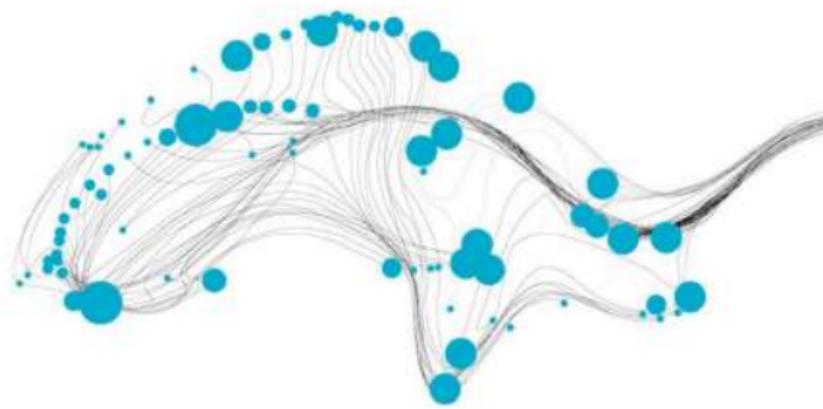


Franck

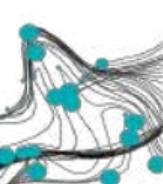
The Network (Science) Wizard

Marc Damie

May 23, 2025 (SCS Cybersec seminar)



UNIVERSITY
OF TWENTE.



DISCLAIMER

A stylized, black, wavy line drawing of a human figure. The figure is standing on the left side of the slide, facing right and pointing its right index finger towards the text. The drawing is minimalist and abstract.

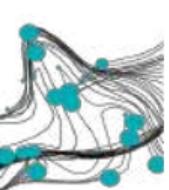
Network science \neq Computer networking



Goal of this presentation



- Introduce **network science** via the work of an atypical researcher.
- Present a project of mine related to network science.
- Illustrate the **potential of network science in cybersecurity**.

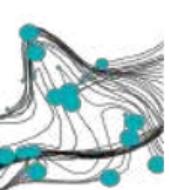


Who the hell is Franck?

- Franck Ghitalla (deceased in 2018)
- Ph.D. of Linguistic in 1995, Associate Prof. at a Uni. of Technology since 1999
- Transitioned to an unknown science around 2000: Network science



Credits: Le Monde



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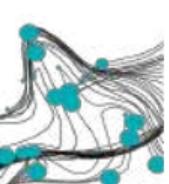
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- Published **no paper in 20 years**
- Received a **massive research funding** from the army!



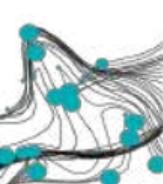


Overview



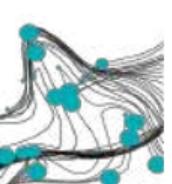
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2. Franck's "undisciplined" research
3. My tribute: Fedivertex
4. Network science for security researchers

