Enhanced extraction of weighted networks backbones

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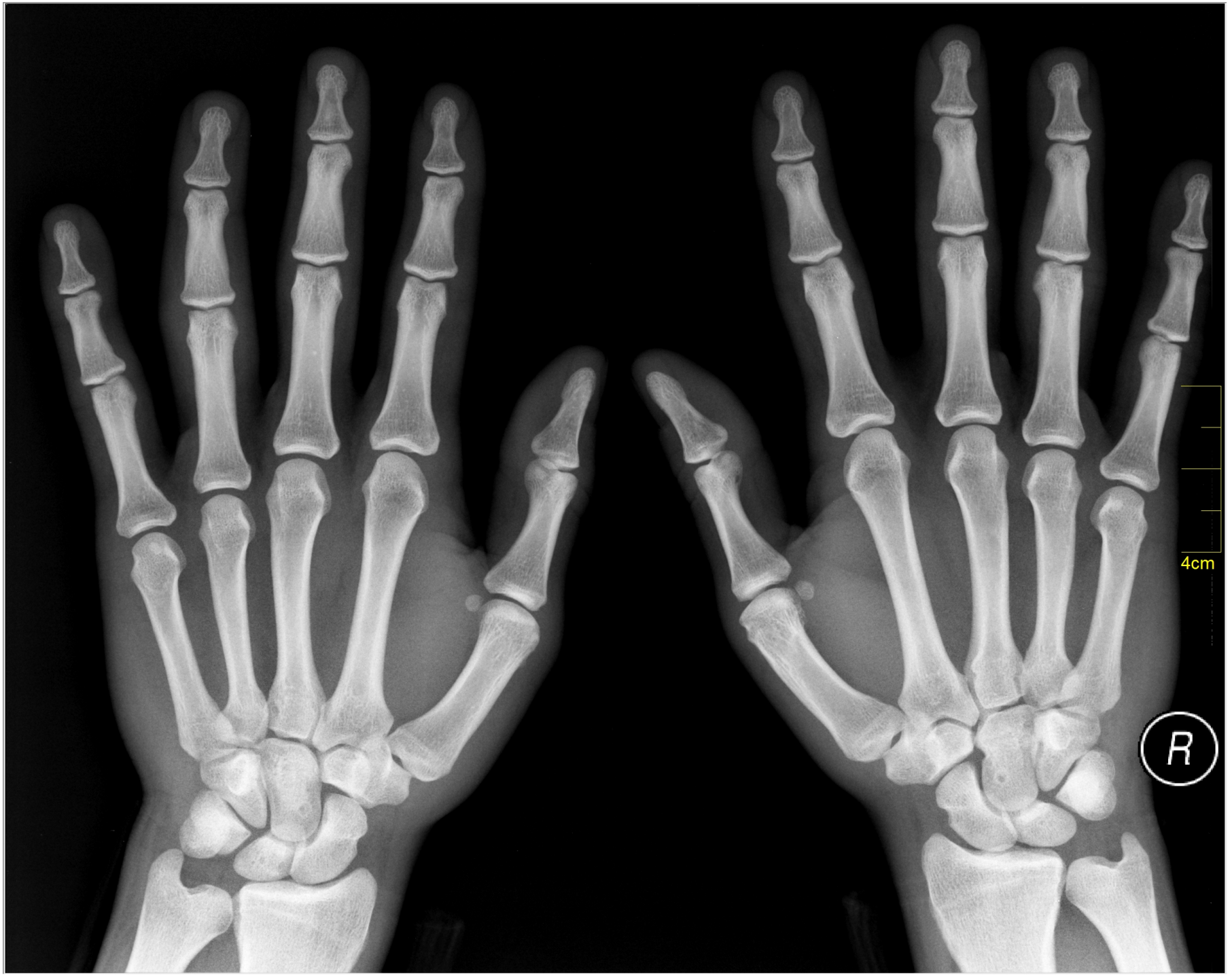
École polytechnique fédérale de Lausanne (EPFL), Lausanne, Switzerland

Tuesday 21 March 2017, Complenet 2017, Dubrovnik, Croatia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Motivation


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EVERY
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COST
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CITATION
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DIFFICULTY
TARGET
ABILITY
SETS
EXAMPLES
APPLIED
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AMOUNT
DESCRIBING

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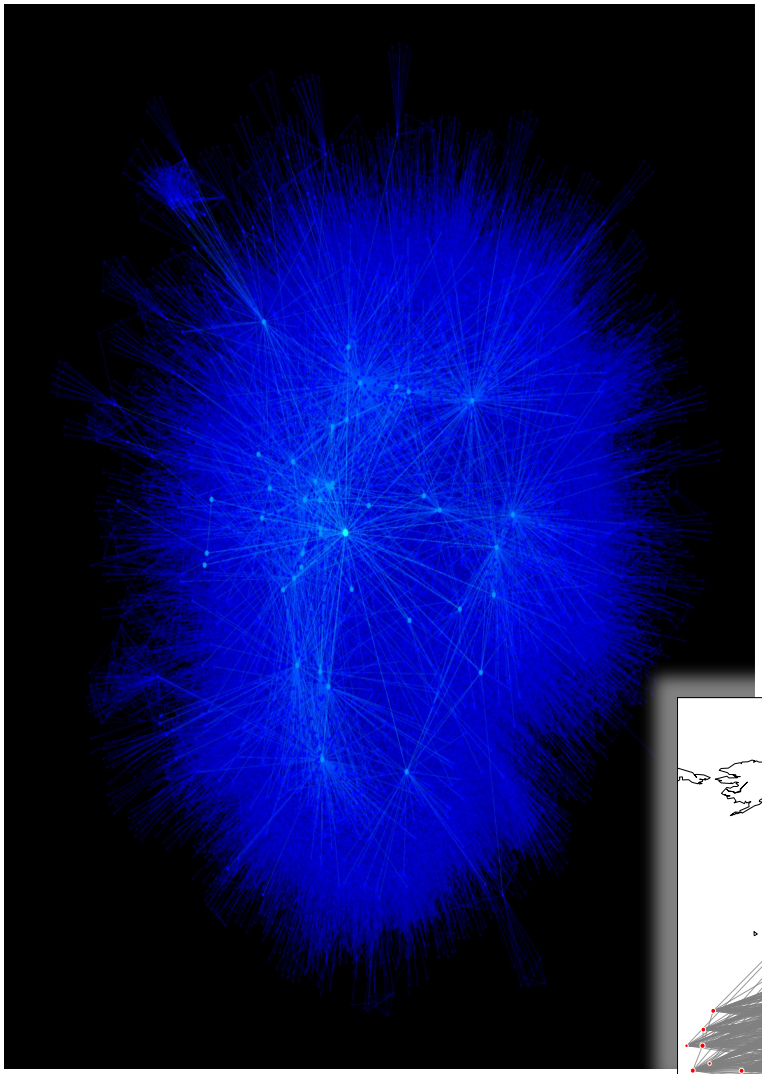
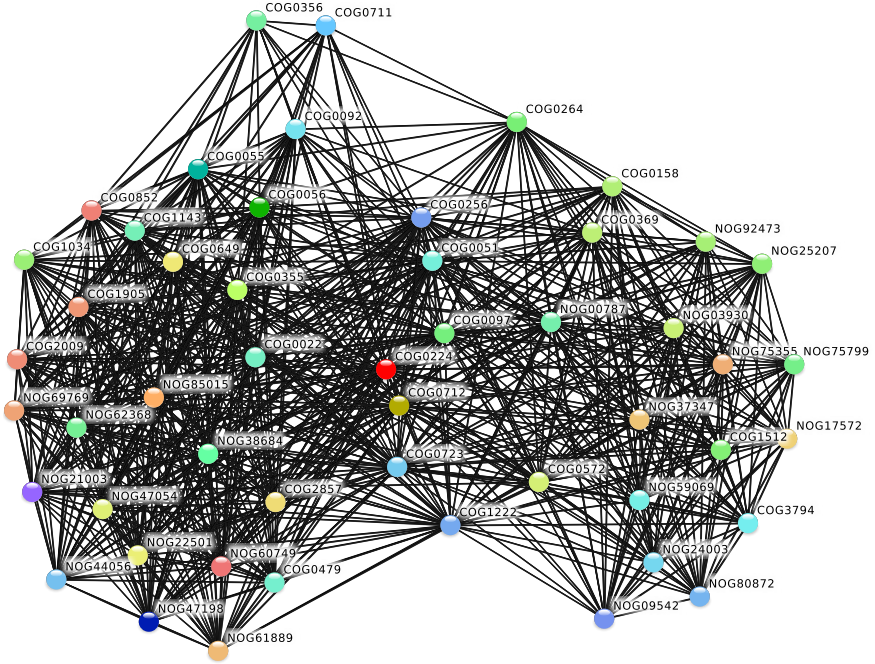
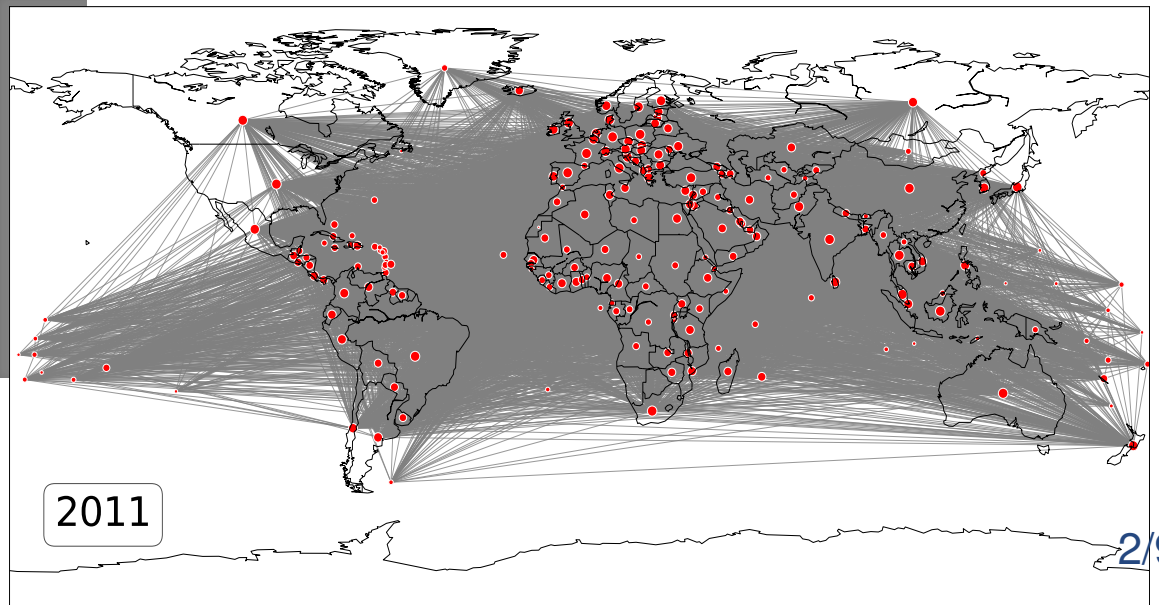
Motivation







Motivation

Question:

What can we learn from a complex system whose network representation is **noisy** and/or extremely **dense**?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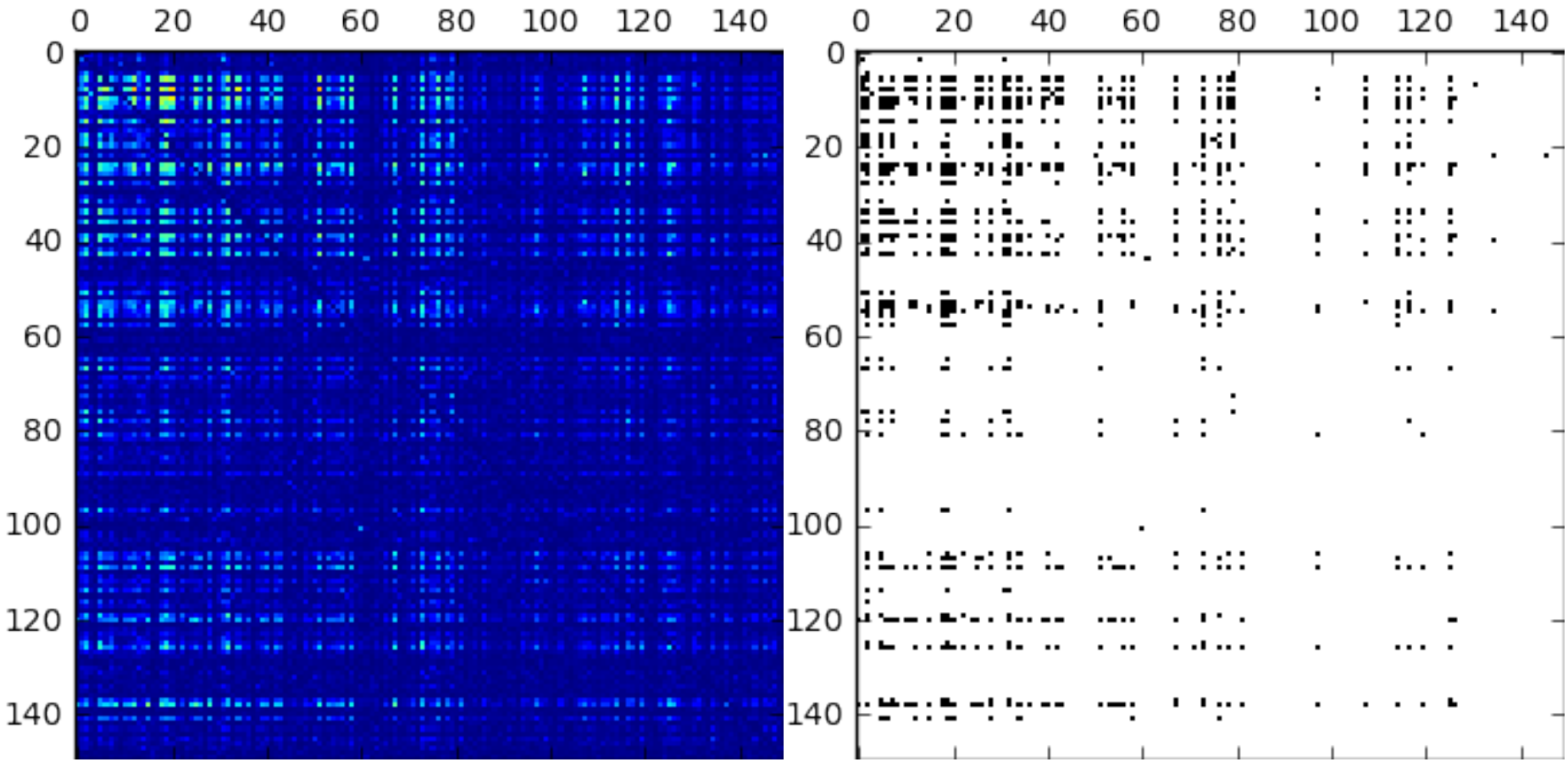
Other methods



