Brief Intro to KEYPLAYER

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U of Kentucky LINKS Center workshop
ADVANCED Session

Key Player Project

Who are the key players in a network?

- It depends on …
  - whether you are looking for individuals or ensembles
  - the purpose
- On the value of problem-centered research

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Thanks Rebecca Goolsby!

Borgatti, S.P. 2003. The Key Player Problem. Pp. 241-252 in *Dynamic Social Network Modeling and Analysis: Workshop Summary and Papers*, R. Breiger, K. Carley, & P. Pattison, (Eds.), National Academy of Sciences Press.

Why do we want to know who the key players are?

We want to **remove them** – to maximally **disrupt** the network	**DISRUPT**
We want to **help** them – in order to make network as a whole **function better**	**ENHANCE**
We want to identify key opinion leaders – to influence the network	**INFLUENCE**
We want to know who is in the know – so we can question or surveil them	**LEARN**
We want to remove them – to redirect flows in the network toward more convenient players -- pruning	**REDIRECT**

Key Player Needs by Field

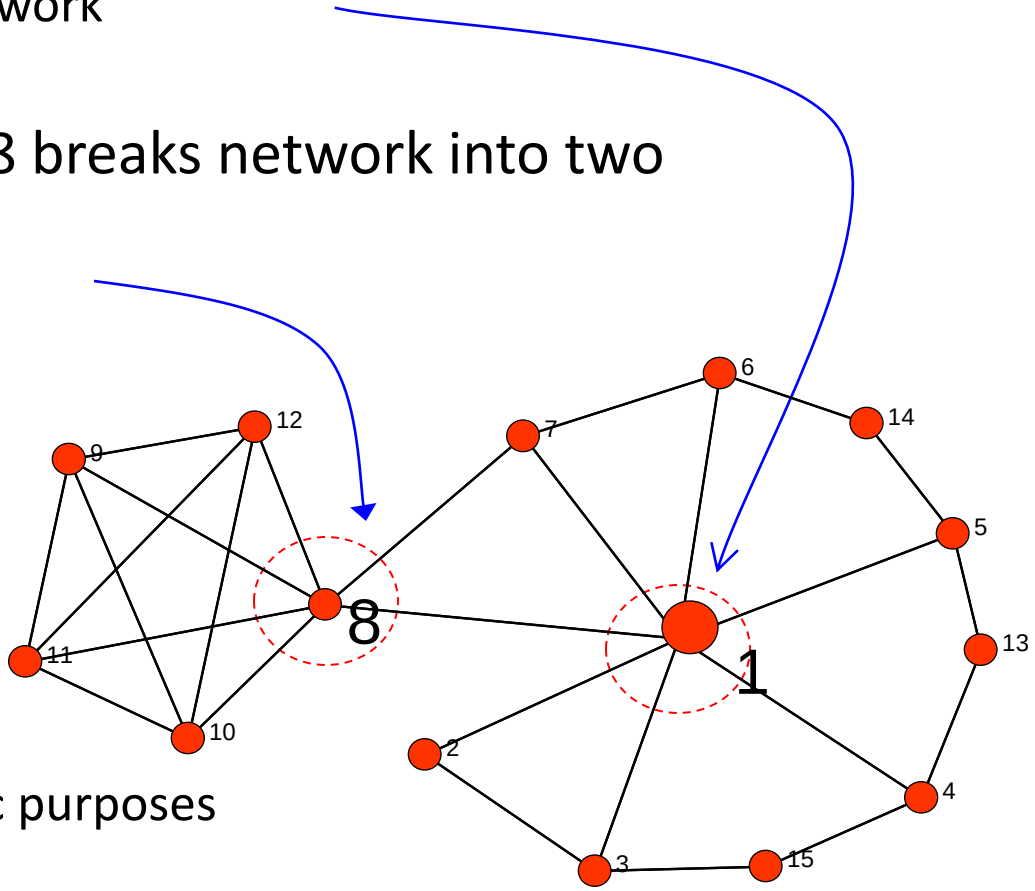
	DISRUPT	PROTECT	INFLUENCE	LEARN	REDIRECT
SECURITY	Who to **arrest or discredit** to disrupt ops	Who to **protect** among allied group	Who to turn or plant info with	Who is best positioned to know most	Who to remove to redirect flows
PUBLIC HEALTH	Who to **immunize or quarantine**		Who to select as PHAs for interventions	Who to study explain spread	
MANAGE MENT	Who to hire away from competitor	Who to give more of a stake in org to avoid turnover	Who to get on board before launching reorg		Who to add/replace to remove drag on good emps
MARKETING		Which happy users to empower	Identify key mavens to sell on your stuff		

KeyPlayer Research Objectives

- Develop metrics to quantify potential disruption, influence, surveillance etc.
  - Off-the-shelf SNA measures not optimized for these tasks
- Develop combinatorial optimization algorithms and fast heuristics for maximizing metrics given solution parameters
- Predict what happens to the network post-intervention

