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Topological and Temporal Complexity in Socio-Technical Systems

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Chair of Systems Design
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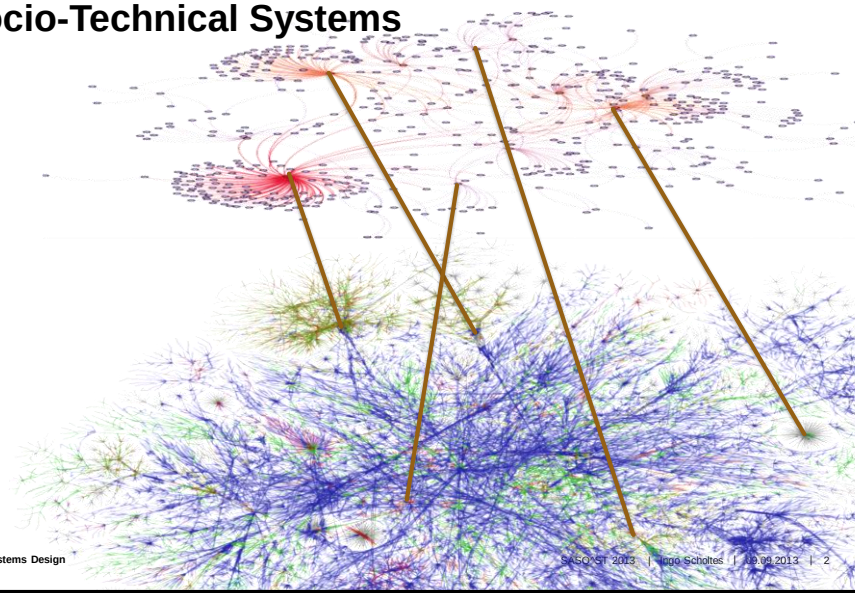
Socio-Technical Systems



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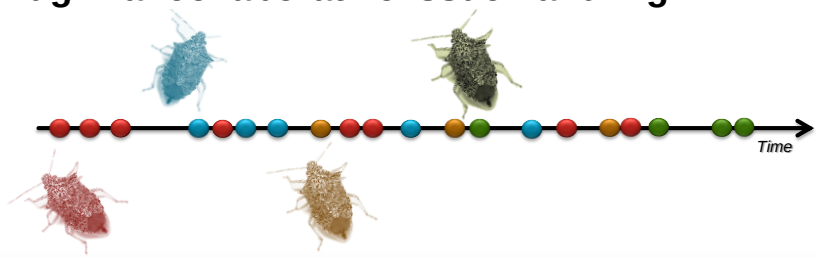
Bugzilla: collaborative issue handling



	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)	-	2484 (0.06)	20,350 (0.07)

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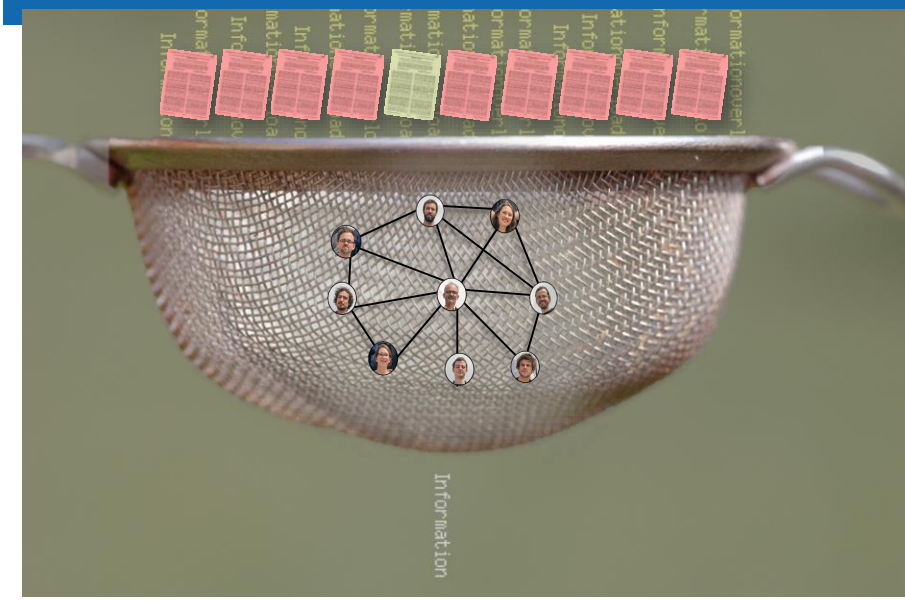