Other methods

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RESEARCH ARTICLE

A Topological Criterion for Filtering Information in Complex Brain Networks

Fabrizio De Vico Fallani, Vito Latora, Mario Chavez

Version 2

Published: January 11, 2017 • http://dx.doi.org/10.1371/journal.pcbi.1005305

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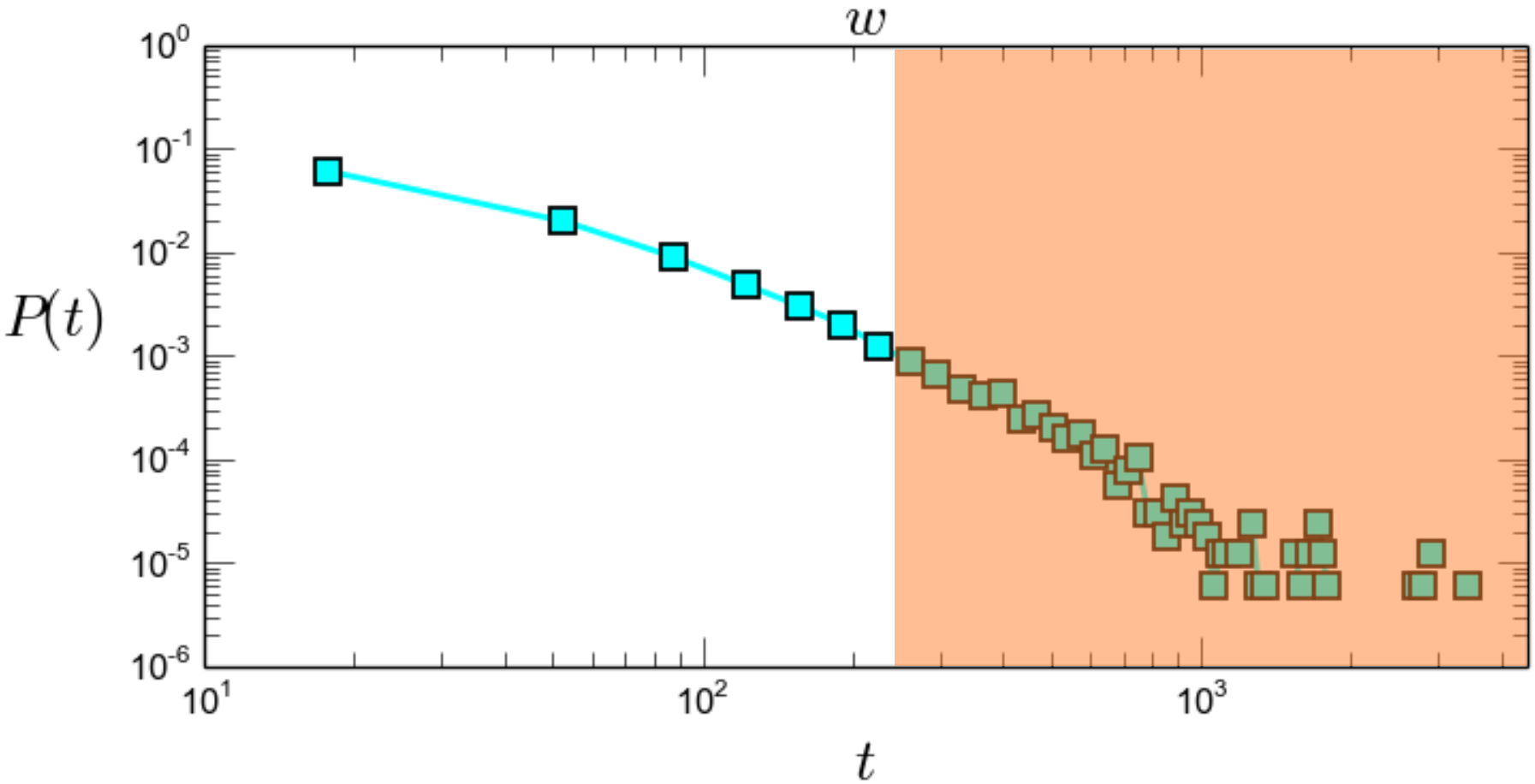
- De Vico Fallani F., *et al. A Topological Criterion for Filtering Information in Complex Brain Networks*. PLoS Comp. Bio. **13** e1005305 (2017).

Other methods



- Granovetter, M. S. *The Strength of Weak Ties*. Am. Jour. Soc., **78**, 1360 (1973).

Other methods

- Serrano M.A., *et al. Extracting the multiscale backbone of complex weighted networks*. Proc. Natl. Acad. Sci. (USA) **106** 6483 (2009).

Other methods

• Radicchi, F., *et al.* *Information filtering in complex weighted networks*. Physical Review E, **83** 046101. (2011).

ECM-filter

Main Features

1. Based on the comparison between the observed network and a null model one.

ECM-filter

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2. Null model: maximum-entropy canonical ensemble of networks satisfying given constraints.

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• Mastrandrea, R., *et al. Enhanced reconstruction of weighted networks from strengths and degrees.* New Jour. Phys., **16**, 043022. (2014).

ECM-filter

Main Features

1. Based on the comparison between the observed network and a null model one.
2. Null model: maximum-entropy canonical ensemble of networks satisfying given constraints.
3. Constraints: $\{k_i\}$ and $\{s_i\}$ preserved (on average).
4. Two versions: **local** (focus on links) and **global** (focus on entire network).

Local ECM-filter

1. Generate the null model ensemble and compute:

$$q_{ij}(w) \equiv \frac{\left(x_i x_j\right)^{\Theta(w_{ij})} \left(y_i y_j\right)^{w_{ij}} \left(1 - y_i y_j\right)}{1 - y_i y_j + x_i x_j y_i y_j} \, .$$

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2. Associate for each link a p-value, γ, such that $P(w_{ij} > w_{ij}^{\star})$.

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2. Associate for each link a p-value, γ, such that $P(w_{ij} > w_{ij}^{\star})$.
3. Select a threshold $\widetilde{\gamma}$ and remove all the links with $\gamma_{ij} > \widetilde{\gamma}$.

Results

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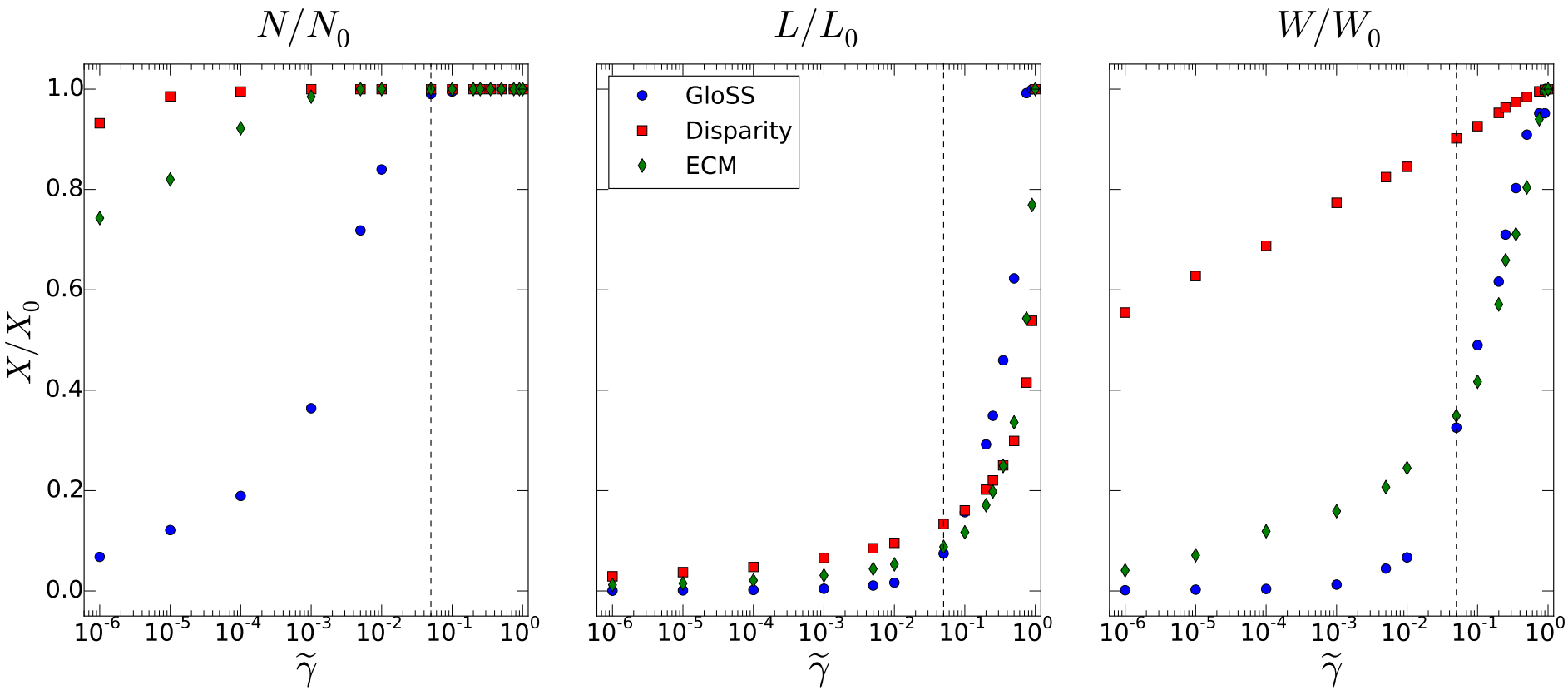
Comparison among methods



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A serious example . . .

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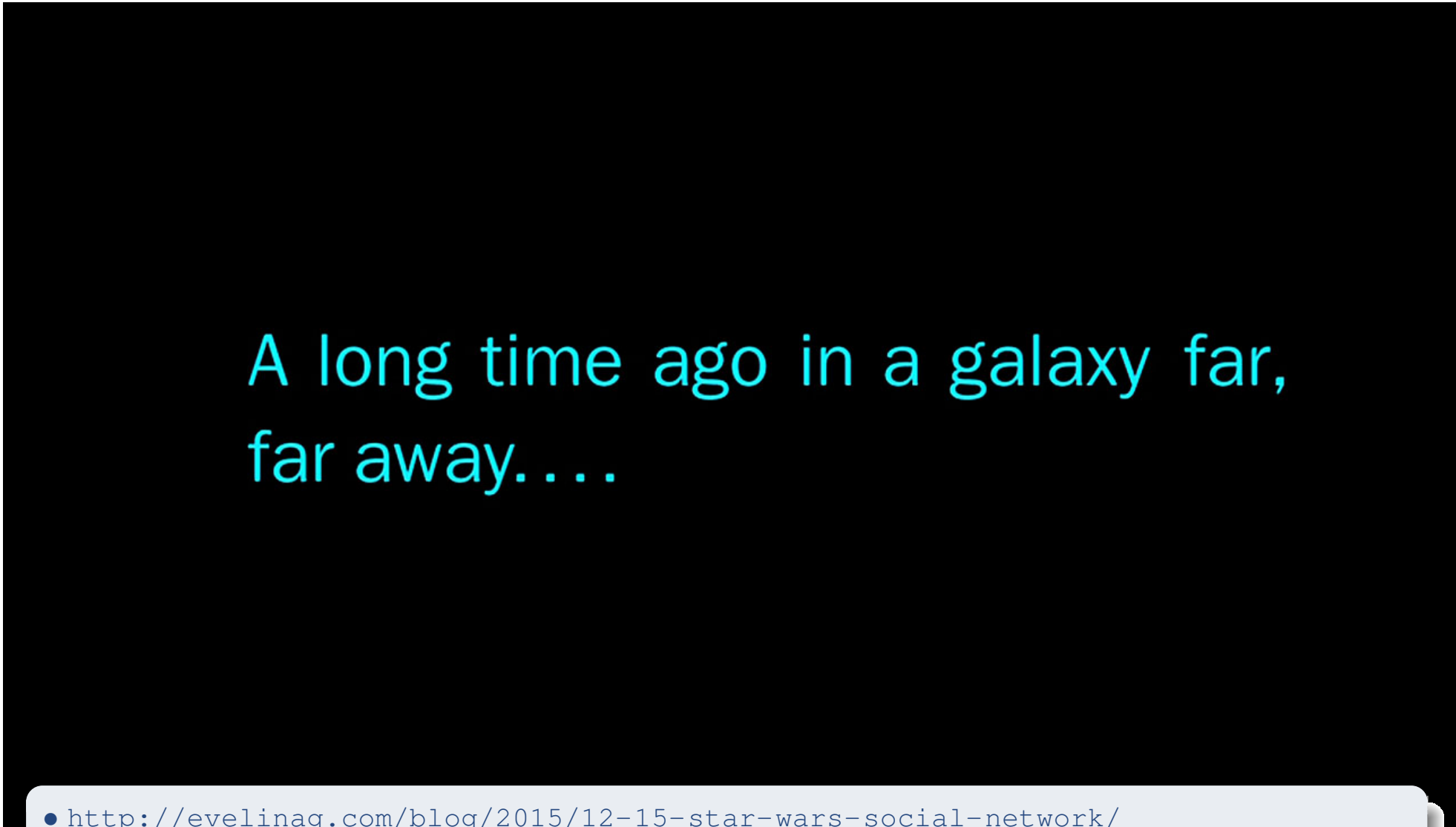