The Design Issue

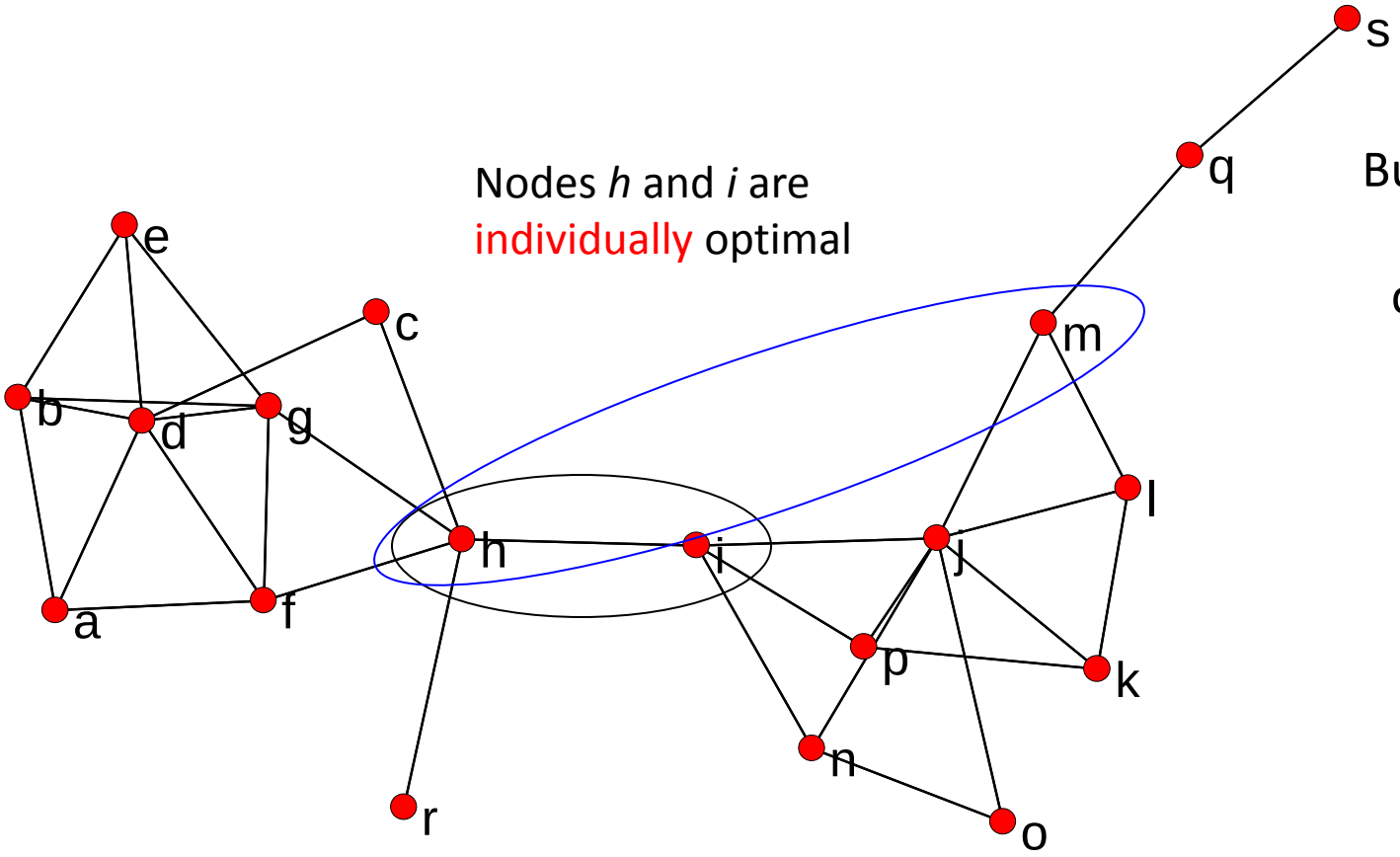
- By standard off-the-shelf measures of node centrality, node 1 is the most important player, but deleting it …
  - does not disconnect the network
- In contrast, deleting node 8 breaks network into two components
  - Yet node 8 is not highest in centrality
- No off-the-shelf centrality measure is optimal for the purpose of disrupting networks
  - Nor any of the other specific purposes



DISRUPTION

The Ensemble Issue

Structural redundancy creates need for choosing complementary nodes



Nodes *h* and *i* are individually optimal

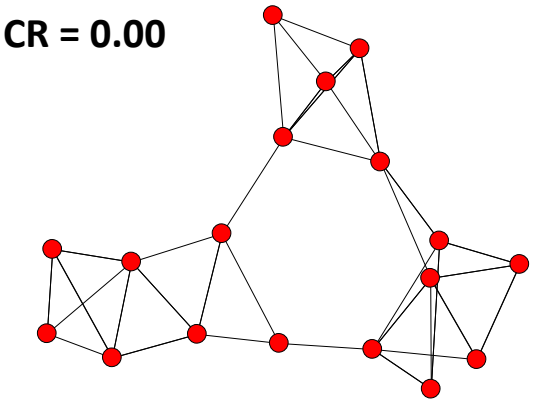
But deleting both is no better than deleting *h* alone -- *h* and *i* are redundant

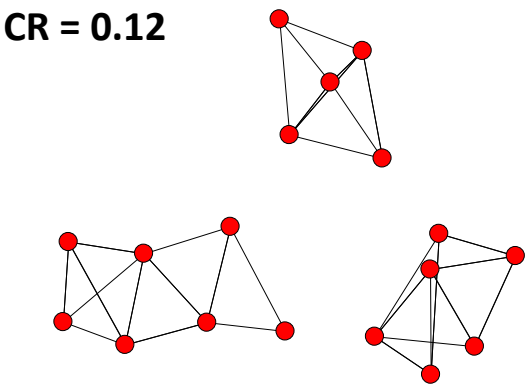
In contrast, {*h,m*} splits graph into 4 fragments (is optimal)

