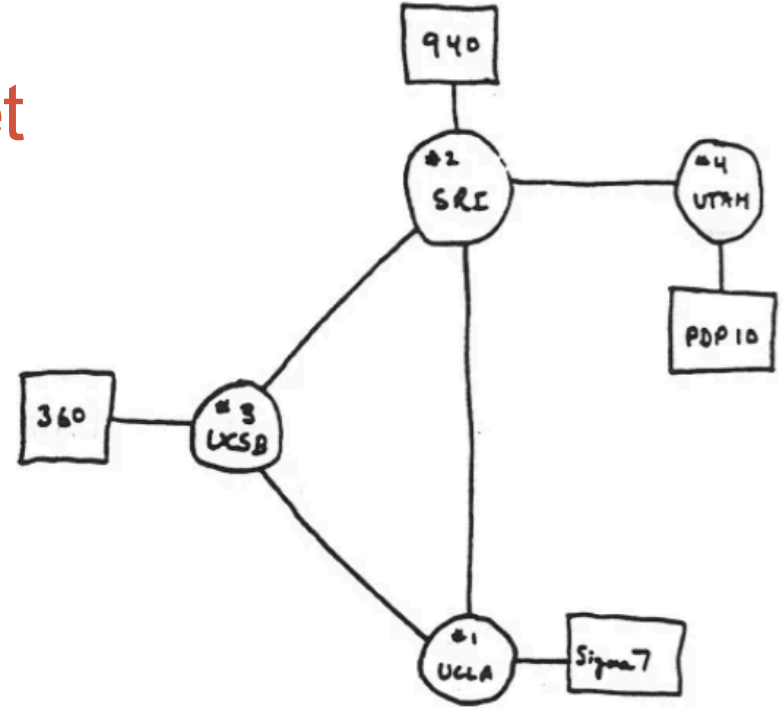
GRAPHS

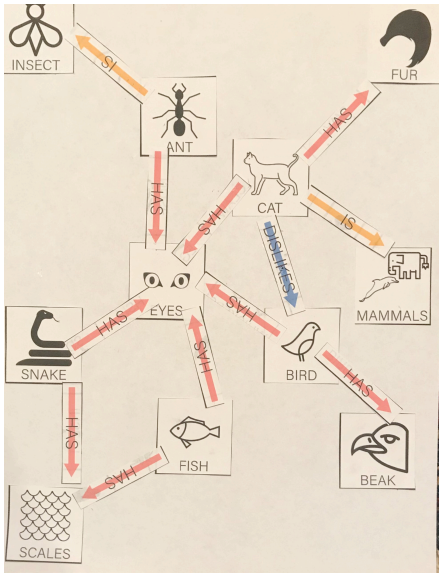
The first four nodes of the internet

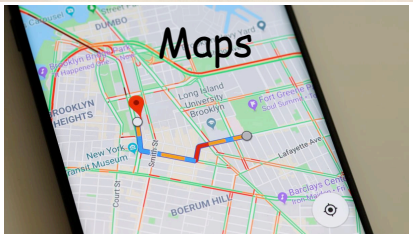


The IBM 360, the IMP, and the workstations were all located in North Hall.
https://jeweledplatypus.org/news/text/ucsbnet.html

