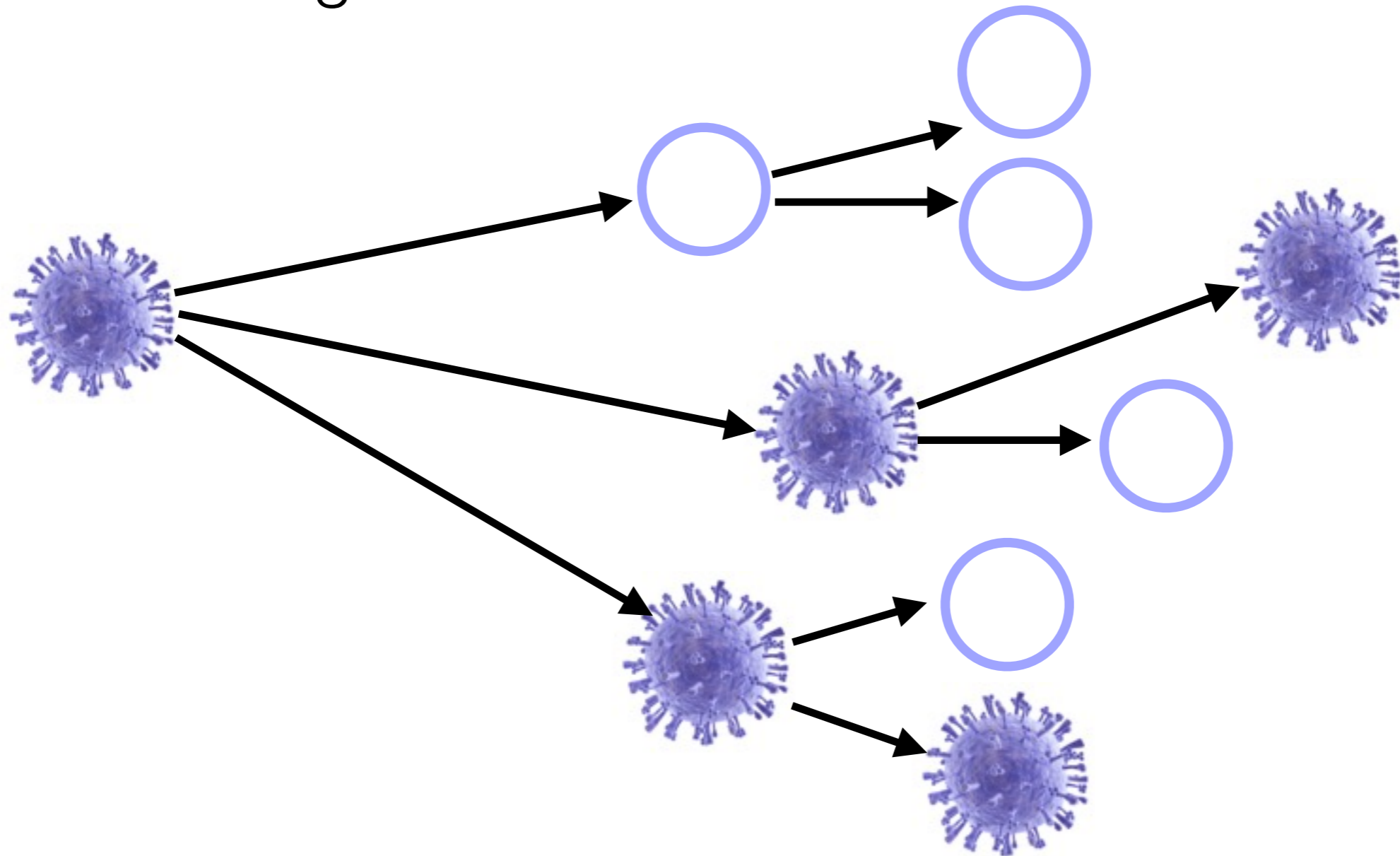# Diffusion of Information:
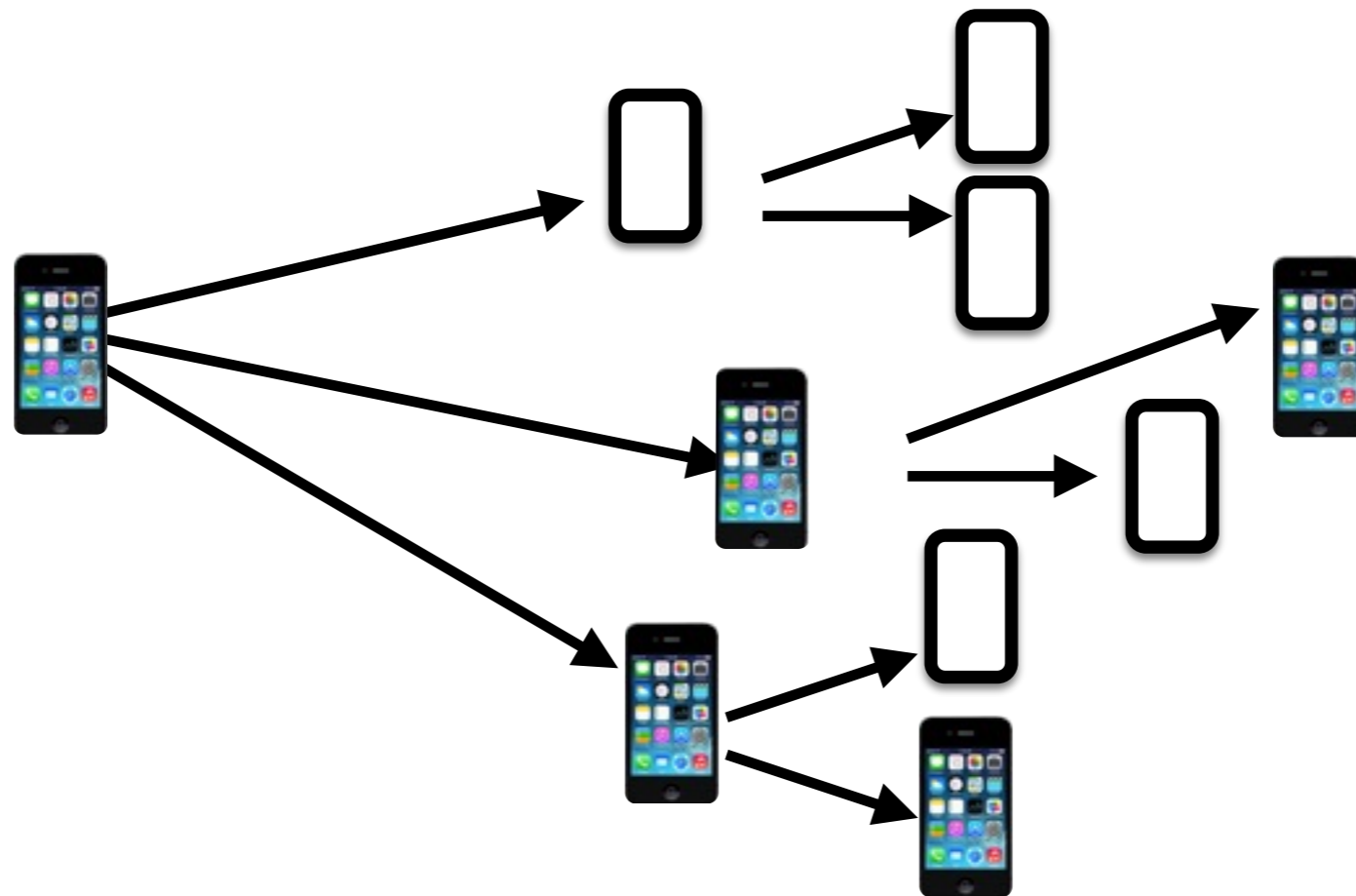# Fads, Viral Videos, Herding and Cascades

Disease vs Information

So far, we've been talking about the spread of disease through a network…

Disease vs Information

But do the things we've learned about the spread of disease transfer to other contexts: information, social norms, political opinions, new technologies?

Disease vs Information

To some extent, yes…

The Bass Diffusion Model models the spread of a new technology, and works much the same way as the SI model
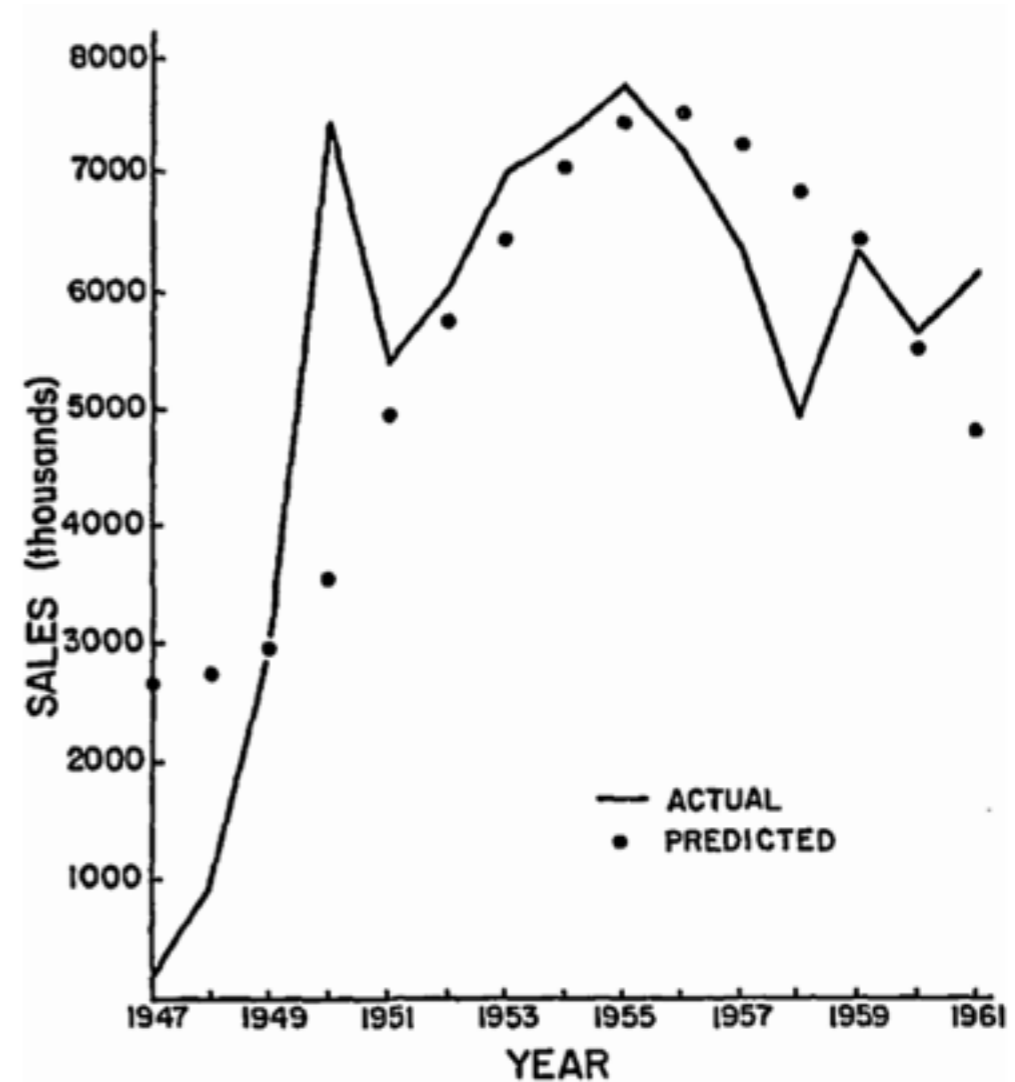
Non-Adopter   Adopter
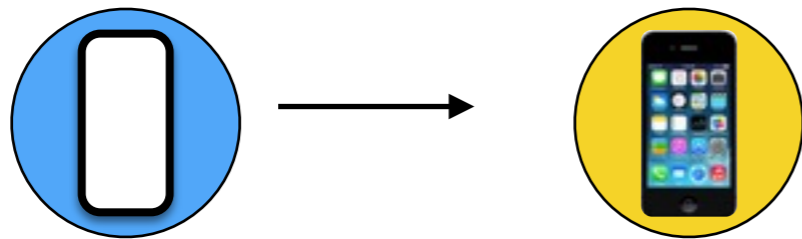

Fig. 6. Actual sales and sales predicted by regression equation (black & white television)
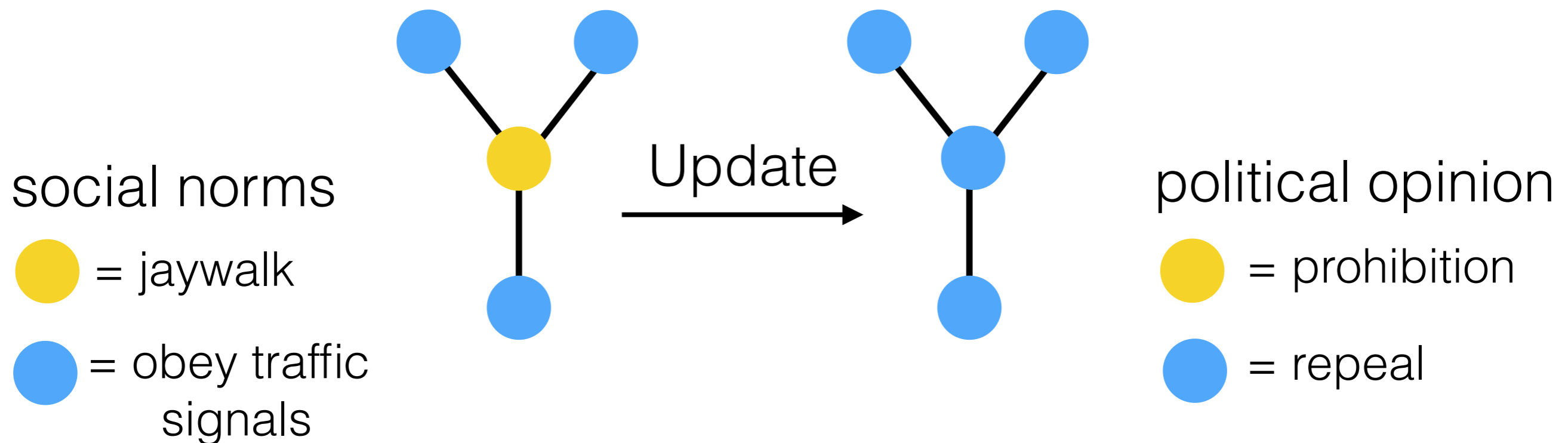
The SIR model in different contexts

Context	S	I	R
virus	suseptible	infected	recovered (dead)
technology	non-adopter	adopter	committed non-adopter
rumors	don't know	know	choose to ignore
fads	unaware	into it	over it

Opinions and Social Norms

Some cases don't fit the SI model quite as neatly (because people can move from I➜S and back again), but they are clearly related:

- Spread of opinions (you change my mind)
- Spread of social norms (we coordinate)

social norms

⬤ = jaywalk

🔵 = obey traffic signals

Update ➜

political opinion
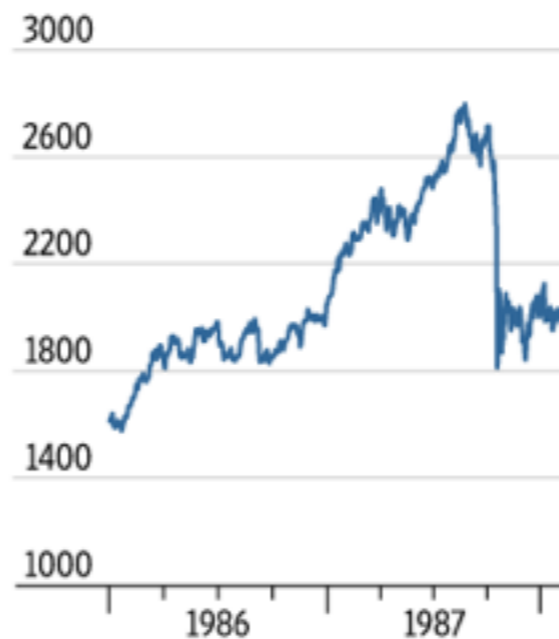
⬤ = prohibition

🔵 = repeal

Social Effects: Herding, Network Effects, and Cascades

But the choices we make (products we adopt, political causes we back, rumors we believe, people we trust) depend on the people we talk to in complex ways, that are often different than the way we get diseases.

US News

Disease vs Information

- Your probability of adopting may not be linear in the number of neighbors who adopt (political opinions, social norms, new technologies, network effects, coordination benefits)

- Inward flow may be deliberately filtered (you may pay more attention to some sources than others)

- Outward flow may be deliberately filtered (you may not bother distributing some information to some parties)

- May be strategic (information may be withheld from some parties or even be deliberately falsified)

Some things to consider about people's behavior…

Case 1: The Solomon Asch Experiment: Social Pressure and Herding

Which of these lines is closest in length to the line at the left?
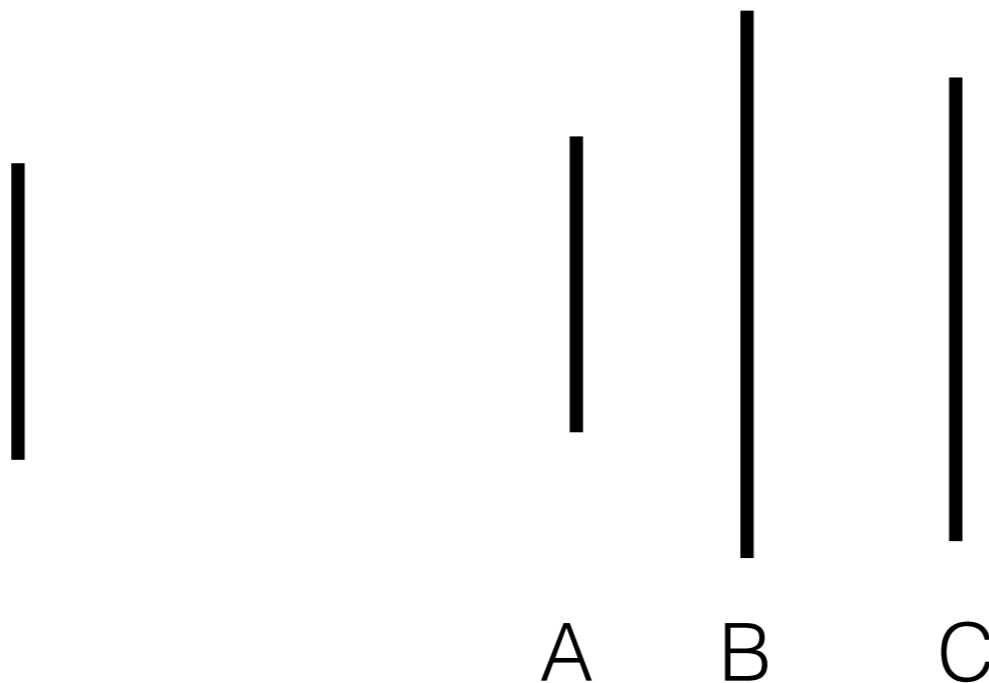

A   B   C

Solomon Asch Experiment

This question was designed to have an obvious answer, but when 7/8 (planted) subjects gave the wrong answer, a surprising number of real subjects wound up agreeing with the majority

A   B   C

This kind of social influence is sometimes called "herding"

Case 2: Perceptions of neighbors

Your heritage is being vandalized every day by theft losses of petrified wood of 14 tons a year, mostly a small piece at a time.