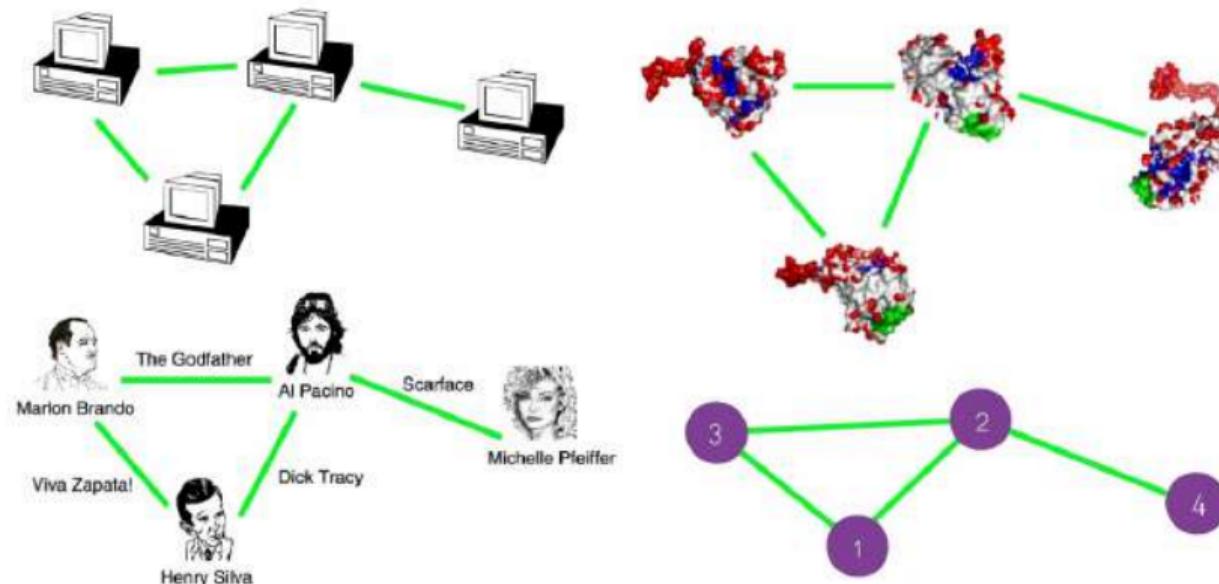


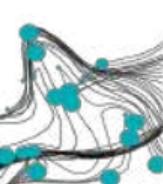
A bit of vocabulary

- **Network/Graph Theory** (Mathematics): the study of graphs as a representation of relations between discrete objects.
- **Network Science** (Transdisciplinary): the study of complex networks.
- **Network**: a catalog of a system's components often called nodes or vertices and the direct interactions between them, called links or edges.
- **Applications**: telecommunications, computer networks, biological networks, cognitive and semantic networks, social networks, etc.



Networks vs. Graphs

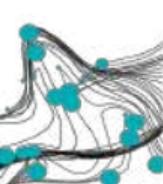




Why is a graph so useful?



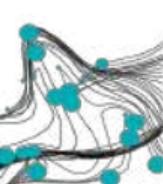
imgflip.com



Why is a graph so useful?



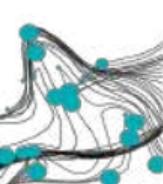
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↔ Our ability to write lists, tables and formulas changed our way to think



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 \iff Our ability to write lists, tables and formulas changed our way to think
- \Rightarrow **Graphs are the next stage of written reasoning.**



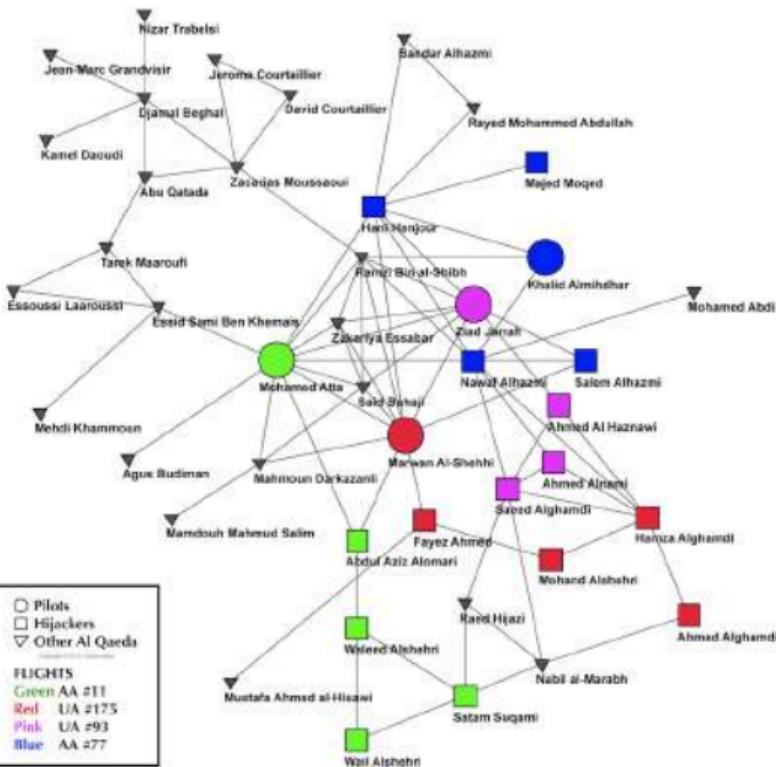
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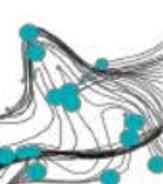


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 \iff Our ability to write lists, tables and formulas changed our way to think
- \Rightarrow **Graphs are the next stage of written reasoning.**
- Franck Ghitalla: “[Graph] is the compass of digital universes.”

