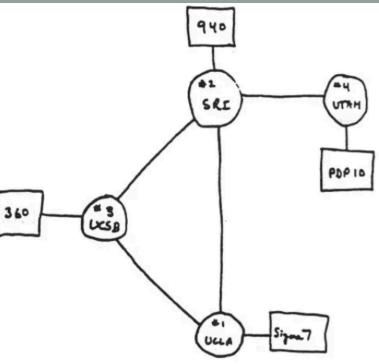
GRAPHS

~

The first four nodes of the internet



2

THE ARPA NETWORK

DEC 1969

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

YNODES

940 **Graphs:** applications # ų Semantic networks SRE UTAH INSECT Social networks **Biological networks** PDPID ANT How to Read the Circle of Life Primordial life begins at the center and branches out in all directions. 360 Arthropods (insects, leading to the groups of species that exist today (colored rings) UCSA arachnids, crustaceans) Outer ring: Estimated proportion of all species* Scientists have identified about Inner ring: Proportion of the groups one million arthropods (tan); named to date millions more remain undescribed 0.0 Each black line represents at least 500 descendant species Experts expect that MAMMALS Dark lines: Many species have most new species to be been genetically sequenced discovered will be 4 Light lines: Few species bacteria (orange) and have been genetically archaea (magenta) sequenced Nematode roundworm The first single-celled organism from which all N Archaea (sing life has descended arose celled micro 3.5 billion years ago organisms tha BEAK lerate extrer conditions SCAL F THE ARPA NETWORK Deuterostomia Maps (vertebrates, sea stars and urchins. certain worms) SARs[†] (diatoms amoeboids, Early divergin brown algae) nb jellies, spong 1969 DEC Many deuterostomia (gold) and plants (dark green) are already genetically are averages from Fungi sequenced (dark lines) because they are ۲ culturally or economically important Stramenopiles. (such as humans!)

3

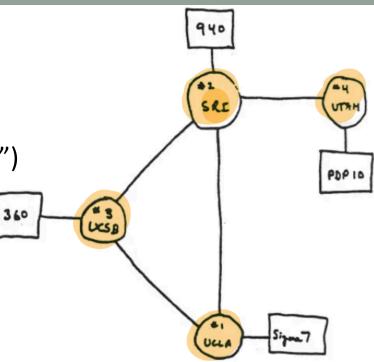
source: https://www.scientificamerican.com/article/all-2-3-million-species-are-mapped-into-a-single-circle-of-life/ 4NoDes

Graphs: terminology

A collection of elements ("nodes" or "vertices") A set of connections ("edges" or "links" or "arcs") between pairs of nodes.

