SMALL WORLDS:

Competitive and Cooperative Structures in Online Worlds

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What we're going to cover

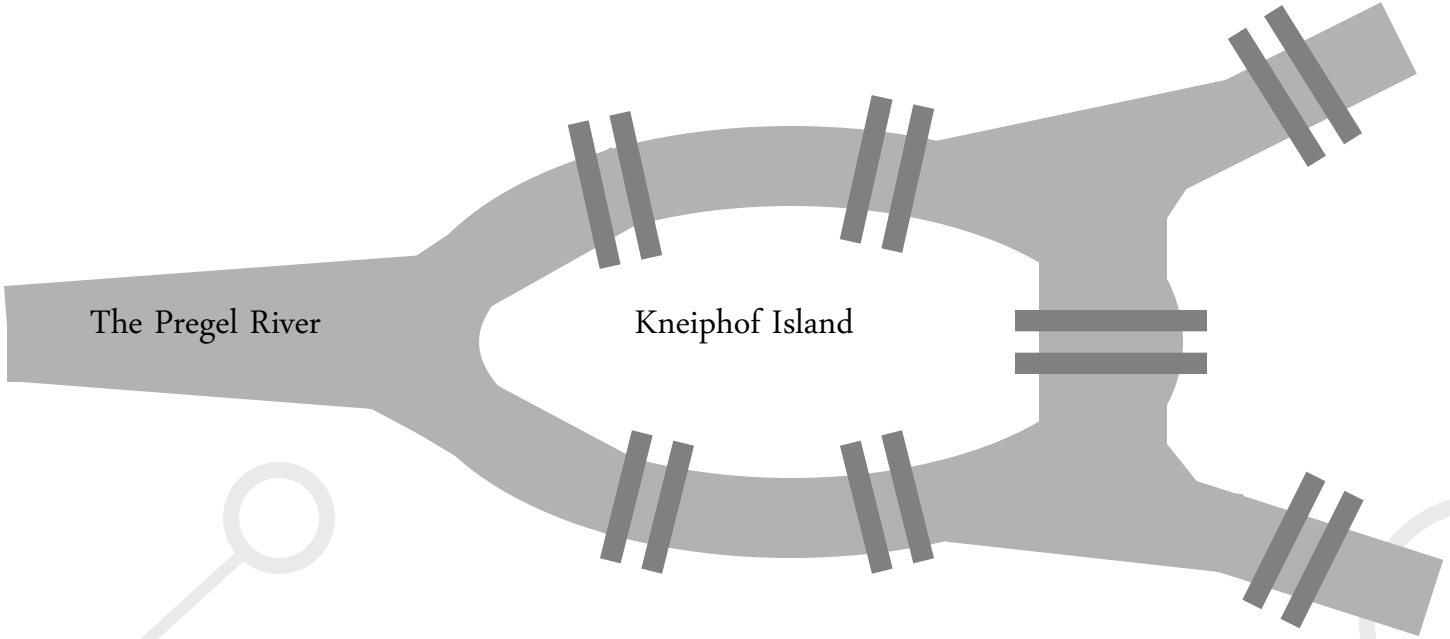
- **Graph theory**
  - What are scale-free networks and why care?
- **Social networks**
  - What is the structure of social networks?
- **Game theory**
  - How do people in social networks interact?
- **Pareto's Law**
  - How does skill affect networks?
- **Conclusions and recommendations**
  - Concrete advice.
- **Bibliography**
  - Many many pages long!

We're going to go very very fast. Be warned.

GRAPH THEORY

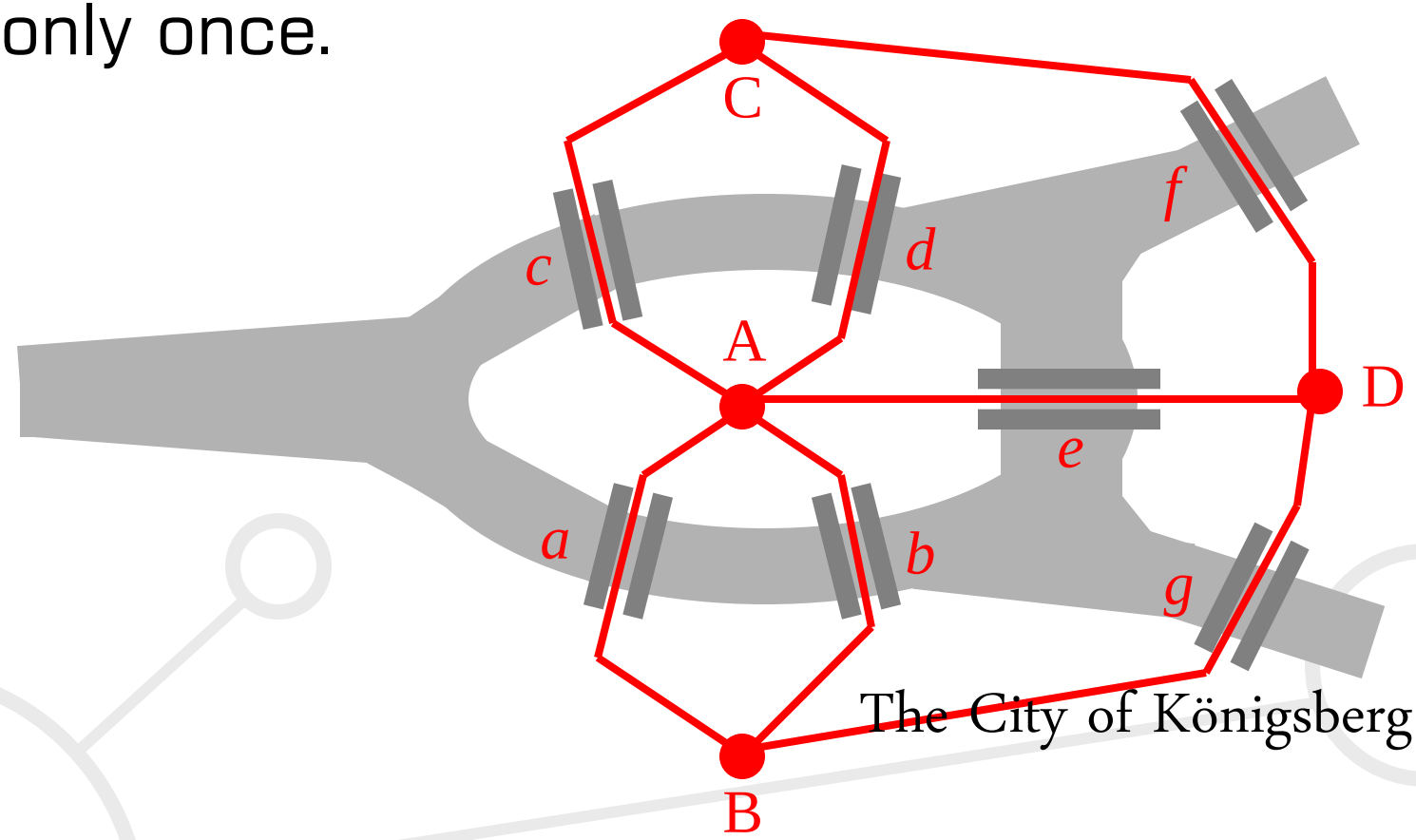
From Bridges to Google, or "What's a scale-free network?"

- The Seven Bridges problem: can you walk the whole city but cross every bridge only once?



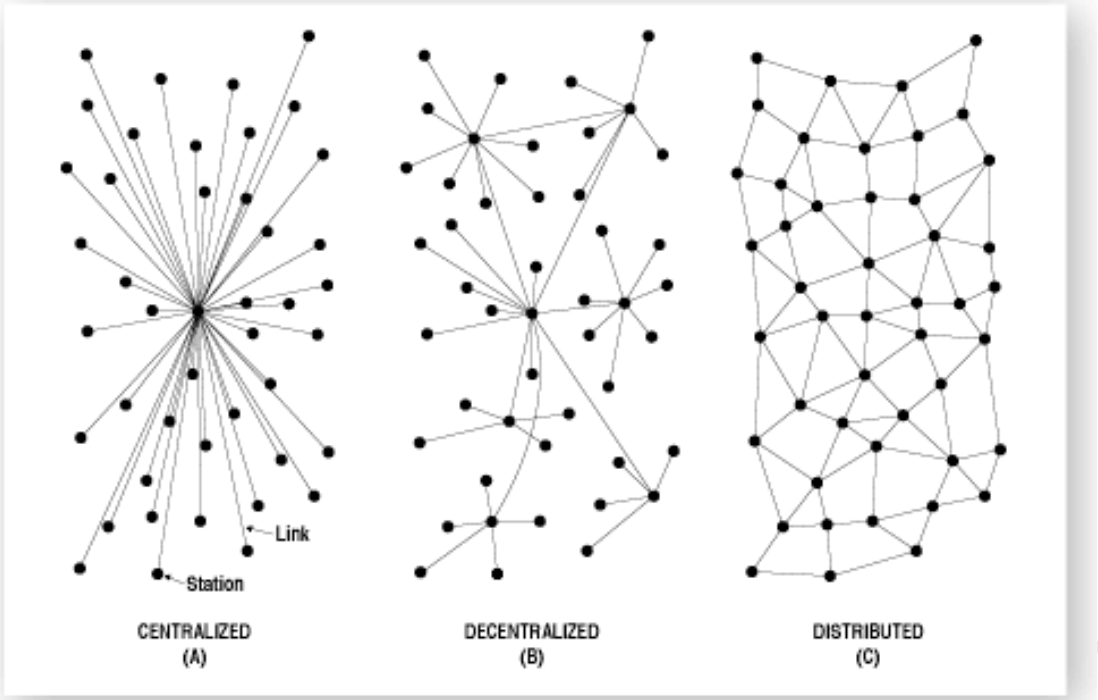
The City of Königsberg

- Leonhard Euler creates graph theory and proves that you can't cross each bridge only once.

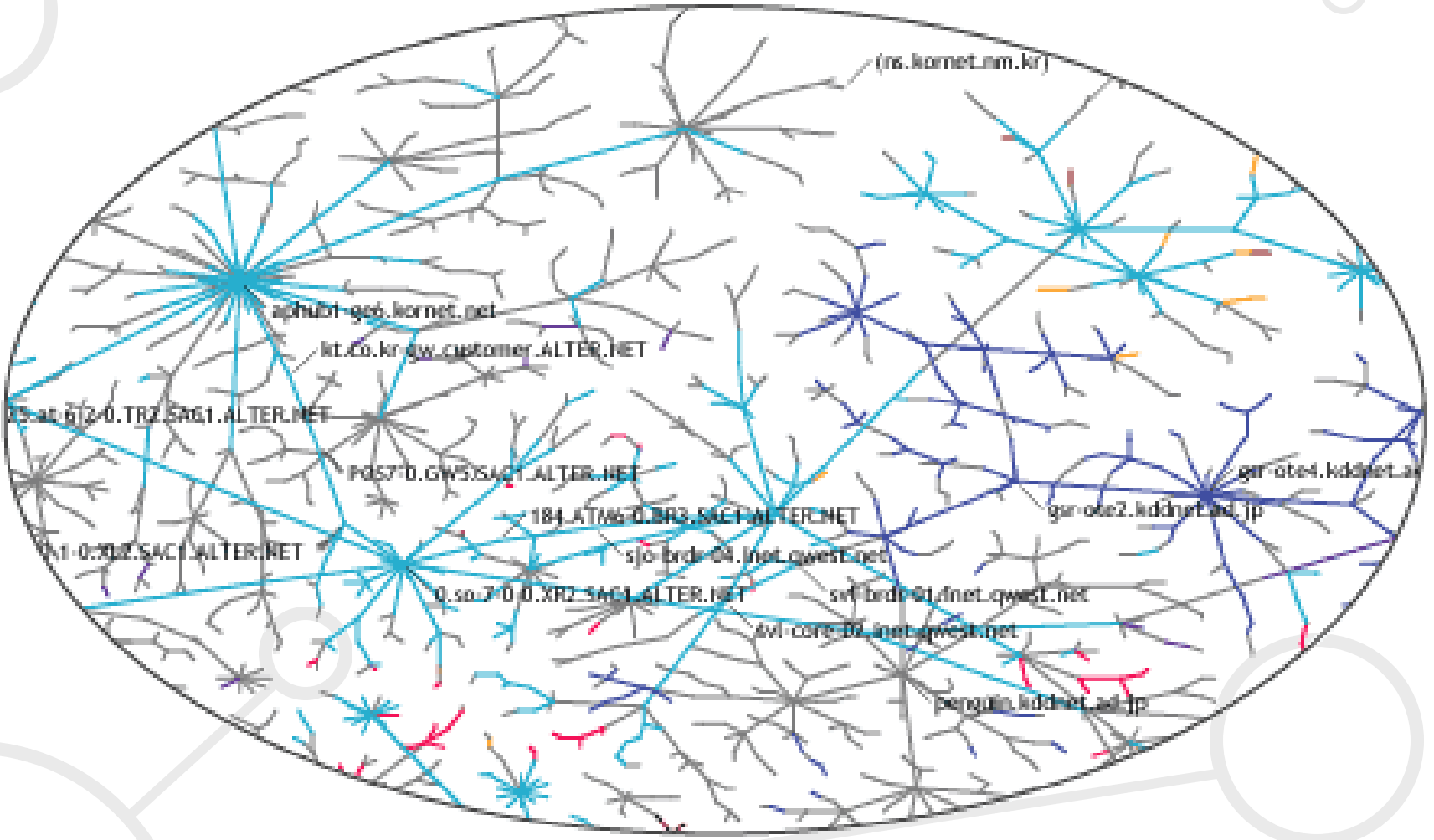


The City of Königsberg

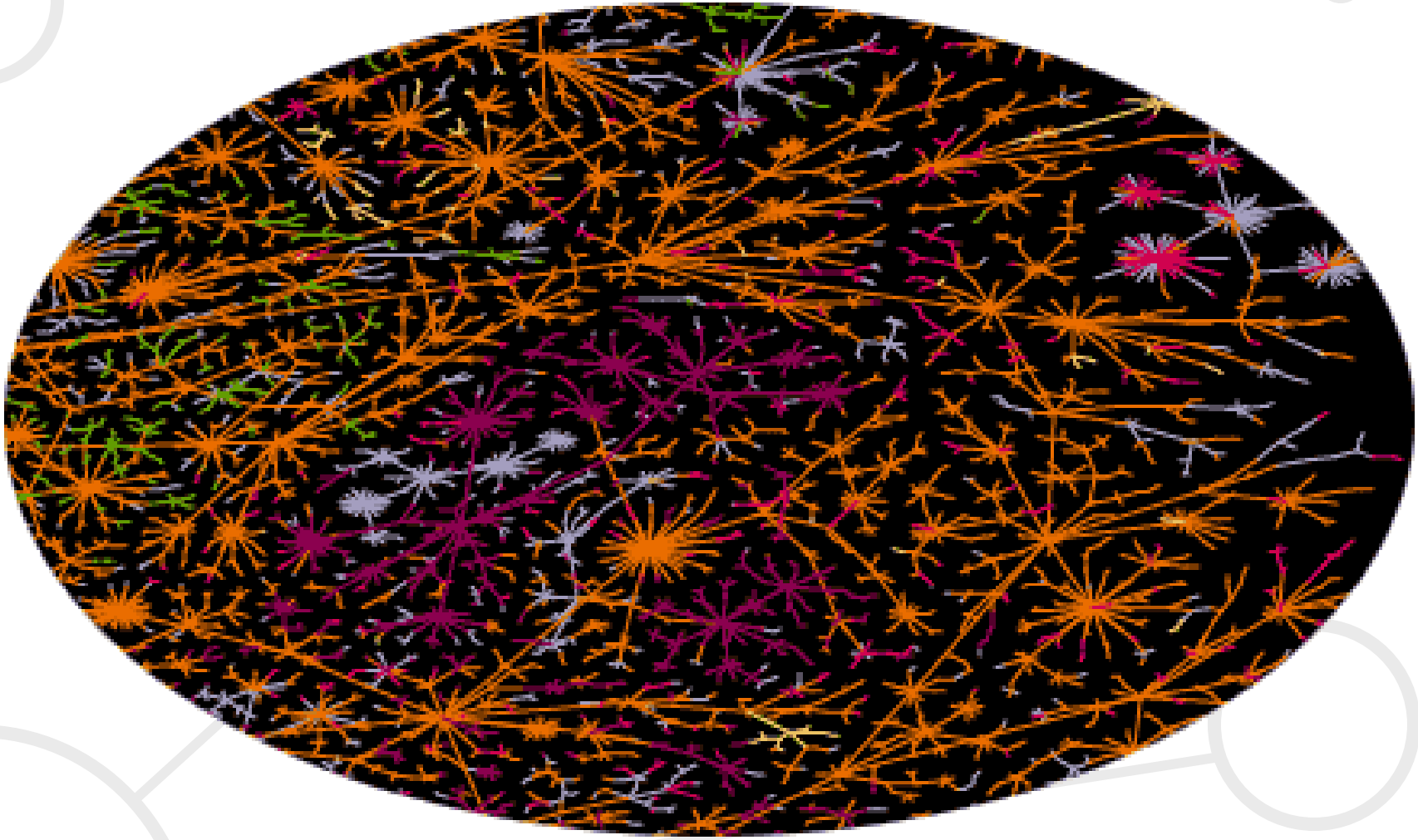
- Paul Baran designed the preliminary network forms for the Internet. But it actually looks very different.