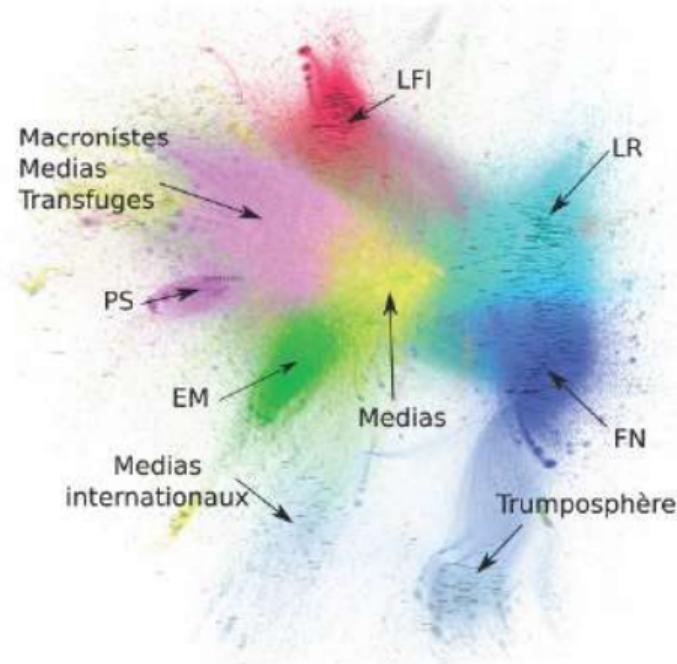


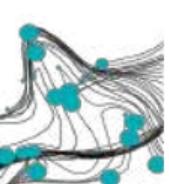
Example 1: Terrorist Networks (by Valdis Krebs)





Example 2: Social Media Analysis (by Ratinaud et al.)