- Choosing optimal **set** of *k* players is not same as choosing the *k* best players

No. of components

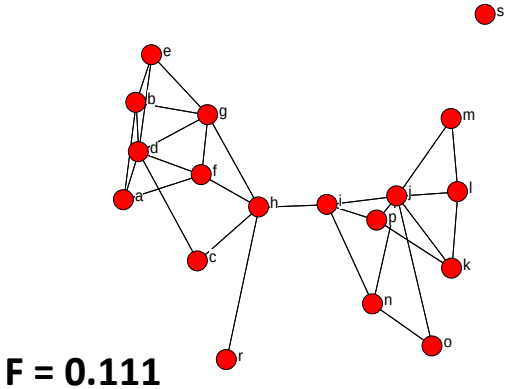
$$CR = \frac{c-1}{n-1}$$

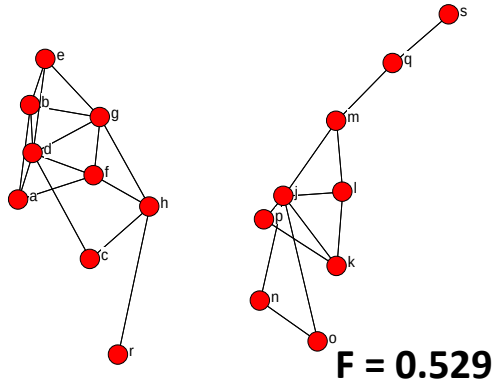




No. of disconnected pairs

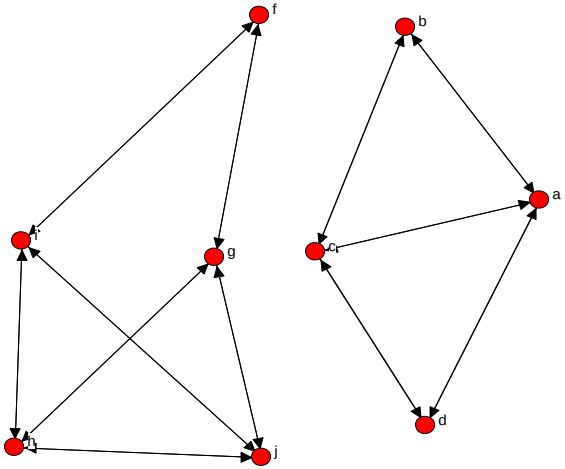
$$F = 1 - \frac{2\sum_{j<i} r_{ij}}{n(n-1)}$$

