Social Networks and Marriage Matching

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Outline

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Matching Problems

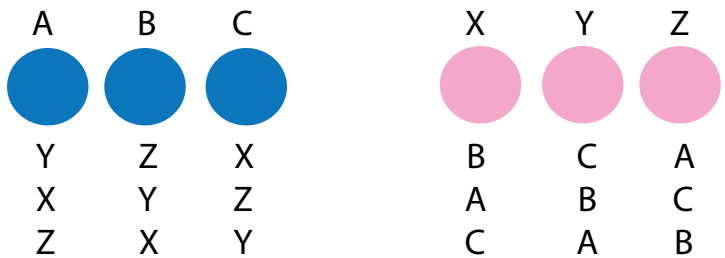
- Goal is a stable match
  - One:one, one:N
  - Bipartite 1:1 (called “Marriage Problem”)
- Algorithms assume
  - Full scope search
  - Lengthy search
- But real marriage search
  - Limited length search
  - Limited scope search

Matching Problems: Algorithms with full scope search

Medical graduates	$\longleftrightarrow$	Hospitals
H.S. students	$\longleftrightarrow$	Schools
Organ donors	$\longleftrightarrow$	Recipients
Rabbinical graduates	$\longleftrightarrow$	Synagogues
Law school graduates	$\longleftrightarrow$	Firms

Matching Problems: Gale-Shapely (G-S) algorithm

- N men and N women rank potential partners (no ties)
- Men propose to the most-preferred woman not yet proposed to
- Women accept if unmatched, or if proposal is improvement
- Up to $n^2 - n + 1$ rounds to stable solution



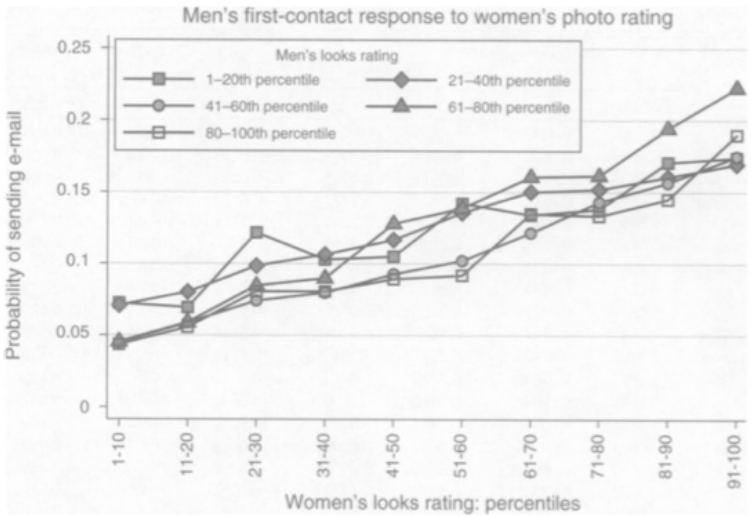
Stable Solutions
(AZ, BX, CY)
(AY, BZ, CX)
(AX, BY, CZ)

Matching Problems: G-S results & limitations

- Stable Solution
  - If a man prefers another, he must have already proposed and been rejected
  - If a woman prefers another, she must be less preferred than his partner
- Optimality
  - Men get best feasible partner
  - Women get worst feasible partner
- Real “marriage problem”
  - Limited time to search
  - Limited scope for search

Empirical Evidence: Full scope search

- Full scope: Online dating platform
- Limited scope: Personal social network
- G-S algorithm predicting exchange of email/contact info

