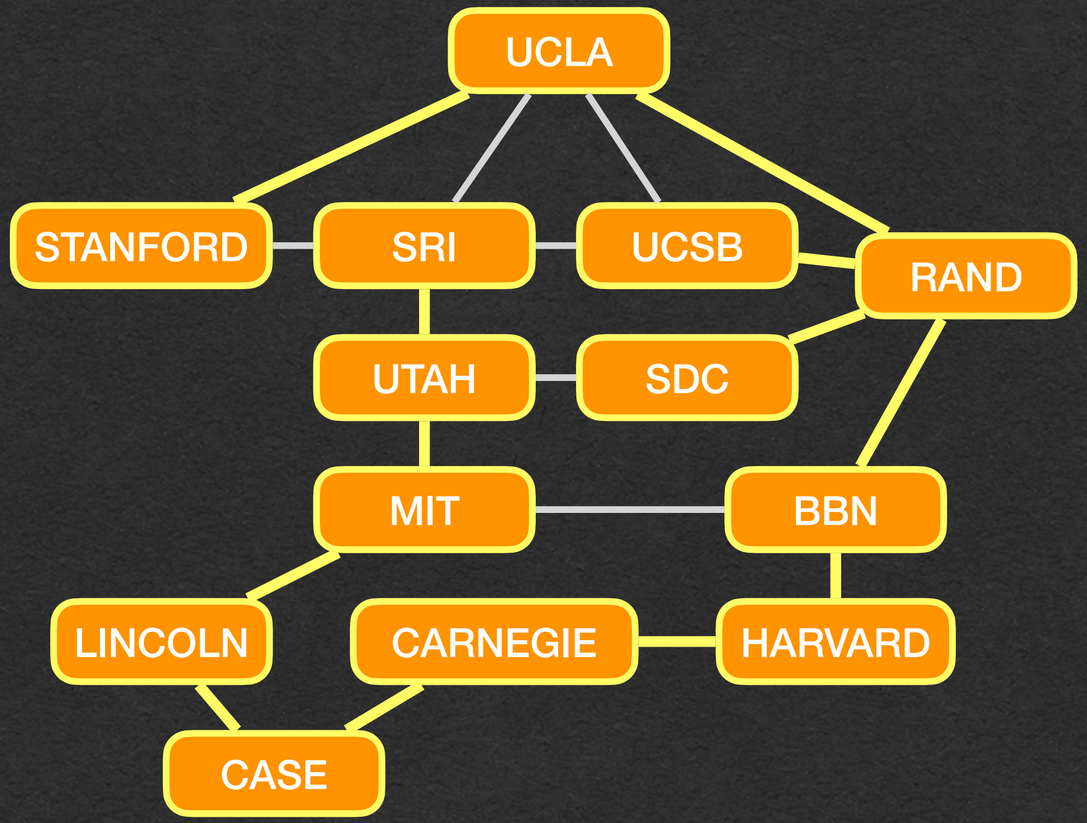
BFS and Distance



UCLA	4
STANFORD	∞
SRI	5
UCSB	4
RAND	3
UTAH	4
SDC	4
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

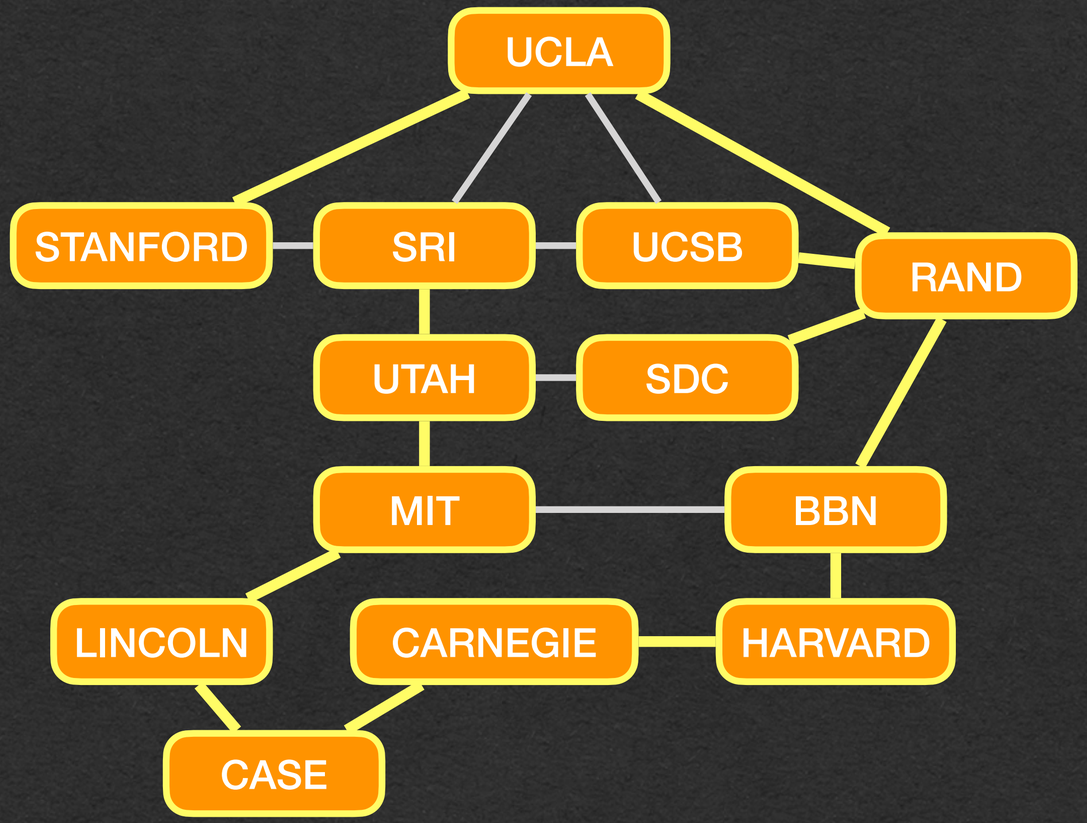
UCSB | SDC | SRI | STANFORD



UCLA	4
STANFORD	5
SRI	5
UCSB	4
RAND	3
UTAH	4
SDC	4
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