VS

Please don't remove the petrified wood from the Park, in order to preserve the natural state of the Petrified Forest

Perceptions of neighbors

| Condition and Graphic	Doorhanger Text	
Descriptive Normative Information	**Join Your Neighbors in Conserving Energy**. Summer is here and most people in your community are finding ways to conserve energy at home. How are San Marcos residents like you conserving this summer? By using fans instead of A/C! Why? In a recent survey of households in your community, researchers at Cal State San Marcos found that ____% of San Marcos residents often use fans instead of air conditioning to keep cool in the summer. Using fans instead of air conditioning- Your Community's Popular Choice!	−
Self-Interest	**Save Money by Conserving Energy**. Summer is here and the time is right for saving money on your home energy bill. How can you save money this summer? By using fans instead of A/C! Why? According to researchers at Cal State San Marcos, you could save up to $54 per month by using fans instead of air conditioning to keep cool in the summer.	+
Environment	**Protect the Environment by Conserving Energy**. Summer is here and the time is right for reducing greenhouse gases. How can you protect the environment this summer? By using fans instead of A/C! Why? According to researchers at Cal State San Marcos, you can prevent the release of up to 262 lbs of greenhouse gases per month by using fans instead of air conditioning to keep cool this summer! Using fans instead of air conditioning- the Environmental Choice.	++
Social Responsibility	**Do Your Part to Conserve Energy for Future Generations**. Summer is here and we need to work together to conserve energy. How can you conserve energy for future generation? By using fans instead of A/C! Why? According to researchers at Cal State San Marcos, you can reduce your monthly demand for electricity by 29% using fans instead of air conditioning to keep cool this summer! Using fans instead of air conditioning- the Socially Responsible Choice.	+++
Information Only	**Energy Conservation**. Summer is here and the time is right to conserve energy. How can you conserve energy this summer? By using fans instead of A/C!	++++

Case 3: Self Fulfilling Prophecies

You want to go to a party if it is well-attended, but not if nobody is there.
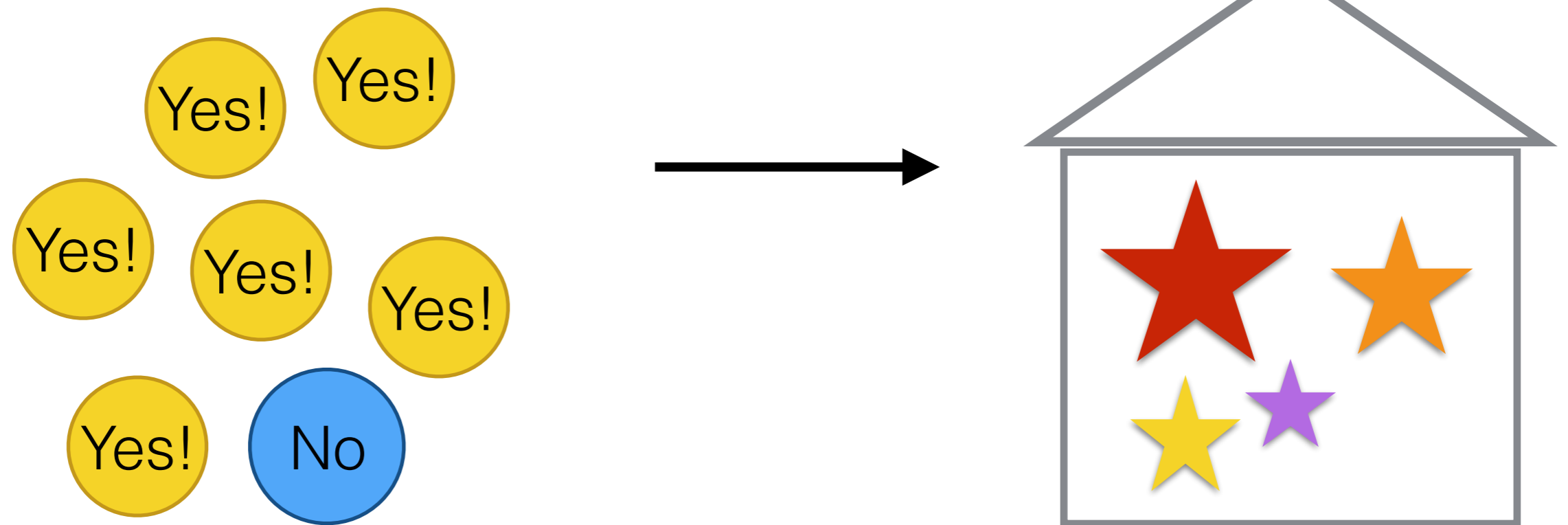
If lots of people *think* the party will be well-attended, then they will go. And it will be well-attended.

Self Fulfilling Prophecies

If people believe that it will be poorly attended, nobody will go, and it will be poorly attended.
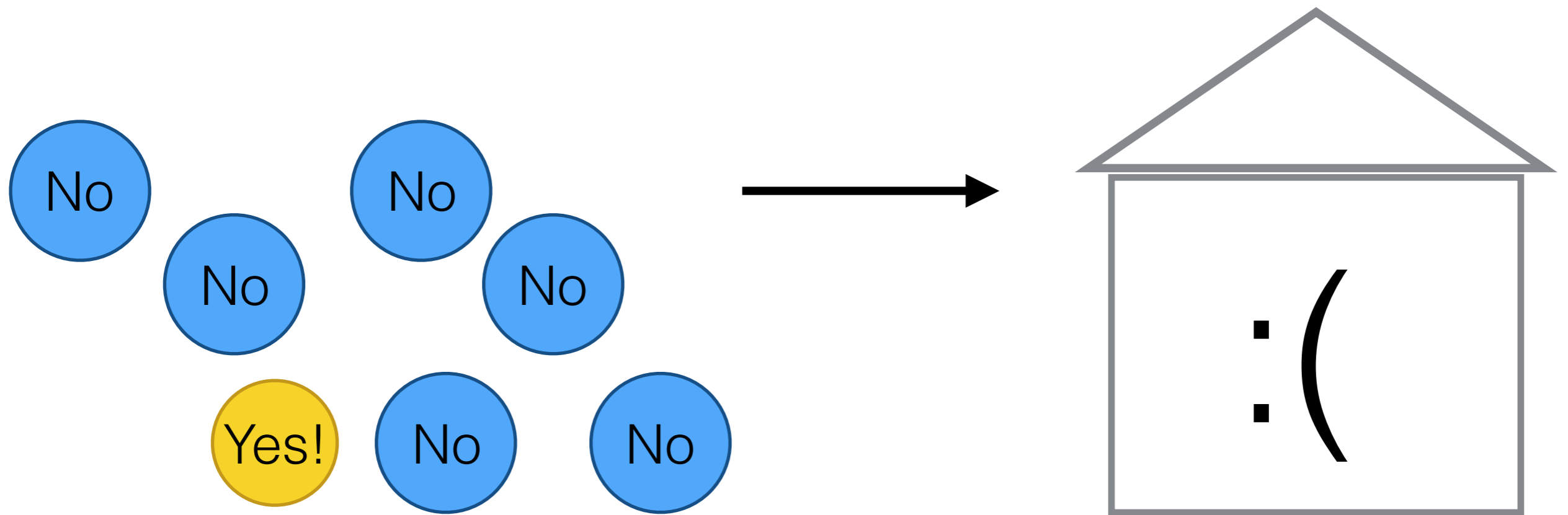
This is true, *regardless of how many people would have enjoyed themselves if everyone had attended*: perception becomes reality

Self Fulfilling Prophecies

If people talk to each other, they may become convinced their initial guess was wrong, even if it wasn't

This may even change the outcome

:(
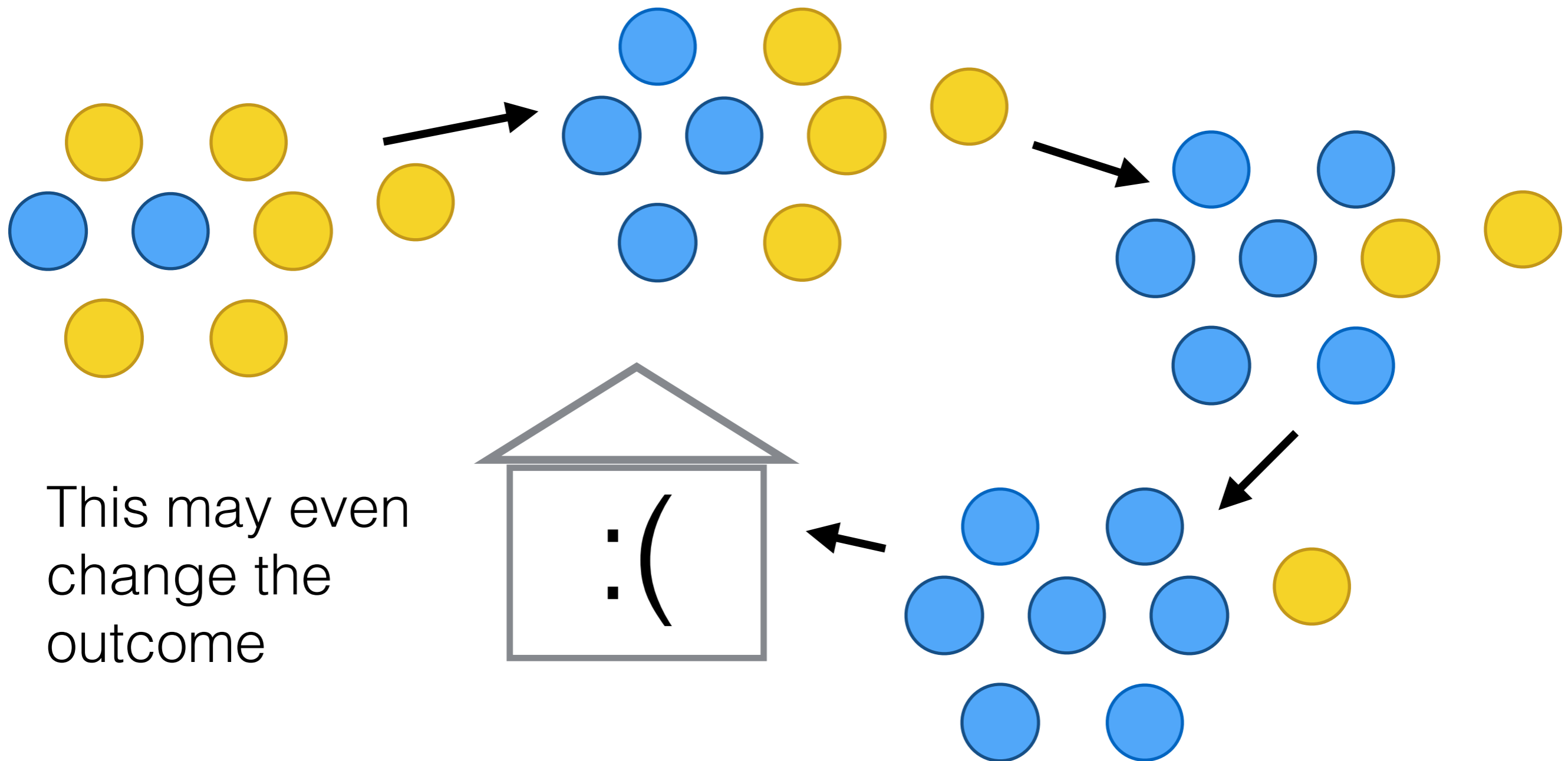
An aside about tulips…

In the mid 17th-century, the Netherlands was a nation full of newly-wealthy merchants.

One way to display of wealth was gardens: tulips were a new and ultra-exclusive flower

An aside about tulips…
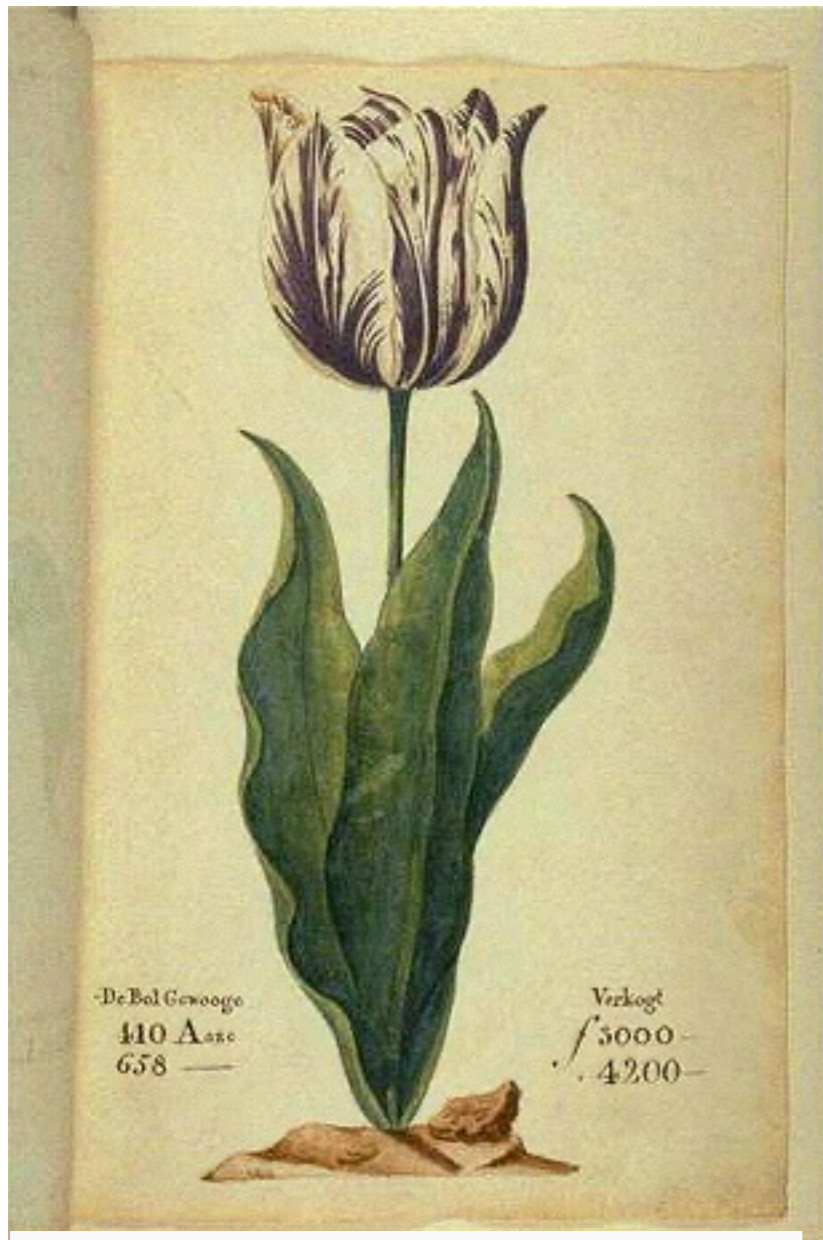
The "Viceroy" tulip in the 1637 Dutch catalog 'Verzameling van een Meenigte Tulipaanen'

Tulips became a huge fad: a viral product before that term existed.

The popularity of tulips led to a proliferation of varieties.

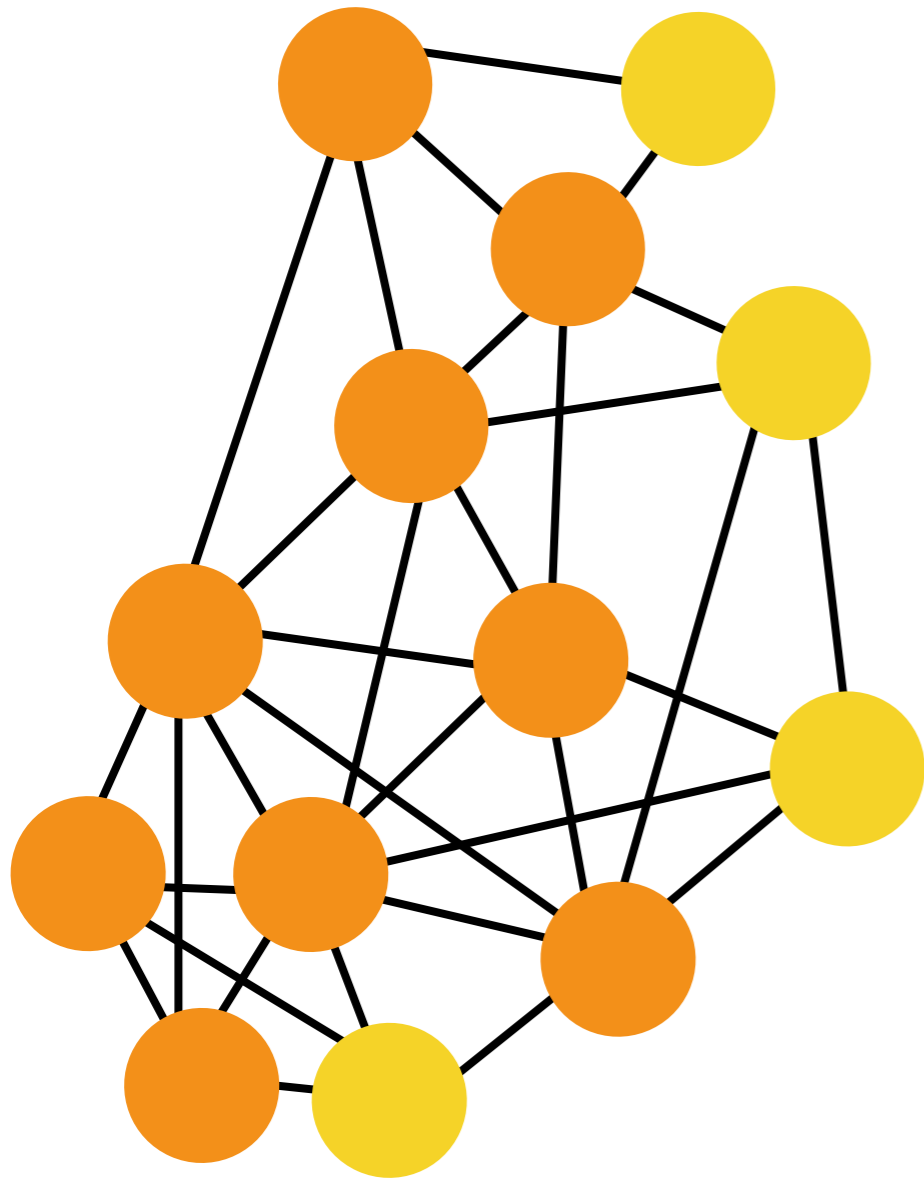The most desirable varieties became increasingly expensive.
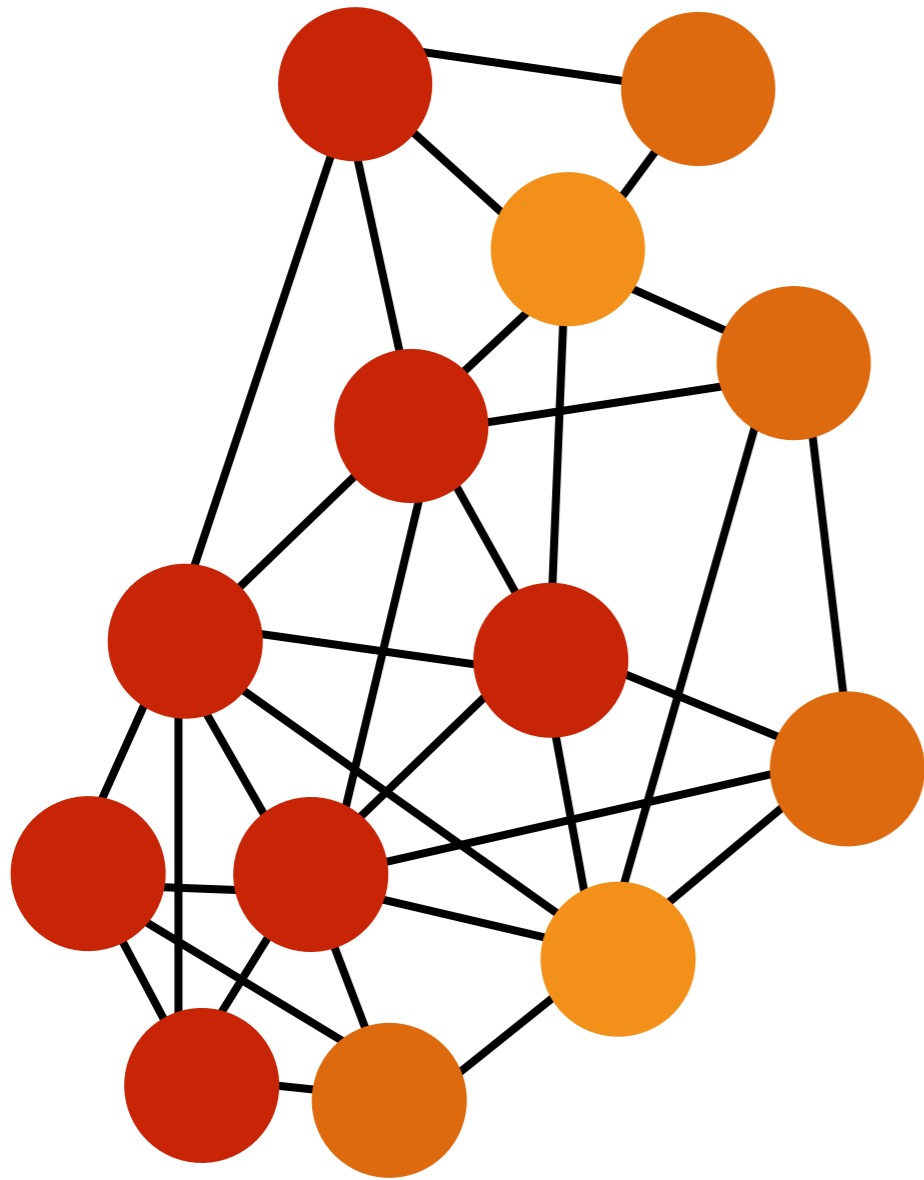
An aside about tulips…

Speculators started buying bulbs, not to plant, but as an investment

Very few people actually sold the bulbs, but there was a lot of talk!

That talk fueled the belief that the bulbs were a good investment, which drove prices even higher!

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An aside about tulips…

The *Semper augustus*, famous for being the most expensive tulip sold during tulip mania.
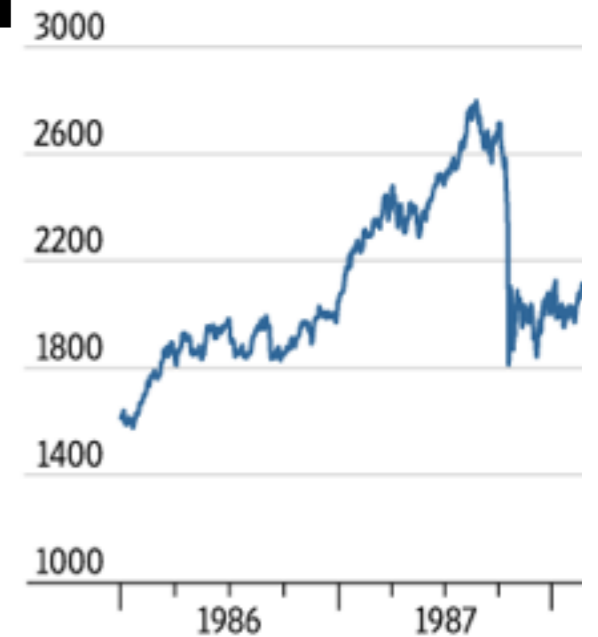
Eventually, prices got totally out of control.