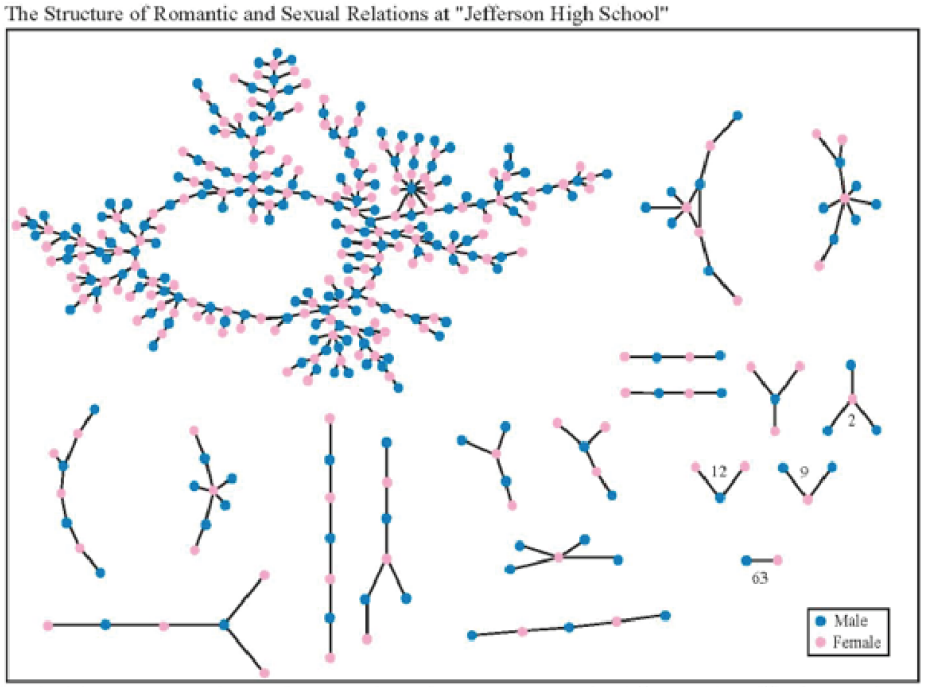


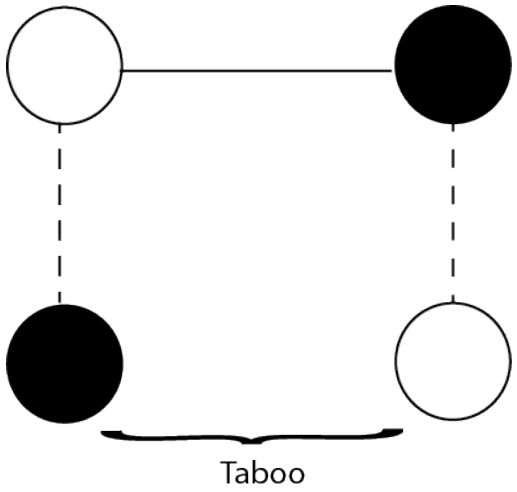
- Internet dating less homophilous than real life (e.g. edu)

Günter, Hortacsu, and Ariely, 2010

Empirical Evidence: Scope limited by dating history

- Simulate relationship histories
- Accurate prediction only limiting scope by relationship history





(Moody, Bearman, Stovel, 2004)

Hypotheses

	Simulation/Mechanism	*Empirical Confirmation*
Match Utility lower w/ limited scope	**Unable to offer good matches**	Less happy relationships meeting through friends
Women's Utility higher w/ limited scope lower w/ limited time	**Offers to lower-ranked** **Accepted offers improve with time**	Women happier meeting through friends, less meeting young
Dating History loops with longer time/ limited scope, trees with limited time/limited scope	Initial matches follow social network, then cycle w/in clique	Add Health evidence, high school context

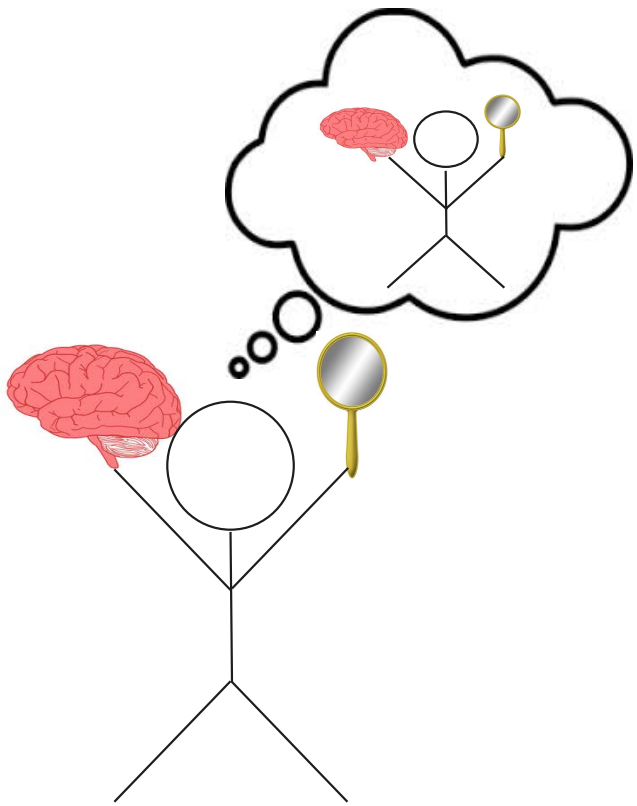
Method: Agent Based Model (ABM)

