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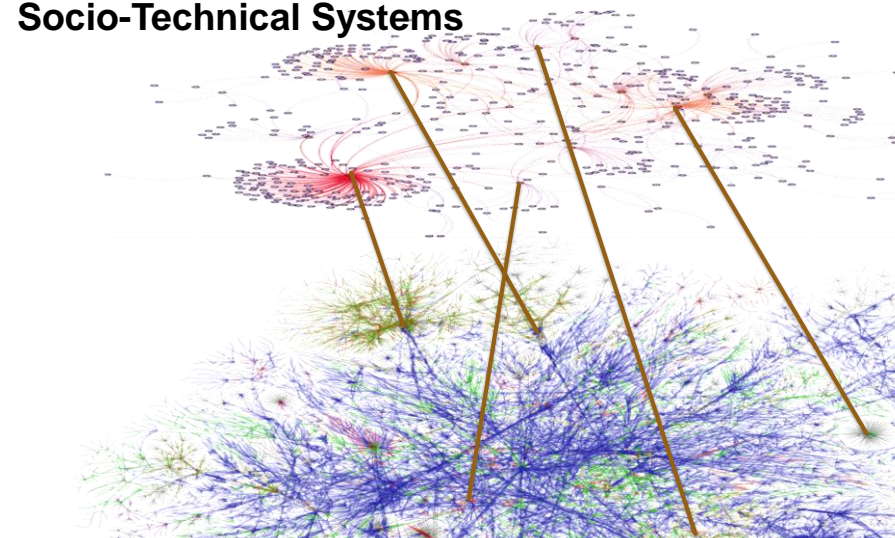
Topological and Temporal Complexity in Socio-Technical Systems

Ingo Scholtes
Chair of Systems Design
ETH Zürich

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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)	-	2,484 (0.06)	20,350 (0.07)

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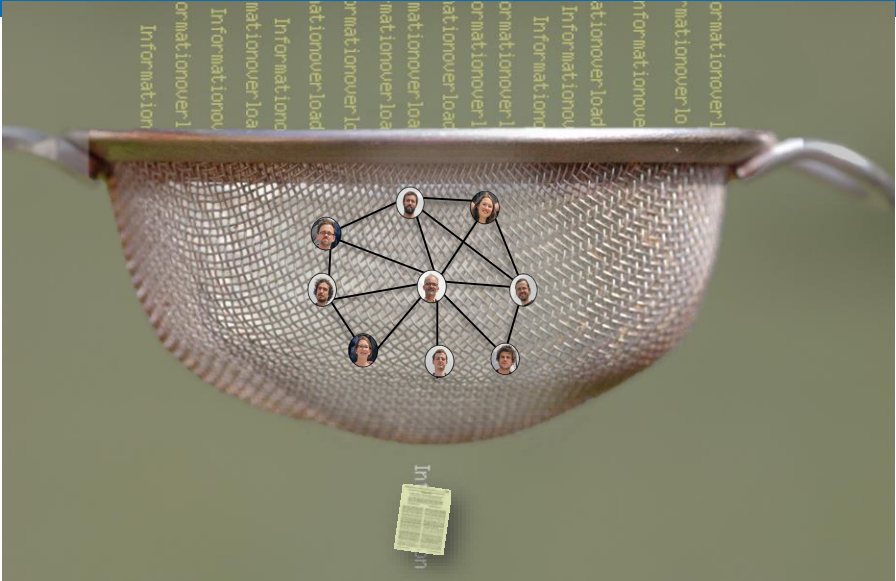
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Information

Image: Marina Noordegraaf, Flickr

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Information overload

Information

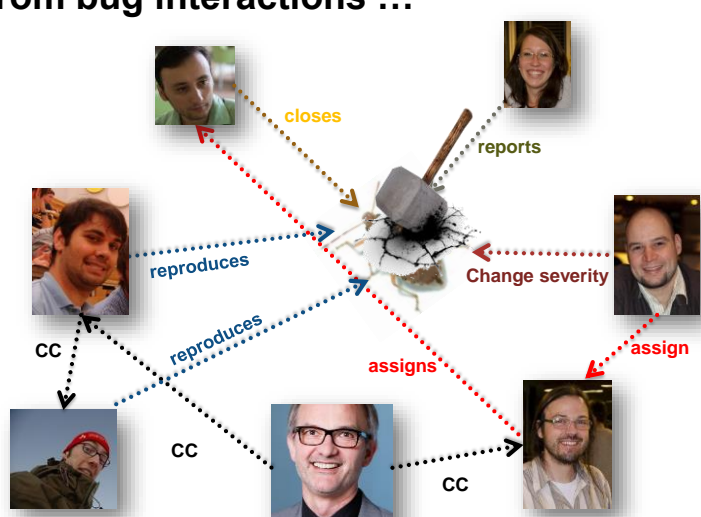
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From bug interactions ...



