How do we think about social nets using graphs?

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Overarching question: What kinds of "social networks" phenomena can we describe using graph theory?
Deep challenge: social networks are

- Huge
- Complex
- Messy
- Hard to measure

So in using graph theory (which is regimented, precise, abstract) to study social nets, need to be careful to ask the right questions.

Major concept to study in this course:

- Local properties of nodes/links <--> global properties of graphs/networks
- However, what local properties matter?

Motivating question:

- 1960s, Mark Granovetter found empirically that people tended to hear about new jobs from distant acquaintances, not close friends. Can we develop graph theory to understand why?

Triadic Closure

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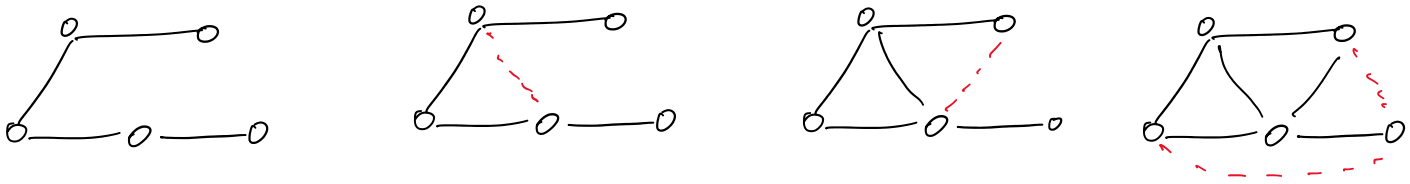
Q: what kinds of structure might social networks have?

Already conjectured: global structure
- ↳ giant component
- ↳ small diameter

what about local structure?

Idea: If I'm close friends w/ Alice and Bob, then
1. eventually they'll run into each other
2. they're more likely to trust each other
3. I may have an incentive to introduce them.

Thus, over time, we may see networks evolve like this:



Concept: "Triadic Closure"

Now: what kind of statement is this?
- qualitative
- intuitive
- cartoony
- can prompt further investigation

What about hearing about jobs?

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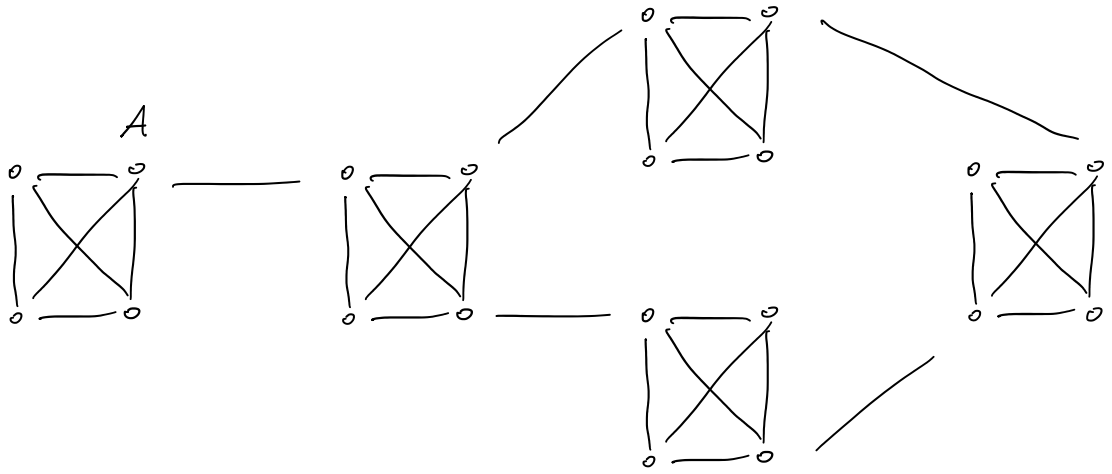
Triadic closure: clustering leads to clustering, so we might expect nets like this:



many clusters that are tightly connected, joined by fewer links.

Q: if new info comes to someone, is that person likely to be in my group?

only a $\frac{1}{5}$ chance!

So if info spreads along network links, this means info is likely to come to me via one of those weird connector links.