- Initialize
  - Agents w/ heterogenous characteristics & preferences
  - Calculate match utility & partner rankings
- Construct social network
  - Set parameters
  - Assign edges
- Run G-S algorithm
  - Full scope (varied search length)
  - Scope limited to 2-hop network (varied search length)

Method: Initialization, heterogeneous agents

- N male agents & N female agents
- *Symbolic* characteristics & preferences

Attractiveness	$a = norm(\mu = 5, \sigma = 1)$
Intelligence	$s = norm(\mu = 5, \sigma = 1)$
Preference for partner's *a*	$\alpha = uniform(0, 1)$
Preference for partner's *s*	$= (1 - \alpha)$



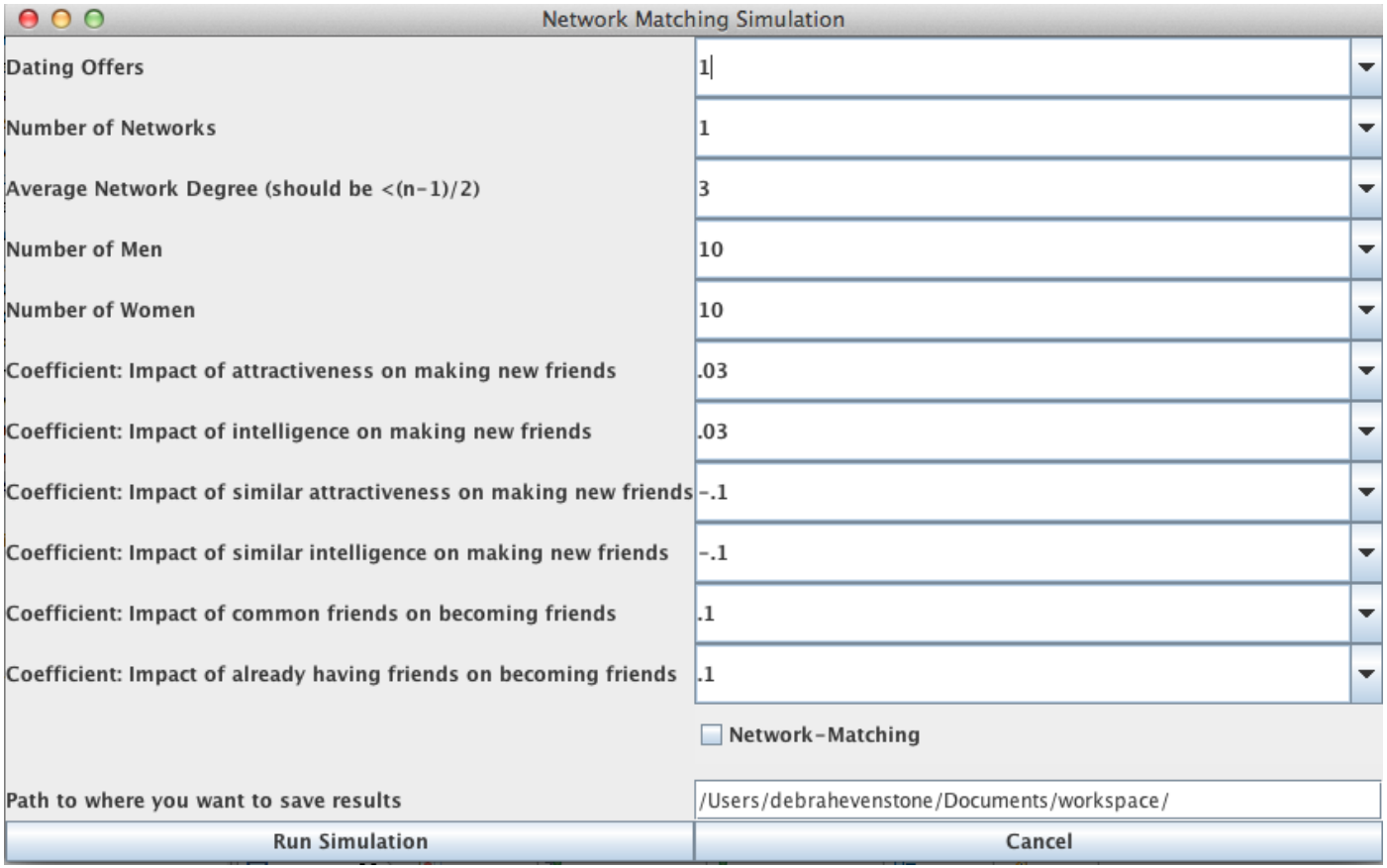
Method: Initialization, match utility & partner rankings