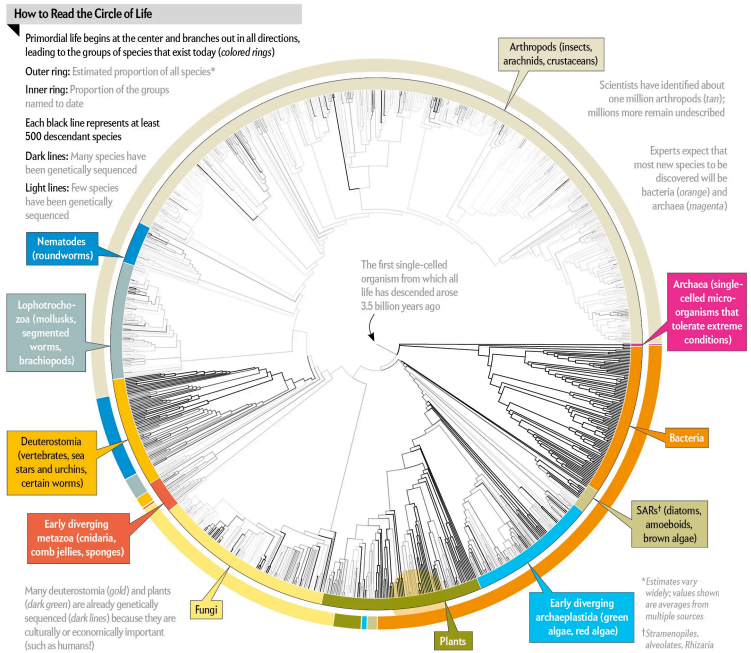
Graphs: applications

Semantic networks

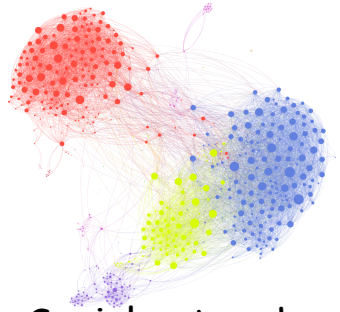


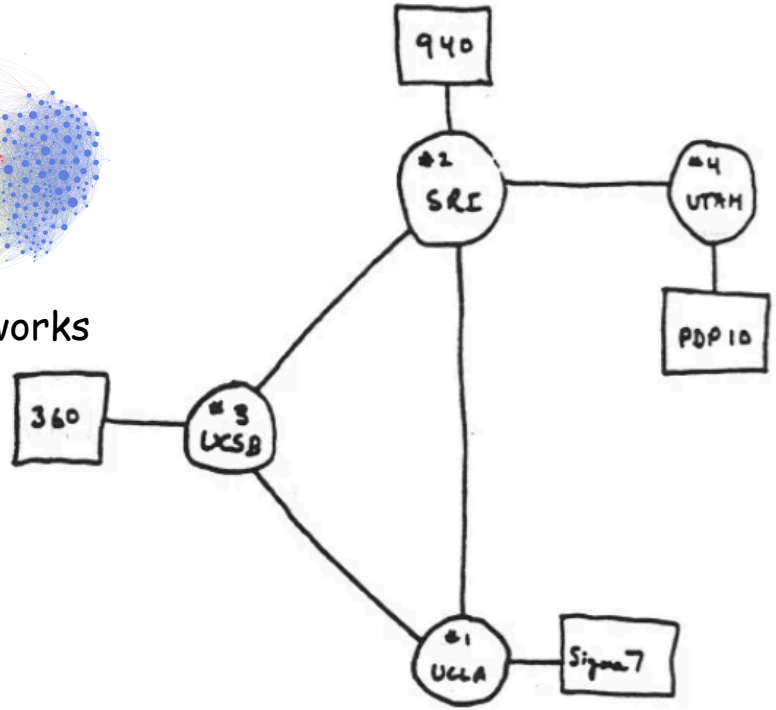


Biological networks



Social networks





THE ARPA NETWORK

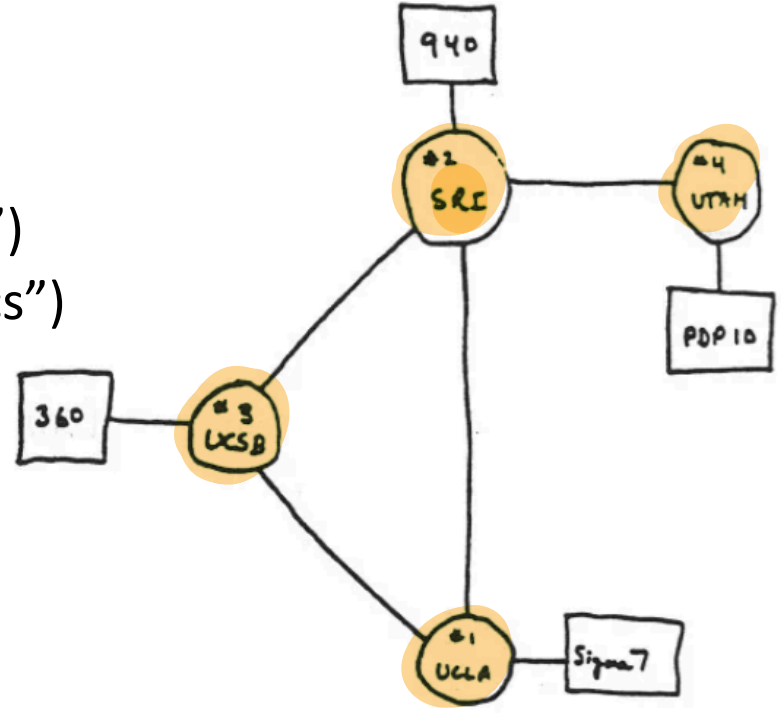
DEC 1969

4 NODES

source: https://www.scientificamerican.com/article/all-2-3-million-species-are-mapped-into-a-single-circle-of-life/

