The Sexual Network of HIV in Botswana

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What is HIV?

- Human Immunodeficiency Virus
- A lentivirus that causes HIV and AIDS
- HIV-1 and HIV-2 both originated in nonhuman primates in West Africa.
- It is believed that HIV is the result of a mutation of SIV. That it jumped the species barrier and was transmitted from person to person.

How is HIV Transmitted?

- Exchange of bodily fluids through sexual activities
- Sharing of syringes and needles
- Mother to child

How Can Transmission be Prevented?

- Condom use
- Male circumcision
- Antiretroviral therapy (ART)
- Microbicides
- Pre-exposure prophylaxis (PrEP)

Victor's and Rui's Research

- Model the sexual network of communities in Botswana.
- Believed to be transmitted heterosexually
- Compare the effects of standard treatments of HIV to combination treatments.
- Simulate the effects of treatments on the sexual networks.
- Do combined efforts achieve community level control?

Goals of HIV Research

- The goal of this research is to investigate the effects that monogamy has on a sexual network.
- Because there is no cure for HIV, research is aimed at optimizing the prevention of new cases.

Project Outline

- Network Basics
- Small World Properties
- Setup
- Assumptions
- Methods
- Method Comparison
- Further Investigation

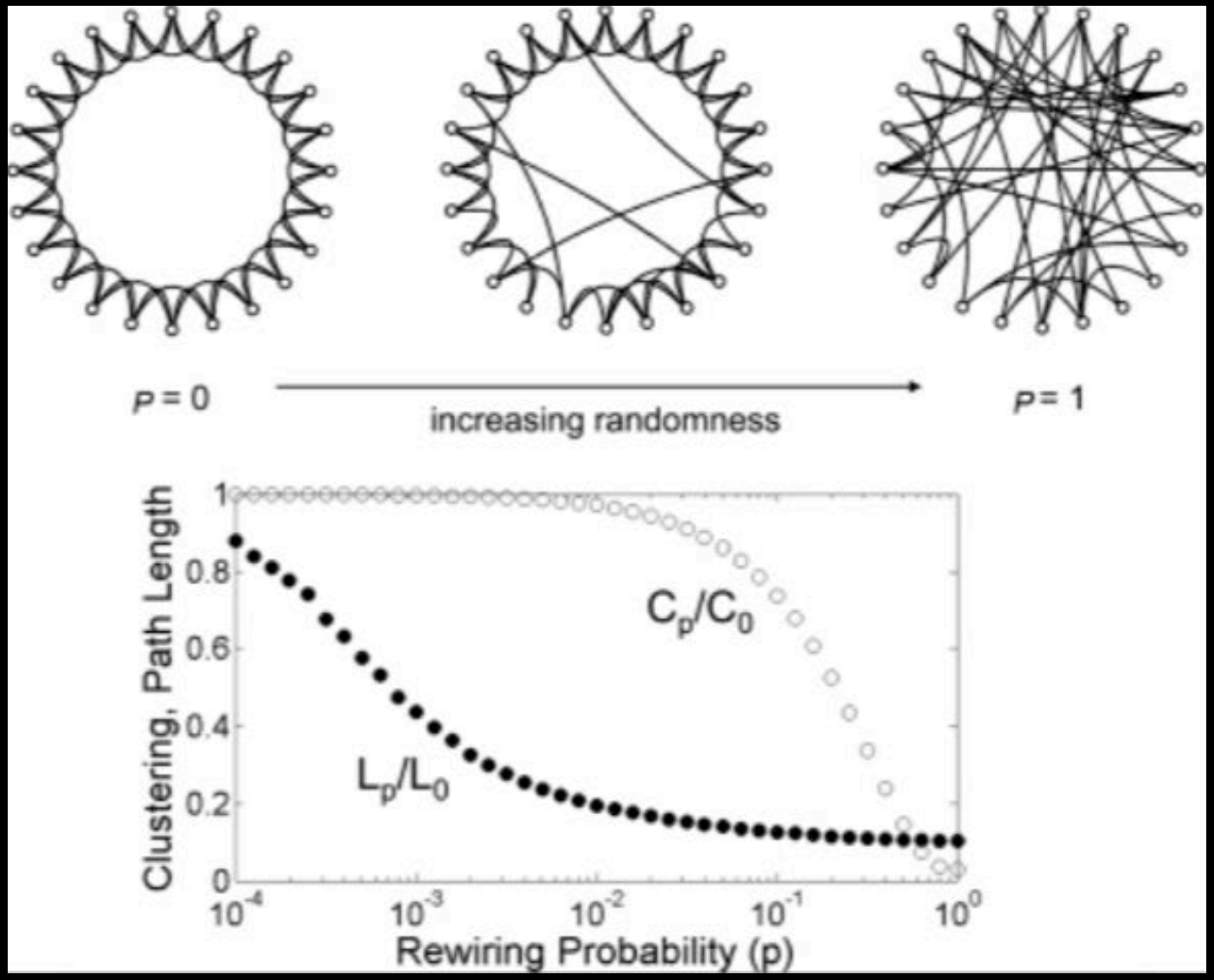
Networks Basics

- An undirected network *G = (N, E)*
- *N* = the set of nodes within the network
  - In this case *N* = number of couples in the network
- *E* = the set of edges that connect the nodes
  - These are always unordered pairs of the elements of *N*
- K = number of neighbors each node has

Small World Properties

- Clustering coefficient
  - measure of the degree to which nodes in a graph tend to cluster together
- Rewiring Probability
  - $0 < \beta < 1$
  - As $\beta \rightarrow 1$ the clustering coefficient decreases
- Hubs
  - High degree nodes

Small World Properties



Network Setup

- Nodes n = 200 couples
- Rewiring Probability β = .5
- Trials = 200
- Degree d = 2
- Mean degree k = 4
- Period = 1 year
- Simulated over 10 years
- Undirected network

Network Assumptions

- HIV is transmitted only heterosexually
- Behavioral Change is set to .1 probability/year
- Monogamy occurs 30% of the time
- Edges represent the non-monogamous relationship between nodes.

