Mapping new models of complex data

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Computational social science

Small-scale questionnaire-based approaches

Fingerprints of individuals in electronic media (offline: mobile phone, or online: email, Facebook, etc.)
+ Large-scale experiments in online media

Possibility to analyse the dynamics and organisation of large-scale social systems

D. Lazer, A. Pentland, L. Adamic, S. Aral, A.-L. Barabási, D. Brewer, N. Christakis, N. Contractor, J. Fowler, M. Gutmann, T. Jebara, G. King, M. Macy, D. Roy, M. Van Alstyne, Science 323, 721-724 (2009).

Social scientists
(their interactions)

Psychologist
(people)

Urban planners
(where they live)

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Physicists
(models)

Computer scientist
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Applied mathematician
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M. Szell (MIT) and S. Thurner (Vienna) => Online games

E. Fleury (ENS Lyon), A. Friggeri (Facebook), and D. Quercia and M. Kosinski (Cambridge) => Personality

Mason Porter and Till Hoffman (Oxford) => Modeling of temporal networks

Tim Evans (Imperial College) and Pietro Panzarasa (Queen Mary) => Communities

Michael Gastner (Bristol) => Mobility

Vsevolod Salnikov (UNamur) => App development, and networks

Lionel Tabourier (UNamur) and JC Delvenne (Louvain) => Algorithms for temporal nets

Martin Rosvall (Umea) => Communities and ranking

C. Mascolo, A. Noulas (Cambridge) and S. Scellato (Google) => Mobility

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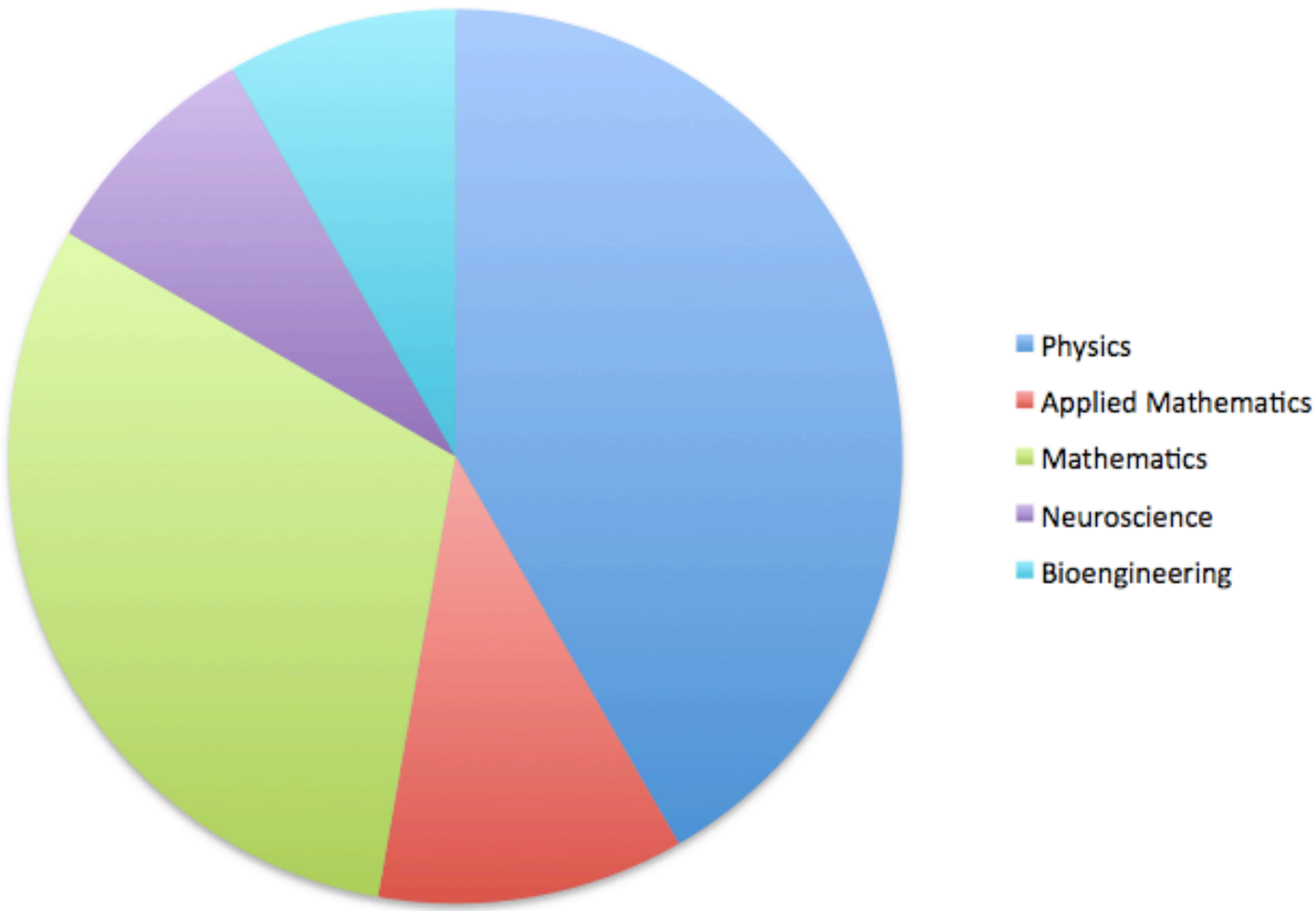

