

Social networks for physicists . . . and . . . the structure of an Internet dating community

January X, 2003

Petter Holme

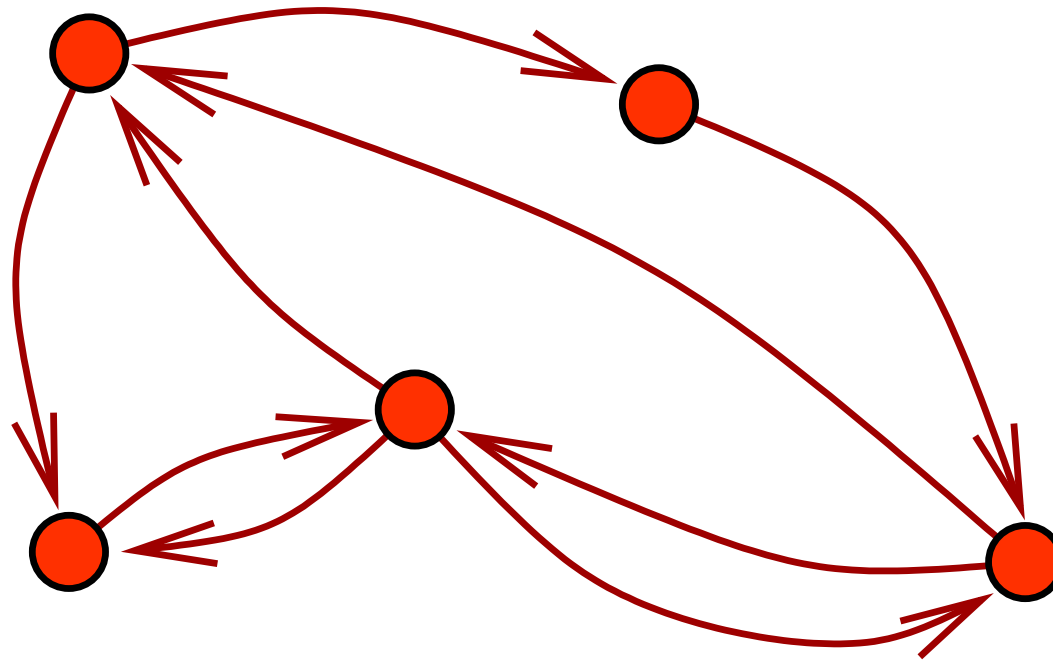
Department of Physics,
Umeå University

**Fredrik Liljeros &
Christofer Edling**

Swedish Institute for
Infectious Disease Control
Department of Sociology,
Stockholm University



NETWORKS



A *network* is any system that can be modeled as a *graph*—a set of *vertices* and *arcs* (or *edges*).

The in/out-degree of a vertex is the number of arcs going in/out.

SOCIAL NETWORKS

- from group psychology . . .
- . . . to graph theory
- most intangible of networks
- epidemiology
- anthropology
- psychology
- defense

