Multilayer networks and the POPNET data

Eszter Bokányi

SICSS | Erasmus University, 21st June 2022

POPNET

Universiteit van Amsterdam

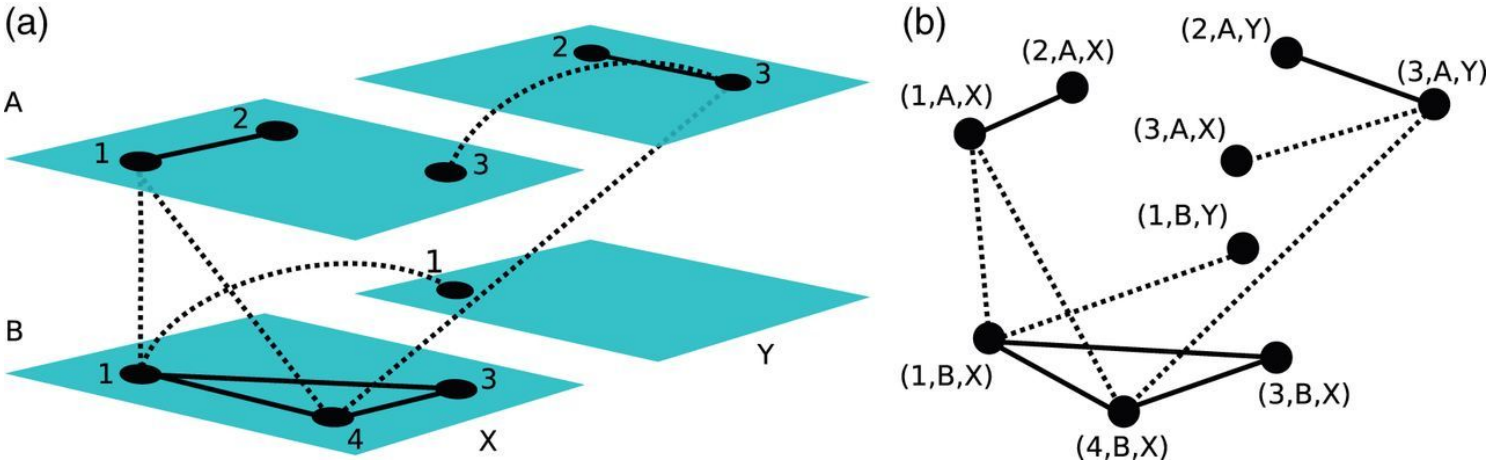
Universiteit Leiden

Centraal Bureau voor de Statistiek

PDI SSH Platform Digitale Infrastructuur Social Sciences & Humanities

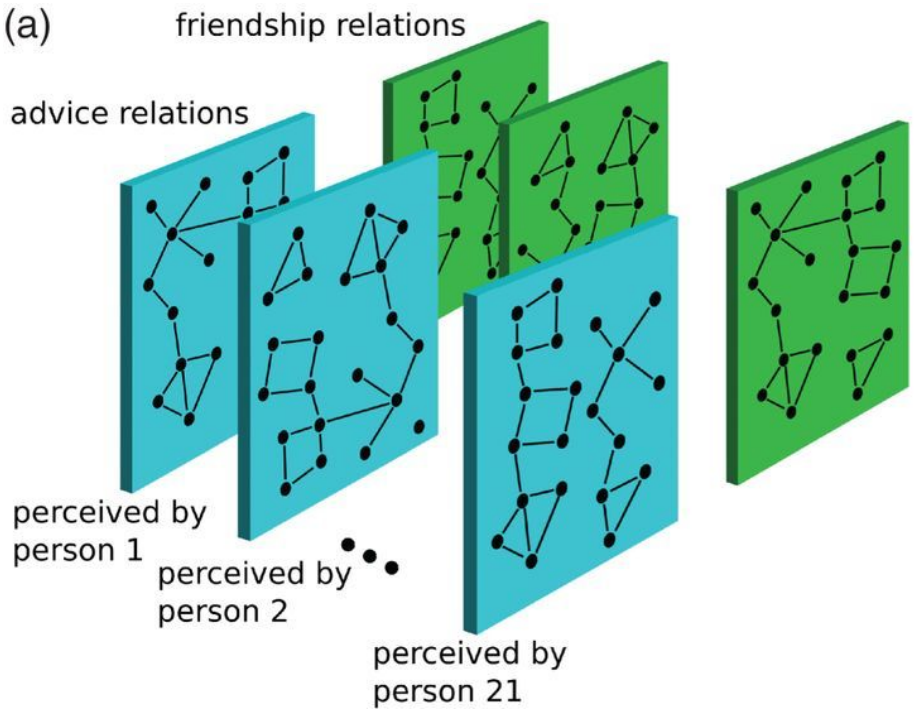
I. Multilayer networks

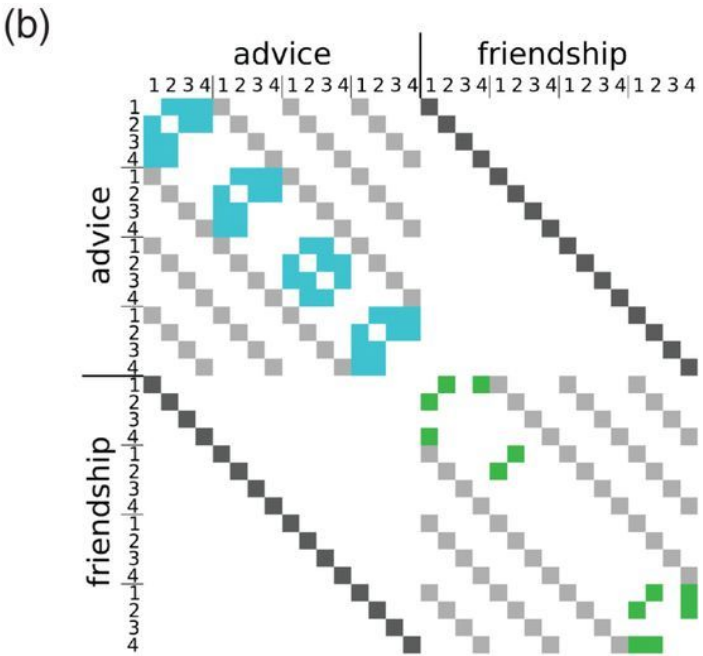
General problem



Kivelä, M., Arenas, A., Barthelemy, M., Gleeson, J. P., Moreno, Y., & Porter, M. A. (2014). Multilayer networks. Journal of Complex Networks, 2(3), 203-271.