- Cobb Douglas match utility
- Constant returns to scale
- Function of partner's characteristics & ego's preferences

$$u_i = a_j^{\alpha_i} s_j^{1-\alpha_i}$$

u_i	Utility of ego i
a_j	Attractiveness of partner j
α_i	Importance of attractiveness in partner for ego i
s_j	Intelligence of partner j
$1 - \alpha_i$	Importance of intelligence in partner for ego i

Method: Construct network, parameter settings



Method: Construct network, assign edges

- Pull two random agents
- Calculate edge probability

$$Pr_{i \cdot j=1} = \frac{e^f}{1+e^f}$$

$$f = \beta(\mathbf{x_i} + \mathbf{x_j}) + \gamma x_{ij} + \psi(D_i + D_j) + \gamma T_{ij}$$

x_i	individual characteristics (*not preferences!*)
x_{ij}	similarity of characteristics
D_i	current degree
T_{ij}	number of friends in common
$\beta, \gamma, \psi, \gamma$	coefficients

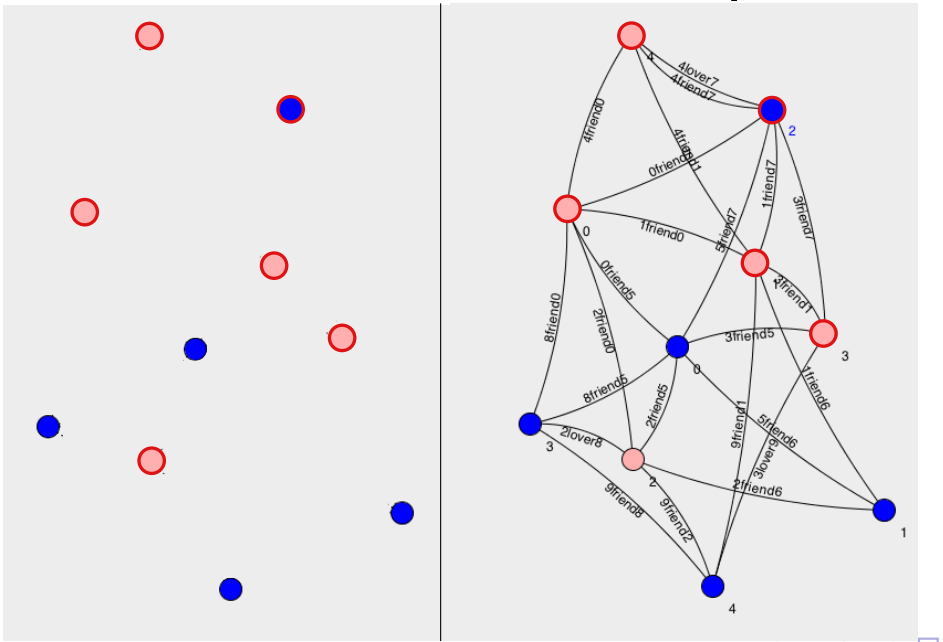
- if (random uniform (0,1) $>$ $Pr_{i \cdot j=1}$), $(i \cdot j) = 1$