Overview



1. A short course on Network Science

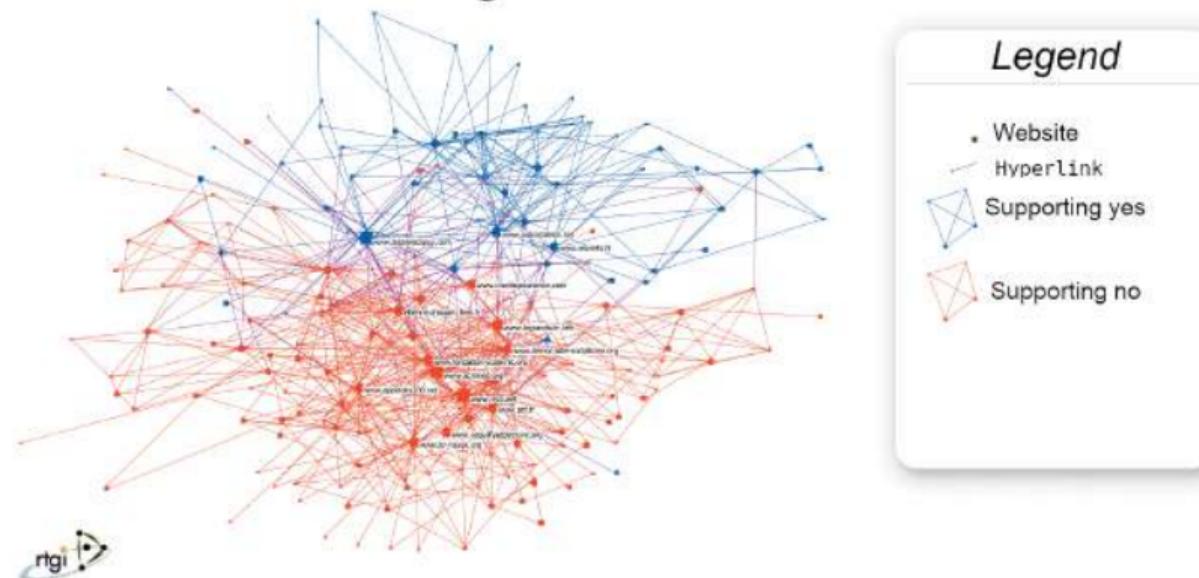
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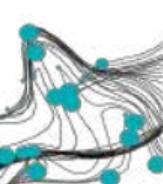
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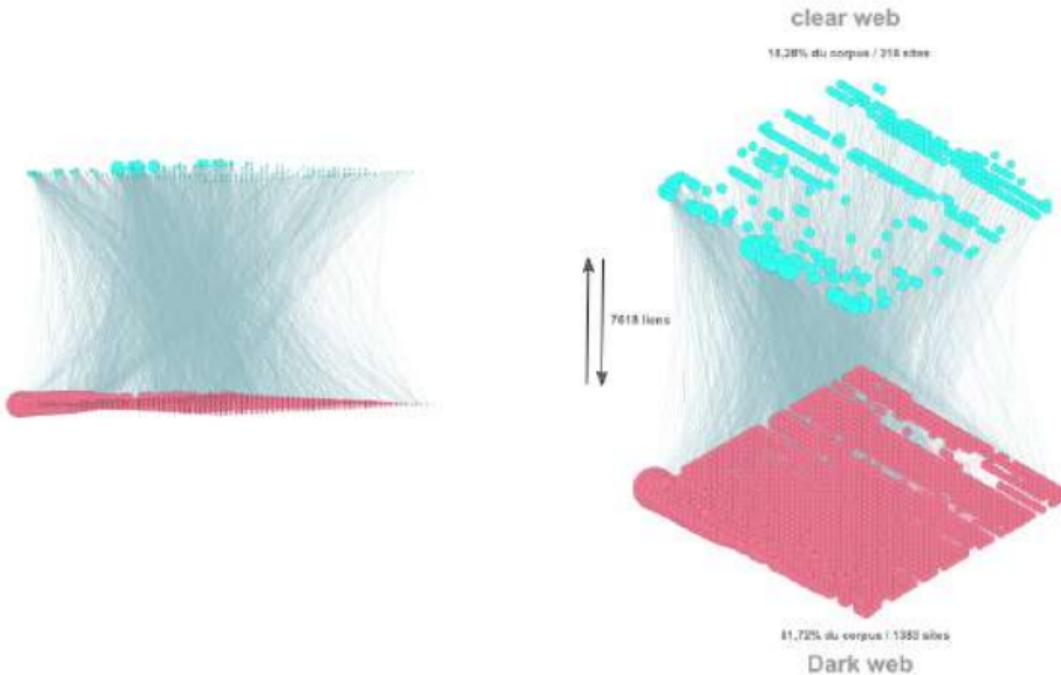
Example 1: 2005 European referendum

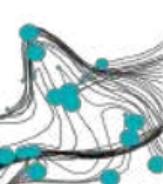
Website debatting about the referendum



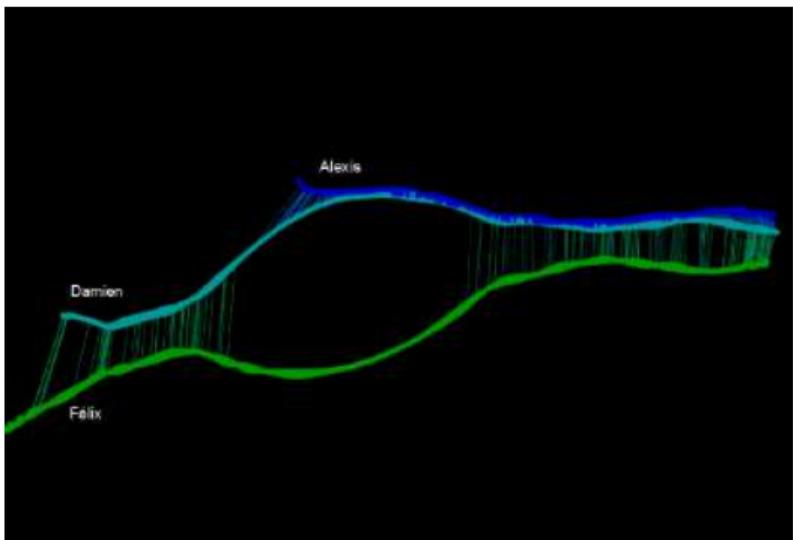
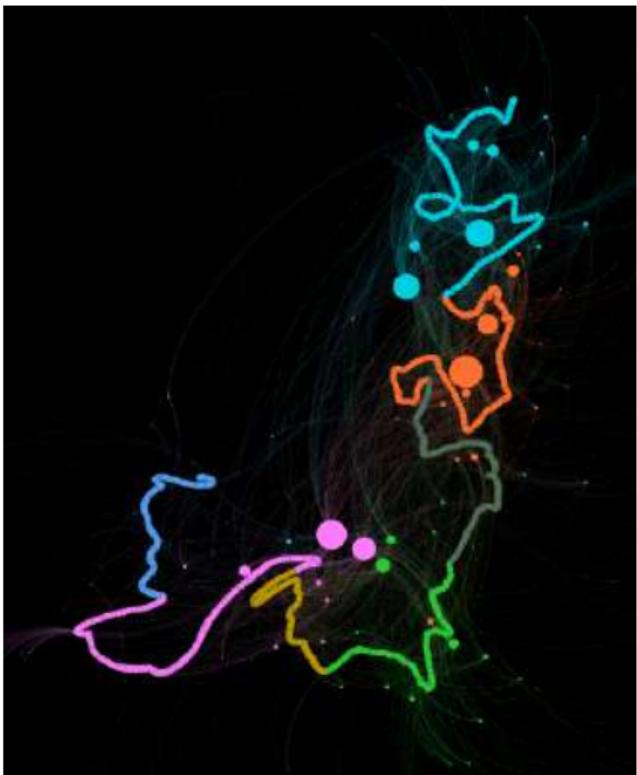