Image: Marina Noordegraaf, Flickr

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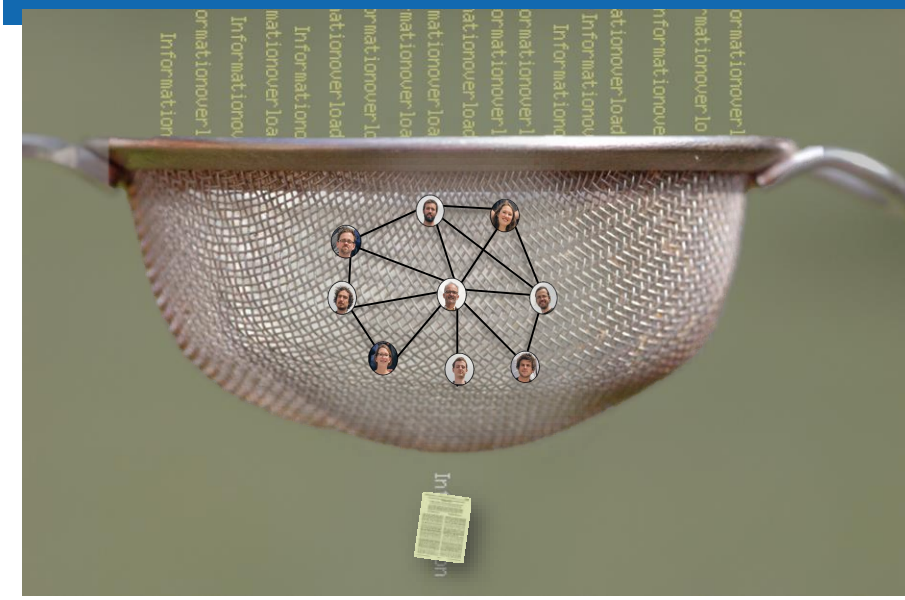

Image: Marina Noordegraaf, Flickr

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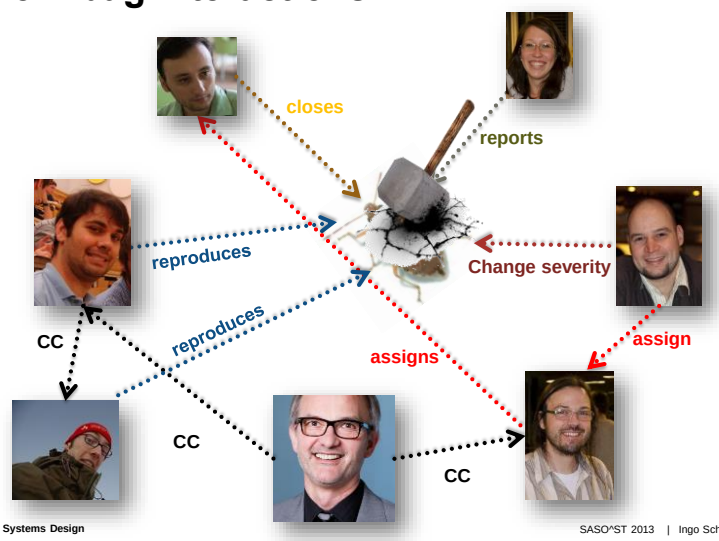
From bug interactions …



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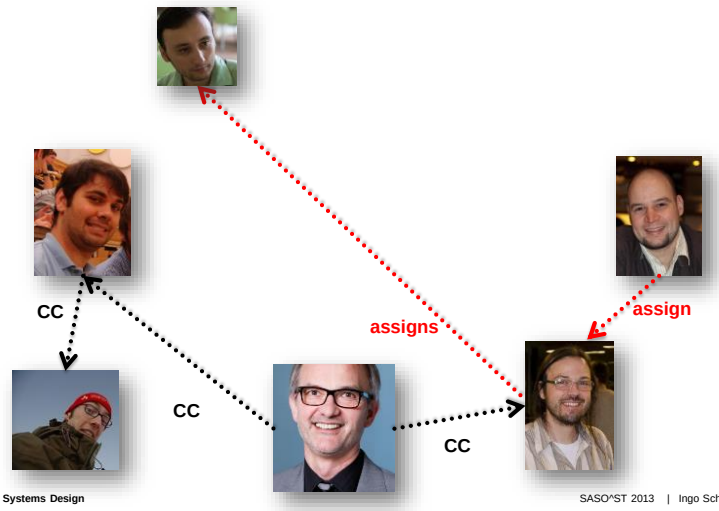
… to evolving collaboration networks