Q: what makes them special?

Bridges

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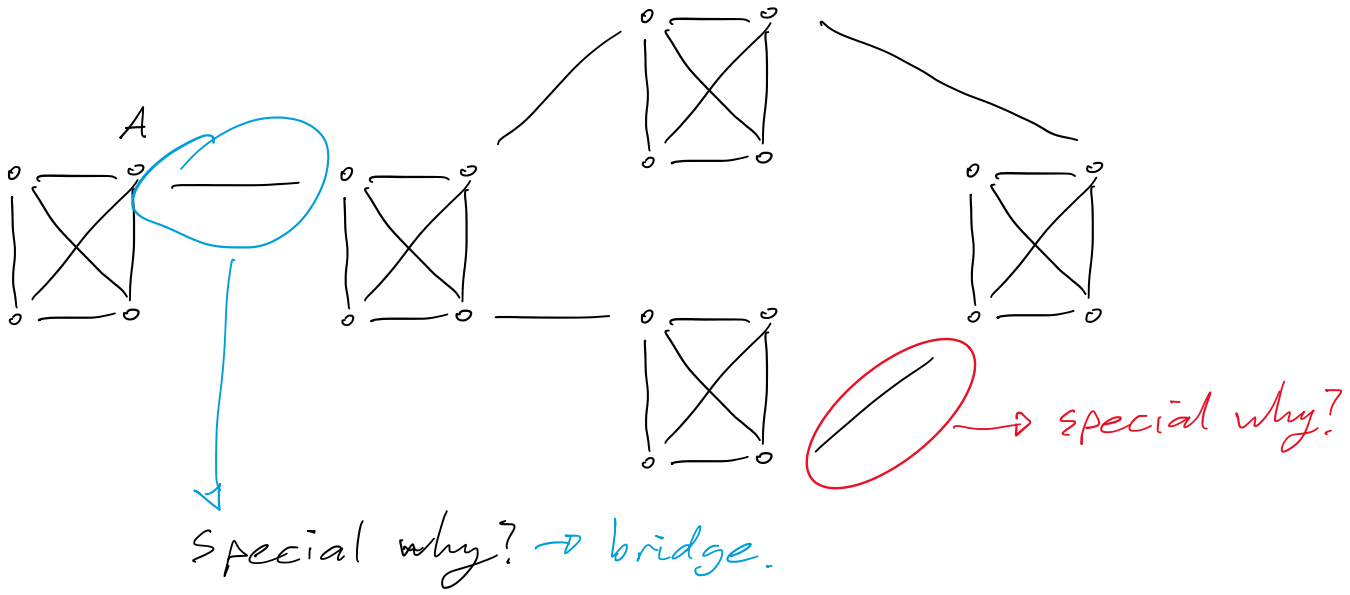

Def: if deleting a link makes a graph disconnected, the link is called a bridge.

Q: how many bridges above? 1.

Def: if deleting a link makes its endpoints farther apart, the link is called a local bridge.

Alternate: (A, B) is a local bridge if A and B have no common friends.

From before: local bridges are crucial for spreading new information!

Intuition: everyone in my local group already knows what I know!

But what about job info?

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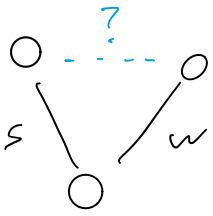
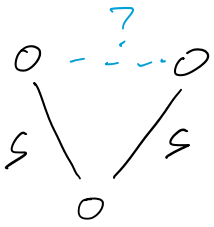
Need to distinguish betw. strong/weak friends.
Label each edge! Note: have not done this yet!
↳ but will be very normal someday.

s = "strong", close friend

w = "weak", acquaintance

Q: when does triadic closure make the most sense?

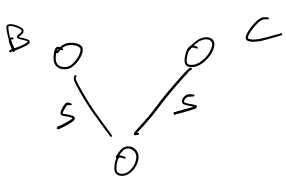




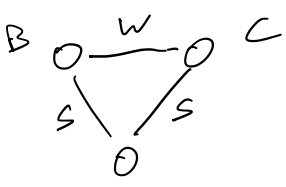
this triad would be the most likely to close.