Physicists
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Applied mathematician
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Social scientists
(their interactions)

10^2

Psychologist
(people)

10^0

Urban planners
(where they live)

10^4-10^6

Physicists
(models)

∞

Computer scientist
(data)

10^6-10^9

10^6-10^9

Applied mathematician
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Social scientists
(their interactions)

10^2

Psychologist
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10^0

Urban planners
(where they live)

10^4-10^6

Different scales
Different methodologies
Different interests

Yet the same problem

Bridge the gap
Enhance the dialogue between the fields

Physicists
(models)

∞

10^6-10^9

Applied mathematician
(algorithms)

Computer scientist
(data)

10^6-10^9

Plethora of new services - new opportunities

Interweaving the social and the physical world
Offering more and more refined data about individuals and their interactions

New data need new methods and new models

New models?

Call Data Records Database

Cell site location		Cell site location								
Cell ID (A)		Cell ID (B)								
Start cell	End cell	Start cell	End cell	Number making call (A)	Number receiving call (B)	Start date/time	Call duration (min:sec)	Call type	CDR type	Dialled digits
'0301063492	'	'	'	447875477828	'	03/12/2010 20:40	01:12	PS	GPRS	'
'0014451843	'	'	'	447875477828	'	03/12/2010 20:41	00:14	PS	GPRS	'
'0301052339	'	'	'	447875477828	'	03/12/2010 20:41	51:34:00	PS	GPRS	'
'	'	'0301052339	'0301052339	447875477828	447772000987	03/12/2010 20:54	00:12	CS	MTC	'
'0301037492	'0301037492	'	'	447875477828	7772000987	03/12/2010 20:54	00:11	CS	MOC	447772000987
'0014457988	'	'	'	447875477828	'	03/12/2010 21:33	04:47	PS	GPRS	'
'0301052339	'	'	'	447875477828	'	03/12/2010 21:38	21:51	PS	GPRS	'
'0301052339	'	'	'	447875477828	'	03/12/2010 22:00	60:00:00	PS	GPRS	'
'0301052339	'	'	'	447875477828	'	03/12/2010 23:00	60:00:00	PS	GPRS	'
'	'	'	'	'7708026012	7875477828	03/12/2010 23:52	00:02	CS	PSTNO	07875477828
'6553565535	'6553565535	'	'	447875477828	1447875477828	03/12/2010 23:52	00:02	CS	CF	'
'	'	'	'	7875477828	1447875477828	03/12/2010 23:52	00:02	CS	CTR	'
'	'	'0301037492	'	'447708026012	447875477828	03/12/2010 23:52		SMS	SMST	'

Location, mobility, etc.

Social relations

Timings

New models?

