
# *Complex Networks 1*
# *Small World Networks*

Kara DeSouza

March 6th, 2006

CS790R, University of Nevada, Reno

# *Small World Networks*

- Introduction
- Travers & Milgram (1969)
- The Oracle of Bacon
- The Big World Critique
- General Commentary & Questions

# *Introduction*

- Milgram: 1933-1984
  - Authority, Conformity, Small World Networks, and Violence
  - Yale, Harvard, & CUNY
- Mark Granovetter – "The strength of weak ties"
- "It's not *what* you know, but *who* you know…"

# *Travers & Milgram, 1969*

- What is the probability that any two arbitrarily chosen citizens know each other?
- Based on Rapoport, and Pool & Kochen
  - Node + Axon models
- Test using real people & relationships

# *Travers & Milgram, 1969*

- Pilot study conducted
- Procedures
  - An arbitrary “target” was selected
  - Three groups of “starting people”
    - Groups of Random Nebraskites (RN), Stockholding Nebraskites (SN), and Bostonians

# *Travers & Milgram, 1969*

- Procedures, cont'd
  - Target person:
    - Lived in Sharon, MA; worked in Boston
    - Target info given included name, address, occupation, education, family info
  - Starting N=296 across three groups
  - Ultimately 453 intermediaries became attached to the project
  - "Starters" were sent document packet with instructions and materials

# *Travers & Milgram, 1969*

- Packet Included:
  - Document detailing experiment
  - Target person information
  - Roster to keep track of who sent to whom
  - Postcards to be mailed in with intermediary information
  - List of the very specific rules

# *Travers & Milgram, 1969*

- Rules
  - Add your name to roster
  - Send researchers a postcard
    - Personal info, plus that of person sending packet to, plus reasoning
  - If you know the target on a first-name basis, send it directly to them
  - If you don't know the person at all, or only know of them, send it to another acquaintance

# *Travers & Milgram, 1969*

- Results:
  - 217 of the 296 made it past first iteration
    - Nearly 1/3 didn't make first connection
    - Folders were passed if:
      - Recipients were motivated to participate
      - Recipients could think of someone to send it to, in order to get it closer to the target
      - The entire chain was of a reasonable length such that it didn't lose momentum, or require too many and too weak of interchanges to reach the target

# *Travers & Milgram, 1969*

- Results
  - Approx. 27% never sent, 27% sent at least once, 29% reached target
  - 64 of the folders reached the target
  - The mean chain length was 5.2 links, but is more accurate at mean 4.6 links coming through his job, and mean 6.1 links coming to his home

# *Travers & Milgram, 1969*

- Chains which reach hometown "stall out" until they reach some next inner circle that gets it to his home
- Chains that reach business circle reach target more directly

# *Travers & Milgram, 1969*

- Incompletions:
  - Of this 27% who didn't finish, some drop out due to lack of interest, and some due to lack of ability to carry on
- Unfortunately, impossible to tell:
  - Which is which
  - Is drop-out random, or a function of some characteristic(s) of chain sub-groups?
  - Tracer cards did not provide further info on this point

# *Travers & Milgram, 1969*
# *More Conclusions*

- Geography was 1st predictor of length
  - Bostonian originated chains shorter
- Occupation was next predictor
  - 5.7 vs. 5.4 (not-significant) links for Stockholding vs. Random Nebraskites
  - 60.7 of SN chains went through financially-occupied people, while only 31.8 of RN chains did so
  - Shorter chain length weakly predicts chain completion, but not significantly
    - Chain lengths from three groups are not disparate enough to make difference here (4.6 – 5.7 links)

# *Travers & Milgram, 1969*
# *More Conclusions*

- Common channels appeared; supports node/axon theories of Rapoport and Pool & Kochen
  - 64 final letters sent by 26 people
    - 16 from a clothing-merchant neighbor
    - 10 and 5 respectively from two business associates
  - Very likely to send to friend, acquaintance, person of own age
  - Not very likely to send to relative