Approach: formalize this, chase the consequences!

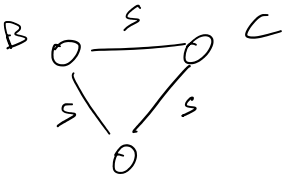
Def: Node A violates the strong Triadic Closure Property (STC) if has strong links to both B and C, but B and C have no link between them.



violates



satisfies



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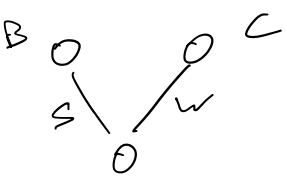

satisfies

Does STC make sense?

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Perspective: STC is deliberately extreme.
"caricature" of a real phenomenon we expect to see in real networks.

Note: not nearly as extreme as it could be!
could say "all triads are closed."
instead, STC says "some triads are closed."

General approach in this class: think abt overarching problem, then formalize a "cartoon" model of it!

Q: How do you know which cartoon model is good?
↳ very hard to say ahead of time!
↳ learn the "art" over time
↳ judge assumption's value somewhat by consequences

Q: What make consequences interesting?
- not already obvious
- counterintuitive
- "robust"
- explain real observed phenomenon

Consequences of STC

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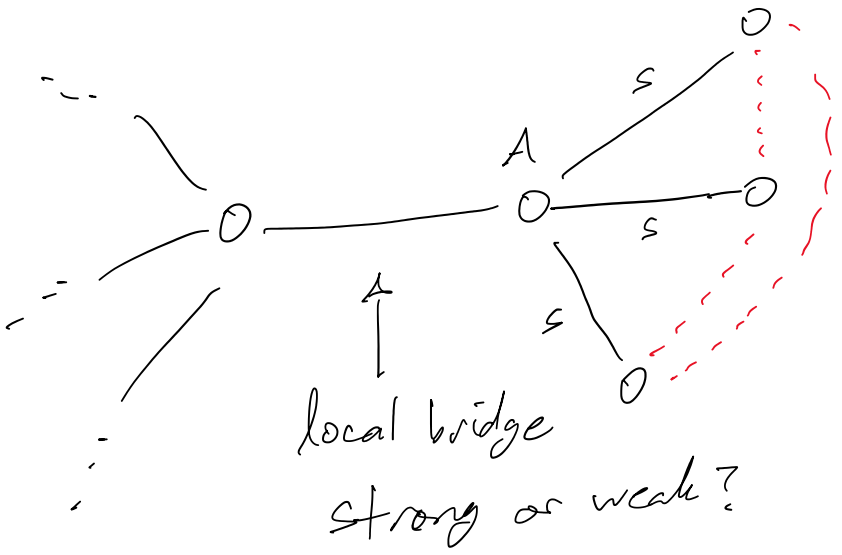
Fact: if node A has ≥2 strong ties & satisfies STC, then any local bridge it is connected to is a weak tie.

Hypothesis: node A has ≥ 2 strong ties



dotted links are there, since A satisfies STC!

MUST be weak, since strong + STC ⇒ not a local bridge.

So: – local bridges are likely sources of new info

– local bridges are likely to be weak ties

– thus, a disproportionate amt of new info comes via weak ties.

Think about the theorem more

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Fact: if node A has ≥2 strong ties (P) & satisfies STC (Q), then any local bridge it is connected to is a weak tie (R).

$P \wedge Q \Rightarrow R$.

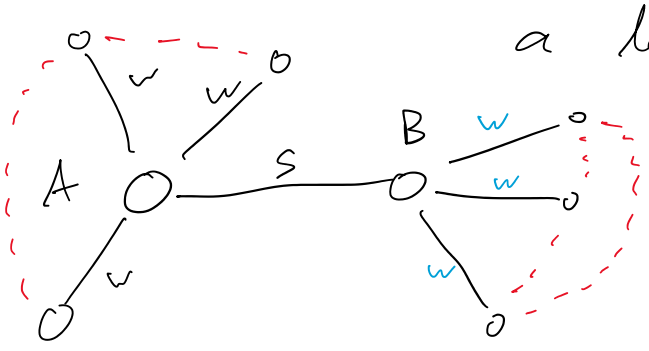
Approach: when you see new theorem, pick apart its assumptions so you understand it.