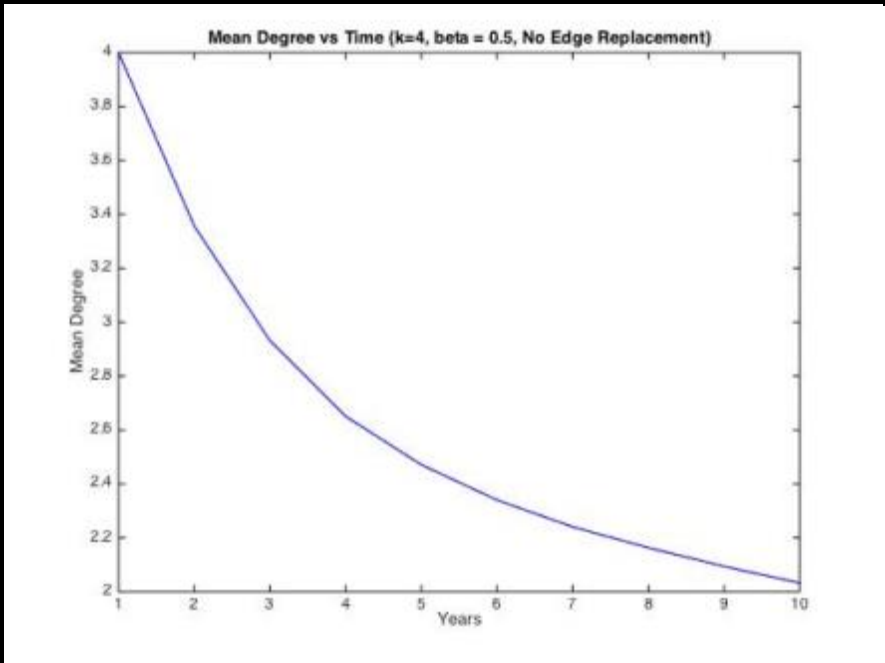
Methods: No Edge Replacement

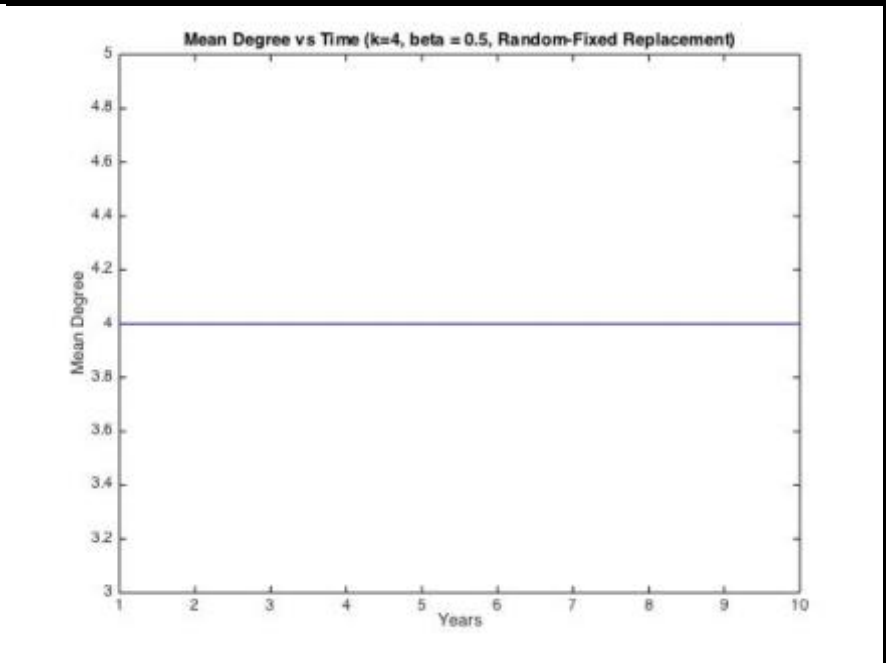
- As monogamy takes over the network nodes become isolated.
- No edge replacement or reassignment
- Changing mean degree

Methods: Random Assignment with Fixed Edge

- If node A becomes isolated, the neighbor node B maintains their end of the edge, but the side previously belonging to the now monogamous node A is reassigned to some living node C, iff node C is not already connected to node B.
- If node A and node B become isolated in the same year a pure random assignment rule is applied to the link and it's reassigned randomly to preserve the mean degree.

Mean Degree


Mean Degree vs Time (k=4, beta = 0.5, No Edge Replacement)
Mean Degree
Years
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1
2
3
4
5
6
7
8
9
10