- http://evelinag.com/blog/2015/12-15-star-wars-social-network/

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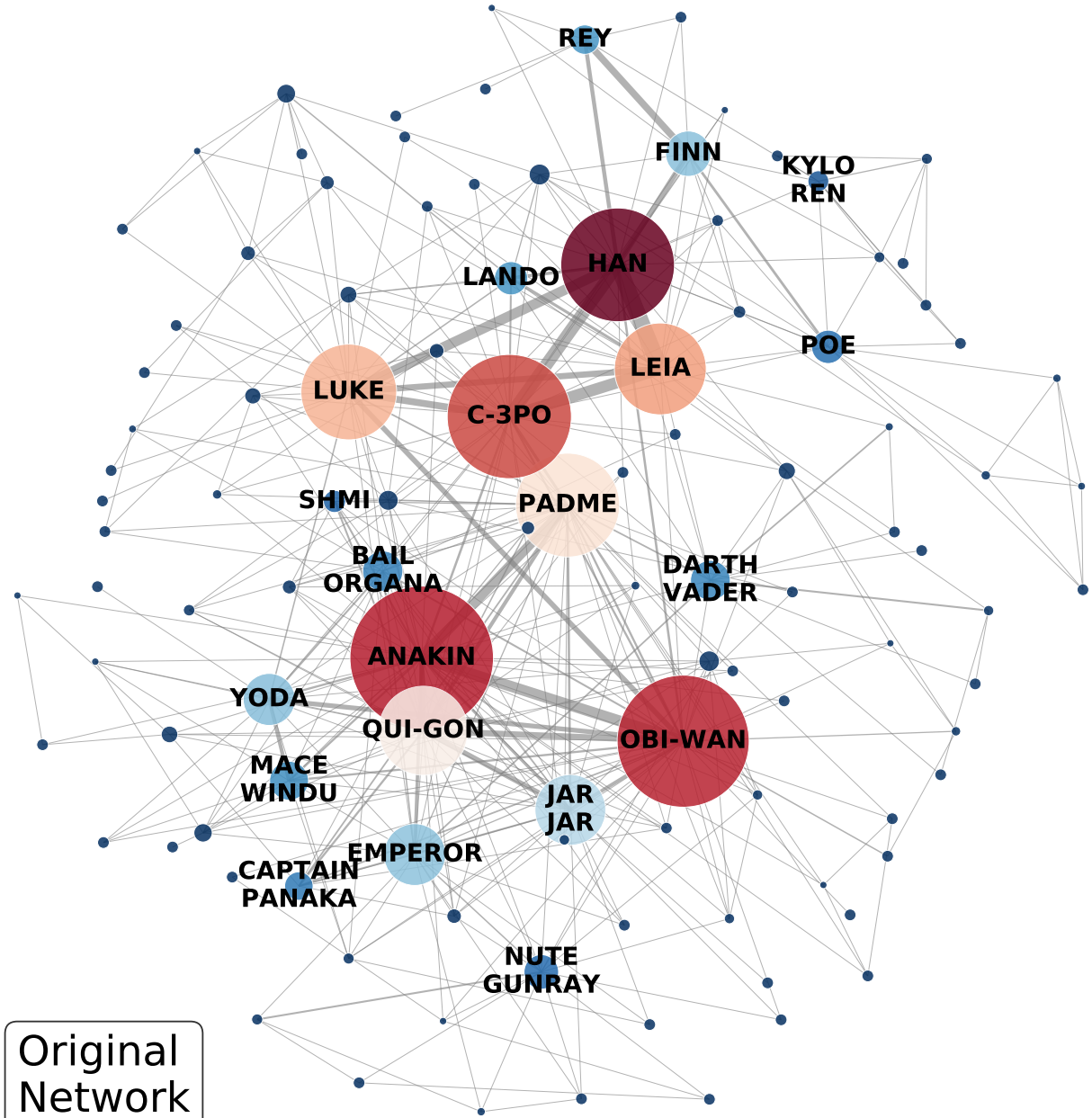
A serious example . . .



Original Network

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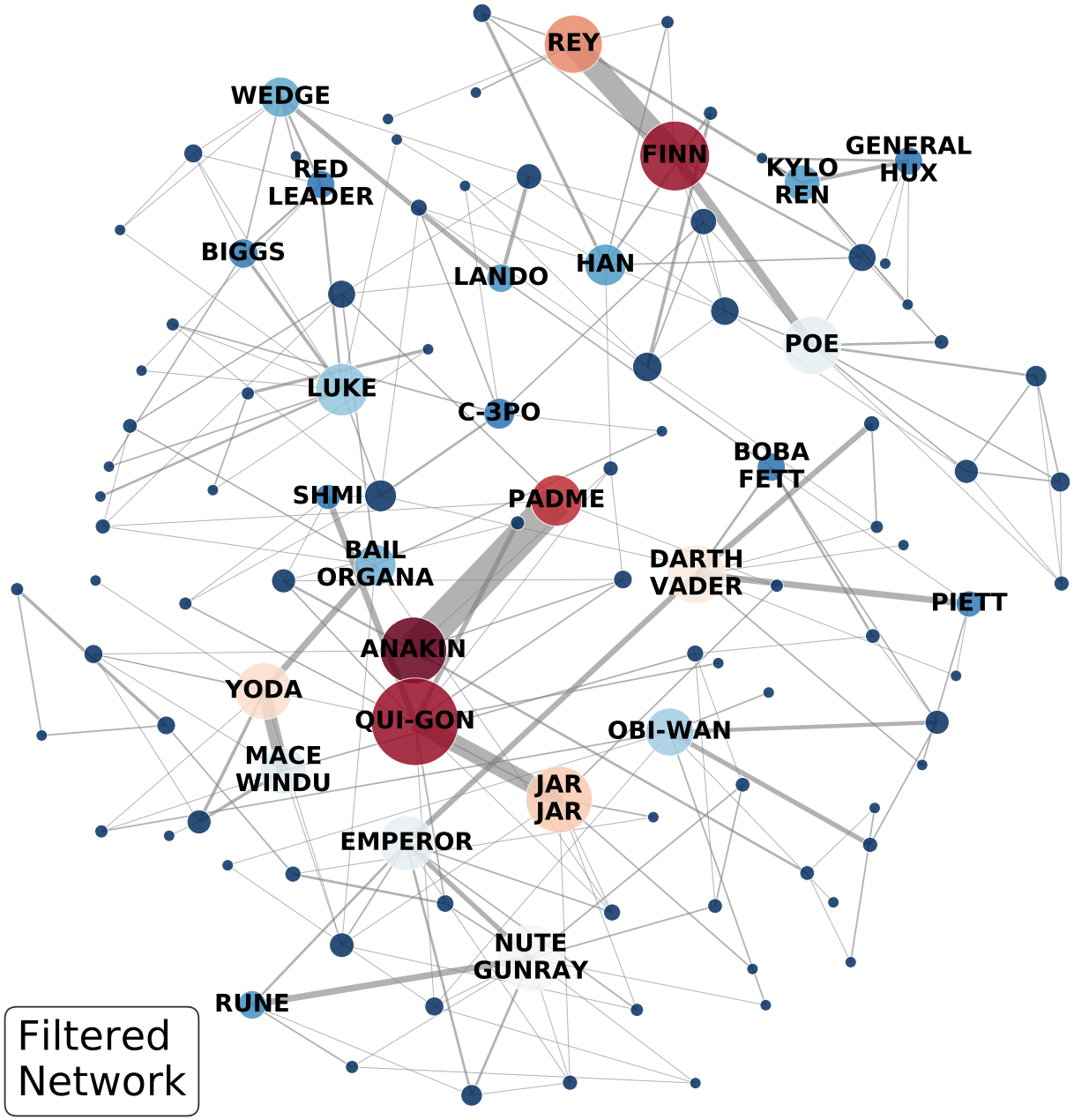
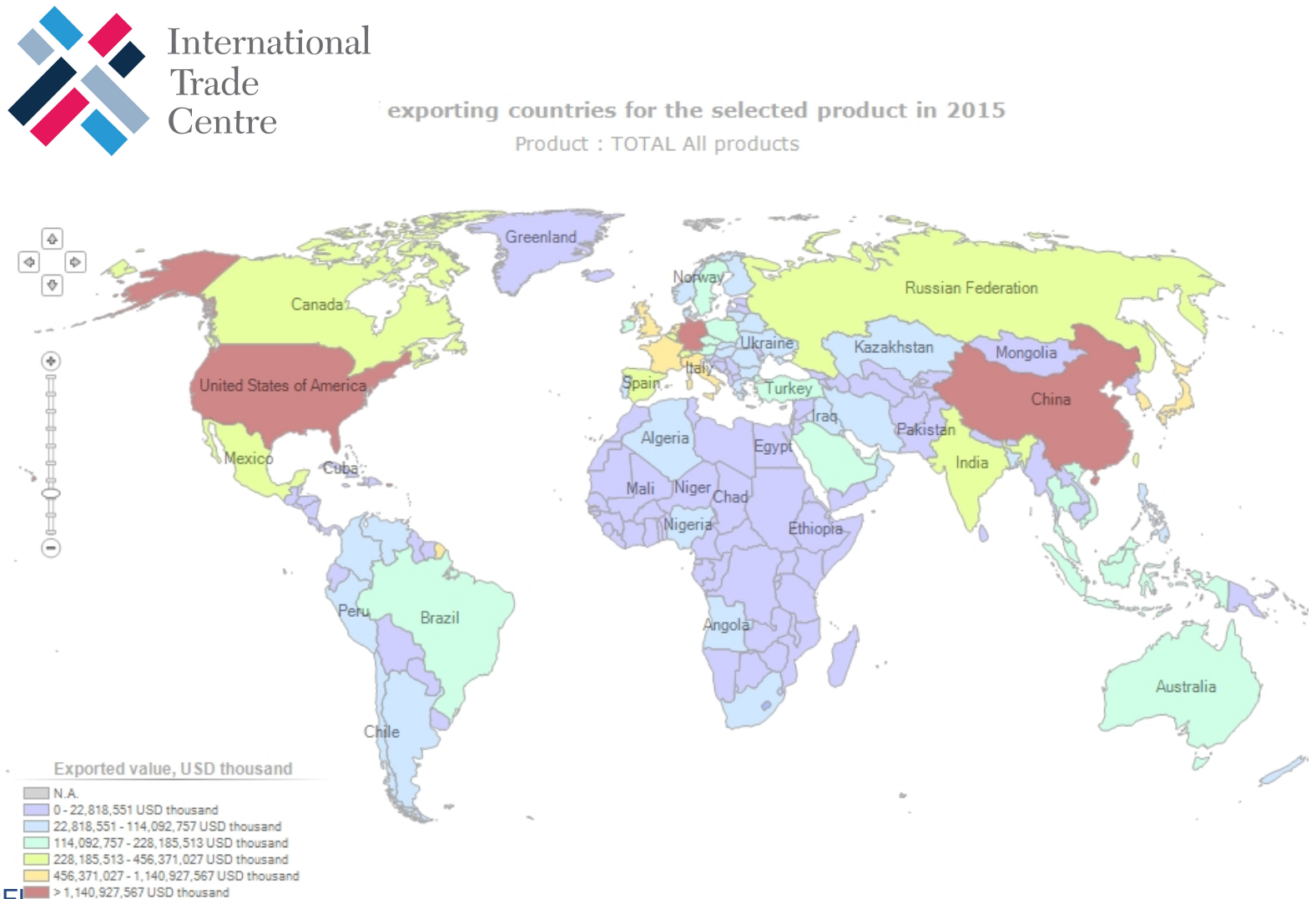
A serious example . . .



Filtered Network

International Trade Network 1998 – 2011



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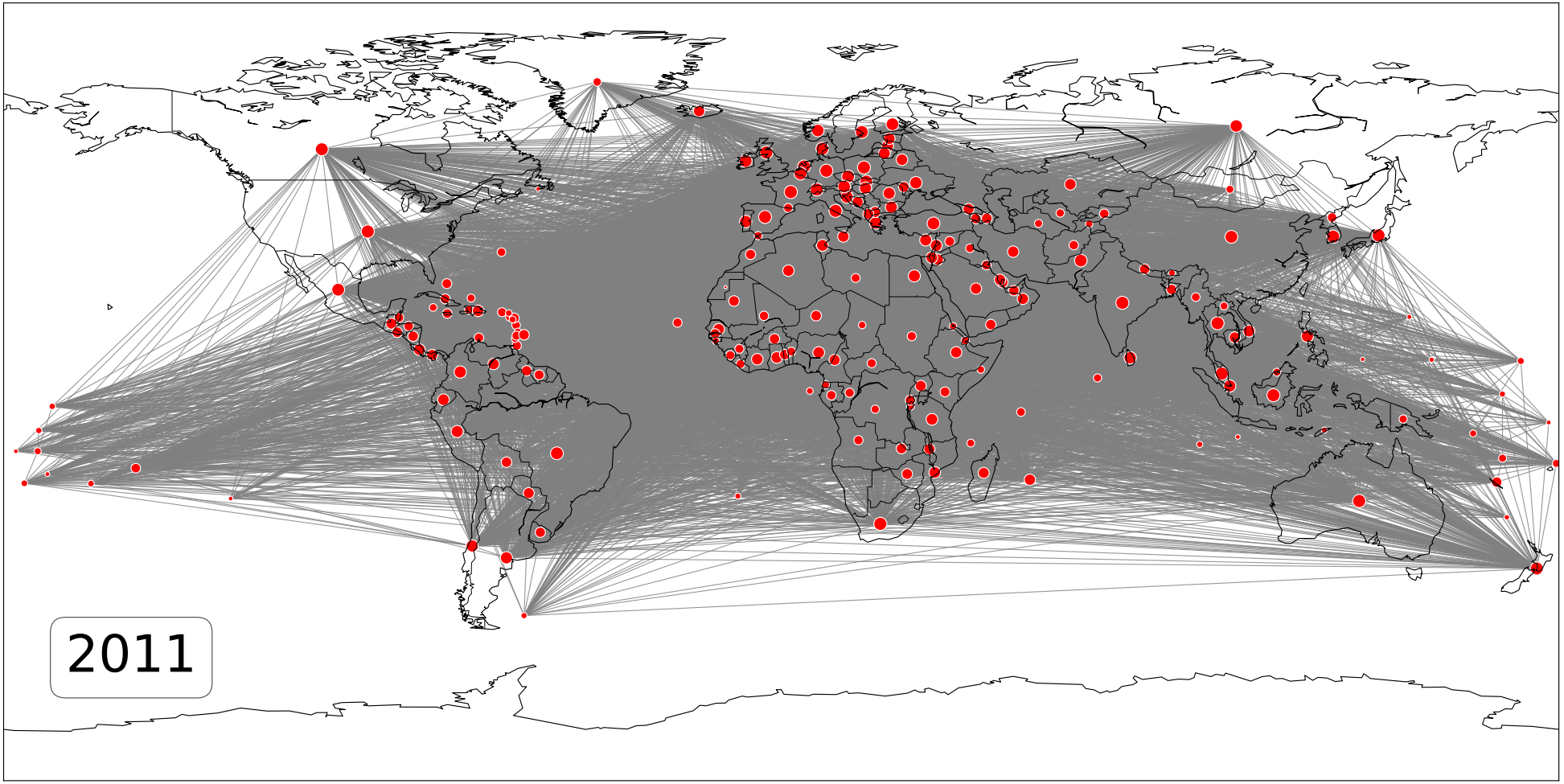

