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# Topological and Temporal Complexity in Socio-Technical Systems

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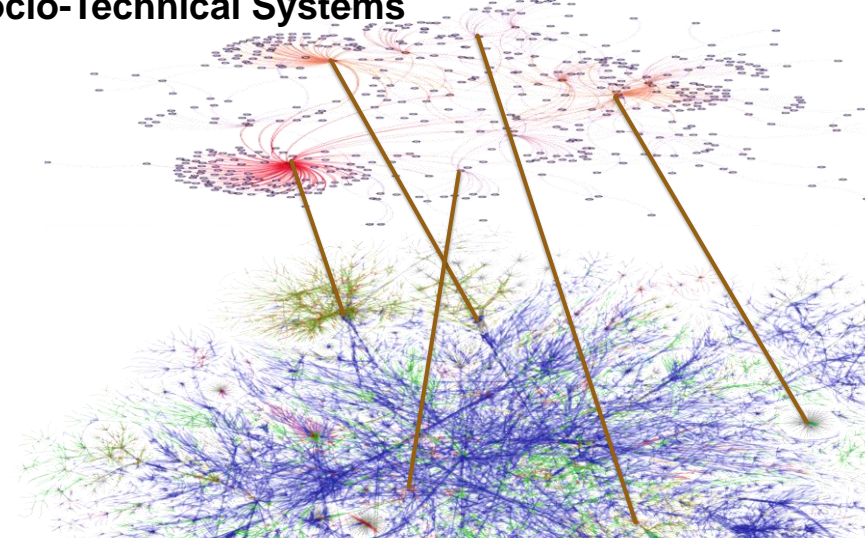
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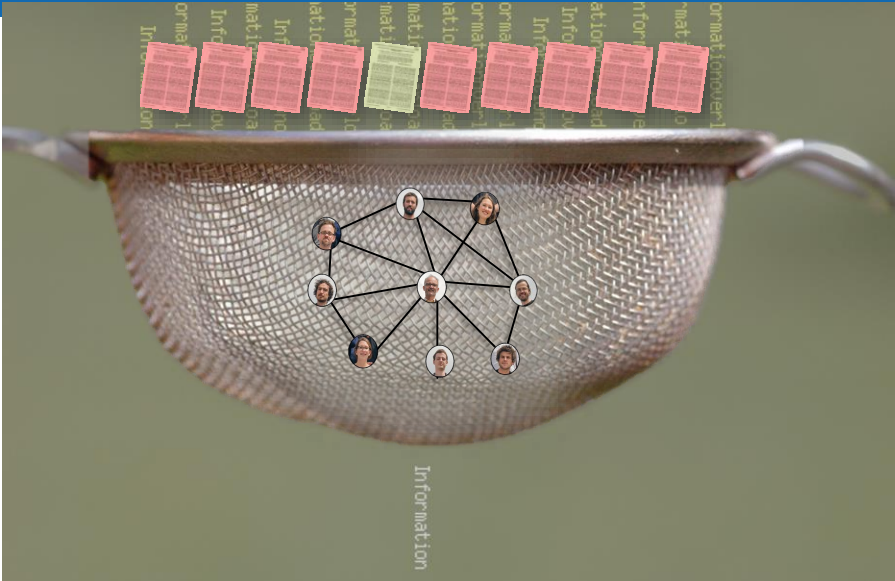
# Socio-Technical Systems



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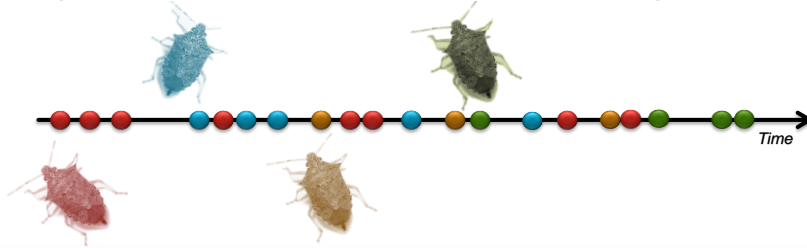
Information