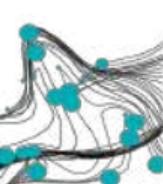
Example 2: Dark Web graph





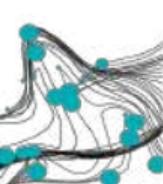
Example 3: Temporal Data Skeletons





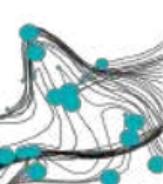
Work process: never stop scrapping!





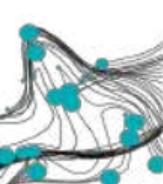
An unfinished work...

- **2015 Paris attacks**, a turning point...
- ... started applying his research to counterterrorism
- End-2018: an unexpected end.



His uncredited achievements

- His research project was successfully conducted



His uncredited achievements

- His research project was successfully conducted
- **Gephi**, a popular graph visualization software

[Gephi: an open source software for exploring and manipulating networks](#)

14205 2009

M Bastian, S Heymann, M Jacomy

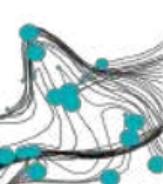
Proceedings of the international AAAI conference on web and social media 3 ...

[ForceAtlas2, a continuous graph layout algorithm for handy network visualization designed for the Gephi software](#)

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PloS one 9 (5), e98679



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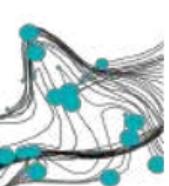
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- Contaminated many students with the “network-science virus.”



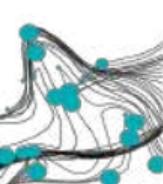
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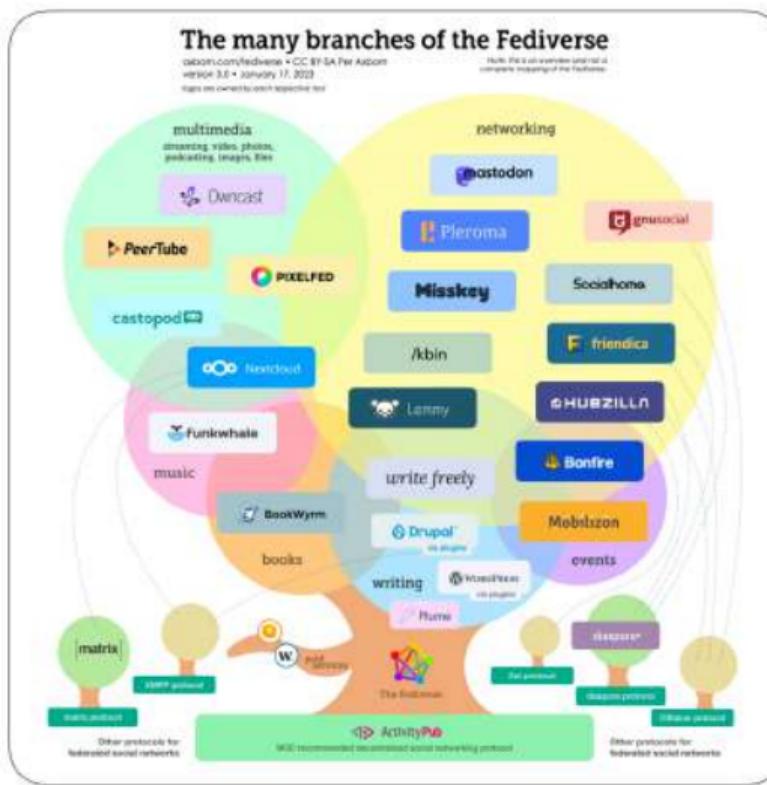
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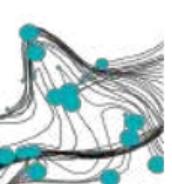
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The Fediverse