reports

Change severity

assigns

reproduces

reproduces

closes

CC

CC

CC

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... to evolving collaboration networks

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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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... 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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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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... to evolving collaboration networks

The diagram illustrates the evolution of a collaboration network over time. A horizontal axis represents time, with a bracketed region from $t-30d$ to t containing a network graph. A red arrow originates from a central node in the graph and points to a profile picture of a woman. A black arrow points from the profile picture to a screenshot of a bug report interface.

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Filtering helpful bug reports

The flowchart details the process of filtering bug reports. It starts with a list of features used for classification:

1. in largest connected component?
2. eigenvector centrality
3. closeness centrality
4. betweenness centrality
5. k-coreiness
6. total degree
7. in-degree
8. out-degree
9. local clustering coefficient

These features are fed into a **Support Vector Machine**, which outputs a classification: **valid or faulty?**. A **training set** (represented by a grid of colored cards) is used to train the SVM. A red arrow from the network graph in the previous slide points to a person's profile, which then points to a screenshot of a bug report with a red diagonal overlay, indicating its classification.

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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

Social awareness in bug trackers can mitigate information overload


Temporal Complexity



Dynamics of networks can invalidate results of static network analysis

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A typical day at ETH Zürich

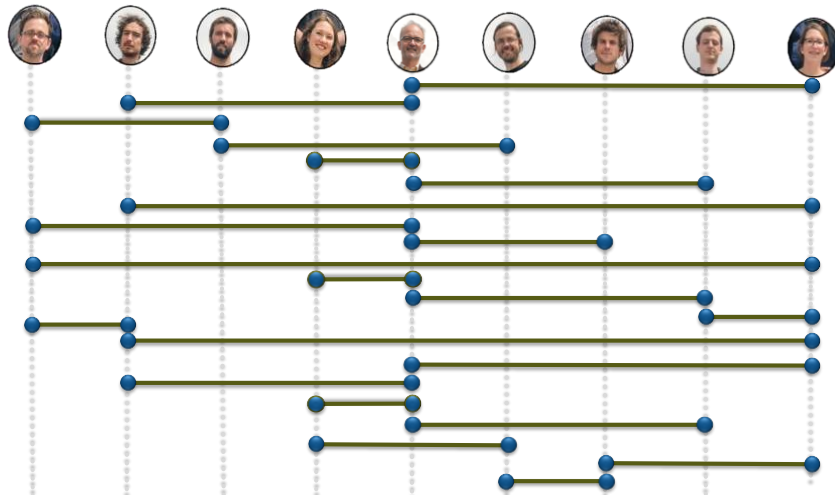


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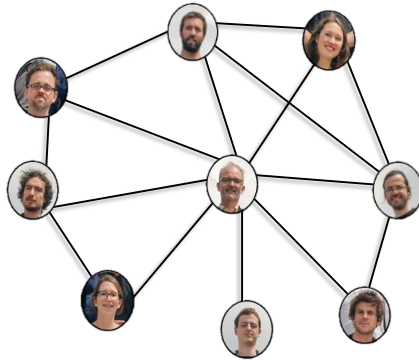
A typical day at ETH Zürich