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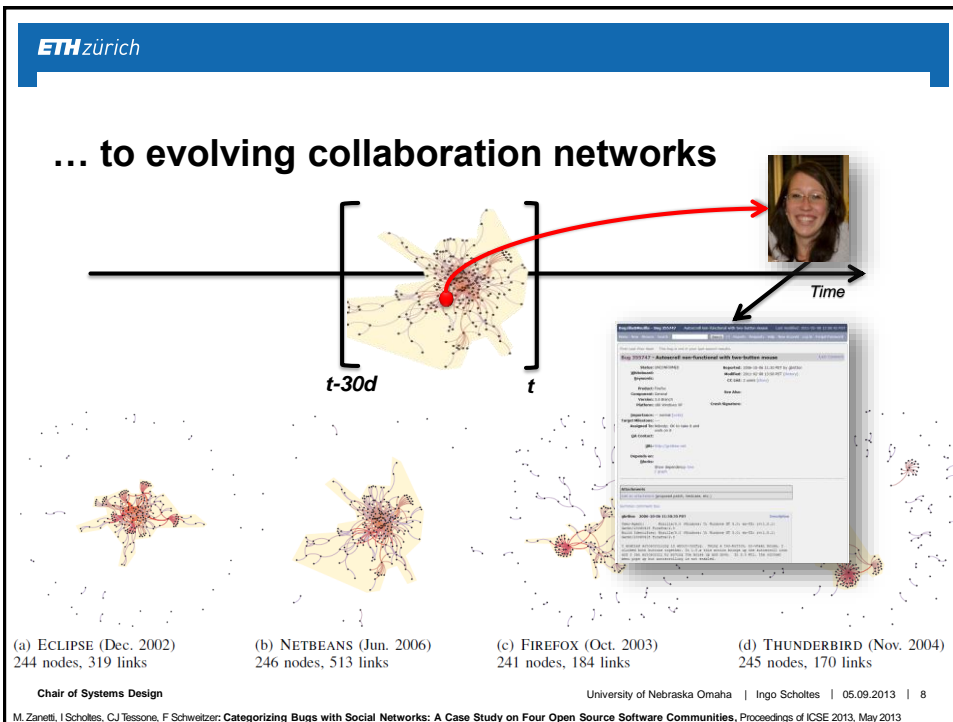
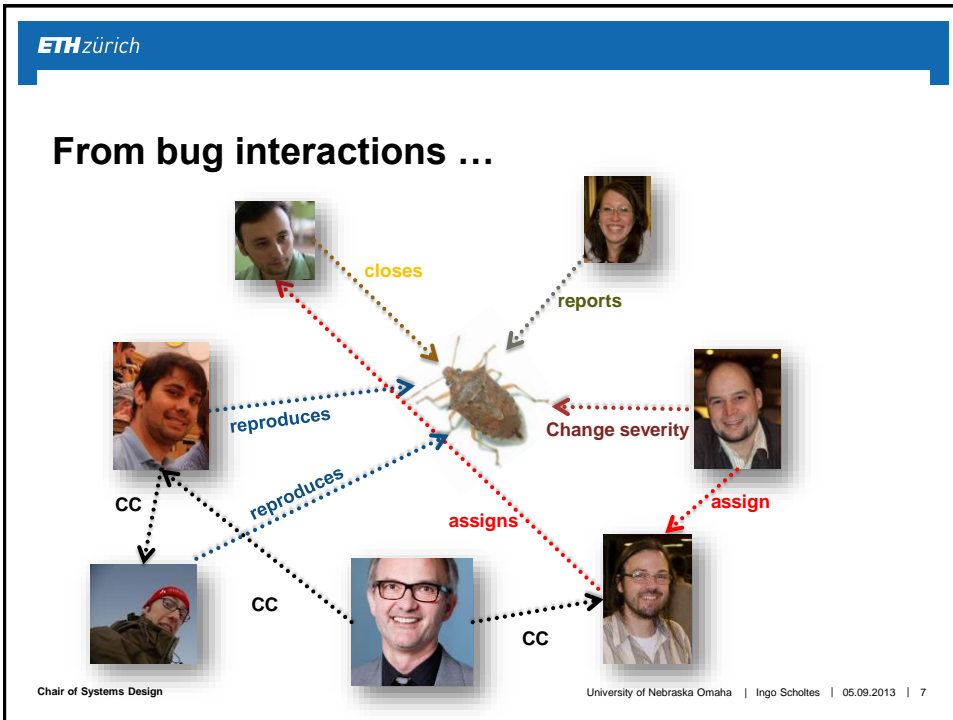
## Bugzilla: collaborative issue handling

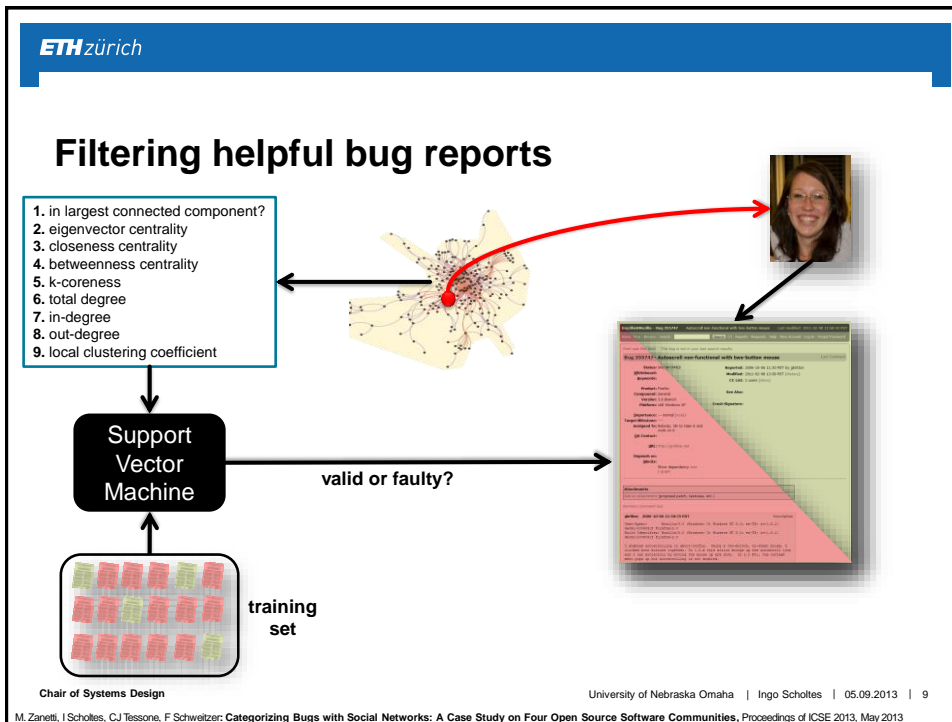


	FIREFOX	THUNDERBIRD	ECLIPSE	NETBEANS	Total
Start date	April 2002	January 2000	October 2001	January 1999	–
Total bug reports	112,968	35,388	356,415	210,921	715,692
Change events	1,068,070	313,957	2,594,385	1,875,878	5,852,290
Changes / report	9.45	8.87	7.28	8.89	8.18
Resolved bugs (resolved/total)	64,088 (0.57)	21,644 (0.61)	158,957 (0.45)	42,851 (0.19)	287,540 (0.40)
FIX (FIX / resolved)	10,856 (0.17)	4,508 (0.21)	103,453 (0.65)	21,442 (0.50)	140,259 (0.49)
DUP (DUP / resolved)	24,263 (0.38)	10,336 (0.48)	28,227 (0.18)	9,328 (0.22)	72,154 (0.25)
INV (INV / resolved)	11,785 (0.18)	2,829 (0.13)	12,601 (0.08)	4,082 (0.10)	31,297 (0.11)
WOF (WOF / resolved)	2,708 (0.04)	581 (0.03)	14,676 (0.09)	5,515 (0.13)	23,480 (0.08)
INC (INC / resolved)	14,476 (0.23)	3,390 (0.16)	-	2,484 (0.06)	20,350 (0.07)