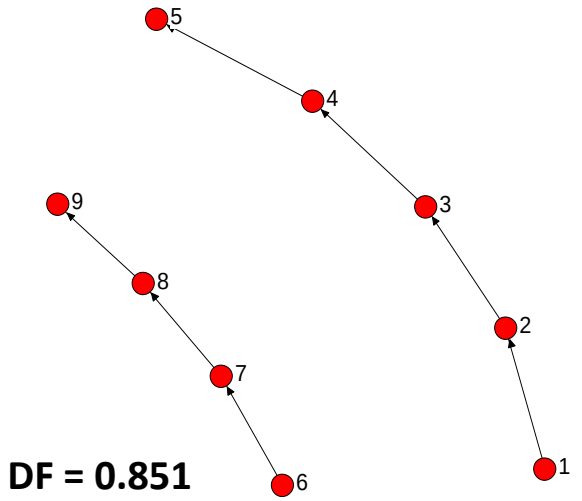




Distance-weighted fragmentation

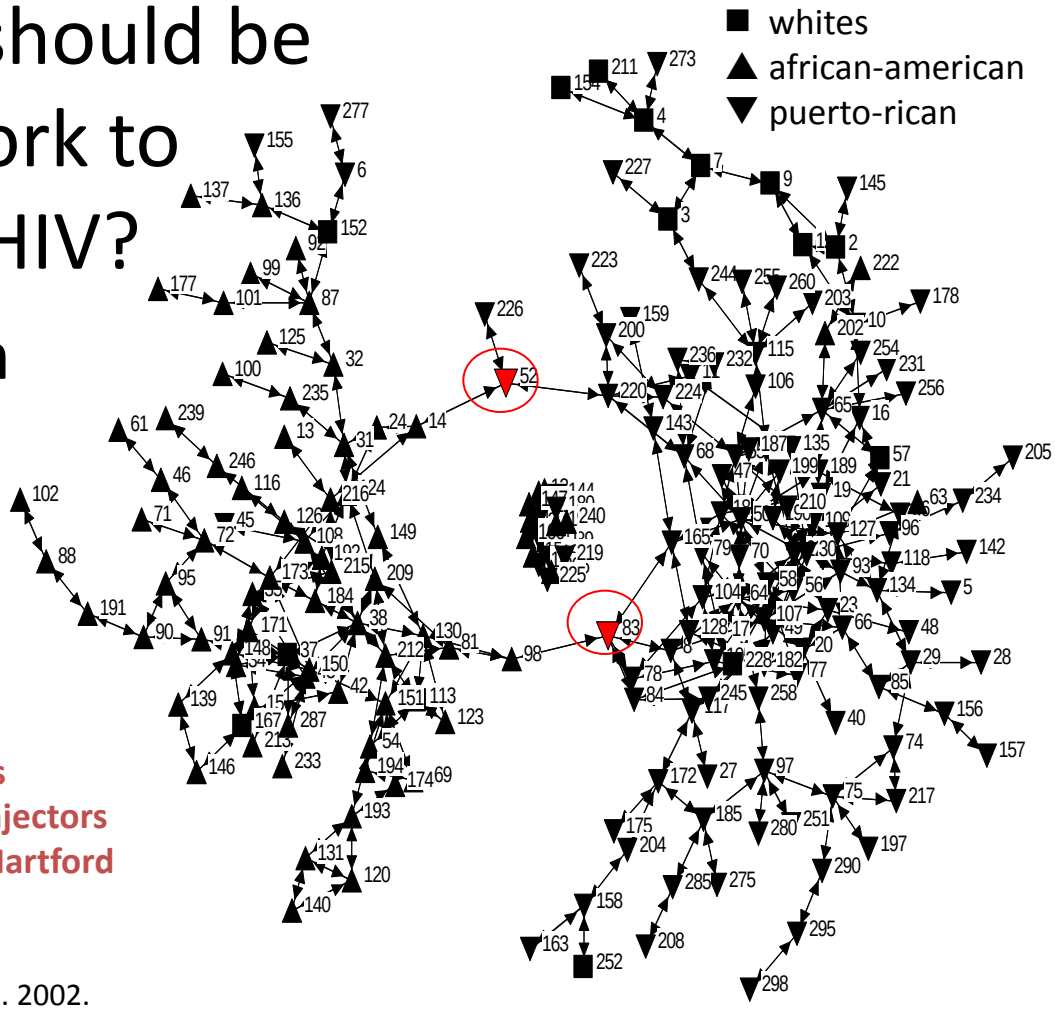
$$dwF = 1 - \frac{2\sum_{i>j} \frac{1}{d_{ij}}}{n(n-1)}$$





Disruption Example – health context

- Which <u>two</u> people should be isolated from network to slow the spread of HIV?
  - KeyPlayer algorithm identifies the two red nodes