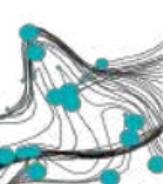




Starting point: Federated Learning for the Fediverse

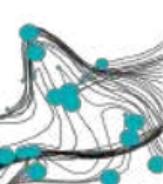


- With Edwige Cyffers (a French colleague of mine), we wanted to apply our work on Federated Learning to the Fediverse.
- Goal:** Federated Recommender System for Peertube.
- Problem:** existing works are not tested on graphs realistically simulating Federated Learning deployments.
- Need new graphs.**



Fedivertex: Scope

- **New graph dataset** modeling interactions between Fediverse servers.
- Weekly crawl to **capture the temporal evolution**.
- **7 Fediverse social media** covered: Bookwurm, Friendica, Lemmy, Mastodon, Misskey, Peertube, Pleroma
- 13 unique graphs, 14 weekly snapshots \Rightarrow **182 graphs**.

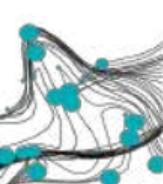


Fedivertex: Developing a crawler



Before deploying a crawl:

- 1 year of discussion with the legal department...
- Special declaration to the SOC.



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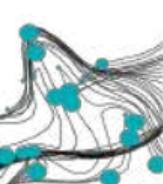


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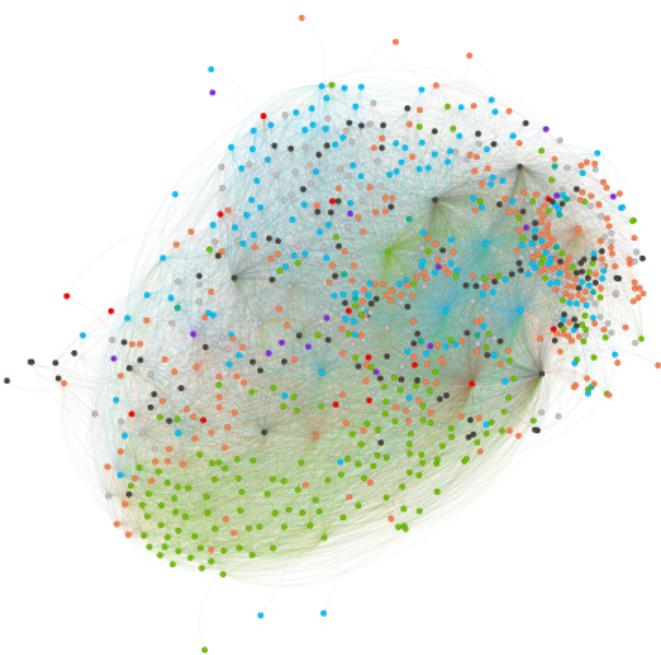
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Ethical concerns regarding a crawler:

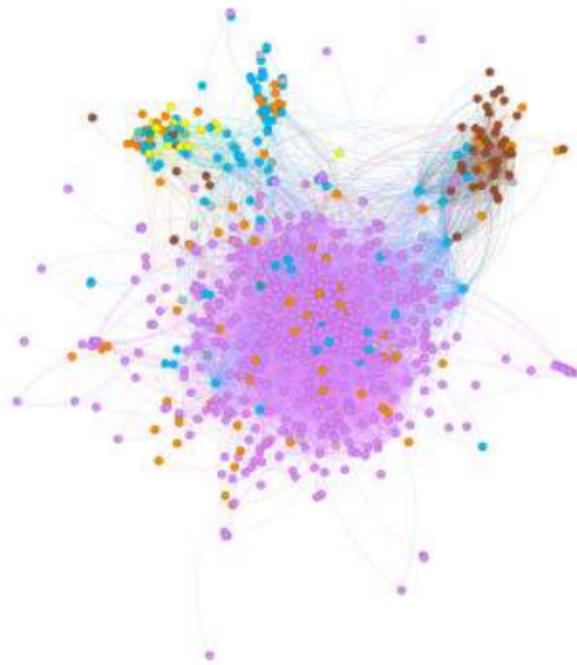
- **Privacy:** only query public APIs, only publish aggregated data.
- **Acceptability:** respect `robots.txt`, “slow” crawl, do not lie in the user agent.



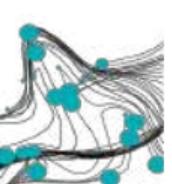
Fedivertex: Example graphs



Peertube



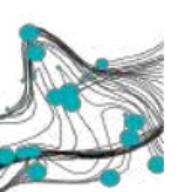
Misskey



Fedivertex: from a dataset to a paper

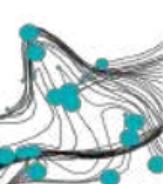


- What is a dataset paper?



Fedivertex: from a dataset to a paper

- What is a dataset paper?
- What are the requirements?
 - ⇒ Dataset presentation, Novelty vs. existing datasets, Applications



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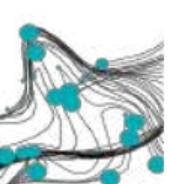
- What is a dataset paper?
- What are the requirements?
⇒ Dataset presentation, Novelty vs. existing datasets, Applications
- Where can I submit it?
⇒ NeurIPS, KDD, SIGMOD/PODS



What's next for Fedivertex?



- Get the paper accepted
- Keep updating the dataset with new graphs
- Reproducing decentralized ML papers on this dataset \approx SoK?
- **Social science research:** does the Fediverse support “better” interactions than mainstream social media?
- **Security research:** how to efficiently stop spam waves in the Fediverse?

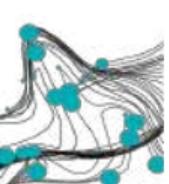


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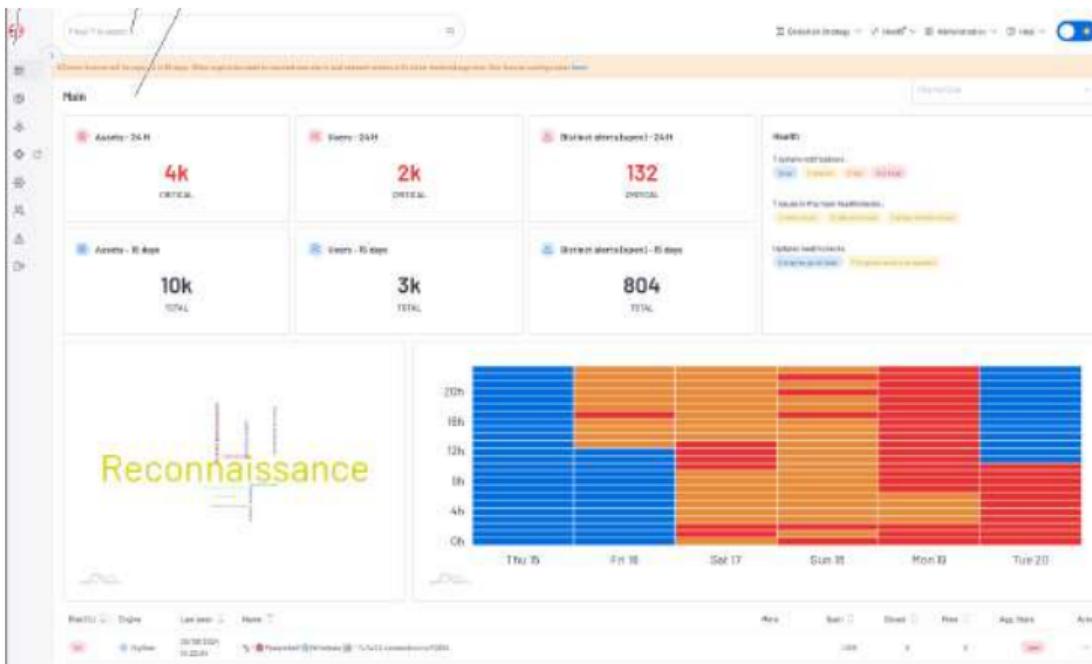
Towards network science in security research