These days, there is considerable disagreement over how bad it got at the peak: the original source of the story puts a single bulb being priced at a year's wages for 16 skilled laborers

An aside about tulips…

The bubble burst, as all bubbles do.
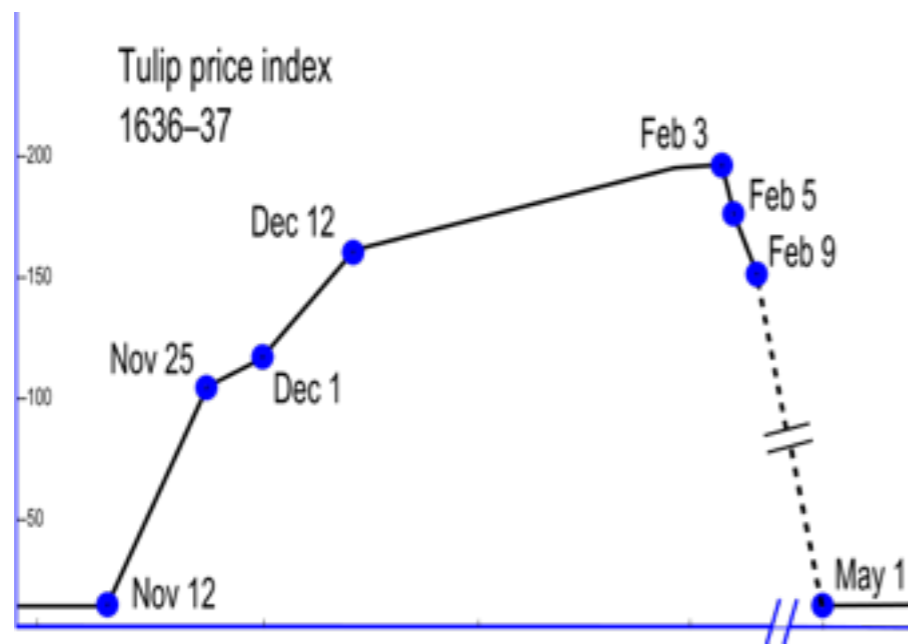
ref: Earl Thompson
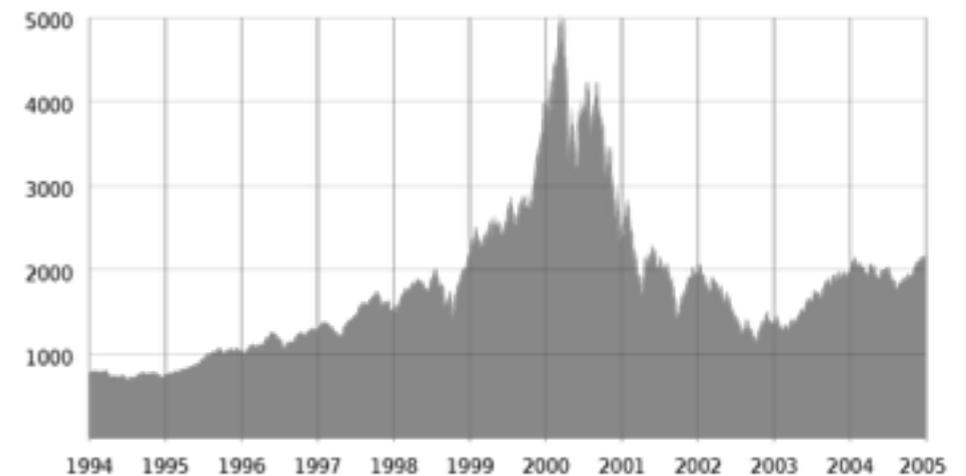
It is uncomfortably unclear what makes bubbles burst, and in particular, what governs the timing. But it seems like the mechanism is similar to their growth, just in reverse.

Case 4: Network Effects

Sometimes, you are influenced by your social circle, not because of peer pressure or information, but because they are more useful if more people have them

Nobody wants to be the only person with a video phone.
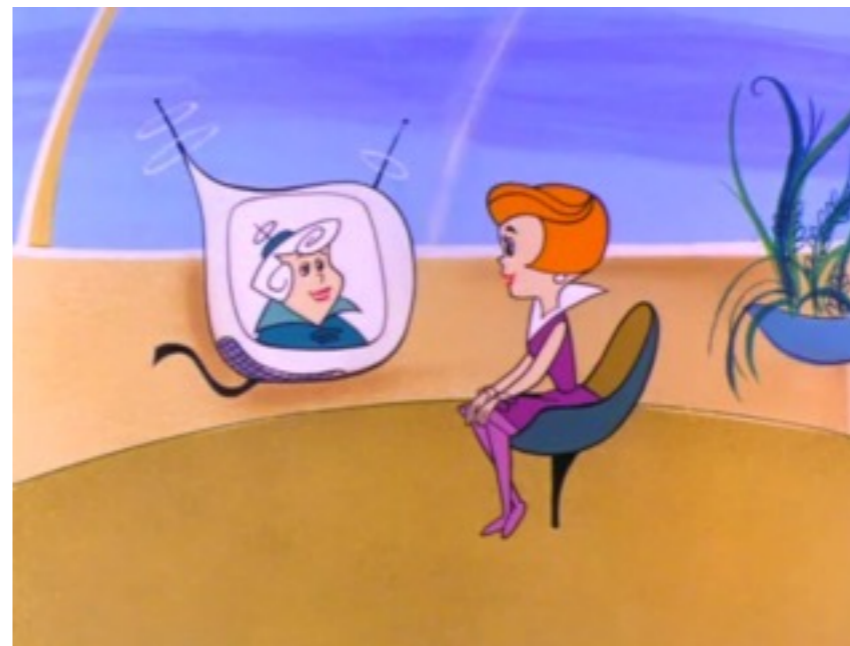
Network Effects

This is one of the things that is preventing the spread of hydrogen-powered cars…nobody wants a car that you can't fuel up.

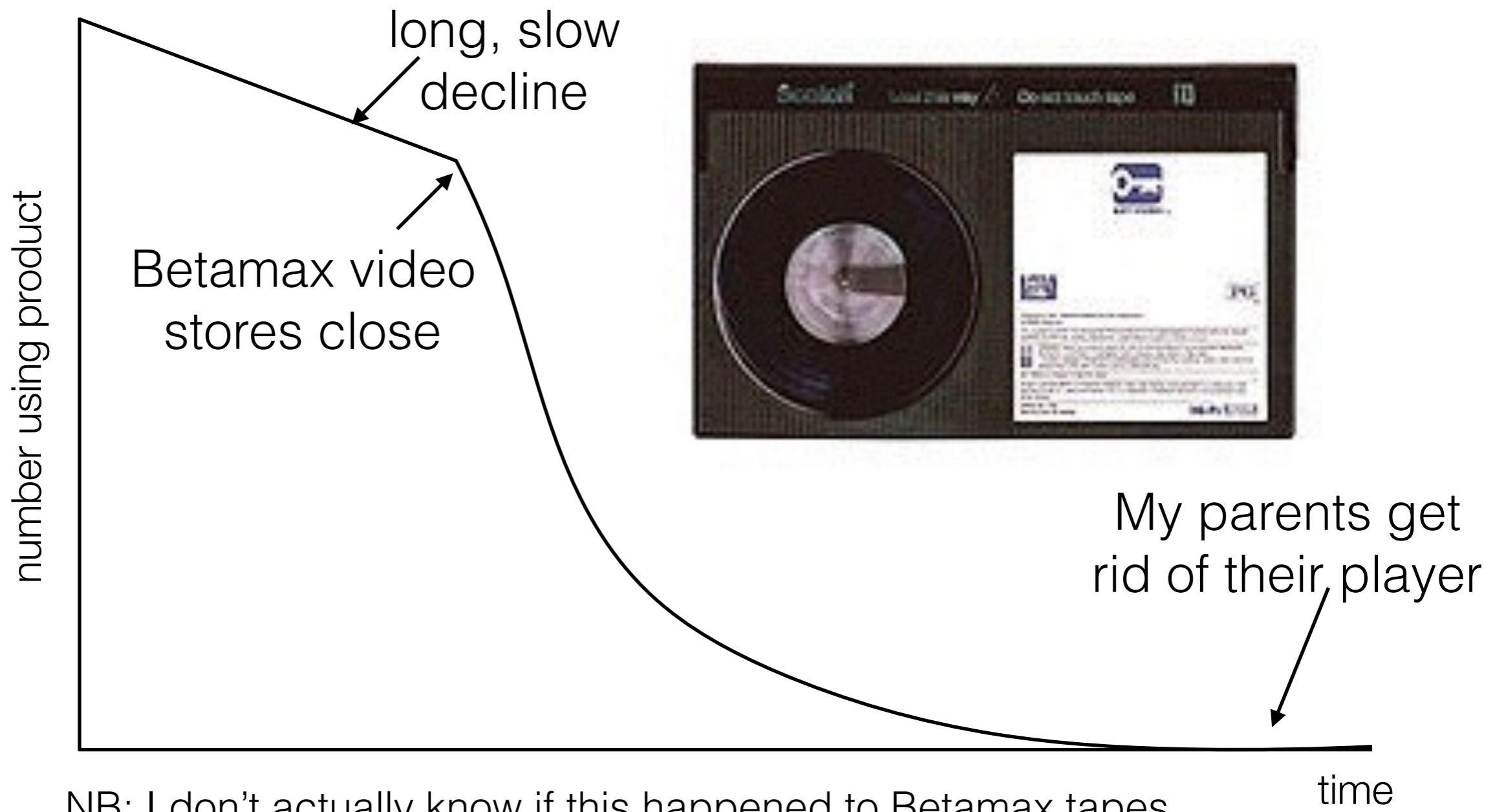But there will only be fuel points when enough people own hydrogen-powered cars.

Network Effects

This creates a kind of threshold effect: the adoption of a product is limited at first, then takes off.

number using product

Everyone is using it

Explosive growth

Somewhere around here enough people start using the product to make it useful

(This curve should look more than a little familiar)

Early Adopters

time
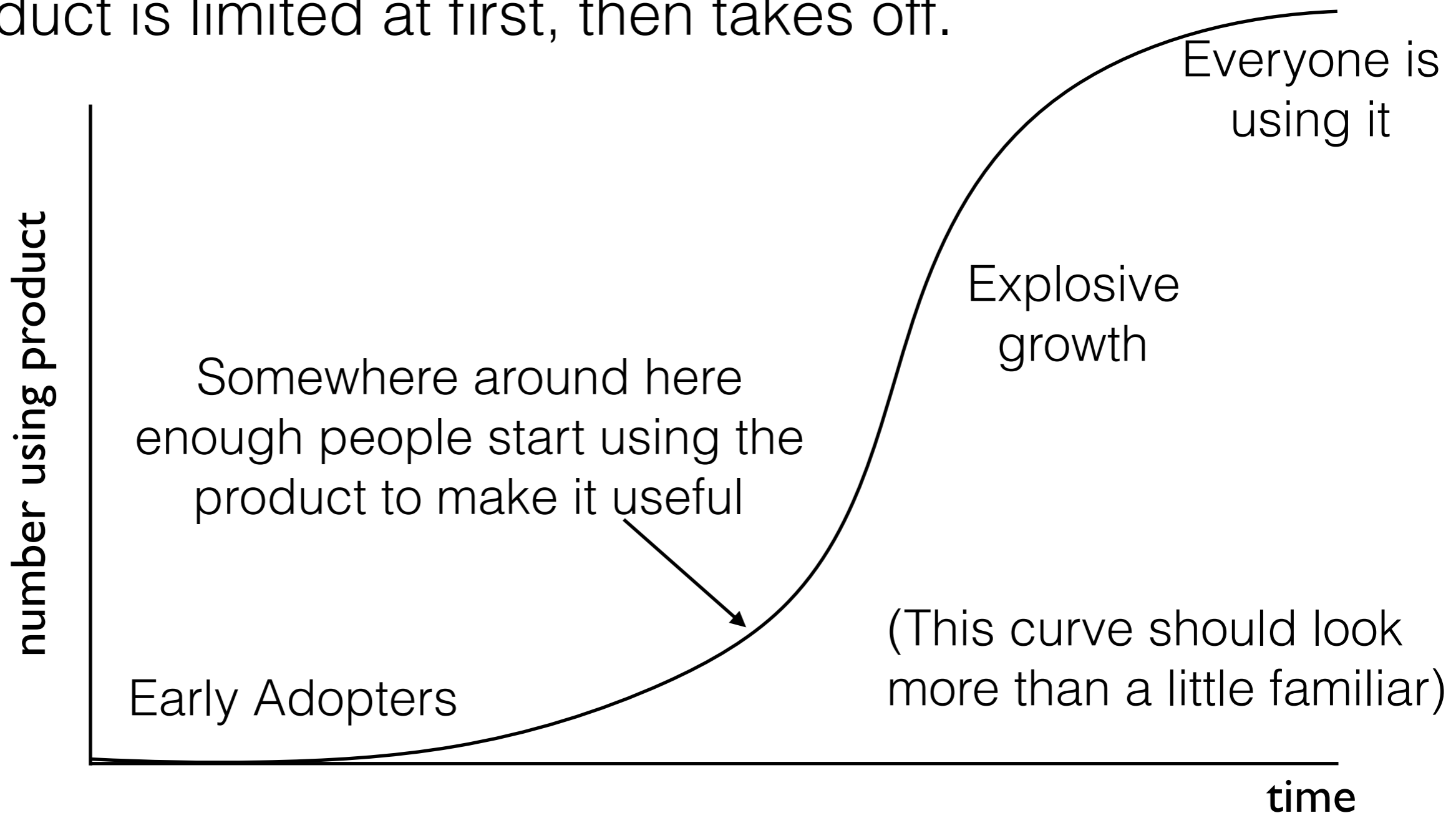
Network Effects

The effect can work in reverse too…it can completely kill products that otherwise might have lingered on

long, slow decline

Betamax video stores close

number using product

My parents get rid of their player

time

NB: I don't actually know if this happened to Betamax tapes. I don't have the data on that But it seems plausible.

Network Effects

Getting past that initial threshold is a challenge many modern products face, because they involve a social element. Social products only work once they have a large enough user base
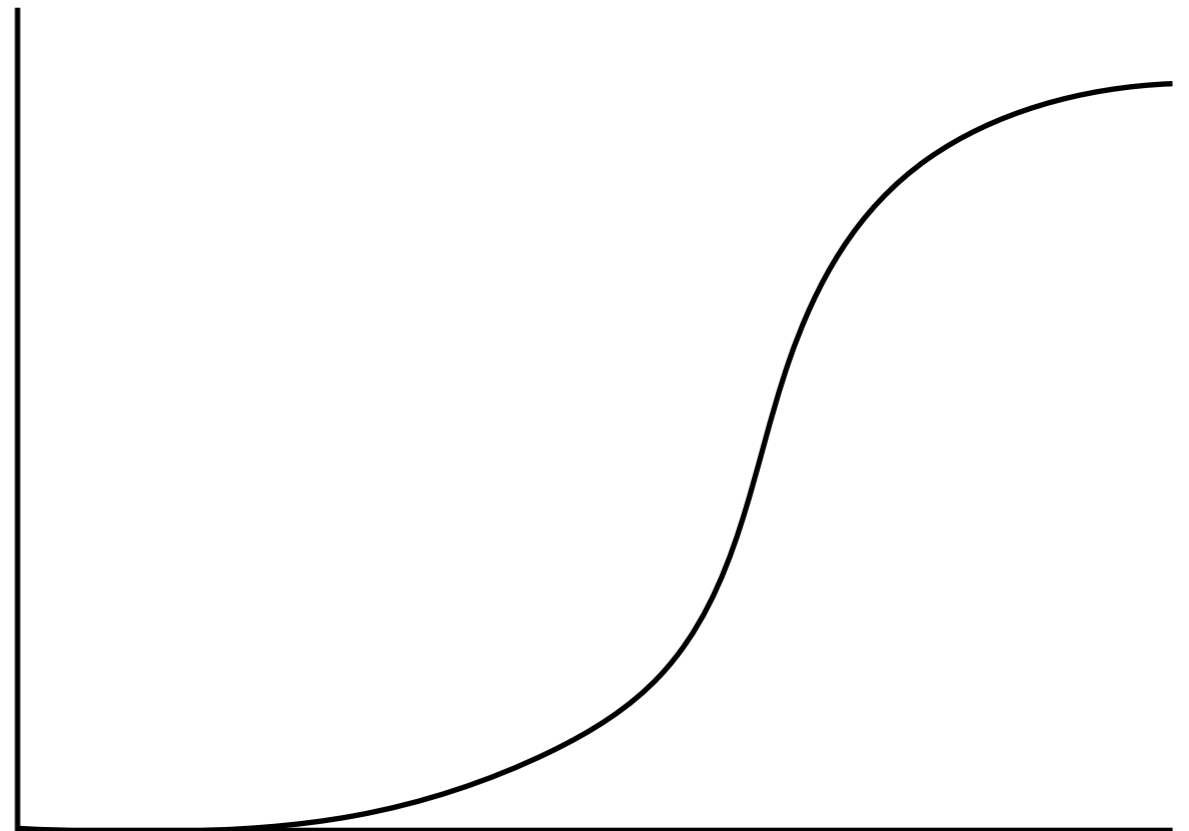
Now, to apply some of these things to social networks…