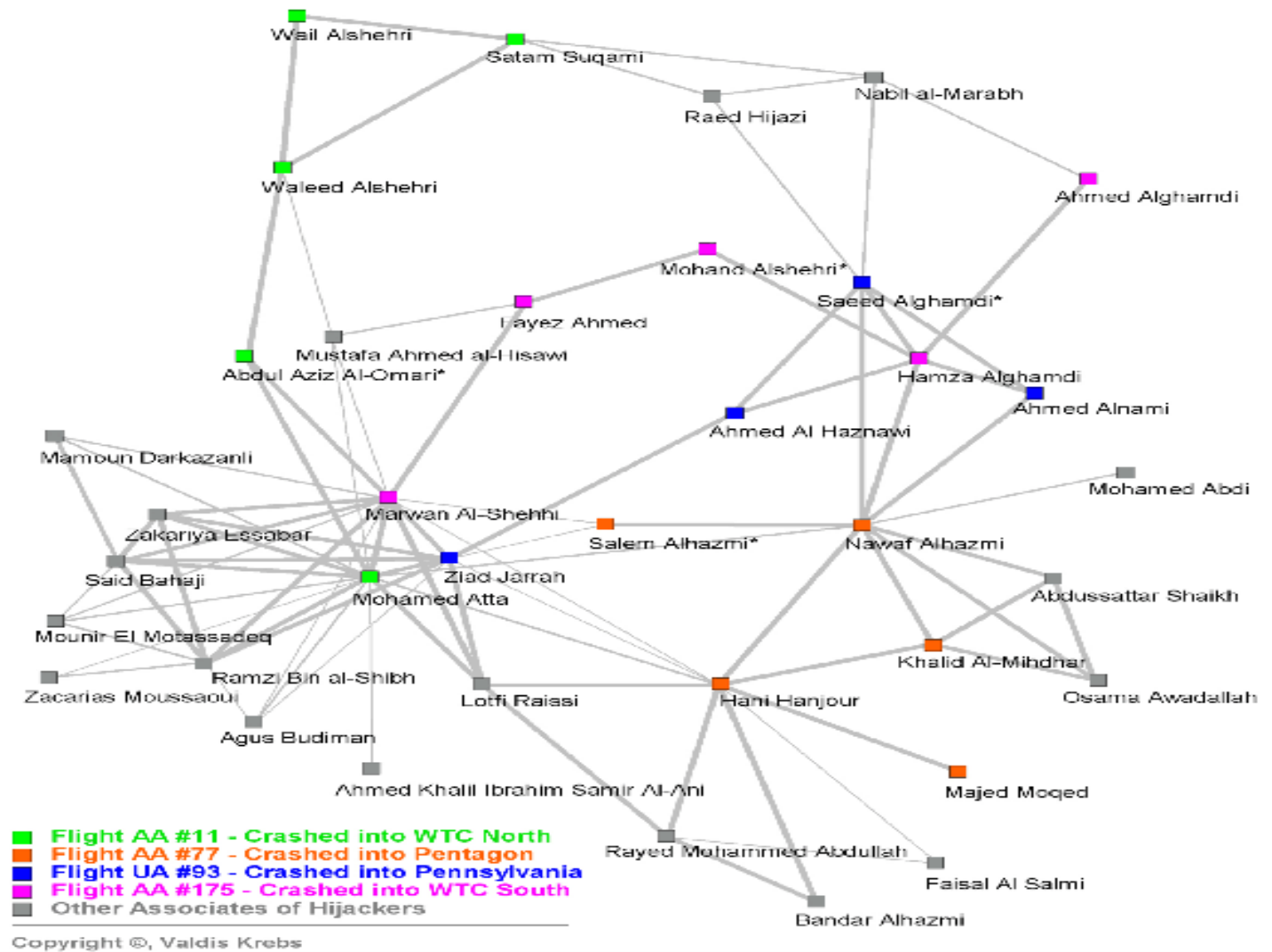


Figure 4. Hijacker's Network Neighborhood

WHY INTERNET COMMUNITIES

- large size (nice for statistical mechanics style approach)
- precise timing resolution
- formation more close to real acquaintance network than other methods
- interesting *per se* (I think)

about pussokram.com:

- ~ 130 000 users
- ~ 70% female
- average age 21 yrs (?)

Hey you Friday, July 5, 2002 | Newest user: User B P16

» [Community](#) / [user A F20](#)

User A F20 *City*

You are logged in as: [user Z P20](#)

You have one new message

all in one place

[Message box](#)

[Secret corner](#)

[Community](#)

[Your homepage](#)

[Your questbook](#)

[Your diary](#)

[Write in your diary](#)

[Your friends](#)

[Search member](#)

[Forum](#)

[Member of the week](#)

[Ask Dr. Love](#)

[Cell phone](#)

[Competitions](#)

[Your settings](#)

[About pussokram](#)

[Log out](#)

number of online members
29

Here User B has space to write about herself . . .

No picture uploaded

[Email me](#)

[Be my friend](#)

[Read my diary](#)

[Write in my questbook](#)

Member since:
April 16, 2000

Last time online:
13:02, June 20

Personal information:

E-mail: [someone@somewhere.se](#)

ICQ: . . .

Most recent visitors:

[User D P23](#)

[User E P33](#)

[User F P19](#)

[User G F12](#)

[User H P30](#)

Fast facts:

Residence:	Apartment	Civil status	Single
Economy:	Rich	Favourite color:	Red
Movie taste:	Horror	Likes:	The World
Hair color:	Dyed	Hobbies:	Watch TV
Sense of humour:	Normal	Style of clothes	Streetwise
Length:	Taller than most	Favourite food:	Various
Music taste:	Everything	Eye color:	Blue
Personality:	Serious	Occupation:	Working

If you like User A you'd also like . . .

User D F25	User H F25	User L F23
User E F21	User I F25	User M F22
User F F28	User J F22	User N F27
User G F20	User K F29	User O F26

friends online

None of your Pussokram friends are currently online

sökofindern™

name of member

dr. love's answers

Here starts the text of a mail to "Dr. Love" . . .