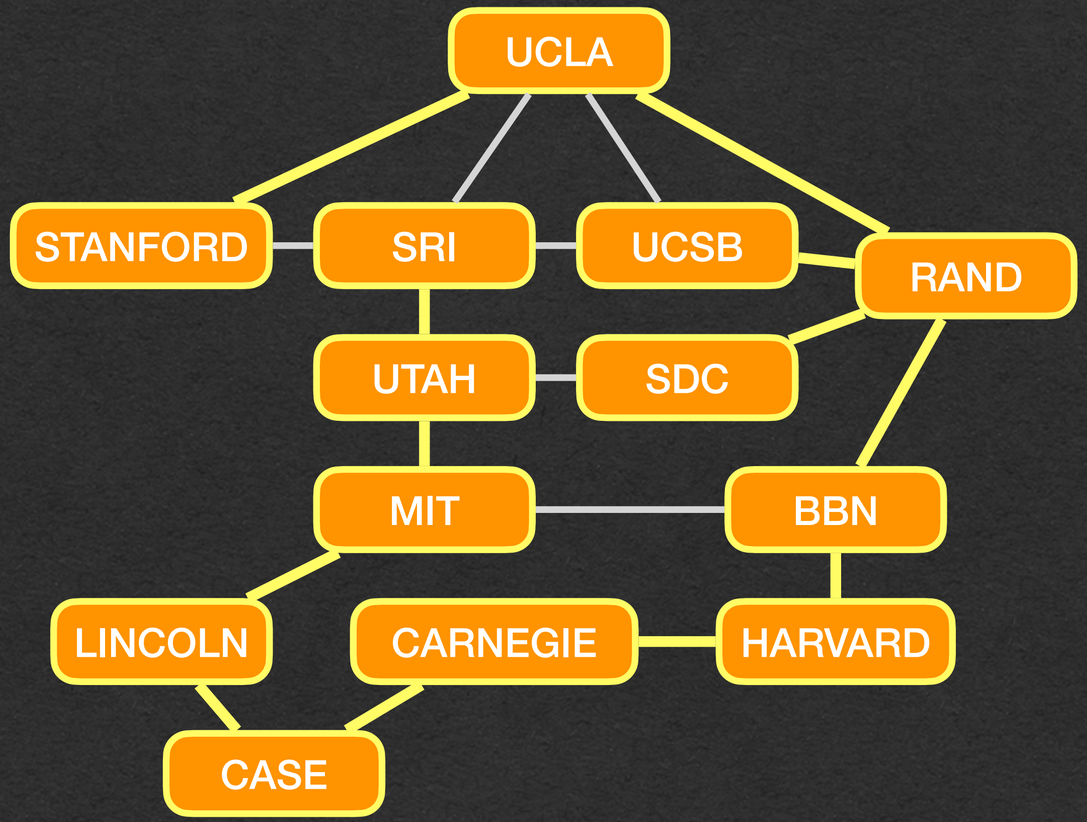
SDC | SRI | STANFORD



UCLA	4
STANFORD	5
SRI	5
UCSB	4
RAND	3
UTAH	4
SDC	4
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

SRI | STANFORD



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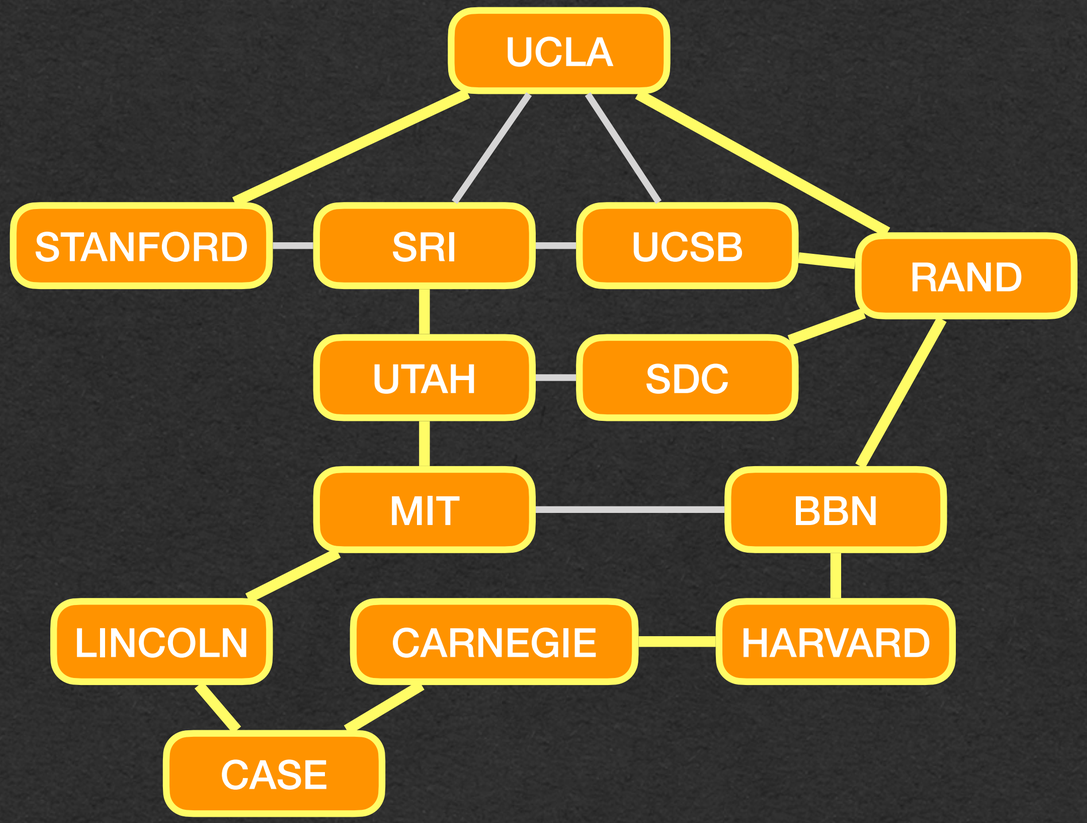
STANFORD	5
SRI	5
UCSB	4
RAND	3
UTAH	4
SDC	4
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

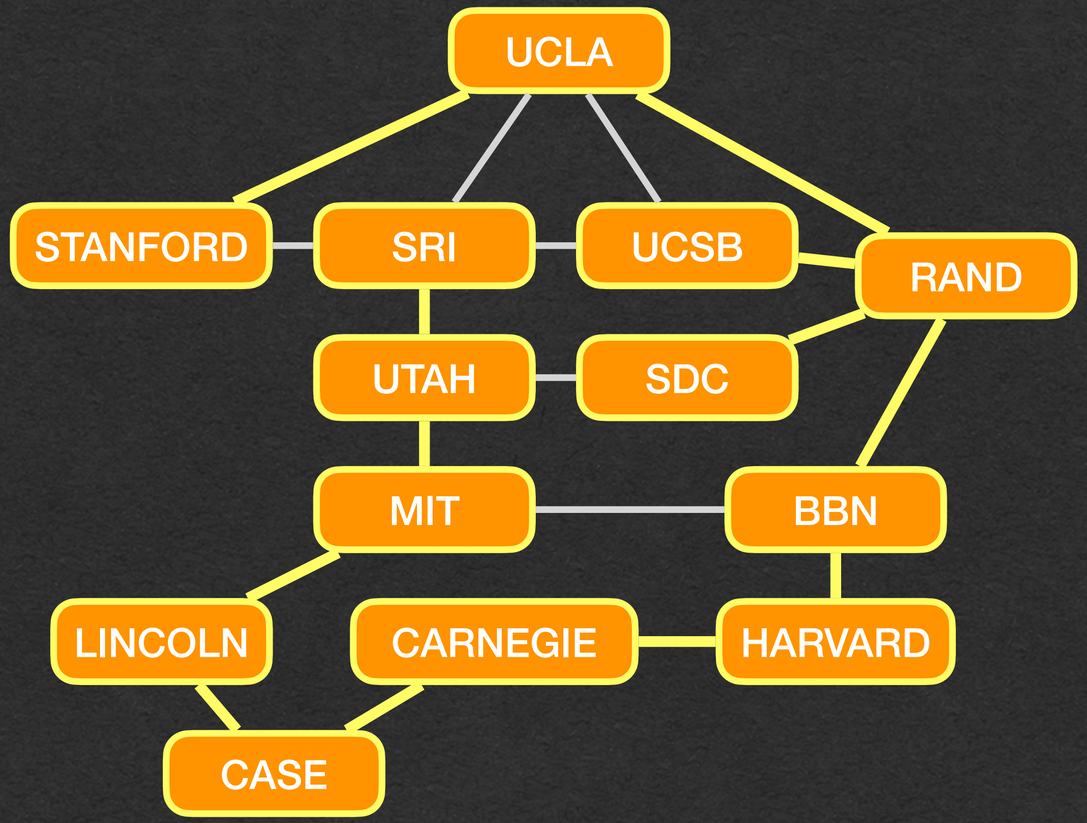
BFS and Distance

STANFORD



UCLA	4
STANFORD	5
SRI	5
UCSB	4
RAND	3
UTAH	4
SDC	4
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