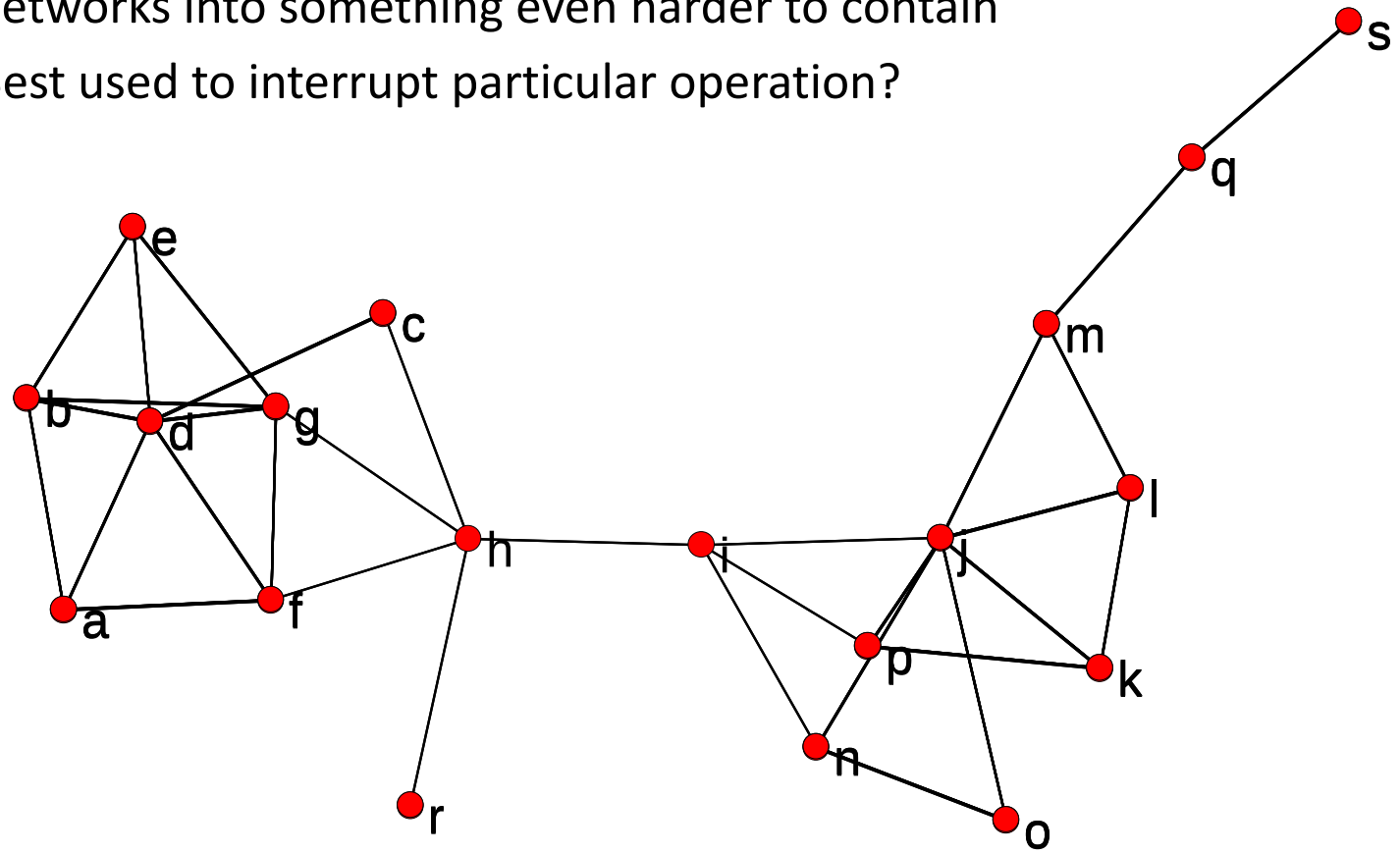


Friendship ties among drug injectors on streets of Hartford

Weeks, M.R., Clair, S., Borgatti, S.P., Radda, K., and Schensul, J.J. 2002. Social networks of drug users in high risk sites: Finding the connections. *AIDS and Behavior* 6(2): 193-206

Caveats

- Strategy of disrupting networks by removing key nodes may be dangerous long-term
  - Ties grow back. Fragmentation strategy may effectively shape enemy networks into something even harder to contain
  - Best used to interrupt particular operation?