Threshold Models of Decision Making

Suppose you are in Asch's experiment: if one person's answer differs from yours, you might just suspect they are thick
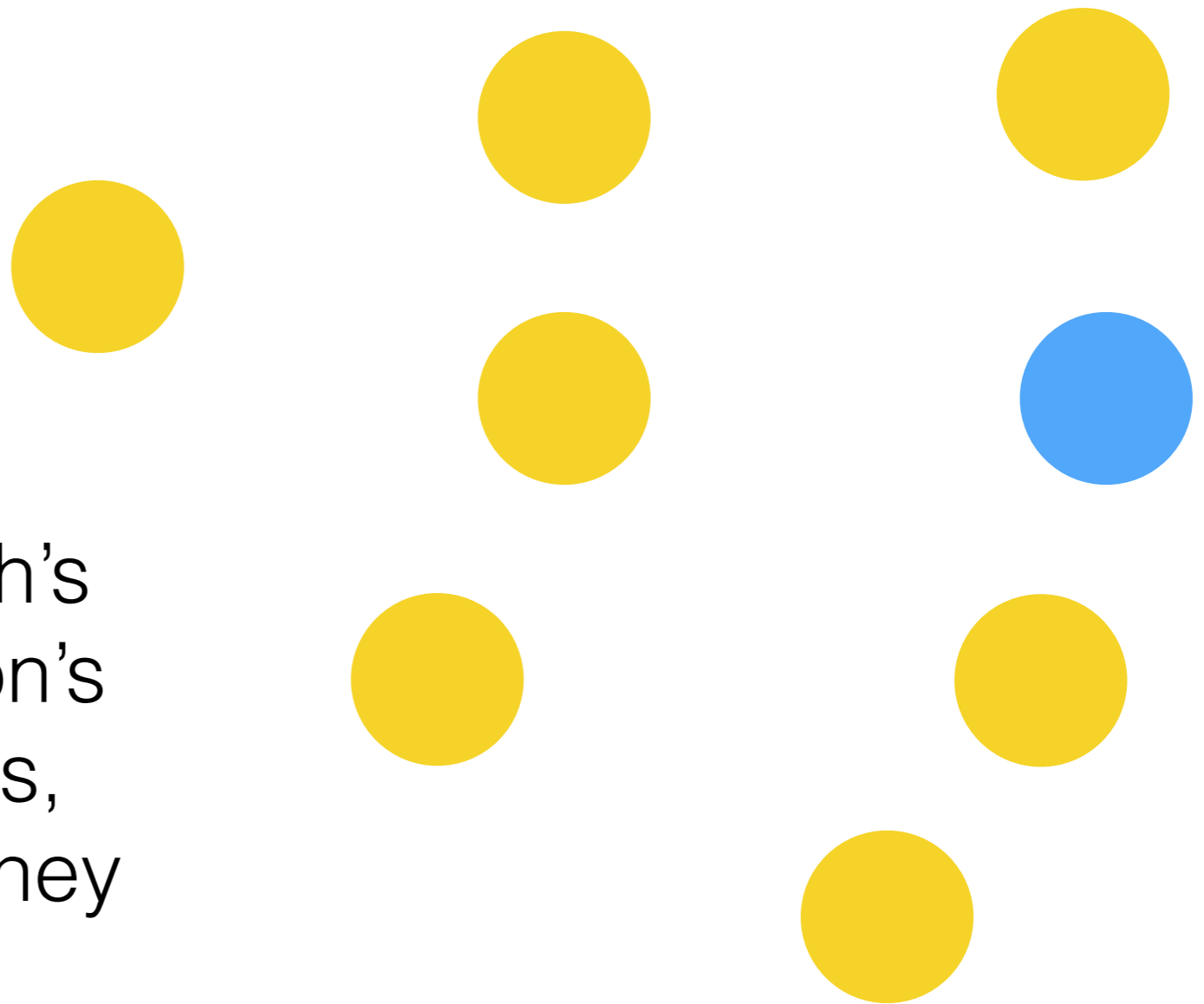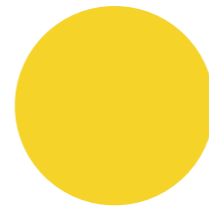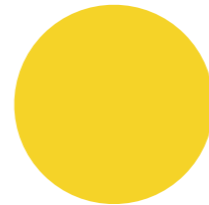
Threshold Models of Decision Making
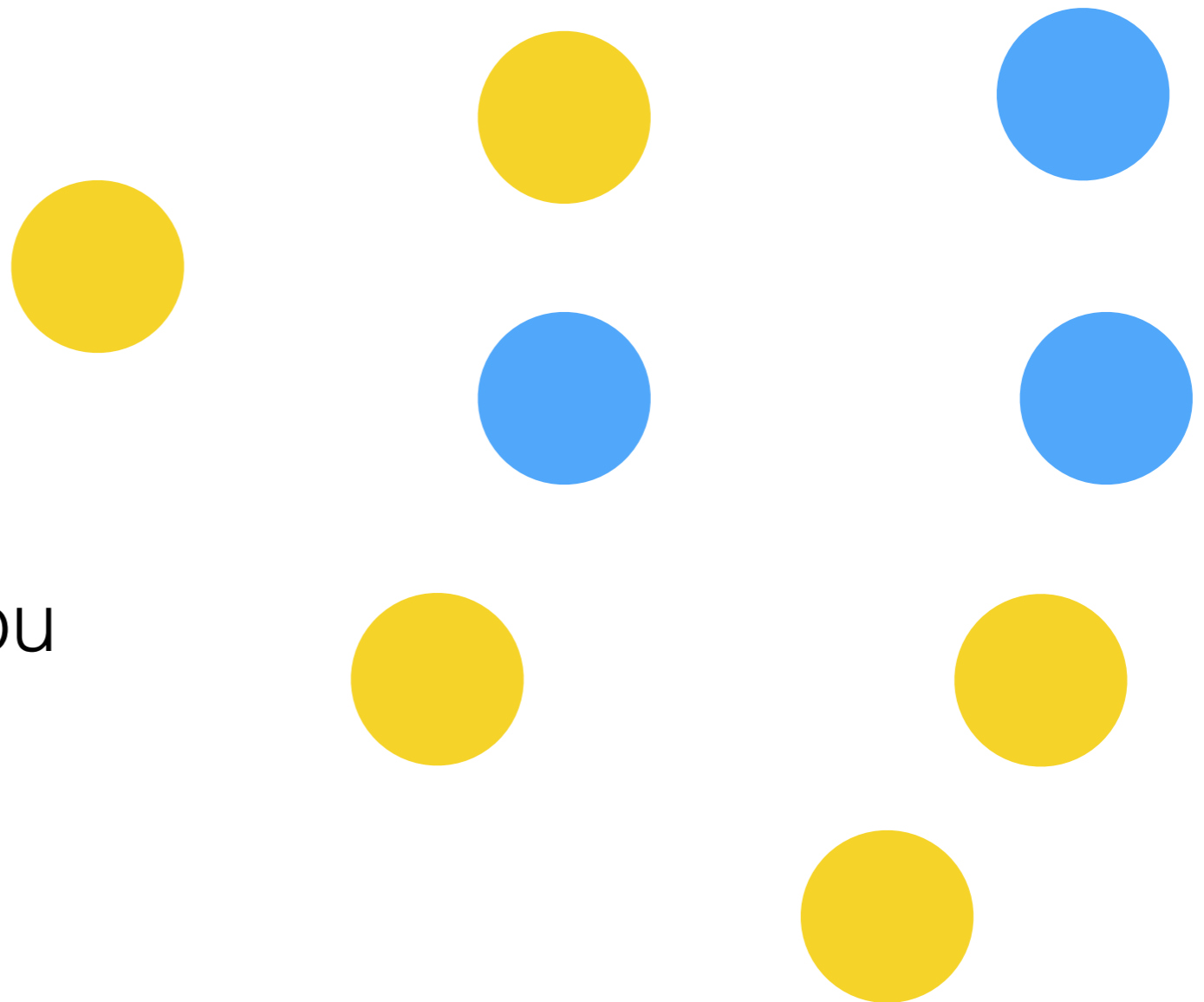
But if several dissent, you may start to doubt your understanding of the problem…

Threshold Models of Decision Making

At some point, enough people will voice a different opinion that you will be convinced to switch your initial opinion.

This is called a *threshold model*
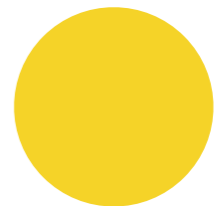
Thresholds in Diffusion

You can apply this to diffusion: suppose instead of requiring only one exposure to something, you need multiple exposures.

More than one person has to tell you a rumor before you believe it…

More than one person has to recommend a restaurant before you'll try it…

More than one friend has to support a political candidate before you'll consider it…

Complex Contagions

Simple contagions: you only need one contact to become infected

> Examples: common cold, what happened in last night's episode, the temperature outside

In *complex contagions* you need more than one contact—a threshold number of contacts

> Examples: adopting a new technology, acting on risky information, social norms, political opinions
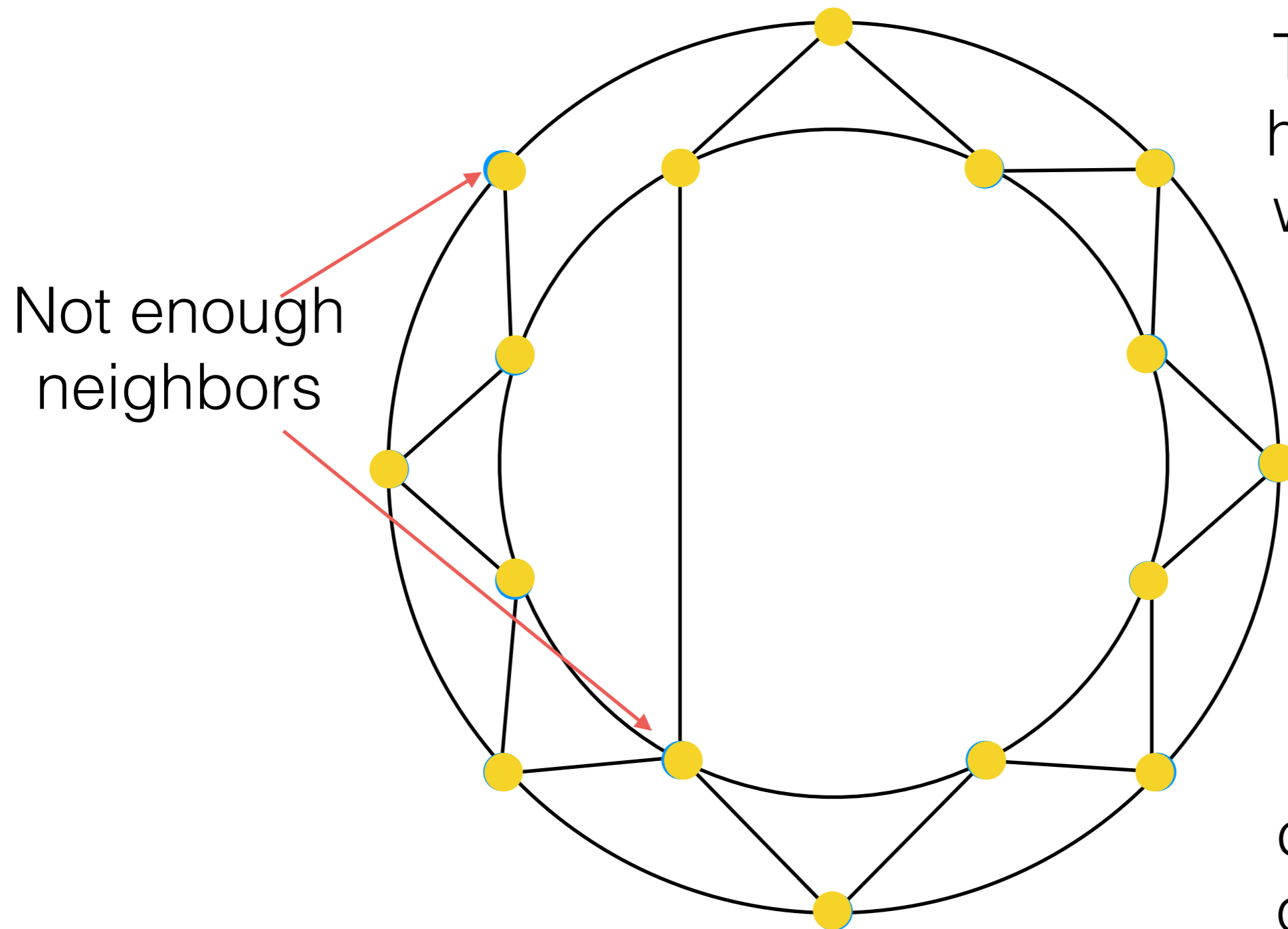
Simple Contagion
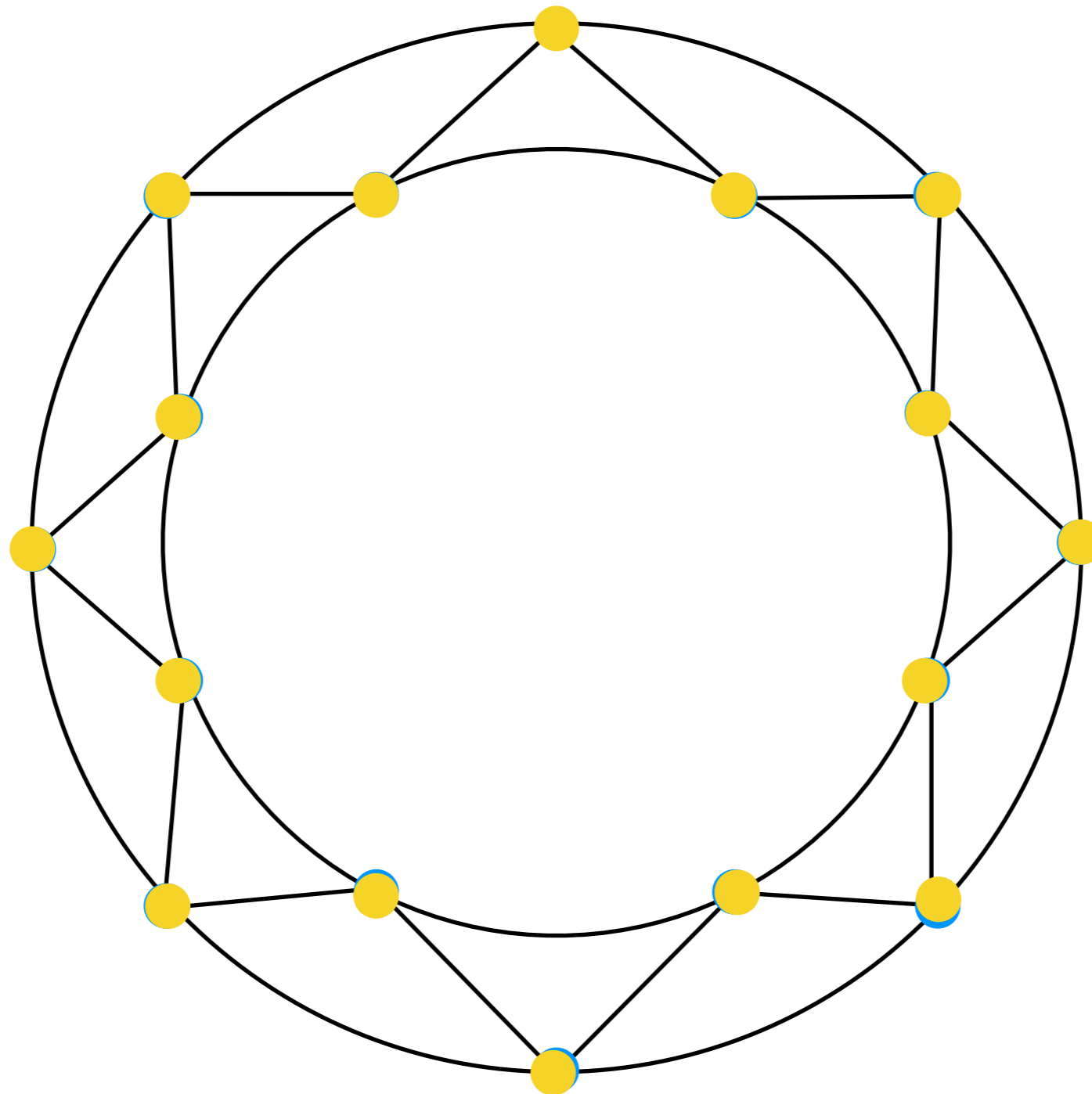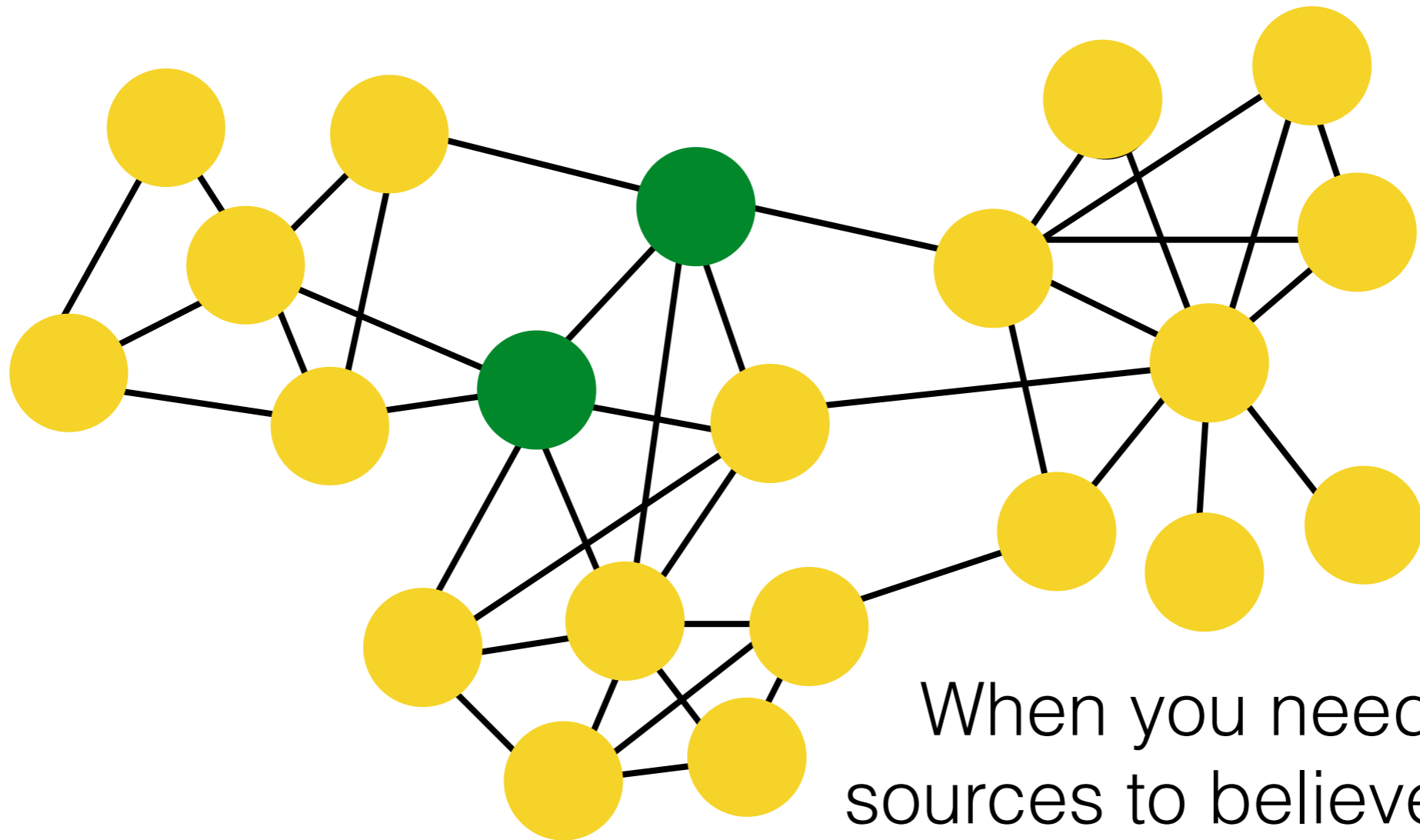
Complex Contagion

Simple Contagion

Complex Contagion
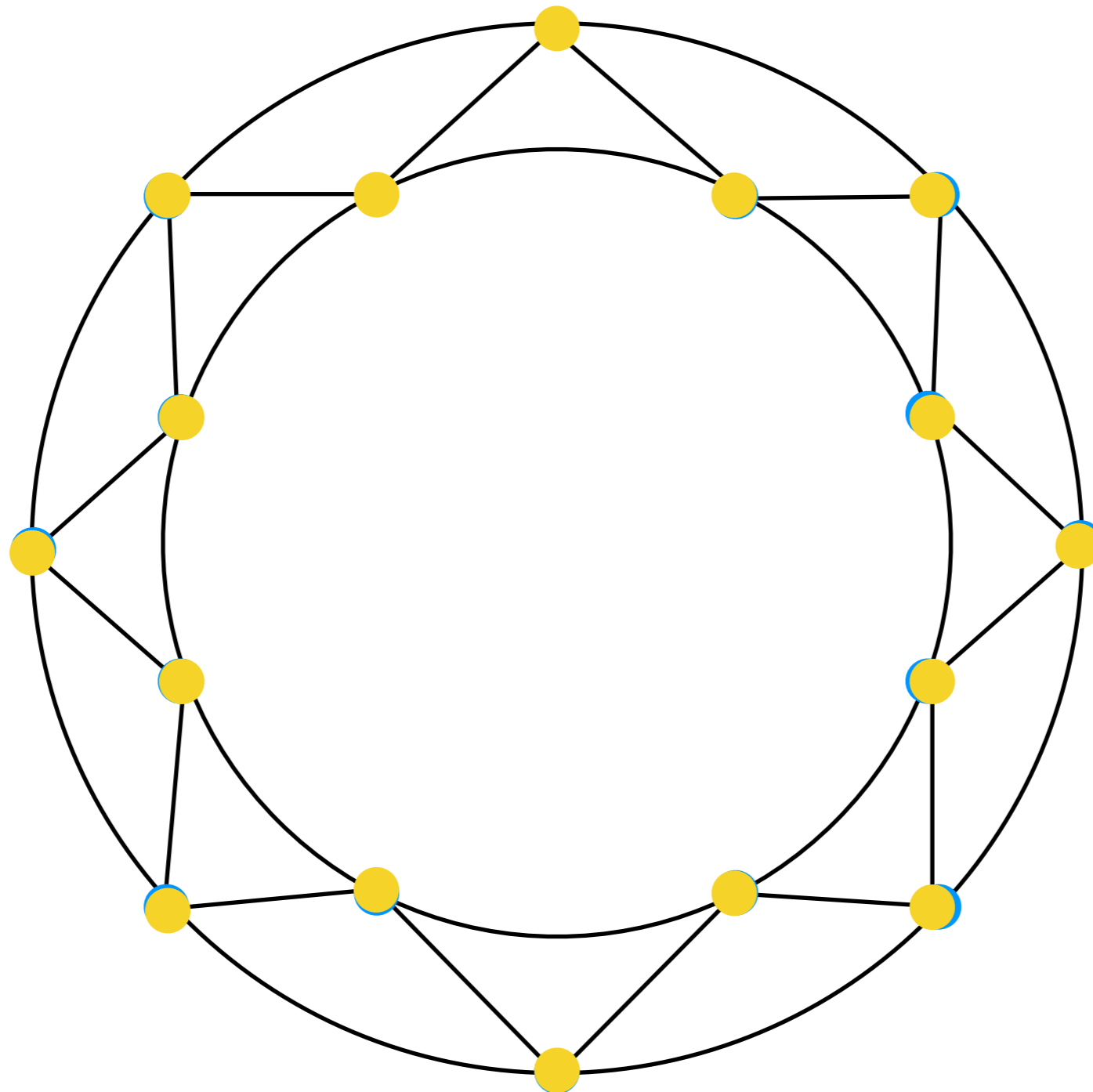
The information has to go all the way around the network!
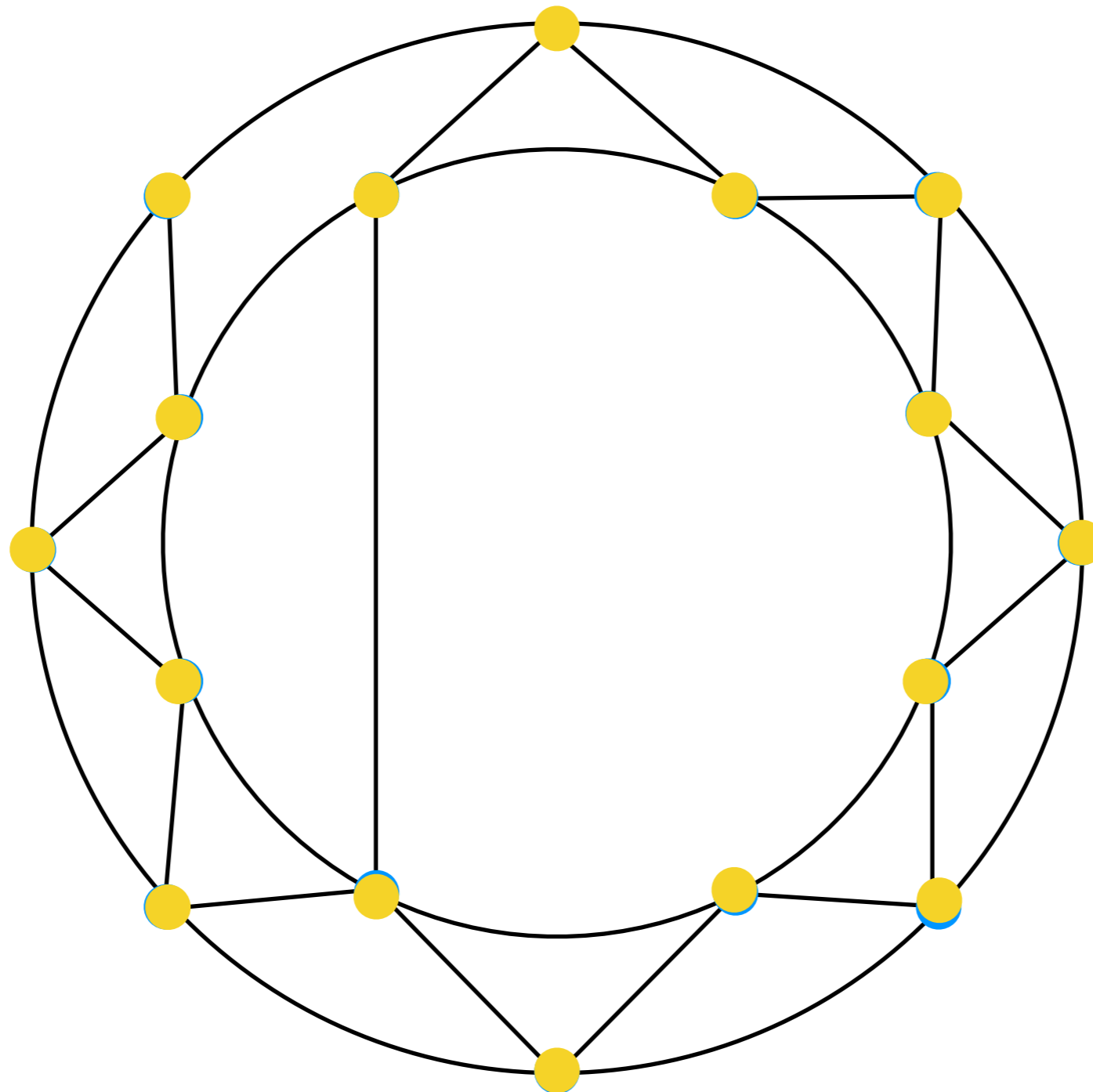
Not enough neighbors