Node alignment and supra-adjacency matrix

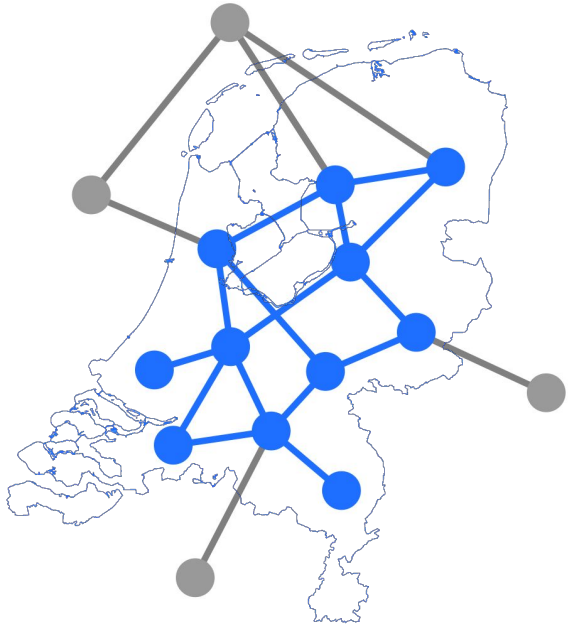




Kivelä, M., Arenas, A., Barthelemy, M., Gleeson, J. P., Moreno, Y., & Porter, M. A. (2014). Multilayer networks. Journal of Complex Networks, 2(3), 203-271.

I. The **POPNET** data

Nodes

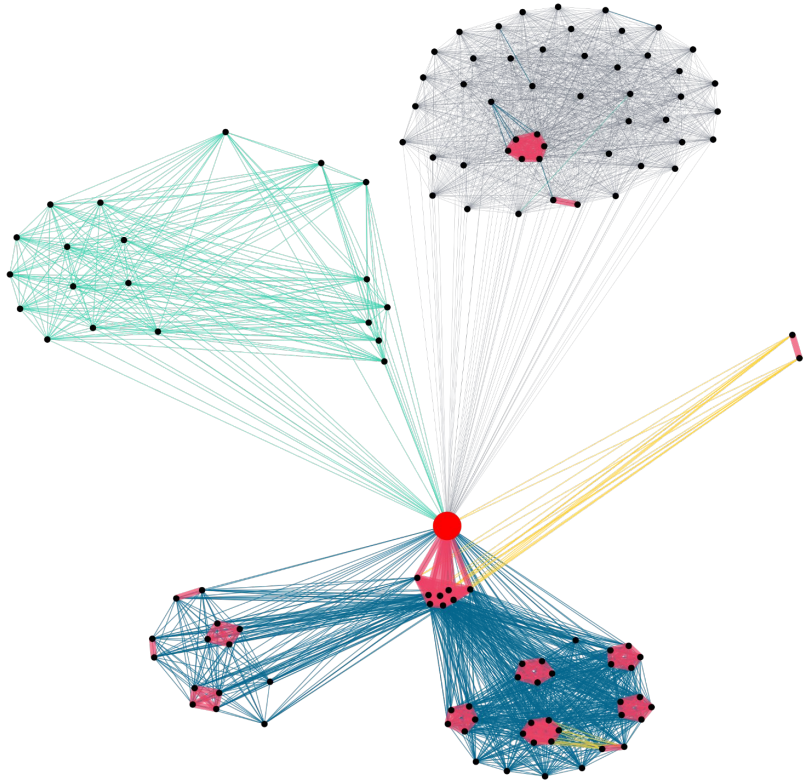


- ~17M people (nodes)
- geography-induced boundary
- various node attributes (age, city / neighborhood, education level, household income, ethnicity, and gender)

E.O. Laumann et. al (1989). The boundary specification problem in network analysis. In *Research Methods in Social Network analysis*, pp. 61-87.
D. Lazer et al. (2021). Meaningful measures of human society in the twenty-first century. *Nature* 595: 189-196.

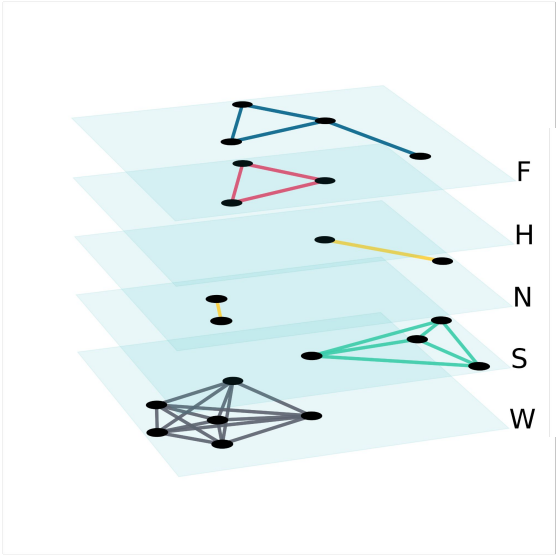
Edges

- **Close family and extended family**: directed parent relationships and inferred other family relations
- **Households**: people registered at the same address
- **Next-door neighbors**: links to people in ten closest households
- **Work**: co-workers employed at same organization, large workplaces sampled to the 100 closest colleagues
- **School**: classmates at primary school, high school, special, applied and higher education

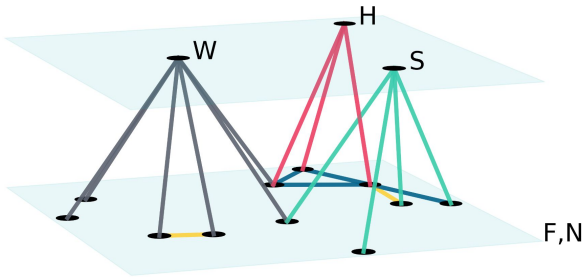


van der Laan, J., de Jonge, E., Das, M., Te Riele, S., & Emery, T. (2022). A Whole Population Network and Its Application for the Social Sciences. European Sociological Review
Kivelä, M., Arenas, A., Barthelemy, M., Gleeson, J. P., Moreno, Y., & Porter, M. A. (2014). Multilayer networks. Journal of Complex Networks, 2(3), 203-271.