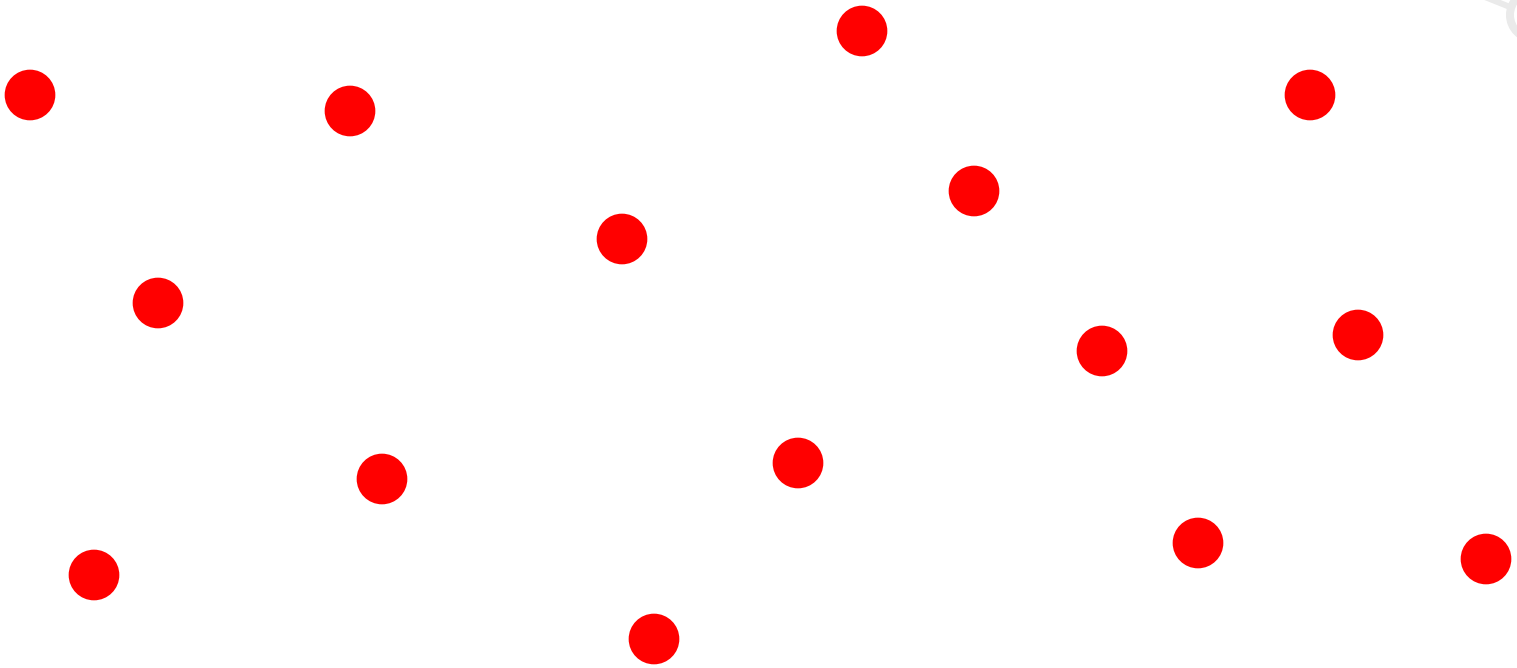


The Internet, 2001



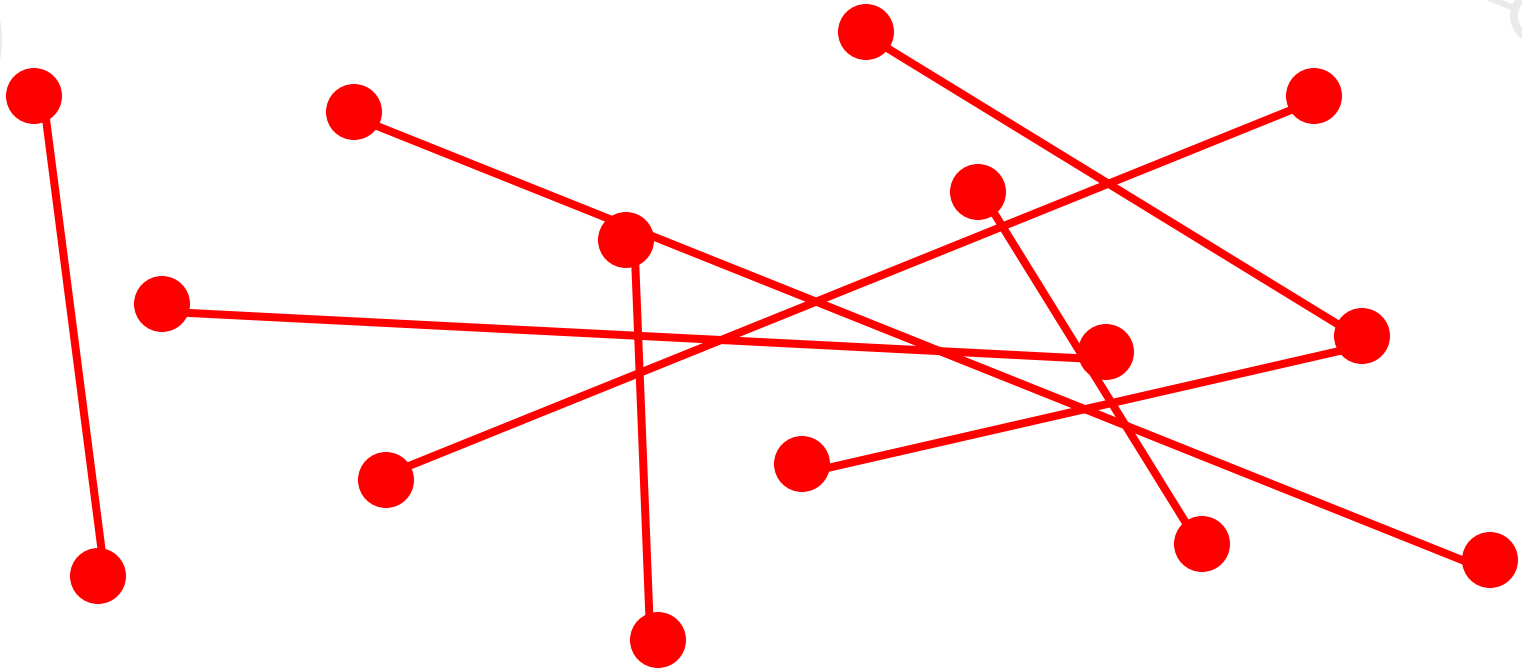
The Internet, 2002





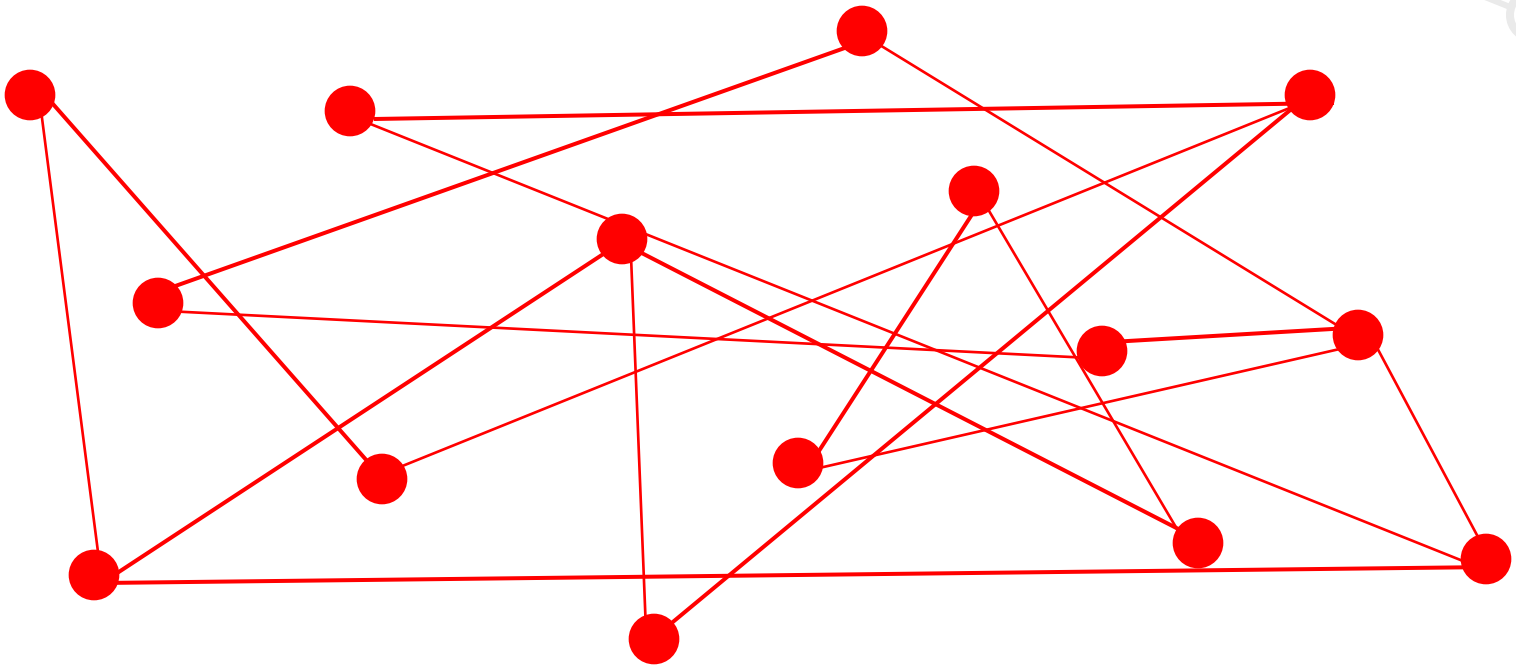
- Paul Erdös and Alfred Rényi developed random graph theory.

$k = 0$



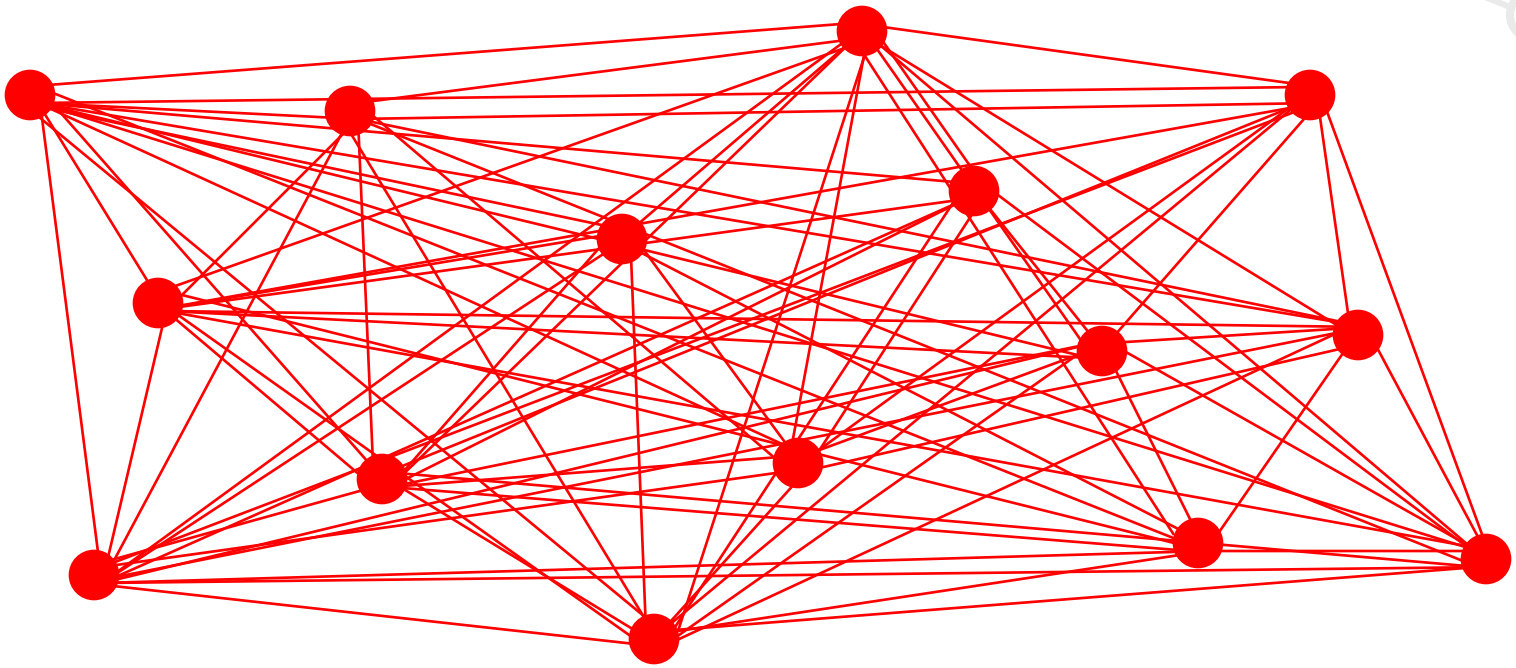
- If you take a set of nodes, like say people, and link them randomly…

$k = 1$



- …you end up with a complex graph where anyone can reach anyone.

$k = 2$



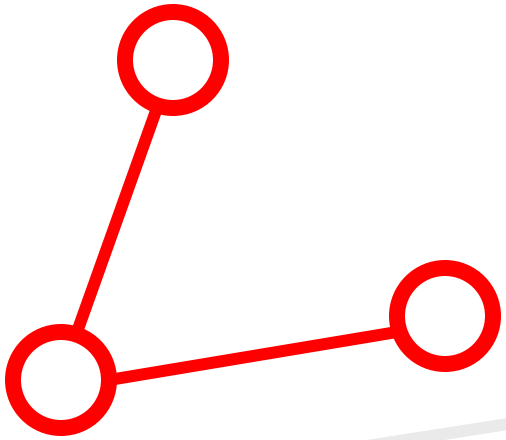
- As *k* increases (avg links per node) islands become rarer.

$k = 15$

Six degrees of separation gets famous!

- The first appearance of "six degrees" (except he said 5) is in Hungarian writer Frigyes Karinthy's story "Láncszemek."
- The next was Stanley Milgram's experiment in 1967, which found that the distance was actually 5.5.
- The term came from John Guare's play from 1991 (and subsequent movie).

- Mark Granovetter did the early research on weak ties. In “The Strength of Weak Ties,” 1973, he found that strong ties tend to form triangles. Your two best friends likely know each other well.



Strong ties

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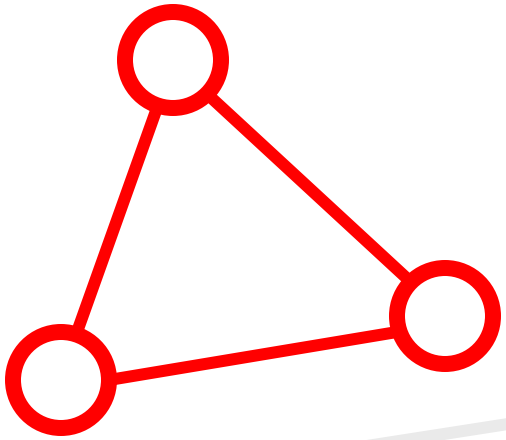
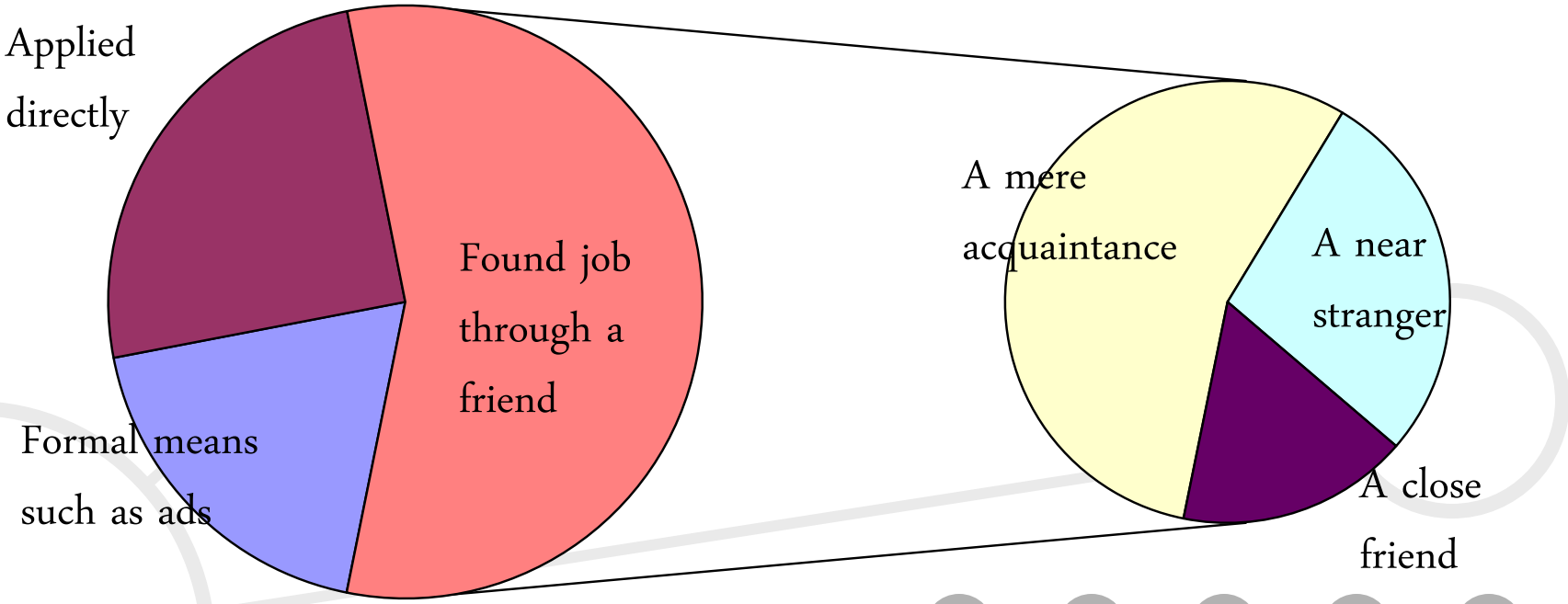


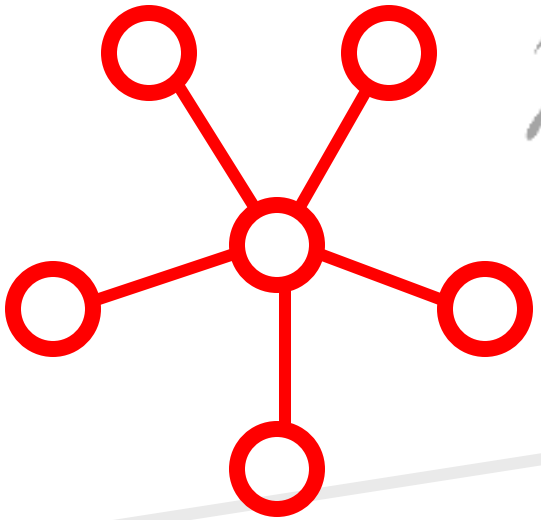
Weak ties vs. Strong ties

- In 1974 Granovetter's "Getting a Job" found that you get most jobs from weak ties, not strong ones, because weak ties inhabit other clusters and therefore have different information.