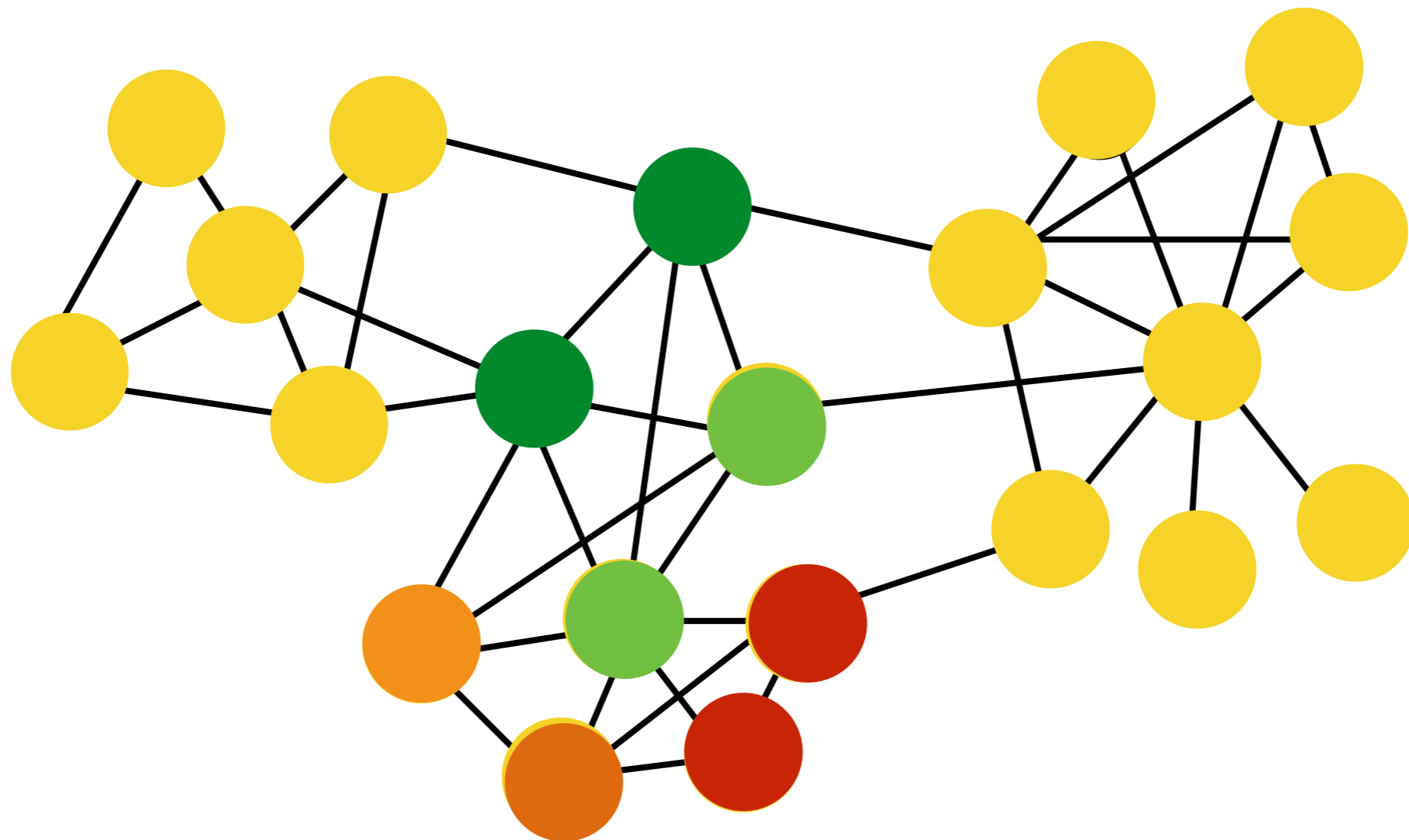The lesson: complex contagions rely on *redundancy*
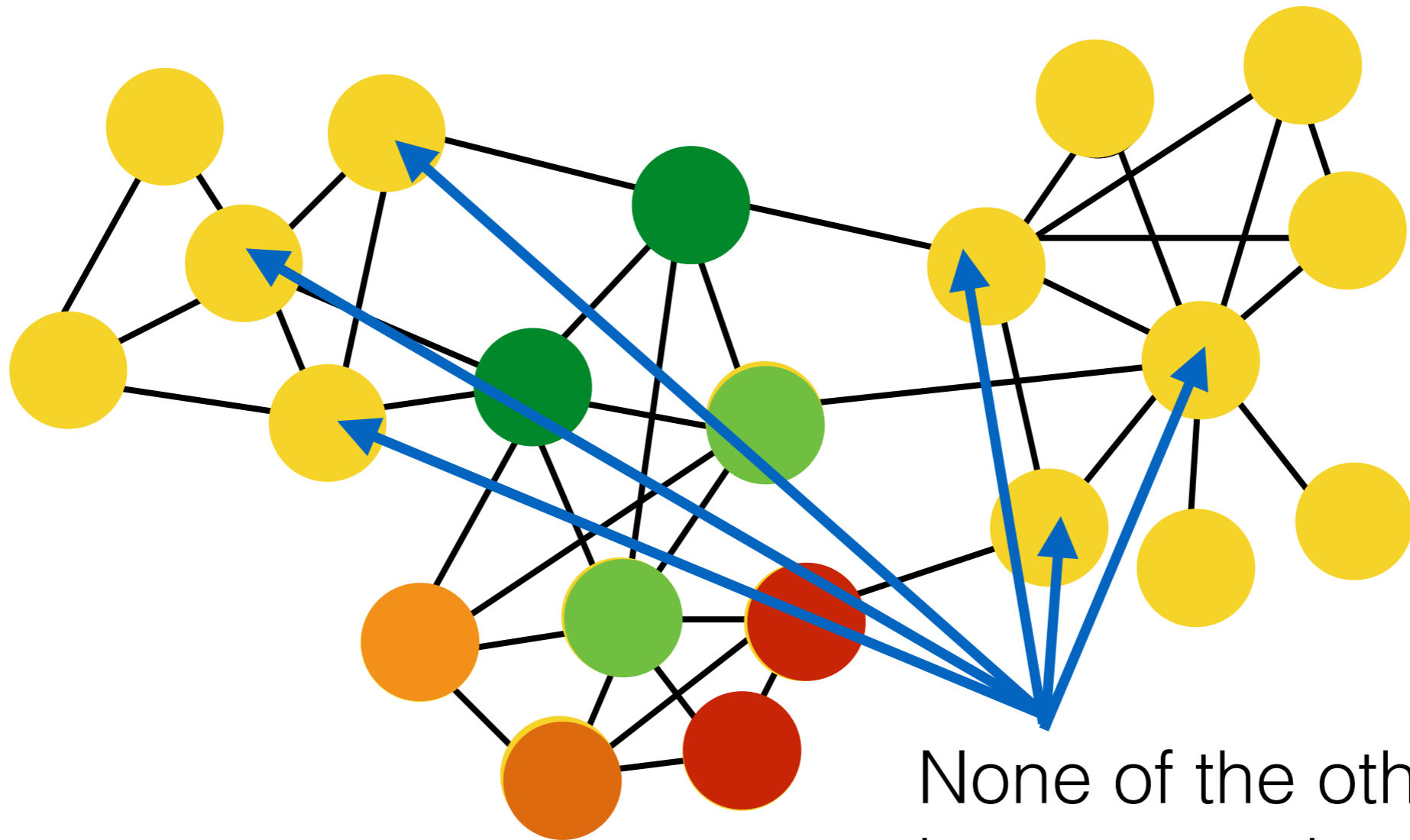
Complex Contagions

When you need multiple sources to believe a piece of information, you can end up with "pockets" of people who believe different things.
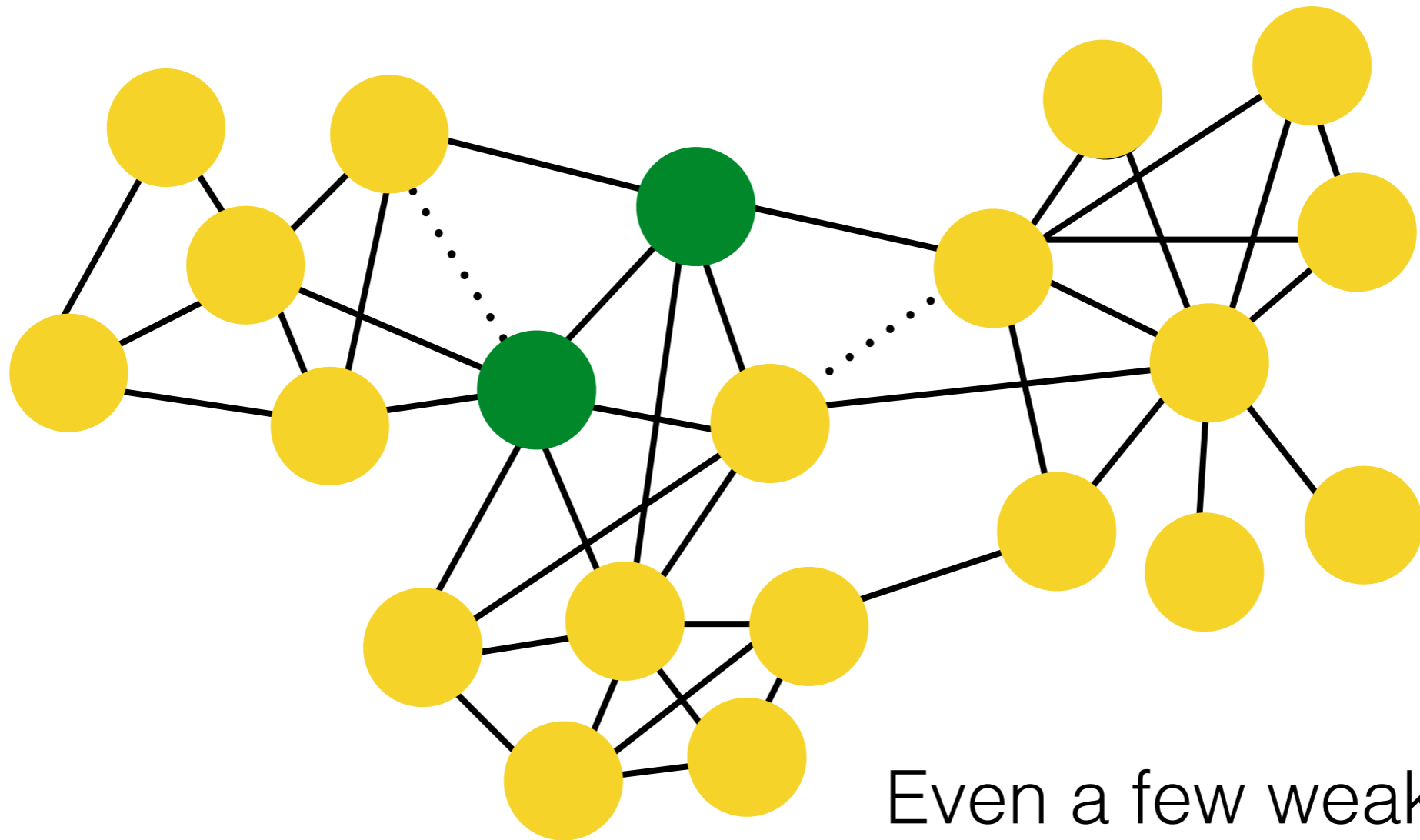
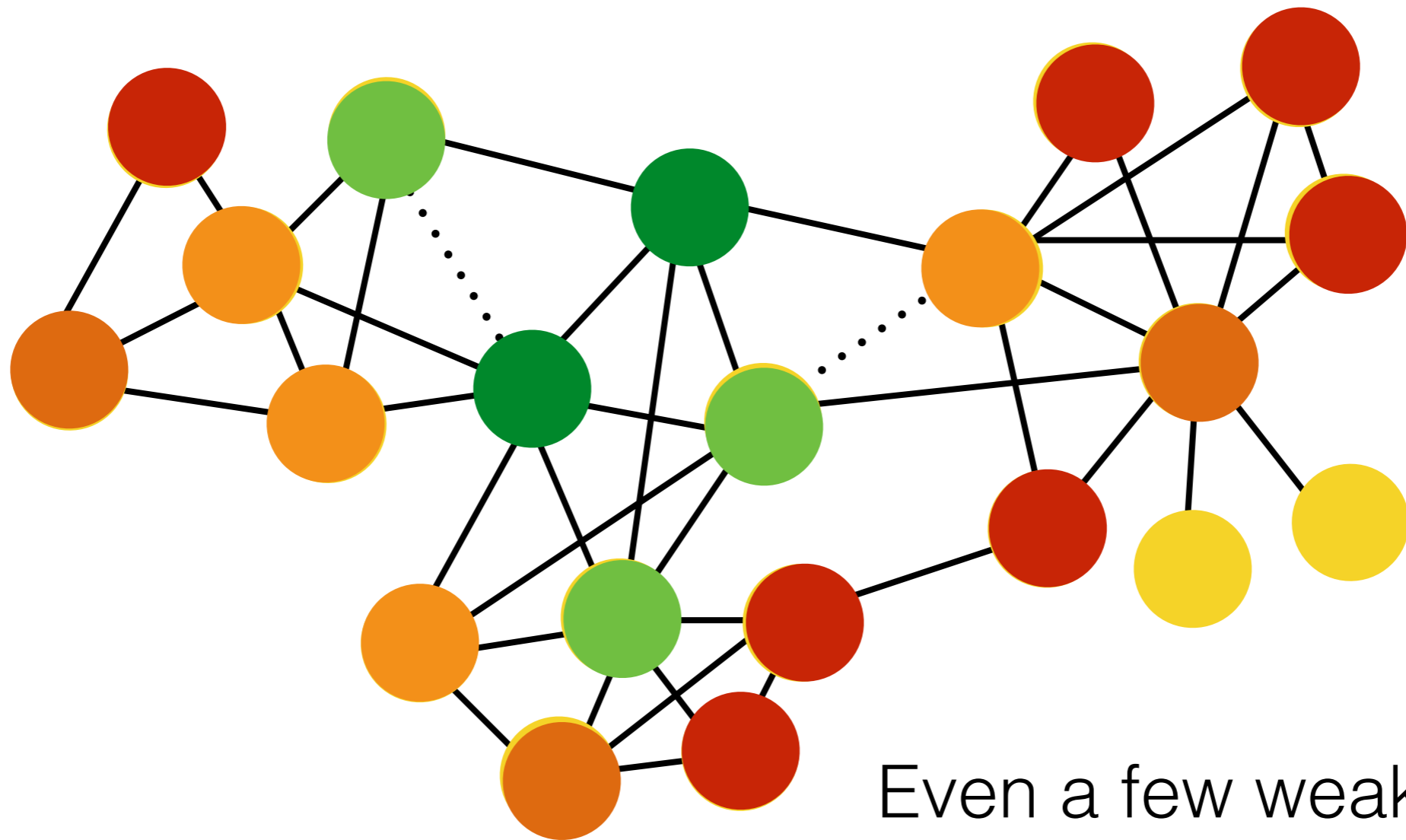# Complex Contagions

Complex Contagions

None of the other nodes have enough sources to believe the information!
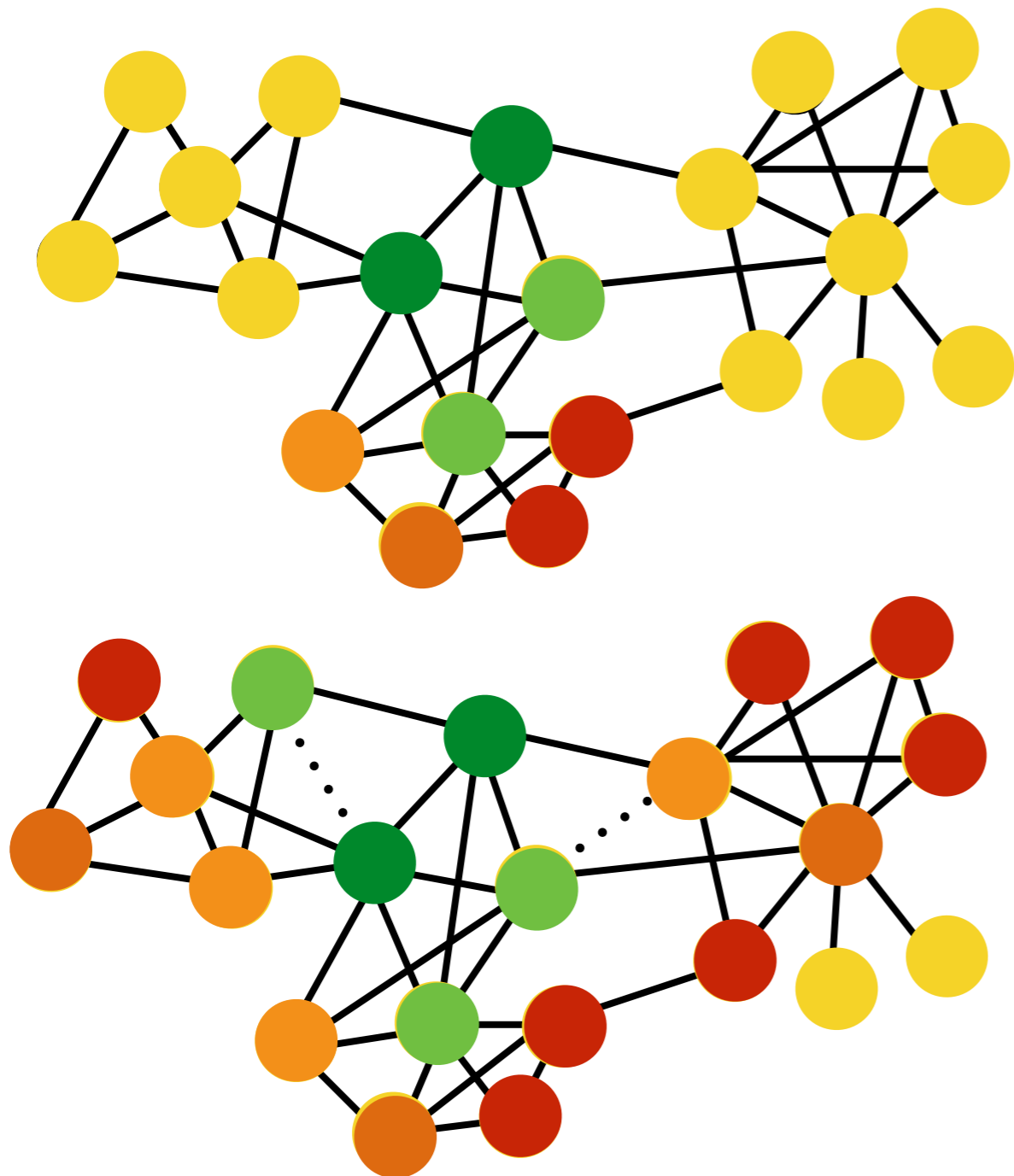
Complex Contagions