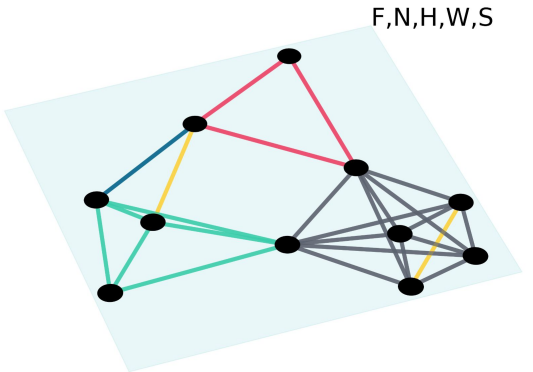
Different viewpoints for the same data



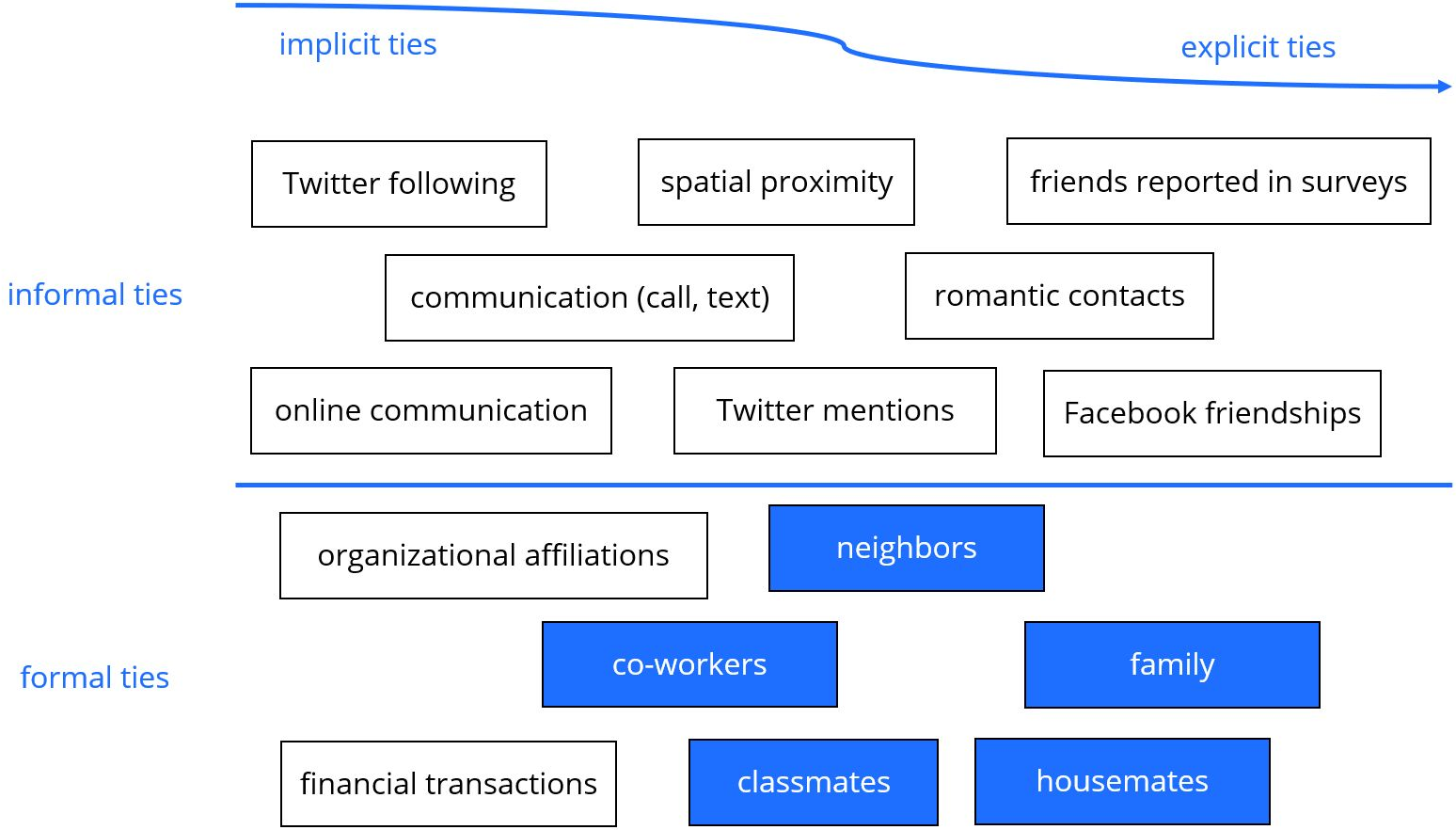
Type 1: node-aligned multilayer network



Type 2: almost bipartite view

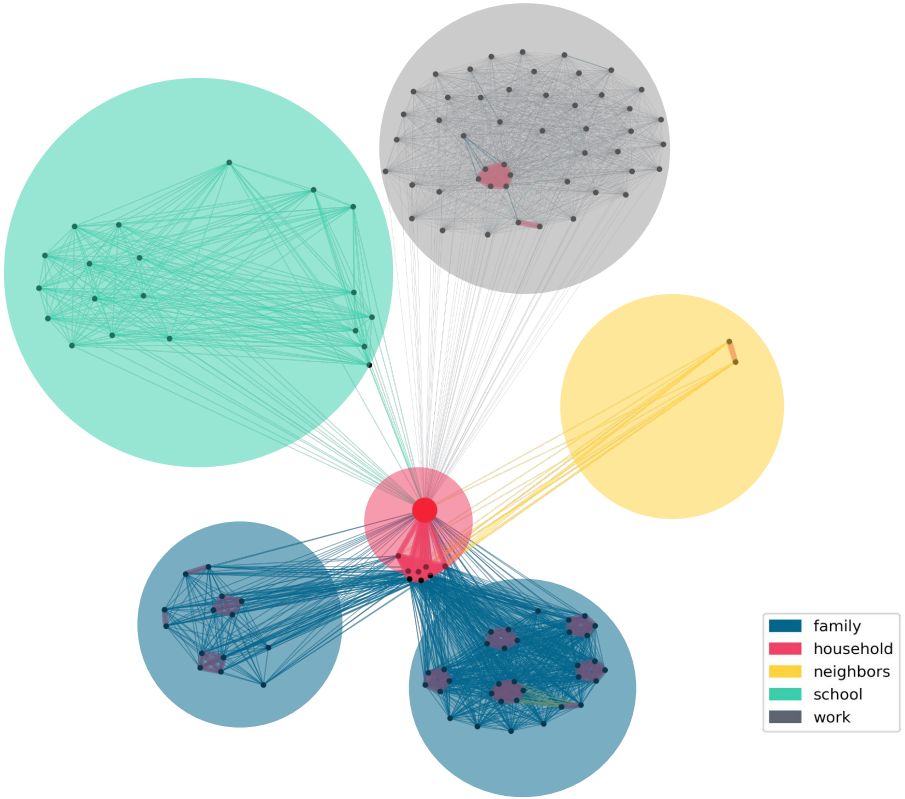


Type 3: projection "flattened" network


implicit ties
explicit ties
Twitter following
spatial proximity
friends reported in surveys
informal ties
communication (call, text)
romantic contacts
online communication
Twitter mentions
Facebook friendships
organizational affiliations
neighbors
co-workers
family
formal ties
financial transactions
classmates
housemates