Model: complex data are seen through the prism of an abstract model, which allows for the use of formal methods, and an interpretation of the system

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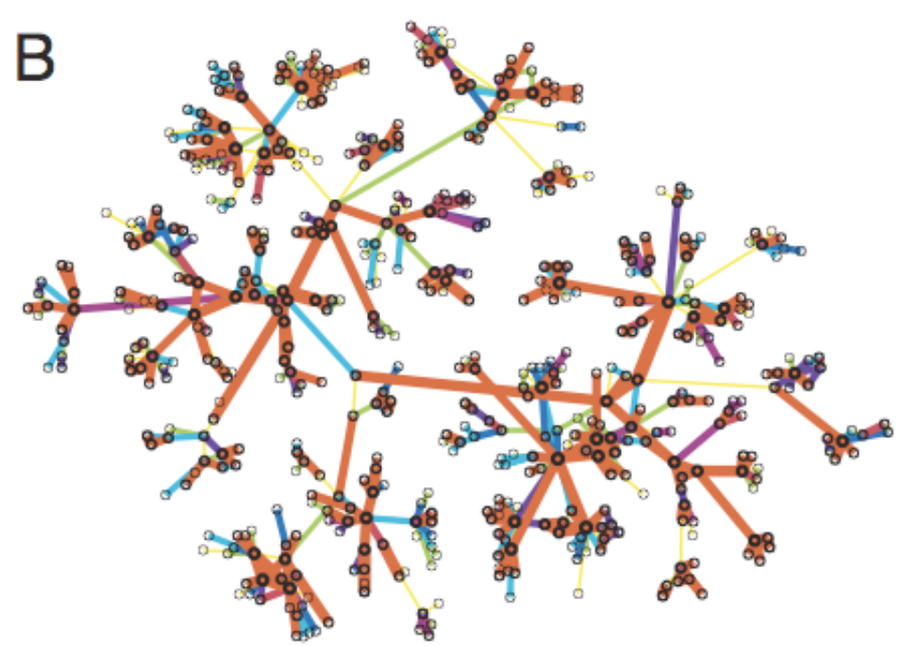
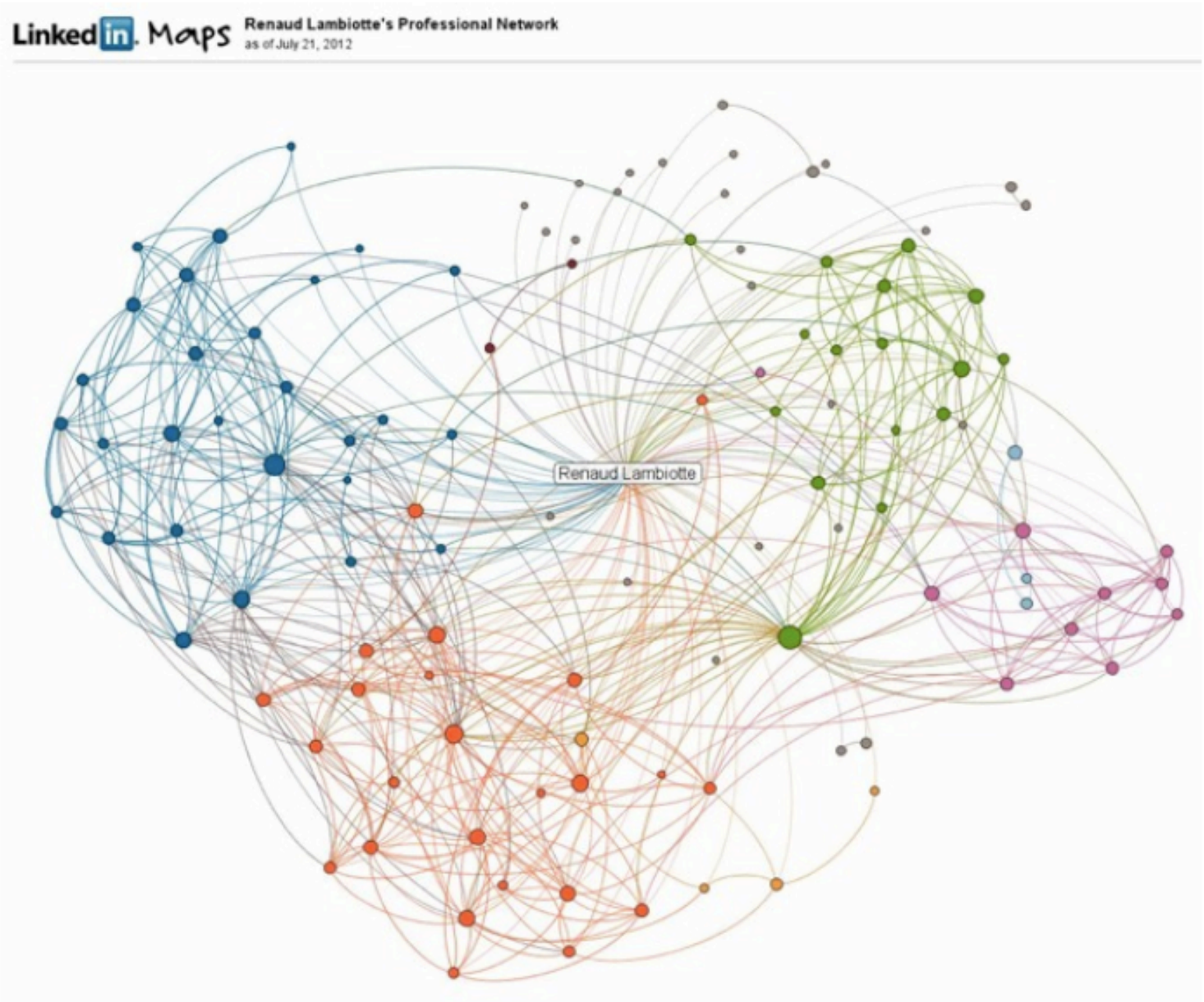
Network paradigm: nodes connected by weighted edges