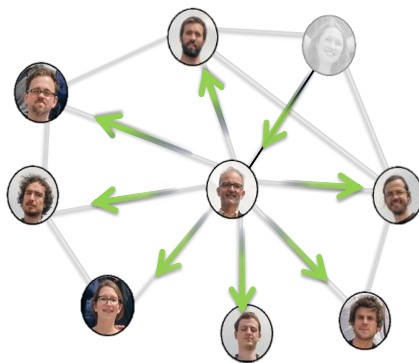
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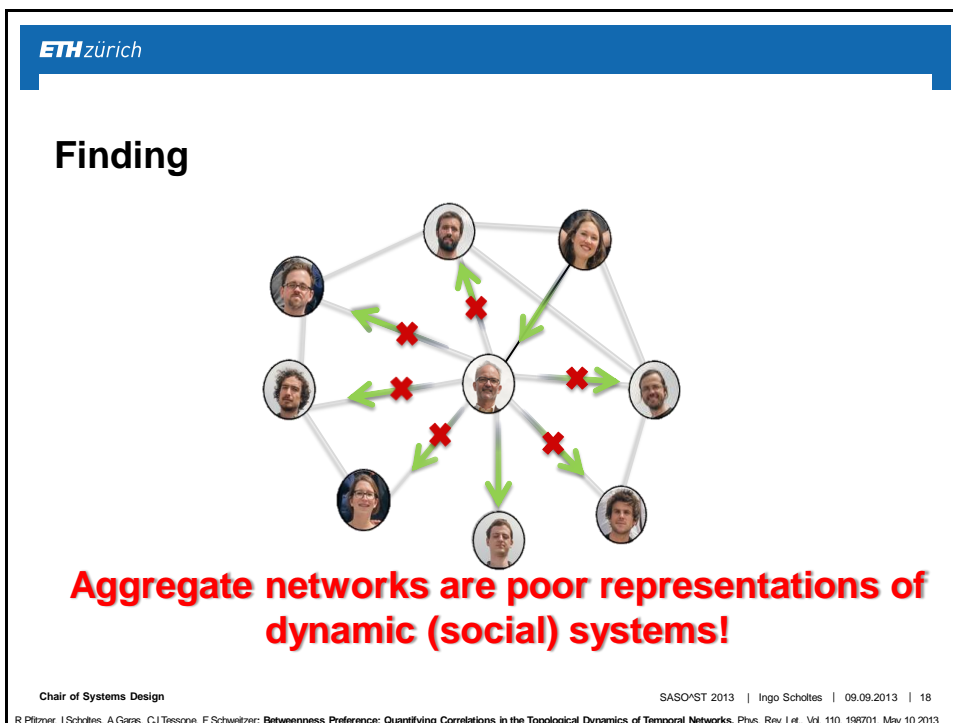
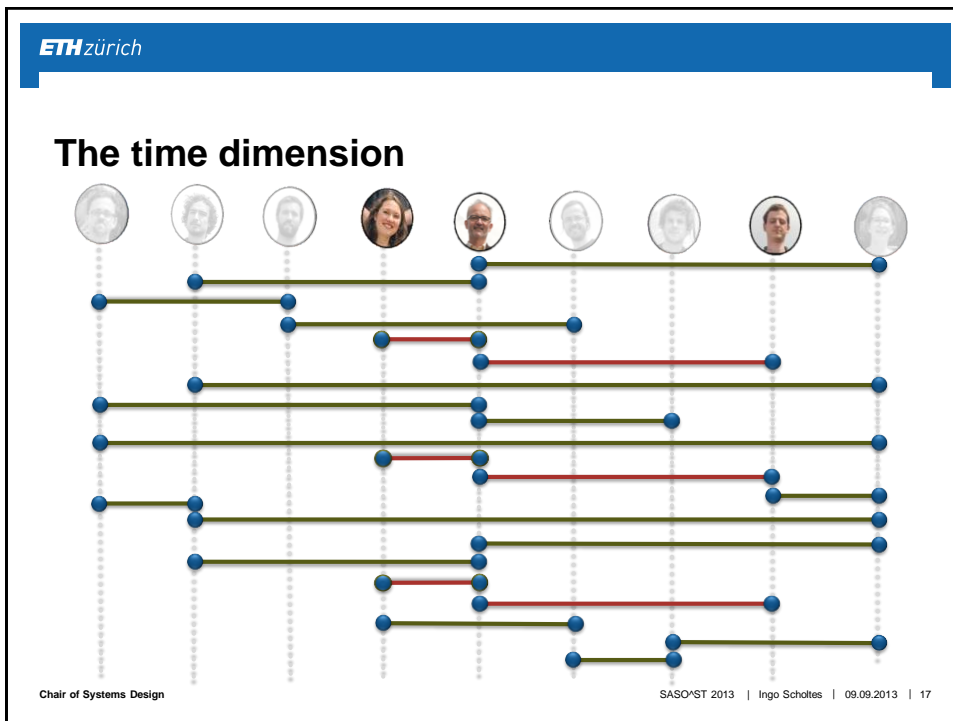