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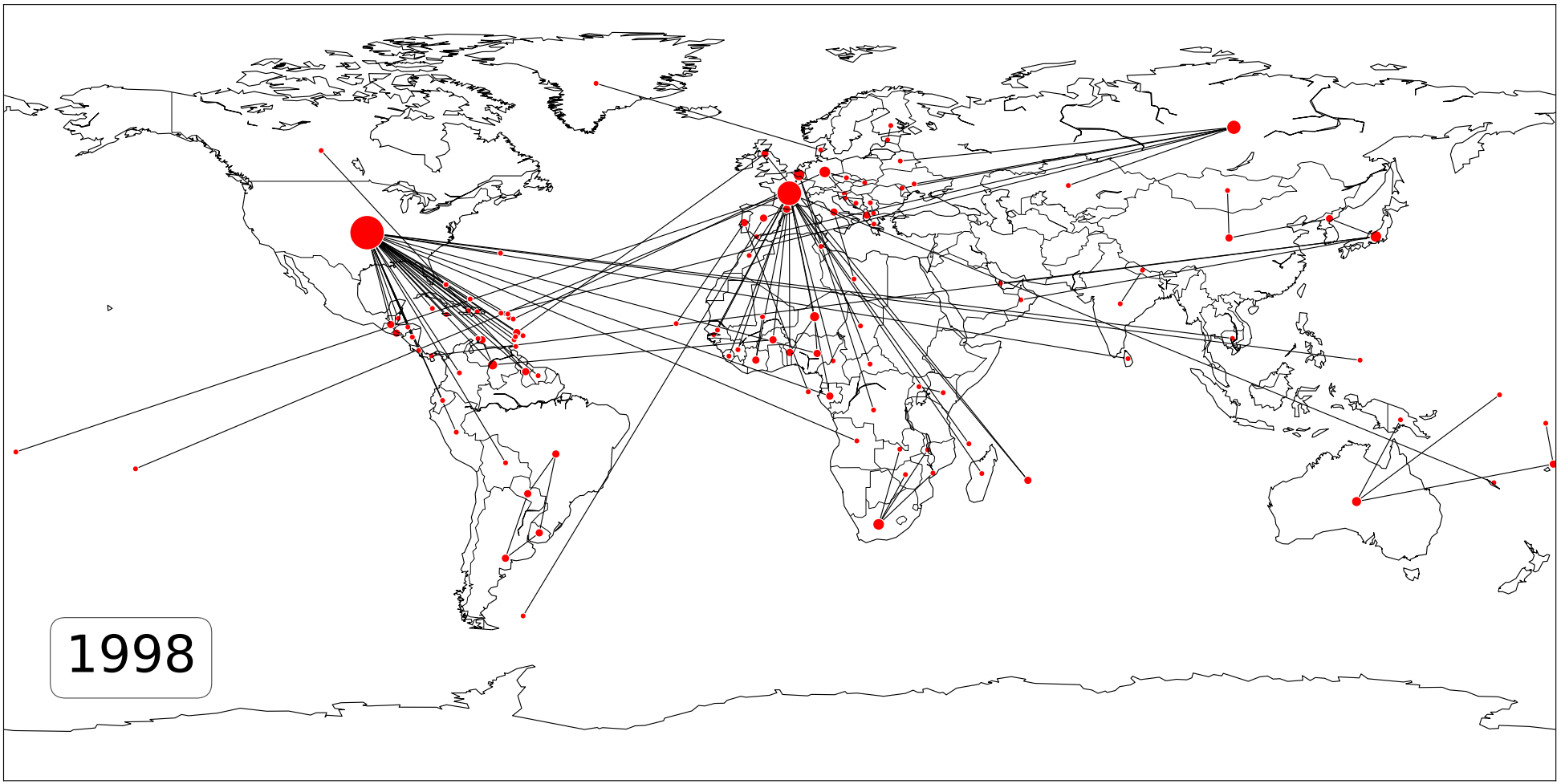

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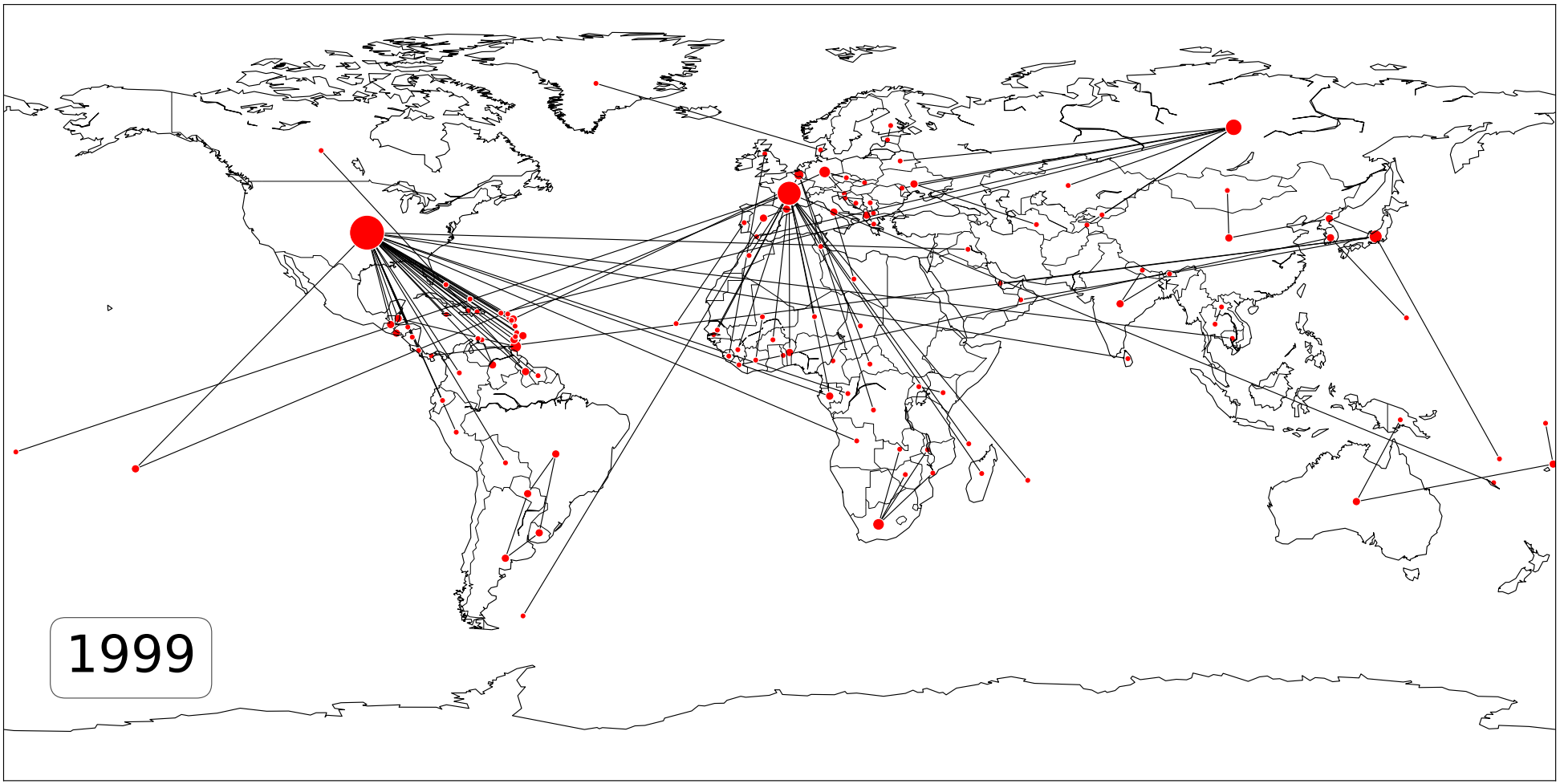

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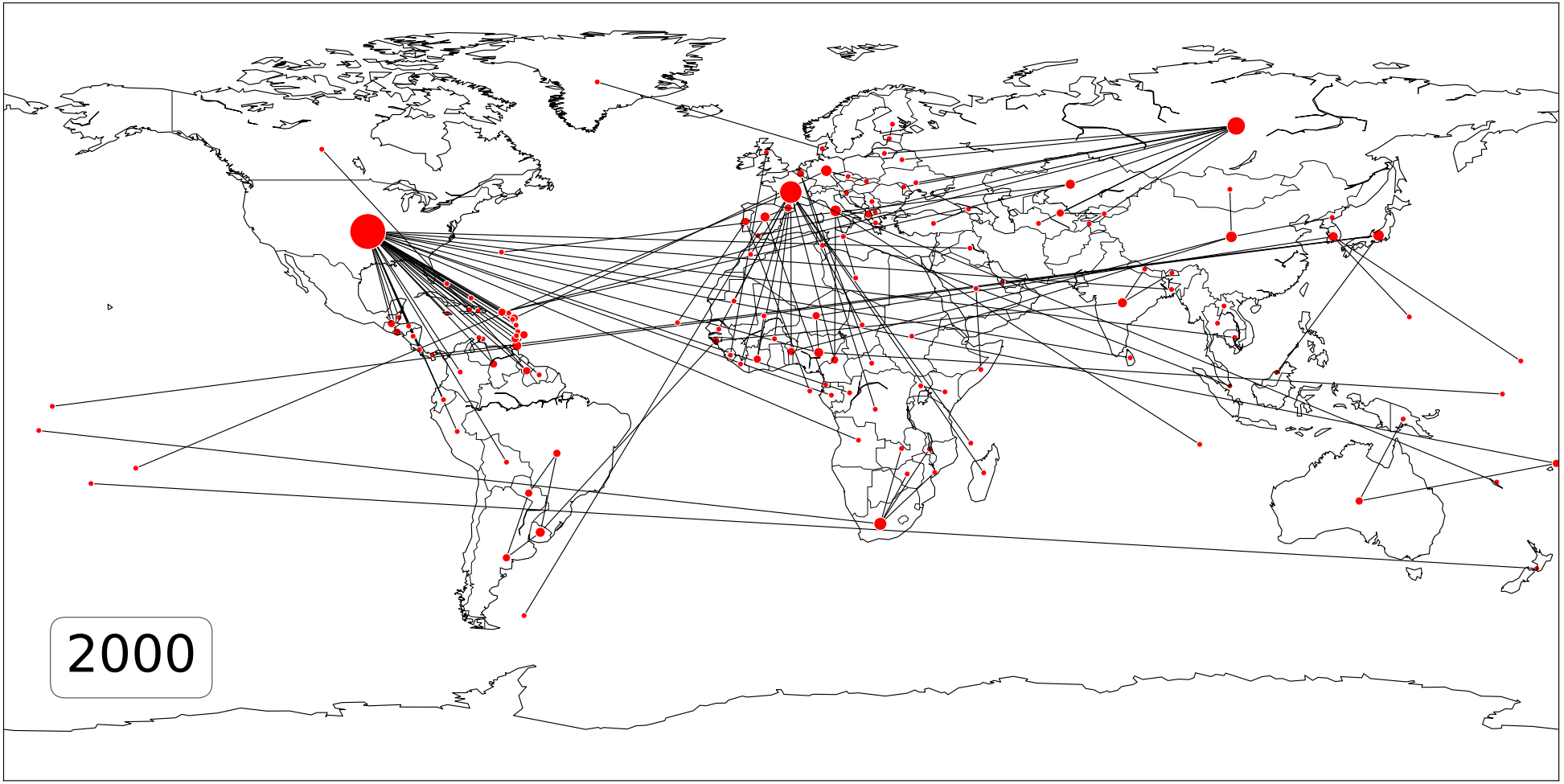