Network toolbox

Algorithms for network visualisation, community detection, centrality, role detection, etc.



Network science in a nutshell

Say that one wants to model epidemic spreading

a) Construction of a network from empirical data, e.g. airline transportation network

b) Definition of a model for epidemic spreading, e.g. meta-population model

Effect of topology on spreading

Modeling step

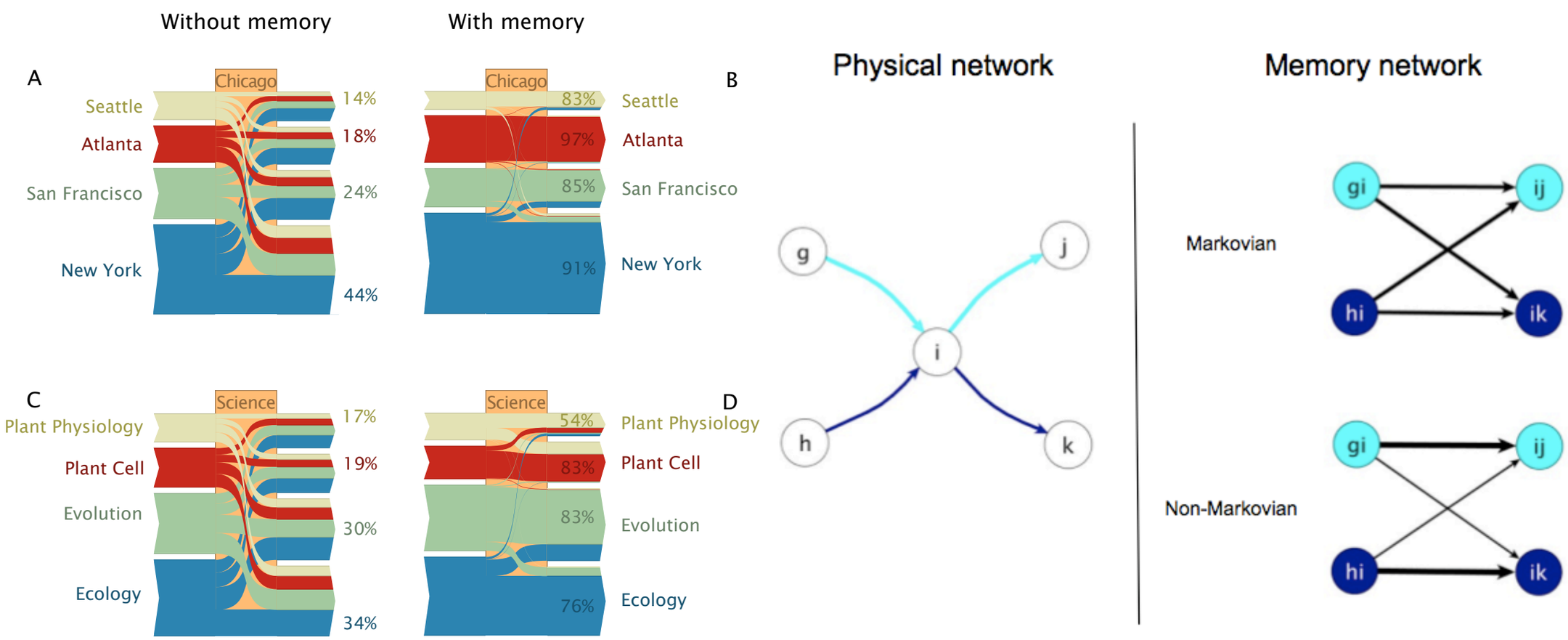
Real-world trajectories of the users are not considered: all that matters are fluxes between node (airports)