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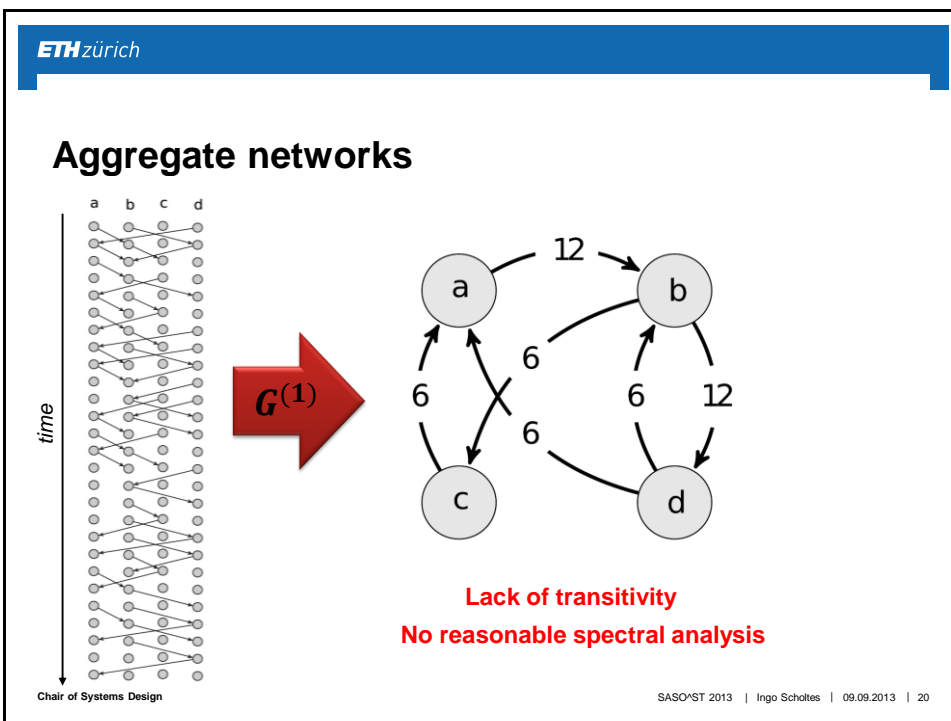
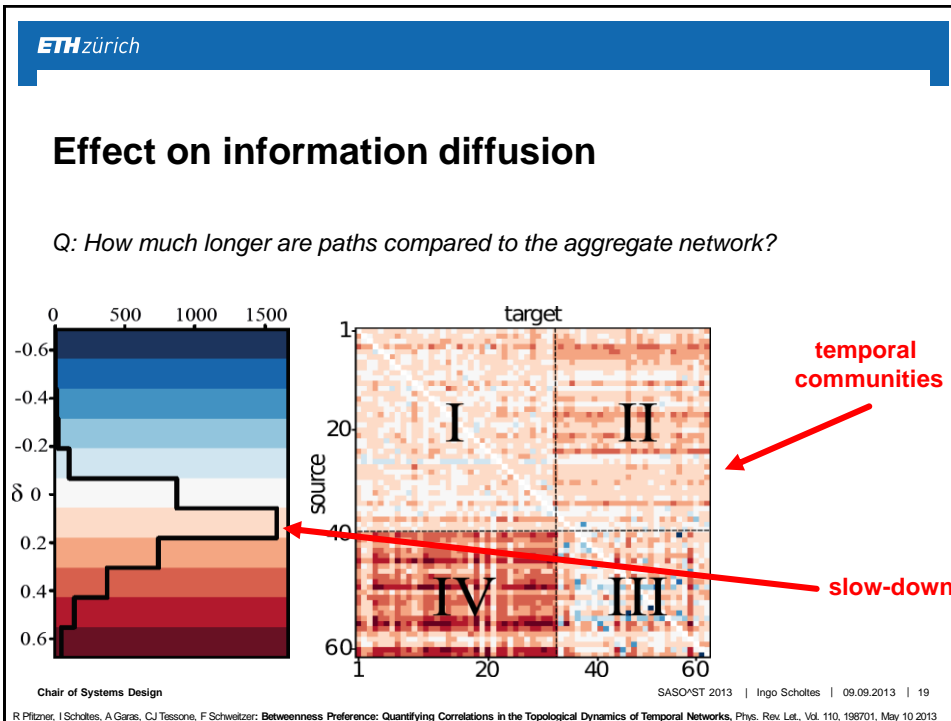
An aggregated perspective