[Read more . . .](#)

most recent diary

[User C F18:](#)

[Here goes the diary . . .](#)

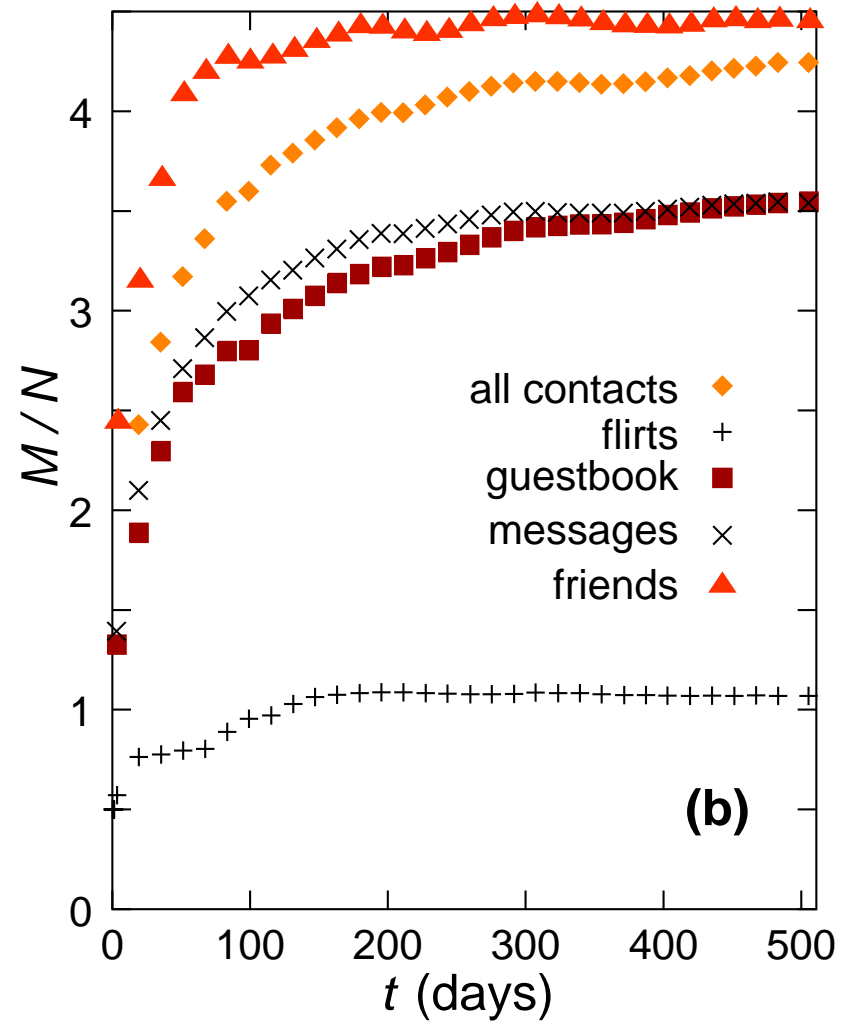
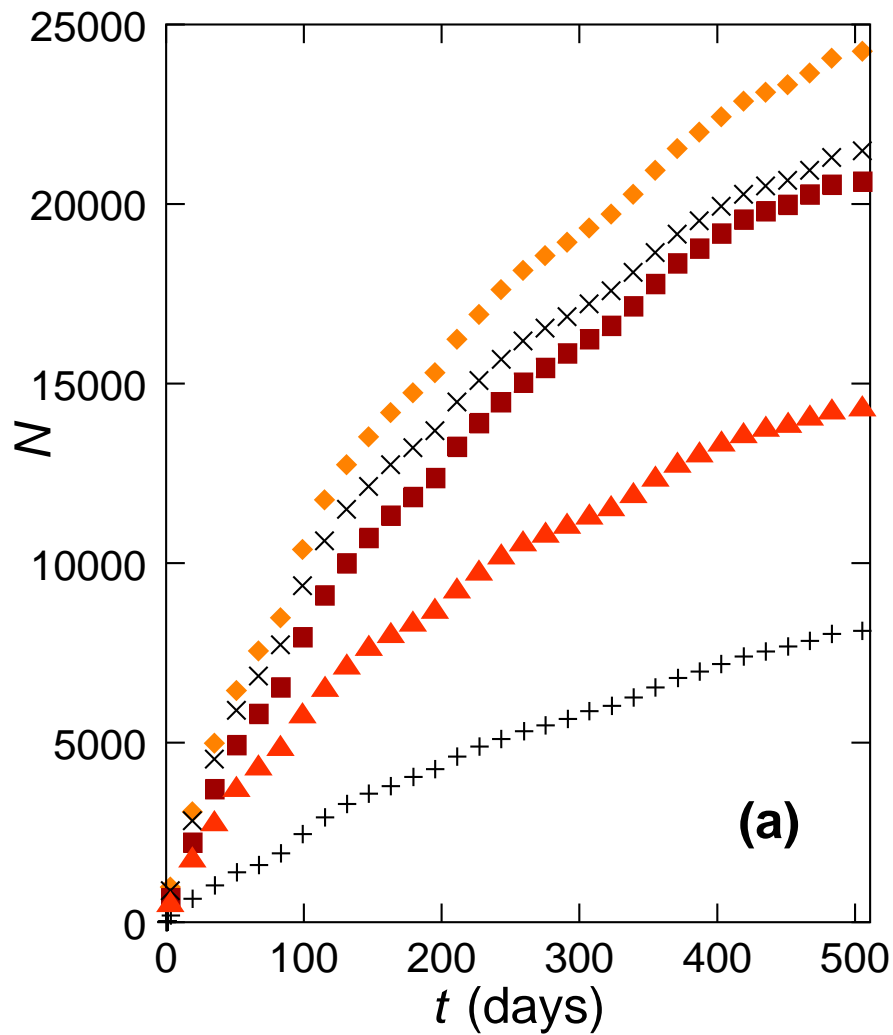
» [More diaries](#)