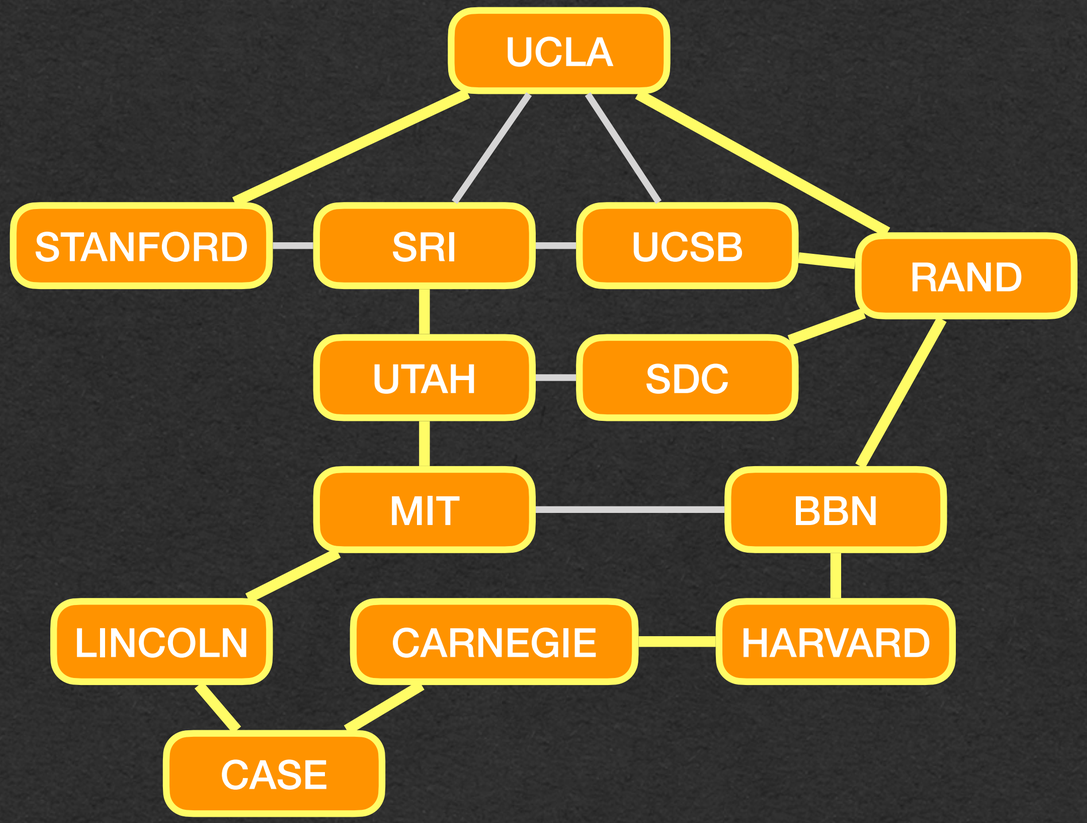
BFS and Distance



UCLA	4
STANFORD	5
SRI	5
UCSB	4
RAND	3
UTAH	4
SDC	4
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Distance

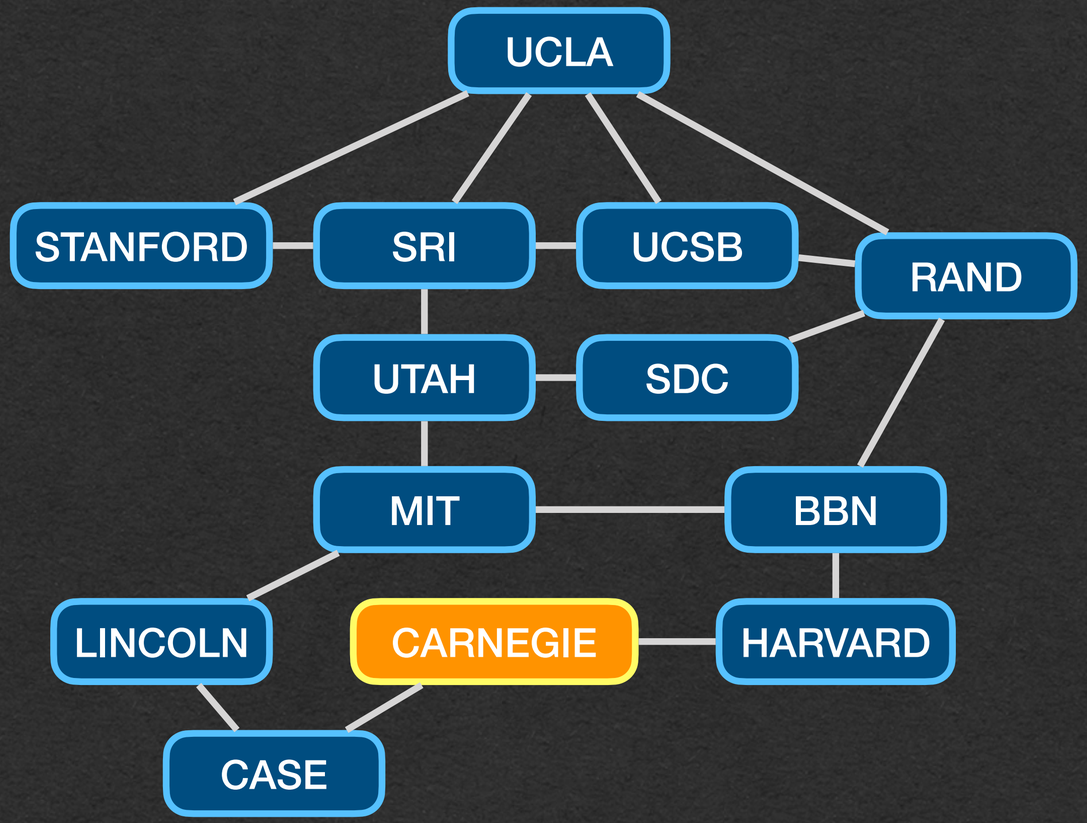
- And we have the distance from the start node to all other nodes in the graph