## Bugzilla: collaborative issue handling







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## Filtering helpful bug reports

PRECISION ( $p$ ), RECALL ( $r$ ) AND  $F$ -SCORE OF FILTERING VALID BUG REPORTS BASED ONLY ON MEASURES OF SOCIAL EMBEDDEDNESS.

	FIREFOX	THUNDERBIRD	ECLIPSE	NETBEANS
Valid	21.0%	23.3%	74.3%	62.4%
$p$ (LCC)	44.1%	62.1%	76.3%	71.9%
$r$ (LCC)	50.9%	44.5%	62.6%	62.4%
$F$ (LCC)	0.47	0.52	0.69	0.67
$p$ (event)	60.4%	68.6%	76.3%	76.7%
$r$ (event)	30.5%	5.4%	62.6%	38.8%
$F$ (event)	0.41	0.10	0.69	0.52
$p$ (SVM)	82.5%	90.3%	88.7%	78.9%
$r$ (SVM)	44.5%	38.9%	91.0%	87.0%
$F$ (SVM)	0.58	0.54	0.89	0.83

**Social network analysis allows to identify helpful bug reports**

**Precision and recall significantly higher than for competing methods**

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M. Zanetti, I. Scholtes, C.J. Tessone, F. Schweitzer: Categorizing Bugs with Social Networks: A Case Study on Four Open Source Software Communities, Proceedings of ICSE 2013, May 2013

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# Temporal Complexity

**Dynamics of networks can invalidate results of static network analysis**




Video: Chronos by Ron Fricke, © Canidae Films

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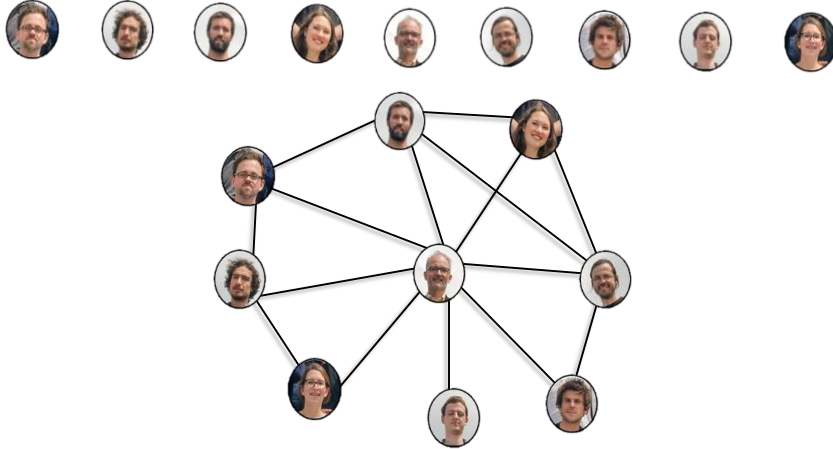
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# A typical day at ETH Zürich

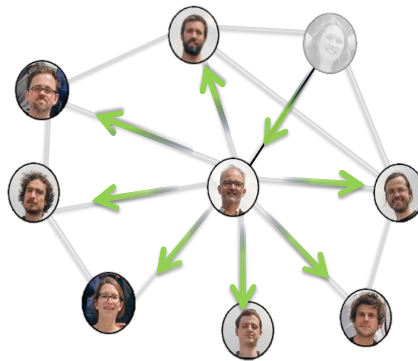


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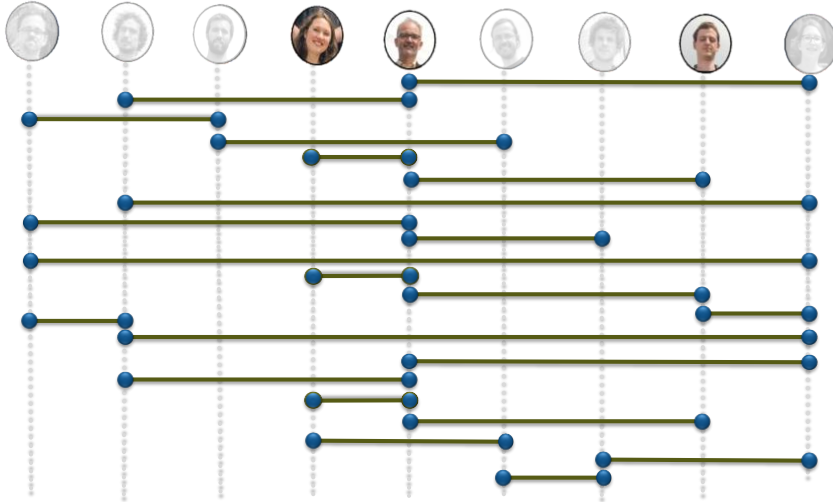
## An aggregated perspective