Method: Run G-S Algorithm (full & limited scope)

- Agents rank *visible* potential partners (no ties)
- Men propose to the most-preferred *visible* woman (not yet proposed to)
- Women accept if unmatched, or if better proposal
- *X* offer rounds

Full Scope

Limited Scope (1-hop)



Experiment: G-S matching w/ limited time and scope

- Hypotheses
  - Match Utility
    - Lower w/ limited scope (unable to find best matches)
  - Female Utility
    - Higher with limited scope (easier competition)
    - Lower with limited time (no chance to dump less preferred)

Experiment: Settings

- Constant conditions
  - 50 men and women
  - Agent characteristic distributions ($norm(\mu = 5, \sigma = 1)$)
  - Coefficients controlling friendship network generation
- Experimental conditions
  - Number of offers: 1:10
  - Full scope search vs limited scope (2-hop) search
- 10 runs per experimental condition

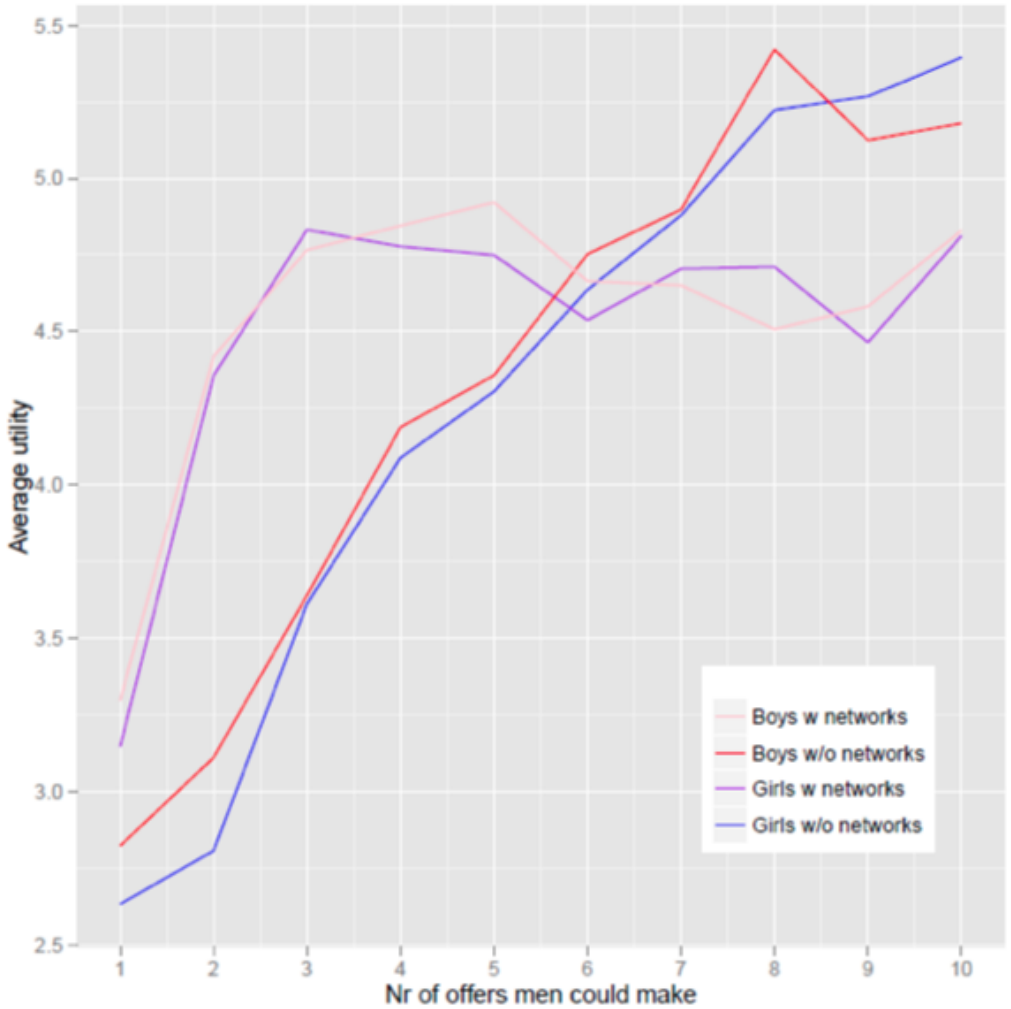
Experiment: Measured output

- *Agent data*
  - Individual characteristics
  - Partner characteristics
  - **Match utility**
- Romantic history network (Intermediate steps)
  - Density at maximum reach
  - Size of the largest component
  - Centralization