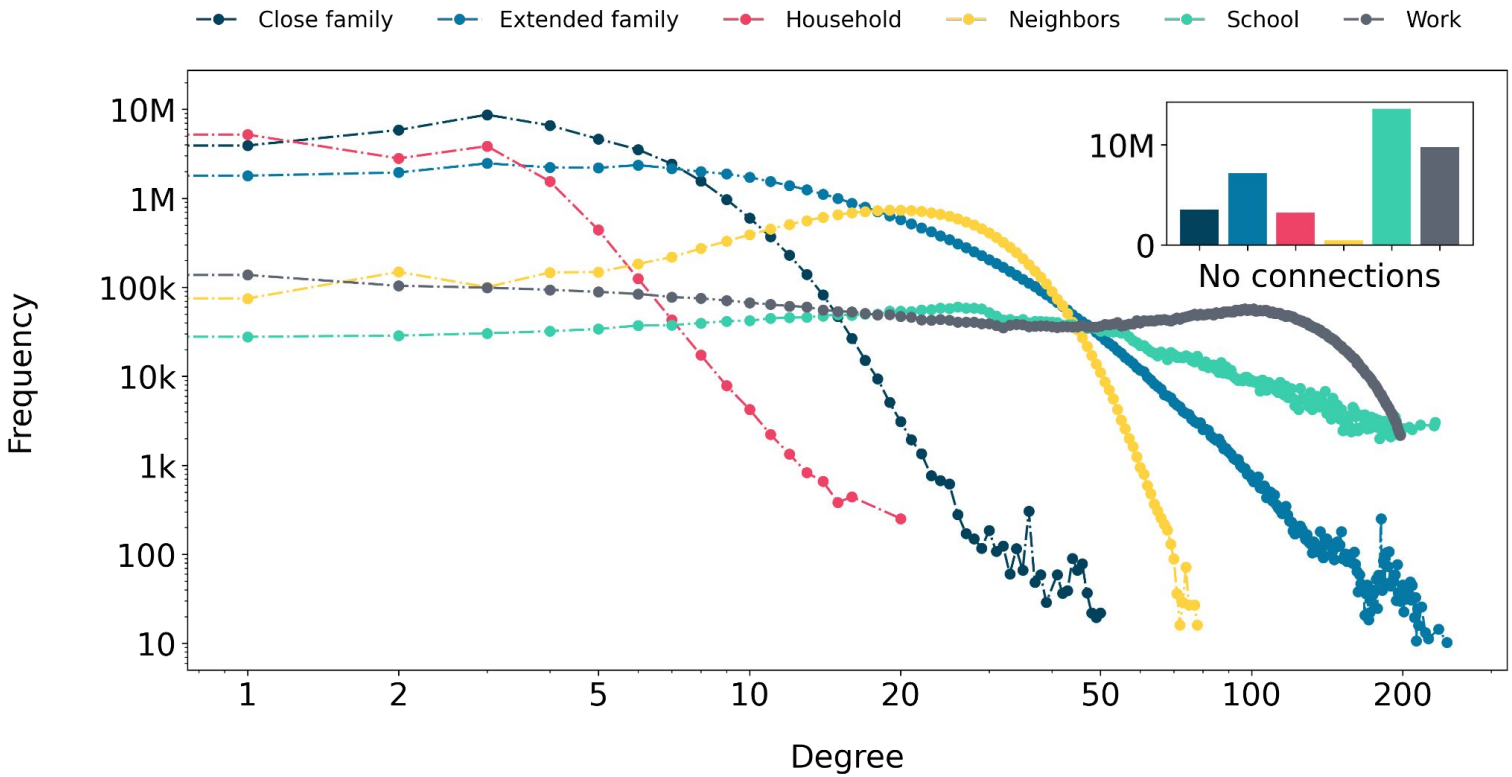
Opportunity structures

a possible interpretation



II. Degree

Degree distribution



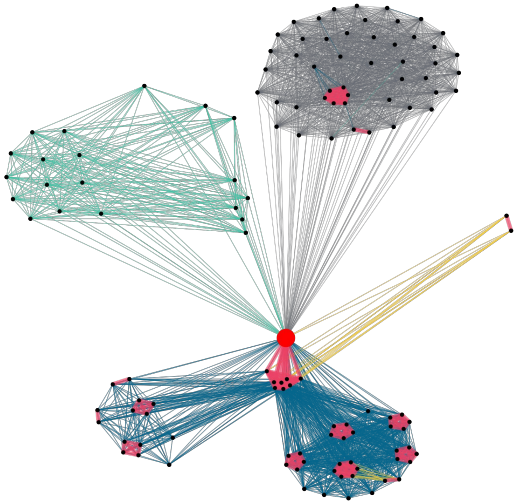
Degree assortativity

	C	E	H	N	S	W
C	1.00	0.53	0.12	0.05	-0.12	0.11
E		1.00	0.07	0.02	-0.02	0.10
H			1.00	0.07	0.10	-0.01
N				1.00	0.04	0.07
S					1.00	-0.04
W						1.00

III. Clustering

Local clustering coefficient