## The fallacy of transitivity



## The time dimension



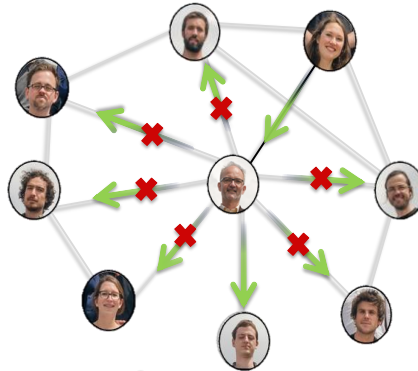
## Findings



**Memory matters in real-world dynamic networks**

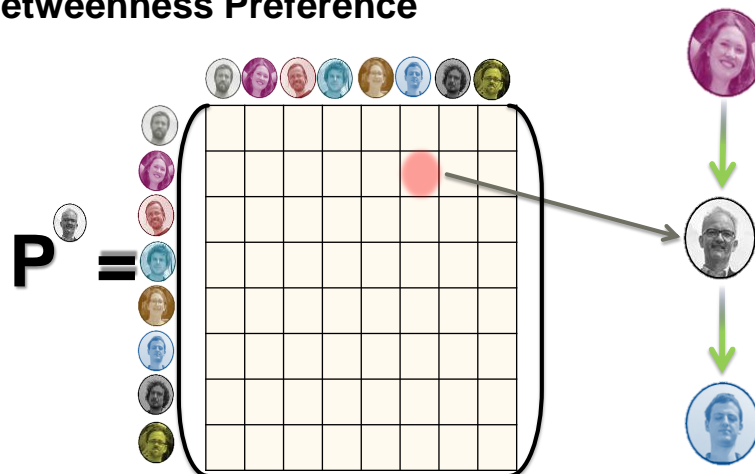


## Findings

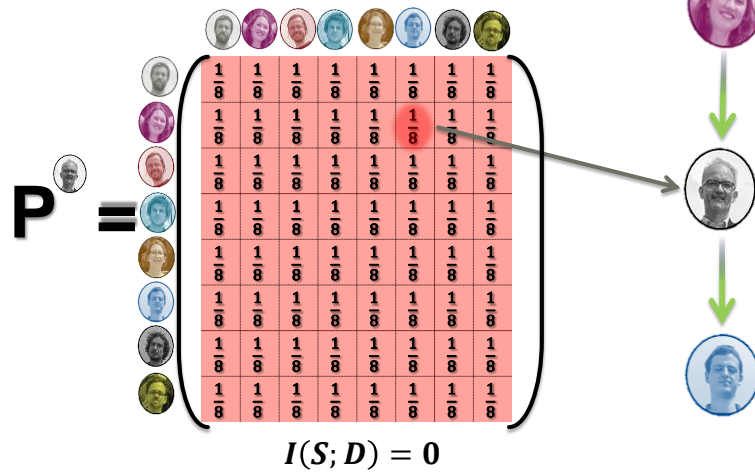