Mean Degree vs Time (k=4, beta = 0.5, Random-Fixed Replacement)
Mean Degree
Years
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
1
2
3
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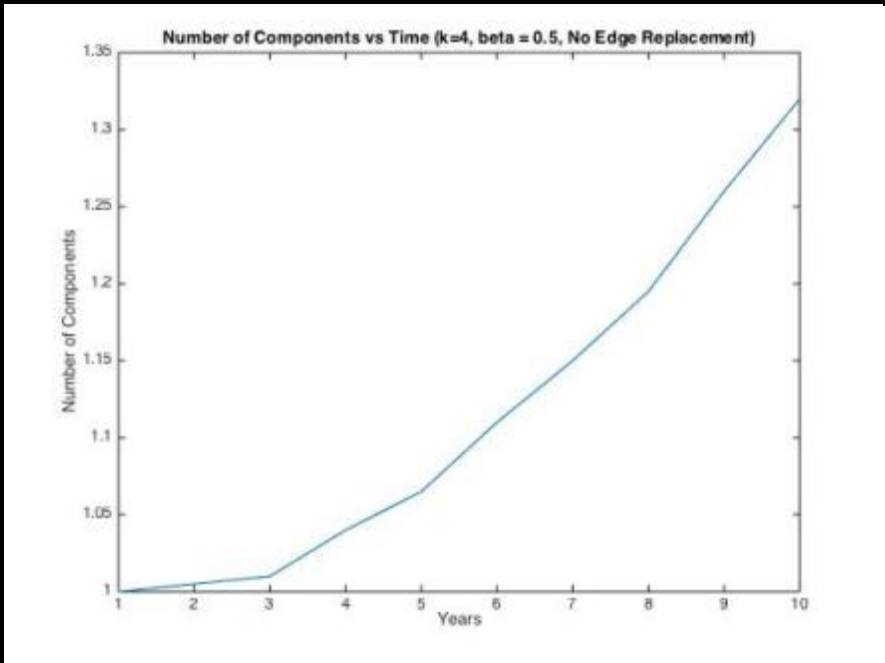
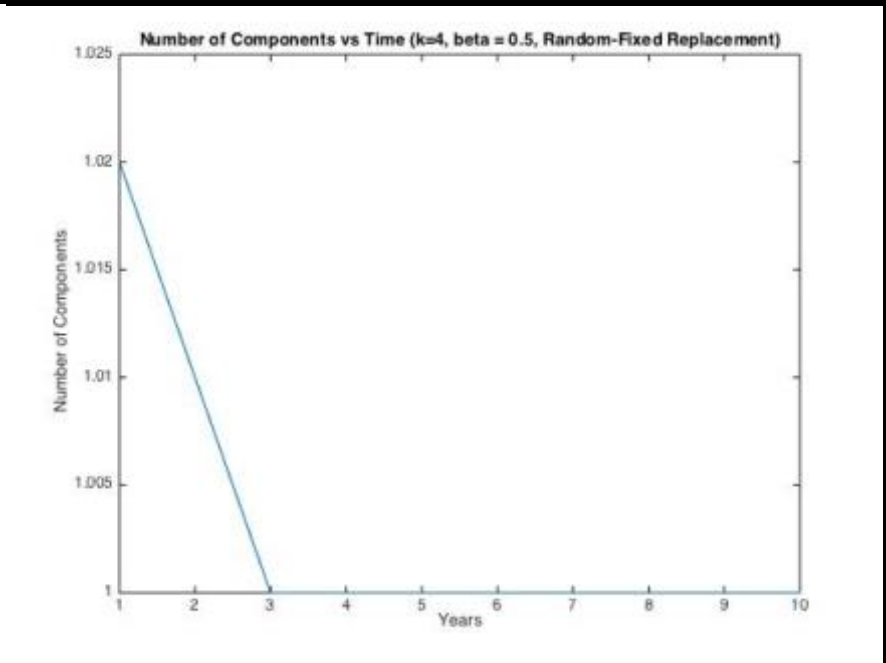
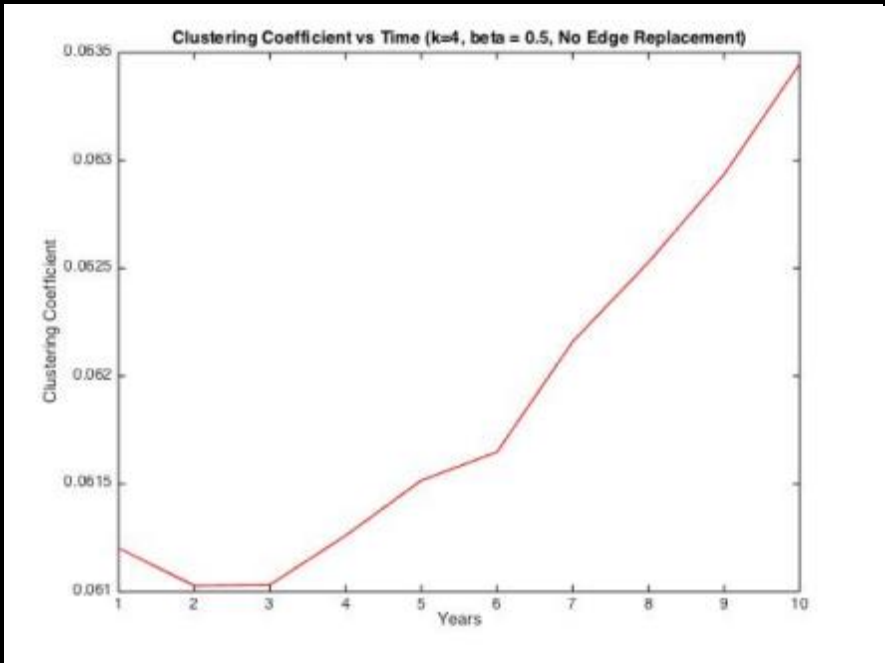
5
6
7
8
9
10