UCLA	4
STANFORD	5
SRI	5
UCSB	4
RAND	3
UTAH	4
SDC	4
MIT	3
BBN	2
LINCOLN	2
CARNEGIE	0
HARVARD	1
CASE	1

BFS and Pathfinding

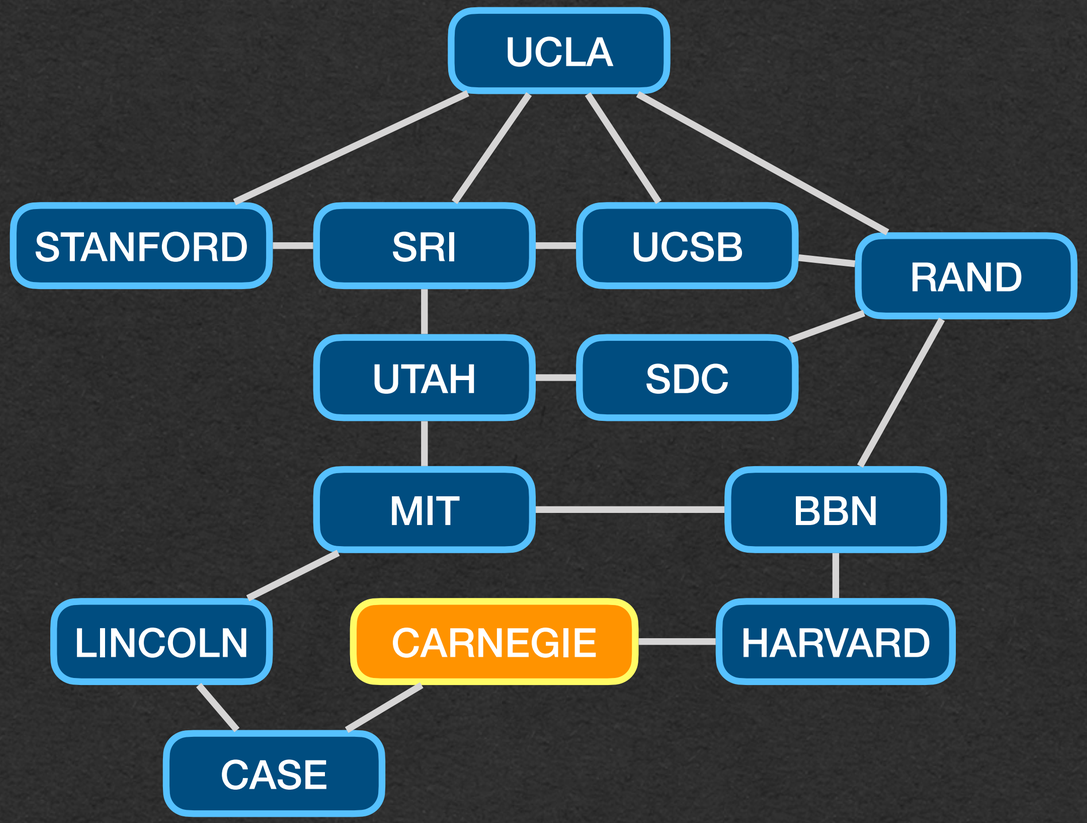
- This gives you the distance of each node
- How do we find a path to each node



UCLA	∞
STANFORD	∞
SRI	∞
UCSB	∞
RAND	∞
UTAH	∞
SDC	∞
MIT	∞
BBN	∞
LINCOLN	∞
CARNEGIE	0
HARVARD	∞
CASE	∞

BFS and Pathfinding

- Instead of tracking the distance, track the node that discovered each node



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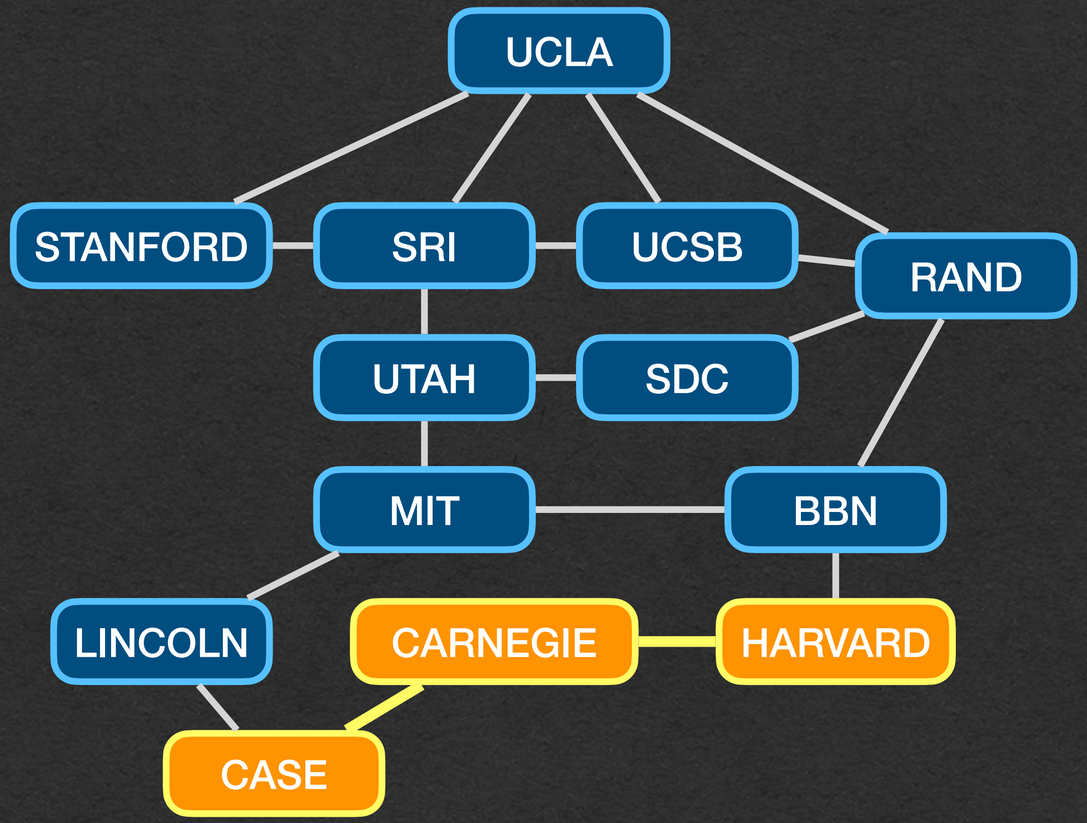
RAND	unexplored
UTAH	unexplored
SDC	unexplored
MIT	unexplored
BBN	unexplored
LINCOLN	unexplored
CARNEGIE	<START>
HARVARD	unexplored
CASE	unexplored

BFS and Pathfinding

- Now each node remembers how it was reached



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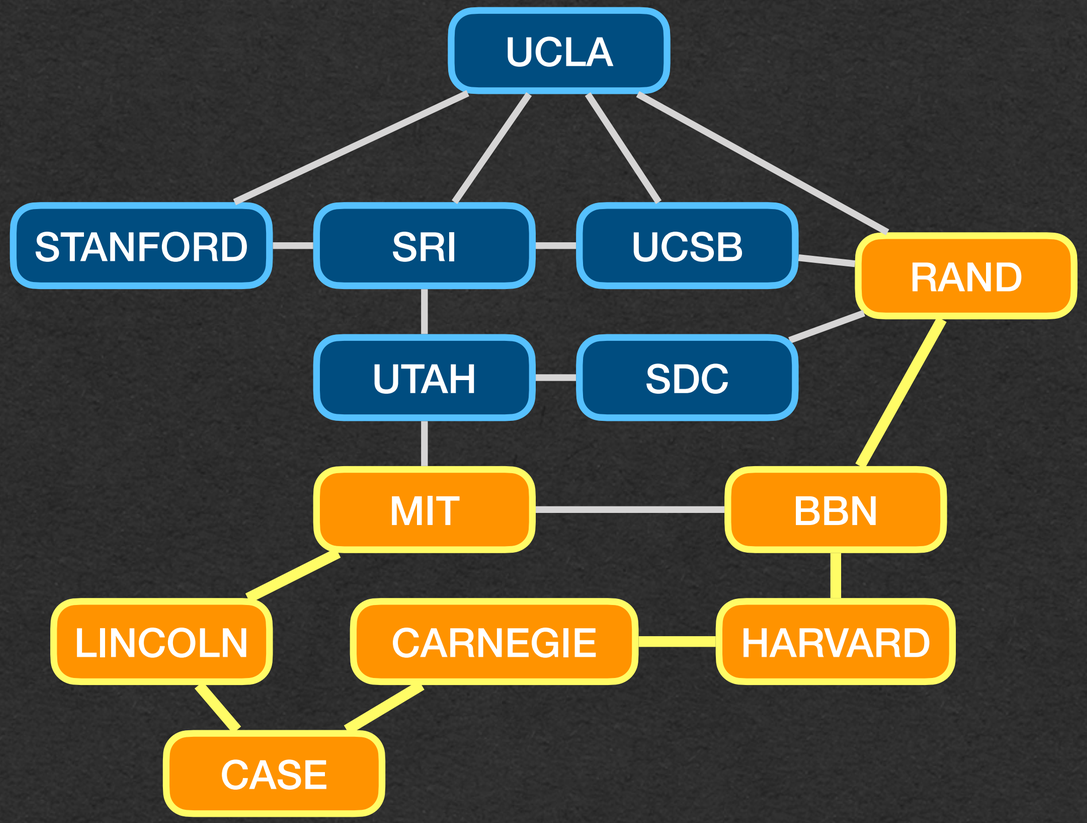
MIT	unexplored
BBN	unexplored
LINCOLN	unexplored
CARNEGIE	<START>
HARVARD	CARNEGIE
CASE	CARNEGIE