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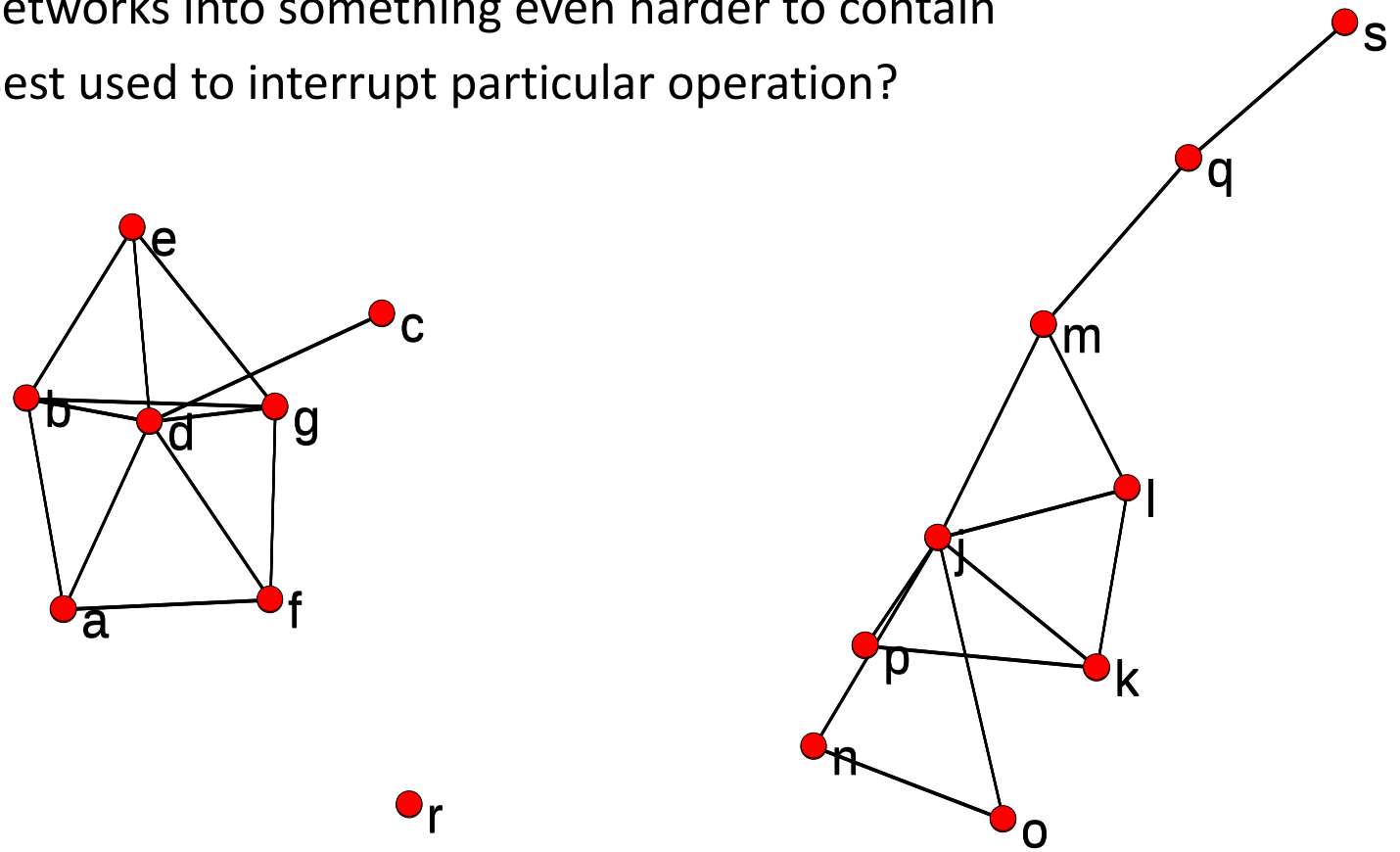
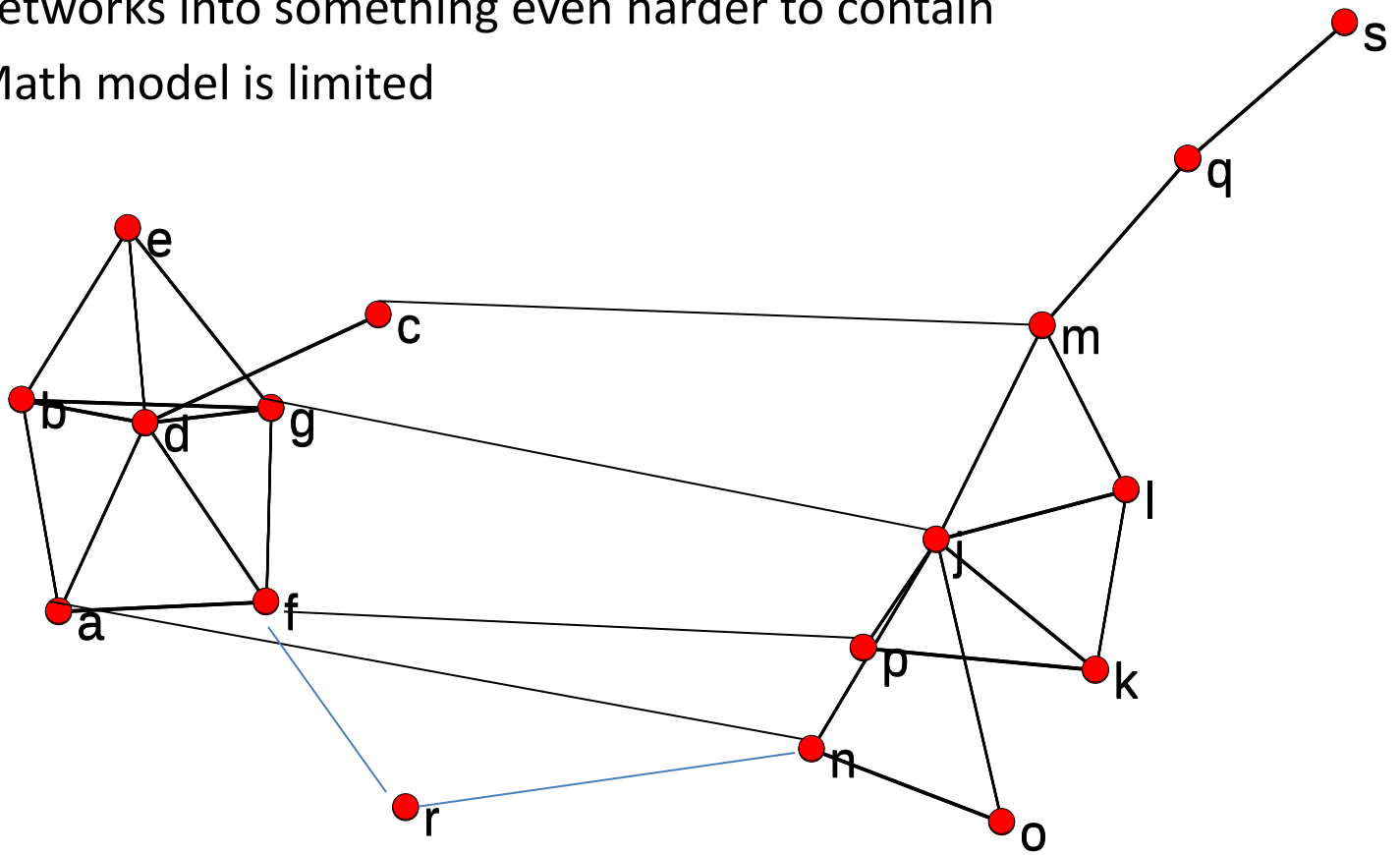