Clustering

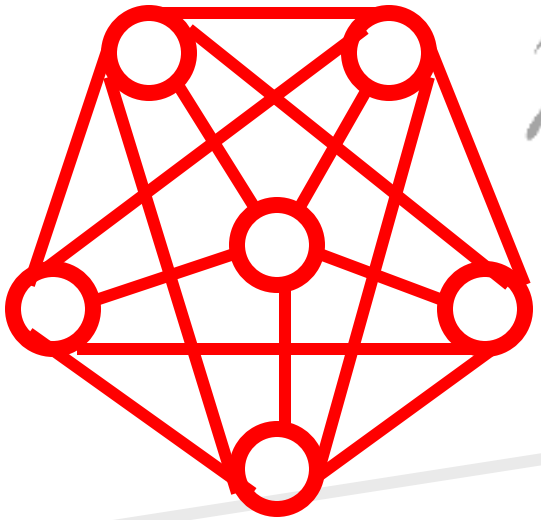
- Watts and Strogatz introduced the "clustering coefficient". It is the percentage of your cluster who are friends of each other. In a star network, the coefficient is low…



$$\gamma_v = \frac{|E(\Gamma_v)|}{\binom{k_v}{2}}$$

Clustering

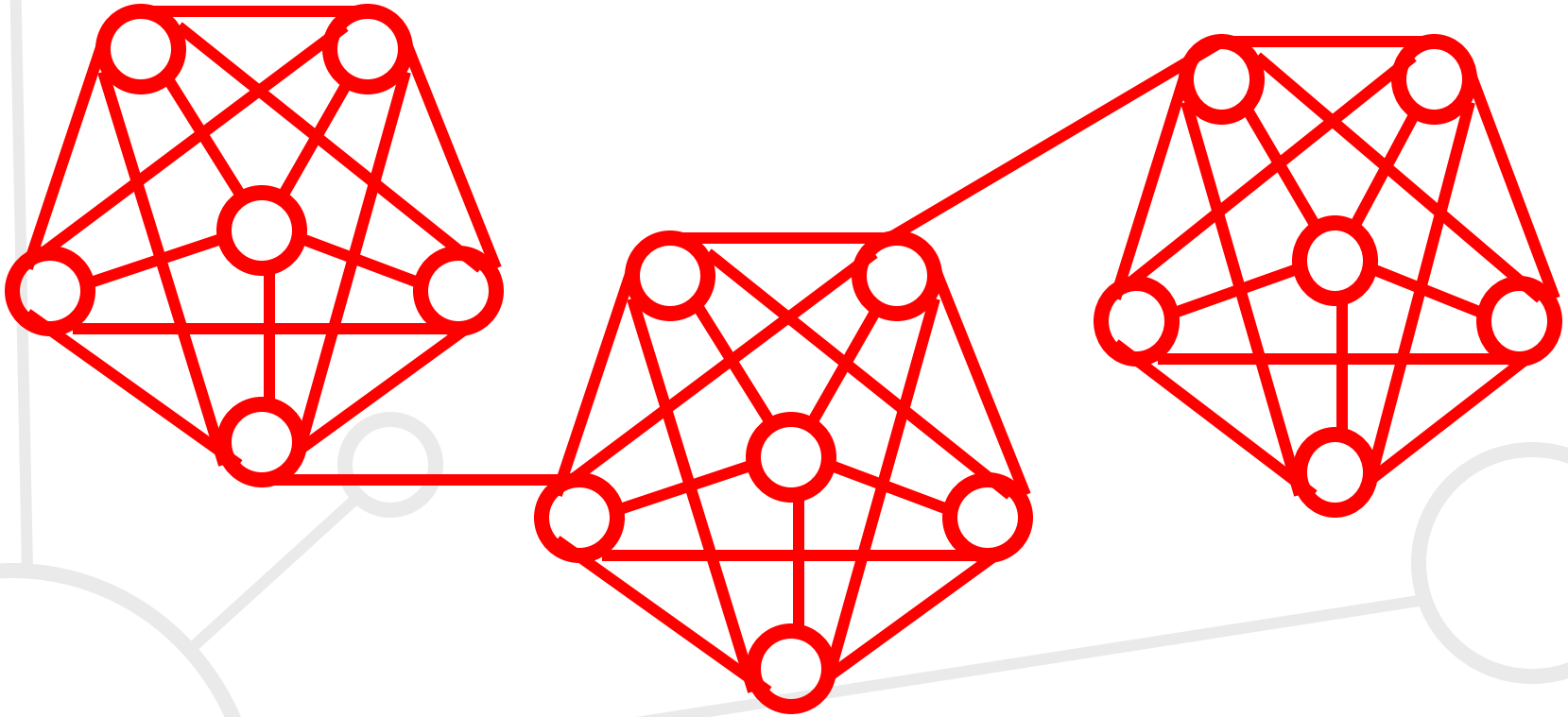
- In a tight cluster where everyone knows each other, it's 1.



$$\gamma_v = \frac{|E(\Gamma_v)|}{\binom{k_v}{2}}$$

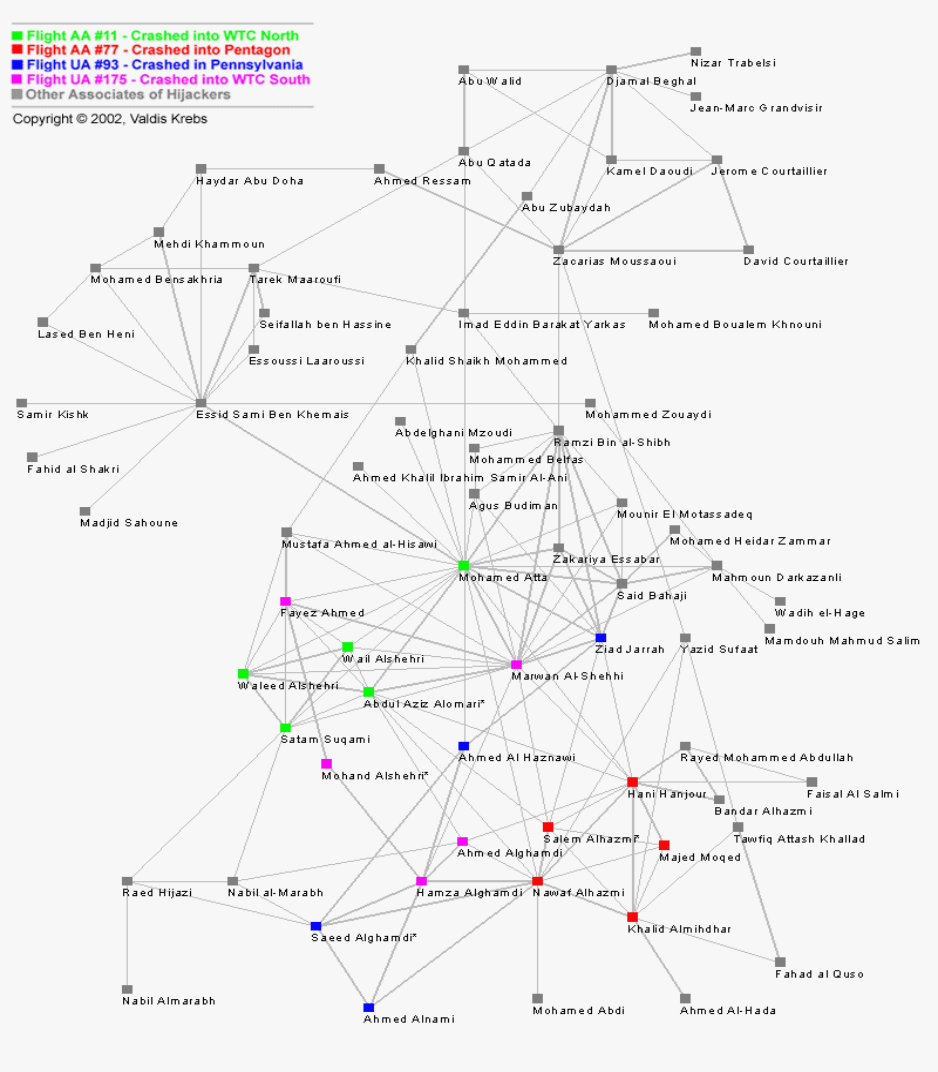
Weak ties are more important

- Why Granovetter was right: weak ties bridge clusters. In the models proposed by Erdös, there are no clusters.

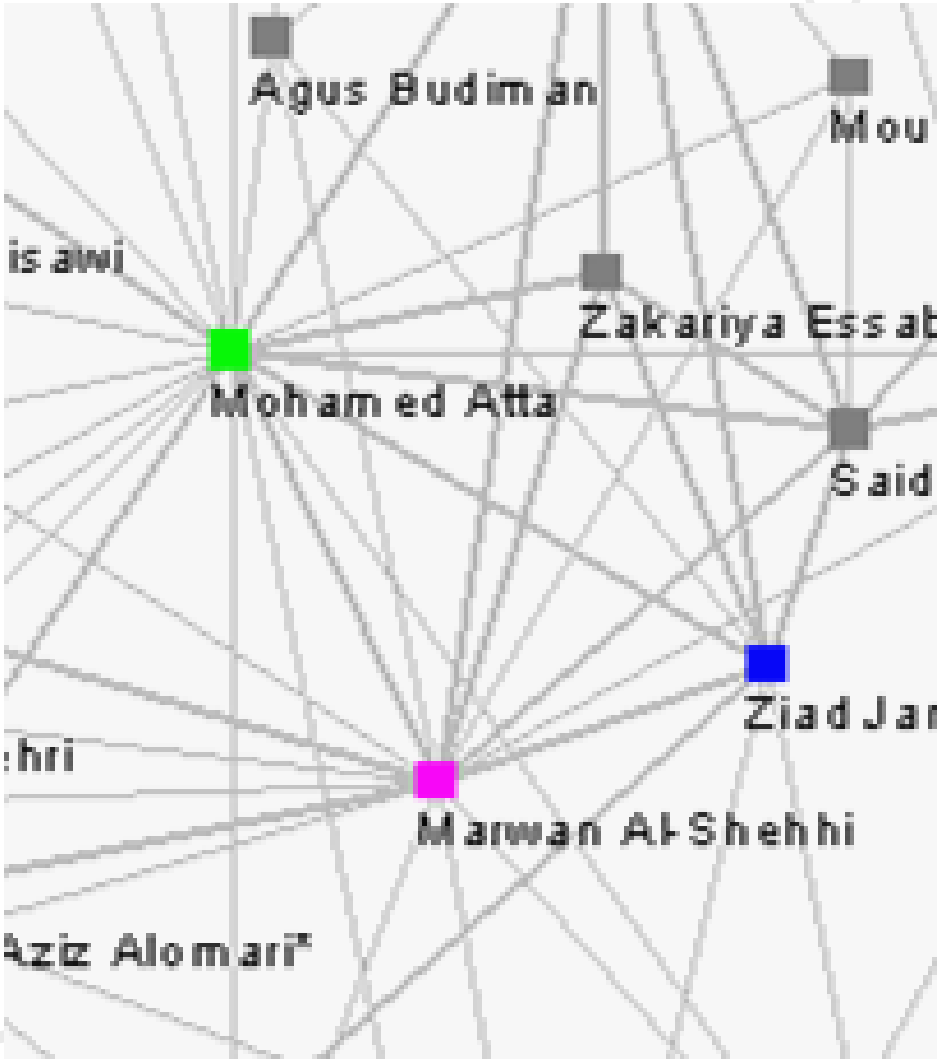


The power of hubs

- In a small world network, six degrees of separation exists because of hubs.
- Hubs are relatively rare, but they bridge multiple clusters.



- Network analysis clearly shows the hubs of the terrorist cells responsible for the Sept. 11th attacks. One to a plane, with Mohamed Atta the likely ringleader.



The diameter of the network

- Albert-László Barabási, Réka Albert and Hawoong Jeong of U Notre Dame found a formula for degrees of separation.

$$= 0.35 + 2 log N$$

- The Web itself has 19 degrees of separation.
- A small diameter doesn't mean it's easy to find the right path to a given node.

Weak ties

- The best weak ties network on the Net is the IMDB and the Six Degrees of Kevin Bacon game.
- Christopher Lee is #1 because he works in many genres. He bridges many clusters.

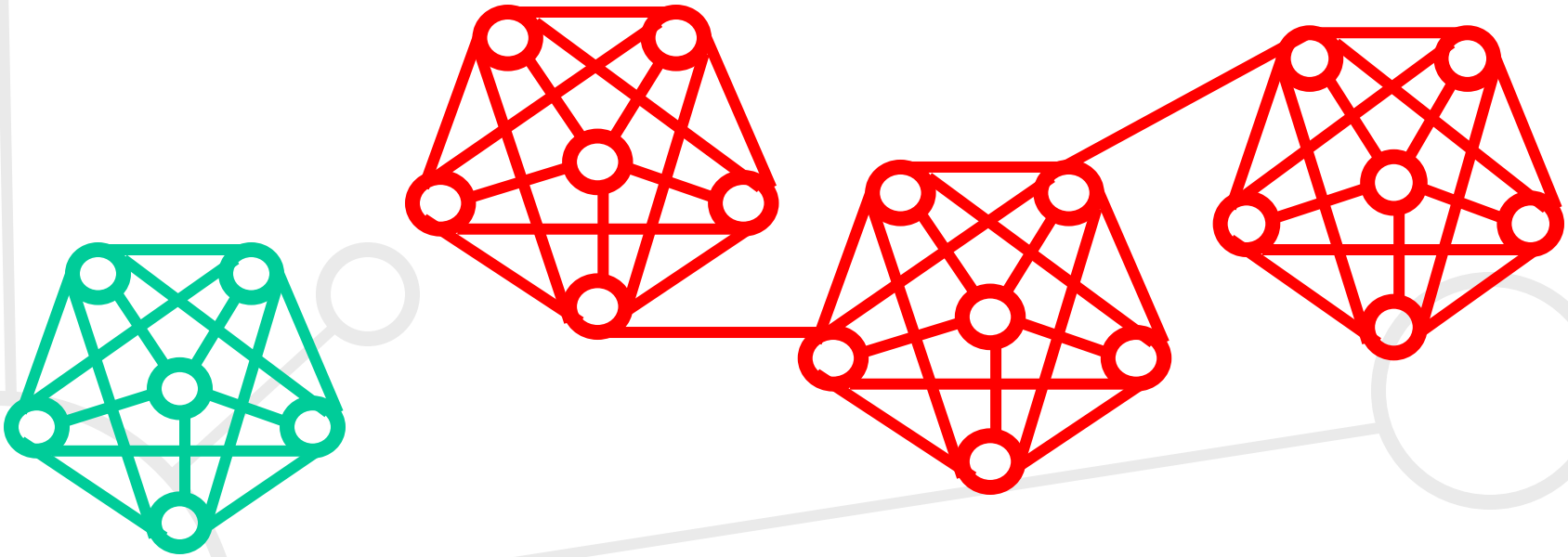
1. **Lee, Christopher (2.622)**
2. **Steiger, Rod (2.627)**
3. **Pleasence, Donald (2.651)**
4. **Welles, Orson (2.661)**
5. **Sutherland, Donald (2.662)**

…

1161. Bacon, Kevin (2.917)

Insularity

- Note that a high *k* doesn't mean that you are highly clustered. The highest *k* actors in IMDB are porn stars who all work with each other. They are an insular community.



The Erdös Number

- The math community uses the Erdös number to track proximity. Clustering is a sign of a highly evolved collaborative network. How advanced is the game industry?

- Google searches by number of links to a site, hence its accuracy. It's a "hub finder" device. This means that much of the web is effectively invisible.

SOCIAL NETWORKS

The Psychology, Geography & Weaknesses of Communities

Channel capacity

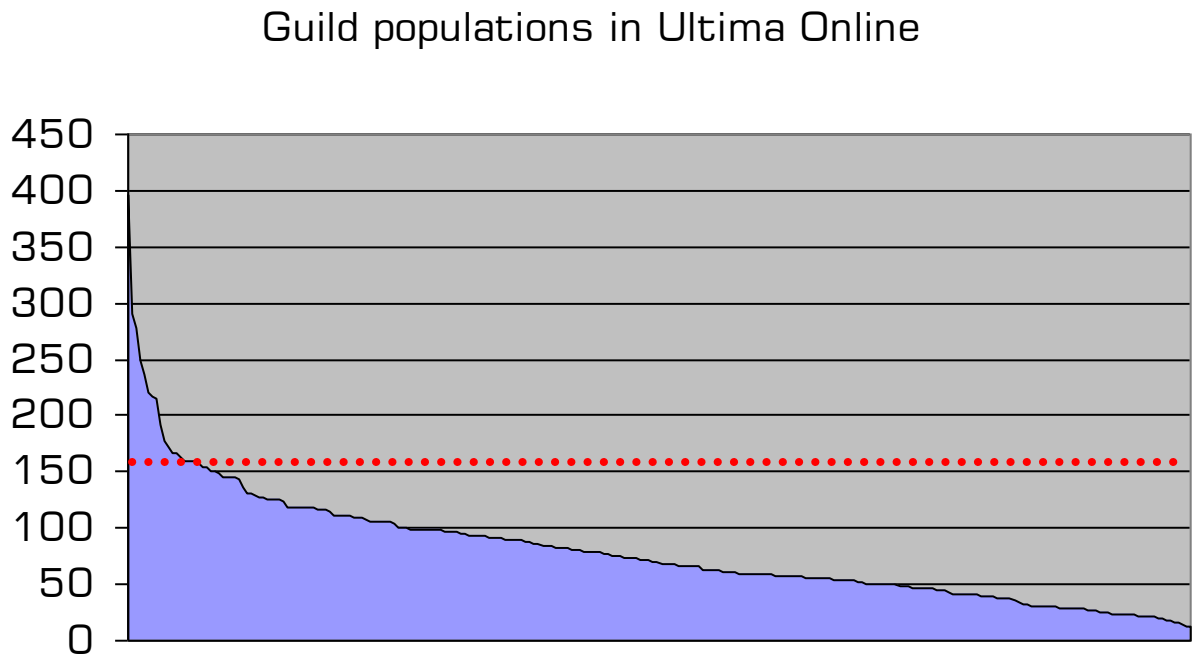
- Caring deeply maxes out at 12-15 people.
- Psychology calls this the "sympathy group."
- This sort of thing is called "channel capacity" in psych.

Human channel capacity

- Robin Dunbar, British anthropologist, says that social channel capacity is correlated to the size of the neocortex, and arrives at a figure for humans of 147.8.
- The average # of members in hunter-gatherer tribes is 148.4.
- Functional fighting units are often scaled to be around 150 soldiers in size.