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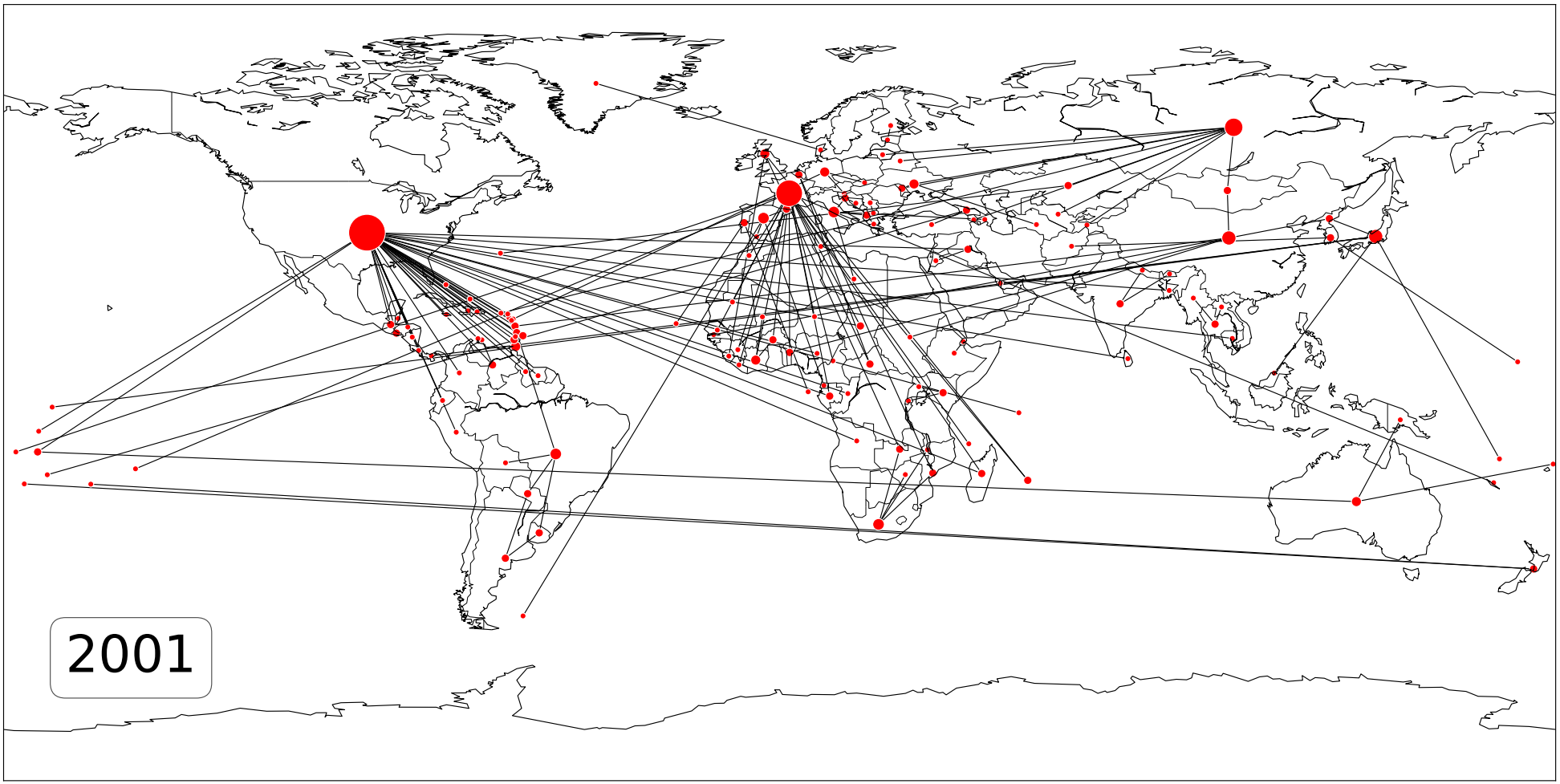

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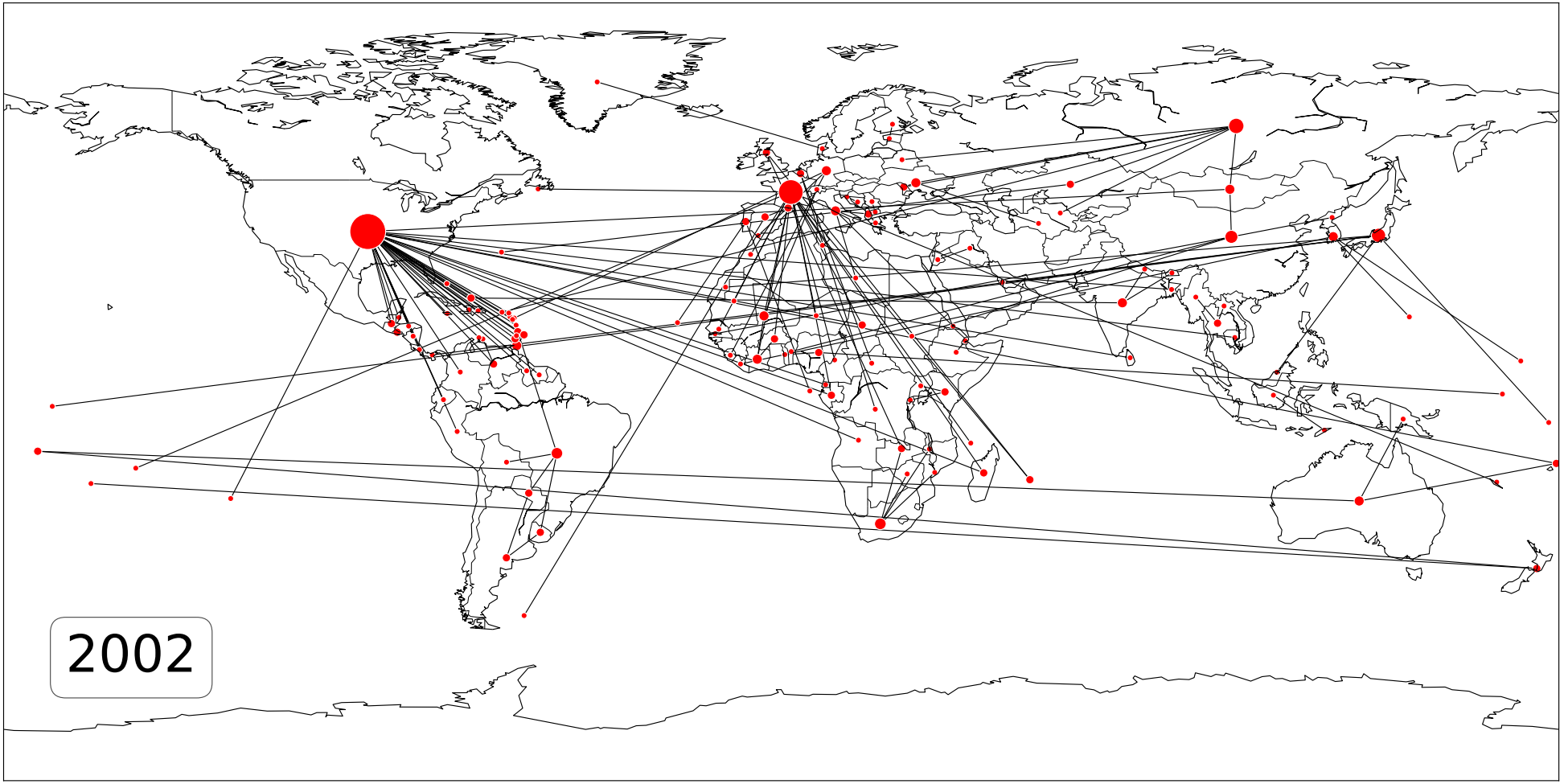

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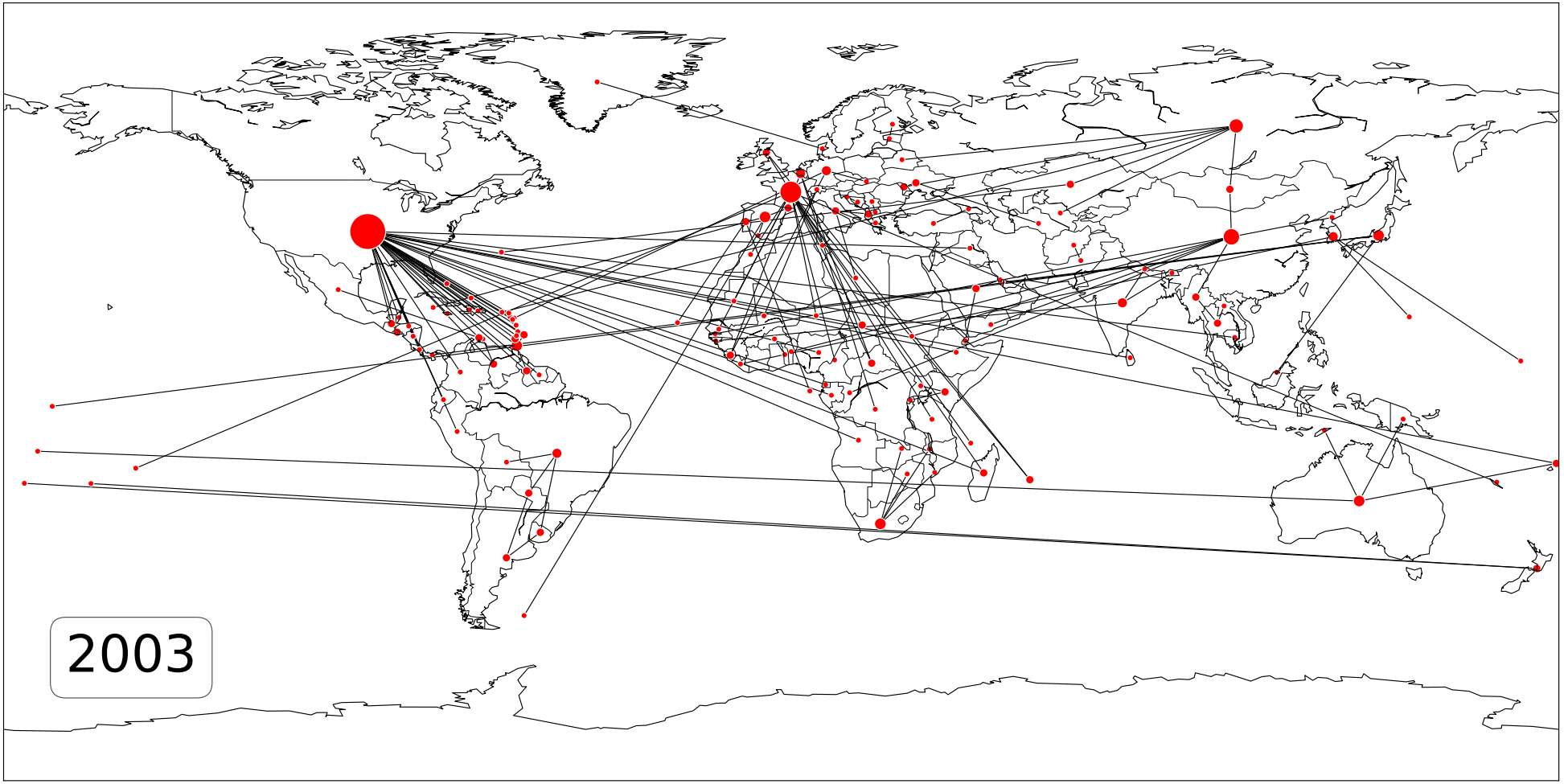

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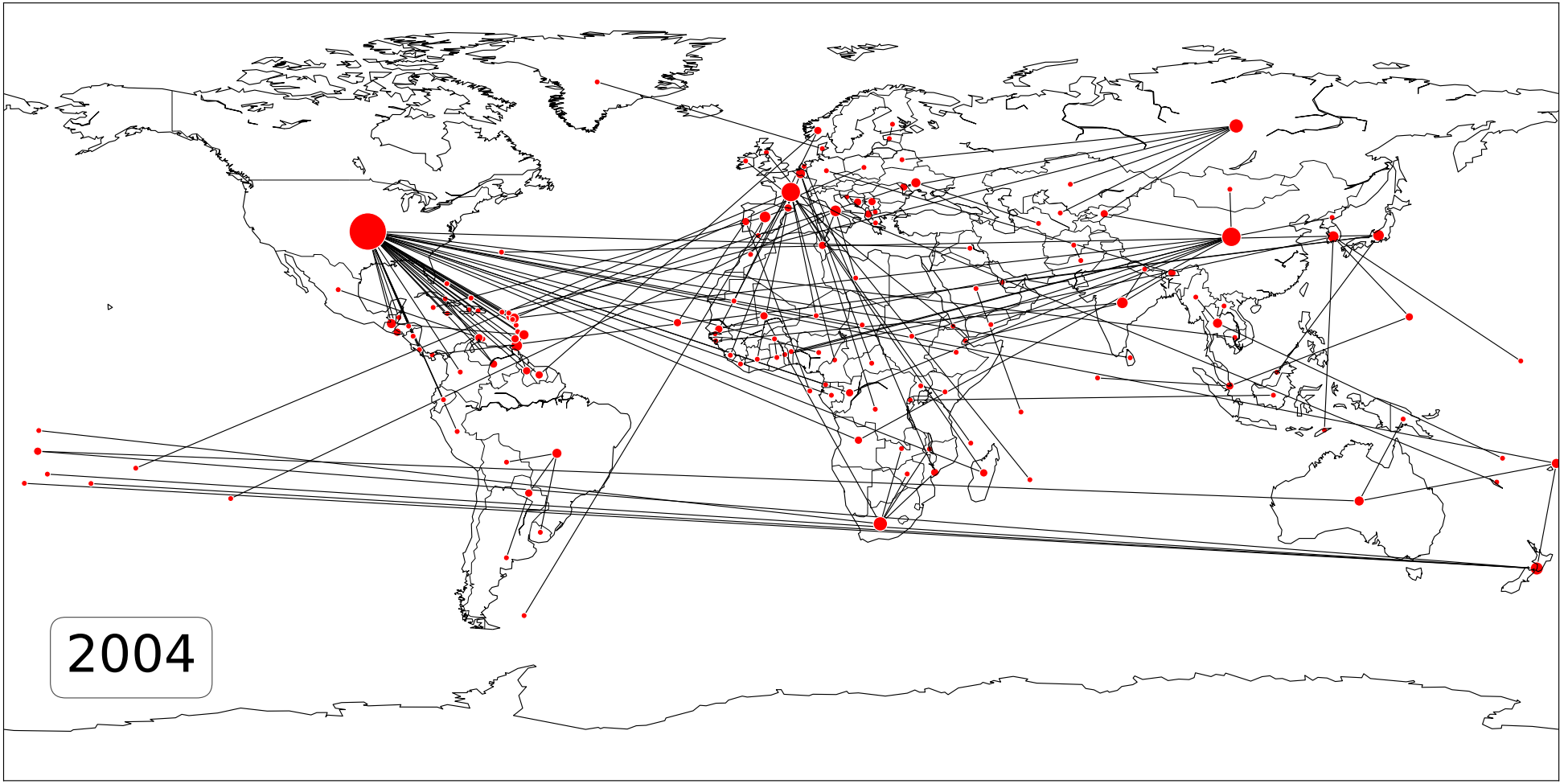