**Aggregate networks are poor representations of dynamic (social) systems!**

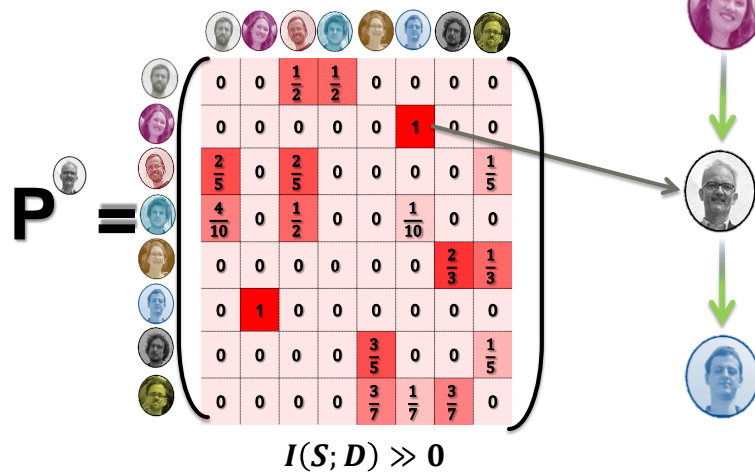
## Betweenness Preference

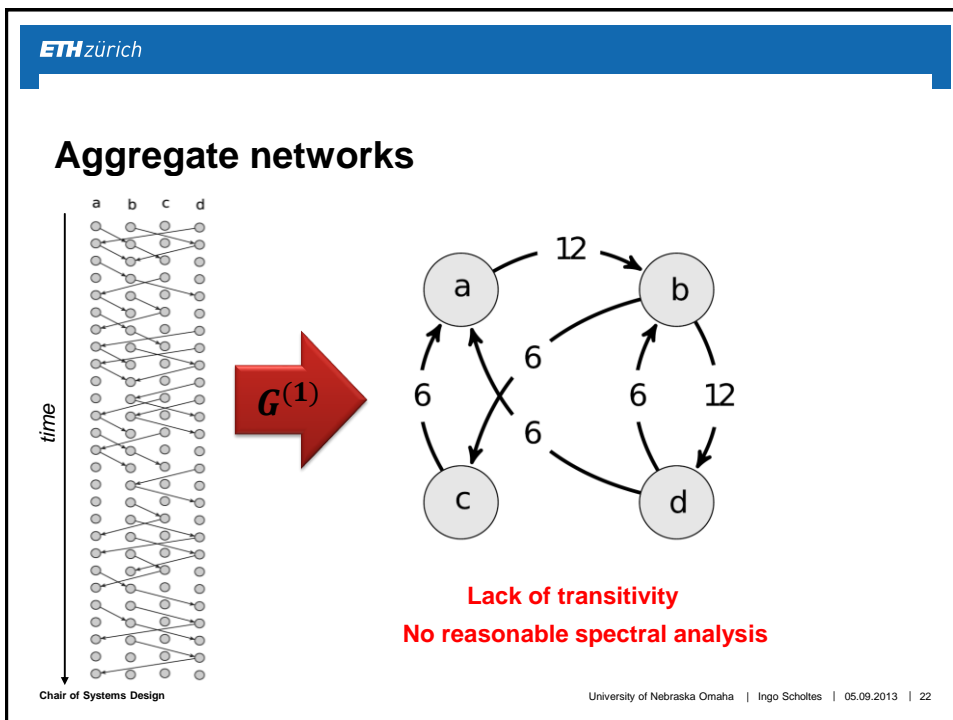
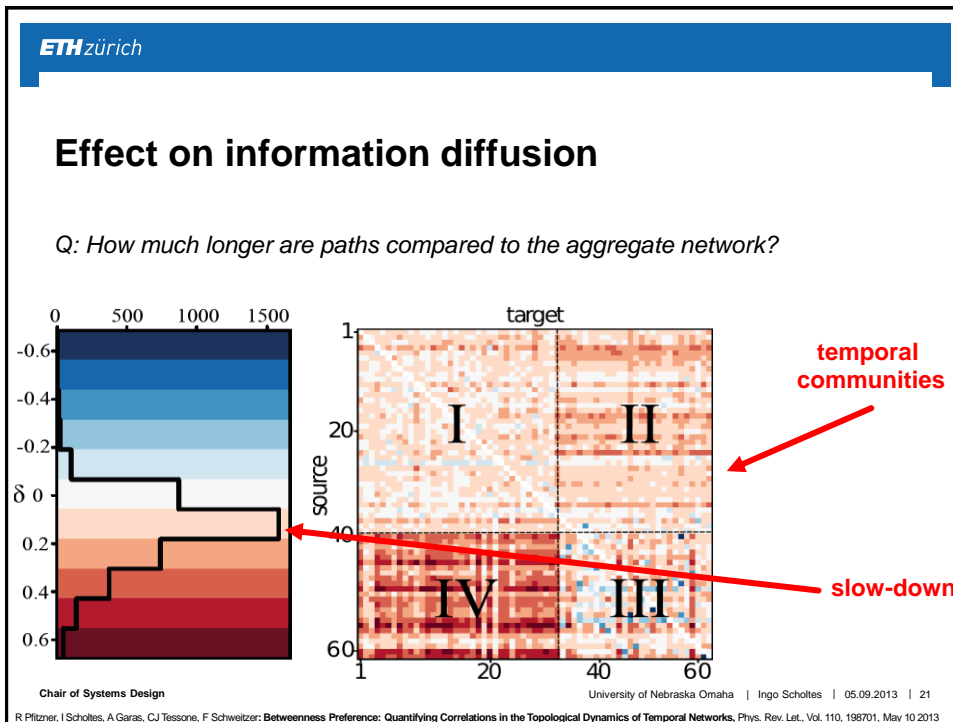


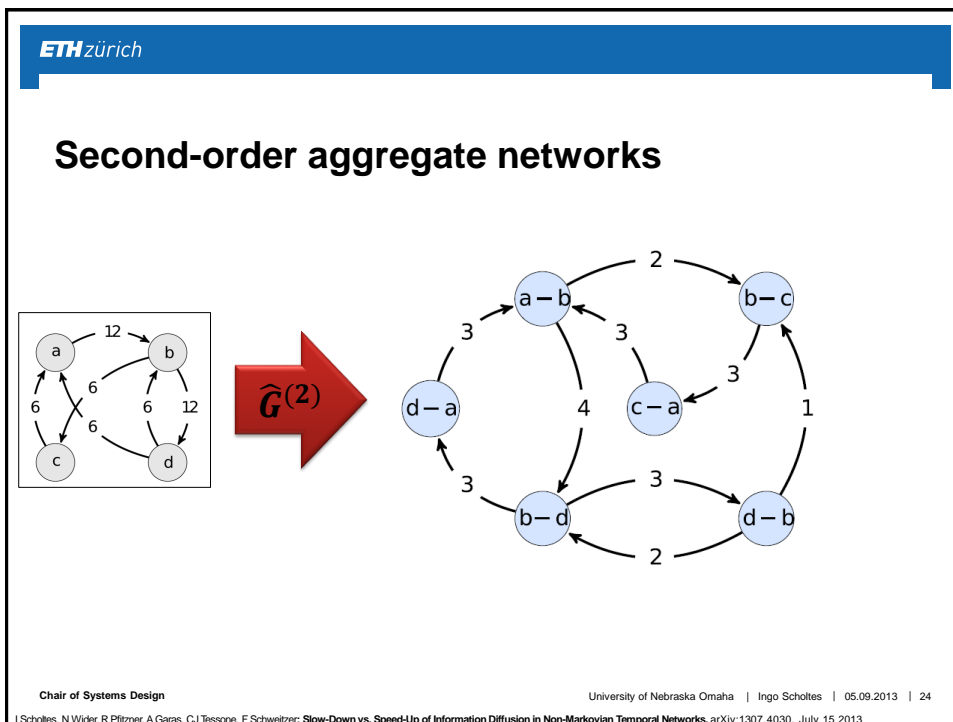
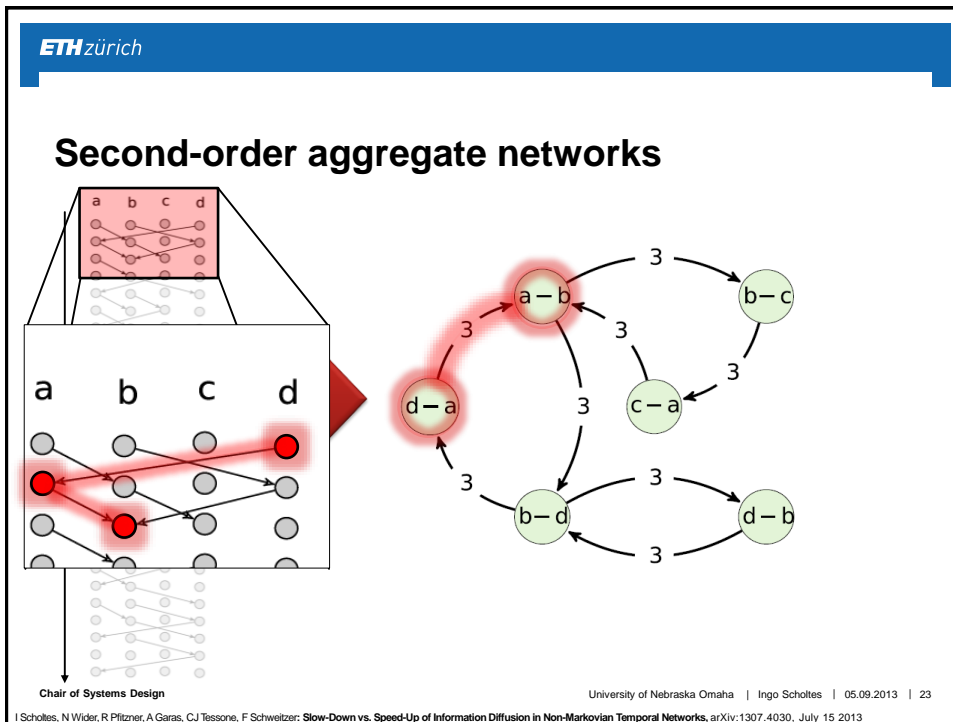
## How you think it is ...