Graphs: terminology

A collection of elements (“nodes” or “vertices”)
A set of connections (“edges” or “links” or “arcs”) between pairs of nodes.
Edges may be directed or undirected
Edges may have weight associated with them



THE ARPA NETWORK

DEC 1969

4 NODES

Representing graphs

	0	1	2	3
0		1	1	
1	1		1	1
2	1	1		
3		1		

Adjacency Matrix

need to index into the vector to get the node's neighbors

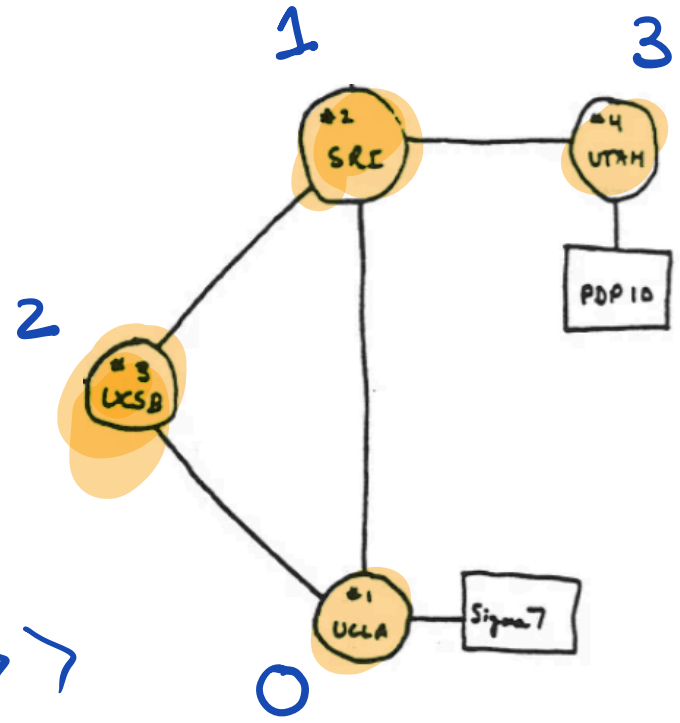
Vector of list

0 : 1→2
1 : 0→2→3
2 : 0→1
3 : 1

Adjacency List

Vector < list <int> >

Each node is identified by its index (0-3)



THE ARPA NETWORK

DEC 1969

4 NODES

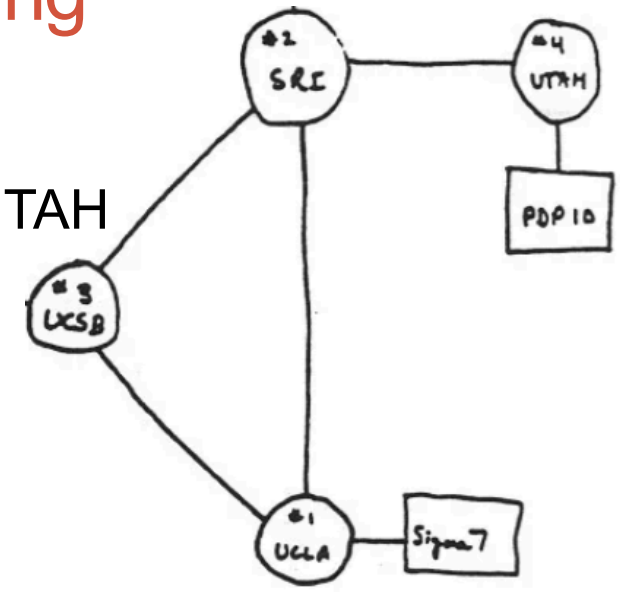
Assume each node is identified by a string

```
class graph{

  private:
  __________ adjlist;
};
```

UCLA : SRI, UCSB
SRI : UCLA, UCSB, UTAH
UCSB : UCLA, SRI
UTAH : SRI

Adjacency List: adjlist



THE ARPA NETWORK

DEC 1969

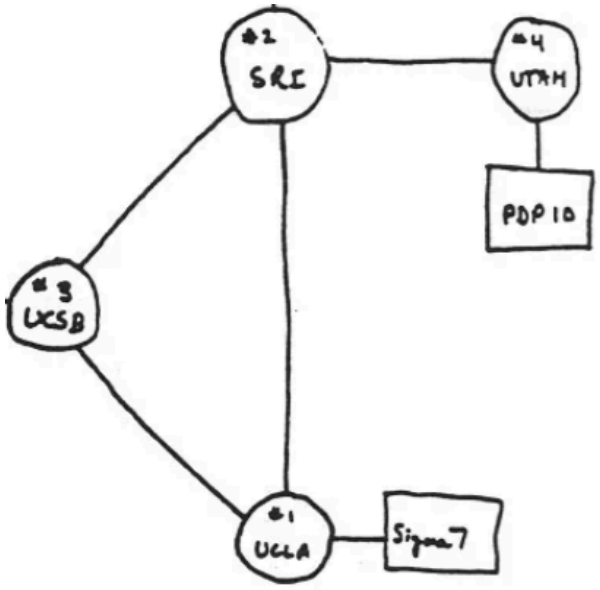
4 NODES

Choose the type for `adjlist`

A. `vector<string>`
B. `vector<list<string>>`
C. `set<pair<string, list<string>>`
D. `map<string, list<string>>`
E. `priority_queue<string>`