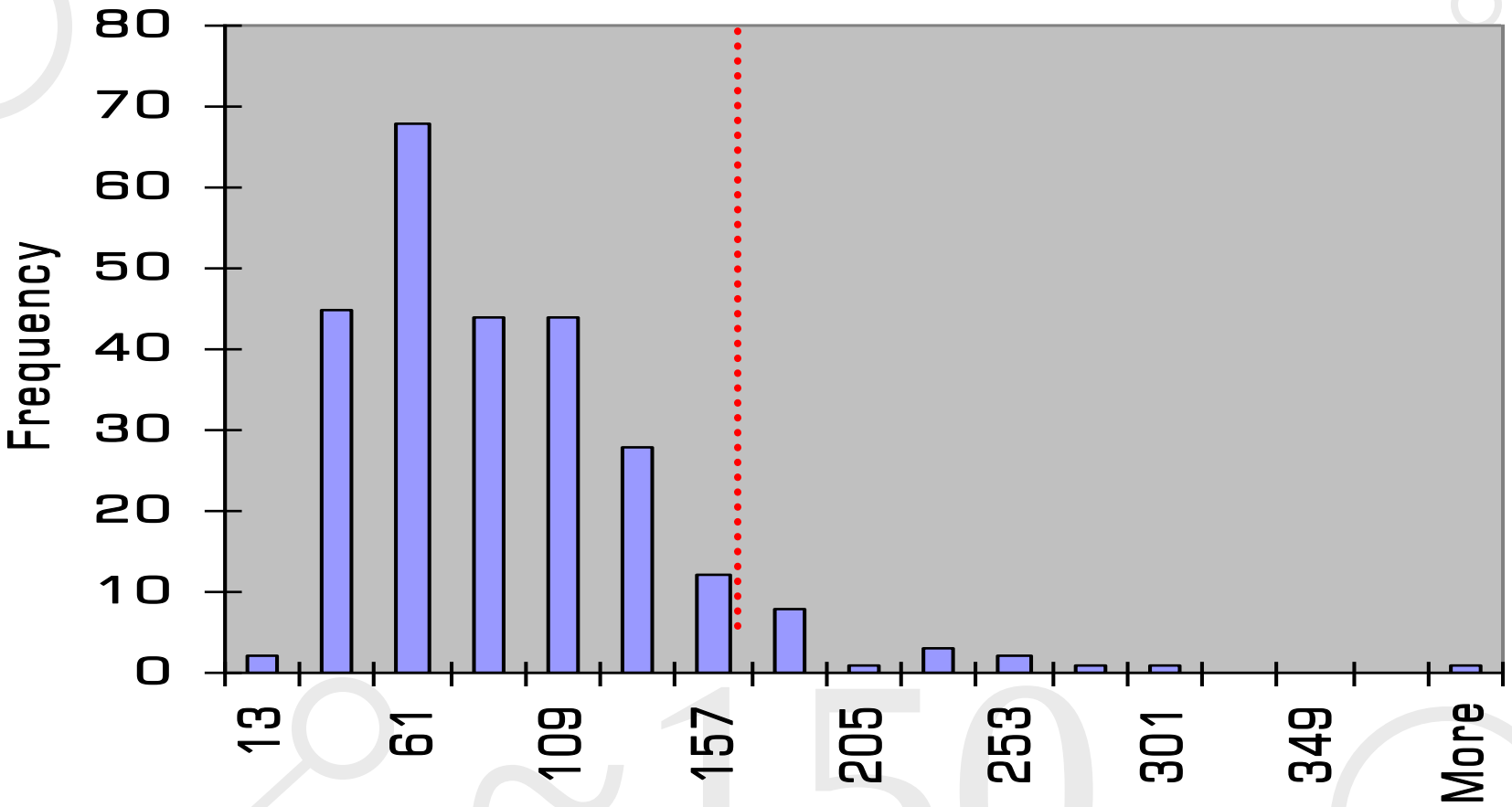
Channel capacity in online games

- Sure, enough, guild sizes show a "knee" at ~150.*



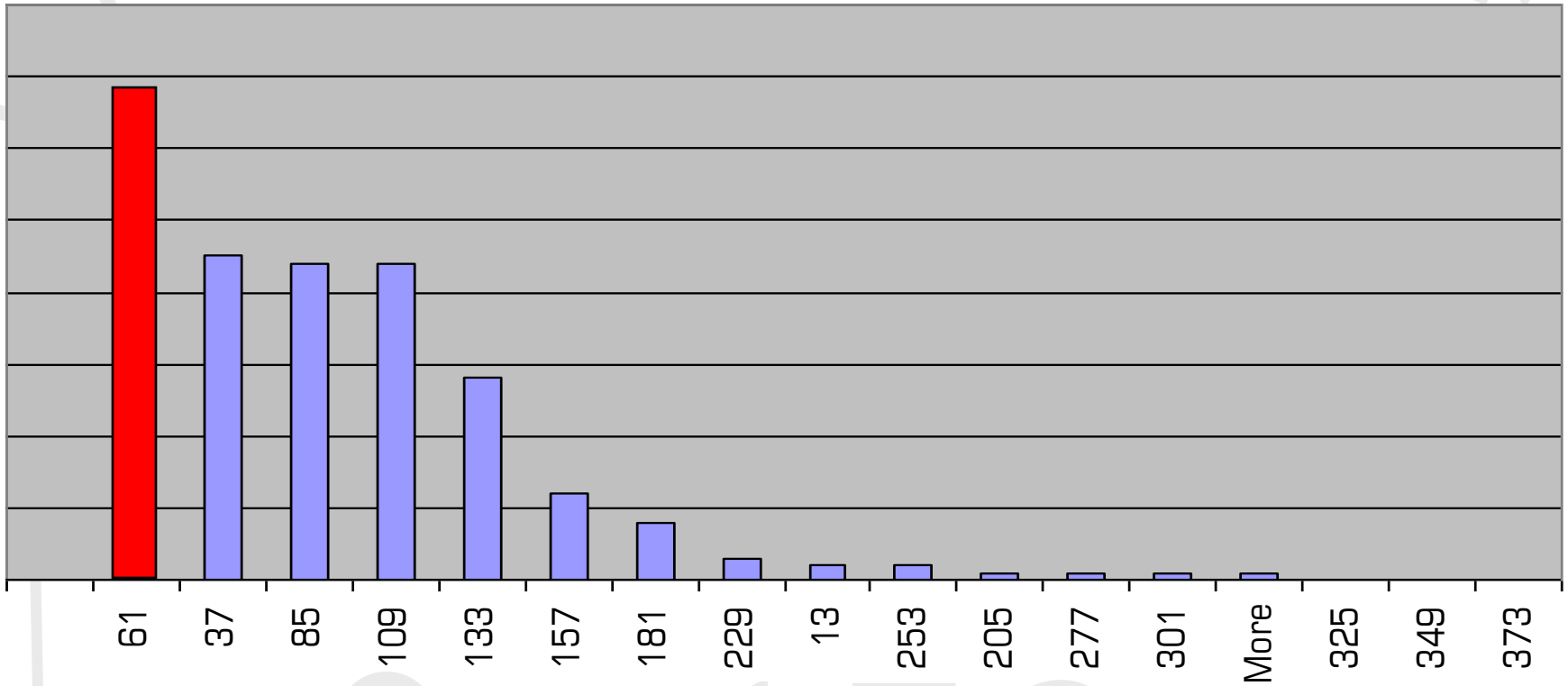
* Data drawn by taking the top ten guild populations on every server on 12/23/02 using the UO website's method of counting "veteran members."

Guild distribution histogram



- A histogram shows it more clearly…

Guild distribution Pareto graph



- Using a Pareto distribution of the histogram, we can see that 60 seems an optimal size, and guilds over 150 are very rare.

- Scale-free networks are resistant to random node failures. As in, random node failures CANNOT destroy a scale-free network.

- Shlomo Havlin, Reuven Choen, Keren Erez, and Daniel ben-Abraham showed that to kill a scale-free network, it must have a power law exponent of less than 3.

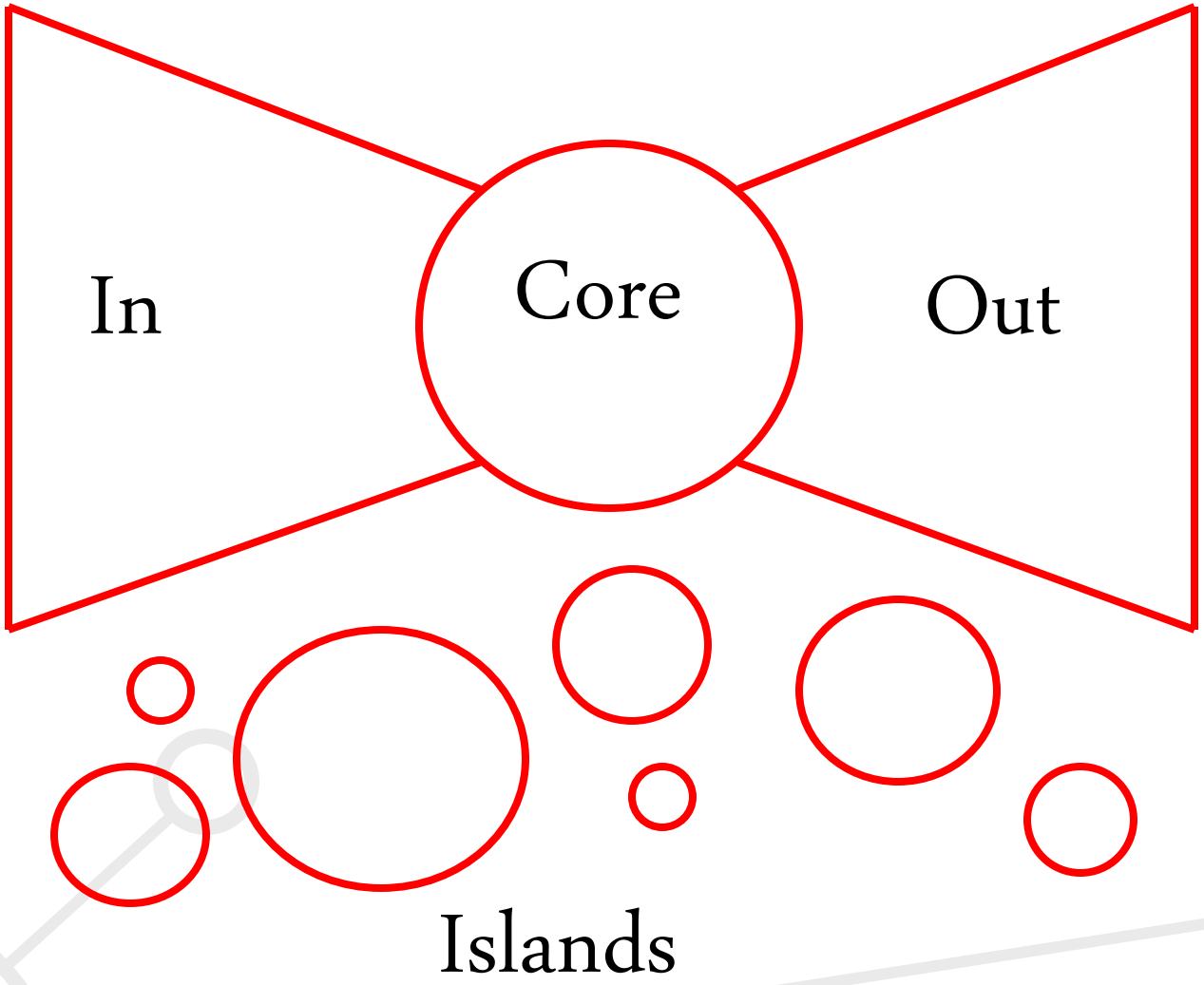
- All significant scale-free networks found thus far have better than 3 for the exponent, and are therefore practically indestructible.

- Hub attacks, as shown by Duncan Calloway of Cornell, with Mark Newman, Strogatz, and Watts, can kill a scale-free network in no time. However, it requires simultaneous removal (so that links do not have time to reattach elsewhere). The problem then becomes cascading failure.

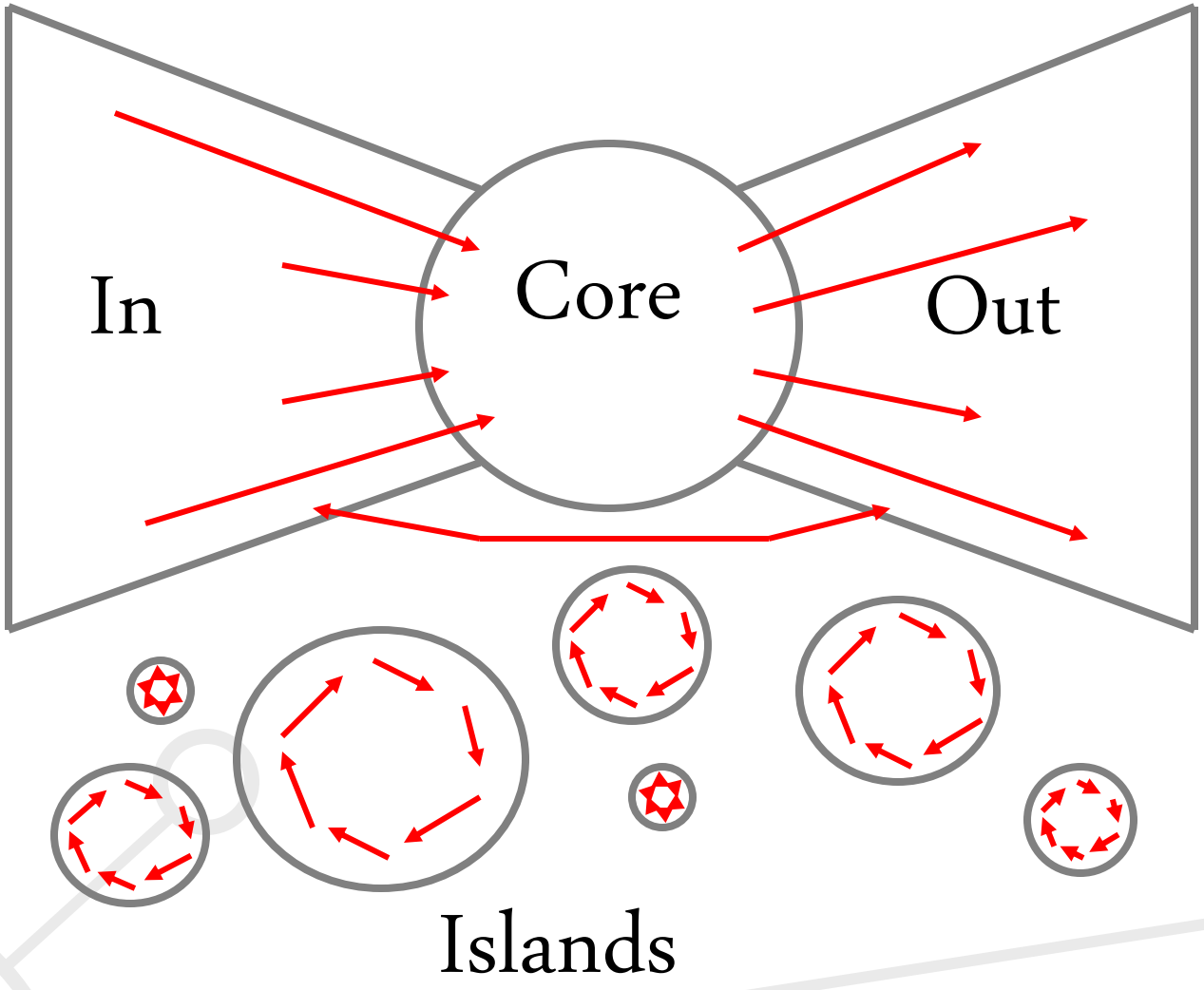
- Cascades are not instant, Duncan Watts showed. There is a tipping point there as well. The initial failure may result in a catastrophe many times its size, a very long time later.

- Steve Lawrence and Lee Giles of NEC Research Institute showed that the Web is too big to know. Search engines can only map a fraction, because from any given page, you can only reach 24% of the Web via linking.

A map of scale-free networks



A map of scale-free networks



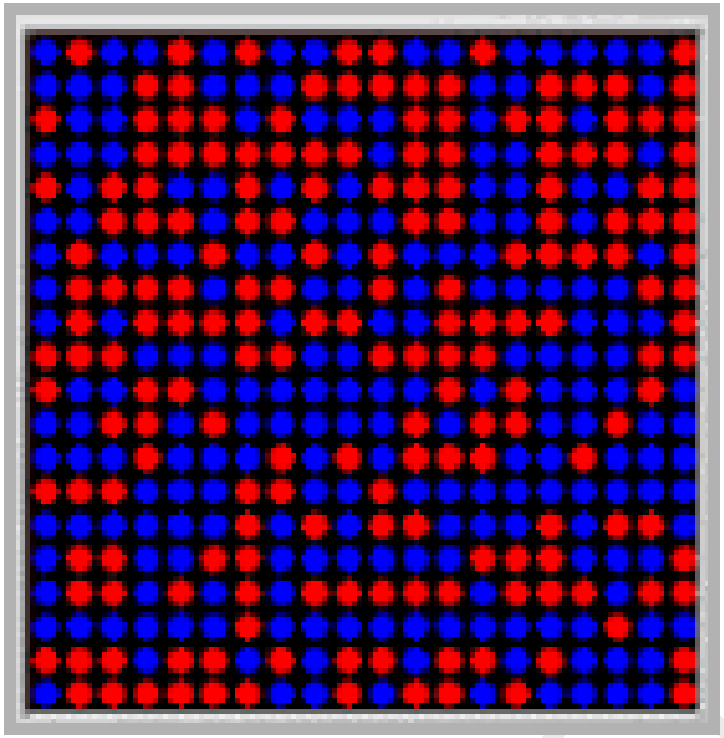
- This is a feature of all scale-free networks made of directed, non-reciprocal links, according to Sergey Dorogovstev, Jose Mendes, and A. N. Samukhin.

- Watts points out that friendships themselves are not symmetric; usually there is a superior/subordinate relationship. An acquaintance of lesser prominence is quicker to claim someone as a friend than someone of high status.

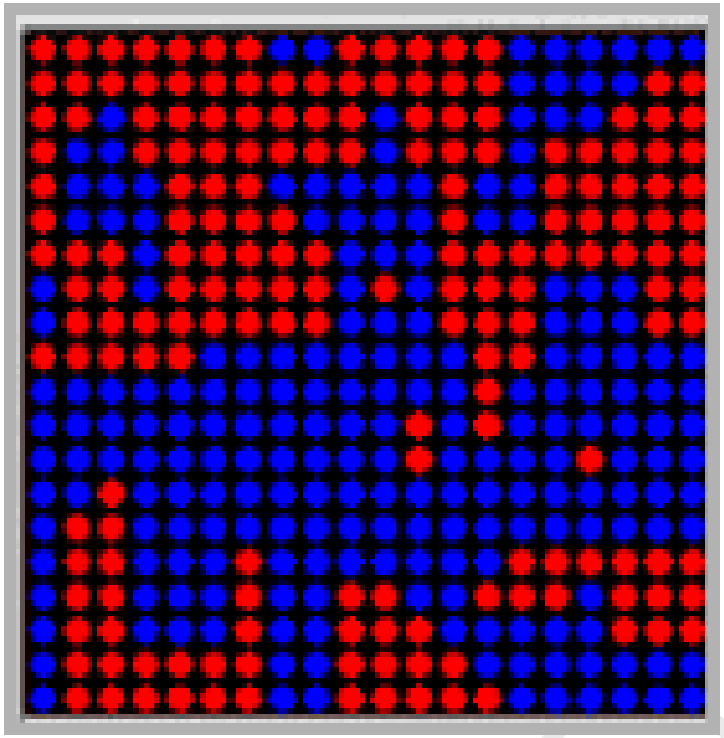
- Cass Sustein, a U Chicago law professor, showed that linking tends to be homogeneous.

- Only 15% of political sites link to opposing political viewpoints, whereas 60% link to like-minded sites.

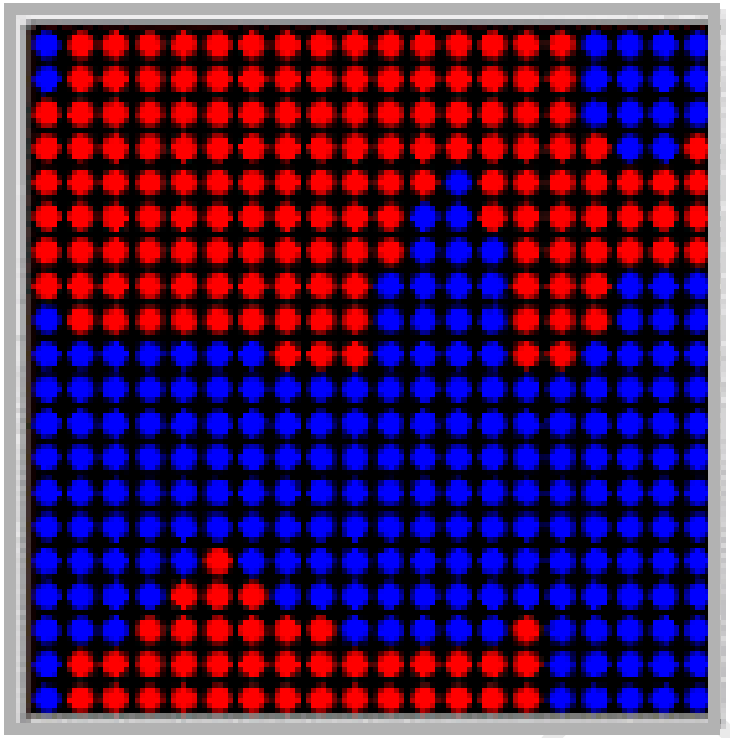
- Schelling has shown via A-life simulations that a peaceful, heterogeneous community will segregate itself.