M. 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, May 2013

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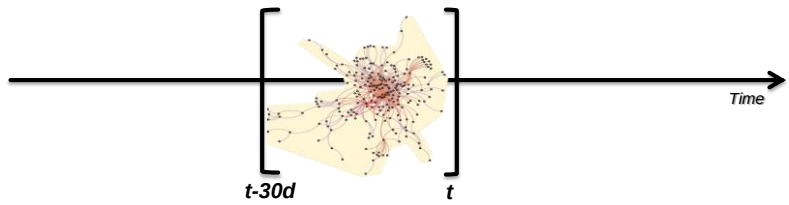
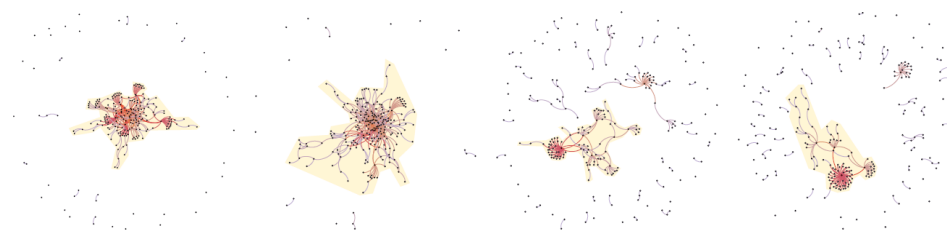
… to evolving collaboration networks





(a) ECLIPSE (Dec. 2002) 244 nodes, 319 links

(b) NETBEANS (Jun. 2006) 246 nodes, 513 links

(c) FIREFOX (Oct. 2003) 241 nodes, 184 links

(d) THUNDERBIRD (Nov. 2004) 245 nodes, 170 links

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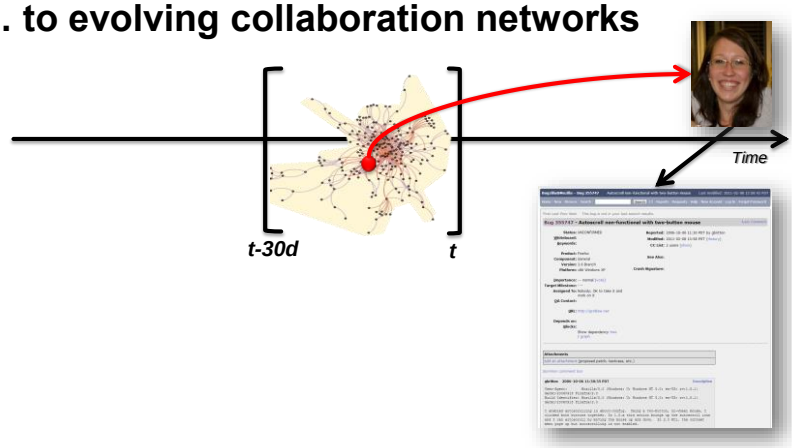

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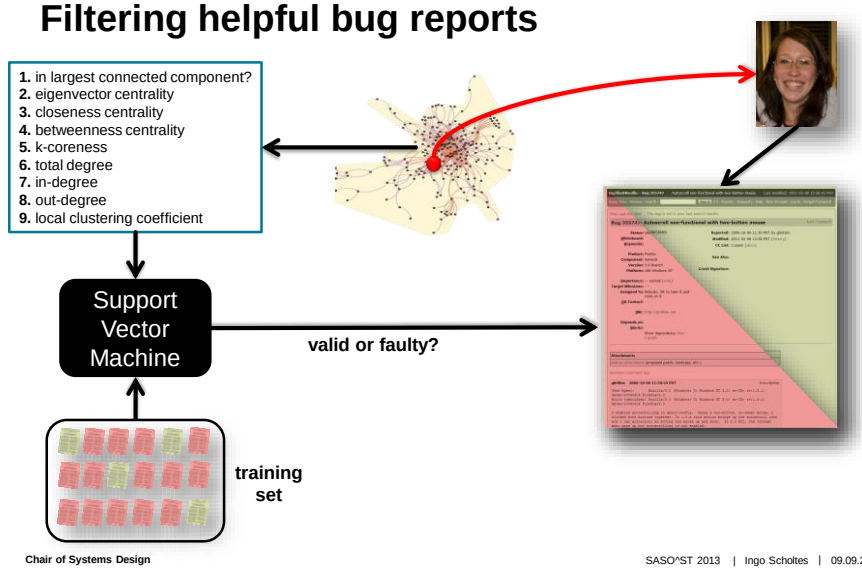
Filtering helpful bug reports