BFS and Pathfinding

- Repeat at each step



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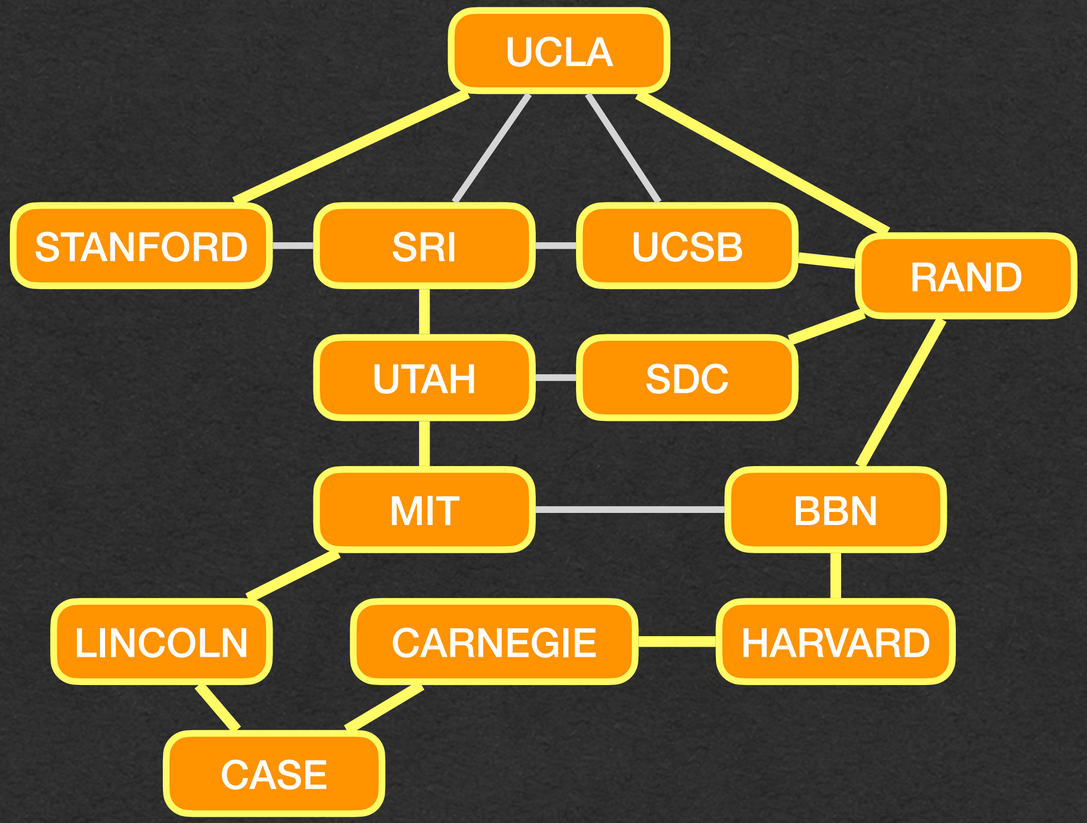
UTAH	unexplored
SDC	unexplored
MIT	LINCOLN
BBN	HARVARD
LINCOLN	CASE
CARNEGIE	<START>
HARVARD	CARNEGIE
CASE	CARNEGIE

BFS and Pathfinding

- At the end of the algorithm you'll know how each node was discovered



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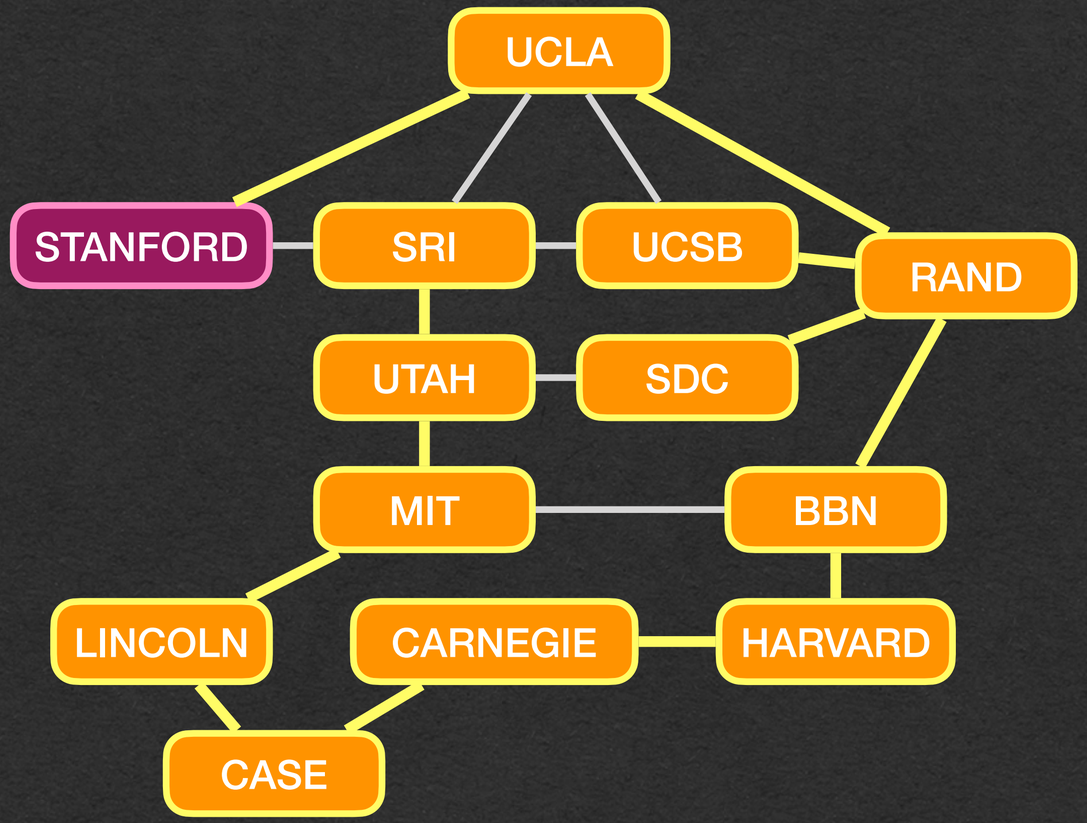
STANFORD	UCLA
SRI	UTAH
UCSB	RAND
RAND	BBN
UTAH	MIT
SDC	RAND
MIT	LINCOLN
BBN	HARVARD
LINCOLN	CASE
CARNEGIE	<START>
HARVARD	CARNEGIE
CASE	CARNEGIE

BFS and Pathfinding

- Work backwards to build the shortest path
- Find path from CARNEGIE to STANFORD