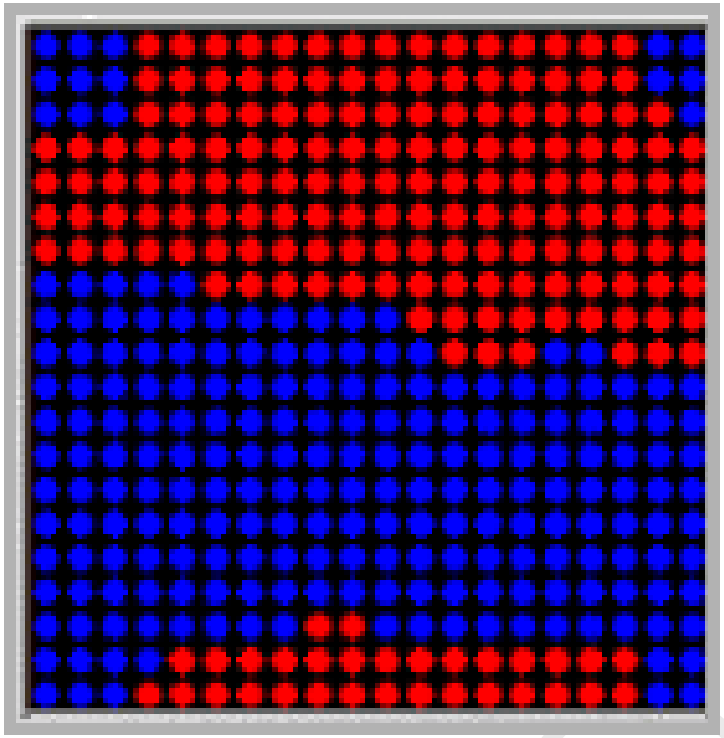
- And this is with agents that LIKE mixed environments.



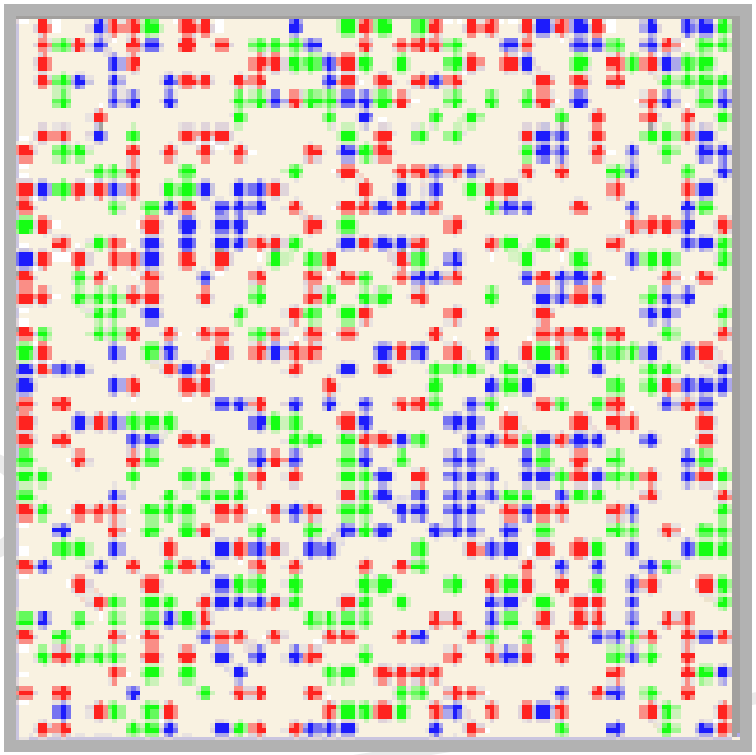
- All he did was set it up so that neighbors would swap places to find two like neighbors.



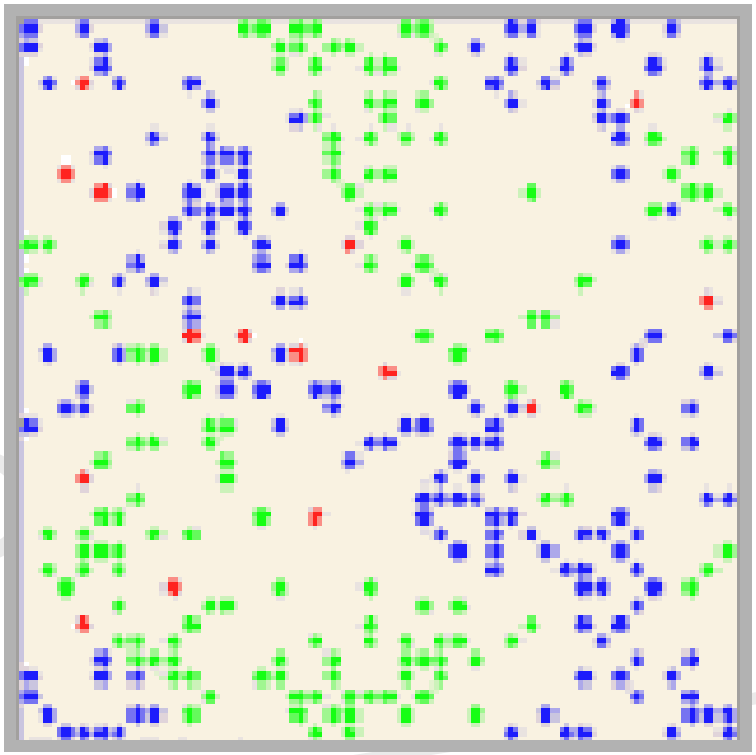
- Even if a given node only wanted ONE neighbor like itself, he still got segregation.



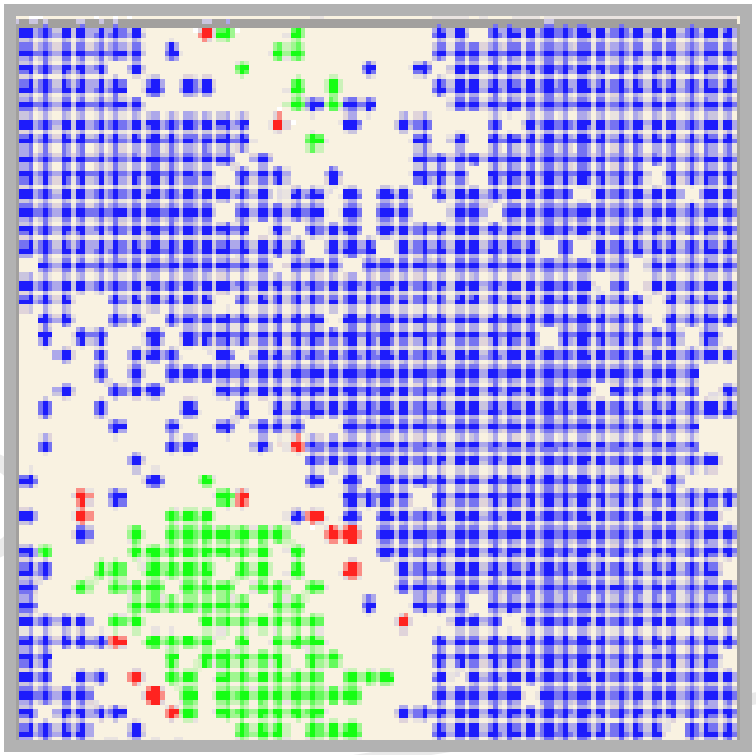
- In mixed environments of simulated "racial tension" using a similar model to the above…



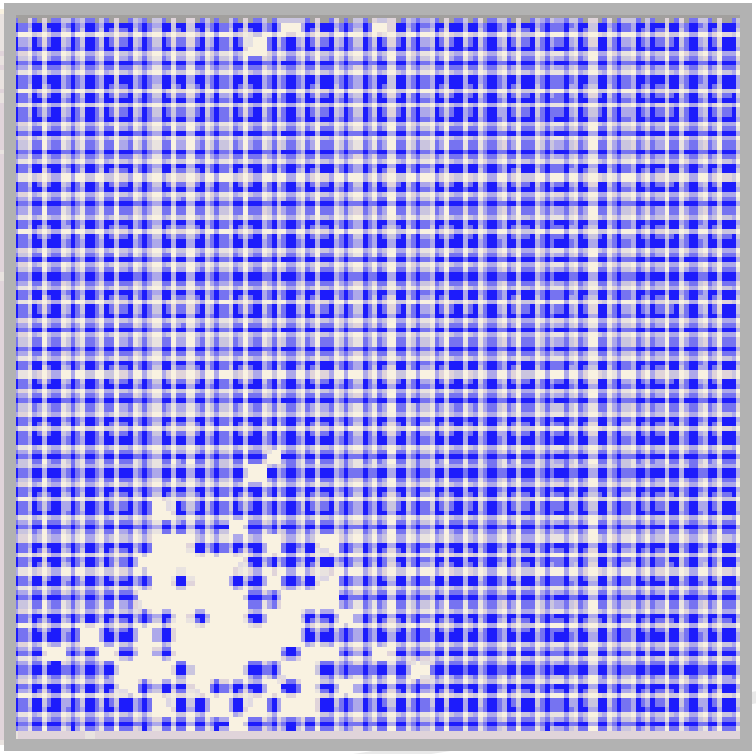
- Epstein showed that genocide is inevitable.



- A proportion of cops can stop the genocide, but you will still get "reservations."



- Even adding cops doesn't help; it just delays the inevitable.



"**Full purges** can be great fun if you are bored…**wipe a tenth** of the persona file, randomly. This way everyone worries it may be them… Personally, I used to like going onto a game as a wizard and **threatening someone**… [Admins] are there for the people above them to abuse, but as a sideline, they are there to **abuse the people** below them… To be successful at being a "big" arch-wizard you need to **be extremely arrogant**… **wipe them and all of their friends** out in one fell swoop. Make a point of doing it loudly…The odd act of kindness, like say, making a novice with a cute name a wizard, can really **annoy people** who have been playing for months…"

*Written by Michael Lawrie, *aka* Lorry, for MIST back in 1991.

- Hammond has shown that unpredictable policing, high-profile, high penalty sweeps are a bigger deterrent to misbehavior than consistency.

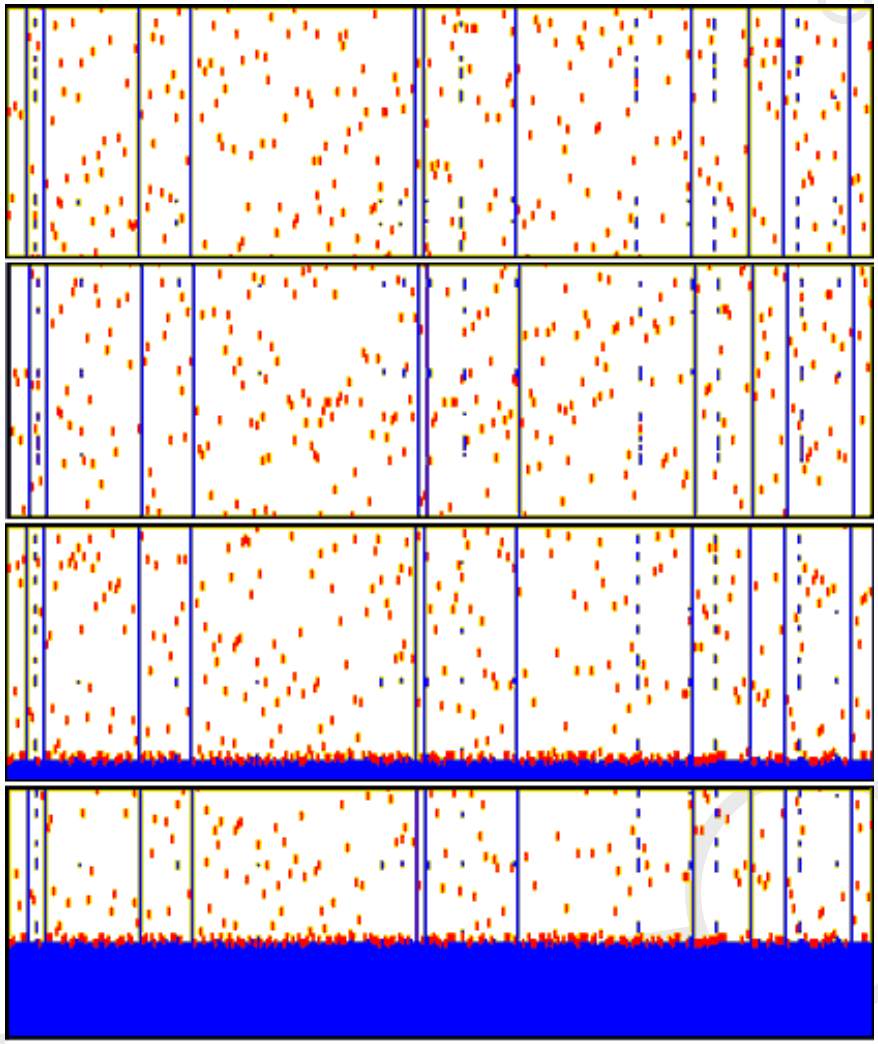


Figure 3.

- In normal epidemiological research, there is a “threshold” value of penetration that a virus must cross in order to become epidemic.
- Some ideas are “sticky” and others aren’t. The principal reason something is sticky is because it fits into someone’s life.
- Research on Sesame Street versus Blue’s Clues found that narrative is “sticky.” Stories retain attention better.

- In scale-free networks, there is no threshold for virii to cross, according to Pastor-Satorras and Vespignani, in Aug 2000. This is because of the hubs.

- You don't need to know exactly who the hubs are—Zoltán Dezsö showed that ANY preferential treatment restores the threshold for infection. So if you've got something to sell, sell to those likely to be hubs.

- "Mavens" are experts on areas of knowledge. The key researcher on Mavens is Linda Price of U. Nebraska.

- We see the future of the market in the reaction of the early, hardcore adopters. Persuade the early adopter and you get a huge market.

- Gaetan Dugas, a French Canadian flight attendant, was Patient Zero of the AIDS epidemic. He had an estimated 2500 sexual partners.

- Bruce Ryan and Neal Gross did famous diffusion studies on the adoption of a new breed of corn in the ’40s. They broke the categories into

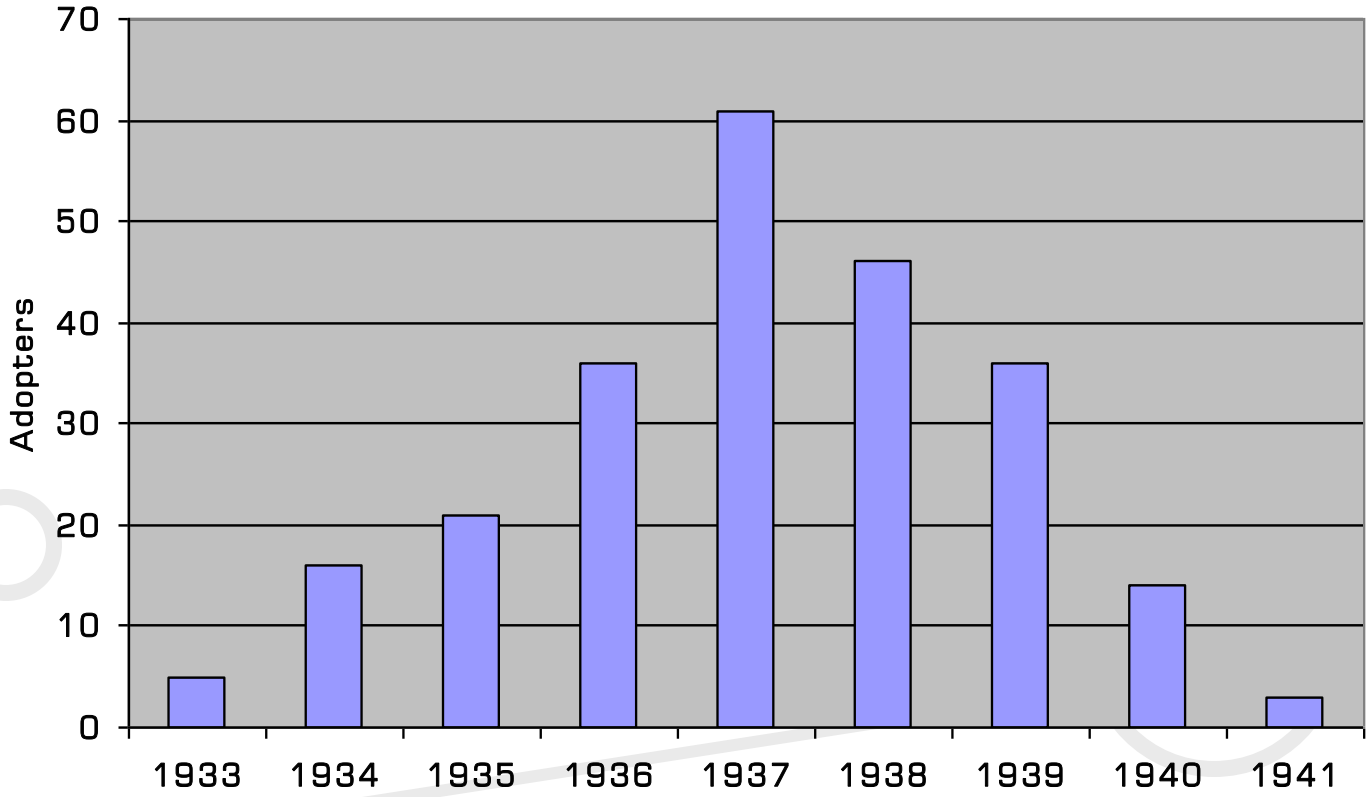
Innovators

Early adopters

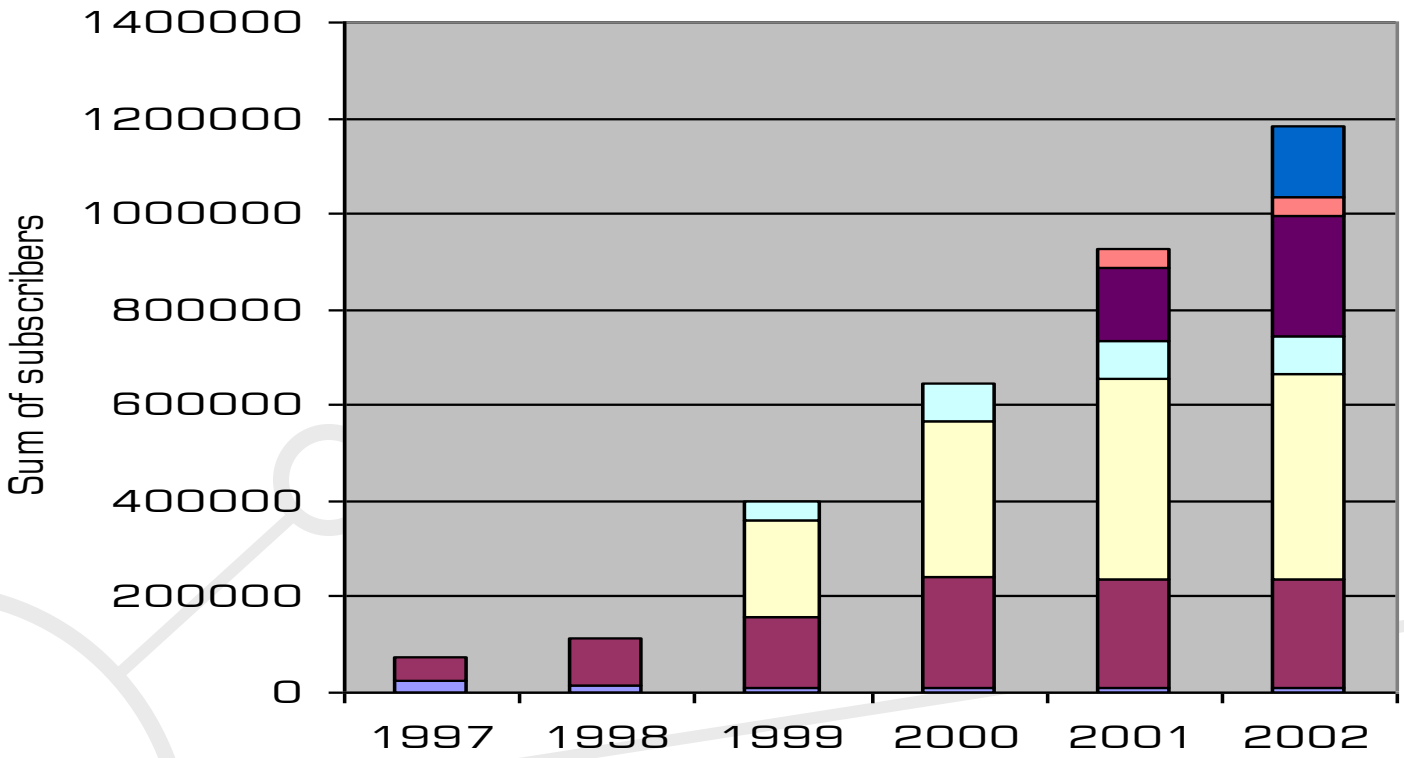
Early majority

Late majority

Laggards

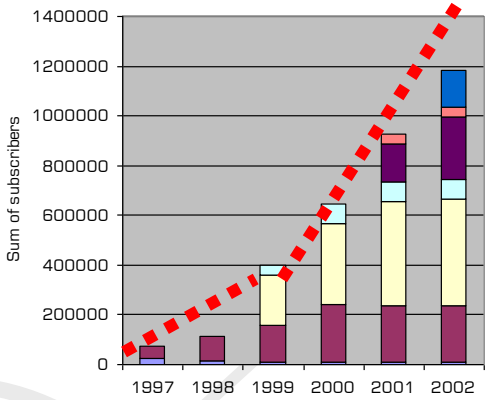


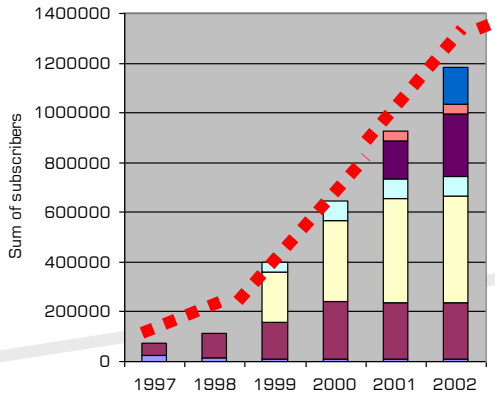
- We can see a characteristic adoption curve, which is also reflected in the MMO industry…



- We just don't know how far along the curve we are.