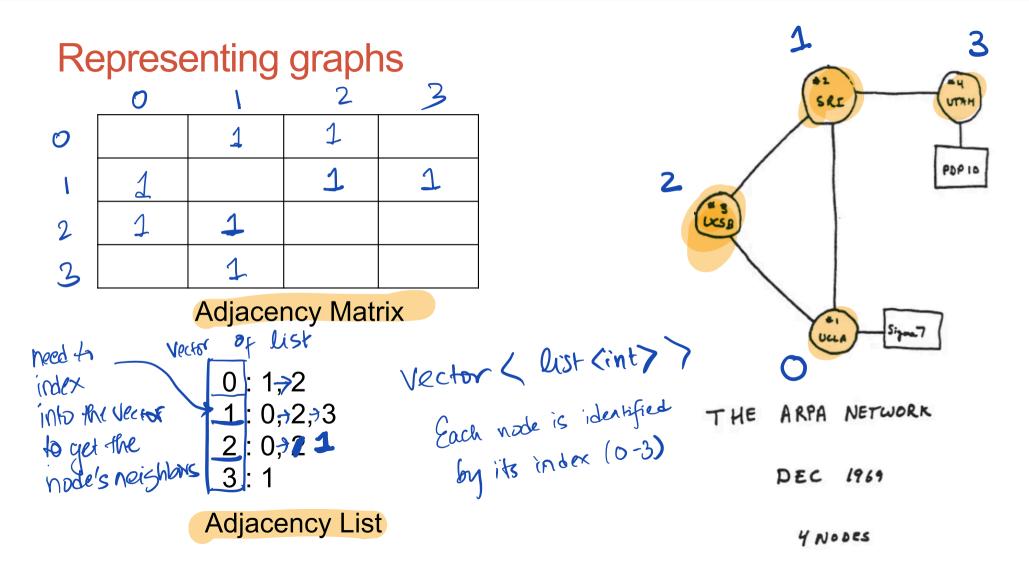
Edges may be directed or undirected

Edges may have weight associated with them

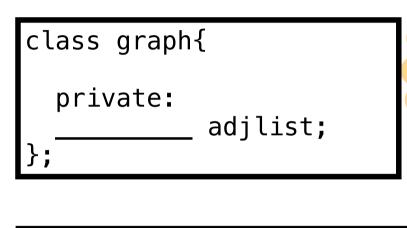


THE ARPA NETWORK

DEC 1969



Assume each node is identified by a string



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

Adjacency List: adjlist

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>

THE ARPA NETWORK

+1 SRE

DEC 1969

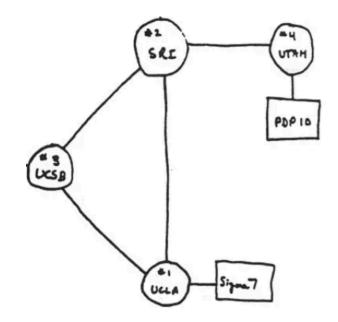
4 NODES

PDPID

Graph search: general approach

Starting with a source node

- find everything that can be explored
- don't explore anything twice



7

THE ARPA NETWORK

DEC 1969

Graph search: breadth first (BFS)

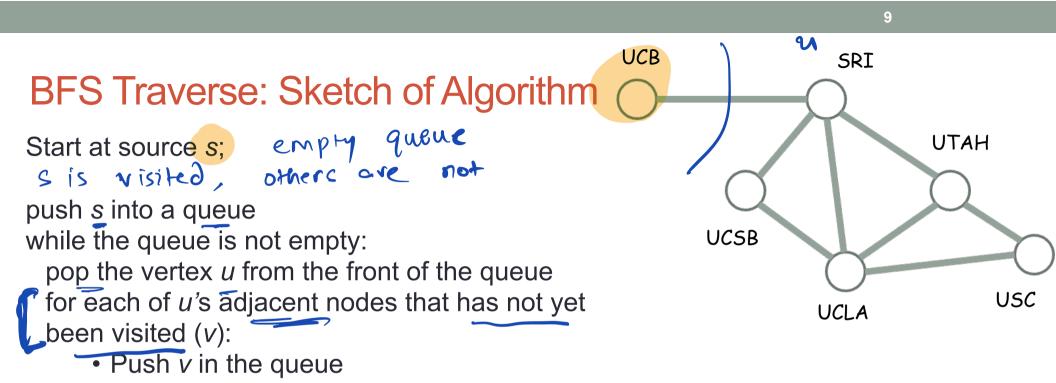
Explore all the nodes reachable from a given node before moving on to the next node to explore

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

0

```
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
```

4



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

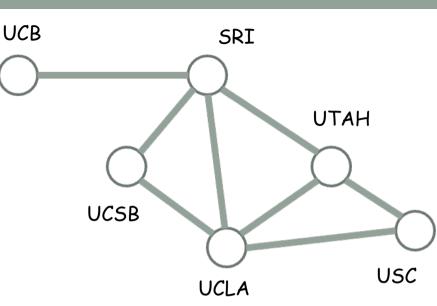
- push s into a queue
- while the queue is not empty:

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?



UCB BFS Traverse: Trace Algorithm				SRI
Node	dist	prev	adjlist	UCSB UCLA USC
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 :)