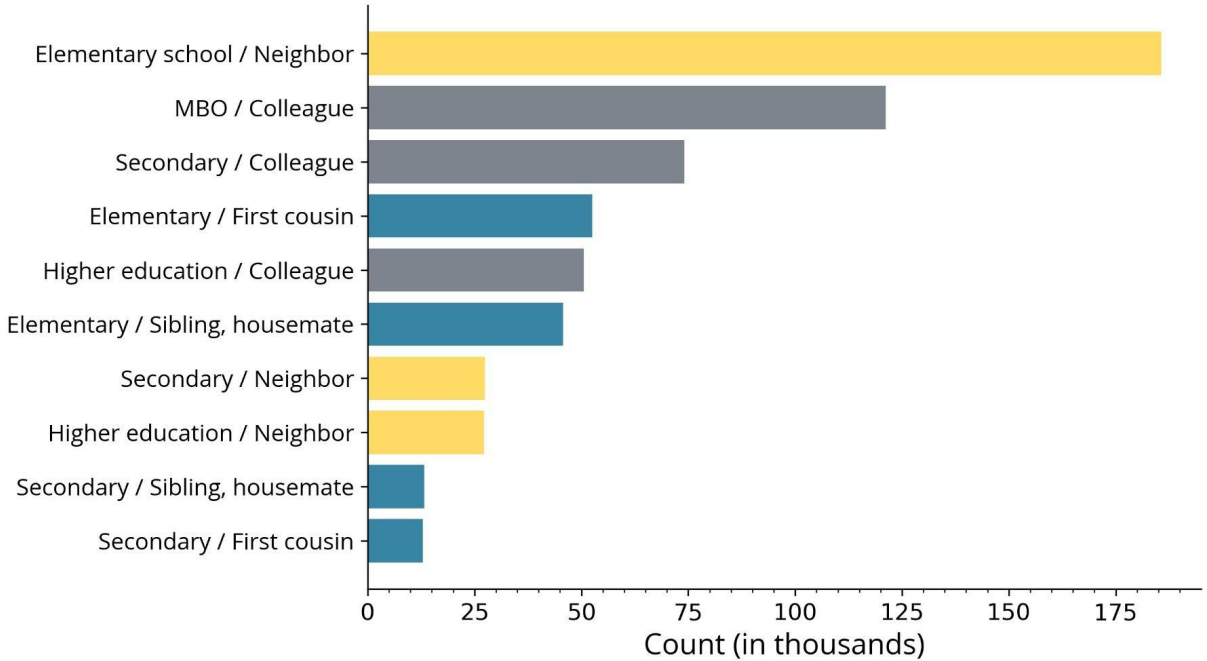
Network	avg(CC)
Google+	0.048
LiveJounal	0.117
YouTube	0.006
Hyves	0.18
Facebook	0.16
CyWorld	0.16
POPNET	**0.40**



Kunegis, J. (2013). KONECT: The Koblenz network collection. In Proceedings of the 22nd international conference on world wide web (pp. 1343-1350).
Corten R (2012) Composition and Structure of a Large Online Social Network in the Netherlands. PLOS ONE 7(4): e34760.