Curve A





Curve B

GAME THEORY

Interactions Between Members of the Community

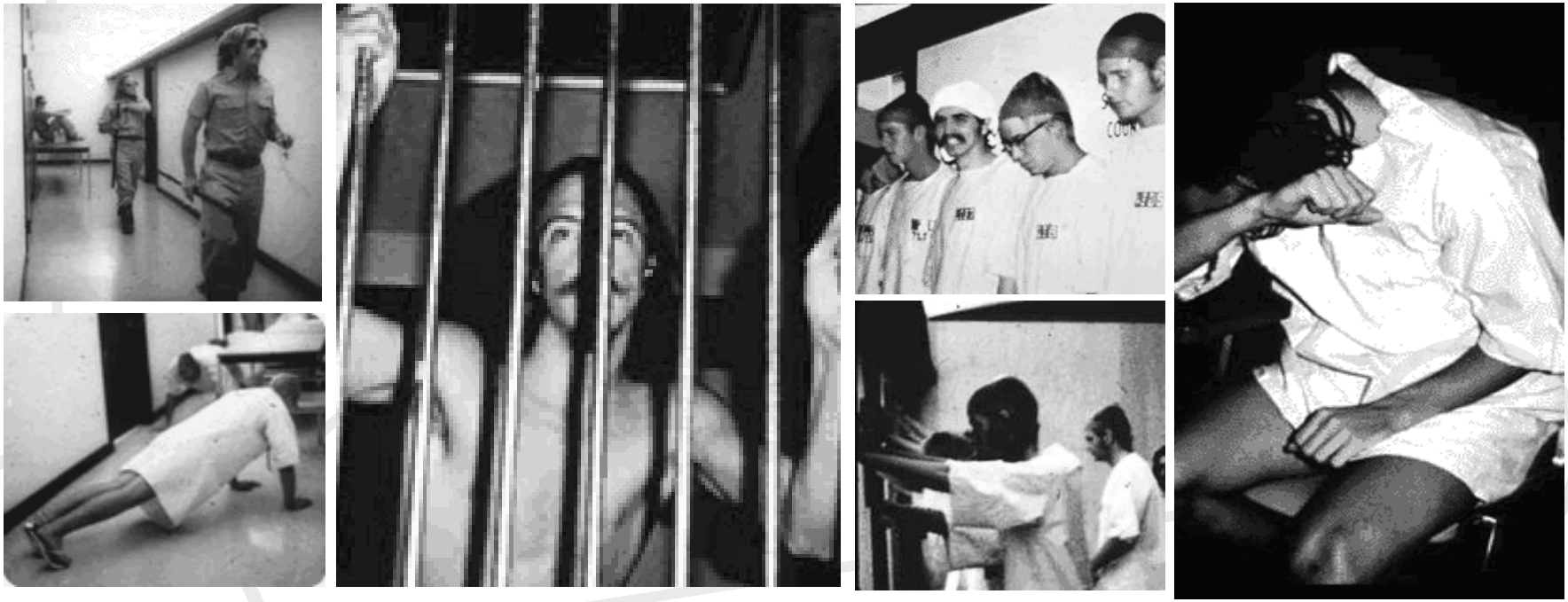
- We are more likely to agree with something if we are nodding when we hear it.

- Very subtle cues change our minds on things. Much of this depends on physical characteristics. William Condon found “synchrony” in physical movement among people talking.

- Robert Cialdini identified six strong persuasive characteristics in humans:
  1. We like people who give us gifts
  2. We hate changing our minds
  3. We imitate those like us
  4. We're suckers for those we like
  5. We trust apparent authority
  6. We overvalue rare things

- "Broken Windows" theory: criminologists James Q. Wilson and George Kelling show that minor misbehavior triggers bigger misbehavior.
- New York City reduced crime by cracking down on graffitti and subway fare-beaters.
- This demonstrates the importance of the overall environment.

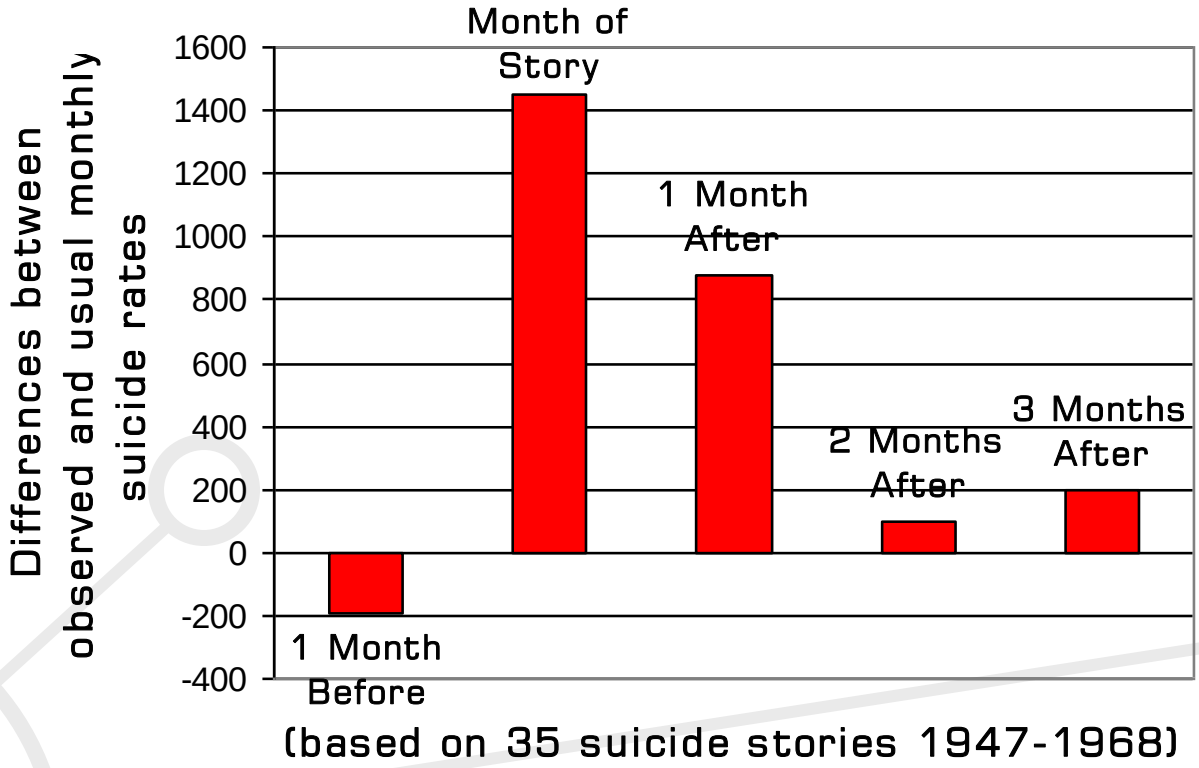
- The Stanford Prison Experiment, done by Zimbardo *et al.* in 1971, showed that people become their roles and indeed act quite atypically.



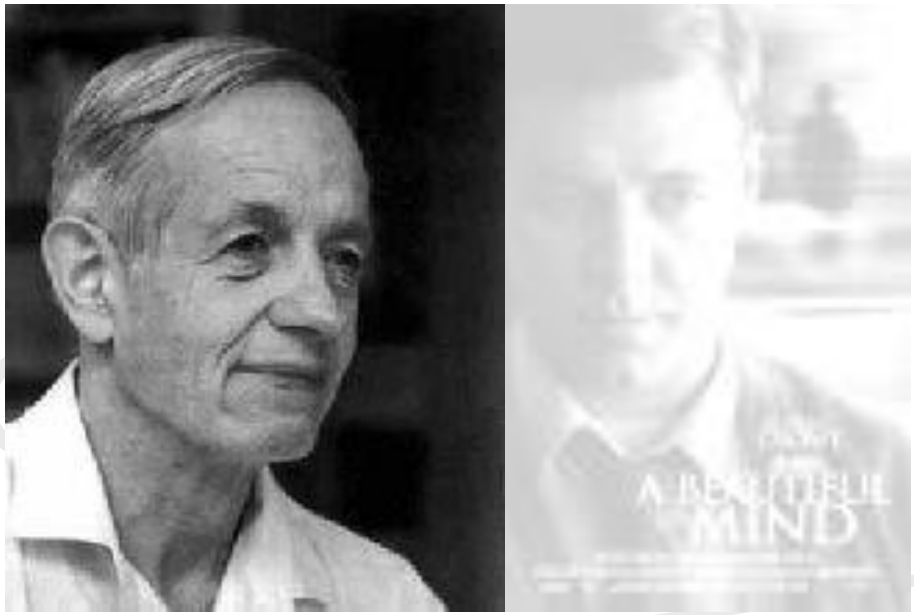
- The Hartshorne and May experiments on cheating show that honesty is not in fact inherent. It's situational.

- In psychology, this is called the Fundamental Attribution Error. Humans always overestimate character and underestimate circumstances.

- You follow the trendsetters. Look at our cultural zeitgeist. People are shaped by their peer group, not by authority figures.



- John Nash showed that with bargaining, all competitors can come out ahead even in zero sum games. But our zero sum games do not have bargaining.



- In the Prisoner's Dilemma, 2 guys are held for a crime, with no communication between them.
- Each is asked to rat out the other. If both rat out, they both get the worst punishment. If neither does, they get the least punishment.
- Given the lack of information, the *rational* thing to do is to rat the other out, which results in the maximum punishment for both.

- The optimal behavior is Tit for Tat, which calls for a history of iteration that the players are aware of (developed by Rapoport).

    1. Be nice. (never be the first to defect)
    2. Be retaliatory (defect if the opponent did last time)
    3. Forgive! (if the opponent stops, you stop)
    4. Be transparent (opponent can tell how you will behave)

- This works if the # of rounds is unknown, eg, there is an expectation of future interaction, as shown by Axelrod in 1984.

For once, human nature pays off...

- A team at Emory recently showed that reciprocal altruism appears to be hardwired into the pleasure centers in our brains. They also showed that knowing when the game ended undermined the altruism.

- They also showed that it only applies if you HUMANIZE the opponent.

- Looking at EQ plane raids: as the number of players competing for the exact same resource rose, complex rules of social standing and precedence started arising spontaneously.

- The phenomenon of plane raids in EQ being "reserved" by guilds that are the size of your average mud's playerbase, for example. This is a direct, literal application of Nash's work.

- Jared Diamond in *Guns, Germs, and Steel* breaks down social complexity into tiers based on population size.

Dozens → Hundreds → Thousands

Bands	Tribes	Chiefdoms
No fixed home	A single home	Many homes
"Egalitarian" leadership	"Egalitarian" or "big-man"	Castes and classes
No real bureaucracy	Organized resource extraction	Cronyism & monarchs
No laws	Still unstratified	Bureaucracy & laws
Unstratified culture		Taxes, indentured labor, and slavery
		Public architecture
		Luxuries for elites

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Cronyism & honorifics

Bureaucracy & laws

Taxes, indentured labor, and slavery

Public architecture

Luxuries for elites

Guild

Uberguild

- It's not literal population that matters. It's economic participation.

- Social structures emerge when all those people are trying to draw from the same resource well (literally trying to extract more calories from the same amount of land).

- Online games have a problem with inconstancy; players aren't economic participants 24/7.
- When logged off, they don't consume resources or contribute to the economy.
- This probably retards social development.

- In GoP games at least, the thing that players work together to increase the efficiency of is the process of extracting more XP per hour.

- Camping is a direct analogue to agriculture! We used to hunter-gather the mobs, now we farm them... even the term "farming" has crept up in common usage), etc etc.

- The work of Toshio Yamagishi of Hokkaido U tackles the "Lemon Problem."
  - The seller of a used car knows more than the buyer.
  - A lemon goes for $10k, and a good car for $20k.
  - They compromise on $15k through bargaining.
- But good sellers will therefore stay out of the market (and only deal with those who trust them) because they want the price they deserve.
- The result is that the open market only has bad cars for sale.

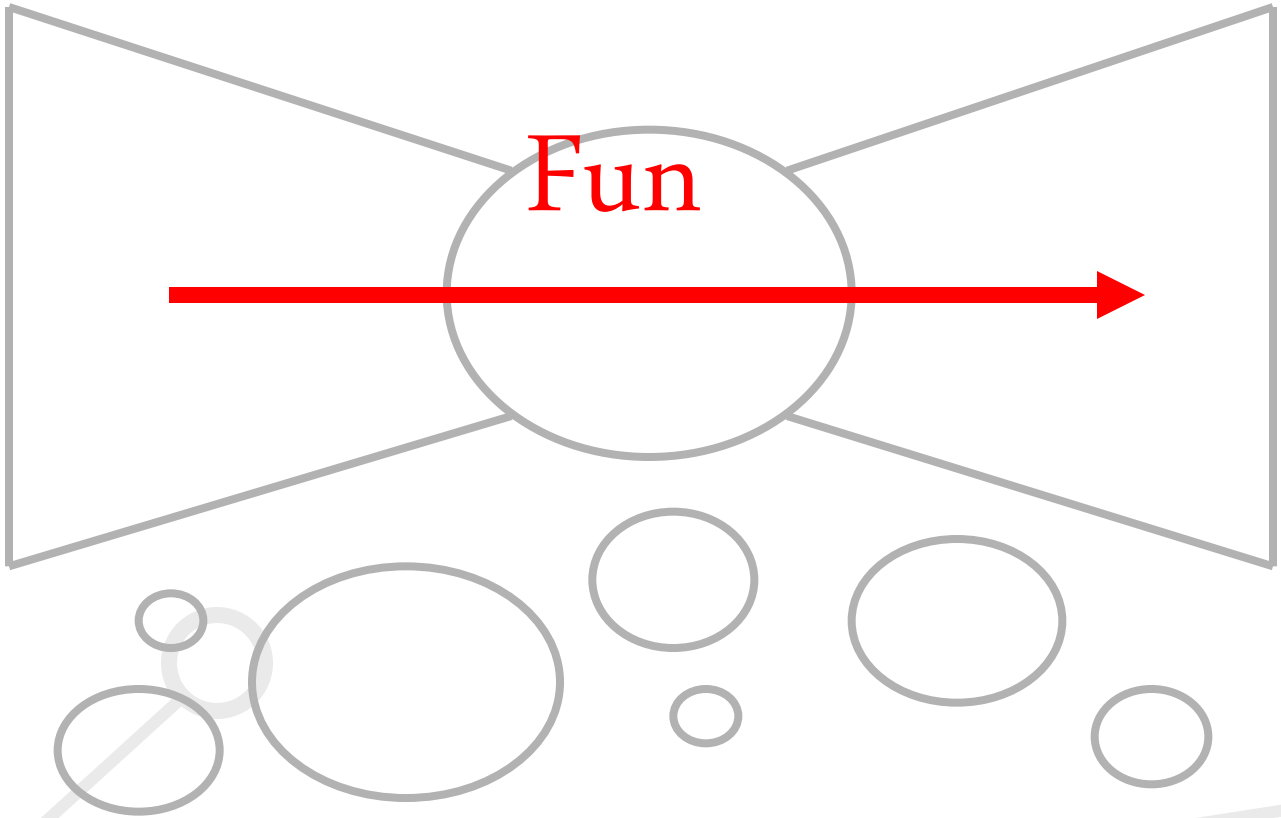
- In the real world, reputation helps resolve this. In online, the ability to change your identity negates it.
- Tracking negative reputation starts out good, then crumbles over time
- In open systems, the most advantageous strategy is Tit for Tat, *e.g.* a positive feedback after the fact rep system.
- Tracking positive reputation starts out bad but builds over time to be almost as good as a closed system

PARETO'S LAW

Power Laws, Fitness, Talent, and Stagnation

- Vilfredo Pareto, Italian economist, found power laws everywhere.
- 80% of Italian land was owned by 20% of the population.
- 80% of money is held by 20% of the people.
- 80% of links point to 15% of websites, for example.