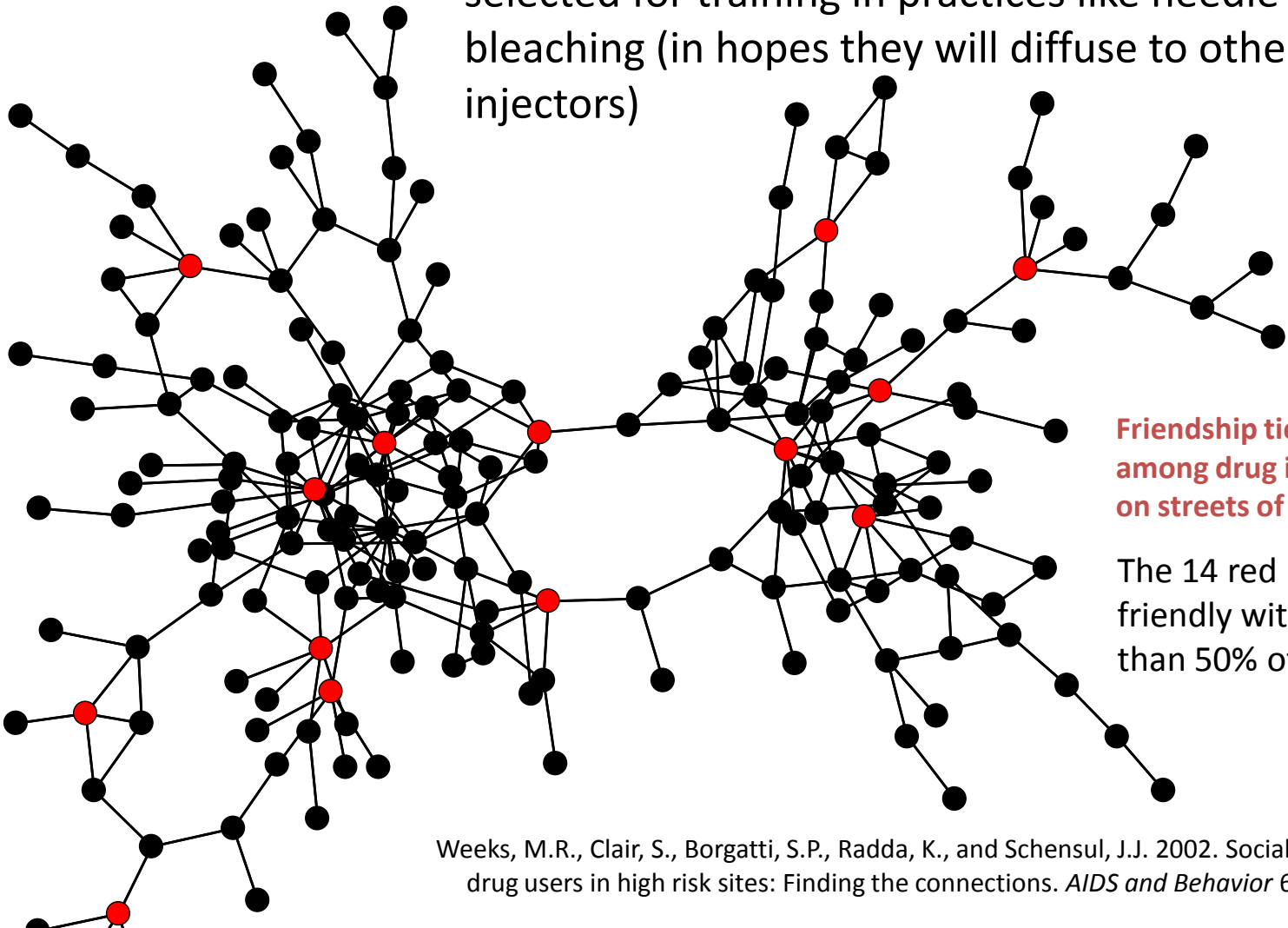
Caveats

- Strategy of disrupting networks by removing key nodes may be dangerous long-term
  - Ties grow back. Fragmentation strategy may effectively shape enemy networks into something even harder to contain
  - Math model is limited



Influence Example – health context

Which small set of drug injectors should be selected for training in practices like needle bleaching (in hopes they will diffuse to other injectors)



Friendship ties among drug injectors on streets of Hartford

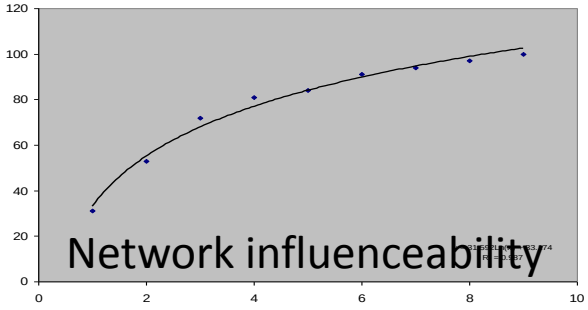
The 14 red nodes are friendly with more than 50% of network