recently visited members

Here you can see the five most recently visited homepages

© 1999–2002 Manickel AB | [Information about pussokram.com](#) | [Press releases](#) | [Contact us](#) | [Disclaimer](#) | [Abuse](#)

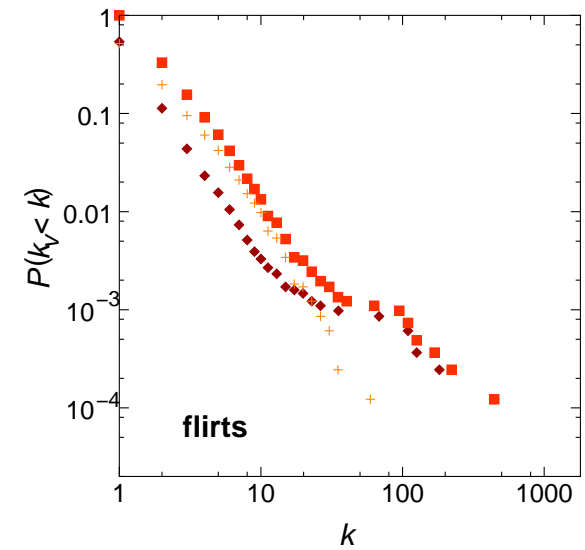
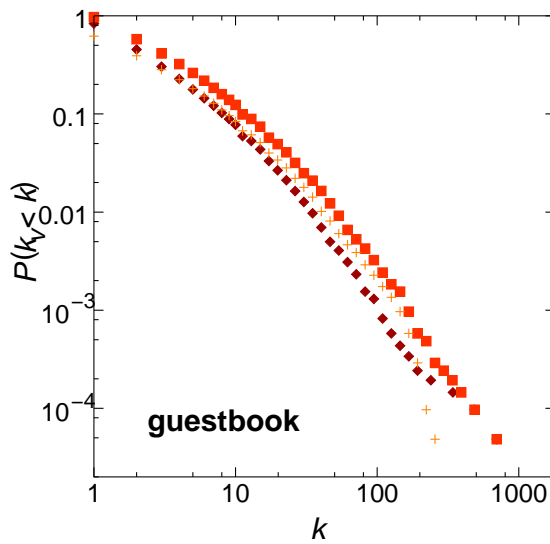
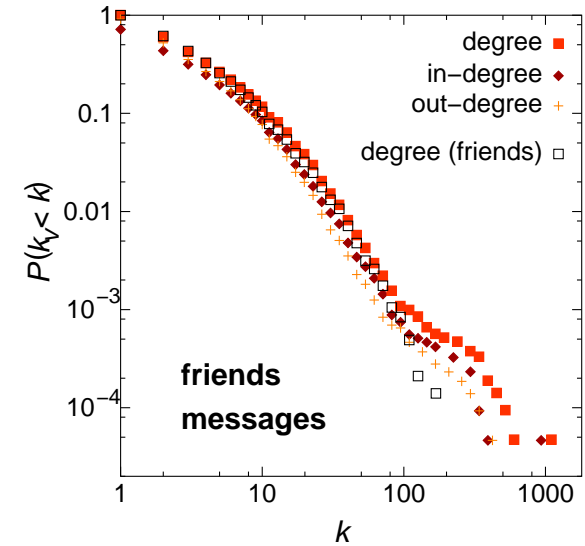
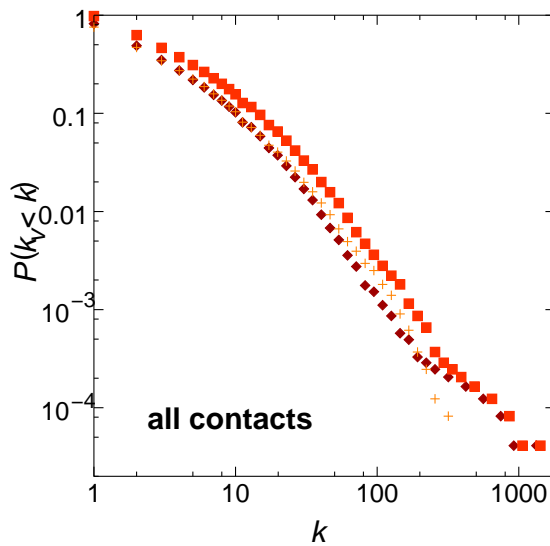
TIME DEVELOPMENT