Even a few weak links can dramatically change that picture, and reduce siloing

Complex Contagions

Even a few weak links can dramatically change that picture, and reduce siloing
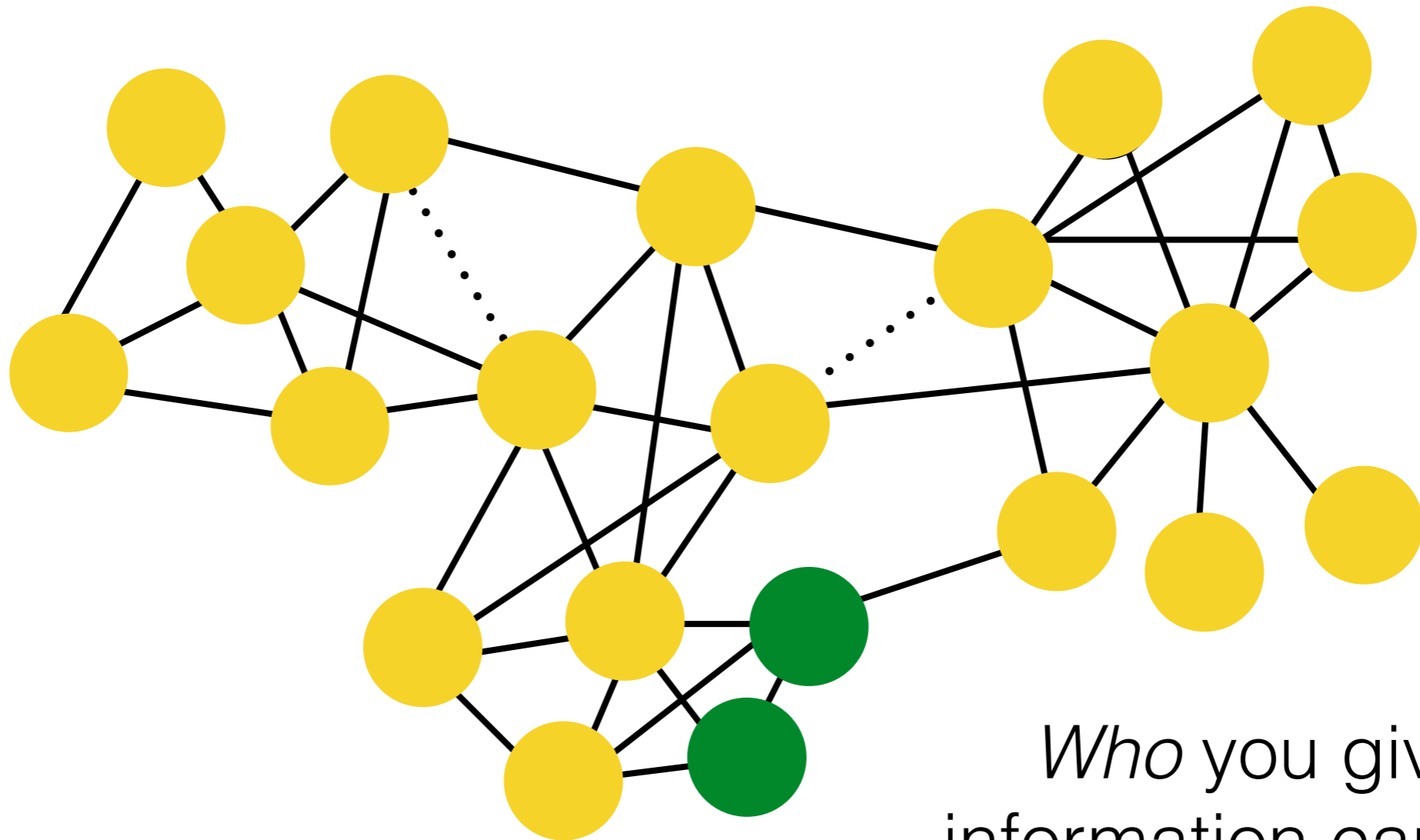
Complex Contagions

This is another example where weak ties play an important role.

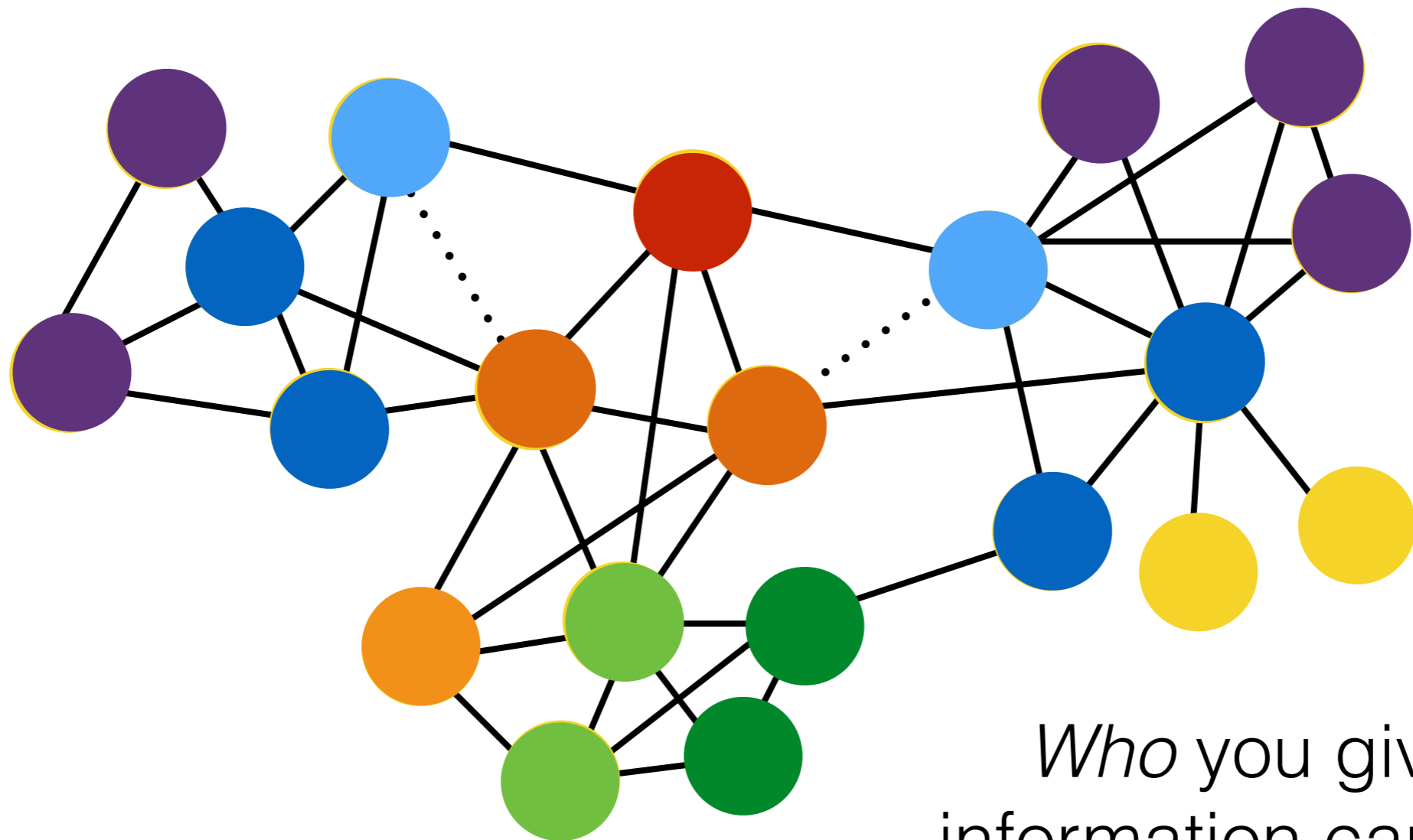A tie doesn't have to be strong to be a second source of information.

Organizations (including places like NASA) work hard at promoting weak ties to serve this role
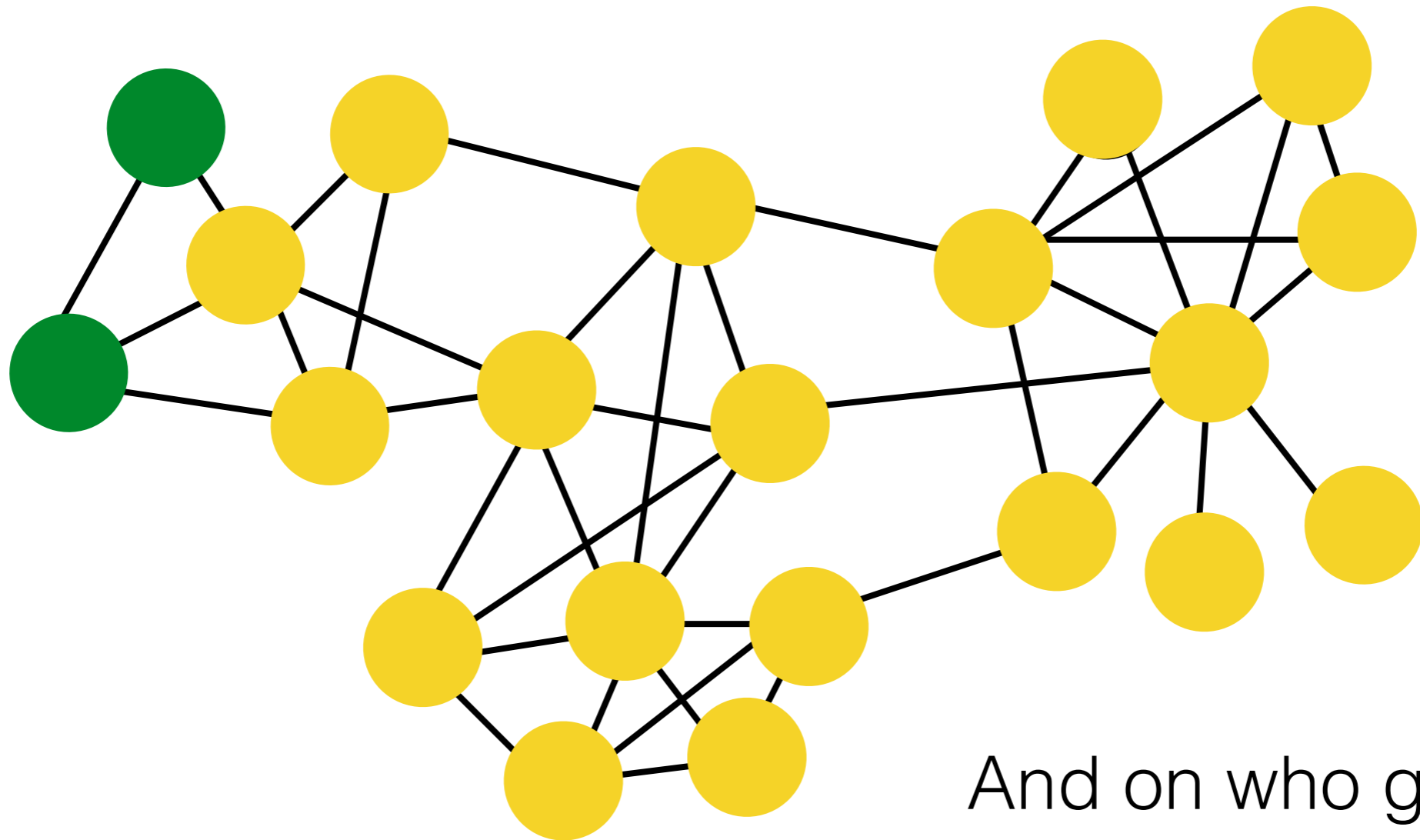
Complex Contagions

Who you give the information can have a dramatic effect on how quickly it spreads

Complex Contagions

Who you give the
information can have a
dramatic effect on how
quickly it spreads

Complex Contagions

And on who gets it…
information can spread from
the left cluster to the middle,
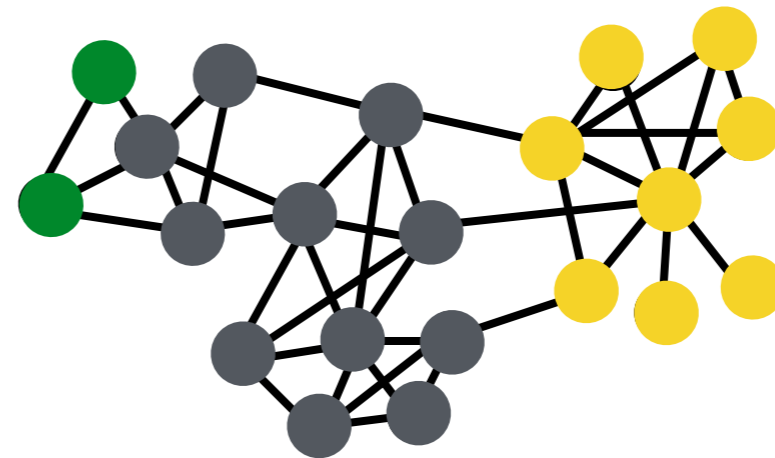but not the other way

Complex Contagions
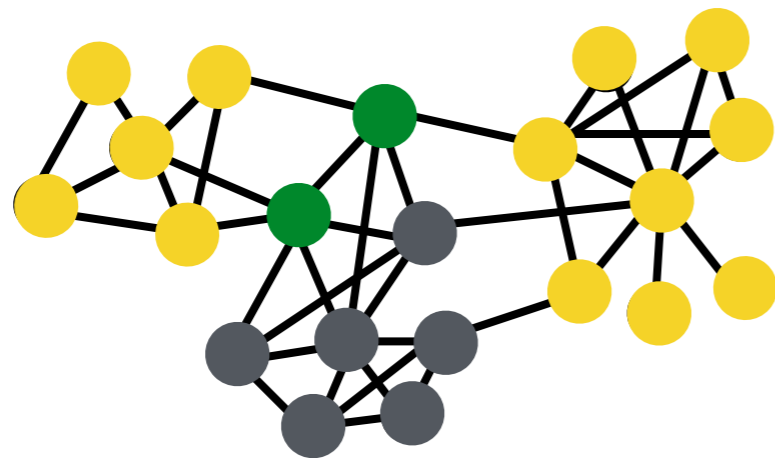

And on who gets it…
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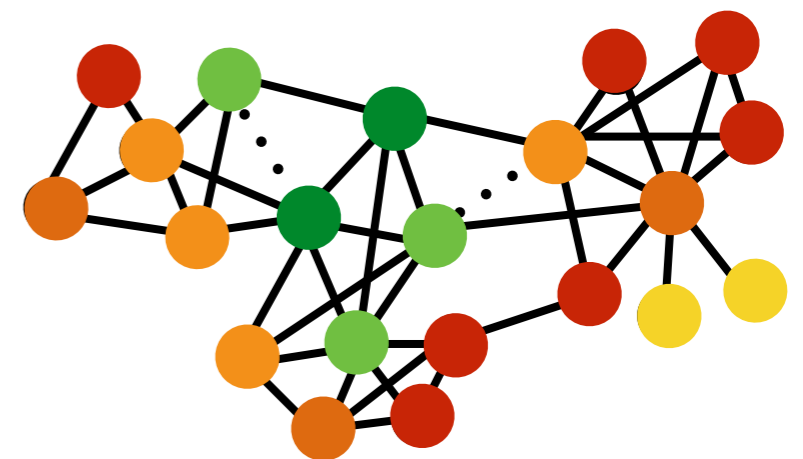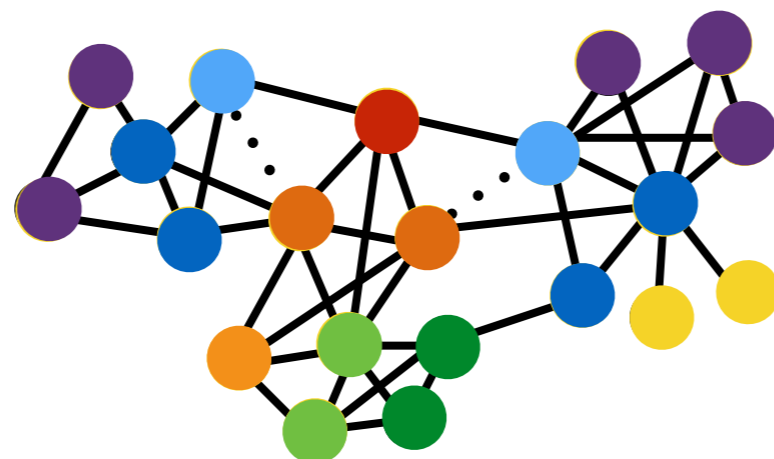but not the other way

Controlling the Flow of Information

So this suggests a question: suppose we want information to spread far and fast—who should we give it to?

farther:


faster:

Case 1: Microfinance in Rural India

Note: The following is based on a presentation by the authors of the paper:

The Diffusion of Microfinance, by Abhijit Banerjee, Arun G. Chandrasekhar, Esther Duflo, Matthew O. Jackson

(It is a great paper: one of my favorites)

Microfinance in Rural India

The context: An organization called Bharatha Swamukti Samsthe (BSS) provides access to a group-based microcredit program in rural southern Karnataka
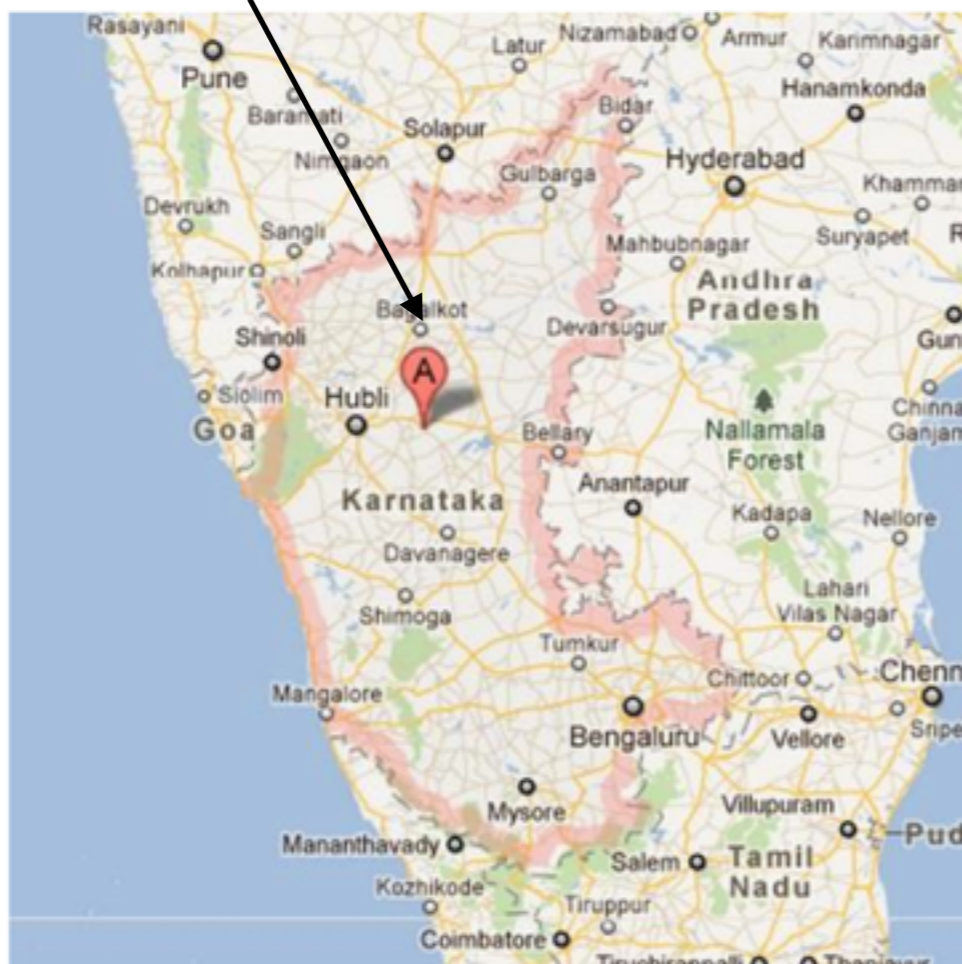
Borrowers form groups of five women, who are jointly responsible for the loan repayment of their group
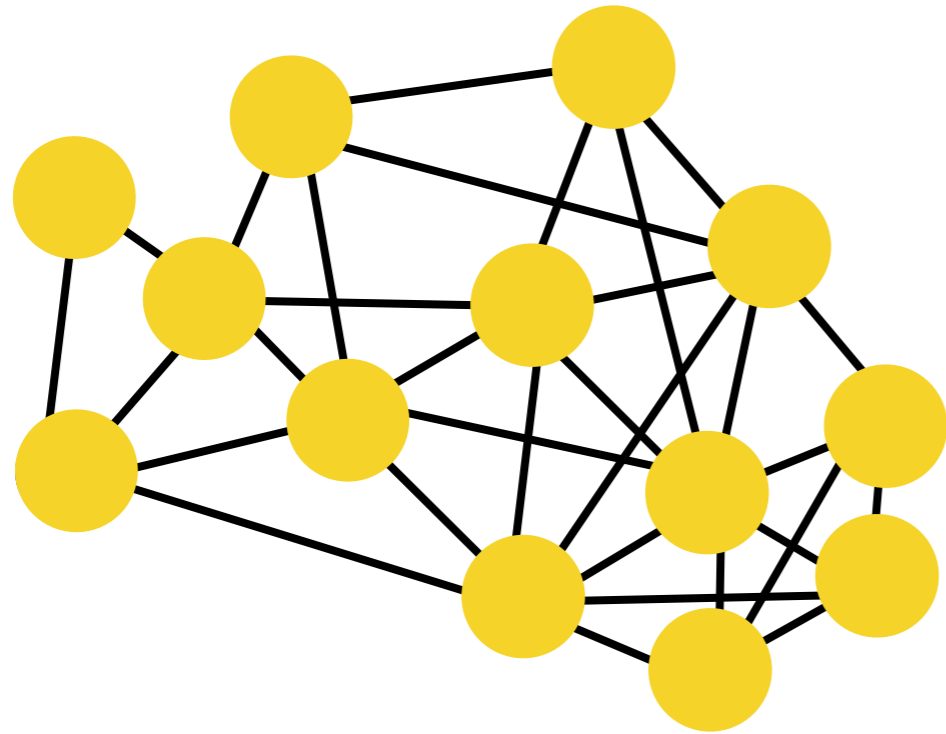
Microfinance in Rural India

It's infeasible for BSS to talk to everyone, so they talk to people they think are important in each village, and ask them to spread the word.