Exact timings at which users meet are not considered: all that matters are fluxes between node (airports)

Now that such data is available: Accuracy of the network paradigm? Other paradigms?

Networks with memory

Second-order Markov: transitions from directed edges to directed edge (memory node)
Mathematics of pathways instead of edges



Networks with Memory, Martin Rosvall, Alcides V. Esquivel, Andrea Lancichinetti, Jevin D. West, Renaud Lambiotte, arXiv: 1305.4807
Slow-Down vs. Speed-Up of Information Diffusion in Non-Markovian Temporal Networks, I Scholtes, N Wider, R Pfitzner, A Garas, C Juan Tessone and F Schweitzer, arXiv:1307.4030

Toolbox for pathways

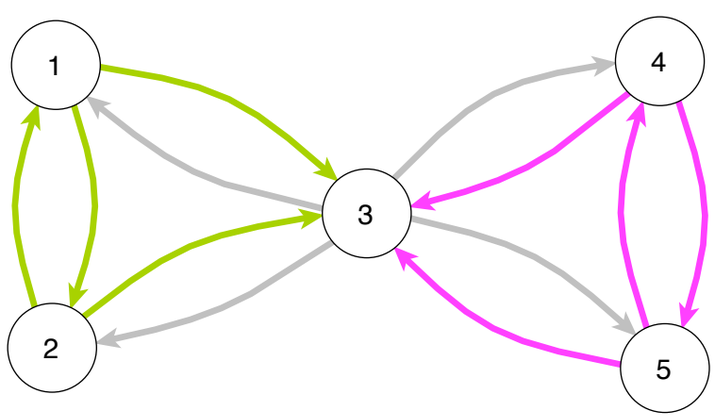
In several empirical systems: memory constraints on flow are statistically significant and temporal correlations strongly modify flows of probability.

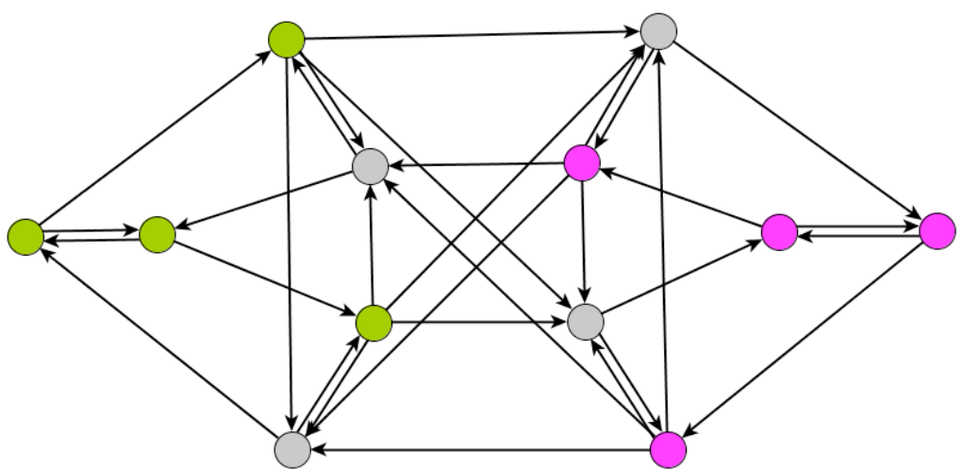
Memory networks are networks, but

- they are much, much larger => computational complexity

- they have a very different structure => require new tools

First insight on community detection, ranking, spreading, but their is a need for appropriate visualisation, statistical and algorithmic tools.





Financial Support

IAP (Belspo): Applied Mathematics

FNRS: Temporal networks

ESF COST: KnowEscape

Postdoc opening

Lectureship