## ... how it actually is!







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## Spectra of dynamic networks

0	$\frac{1}{2}$	$\frac{1}{2}$	0	0	0
0	0	0	1	0	0
0	0	0	0	$\frac{1}{2}$	$\frac{1}{2}$
1	0	0	0	0	0
1	0	0	0	0	0
0	0	1	0	0	0

$\longrightarrow S^* = 1.44 \longleftarrow$

**Slow-down factor**

>1  $\rightarrow$  slow-down  
<1  $\rightarrow$  speed-up

0	$\frac{1}{3}$	$\frac{2}{3}$	0	0	0
0	0	0	1	0	0
0	0	0	0	$\frac{1}{2}$	$\frac{1}{2}$
1	0	0	0	0	0
1	0	0	0	0	0
0	$\frac{1}{3}$	$\frac{2}{3}$	0	0	0

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Ingo Scholtes, N Wider, R Pflitzner, A Garas, CJ Tessone, F Schweitzer: **Slow-Down vs. Speed-Up of Information Diffusion in Non-Markovian Temporal Networks**, arXiv:1307.4030, July 15 2013

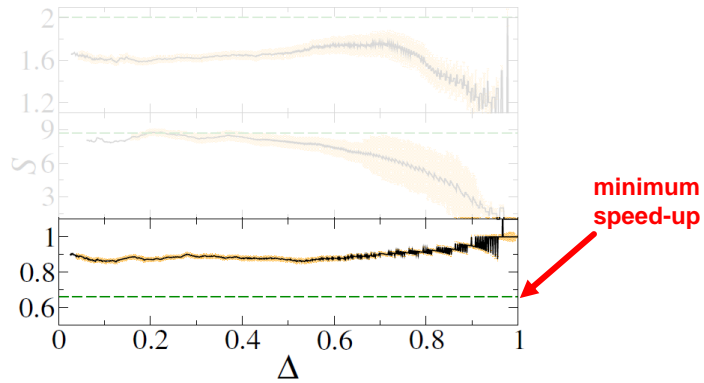
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## Slow-down of information diffusion

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Ingo Scholtes, N Wider, R Pflitzner, A Garas, CJ Tessone, F Schweitzer: **Slow-Down vs. Speed-Up of Information Diffusion in Non-Markovian Temporal Networks**, arXiv:1307.4030, July 15 2013

