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Graphs

$G = (V, E)$

Use parentheses to denote ordered set

V = set of vertices

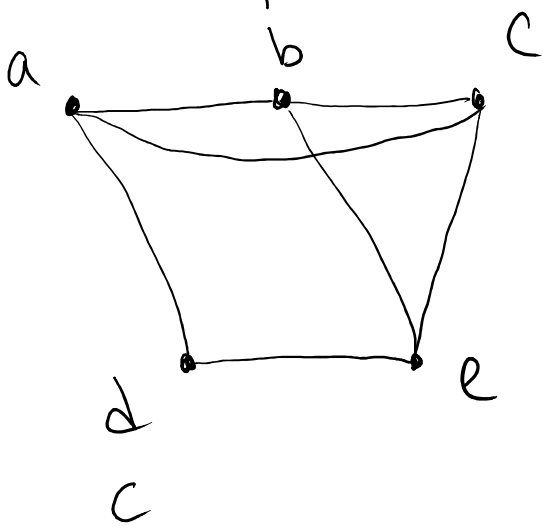
ex: $V = \{a, b, c, d, e\}$

E = set of edges $E \subseteq V \times V$

ex: $E = \{\{a,b\}, \{a,c\}, \{a,d\}, \{b,c\}, \{d,e\}, \{b,e\}, \{c,e\}\}$

each edge is a set consisting of 2 vertex elements.

Draw this Graph:



• a

• b

• c

• d

• e

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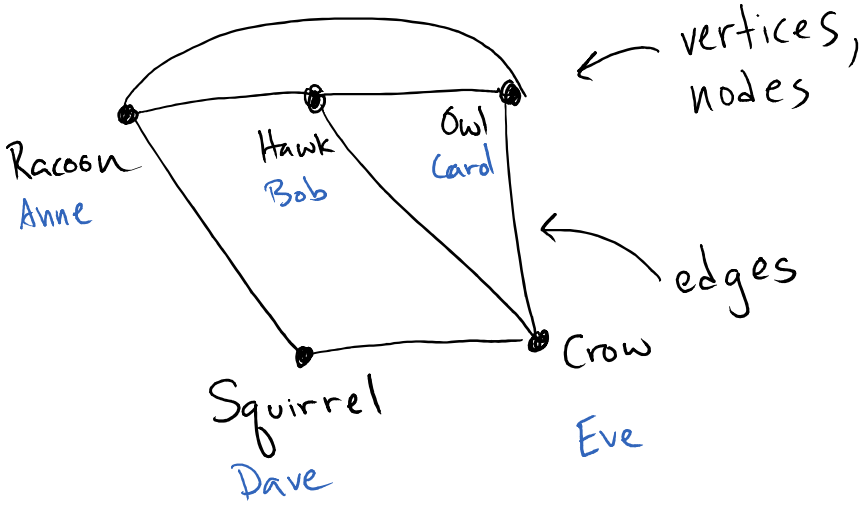
Graphs:



"Niche overlap graph"

⇓

- Connection if share a food source
- Connection if friends on Facebook

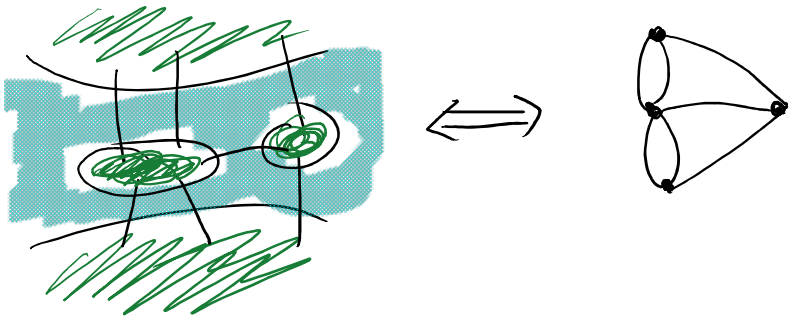
Natural questions:

- Which vertex has the largest degree (# of neighbors)? ← Most omnivorous
- Are two nodes connected? ← map
- What is the shortest path from one node to another? linked in
- What are the fewest edges one would need to remove to separate two nodes? ← cyber attack, rail way attack

The question that started it all:

Is there a path through the graph (starting anywhere) that takes you on each edge once?

Konigsberg Bridge Problem:



Euler solved for any graph

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Directed Graph

$G = (V, E)$

V = set of vertices

E = set of edges

An edge $e = (a, b)$

ordered pair of vertices

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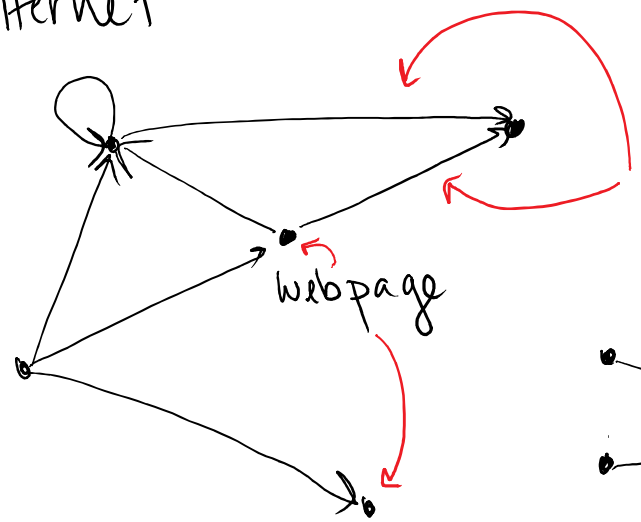
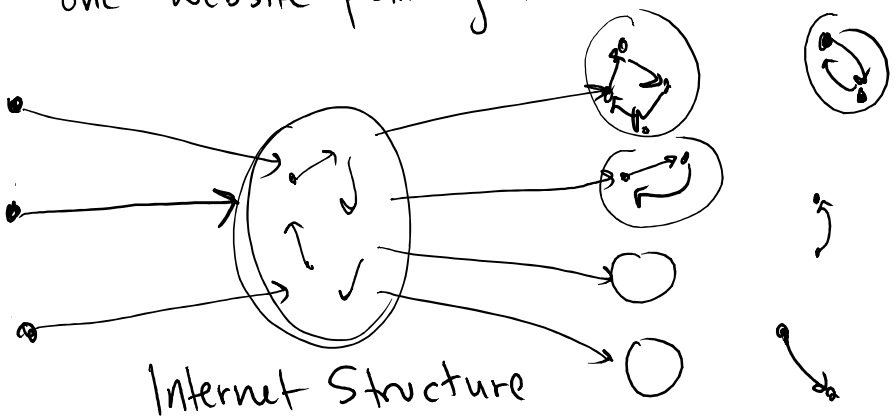
Internet



edge if there is a link on one website pointing to another



Internet Structure
Bow tie

Q: What types of websites are on the left of the bow?

- Personal websites (left)
- Company websites (right)
- Gov't websites (right)
- Facebook

If time: discuss goals, solve generalized bridge problem