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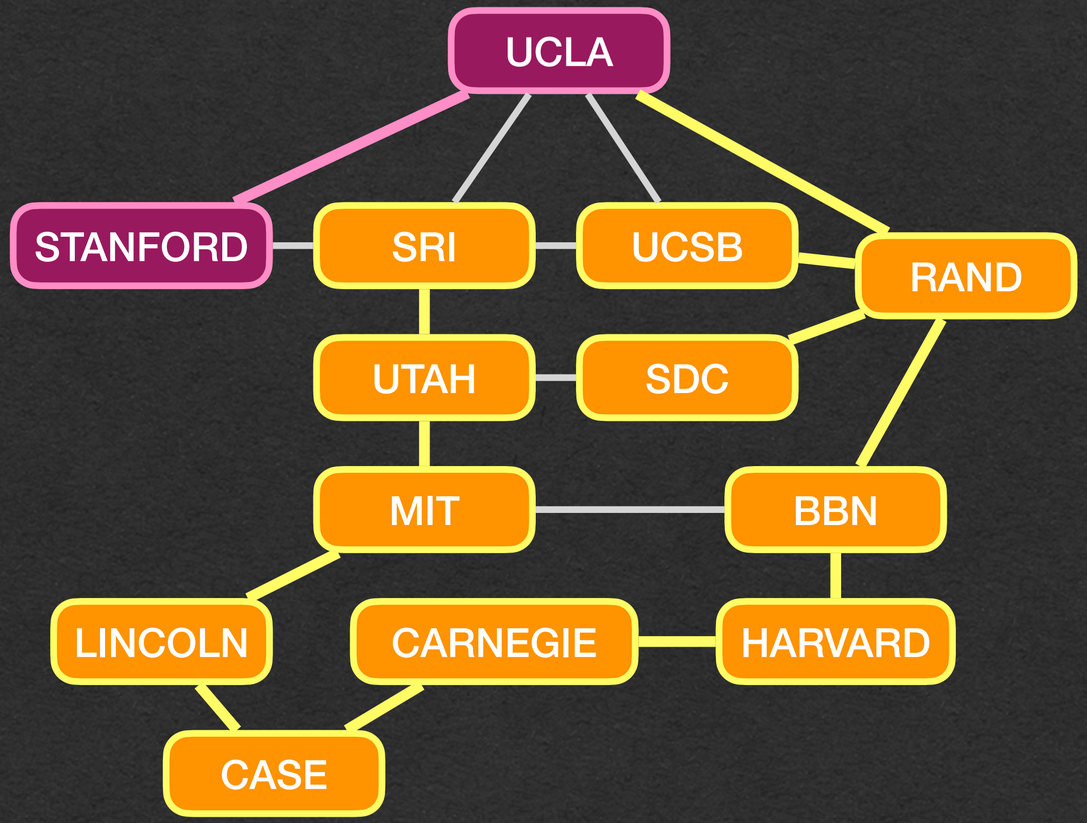
BBN	HARVARD
LINCOLN	CASE
CARNEGIE	<START>
HARVARD	CARNEGIE
CASE	CARNEGIE

BFS and Pathfinding



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UTAH	MIT
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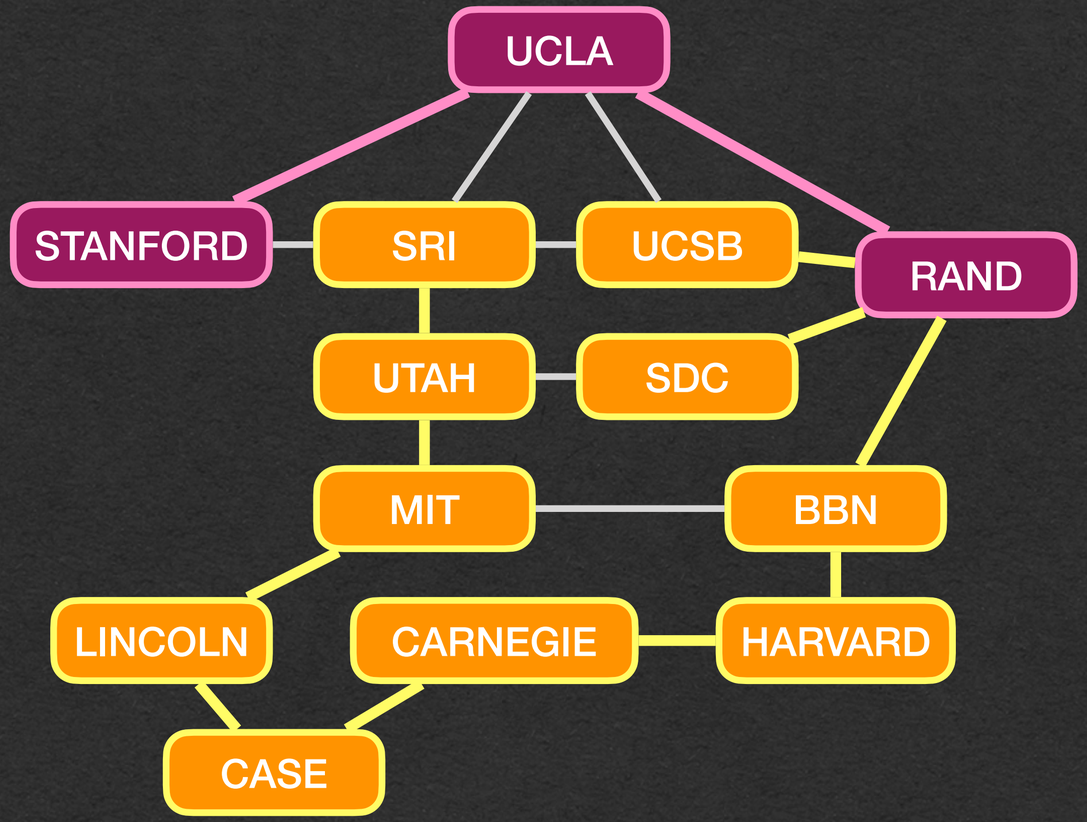
MIT	LINCOLN
BBN	HARVARD
LINCOLN	CASE
CARNEGIE	<START>
HARVARD	CARNEGIE
CASE	CARNEGIE

BFS and Pathfinding



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STANFORD	UCLA
SRI	UTAH
UCSB	RAND
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UTAH	MIT
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MIT	LINCOLN
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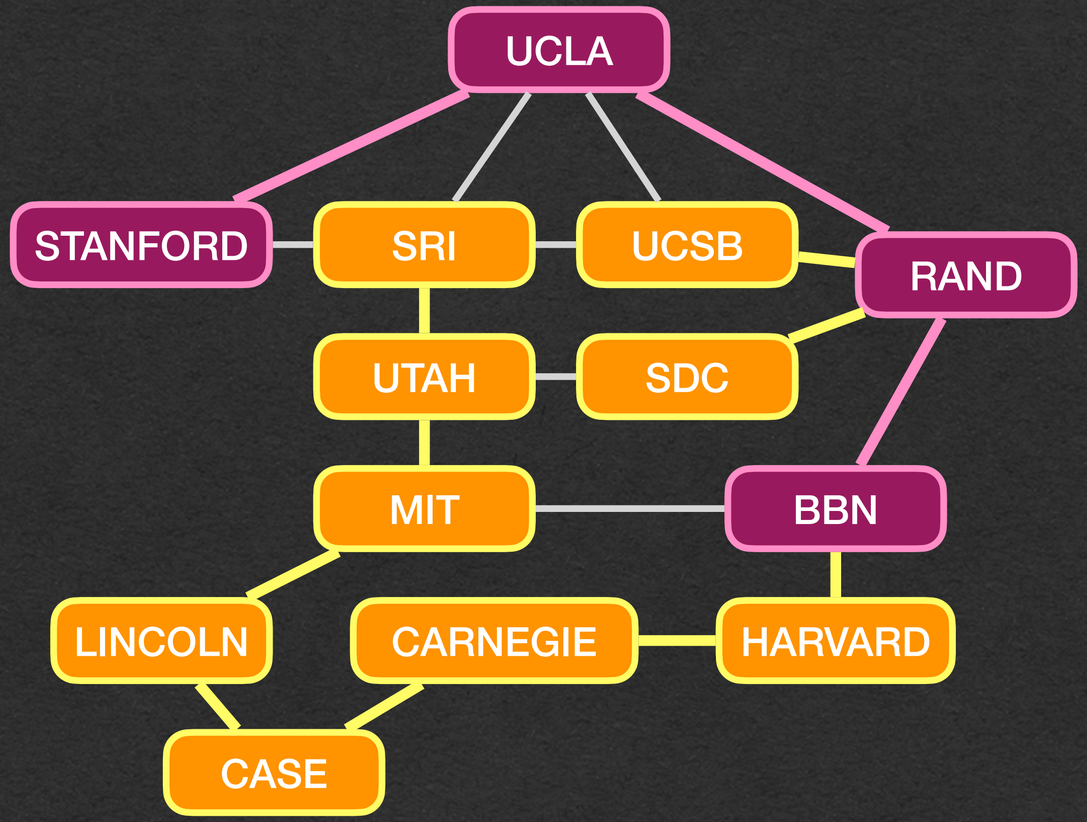
LINCOLN	CASE
CARNEGIE	<START>
HARVARD	CARNEGIE
CASE	CARNEGIE