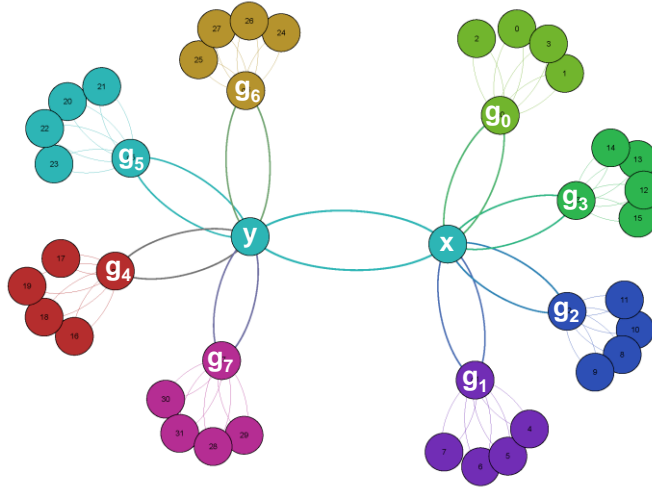
## Speed-up of information diffusion



## Ranking in dynamic networks

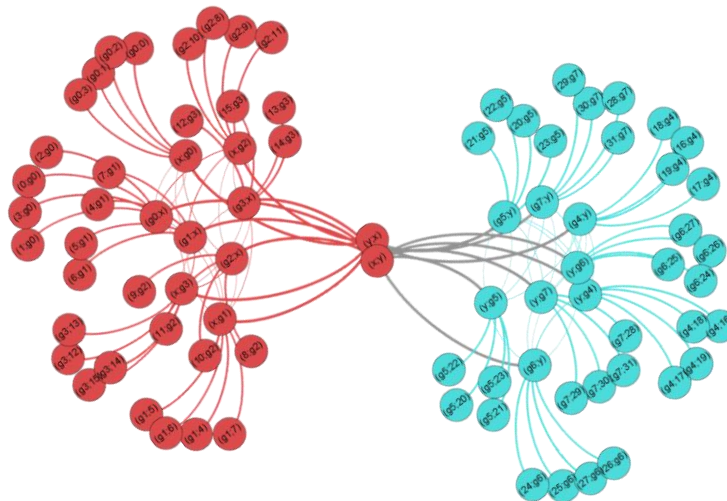


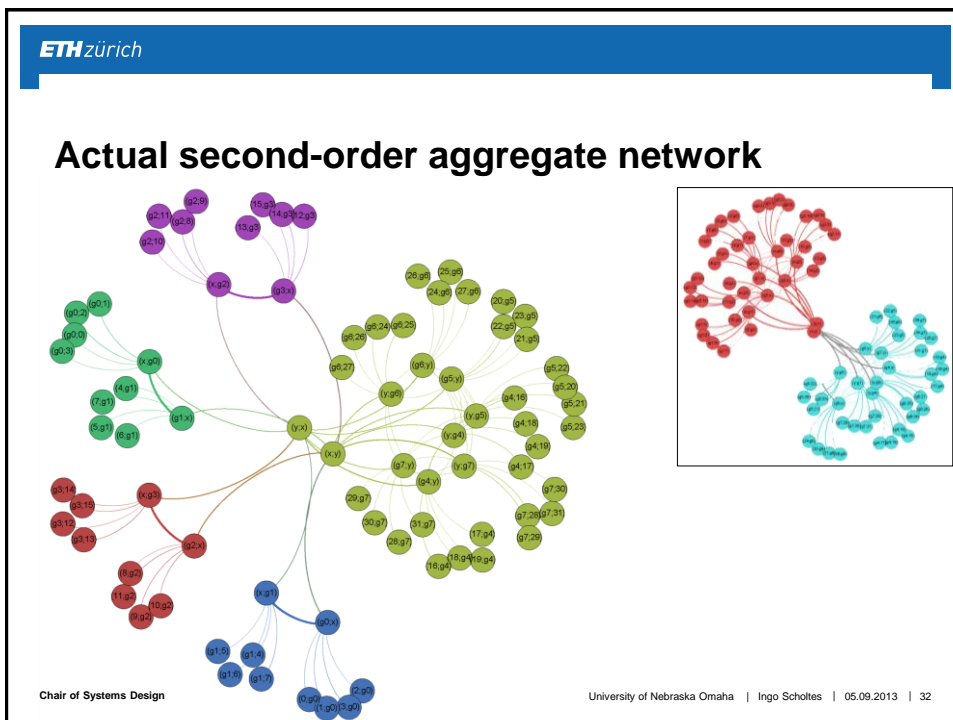
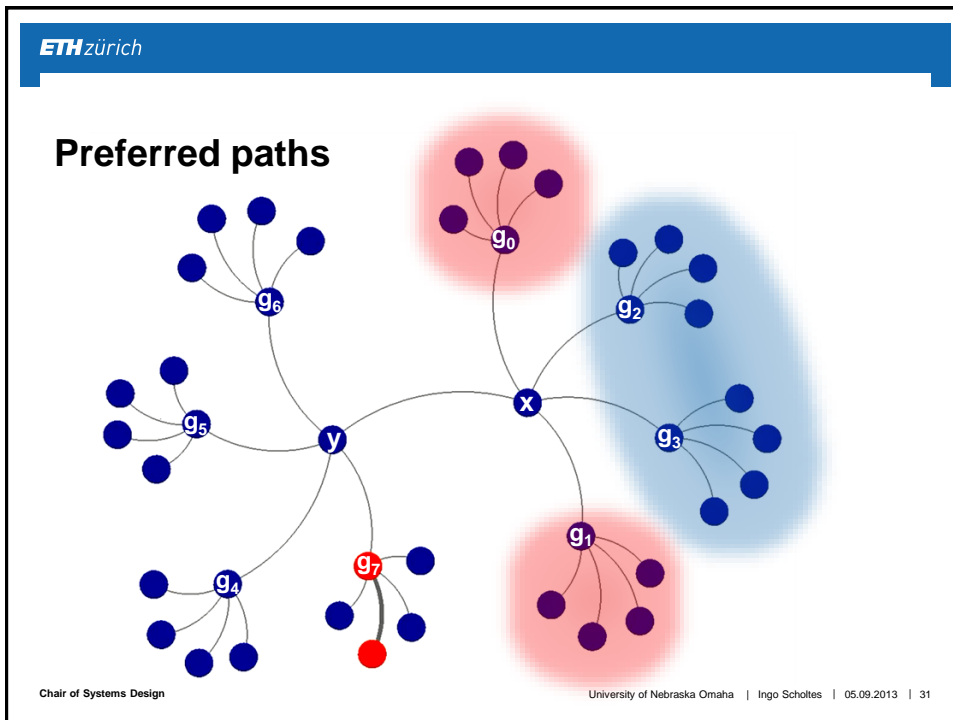
### A simple example