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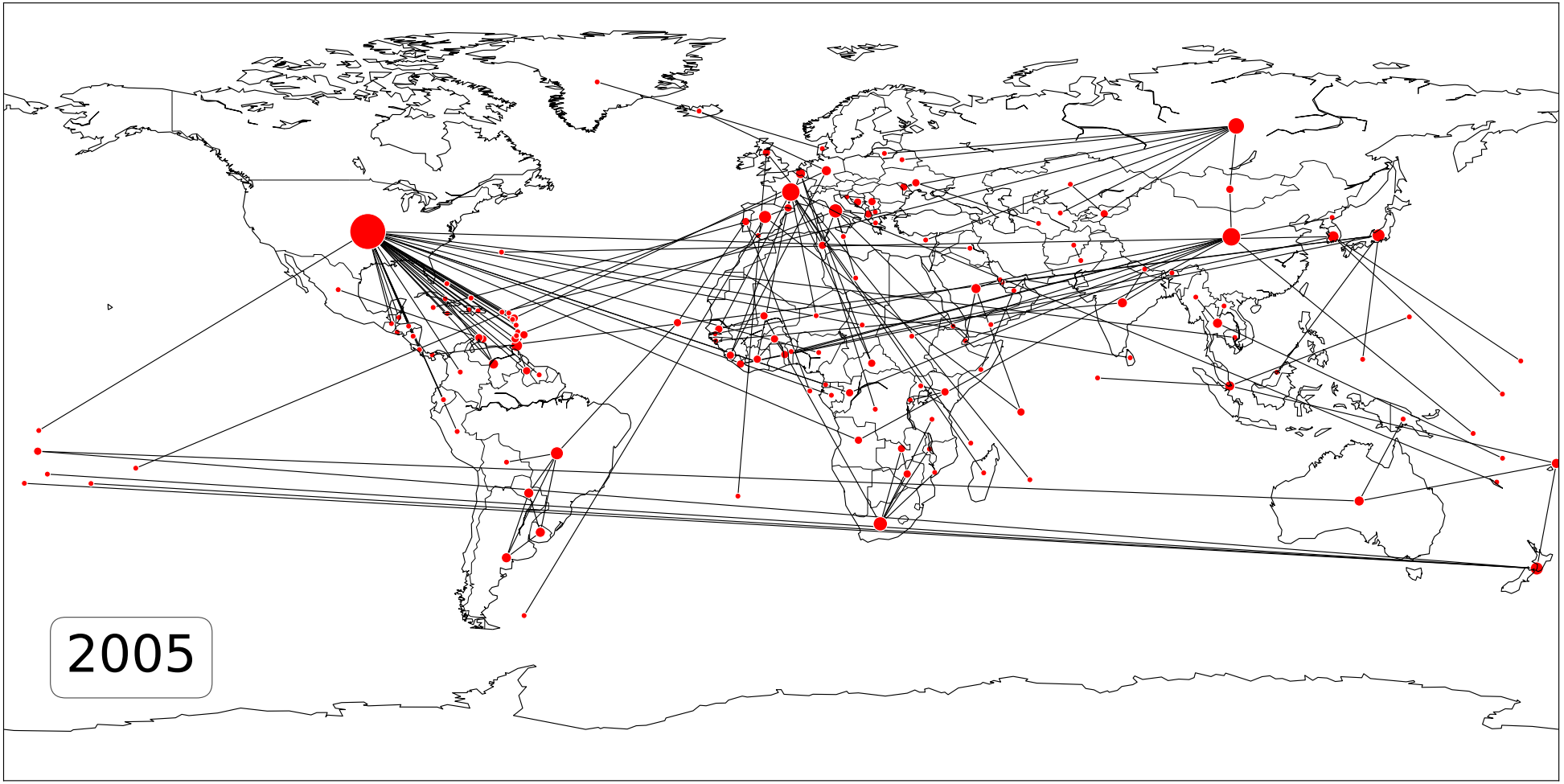

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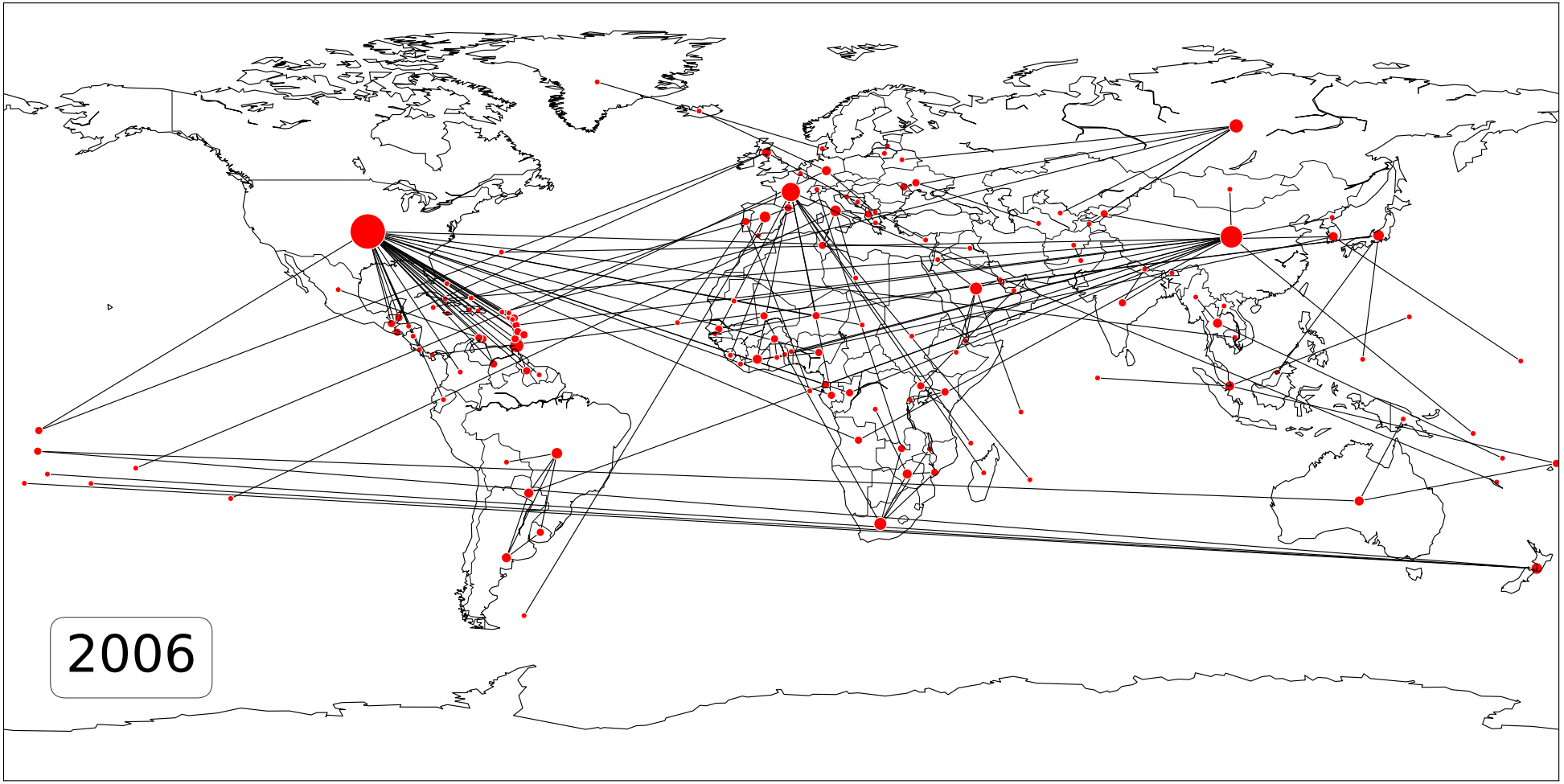

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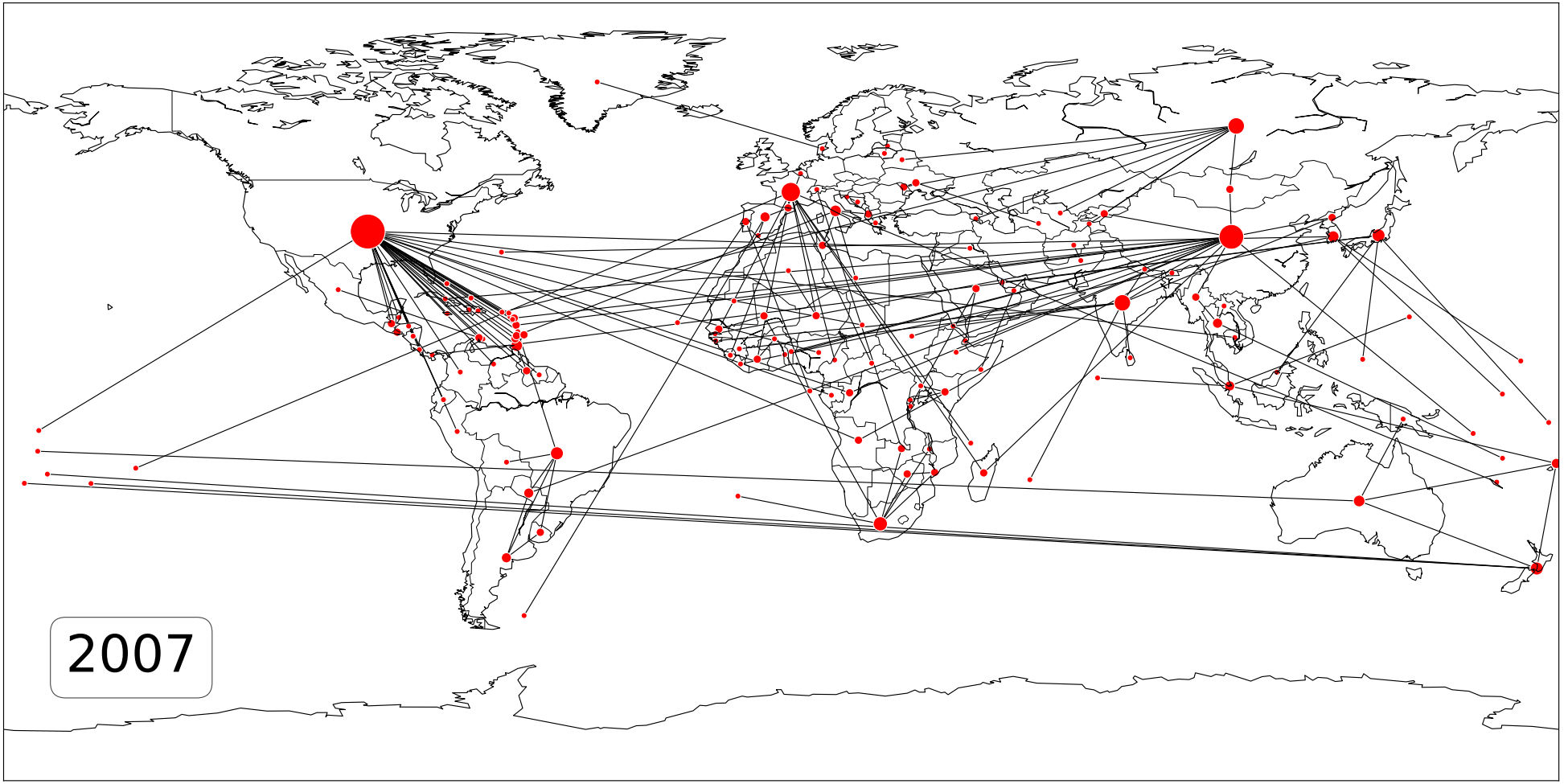

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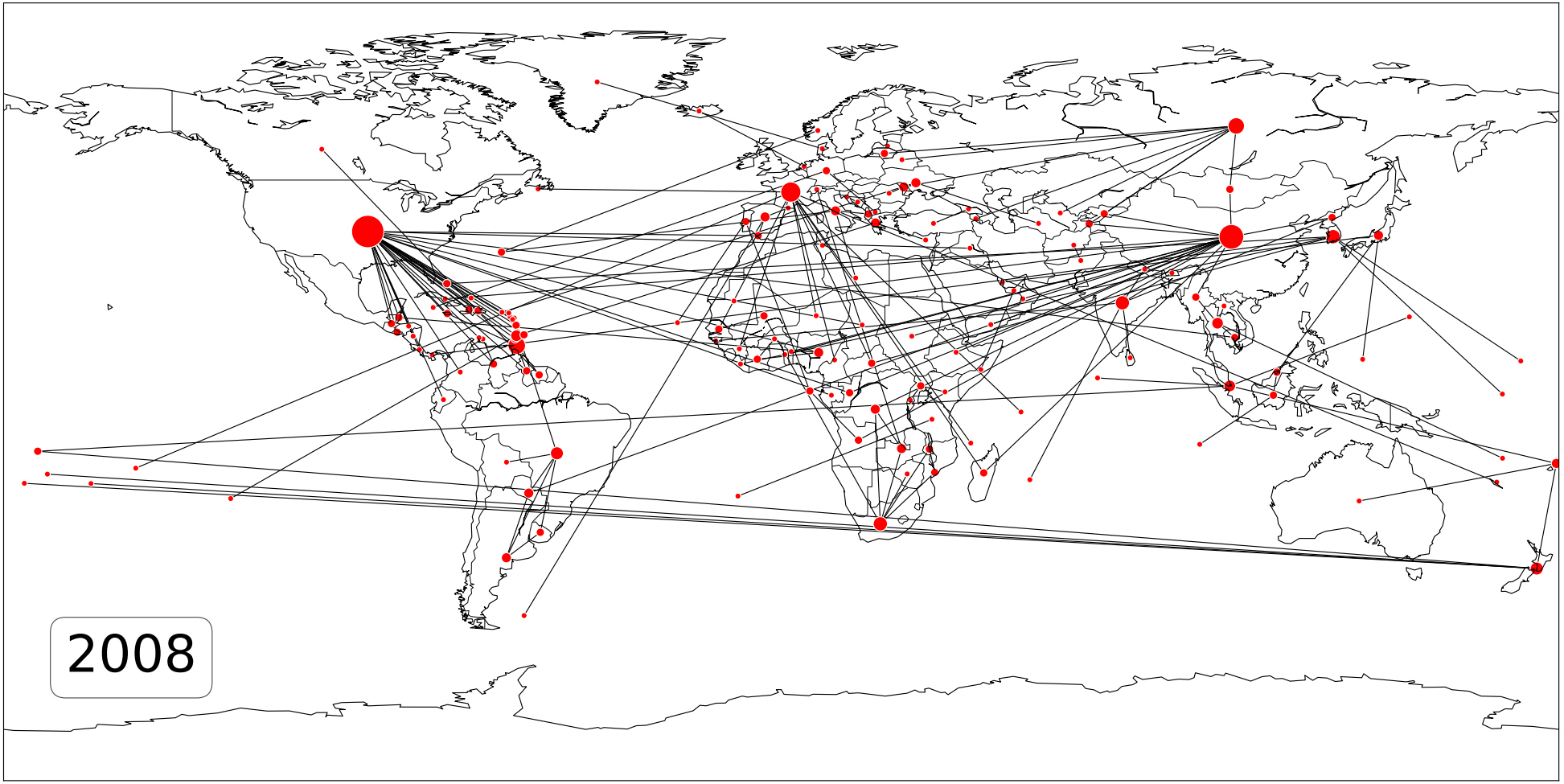