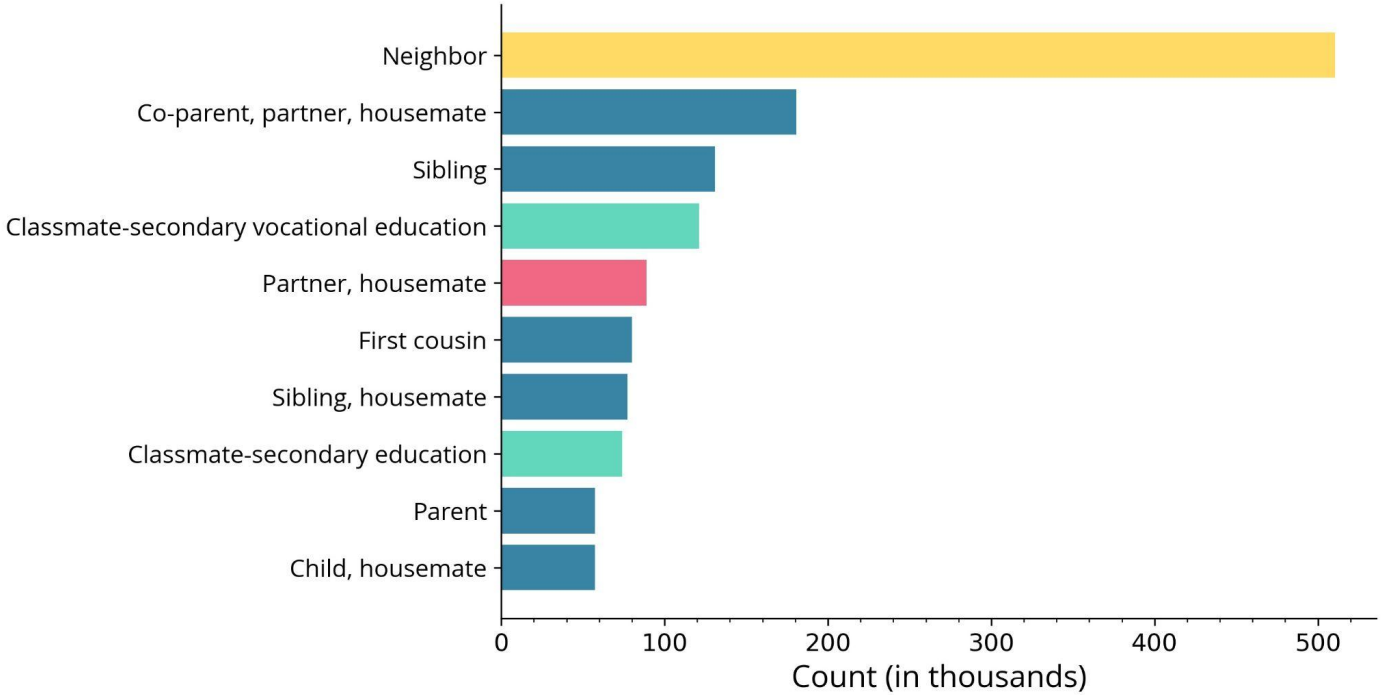
Edges in multiple layers

- Who do people tend to go to **school** with?



Edges in multiple layers

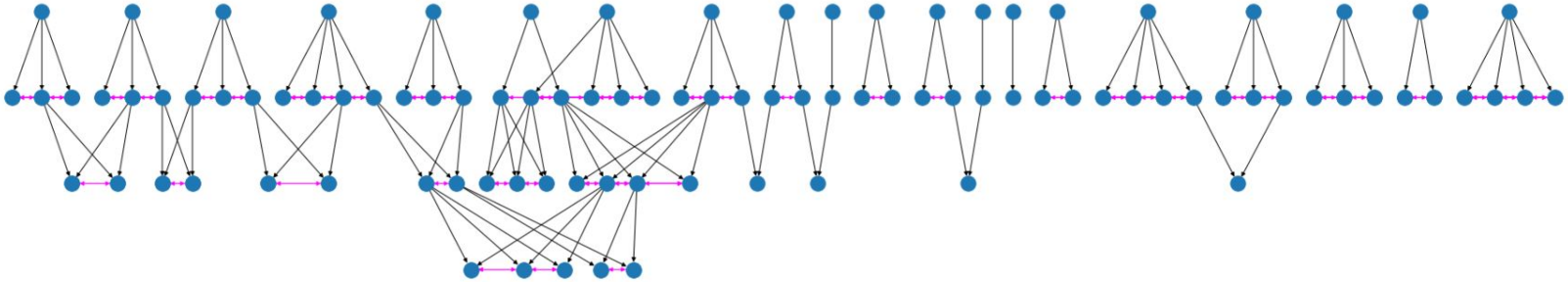
- Who do people tend to **work** with?



IV. Dummy network

Dummy data

1. creating a 4-generation family tree
2. filling it up with different relationships

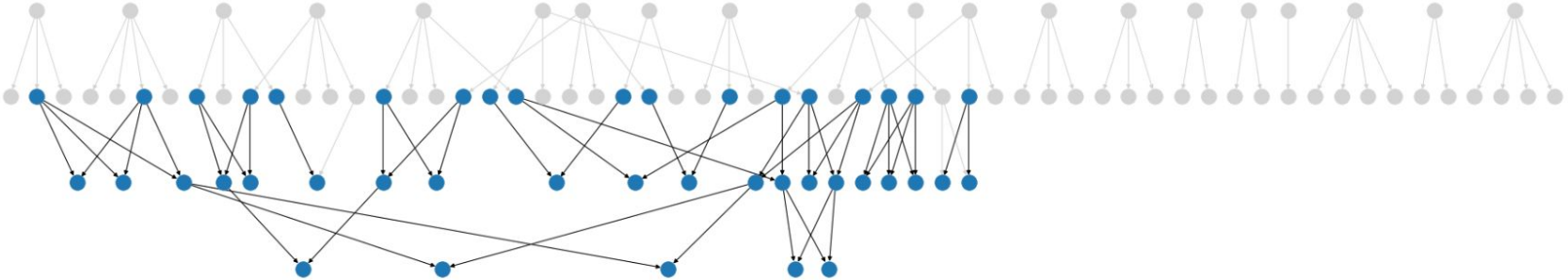


Family structure

- parent
- child
- partner
- grandparent
- grandchild
- sibling
- cousin
- niece / nephew
- aunt / uncle
- cousin

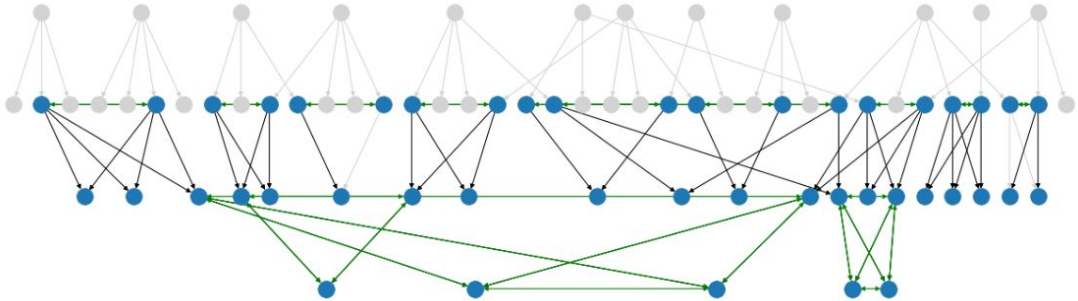
Dummy data

1. creating a 4-generation family tree
2. filling it up with different relationships
3. removing those who “died”