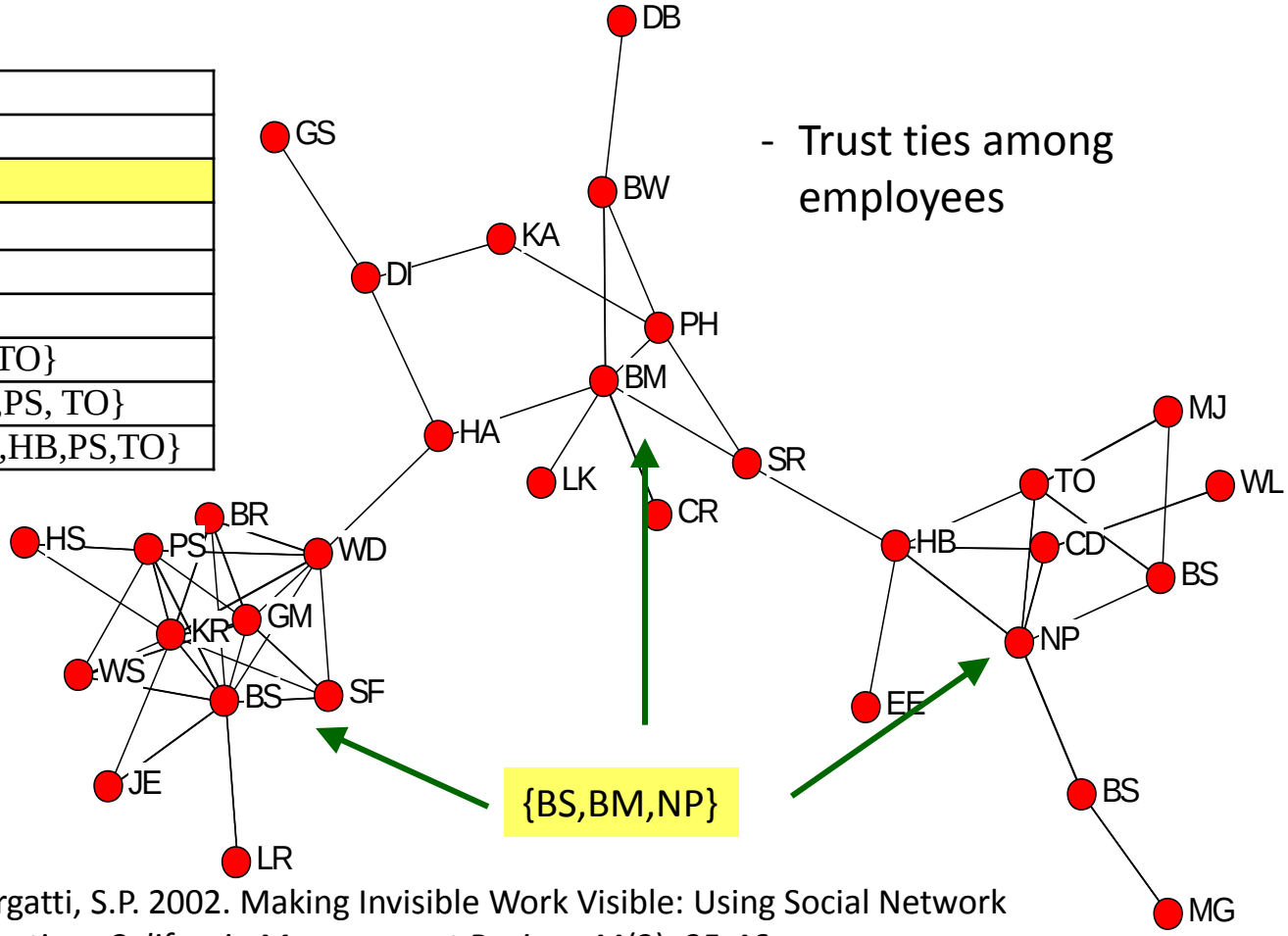
Weeks, M.R., Clair, S., Borgatti, S.P., Radda, K., and Schensul, J.J. 2002. Social networks of drug users in high risk sites: Finding the connections. *AIDS and Behavior* 6(2): 193-206

Influence Example – mgmt context

- Major change initiative is planned. Which small set of employees should we select for intensive indoctrination? in hopes they will diffuse positive attitude/knowledge to others

K	%	KP-Set
1	31	{KR}
2	53	{BM,BS}
3	72	{BM,BS,NP}
4	81	{BM,BS,DI,NP}
5	84	{BM,BS,DI,KR,NP}
6	91	{BM,BS,DI,HB,KR,TO}
7	94	{BM,BS,BS2,DI,HB,PS,TO}
8	97	{BM,BS,BS2,CD,DI,HB,PS, TO}
9	100	{BM,BS,BW,BS2,CD,DI,HB,PS,TO}





- Trust ties among employees

Data from: Cross, R., Parker, A., & Borgatti, S.P. 2002. Making Invisible Work Visible: Using Social Network Analysis to Support Strategic Collaboration. *California Management Review*. 44(2): 25-46

Prospects and Levers

- Objective
  - Use network influence models to maximize persuasive efforts
  - Illustrate how network perspective can be used to work with/through networks rather than against them
- Assumptions:
  - All nodes can be measured with respect to friendliness or unfriendliness to our cause (can be yes/no as well)
  - We know who influences whom
    - E.g., among physicians we have who receives referrals from whom

Borgatti, S.P. and Plant, E. 2008. Prospects and Levers. To be submitted to *Social Networks*

Prospects

- Prospects are “unfriendly” nodes that are surrounded by (influenced by) “friendlies”
  - By activating the nearby friendlies, we can try to “turn” the prospect
- Simplest formulation: $p_i = u_i \sum_j a_{ji} f_j$

Friendliness of neighborhood

  - u_i refers to unfriendliness of prospect *i*, a_{ji} indicates extent that *j* influences *i*, f_j gives the friendliness of node *j*. A node *i* gets a high score if currently unfriendly but surrounded by many friendlies
- Metrics of prospectness provide a way of prioritizing who to go after first
  - Identifying the low hanging fruit

Levers

- Levers are friendly nodes that have influence ties to unfriendly nodes.
  - If activated, can be directed to try to "turn" the unfriendlies who are influenced by them
  - Metrics identify who to activate (e.g., by incentivizing) in order maximize contagion effect per resource dollars
- Simplest formulation: $l_i = f_i \sum_j a_{ij} u_j$
- Incorporating indirect influence: $l_i = f_i \sum_j \alpha^{d_{ij}} a_{ij} u_j$

u_i refers to unfriendliness of prospect *i*, a_{ji} indicates extent that *j* influences *i*, f_j gives the friendliness of node *j*. d_{ij} is the length of the shortest path from *i* to *j*. α is a constant controlling attenuation of influence across long paths.