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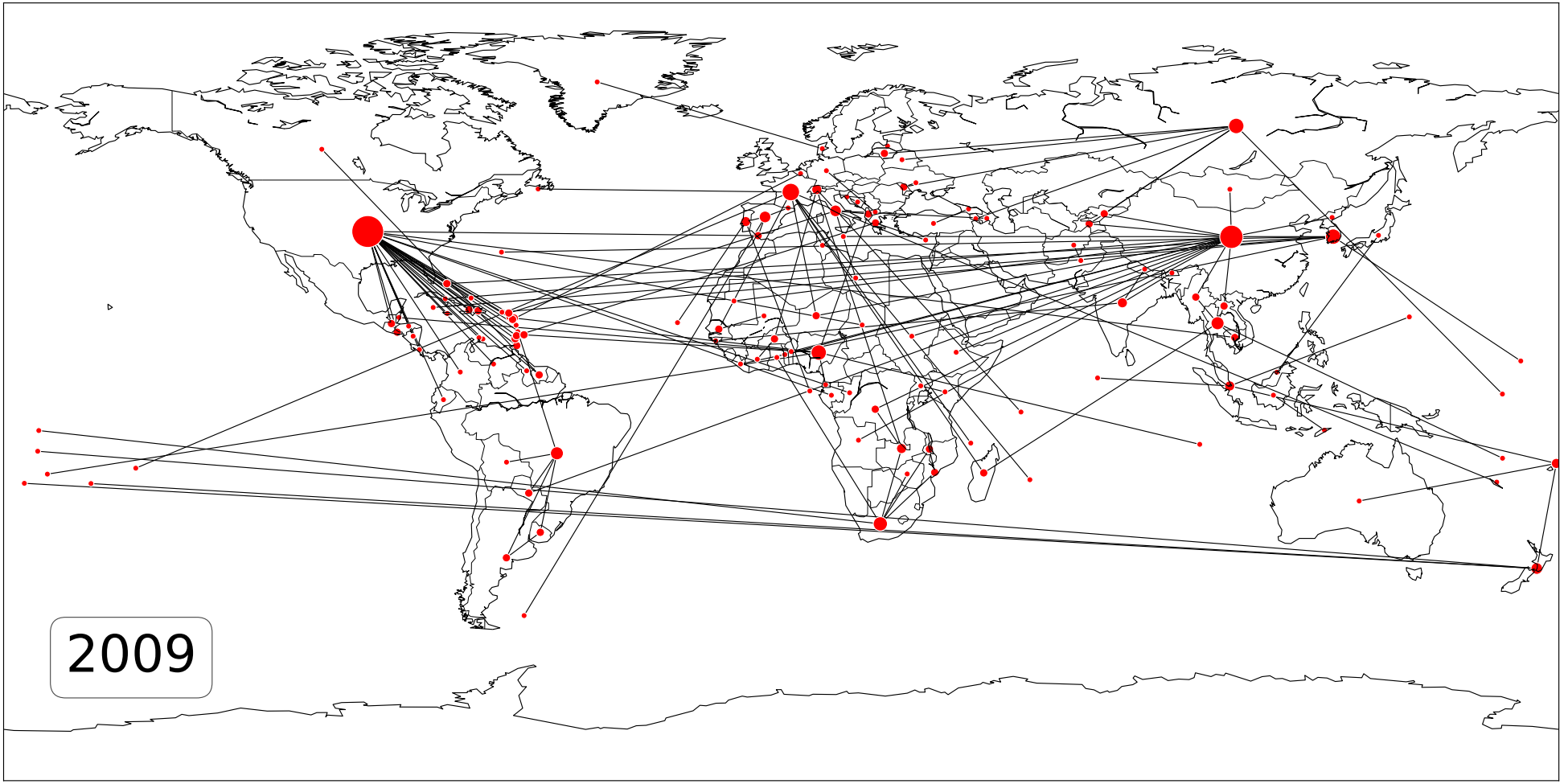

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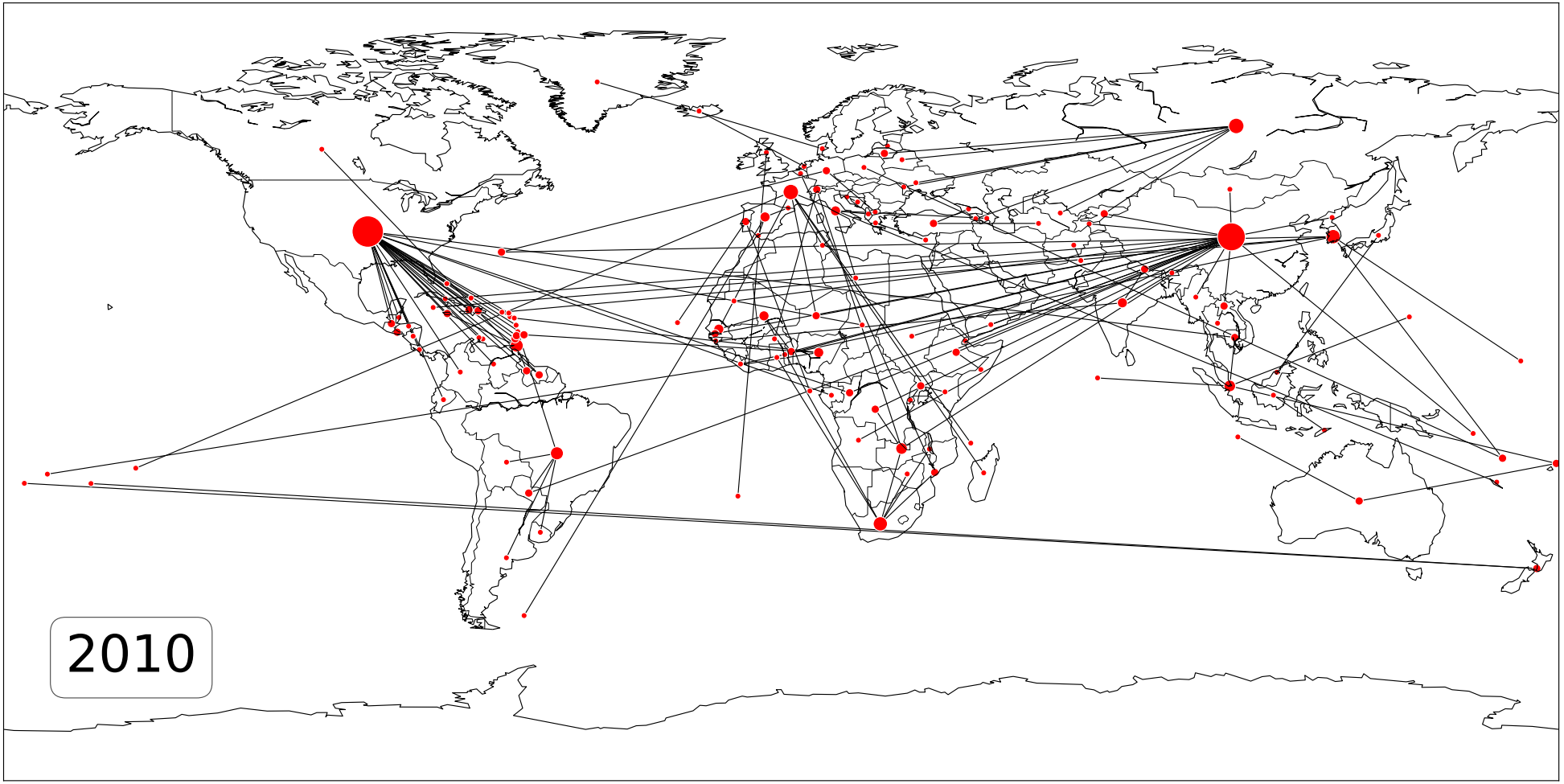

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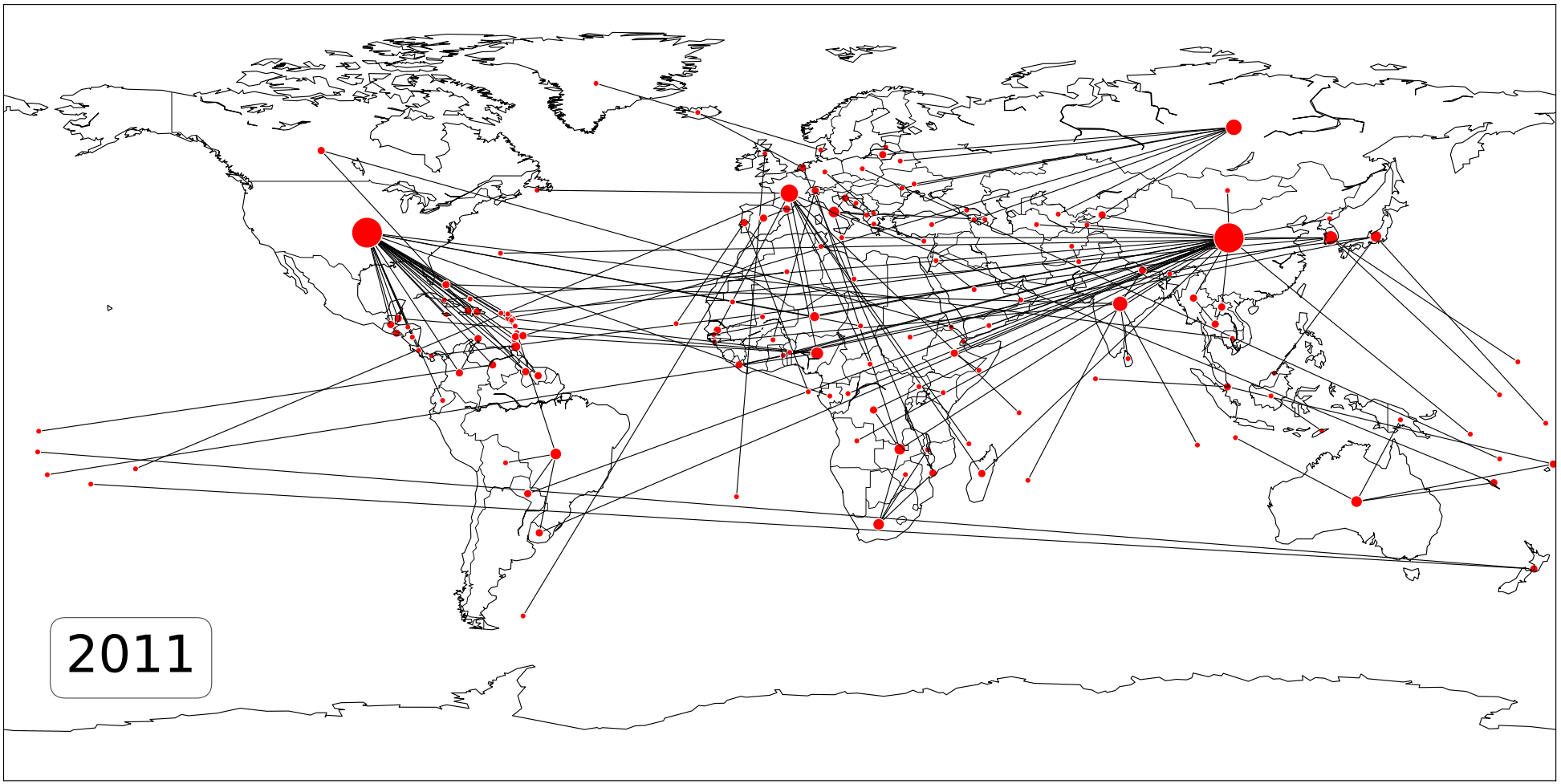

Conclusions

Take home messages

Filtering is becoming a more and more required step to continue using networks in complex systems.