- Local Leaders
- Teachers

But this is much more successful in some villages than in others! They do the same thing, but adoption rates are very different.
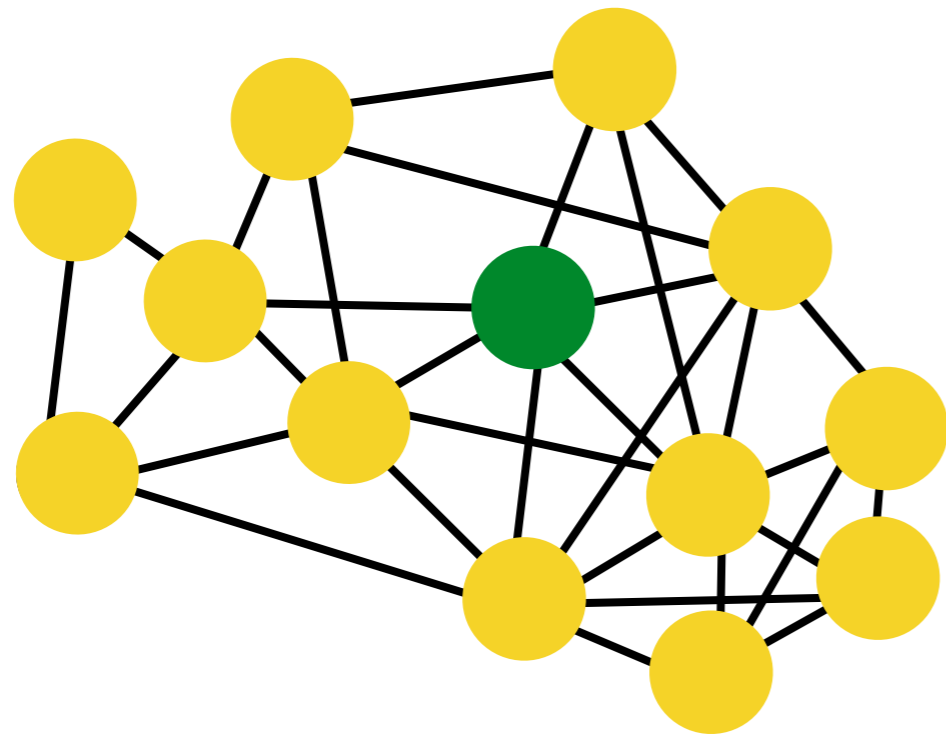
Microfinance in Rural India

Hypothesis: Maybe the problem is differences in the social networks that the information is spreading on.

Two big questions:

1. How does who you tell (the "injection point") affect the spread of information about microfinance?

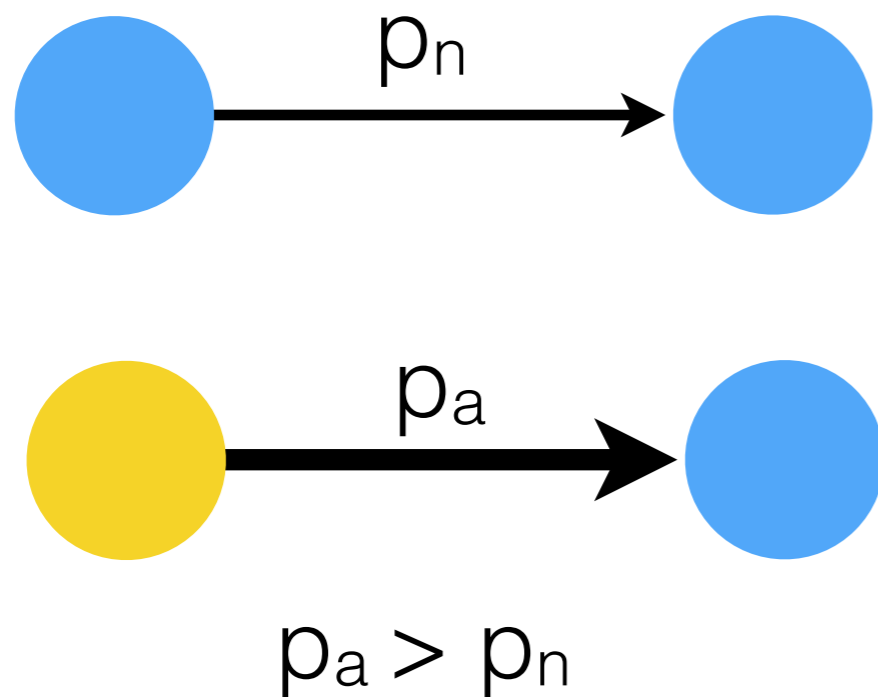2. Does it matter whether the people spreading the information act on it?

Microfinance in Rural India: Some Results

Result 1: The best people to spread information are those with high eigenvector centrality

That is: those people who know other well-connected people

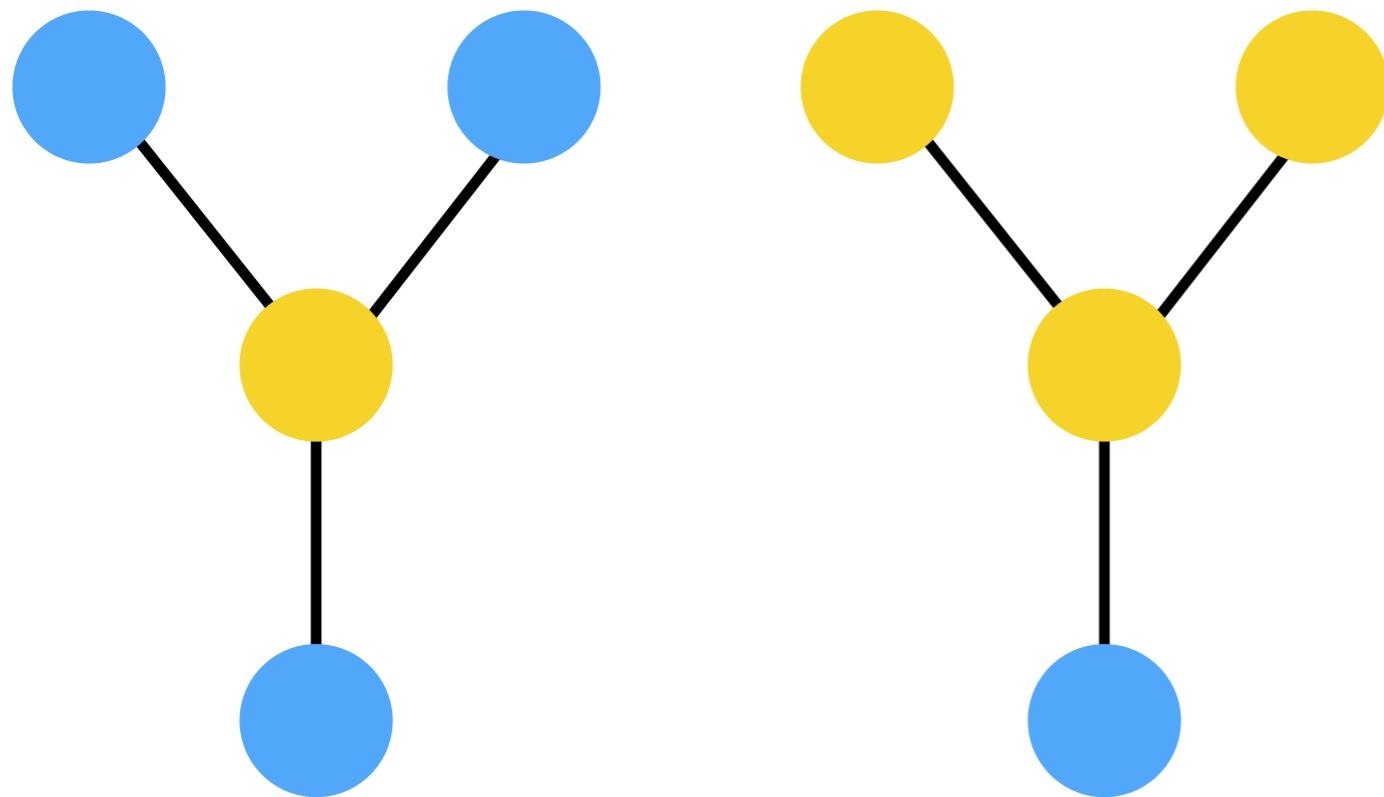# Microfinance in Rural India: Some Results

p_n

p_a

$p_a > p_n$

Result 2: People are more likely to talk about the microfinance program if they have entered the program themselves: the *endorsement effect*

This highlights another difference between information and disease: you might learn about something from an "infected" or "uninfected" person
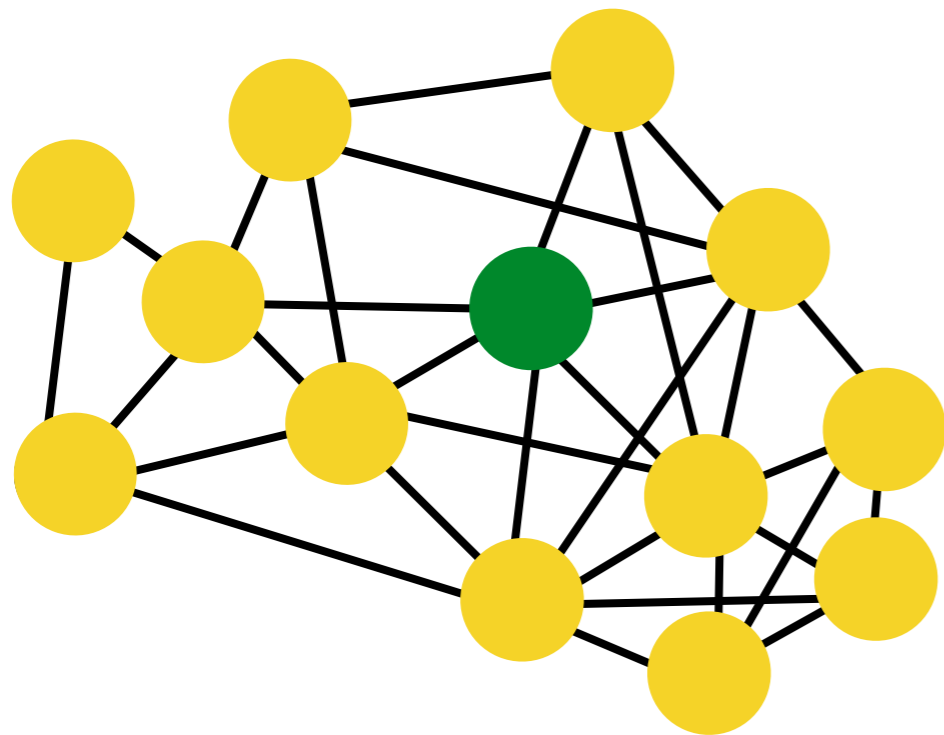
Microfinance in Rural India: Some Results

Result 3: Interestingly, people were not swayed by what their neighbors did

People with few neighbors who joined the program were just as likely to act on the information once they received it.

Microfinance in Rural India:
A final issue

One problem: in order to use the information about injection points, you need to know the network.

Knowing the network is very costly: more costly than just informing everyone in the first place

So can you find people with high eignevector centrality just by asking?

Microfinance in Rural India: A final issue

Surprisingly, the answer is yes!

If you ask who the most important person in town is, people will tend to identify the person with the highest eigenvector centrality, despite not knowing the whole network!

The people everyone talks about are the people with highest eigenvector centrality…
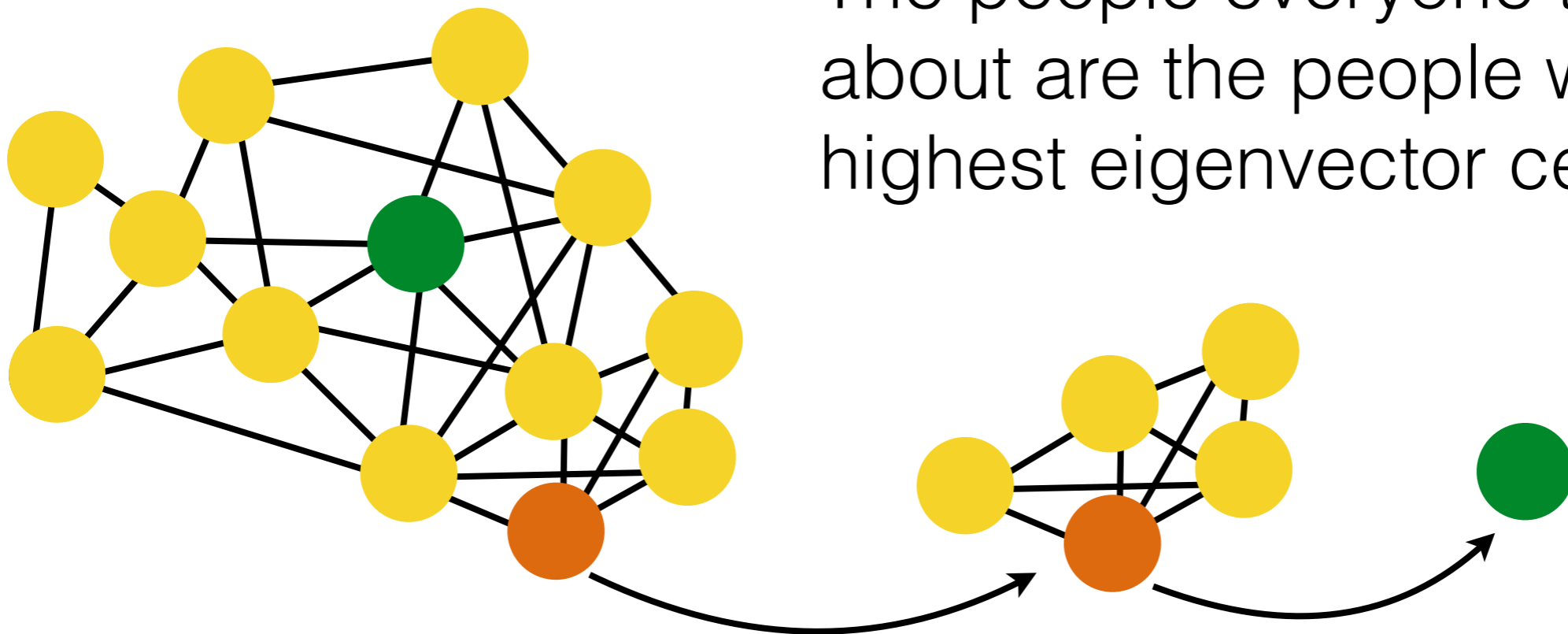
Case 2: Twitter and Social Influence

Suppose you want to encourage a piece of information to spread more broadly on social media:

- new product
- political cause
- funny cat video
- geeky growth chart

Who would you send the information to?

What makes a person a social influencer?

Twitter and Social Influence

A test with data: tracking retweets of links on twitter

- What characteristics of a twitter-user make her more likely to spawn a chain of retweets?

- Which users are most likely to be the influencers in the network?

Bakshy et al (2011)

What makes a person an influencer?

Things that make a person more likely to be an influencer:

- number of followers
- previous success at spawning retweets

Bakshy et al (2011)

What makes a person an influencer?

Things that make a person more likely to be an influencer:

- number of followers
- previous success at spawning retweets

Things that don't seem to matter:

- what they tweet
- how often they tweet

Bakshy et al (2011)

The big problem...

Knowing what makes some twitter users influencers doesn't tell you much about how to make a *particular* link get retweeted

Tweet about Trans Pacific Partnership (changes to copyright law): 2400 RT

Tweet about Save Children UK (support for child refugees): 96 RT

Successful tweets and unsuccessful tweets come from the same sources!

Brand New Questions

All of this raises some questions about marketing and products in a world of increasing social connection
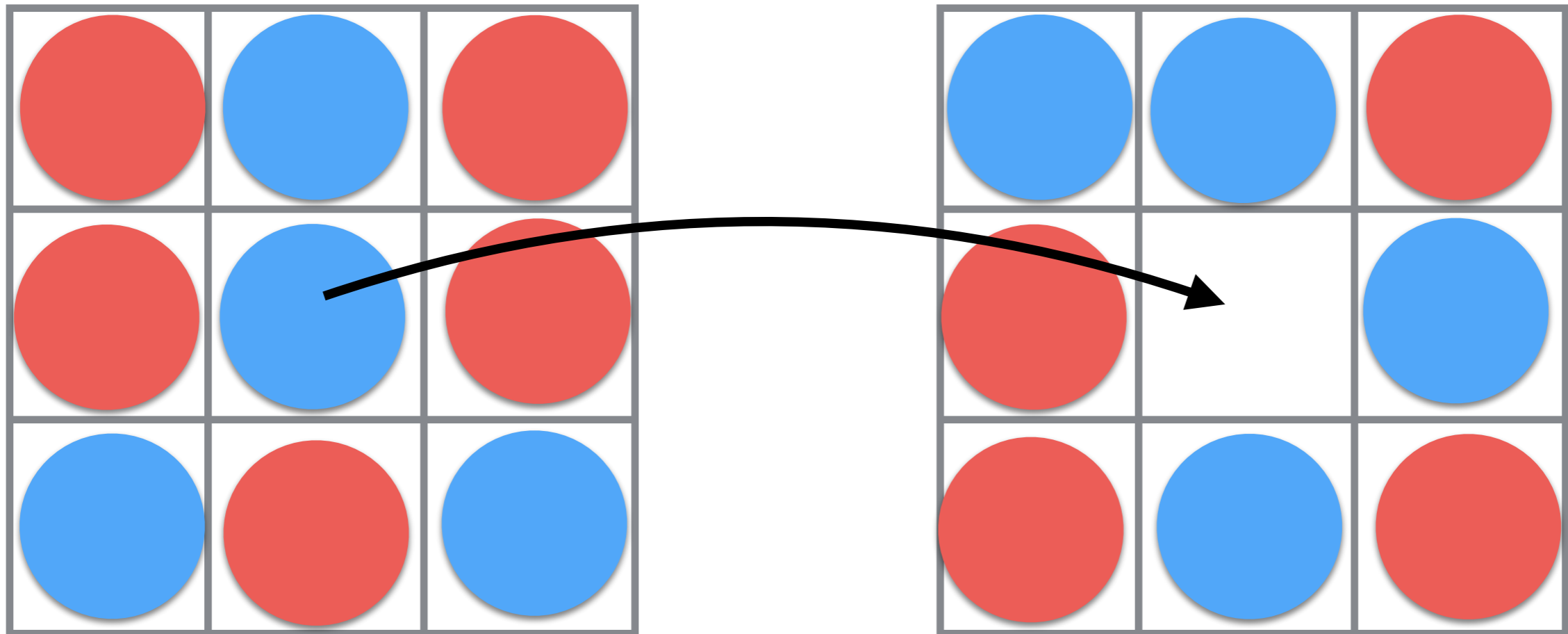
- Is there any way for producers to control information about their products?

- How has the trend towards user reviews changed the product landscape?