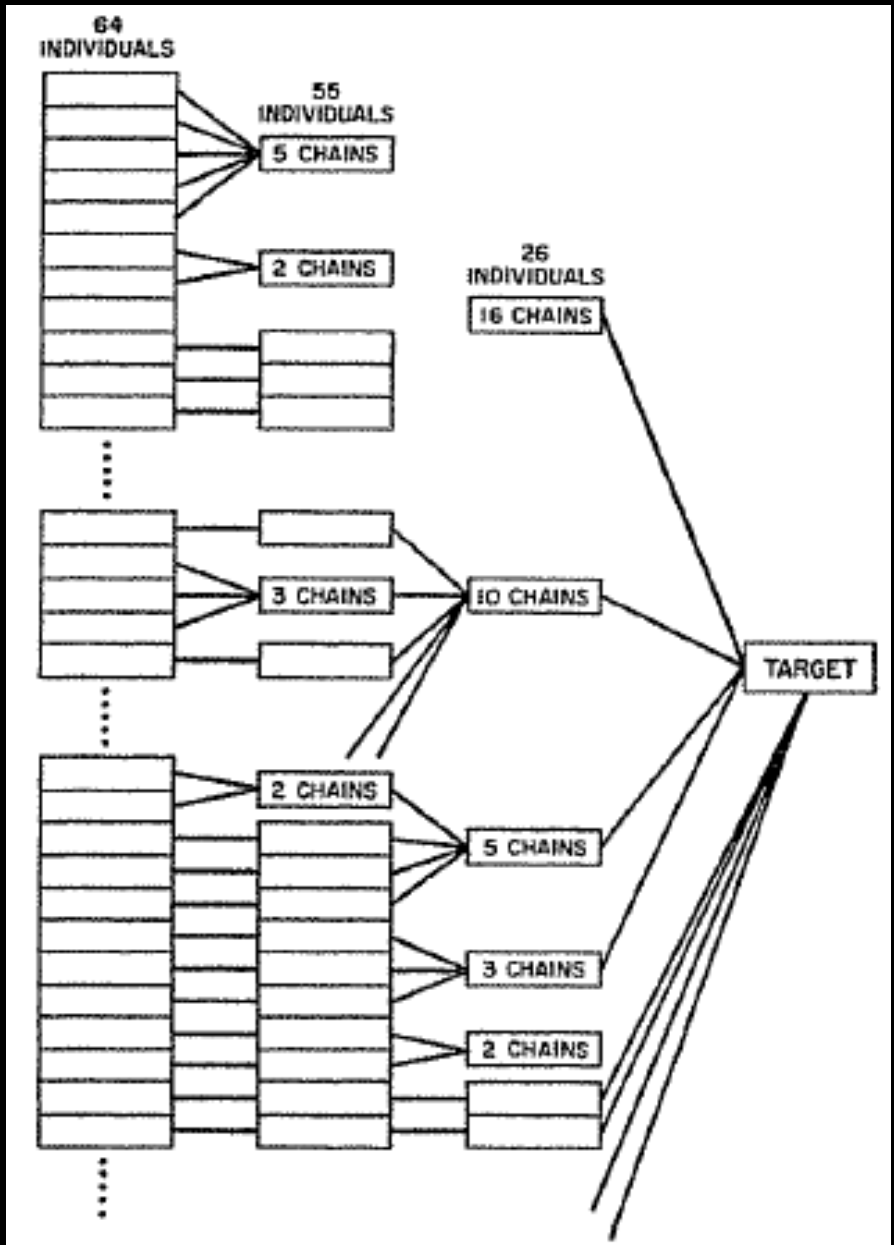


FIGURE 3

*Common Paths Appear as Chains Converge on the Target*

# *Travers & Milgram, 1969*
# *More Conclusions*

- Demographics of chains:
  - Men were very likely to send it to men; Women were equally likely to send it to either gender
    - This is likely affected by gender of target
    - Also, the gender norms of the 1960's?
- Although Milgram references a follow-up, line of research eventually stalls out
  - Probably needs modern-era computing abilities and connectivity to complete

# *The Oracle of Bacon*

- The Erdös number
  - Paul Erdös: 1913-1996
    - Prolific Mathematician (over 1500 papers)
    - Erdös is 0, co-authors are 1, co-authors of co-authors are 2, etc.
- The Oracle of Bacon
  - 10th anniversary
  - Link


*Or is it?*

The Big World Critique

# *The Big World Critique*

- Small world theory is an elegant and seemingly acheivable way of connecting people
  - At least theoretically, and in computer models
  - How does it hold up in the “real world” beyond the Milgram studies?

# *The Big World Critique*
# *Critical Questions*

- New evidence from Yale archives can provide new interpretations
- Psychologically, why are we so attached to the “six degrees” idea?
- Why psychologists should get on the bandwagon…

# *From the Yale Archives*

- Pilot study far different in anecdote than actual evidence
- Bias in studies works both for and against conclusions:
  - Folders were very nice looking, probably contributed to being passed along
  - Kansas (pilot) recruitment marketed to the exceptionally sociable
  - NE and Los Angeles recruitment from phone lists; potential bias toward those who could greater afford to participate

# *From the Yale Archives, cont'd*

- A study sent to Milgram for review suggests that social class/income level may be a strong predictor of ability to complete
  - Could be both knowledge of likely intermediaries and affordability
- Majority of replications were not on a "world" scale, but much smaller scales

# *From the Yale Archives, cont'd*

- NE and Bostonian groups hardly random
- Large racial divide between white and black senders and targets in Korte & Milgram follow-up

# *Popularity of Six Degrees Theory*

- It's psychologically intriguing and endearing
  - People want to believe
  - Fits well with many religious beliefs
  - People overestimate the importance of coincidence; i.e. social connections
- Exploration through social psychology, sociology, as important as through CS/math

# *Links of Interest*

- Search for Milgram, Small World, Erdös, Granovetter, Kevin Bacon, or Six degrees on Wiki
  - Watch out for inaccurate information
- The Erdös Number Project
  - http://www.oakland.edu/enp/
- The Tipping Point by Malcolm Gladwell