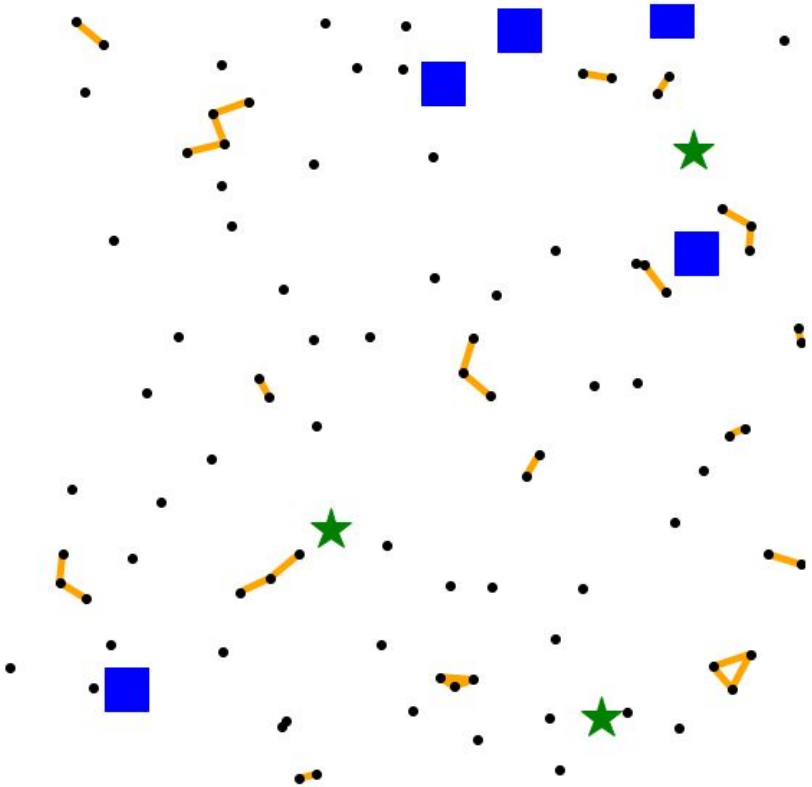


Dummy data

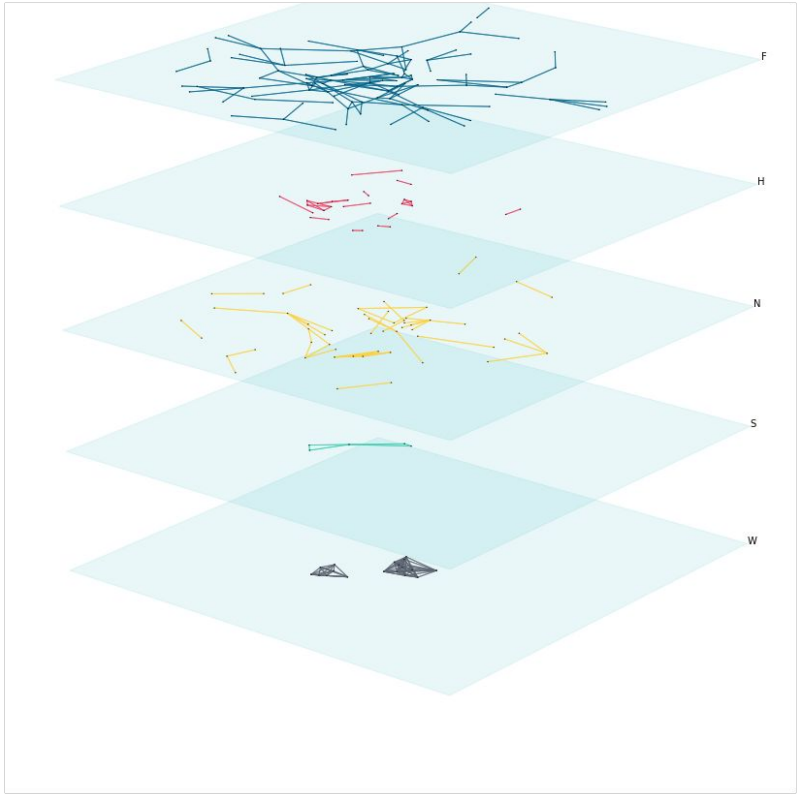
1. creating a 4-generation family tree
2. filling it up with different relationships
3. removing those who “died”
4. arranging households