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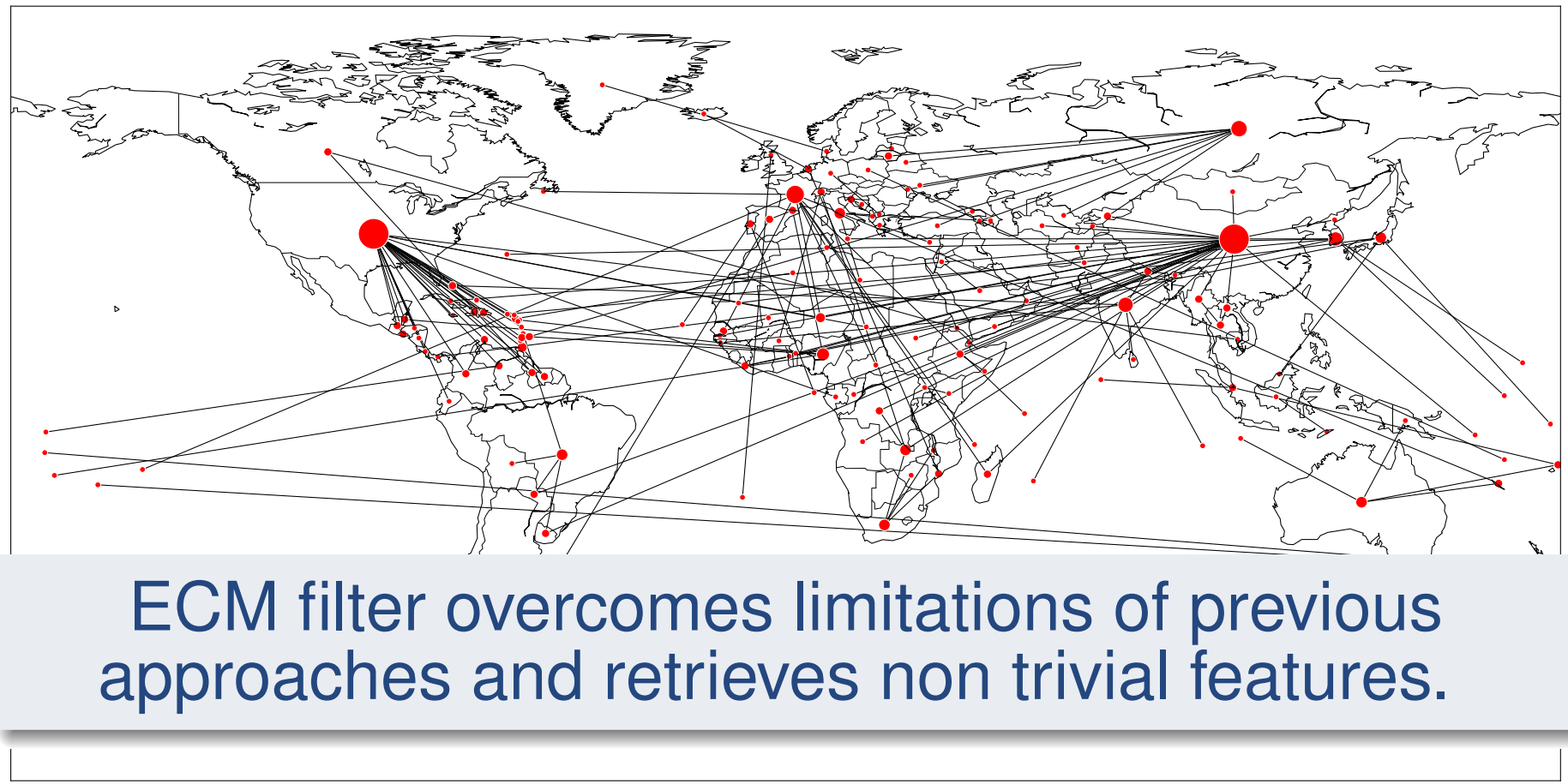
Take home messages



ECM filter overcomes limitations of previous approaches and retrieves non trivial features.

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Acknowledgements

Diego Garlaschelli

Valerio Gemmetto

Acknowledgements

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Wanna know more?

Stay tuned on the arXiv . . .

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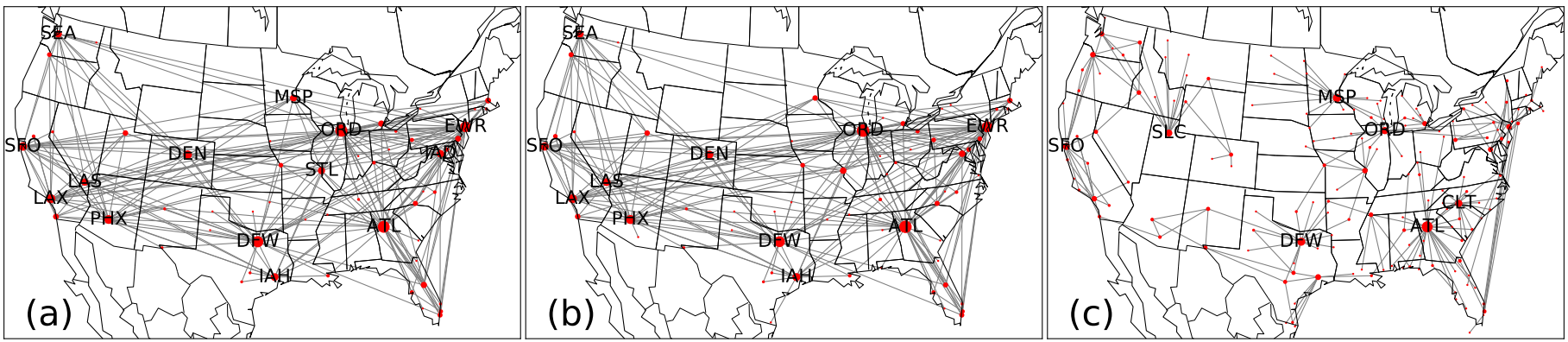
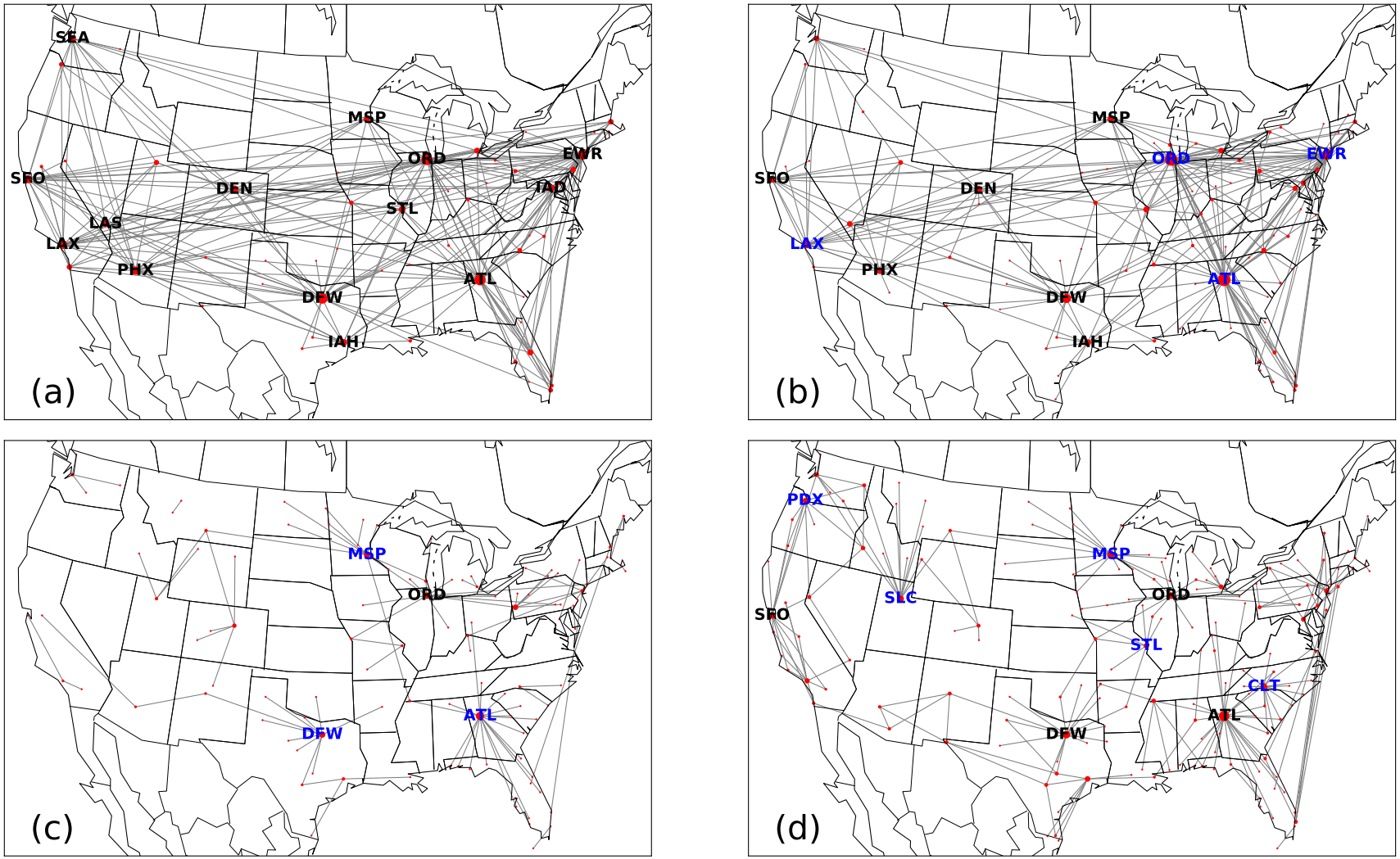
Global vs Local filtering



US Airports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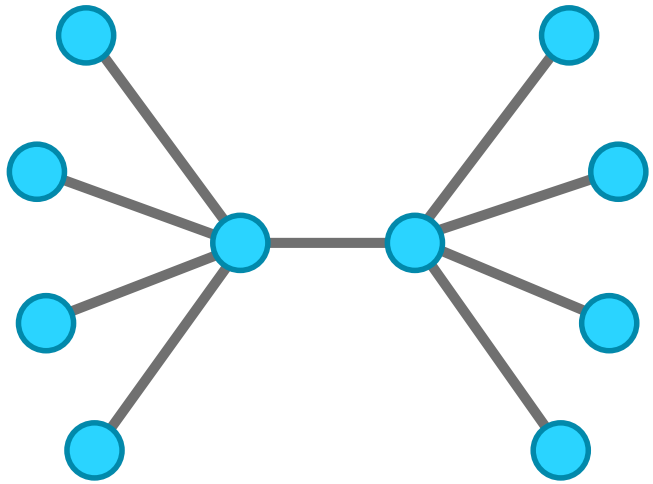
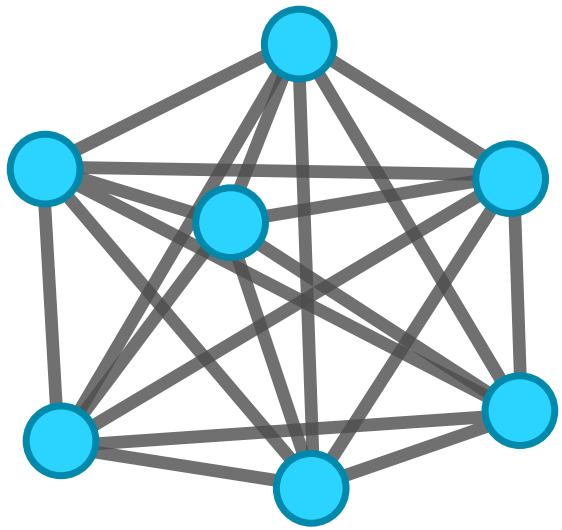
US Airports



Hub and Spoke

Point to Point



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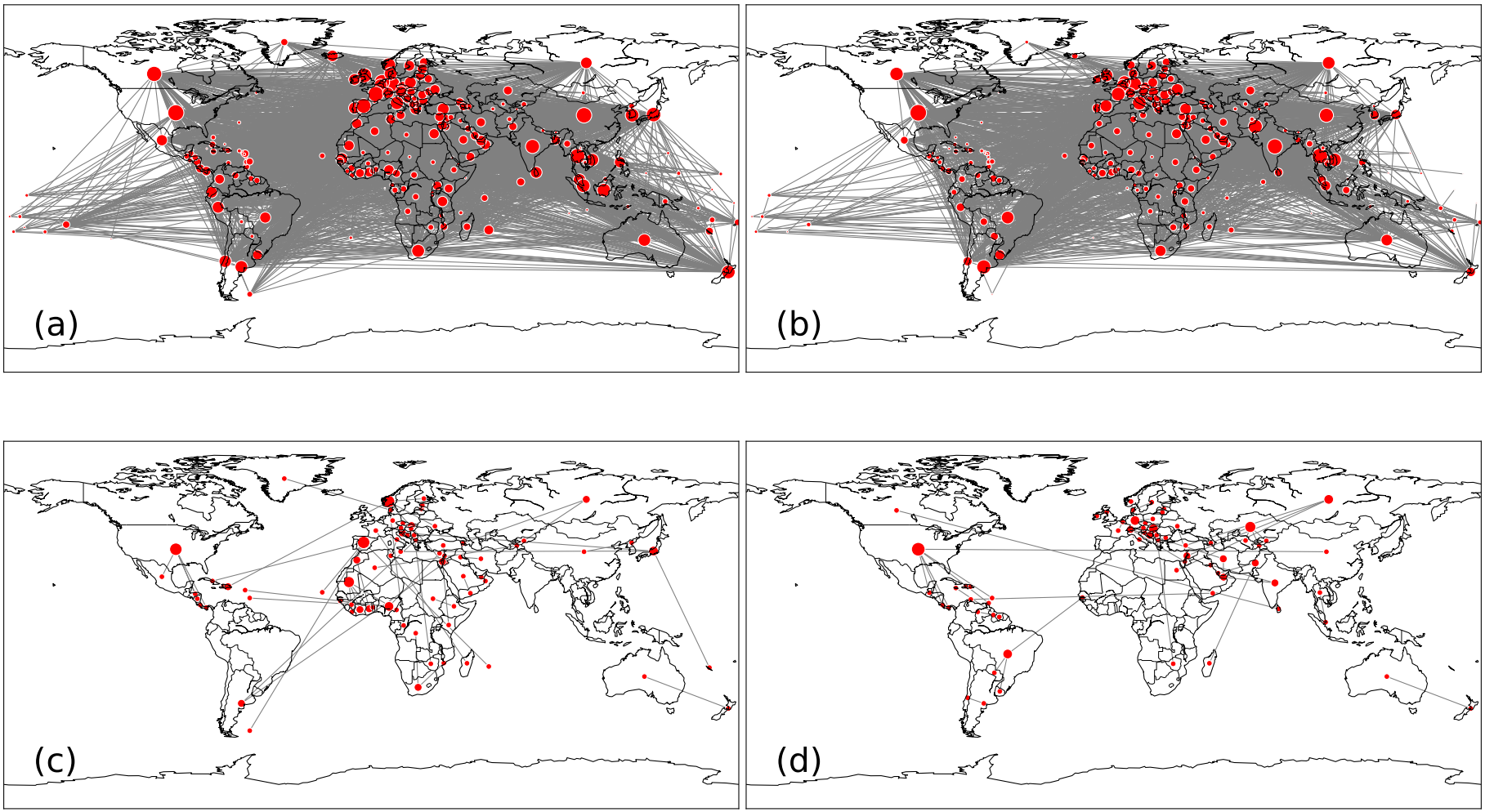
Trade: single commodities

FISH – CEREALS in 2011



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Trade: single commodities

FUEL – IRON in 2011