- Picture a zero-sum game…

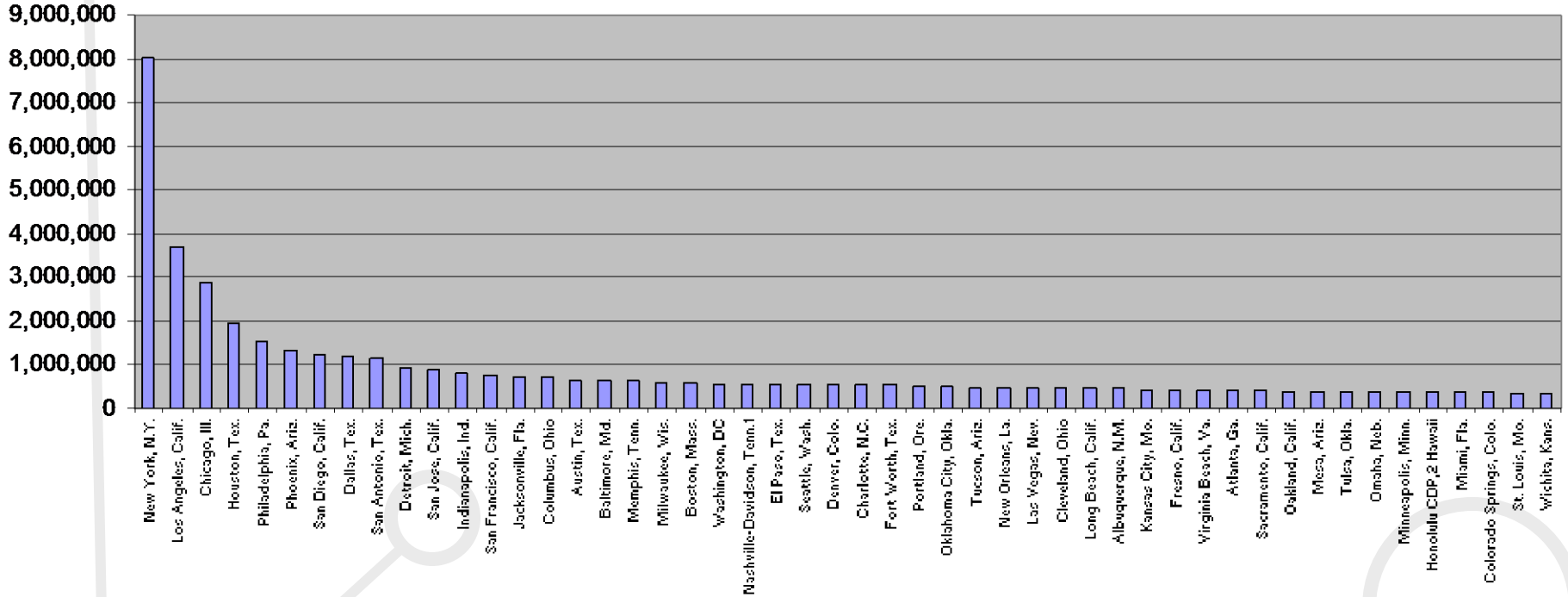


$$P(k) \sim k^{-3}$$

- Nodes have fitness.
- The rules for link addition developed by Barabási *et al* show that the phenomenon is basically "the rich get richer."
- In Model A, Erdös graphs, links attach randomly.
- But in Model B, they prefer to attach to nodes with links already

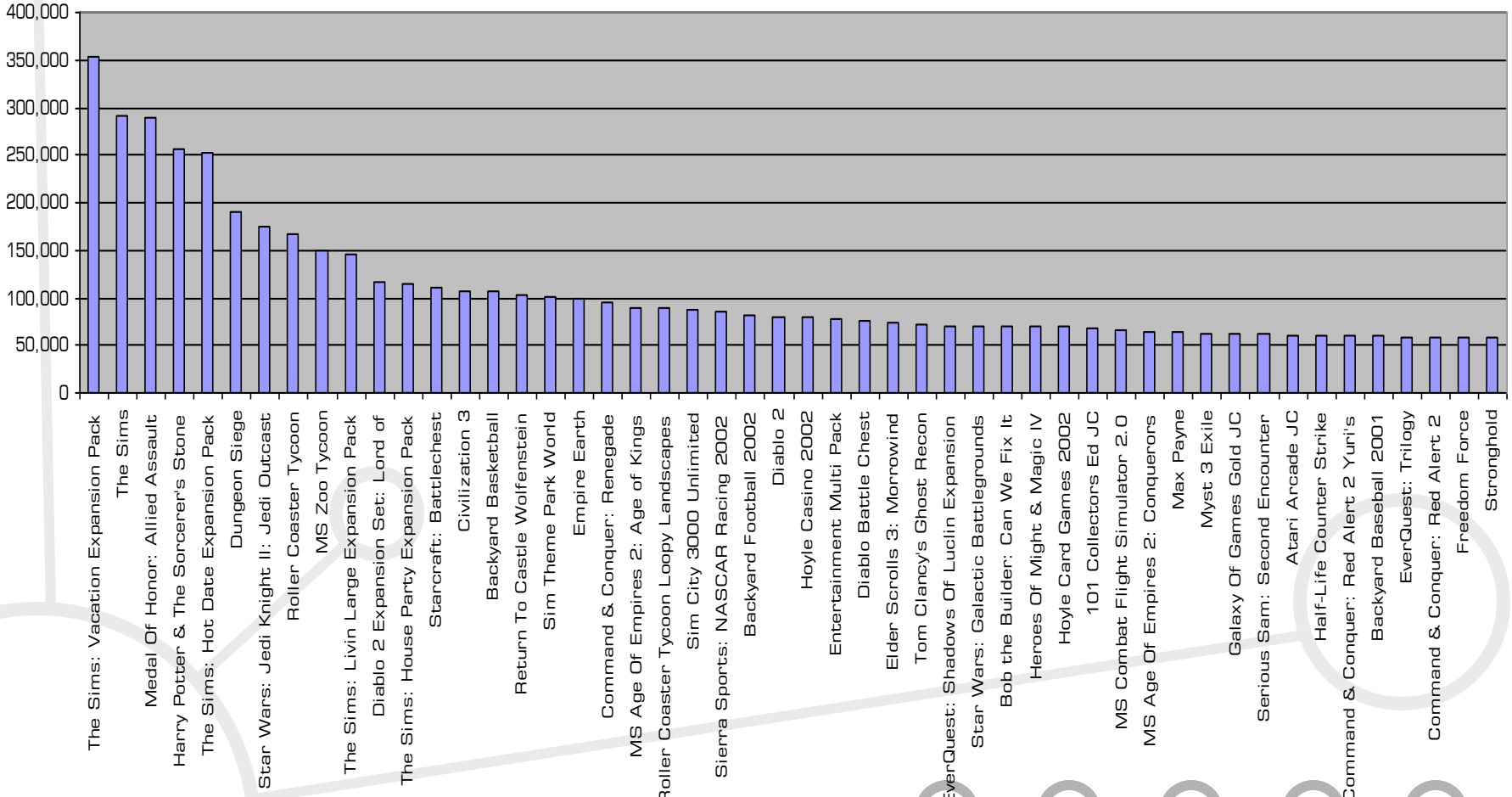
City sizes

- The curve has been invariant since 1900's census.

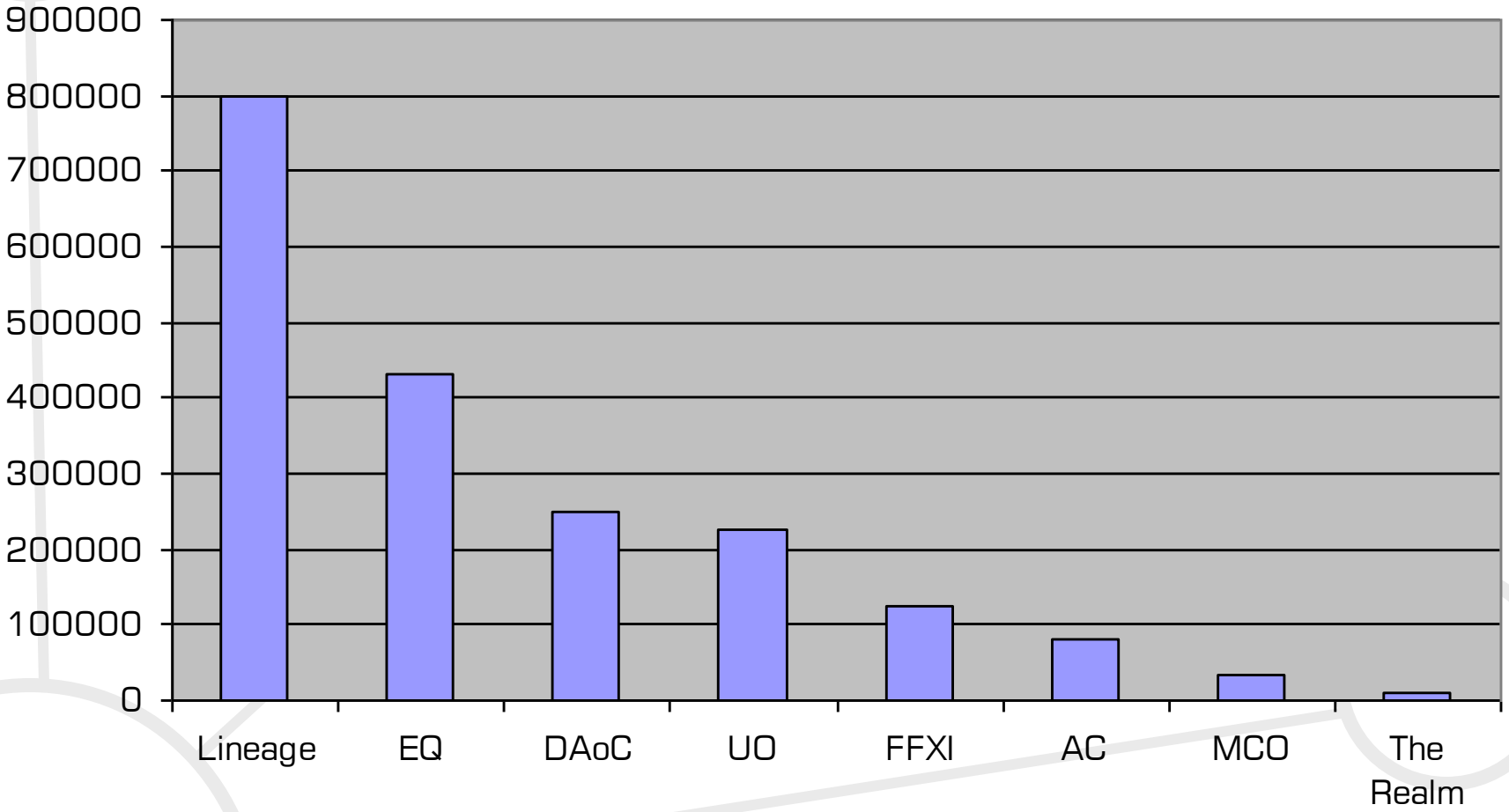


SMALL WORLDS

- NPD tracked sales for the 1st half of 2002. The curve is also invariant.



- Can we predict new game sizes?



- Physics shows that when power law distributions arise in molecules, we get "phase transitions." There is a tipping point where chaos transitions to order.

- Kenneth Wilson won the 1982 Nobel Prize in Physics for showing this.

Stagnation

- Luis Amaral, Gene Stanley, Antonio Scala, and Mark Barthélémy show that if nodes don't get new links after a certain age, the network will cap the hub size.

- And José Mendes and Sergey Dorogotsev showed that age can affect a node's fitness (odds of acquiring a new link). This also affects hub creation.

Fitness distribution

- But fitness distribution also follows a power law. The odds of attaching to a node obey a formula that depends on the number of links the node already has, and how fit it is at acquiring new ones.

$$k\eta / \sum_i k_i \eta_i$$

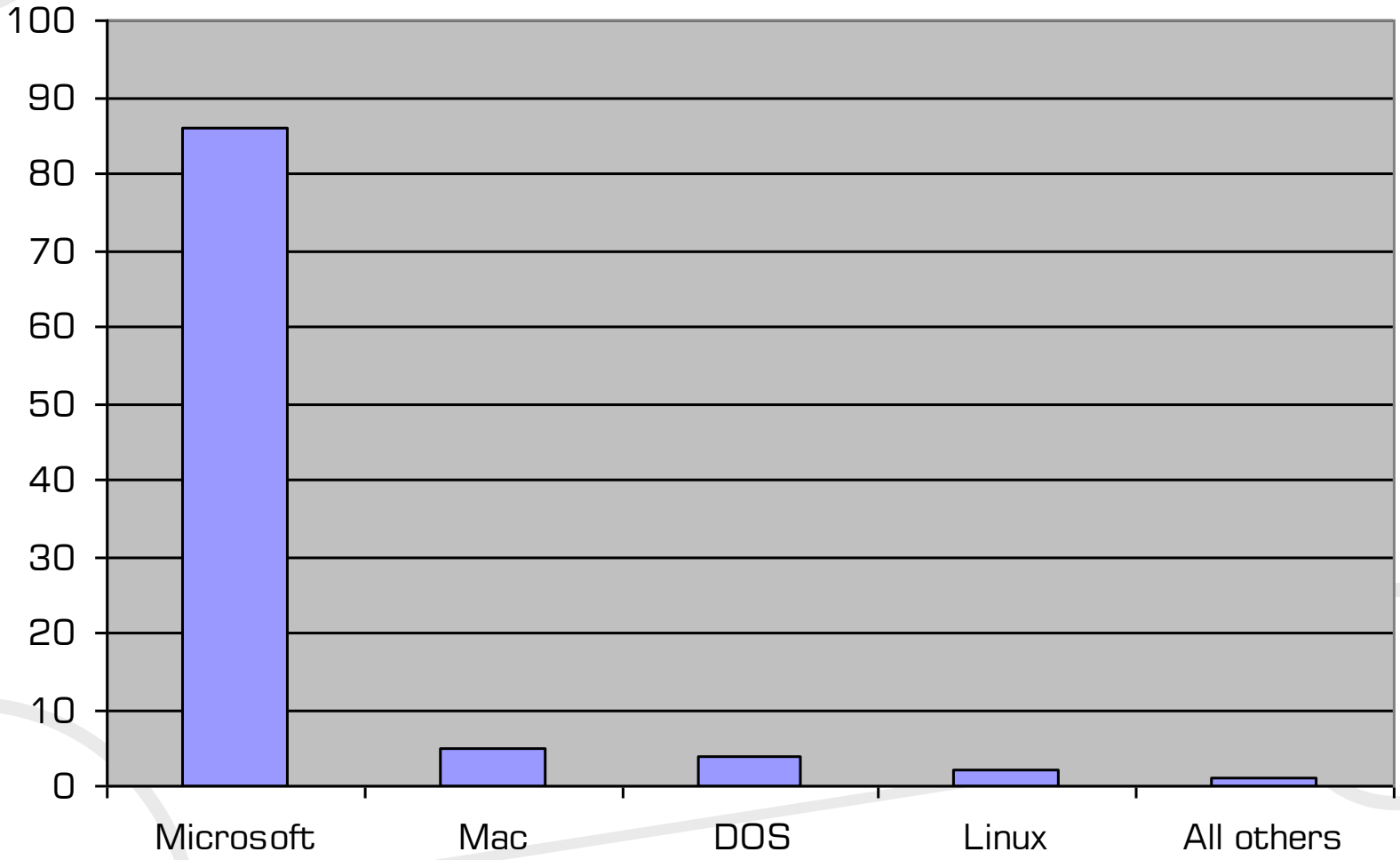
where k is the number of links and η is fitness.

Bose-Einstein condensation

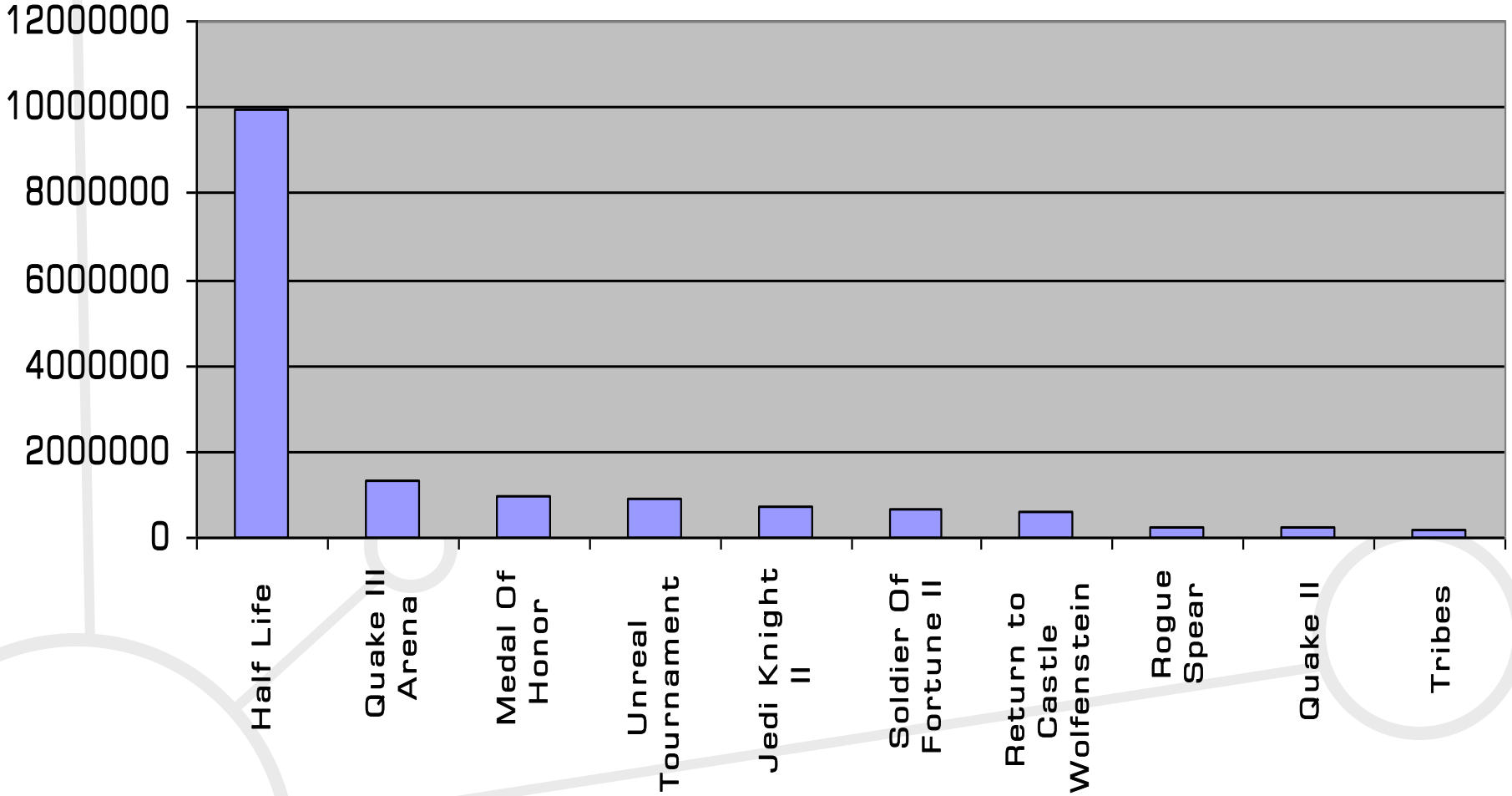
- Networks remain balanced between chaos and order as long as preferential attachment and growth are present. But remove growth and what you get is a term from physics: Bose-Einstein condensation. Also known as "monopolies."

- In other words, in some networks, it is possible for the fittest nodes to grab ALL the links.