Graph search: general approach

Starting with a source node
- find everything that can be explored
- don't explore anything twice



THE ARPA NETWORK

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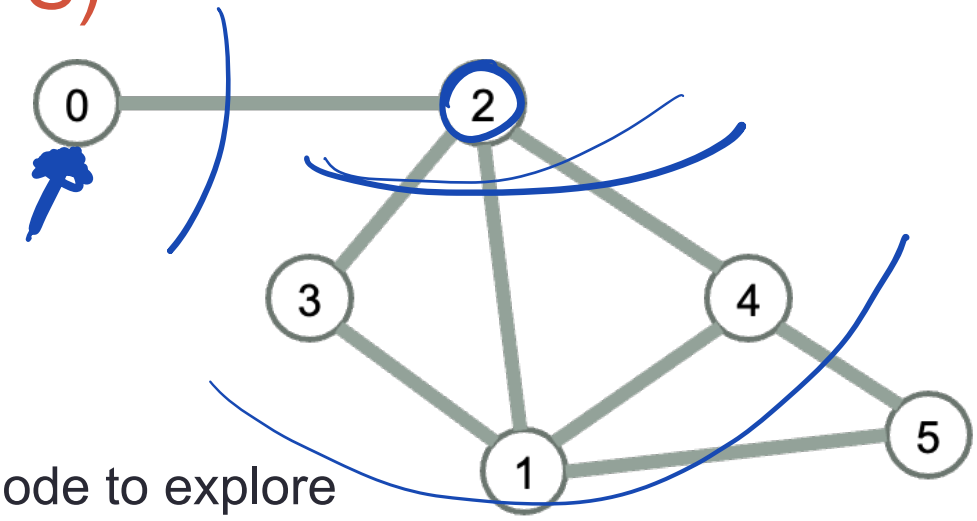
4 NODES

Graph search: breadth first (BFS)

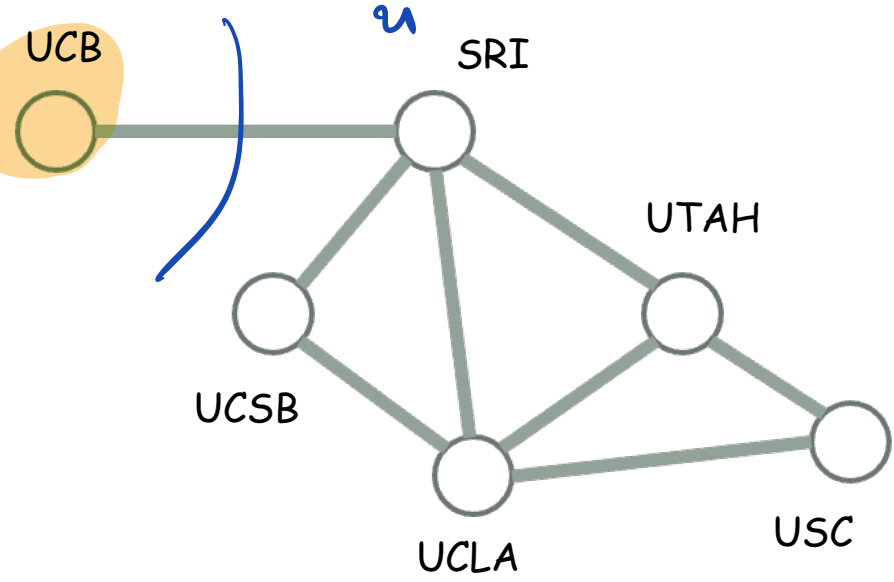
Explore all the nodes reachable from a given node before moving on to the next node to explore



Assume BFS chooses the lower number node to explore first, in what order does BFS visit the nodes in this graph

A. 0, 1, 2, 3, 4, 5
B. 0, 1, 3, 2, 4, 5
C. 0, 2, 3, 1, 4, 5
D. 0, 2, 1, 3, 4, 5
E. Something else

BFS Traverse: Sketch of Algorithm



Start at source *s*;

s is visited, others are not

push *s* into a queue

while the queue is not empty:

  pop the vertex *u* from the front of the queue

  for each of *u*'s adjacent nodes that has not yet been visited (*v*):