$$\frac{\sum(centrality_i - centrality_*)}{max \sum(centrality_i - centrality_*)}$$

  - Mean geodesic length (avg shortest path)
  - Number of 4-cycles

Experiment: Results, match utility



Experiment Results, match utility (OLS)

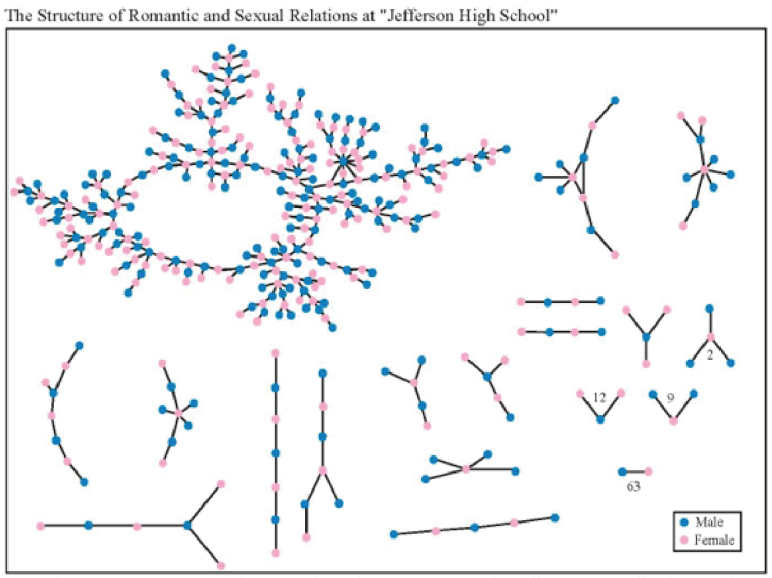
	coefficient	effect type
Ego variables		
isFemale	-3.68***	built-in
Attractive	1.00***	built-in
Intelligence	1.06***	built-in
Experimental variables		
Number of offers	2.43***	built-in
Number of offers^2	-0.37***	built-in
isNetworkMatch	5.55***	emergent?
Experiment-ego interactions		
isFemale$*$ isNetworkMatch	0.46***	built-in
Attractive $*$isNetworkMatch	-0.40***	built-in
Intelligence $*$isNetworkMatch	-0.58***	built-in
isFemale$*$N. offers	0.46***	built-in
Ego-ego interactions		
isFemale$*$Attractive	0.38***	emergent?
isFemale$*$Intelligence	0.51***	emergent?