- Graph of OS market share

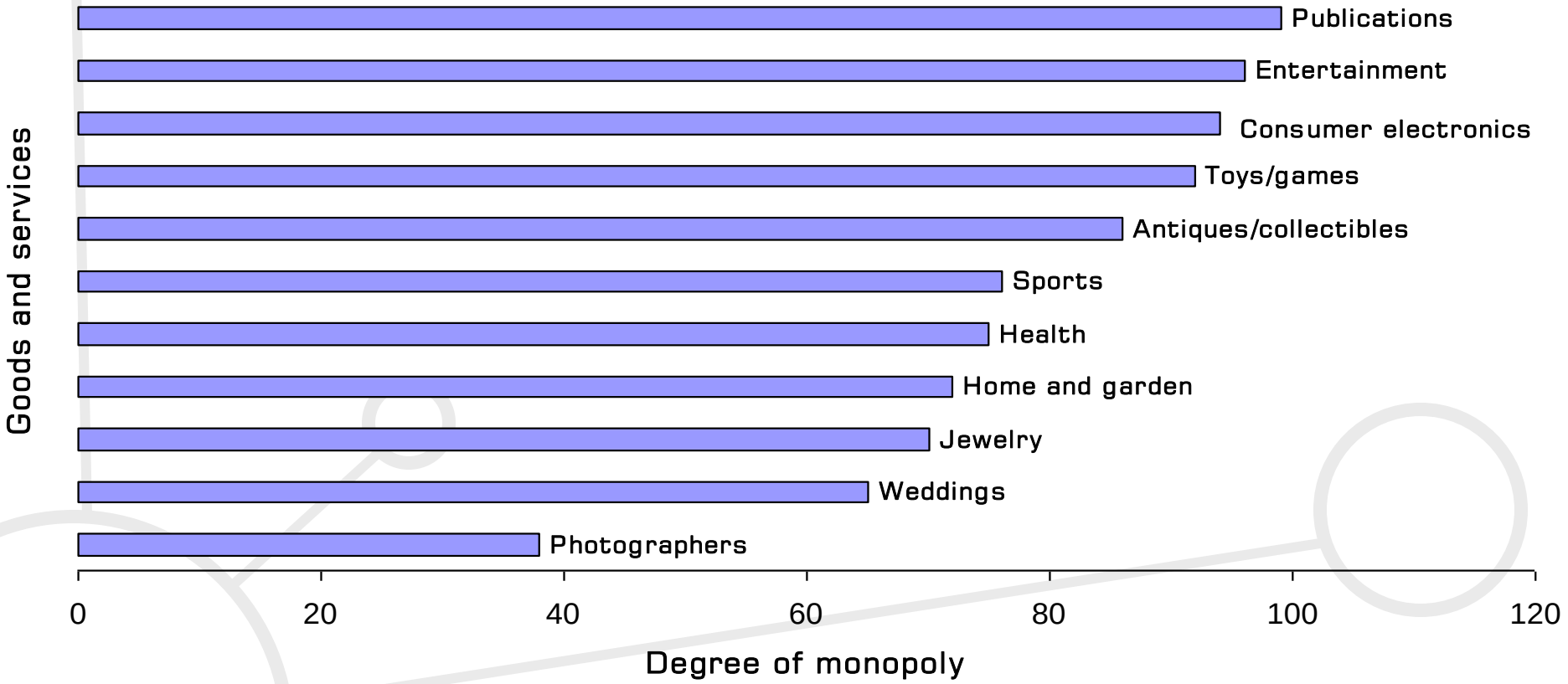


- Is there any point to the shooter market?



Commoditization

- Pennock, Flake, Lawrence, Glover, and Giles at NEC have a formula that predicts the attachment of new links to a scale-free network accurately. The amount of rich-get-richer that occurs varies per e-commerce category.



Commoditization

- The degree of commoditization of the goods/services sold is what drives stasis:

- Fitness of nodes for link acquisition also follows a power law distribution.
- We can call this “talent” if we like.

Tiger Woods

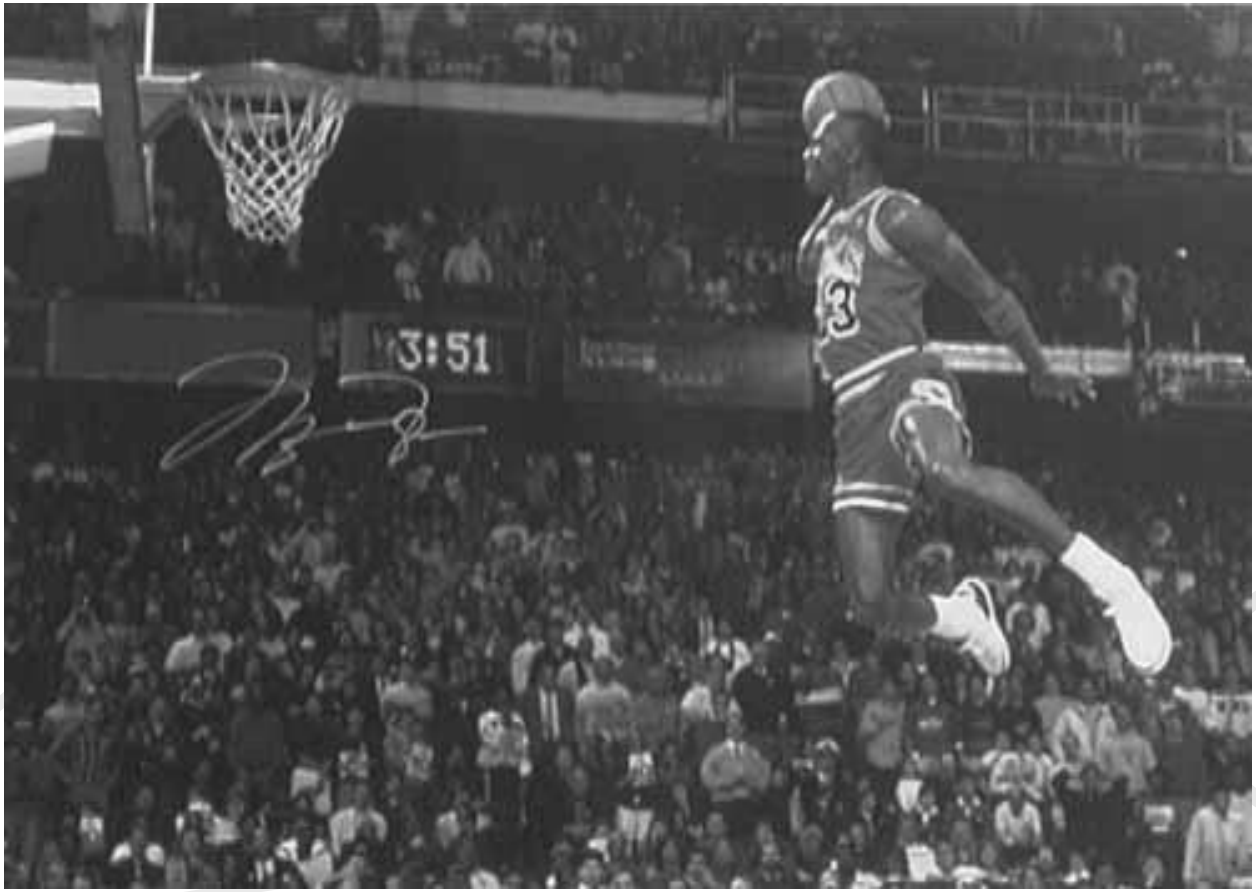
- Total scores in 1st 22 championships, 81 under par. Jack Nicklaus, 40 over.
- In 11 majors, Tiger won 7. In other words, 2 times out of 3, Tiger got the trophy, and the rest of the time, the rest of the field squabbled over it.
- As Nicklaus said, "He's playing a game I am not familiar with."

Babe Ruth

- In 1921 Babe Ruth by himself hit more home runs than ½ the teams in the league.

- In 1981-82, Wayne Gretzky scored twice as many points as the 2nd highest scorer in hockey.

- Jordan's average points per game is 31. The runner up was 25.



- Secretariat won the Belmont Stakes by 31 lengths.

Bobby Fischer

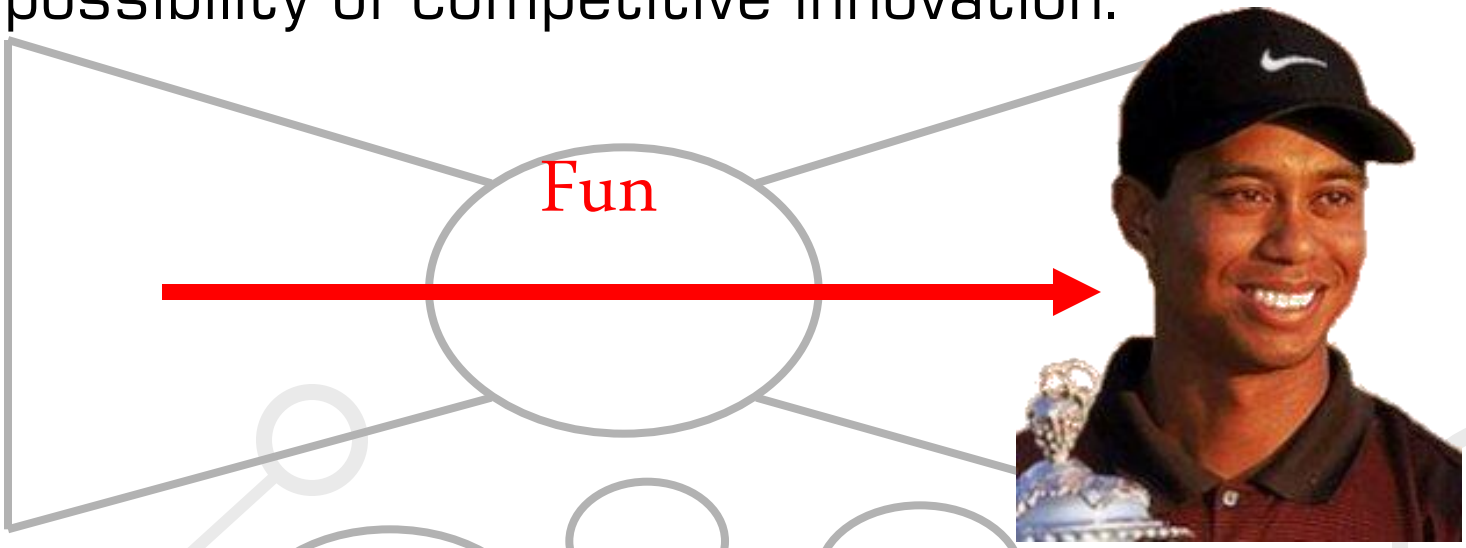
- Bobby Fischer in the 1971 elims at the World Chess Championships, in a game where 80% of tournament games are draws.
- He beat 2 guys 6 games in a row each.
- He had 20 straight victories vs the best players on the planet.

- The #1 playerkiller in UO had 14,000 murders, versus a measly 2000 for the runner-up.

The average player had 2 murders.

Welcome to the condensate

- Assuming there PARITY of fitness, persistence, and freedom of choice to create preferential attachments, Bose-Einstein condensation will start to occur in all systems where there is no possibility of competitive innovation.

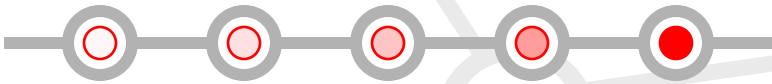


Implications for skill-based games

- This has been observed in persistent team-based games, where the realm, faction, or side with the most victories is switched to by members of the losing side.
- This is why online-skill based games kick most people's ass and they don't play.
- Fortunately for our market space, EA, despite selling 1 in 4 games sold, does not have a lock on innovation. ☺

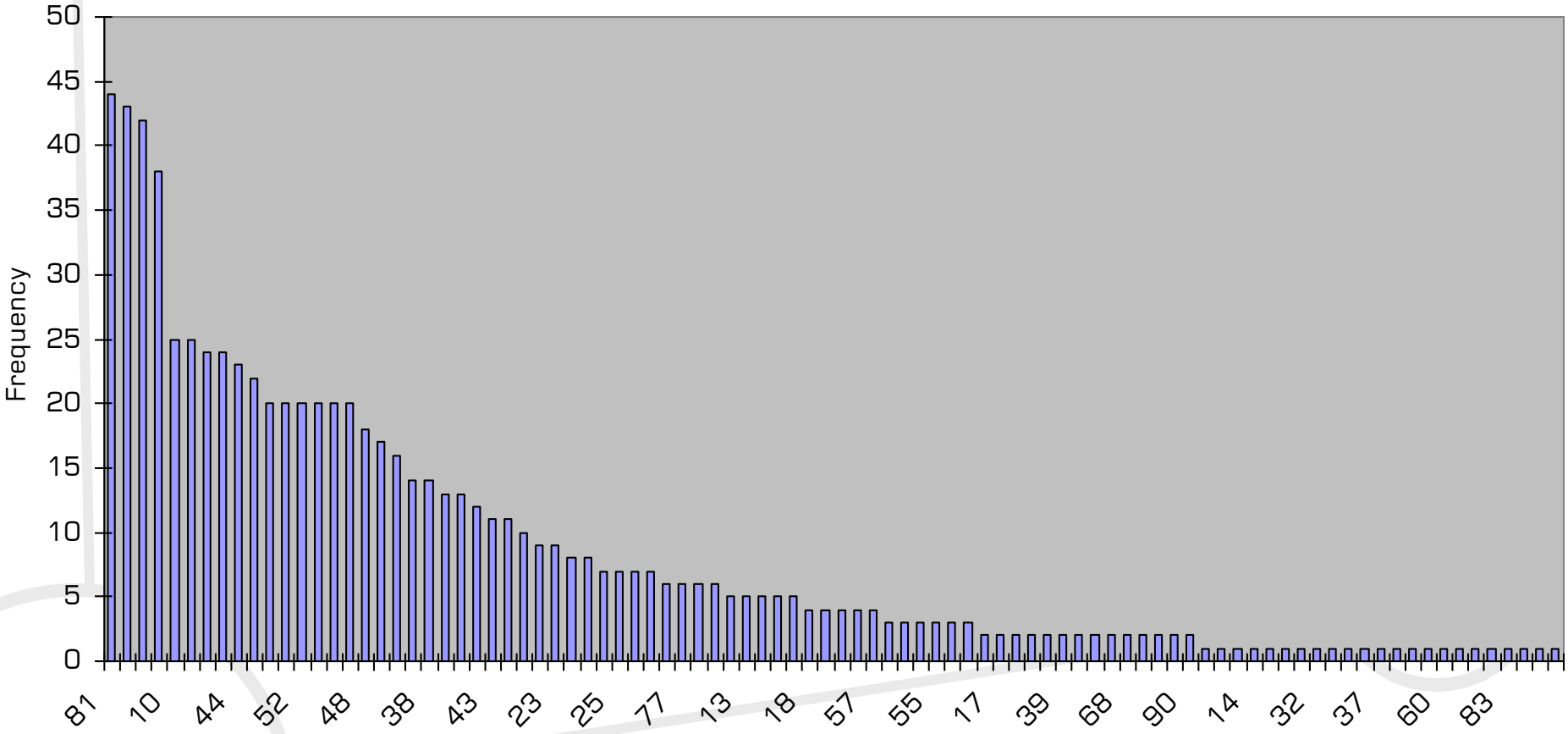
CONCLUSIONS

Concrete Recommendations for Online Game Developers



Conclusions

- Online worlds are susceptible to social network analysis.



New markets

- Seek out the mavens. They provide the word of mouth. If you do not make them happy, NOBODY will be happy.
- Stated another way: you can't get to the mass market unless you go THROUGH the hardcore.
- The hardcore guys hang out on Waterthread, Player2Player, UnknownPlayer, and Usenet. Get to know them. Plan to sell to them.

How do we hook newbies to hubs?

- It's HARD to find the hubs, as a new player. You need to hook them up as quickly as possible.

- Weak ties are best. We should be encouraging acquaintances, not bosom friendships.
  - Matchmakers are a good idea.
  - Multiple guild membership is also a good idea.
  - Ticklers for acquaintances are also a good idea.
  - Ready-made groups are mostly a waste of time.

Are you vulnerable?

- You could probably kill off another game by persuading all its guild leaders to switch to your game simultaneously. Offer 'em free accounts.
- Conversely, don't expose who your hubs are to competitors. Certain types of ladders are dangerous things to display publicly!
- You want them to stick with your game. It makes good business sense to offer incentives to hubs.

Critical mass

- Be sure you have critical mass, because otherwise, your game will never die, and you may be stuck with something unprofitable.

- And if you do shut that down, tit for tat behavior means those people will snub you.

Predicting the market

- We can probably predict the sizes of online games by asking, “bigger than X but smaller than Y”
- I also like to do a Google search and just compare the number of hits for upcoming games.

The death of online?

- If too many games stop growing, the size of the largest games in the network will be capped.
- The more similar the experiences and services that are provided by the games, the more likely we are to end up with monopolization of the category.
- And also with a lack of growth in the genre's audience.

Skill based games

- If your game is zero-sum skill based, that will cap audience size right there. Skill based games on the Internet will never be huge, even with leagues.

- You must find some way to overturn the rich get richer scenario in all games with some form of accumulation. There must be not just drains, but occasional catastrophic behaviors that topple the 20% at the top of Pareto's curve, so that others get a chance.

Treadmills

- In other words, treadmills are not only good, but necessary.

- What's more, the more different treadmills the better. Get parity in one area even if you cannot have parity in all of them. Provide "powergamer" style recognition to as many arenas of the game as possible.

Customer relations aka manipulation

- We don't have physical cues online. So get the best goddamn writer you can find; they are the public face.
- Make sure it's a politician, someone versed in the art of persuasion.
- Always present a human face, not a corporate one.
- You want someone that people see as similar to themselves.

Broken windows

- If you create a setting where cheating is possible, everyone will do it. (Duh).
- Crack down on tacky names, petty crimes, etc, before you crack down on big cheats.
- Never publicize behaviors you don't want repeated.
- Always publicize behaviors you want imitated.

- Given an aggressive group, kick them out of your game. Otherwise, they will dominate via genocide.

- Police inconsistently and with high profile. Occasionally banning an entire guild, etc. Stick to the rules, of course. But do "raids" on the bad guys.

Reputation systems

- Make sure that players have a reasonable expectation of future interaction. This means persistence of identity and limited mobility.

- Use a positive feedback rep system, not a negative one.

- Your guild structure had better support 150 comfortably.
- You need interdependence, so that groups do notably better than soloers.
- You want economic participation 24/7 as much as possible. Let players play while offline, make them pay in game currency while offline.

Reaching your audience

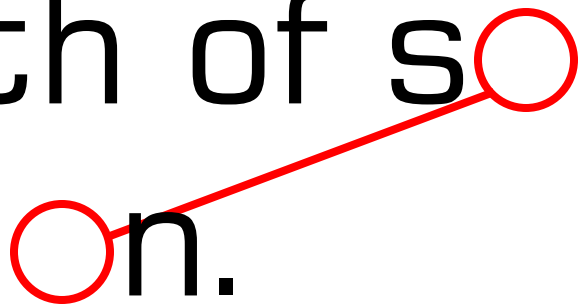
- The only way to fully map your game's community is to get feedback from 100% of them. Expect to miss people.
- Start up SIGs for the different communities you want to reach. Try to notice all the "islands."
- We DO need to lick the "story problem" in online games.

Homogeneity

- There's a natural tendency to homogeneity that works against weak ties. Encourage systems that cross "cultural" boundaries.
- Don't be disturbed to see groups segregate themselves. Provide them with alternate means of self-identification so they can join more than one community at once.
- Don't let your microcommunities get too big.

- The single biggest thing you can do to improve your online game community is to

increase the bandwidth of social interaction.



THE RESOURCES

An Endless Bibliography for Further Reading

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- Raph's Website: http://www.legendmud.org/raph/gaming