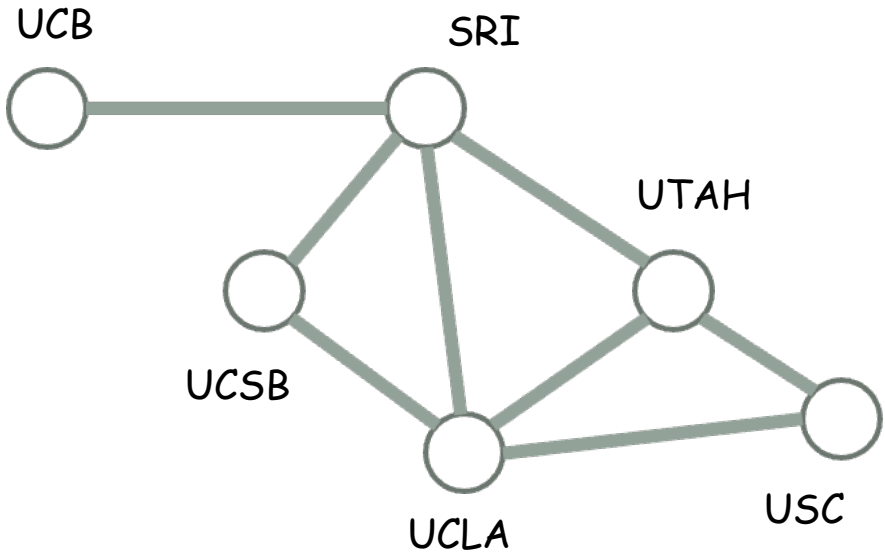
    • Push *v* in the queue

Questions:

-How can you tell if a node has been visited yet?

-What data do you need to keep track of for each node?

BFS Traverse: Sketch of Algorithm

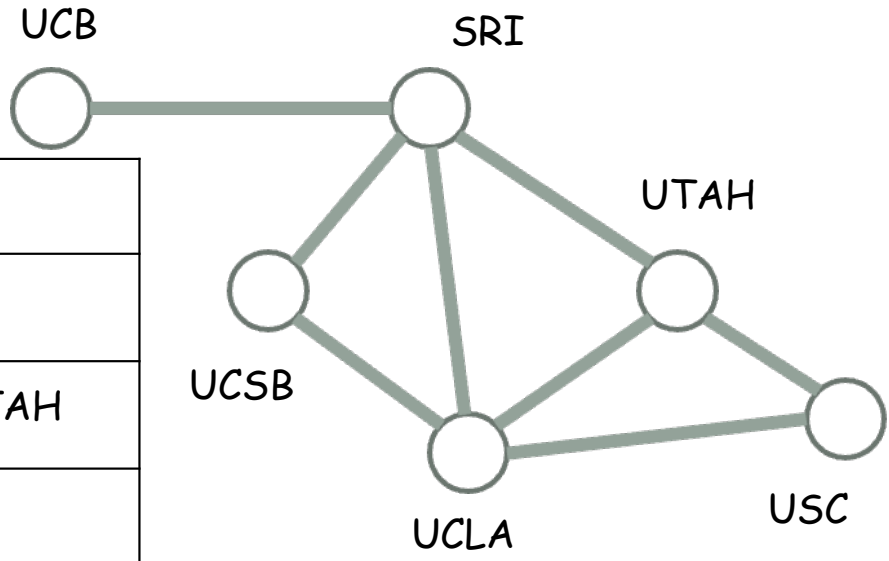


Start at source *s*; give *s* distance = 0
Mark *s* as visited
push *s* into a queue
while the queue is not empty:
  pop the vertex *u* from the front of the queue
  for each of u's adjacent nodes that has not yet been visited (*v*):
    - Mark *v* as visited
    - Mark its distance as 1 + the distance to *u*
    - Push *v* in the queue

Question (discuss 1 min):
This algorithm finds the length of the shortest path from a source node to all nodes.
How can you also find the path itself?

BFS Traverse: Trace Algorithm

Node	dist	prev	adjlist
UCB			SRI
SRI			UCB, UCSB, UCLA, UTAH
UCSB			SRI, UCLA
UCLA			UCSB, SRI, UTAH, USC
UTAH			UCLA, SRI, USC
USC			UTAH, UCLA



GRAPHS

To model a graph and implement BFS we used all the data structures we have learned so far with the exception of priority_queue :)