Q1: what if P fails? (ie., P = False).

then $P \wedge Q$ = False, so R could be false.

P = False: A has ≤1 strong tie.

Can we make that strong tie a local bridge?



Sure!

But what does that say abt B?

only 1 strong tie also!

Think about the theorem more pt 2

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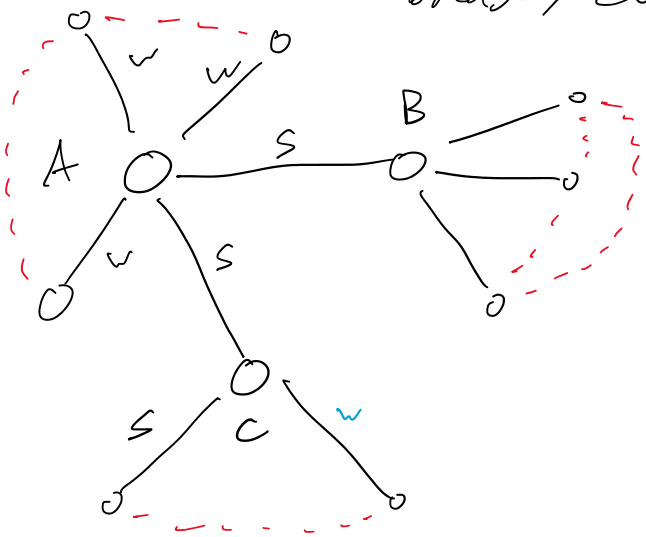
Fact: if node A has ≥2 strong ties (P) & satisfies STC (Q), then any local bridge it is connected to is a weak tie. (R)

$P \wedge Q \Rightarrow R$.

Approach: when you see new theorem, pick apart its assumptions so you understand it.

Q1: what if Q fails? (ie., Q = False).
then $P \wedge Q$ = False, so R could be false.

Q = False: A violates STC.
Now can we make a strong local bridge, even if A has ≥2 strong?



Sure!
But what does that say abt B + C?
both also must violate either P or Q (or both)!

Last note on this

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Read section 3.3 in the EK book: has a lot of info on empirical validation of this idea!

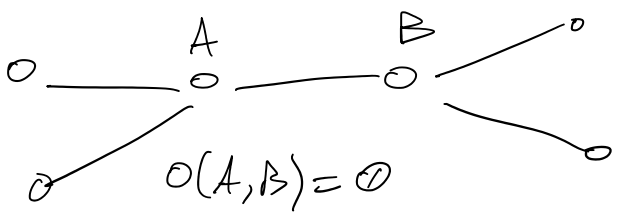
Empirical challenge is interesting; in real life

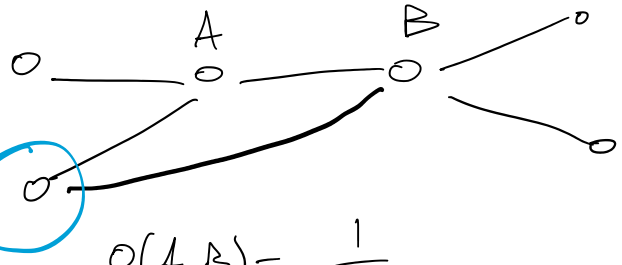
- Ties are not just strong/weak; continuum
- Edges could be "soft" local bridges; important but not sharply so

Cell phone call data:

- Proxy for strength: total time spent on calls
- Proxy for bridge-ness: "neighborhood overlap" of edge:

$$O(A,B) = \frac{\#\text{ nodes connected to both } A, B}{\#\text{ nodes connected to at least one of } A, B}$$





low overlap ⟷ "local bridge-ish"

- Interesting fact: tie strength is positively correlated to neighborhood overlap! (see Fig 3.7 in EK book)