The fallacy of transitivity







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Second-order aggregate networks

time

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I. Scholtes, N. Widler, R. Pfitzner, A. Garas, C.J. 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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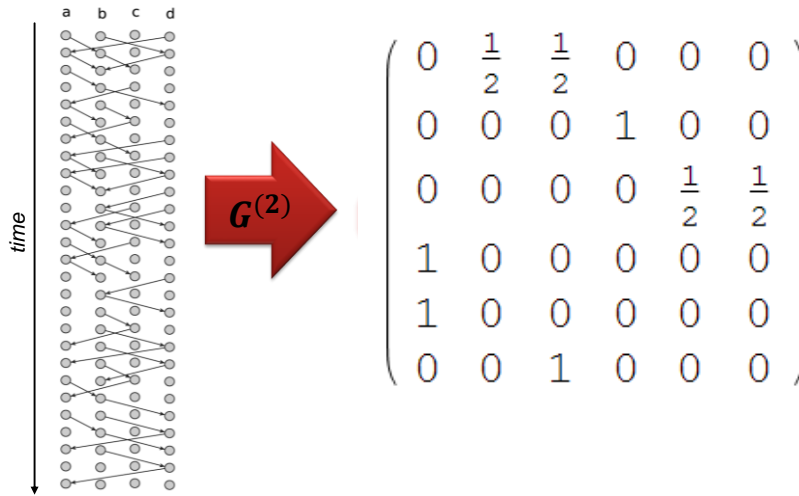
Second-order aggregate networks

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Second-order aggregate networks

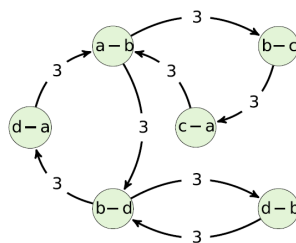


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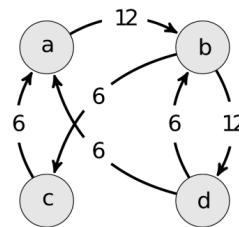
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I Scholtes, N Widler, R Pfitzner, A Garas, CJ Tessone, F Schweitzer: Slow-Down vs. Speed-Up of Information Diffusion in Non-Markovian Temporal Networks, arXiv:1307.4030, July 15 2013

Spectra of dynamic networks



$$\begin{aligned} \lambda_1 &= 1 \\ \lambda_2 &= 0.873 \\ \lambda_3 &= 0.873 \\ \lambda_4 &= 0.61 \\ \lambda_5 &= 0.54 \\ \lambda_6 &= 0 \end{aligned}$$



$$\begin{aligned} \lambda_1 &= 1 \\ \lambda_2 &= 0.816 \\ \lambda_3 &= 0.816 \\ \lambda_4 &= 0 \\ \lambda_5 &= 0 \\ \lambda_6 &= 0 \end{aligned}$$

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I Scholtes, N Widler, 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

Spectra of dynamic networks

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

$$\begin{aligned} \lambda_1 &= 1 \\ \lambda_2 &= 0.873 \\ \lambda_3 &= 0.873 \\ \lambda_4 &= 0.61 \\ \lambda_5 &= 0.54 \\ \lambda_6 &= 0 \end{aligned}$$