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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 (evcent)	60.4%	68.6%	76.3%	76.7%
r (evcent)	30.5%	5.4%	62.6%	38.8%
F (evcent)	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

Social awareness in bug trackers can mitigate information overload

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A typical day at ETH Zürich

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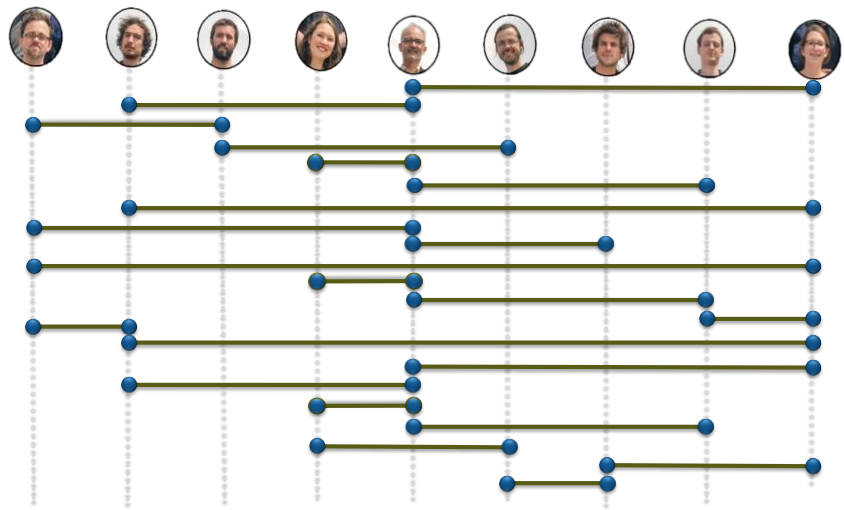
A typical day at ETH Zürich



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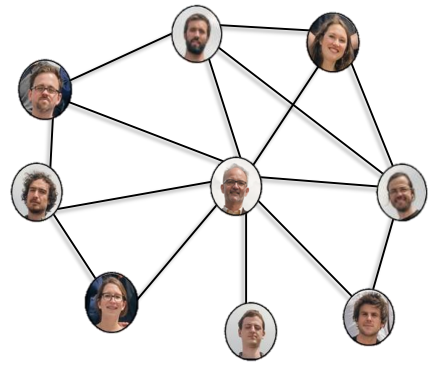
An aggregated perspective



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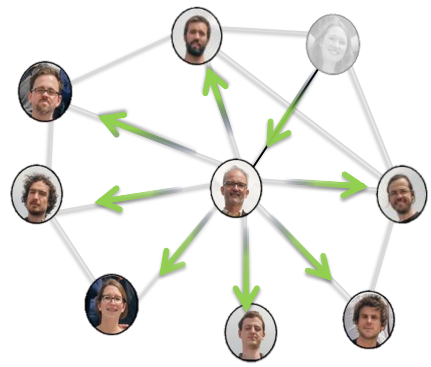
The fallacy of transitivity