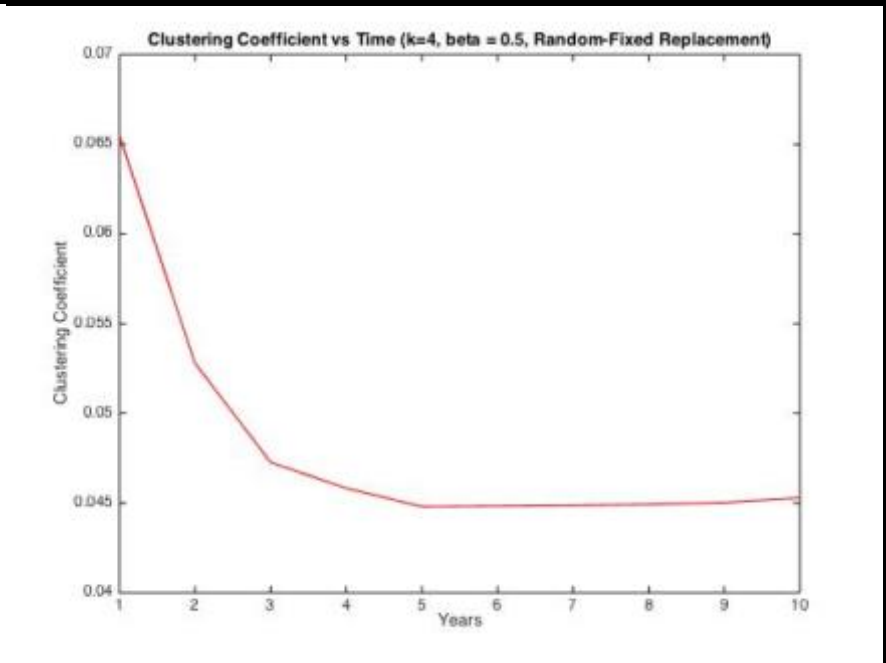
Number of Components



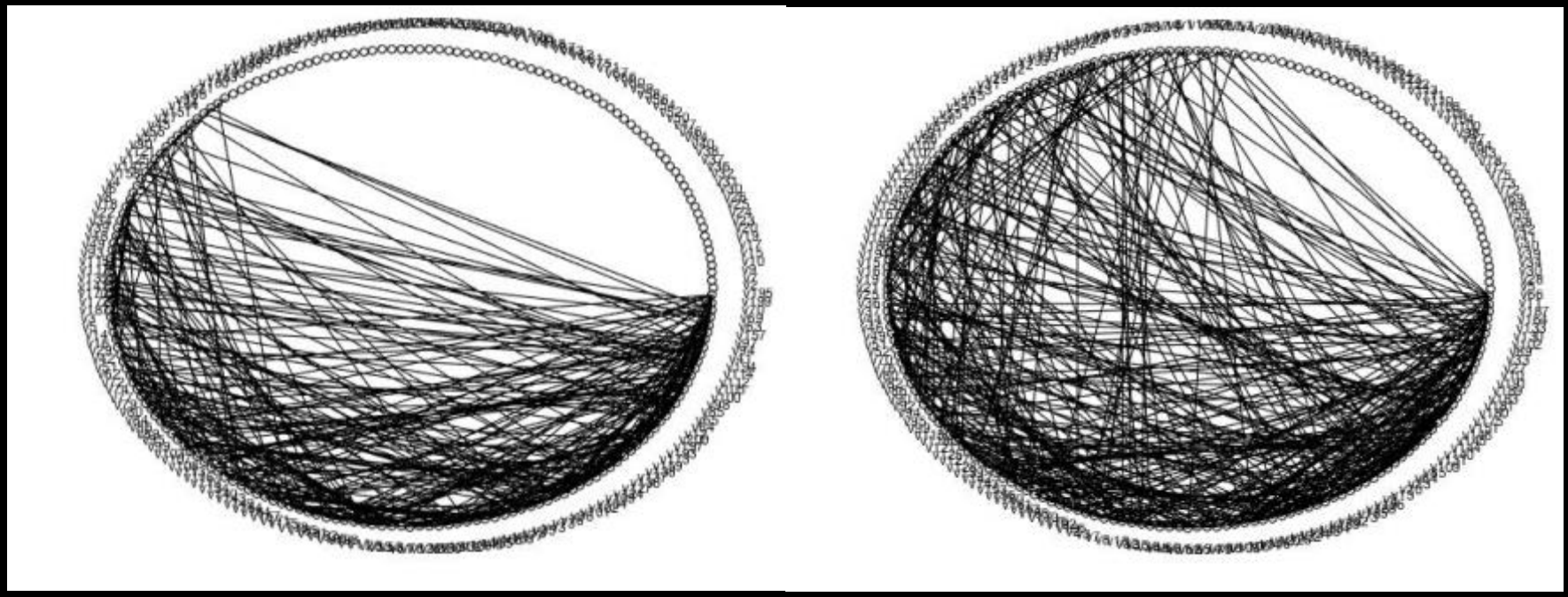


Clustering Coefficients

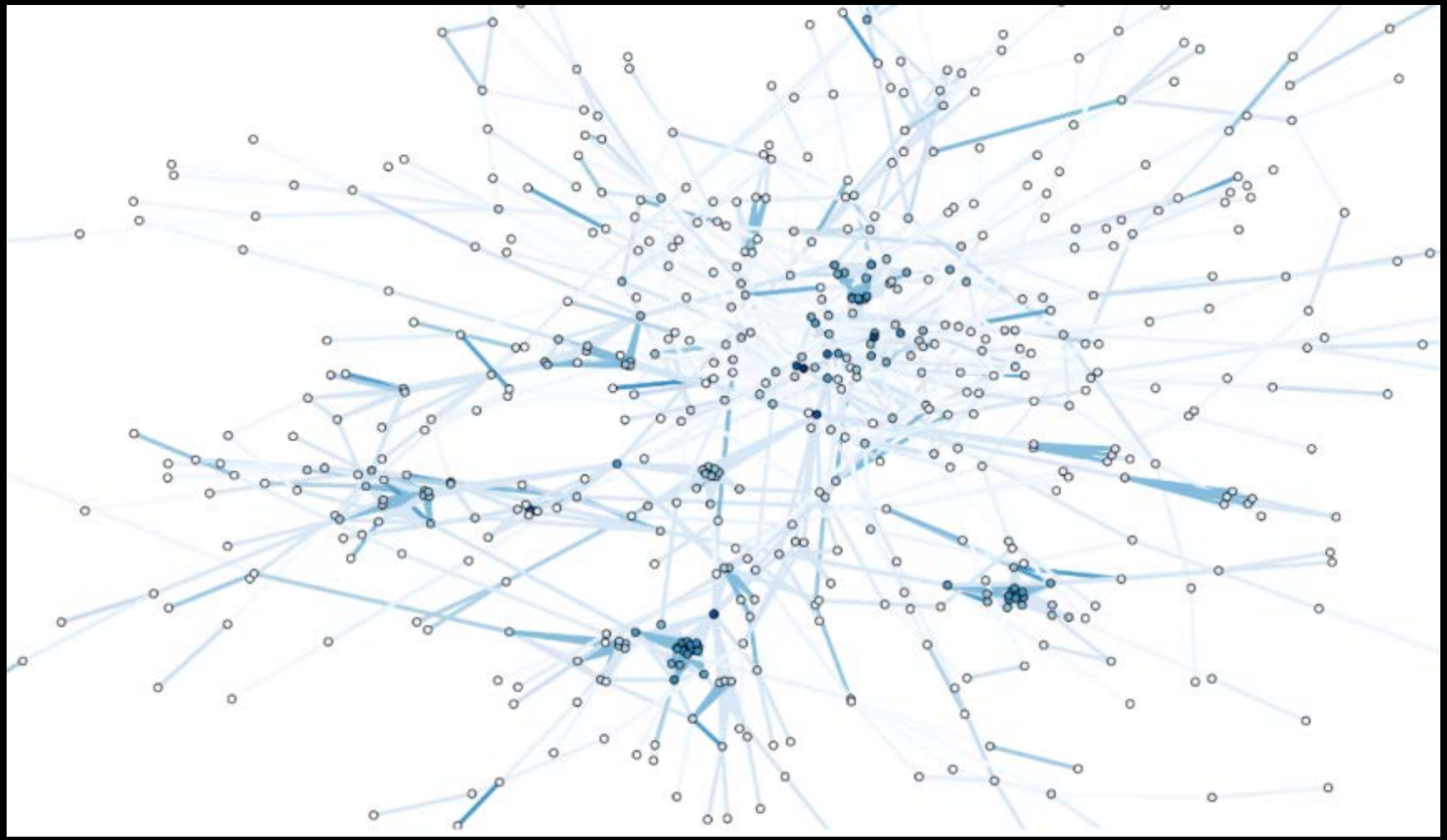




Network Graphs



Network Graphs



Results

- The mean degree in the base case drops from 4 to just over 2 over the course of 10 years.
- Mean degree of Random-Fixed case remains constant.
- In the case of no edge replacement the number of components increases.
- Components maintain about 1 in the case of random-fixed assignment.

Results Continued

- The clustering coefficient in the case of no replacement has a general trend upward.
- The case of random-fixed edge reassignment shows an initial dip in the clustering coefficient indicating that triples are being broken up faster than they can be replaced.

Further Investigation

- -Determining survival rate based on viral load
- -Instead of nodes being couples, gender assignment could be done for nodes to compare sexual contact networks for male and female.
- -Also, contact tracing for an infected node's network can be done to determine the epidemic stage other nodes are in.
- -Expanding on the contact tracing further, when an infected person is identified, and contact tracing is done, apply the different treatment regimens to compare the benefits of each.

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