DEGREE DISTRIBUTION

... quite scale-free, as seen in e.g. web of sexual contacts.

(There has to be a cut-off but its nowhere to be seen)



MECHANISMS FOR THE EMERGENCE OF SKEWED DEGREE DISTRIBUTIONS

Preferential Attachment

(Simon, Barabási, Albert)

A new node v attach to an old u with the probability

$$P_v(u) = \frac{k_u}{\sum_{w \in V} k_w}$$

Possible applications:

- World Wide Web
- Internet
- Collaboration networks in competitive fields

Pairwise introduction

(Davidsen, Ebel, Bornholdt)

Links between neighbors of vertices are formed at random. Nodes loose all their links from time to time.

- Regular acquaintance networks

Walking (Vazquez)

New nodes choose an old node and performs a random walk starting from this node. The random walk is terminated (at a node v) with probability p and an edge is added between the new node and v .

- Citation networks

Pairwise fitness (Caldarelli *et al.*) 1. All vertices are assigned a number x_v , from some

probability distribution. 2. An edge is drawn between a pair (v, u) of vertices with probability $f(x_v, x_u)$.

f is a symmetric function e.g. $\Theta(x_u + x_v - z)$ and the x_v does *not* have to be a power-law to get a power-law degree distribution.

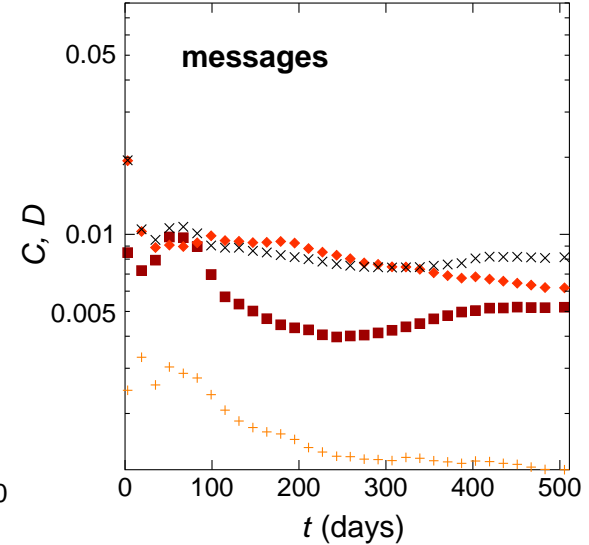
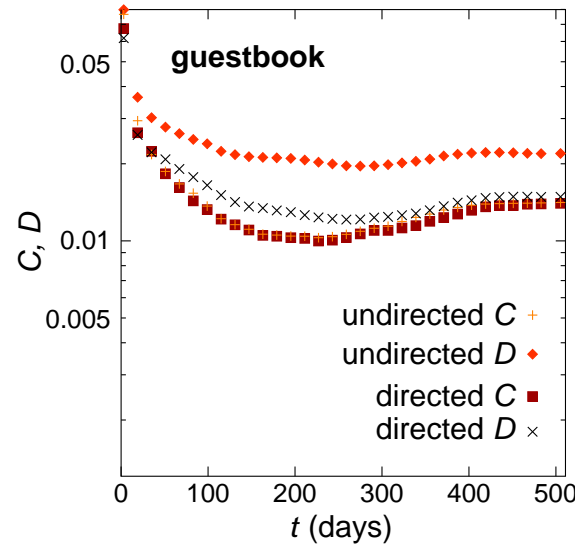
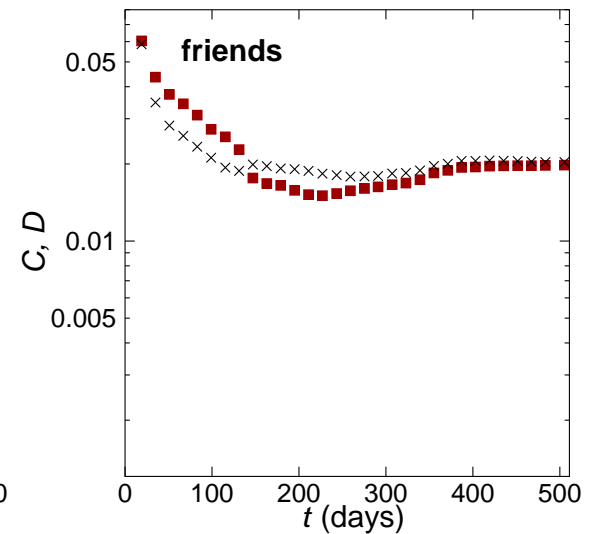
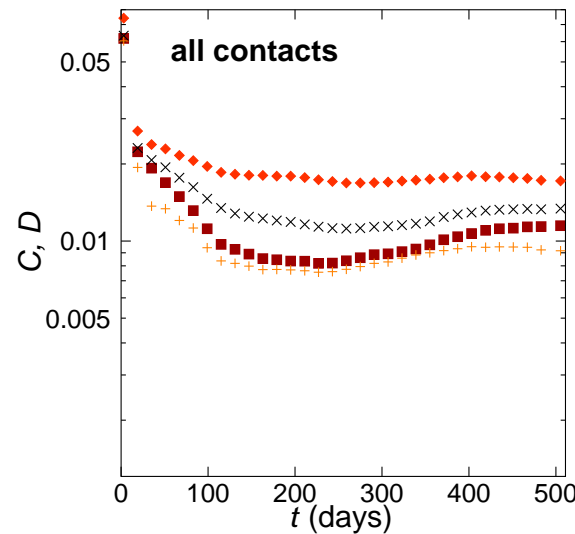
- WWW
- Internet communities (?)

DENSITY OF SHORT CIRCUITS

C —density of triangles,
 D —density of squares.

High C in acquaintance networks.