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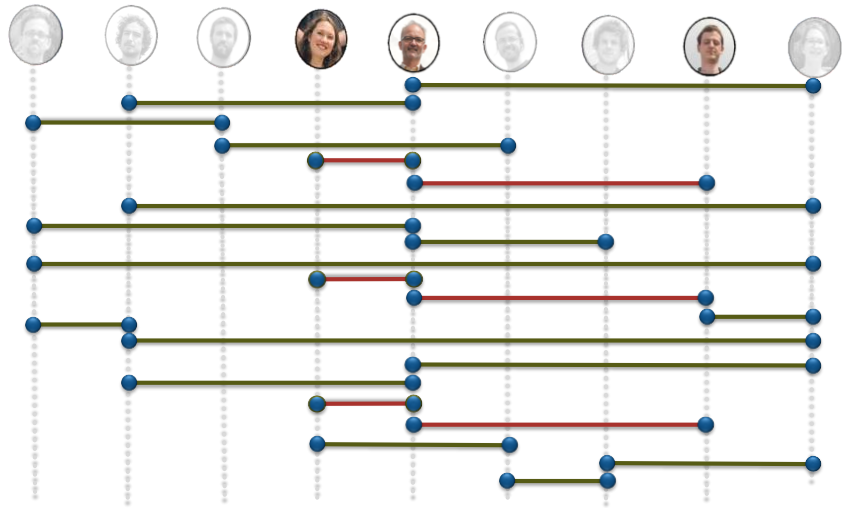
The time dimension



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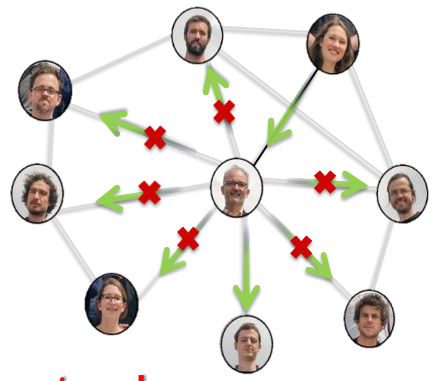
Finding



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

R Pfitzner, I Scholtes, A Garas, CJ Tessone, F Schweitzer: **Betweenness Preference: Quantifying Correlations in the Topological Dynamics of Temporal Networks,** Phys. Rev. Let., Vol. 110, 198701, May 10 2013

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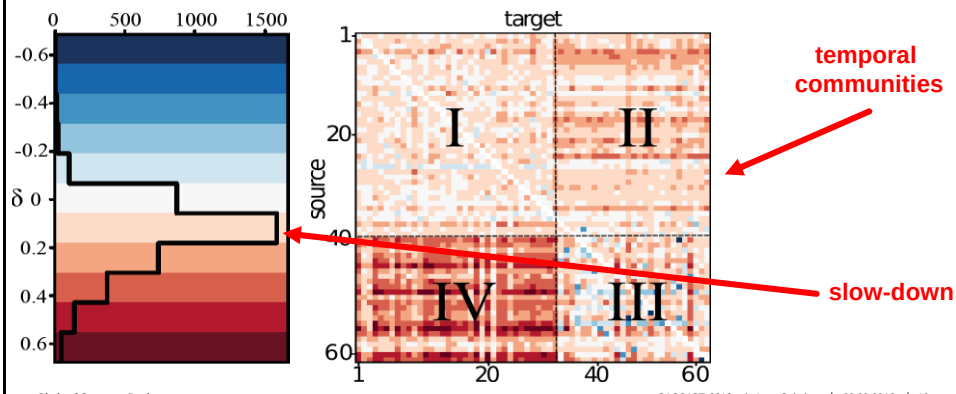
Effect on information diffusion

Q: How much longer are paths compared to the aggregate network?



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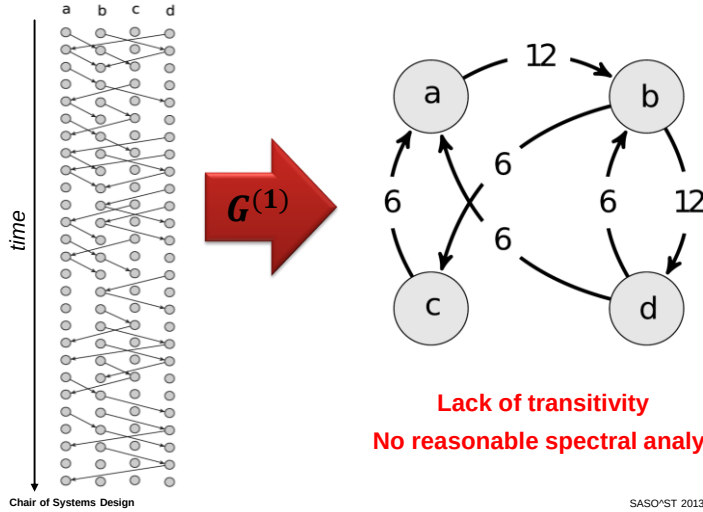
Aggregate networks