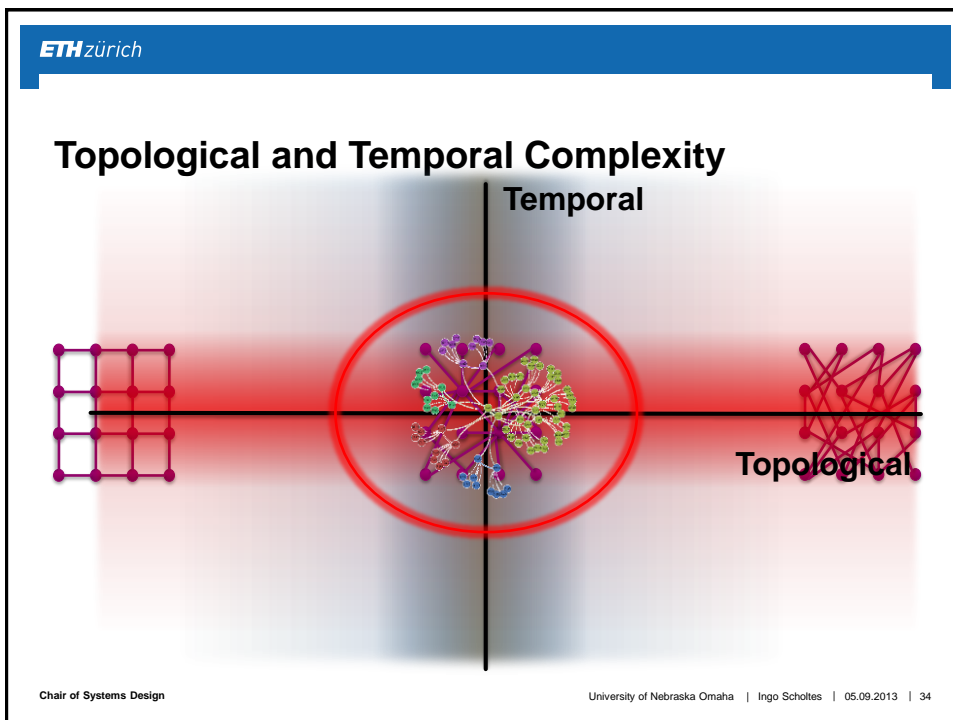
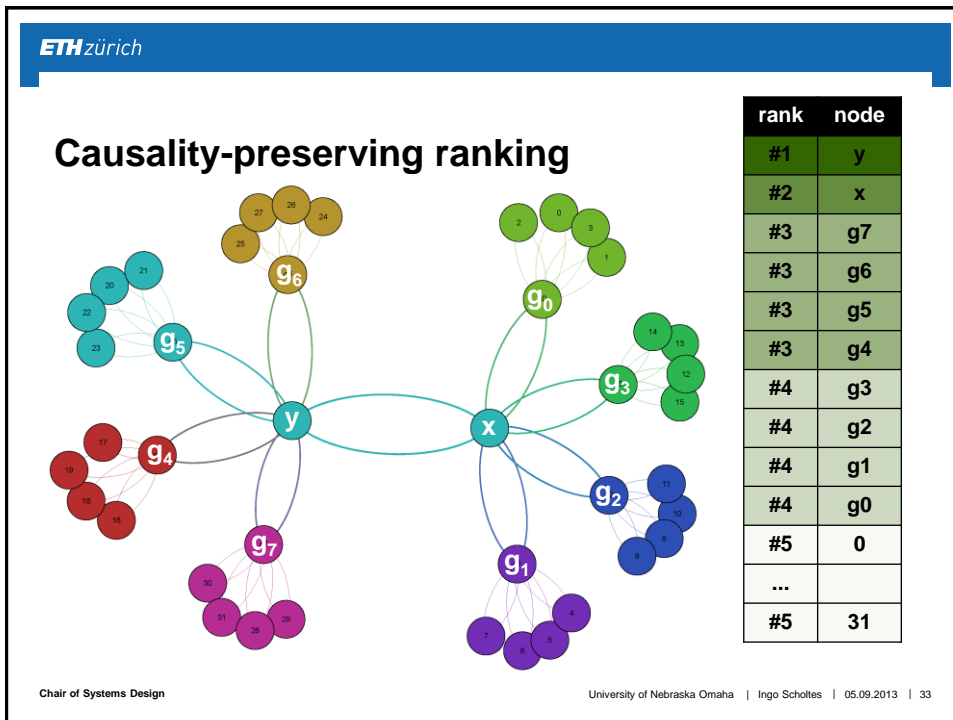
rank	node
#1	x
#1	y
#2	g0
#2	g1
...	
#2	g7
#3	0
...	...
#3	31

### Expected second-order aggregate network









## Let's discuss!



I Scholtes: **Harnessing Complex Structures and Collective Dynamics in Very Large Distributed Systems**, Dissertation, University of Trier, May 2011

MS Zanetti, I Scholtes, CJ Tessone, F Schweitzer: **Categorizing bugs with social networks: a case study on four open source software communities**, Proceedings of ICSE 2013, San Francisco, May 2013

MS Zanetti, I Scholtes, CJ Tessone, F Schweitzer: **The Rise and Fall of a Central Contributor: Dynamics of Social Organization and Performance in the Gentoo Community**, Proceedings of ICSE CHASE 2013, May 2013

R Pflitzner, I Scholtes, A Garas, CJ Tessone, F Schweitzer: **Betweenness Preference: Quantifying Correlations in the Topological Dynamics of Temporal Networks**, Physical Review Letters, Vol. 110, 198701, May 10 2013

I Scholtes, N Wider, R Pflitzner, A Garas, CJ Tessone, F Schweitzer: **Slow-down vs. Speed-up of Information Diffusion in Non-Markovian Temporal Networks**, arXiv:1307.4030, July 15 2013

I Scholtes, A Garas, R Pflitzner, CJ Tessone: **Using Temporal Correlations in the Visualization of Aggregate Representations of Dynamic Networks**, Proceedings of ECCS 2013, September 2013

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