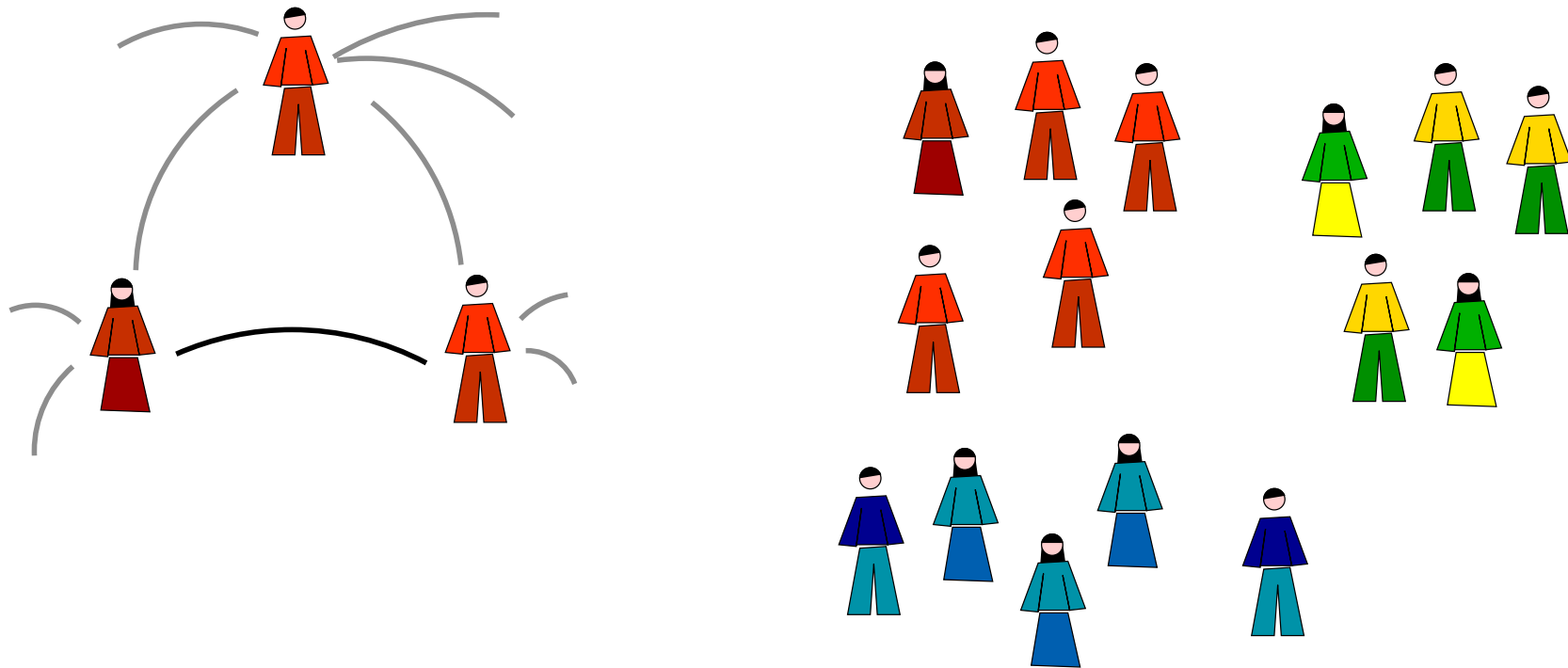
$C > D$ in other empirical network data. Here $D > C$ since most contacts are romantic & heterosexual.



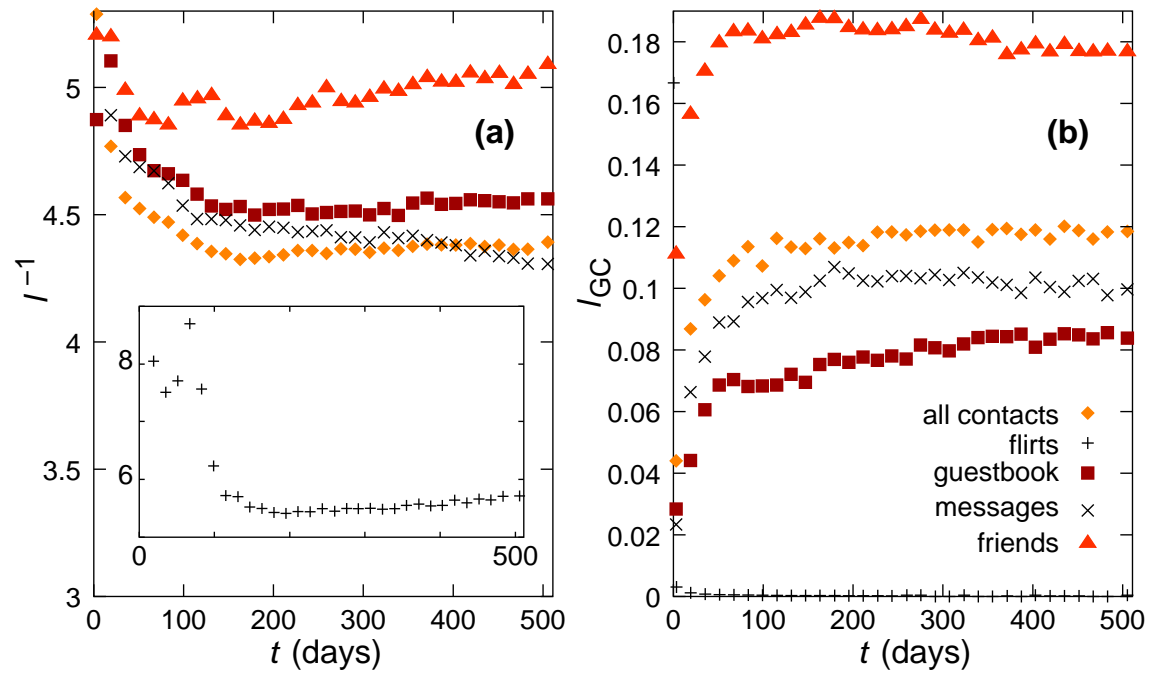
MECHANISMS FOR CLUSTERING

Introduction of friends. (Doesn't work for Internet communities)

Maybe hierarchical (community structure) gives large enough average degree in the clusters to get a finite clustering.