Lack of transitivity

No reasonable spectral analysis

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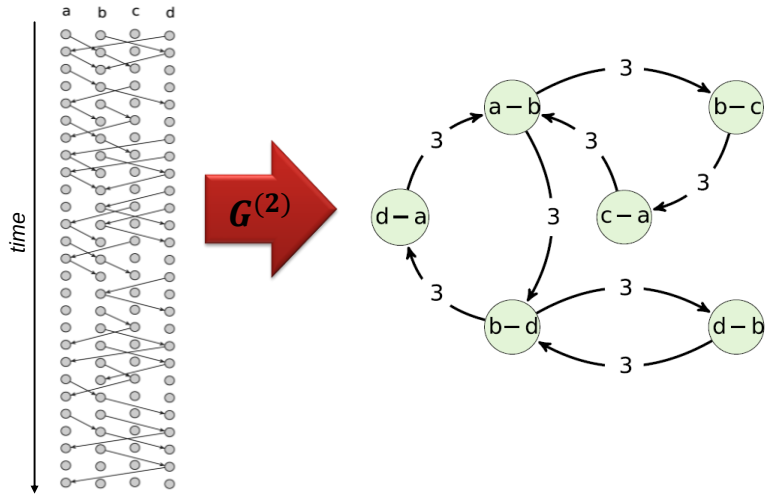
Second-order aggregate networks



I Scholtes, N Wider, R Pfitzner, 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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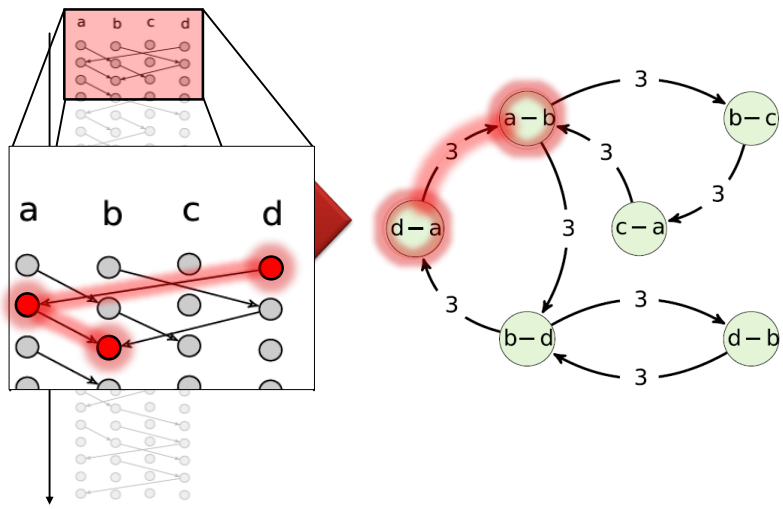
Second-order aggregate networks



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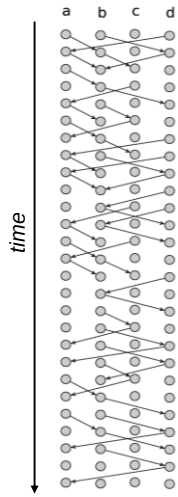

$$G^{(2)} = \begin{pmatrix} 0 & \frac{1}{2} & \frac{1}{2} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{2} & \frac{1}{2} \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \end{pmatrix}$$

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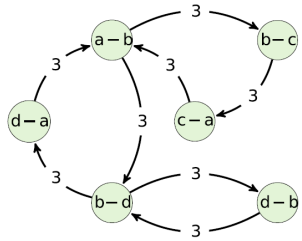
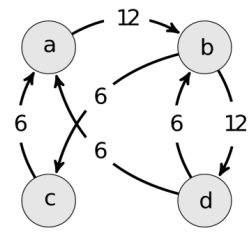
Spectra of dynamic networks



$$\lambda_1 = 1$$
$$\lambda_2 = 0.873$$
$$\lambda_3 = 0.873$$
$$\lambda_4 = 0.61$$
$$\lambda_5 = 0.54$$
$$\lambda_6 = 0$$



$$\lambda_1 = 1$$
$$\lambda_2 = 0.816$$
$$\lambda_3 = 0.816$$
$$\lambda_4 = 0$$
$$\lambda_5 = 0$$
$$\lambda_6 = 0$$