Also controlling for N. offers $*$ network match

Future Simulation Output: Relationship histories

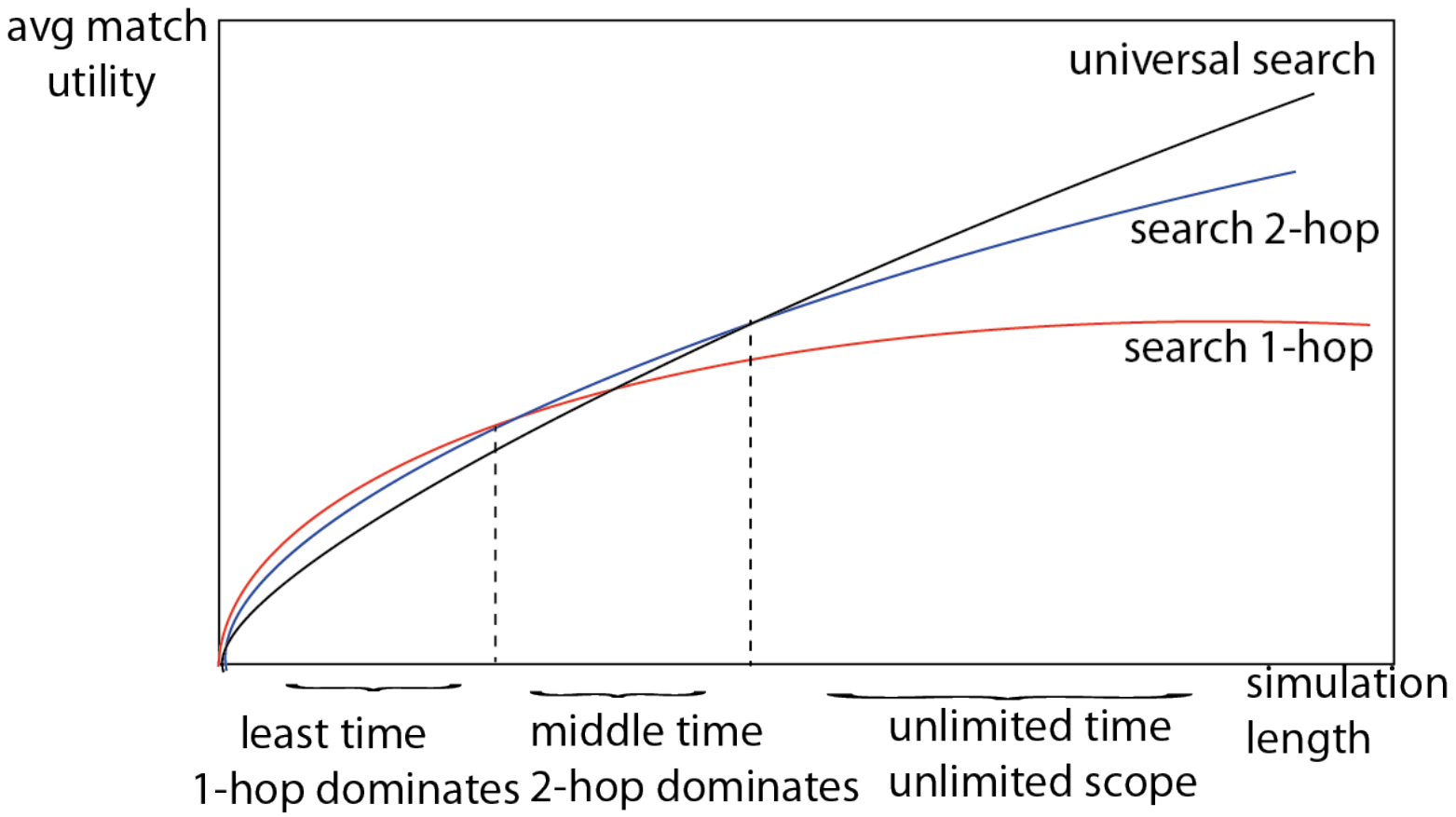
- Treat intermediate matching steps as relationship history
- Causal mechanism

limited search scope & limited time
vs
taboos



Each circle represents a student and lines connecting students represent romantic relations occuring within the 6 months preceding the interview. Numbers under the figure count the number of times that pattern was observed (i.e. we found 63 pairs unconnected to anyone else).

Future Simulation: Continuous information limits



Future Empirical Work: Erasmus/high school dating & friendship networks

- Limitations
  - Search time 6 mo to 2 yrs
  - Unlimited search has boundary problems per definition
  - Cross sectional & retrospective
- Questions
  - What predicts friendship?
  - Does friendship predict partner?
  - Does partner satisfaction vary if matched over network?
  - Male/female differences?

Empirical Limitations: Timing and causality

- Study using Facebook data
- Goal: Identify the relationship edge
- Two hypotheses
  - *Embeddedness*
    Number of i & j's friends in common in i's network
  - *Dispersion*
    Dyads w/ no mutual friend once i and j are removed
- Causality
  Dispersion is observed because edges formed *post*-relationship

Backstrom and Kleinberg, 2013

Conclusion/Who Cares

- Dating/online dating platforms
- Epidemiological implications
- Applications to job search
- Could imposed networks reduce search time?