BFS and Pathfinding



UCLA	RAND
STANFORD	UCLA
SRI	UTAH
UCSB	RAND
RAND	BBN
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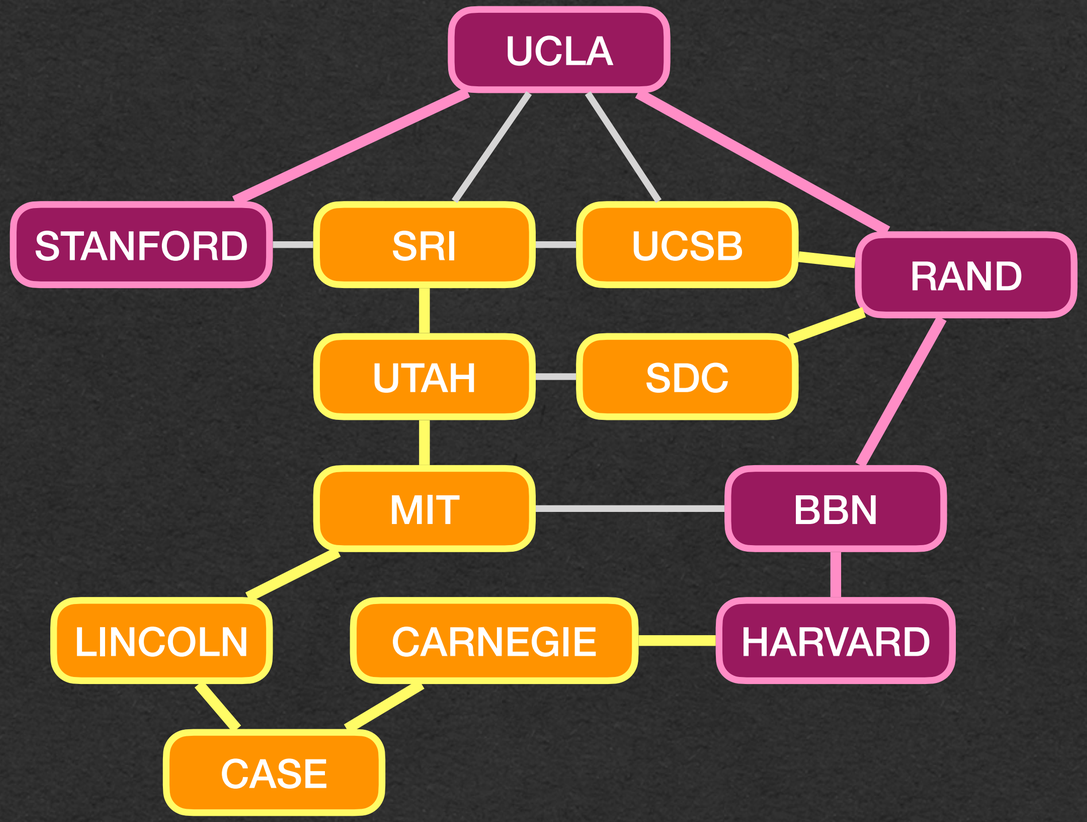
MIT	LINCOLN
BBN	HARVARD
LINCOLN	CASE
CARNEGIE	<START>
HARVARD	CARNEGIE
CASE	CARNEGIE

BFS and Pathfinding



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STANFORD	UCLA
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UCSB	RAND
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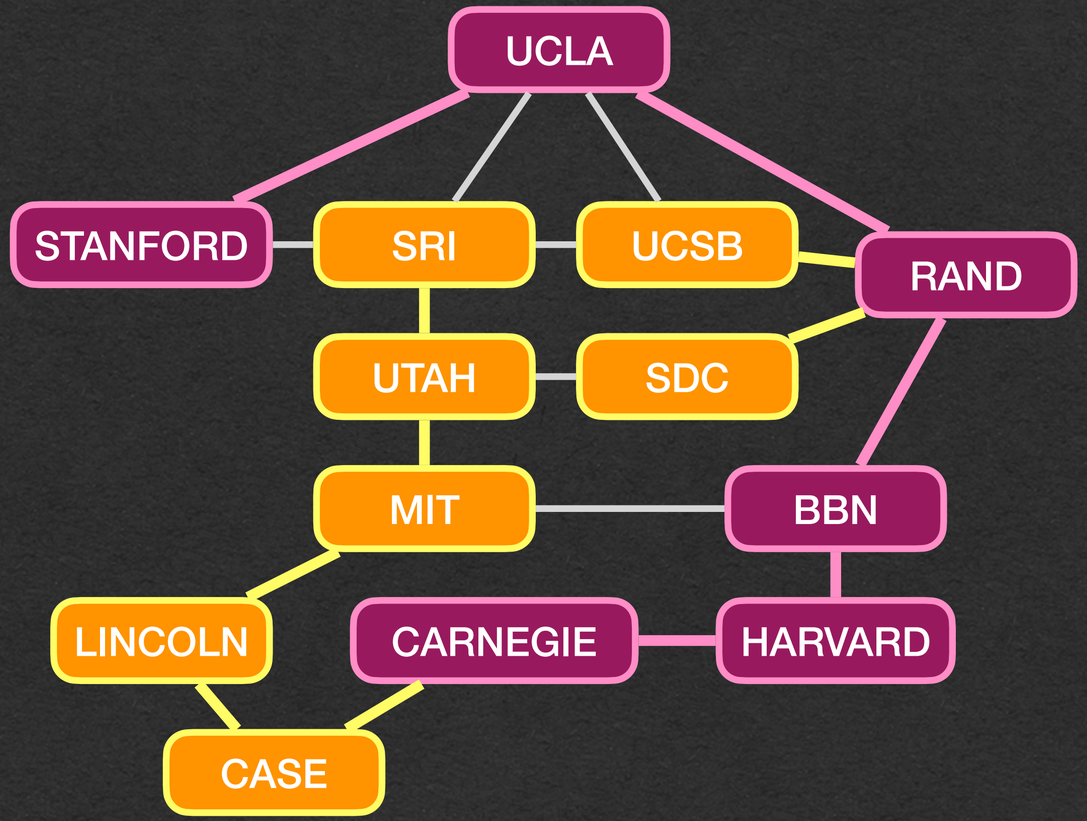
HARVARD	CARNEGIE
CASE	CARNEGIE