$$S^* = 1.44$$

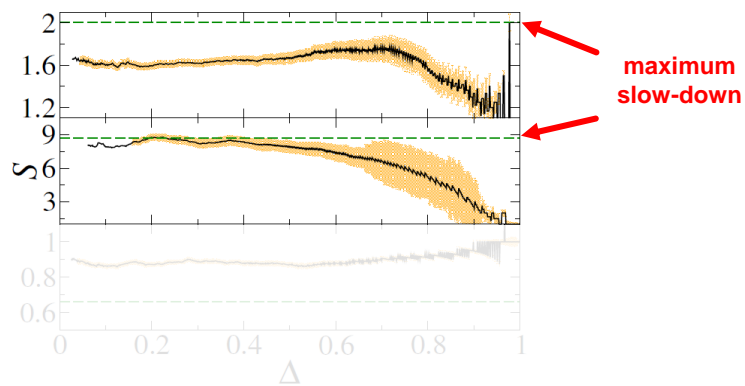
Slow-down factor

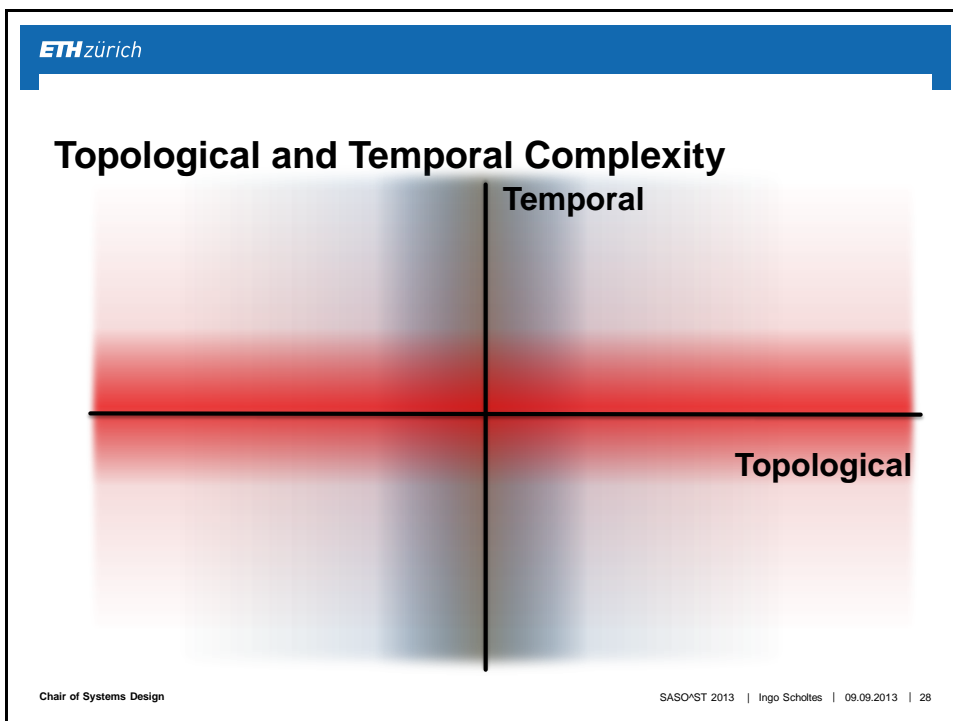
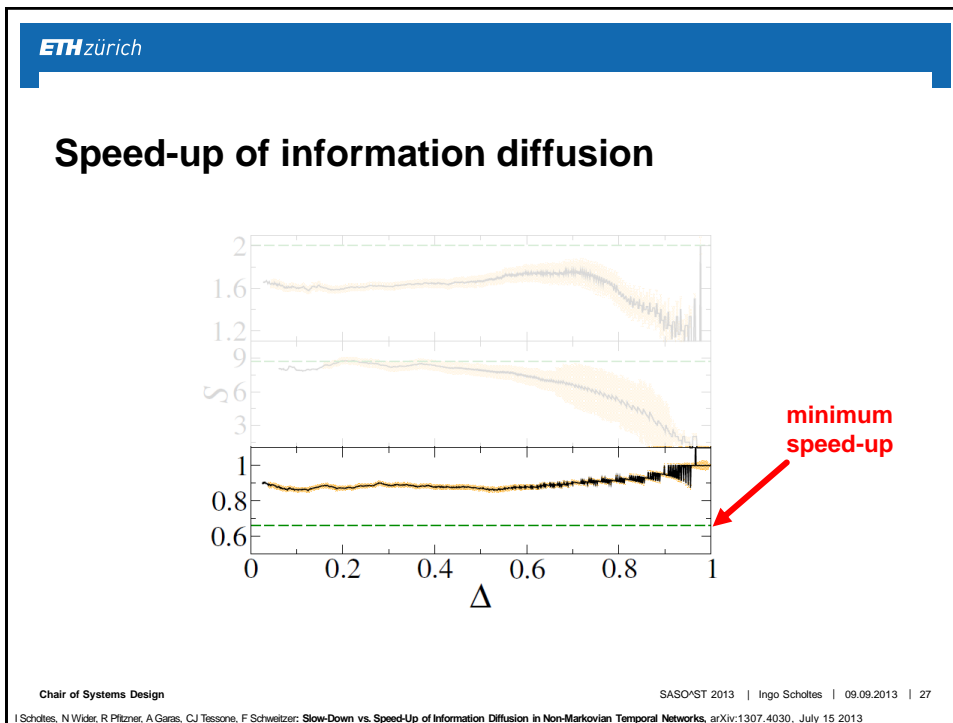
>1 → slow-down
<1 → speed-up

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

$$\begin{aligned} \lambda_1 &= 1 \\ \lambda_2 &= 0.816 \\ \lambda_3 &= 0.816 \\ \lambda_4 &= 0 \\ \lambda_5 &= 0 \\ \lambda_6 &= 0 \end{aligned}$$

Slow-down of information diffusion





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 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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