Neighbor, school, workplace

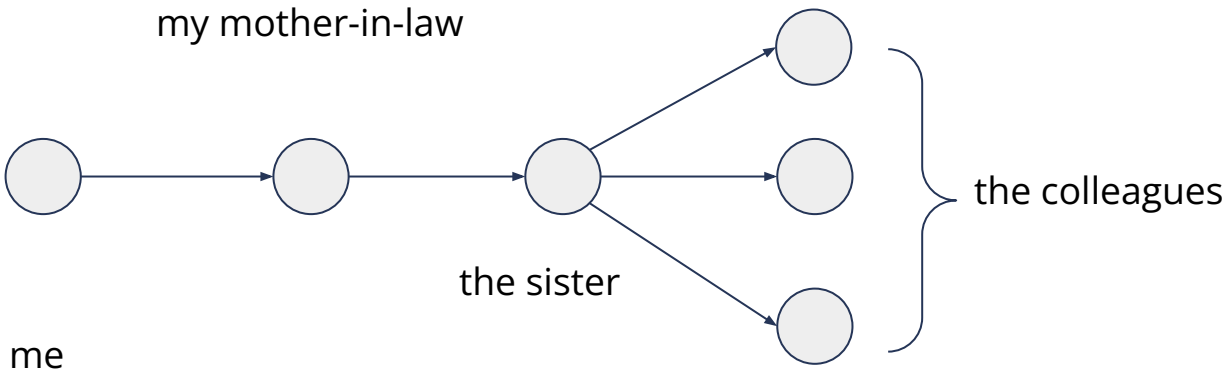


Multilayer network

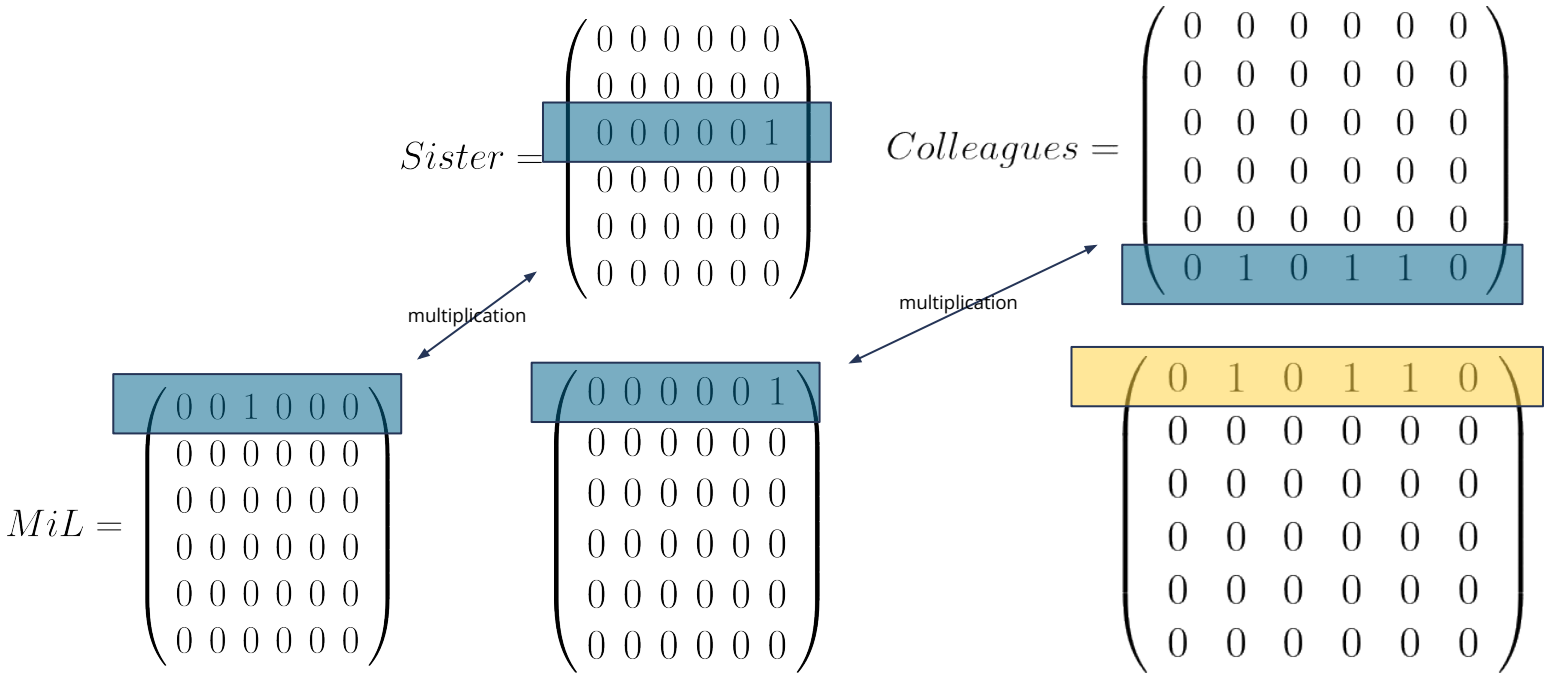


V. Multilayer walks

A guy I met at my mother-in-law's sister's workplace...



Matrices



node 5 is the sister of the mother-in-law of node 0!

nodes 1, 3, and 4 are the colleagues of the sister of the mother-in-law of node 0!

VI. Bipartite projections

School example

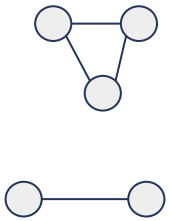
[(101, 0), (102, 0), (103, 2), (104, 2), (105, 0)]

school_id

node_id of child

101,102, and 105 and

103 and 104 go to the same school



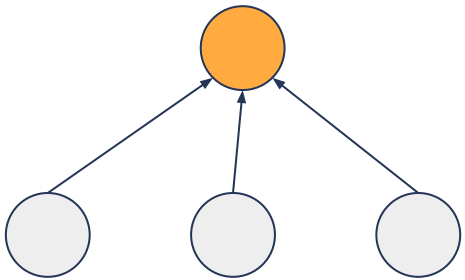
With matrices

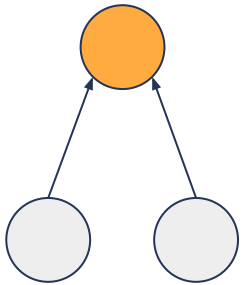
$S =$

	School 0	School 1	School 2
Node 101	1	0	0
Node 102	1	0	0
Node 103	0	0	1
Node 104	0	0	1
Node 105	1	0	0

school

child





Length-2 walk

$$S = \begin{pmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}$$

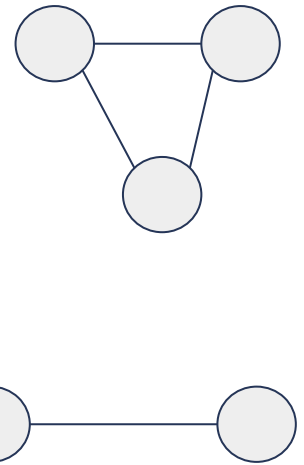
child -> school

$$S^T = \begin{pmatrix} 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 \end{pmatrix}$$

school -> child

Length-2 walk

$$S \cdot S^T = \begin{pmatrix} \cancel{1} & 1 & 0 & 0 & 1 \\ 1 & \cancel{1} & 0 & 0 & 1 \\ 0 & 0 & \cancel{0} & 1 & 0 \\ 0 & 0 & 1 & \cancel{0} & 0 \\ 1 & 1 & 0 & 0 & \cancel{1} \end{pmatrix}$$



POPNET

Eszter Bokányi

✉ e.bokanyi@uva.nl

@bokanyie

Slide/image credits:
Frank Takes and Yuliia Kazmina

POPNET project

✉ popnet@uva.nl

https://popnet.io

@popnet_research

- Biweekly "**POPNET** *Connects*" seminars (online & free!)
- Want to learn more? Subscribe to our mailing list: https://popnet.io/staytuned