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Spectra of dynamic networks

$$\begin{pmatrix} 0 & \frac{1}{2} & \frac{1}{2} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{2} & \frac{1}{2} \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \end{pmatrix} \qquad \begin{pmatrix} 0 & \frac{1}{3} & \frac{2}{3} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{2} & \frac{1}{2} \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{3} & \frac{2}{3} & 0 & 0 & 0 \end{pmatrix}$$

$\lambda_1 = 1$
$\lambda_2 = 0.873$
$\lambda_3 = 0.873$
$\lambda_4 = 0.61$
$\lambda_5 = 0.54$
$\lambda_6 = 0$

$S^* = 1.44$

Slow-down factor

>1 → slow-down
<1 → speed-up

$\lambda_1 = 1$
$\lambda_2 = 0.816$
$\lambda_3 = 0.816$
$\lambda_4 = 0$
$\lambda_5 = 0$
$\lambda_6 = 0$

I Scholtes, N Wider, R Pfitzner, 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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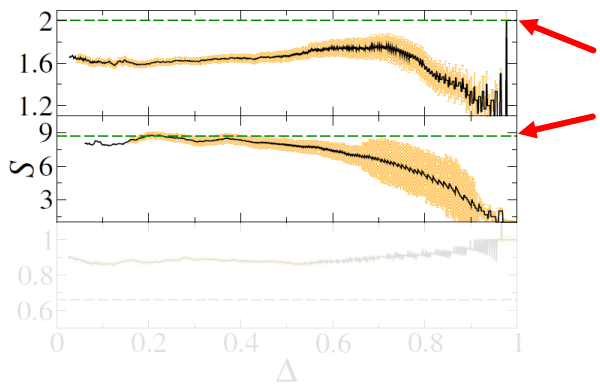
Slow-down of information diffusion



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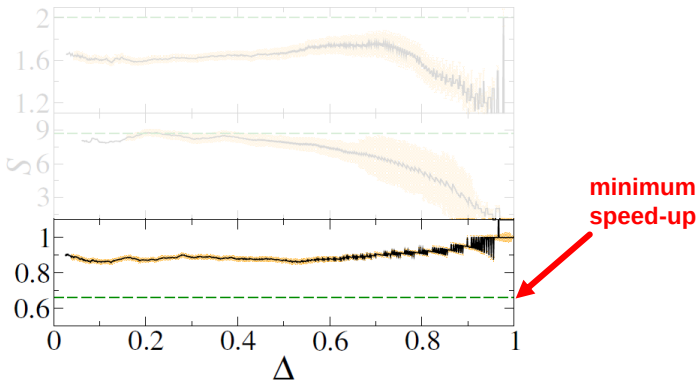
Speed-up of information diffusion



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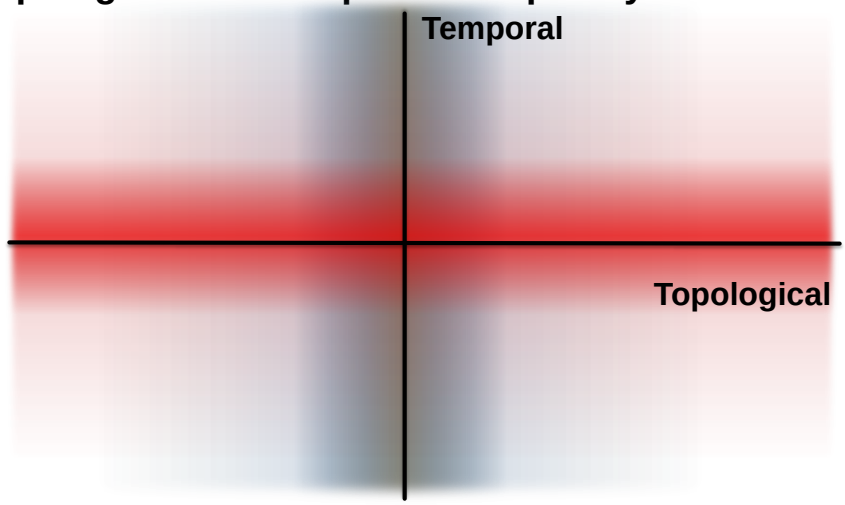
Topological and Temporal Complexity



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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 Pfitzner, 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

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

http://www.sg.ethz.ch
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