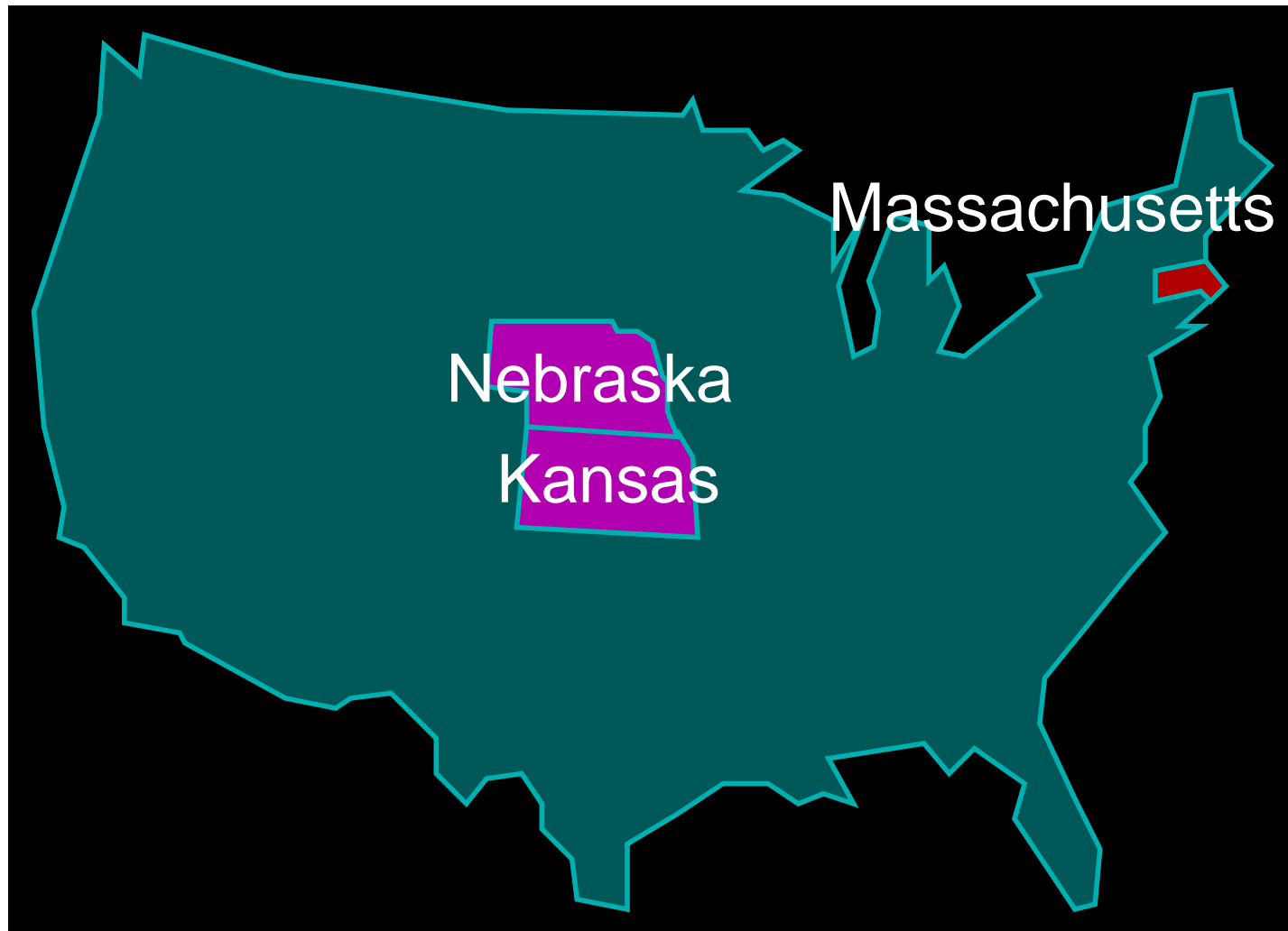
CHARACTERISTIC PATHLENGTH



$$l_{GSCC} = \frac{1}{|A_{GSCC}|} \sum_{(u,v) \in A_{GSCC}} d(u,v)$$

$$l^{-1} = \frac{1}{M} \sum_{(u,v) \in A} \frac{1}{d(u,v)}$$

THE SMALL WORLD PHENOMENON



⇒ six handshakes between you and anyone else in the world . . .