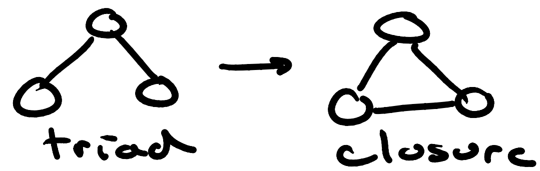
Lecture 5 - Strength of Ties, Diffusion

Tuesday, January 23, 2024 7:00 PM

Last class:

- Triadic closure 

  social network growth
  (link prediction)

- Homophily → selection
  influence
  "like attracts like"
  (vertex classification)

- Temporal networks
  → changes over time

Today: strength of ties
diffusion

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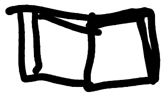
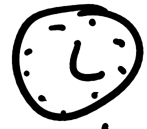
strong vs. weak ties

↳ strength of links
or edge weights

- # of communications
- Time spent together

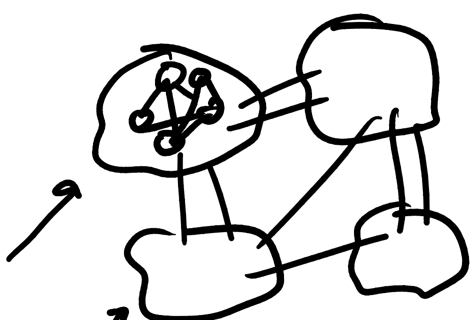
- Time spent together
- etc.

Example:  

story o'clock

Emperically: job seekers found more open positions through acquantences than close friends

Why: consider the structure of a social network



loosely coupled to each other

dense communities

From this: Information spreads very quickly within a community

(diffusion)

but, more slowly from

but, more slowly from
one community to
another

For our story:

within a job seeker's community,
They already have information
of available positions

However, over time, info from
other communities reach them

↳ via "weak ties"

strong tie: strong connection,
usually internal to a cluster

weak tie: weaker connection,
often external to a cluster

In terms of connectivity

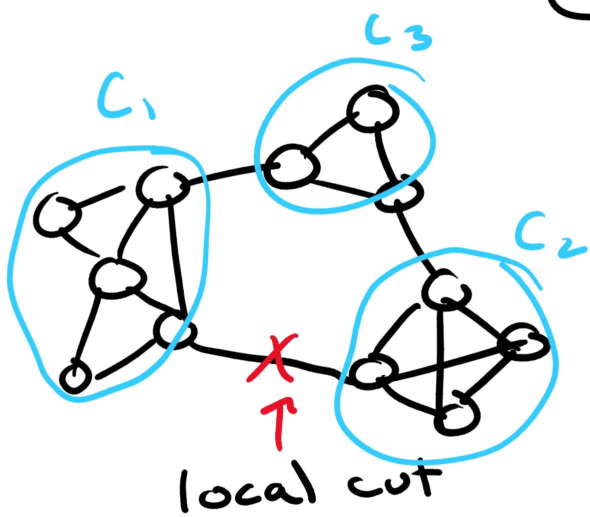
→ weak ties $\approx$ cut edges

not exactly

However, we have the notion of
a <u>local cut</u> or local bridge

a local cut or local bridge

↳ removing an edge increases shortest path lengths for some pairs of vertices



We'll observe how weak ties, local cuts, and diffision are all related

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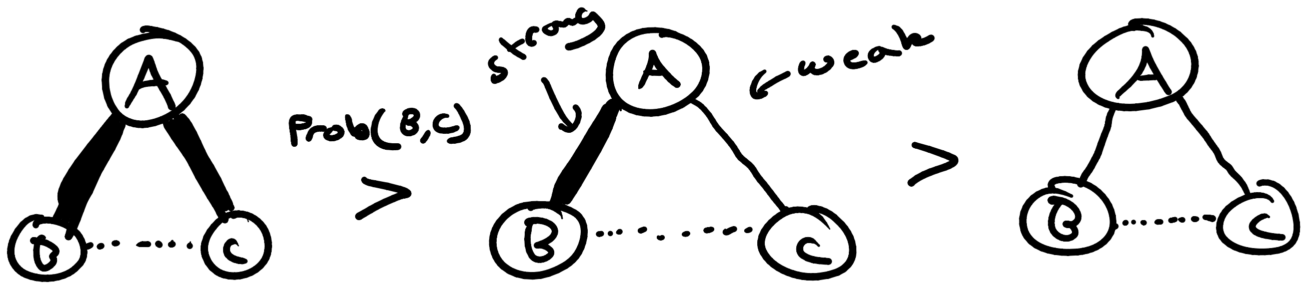
How does stength of ties relate to our triad closure?

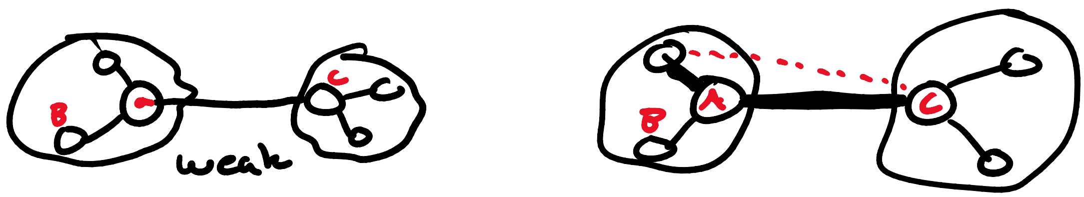
↳ **strong triadic closure**

If A is connected to B, C via strong ties, and B, C are not connected, there's a higher likelihood that B eventually connects to C than if A's connection were weak connection were weak



Think of

weak ties $\xleftrightarrow{\text{more likely}}$ local bridges



Over time, a strong tie connecting two communities is more likely to influence those communities to eventually merge

Let's experiment and observe:

- consider a weighted network

First: correlate neighborhood overlaps with tie strength

Second: remove ties from

Second: remove ties from
strong → weak
and weak → strong

and observe impact on connectivity of the remaining graph

Diffusion processes

Generally: we've considered how information, data, etc. spread through a network

Basic models:
vertex-centric behavior
→ v updates its state based on the states of its neighbors

complexity of this behavior is driven by how the diffusive process spreads across edges

→ updates could be heuristic, random probabilities, reductions over neighbors

random probabilities,
reductions over neighbors

→ small changes locally can influence global dynamics

Simple Algorithm: label propagation

For $v \in V(G)$: ← vertex id label
    state[v] = vid(v)

while updates occur:
    For $v \in V(G)$:
        counts = {0}
        For $u \in N(v)$:
            counts[state[u]] += 1
        state[v] = argmax(counts)
            (ties broken randomly)

Q: How are diffusion and network ties related?

→ cutting weaks increase the avg. shortest paths lengths and decrease the speed of a diffusive process

→ disconnecting a graph can halt a diffusive process

Think: network resilience

* we can strategically cut a network if that's our goal (epidemiology)

Growth Models

Note: our observations depend on some underlying growth process and knowledge of the network properties

(triadic closure)

Many networks also grow via "preferential attachment"

→ high degree vertices are more likely to gain new connections

"Rich get richer"

Story time:

Story time:

Slota won an award

RPI gave me another award

RPI gave me tenure

RPI gave me another award

basic explanation is that high degree vertices are high degree for same underlying reason

Barabasi-Albert model:

start with v_0 vertices

add a vertex and attach it to existing vertices u with probability $p_{v,u} = \frac{d(u)}{\sum_{i \in V(G)} d(i)}$

explains degree skew and other "power-law-ish" measurements and properties