Cybersecurity could benefit from network science insights in different ways:

- Networks naturally emerge in cybersecurity problems.
- Clarify the large load of data (instead of feeding it to an LLM).
- Methods applied to terrorist networks could be transferred to hackers'.

Example problem: information load in NDR products

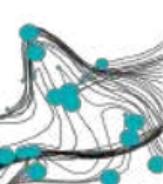




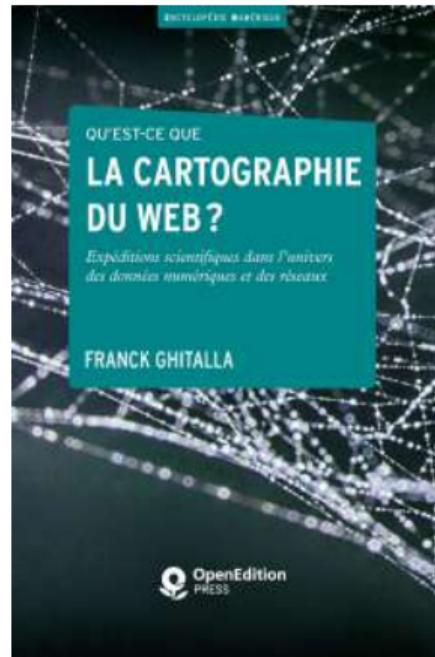
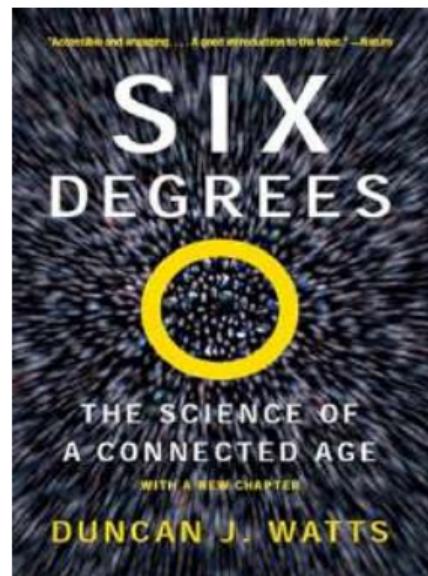
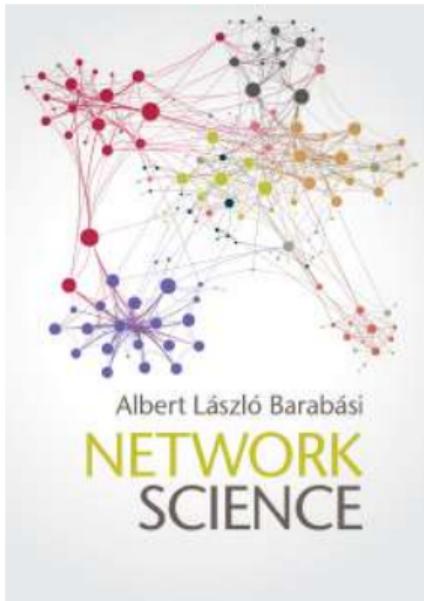
Example: Graph-based visualization for SOC logs?

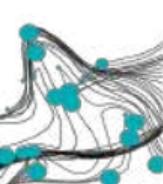


- **Problem:** SOC operators deals with a large amount of logs.
- **Solution:** introduce graphs to synthesize information in their dashboards.
- **Novelty:** automating SOC tasks using AI \Rightarrow simplify SOC tasks using graphs
- **Warning:** Go beyond trivial graphs of communications between IPs.



Wanna learn about Network Science?





Wanna work with Network Science?



- Come talk to me :-)
- (Or even better) Talk to Doina Bucur (DMB)



Questions?