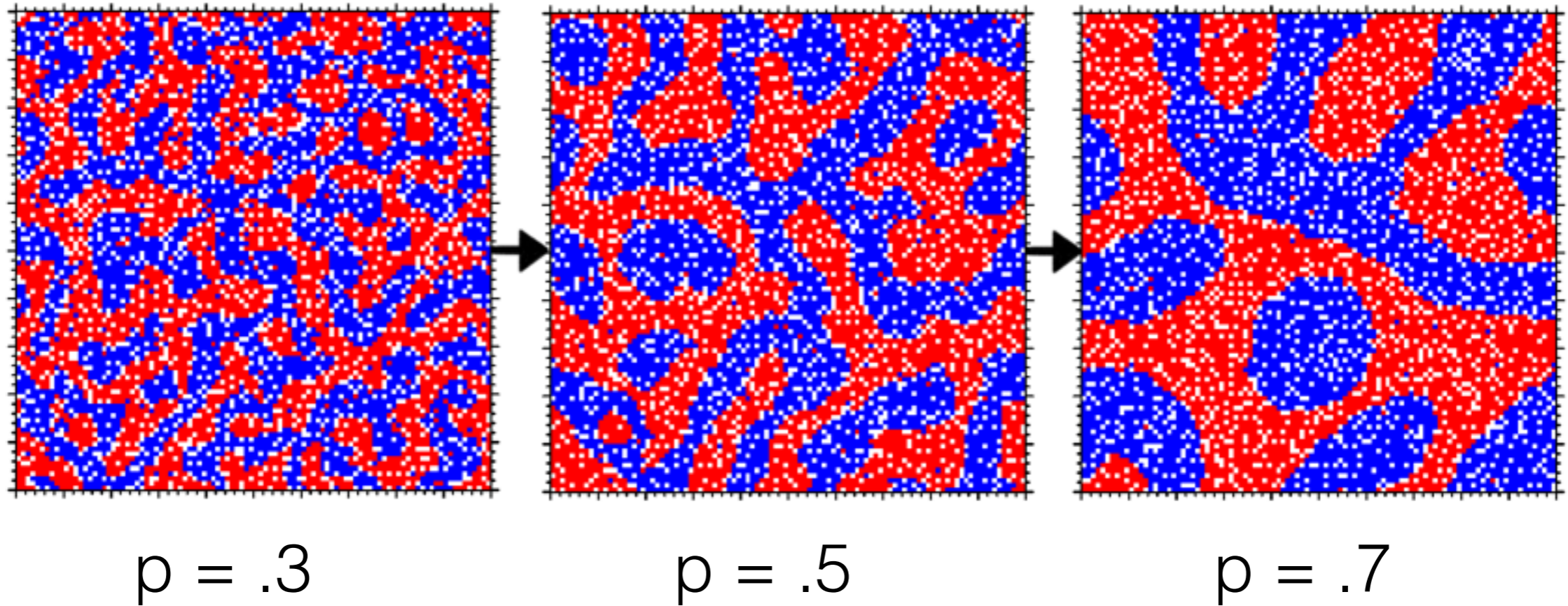- Do we end up with better products this way?

Pajek@IMDB. 1169725 nodes, 3759902 edges.
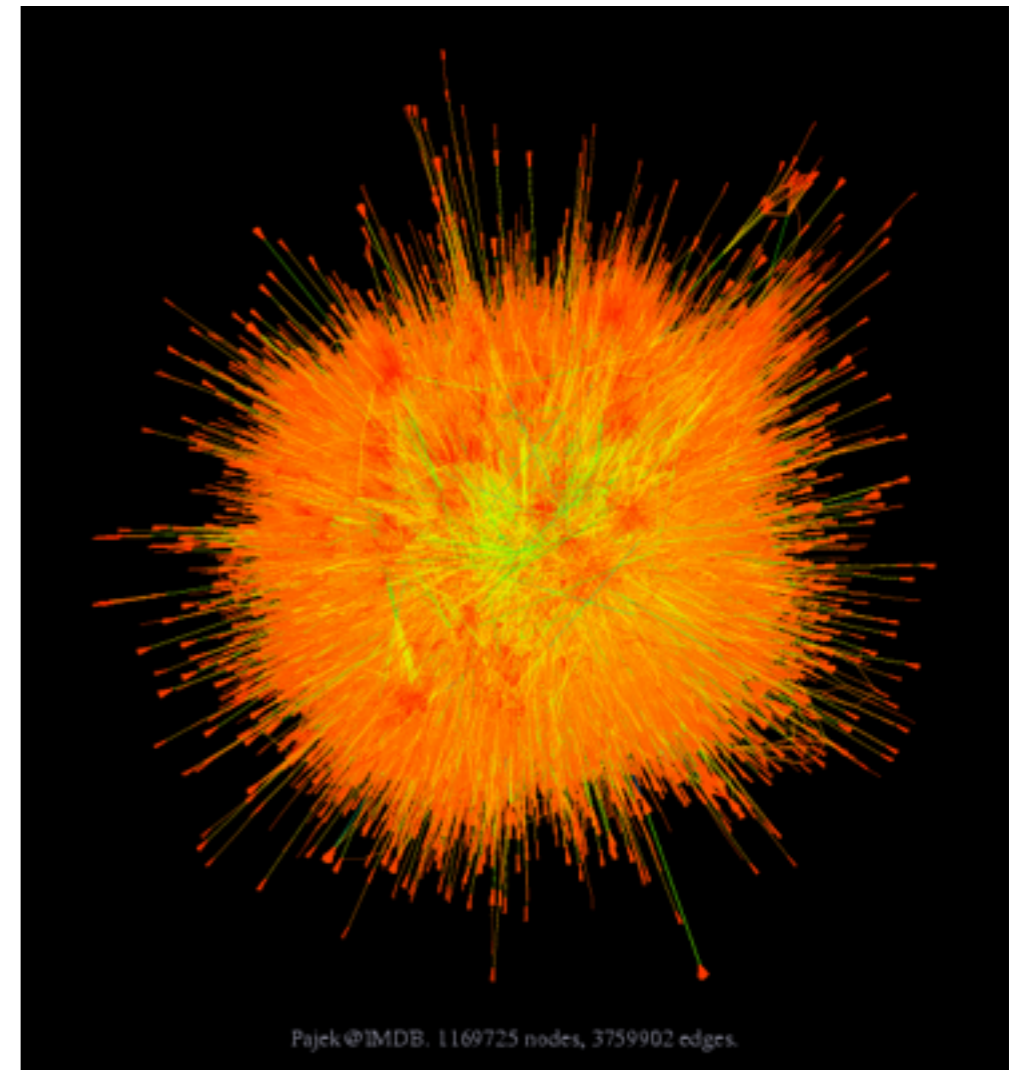
Threshold Fraction: Voting and political opinions
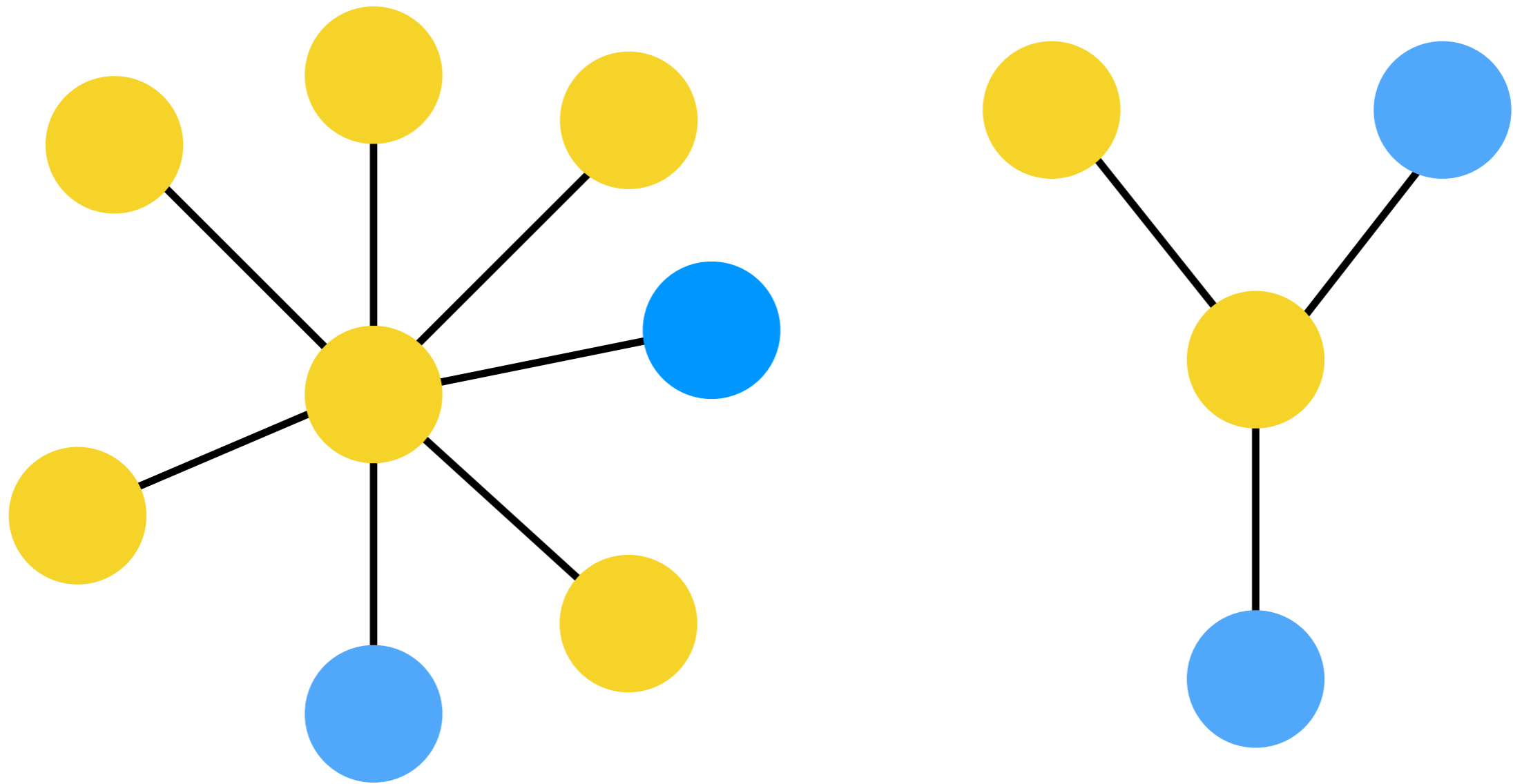
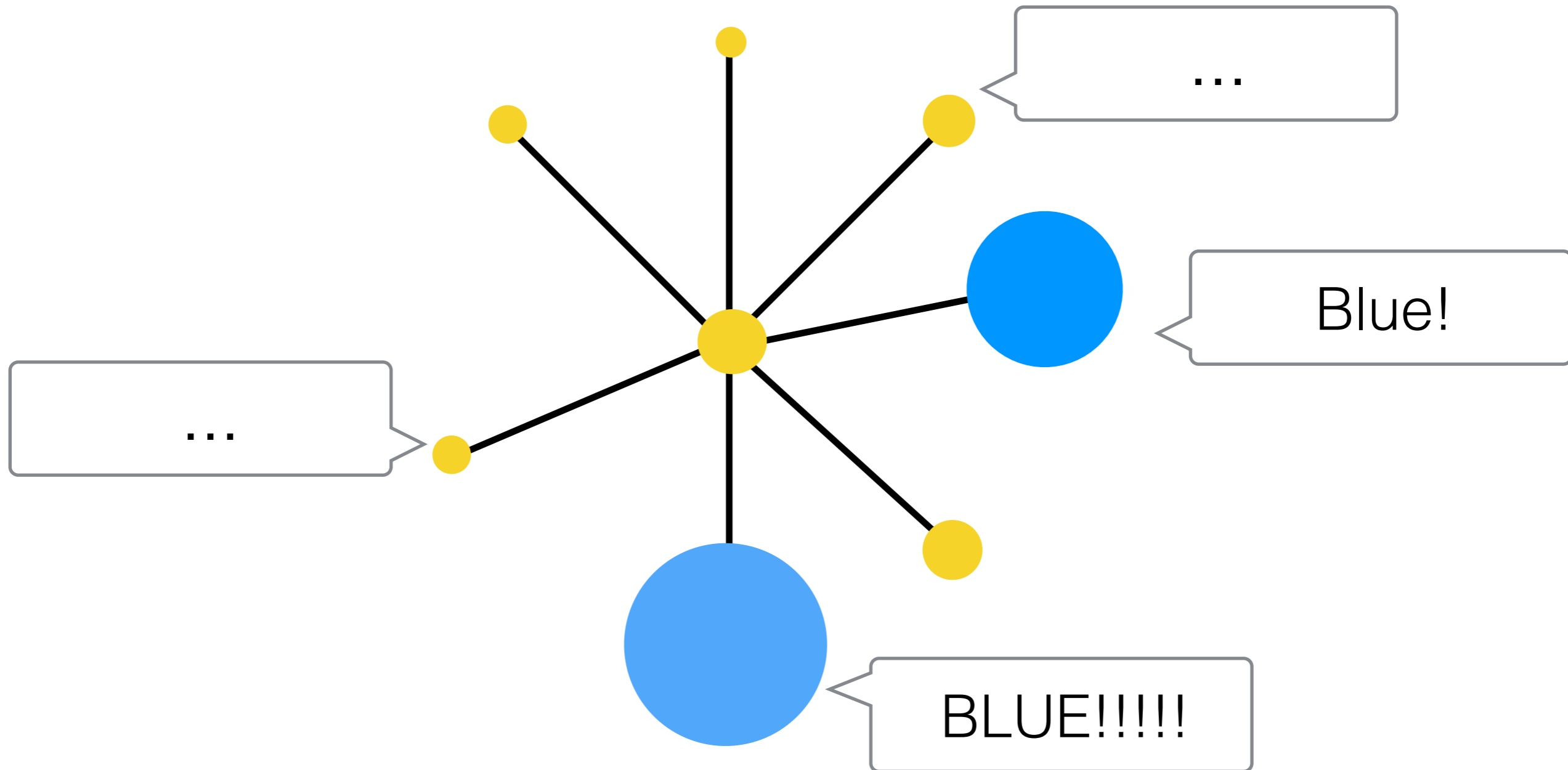# Schelling Segregation Model

Schelling Segregation Model

p = .3   p = .5   p = .7
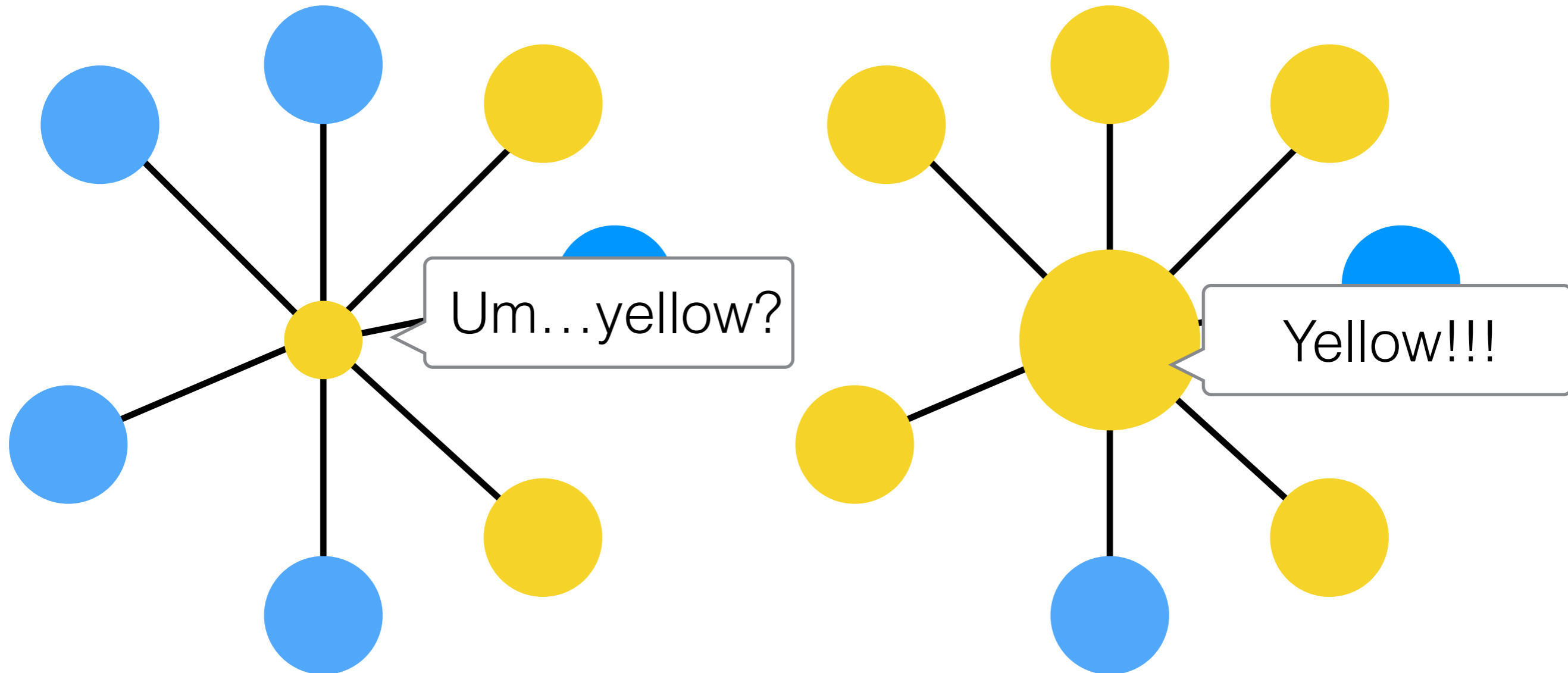
Vocal Minorities and the Silent Majority

Vocal Minorities and the Silent Majority
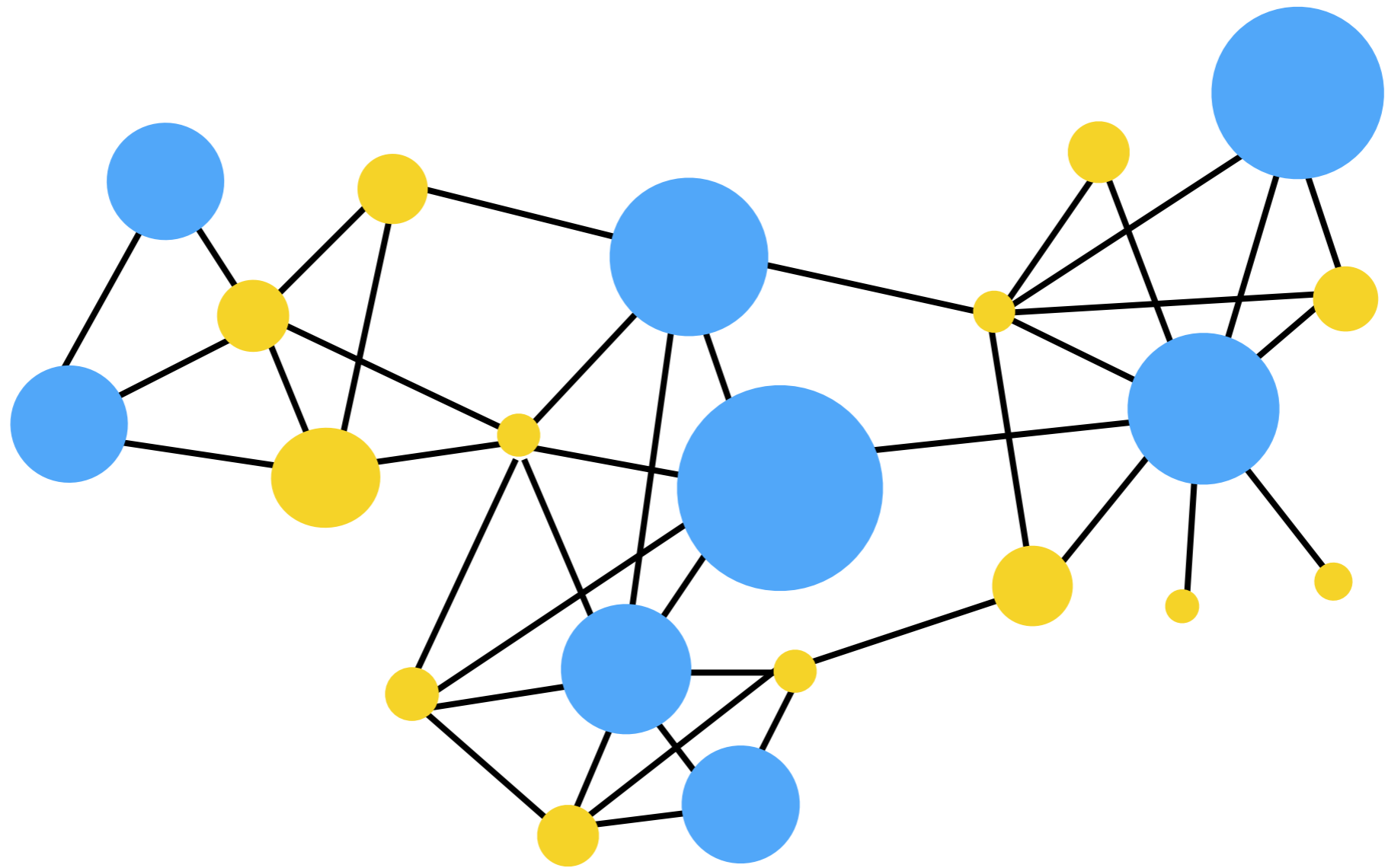
Summary

- Our preferences and opinions depend on the preferences and opinions of those around us
    - We gather information
    - We reduce cognitive load
    - We bow to social pressure
    - We value things differently depending on how our neighbors value them
- The spread of these preferences and opinions is sensitive to the structure of the network
- These effects may be hard to predict