BFS and Pathfinding



UCLA	RAND
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UCSB	RAND
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UTAH	MIT
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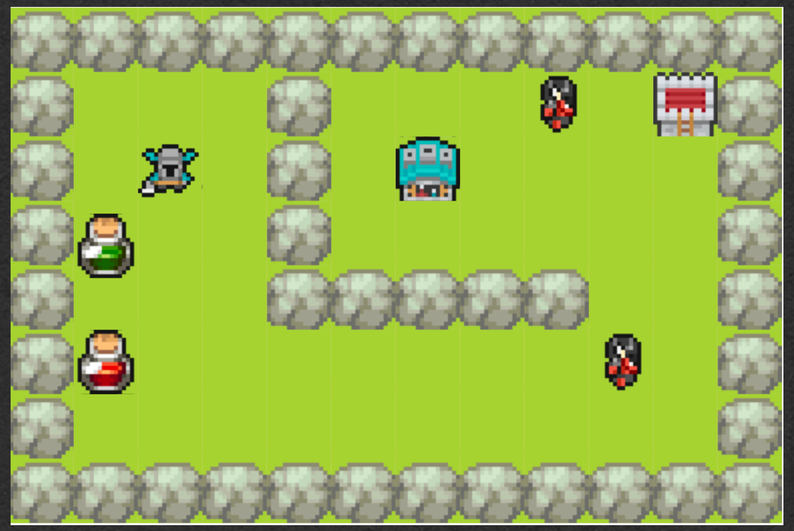
BBN	HARVARD
LINCOLN	CASE
CARNEGIE	<START>
HARVARD	CARNEGIE
CASE	CARNEGIE

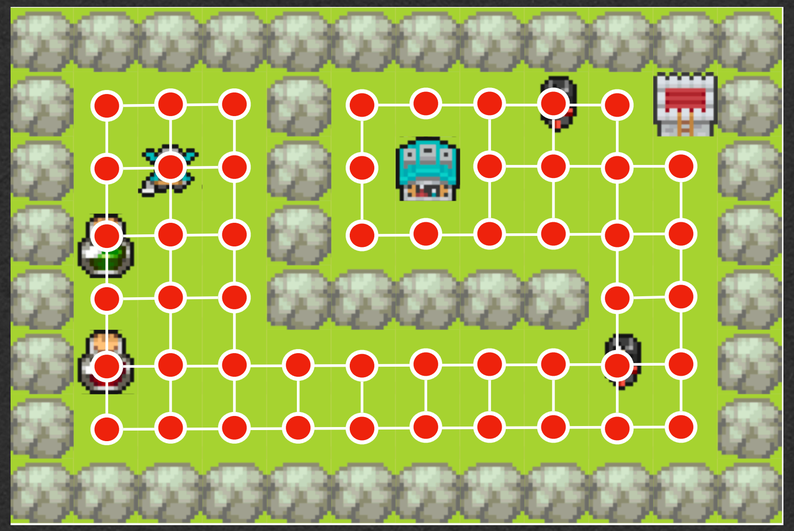
Pathfinding on a Grid

- Convert the level to a graph
- Run BFS from the starting tile
- Backtrack from the end tile to build the path

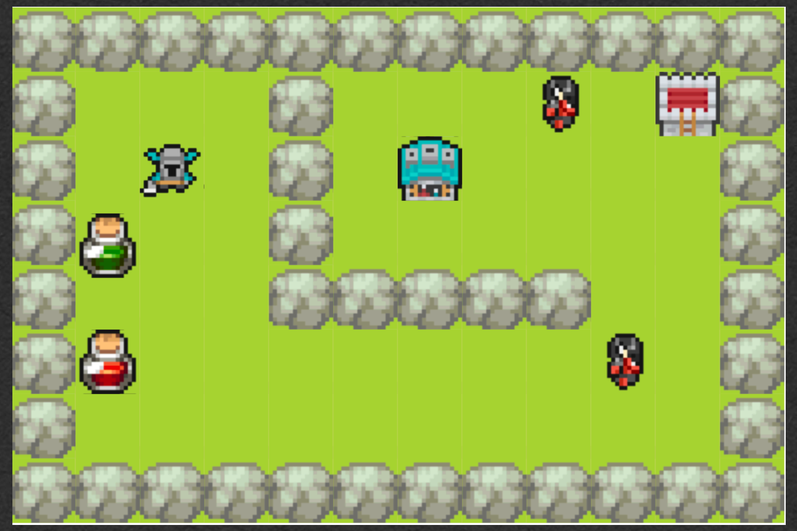


Pathfinding on a Grid

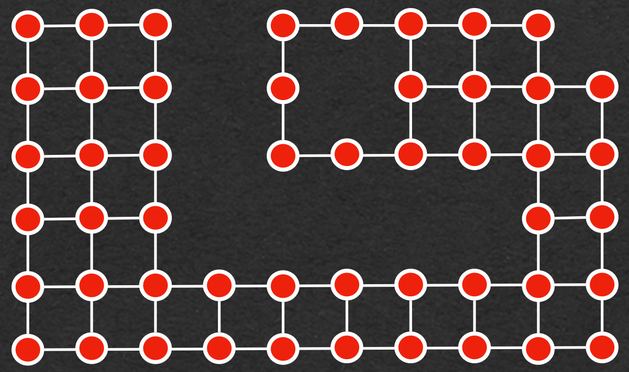
- Build a graph
  - Each tile is a node in the graph
  - Edges connect adjacent nodes
  - No nodes for tiles containing static objects



We see this:

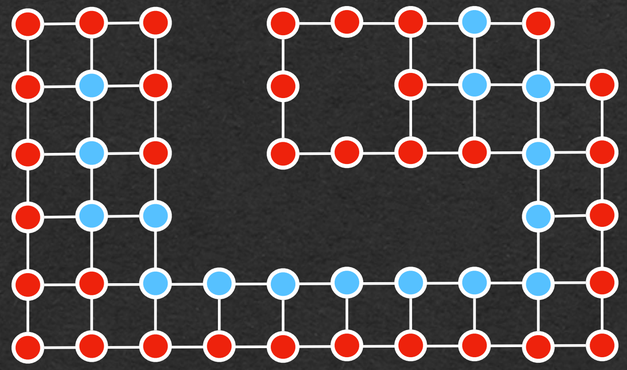


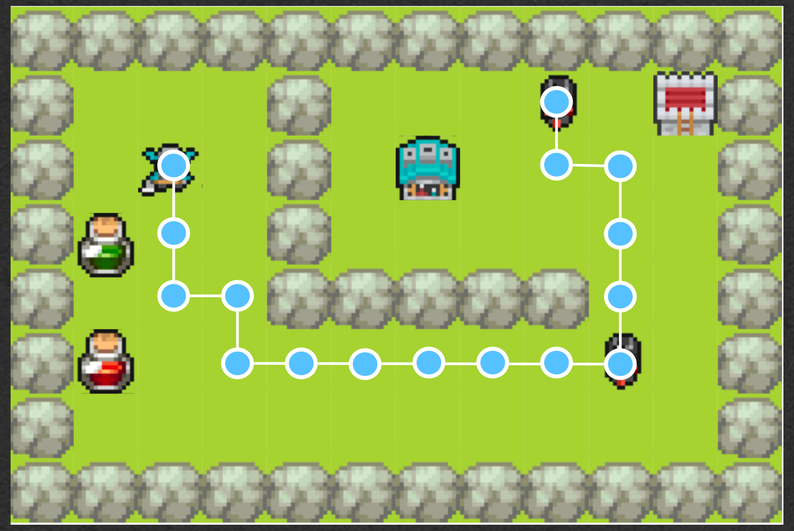
AI sees this:



Pathfinding on a Grid

- AI finds the tile they are on
  - Use it as the starting node for BFS
- Backtrack from the tile containing the player
  - Build the path to travel



Pathfinding on a Grid

- Enemy travels along this path to hunt the player
- BFS guarantees this will be a shortest path to the player that avoids wall (And all tiles containing static objects)