NEMO: EC-project in 6th FP
Network Models, Governance and R&D collaboration networks

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NEMO is a three-year project (2006-2009) supported by the New and Emerging Science and Technology programme of the sixth Framework Programme of the European Commission. NEMO studies ways to optimize the structure of R&D collaboration networks for creating, transferring and distributing knowledge. The Mathematical Physics department of the University of Bielefeld (Prof. Philippe Blanchard), Germany, is involved in work package 2 "Structure and dynamics of complex random graphs and associated processes". *The following are images from our 5 years of (pre-)NEMO research. Similar work is now being carried out in the IRU.*

Network Analysis

Studies and compares databases with respect to connectivity ...

NEMO *Bipartite Network* from ***Organisations*** and **Projects** in CORDIS database (FP = Framework Programme)

then Organisations-Projection (connect when common project)

then SNA = (Social) Network Analysis with standard measures

graph characteristic	FP1	FP2	FP3	FP4
# vertices: N	2500	6135	9615	20873
(N for larg. comp.)	(2038)	(5875)	(8920)	(20130)
N outside larg.comp.	462	260	695	743
# edges: M	9557	64300	113693	199965
(# edges M larg.comp.)	(9410)	(64162)	(113219)	(199182)
mean degree: $\bar{d}$	7.65	20.96	23.65	19.16
($\bar{d}$ larg.comp.)	(9.23)	(21.84)	(25.39)	(19.79)
maximal degree: $d_{\max}$	140	386	648	649
mean triangles per vertex: $\triangle$	22.90	169.70	244.91	146.04
($\triangle$ larg.comp.)	(27.97)	177.16	263.84	151.26
maximal triangle-number	966	5295	15128	10730
cluster coefficient: $\bar{C}$	0.57	0.72	0.72	0.79
($\bar{C}$ larg. comp.)	(0.67)	(0.74)	(0.75)	(0.81)
number of components	369	183	455	467
diameter of largest component	9	7	9	10
mean path length: λ of l.c.	3.70	3.27	3.32	3.59
exponent of degree distribution	-2.1	-2.0	-2.0	-2.1
variance of degree exponent	0.4	0.3	0.3	0.3
exponent of org-size distr.	-2.1	-1.9	-1.7	-1.8
variance of size exponent	0.5	0.3	0.5	0.3
mean # projects per org: $\mathbb{E}(\|O\|)$	2.40	4. 87	5.6	6.24
maximal size ($\max \|O\|$)	130	82	138	172

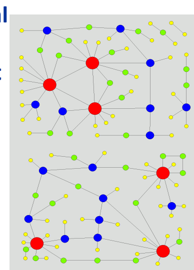
TABLE II: Basic network properties of FP1–4 organizations projection.

Synthetic Networks

Create random networks to identify which measurements are essential

"degree" of a network node = number of neighbors

Networks with **identical** degree distributions can have **very different degree correlations.**



We compared the NEMO empirical networks with differently generated synthetic random networks.

Communication Index

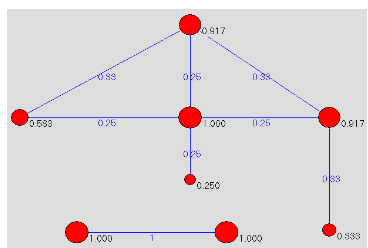
Some networks are balanced better with respect to communication...

Our new network measure is a proxy to estimate the communication saturation of nodes in networks

communication edge weight (blue numbers) = $min(\frac{1}{\deg(x)}, \frac{1}{\deg(y)})$

node-sum (black numbers) = sum of all edge weights around one node

mean value (of all black numbers) in this example network:
0.75 = "communication index" of the network



Generalised Epidemic Process

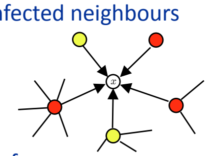
Knowledge Diffusion Model

$\omega(x, t)$ in [0,1]
= node x is knowing / not-knowing at time t

Local infection:

$\Omega(x, t)$ = number of infected neighbours

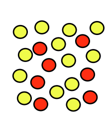
$$= \sum_{y \sim x} \omega(y,t)$$



Mean-field infection:

b_t = total prevalence of knowing nodes at time t

$$b_t = \frac{1}{|V|} \sum_{y \in V} \omega(y,t)$$



Generalised Epidemic Process

Knowledge Diffusion Model

Several ***competing*** and ***resonating*** processes:

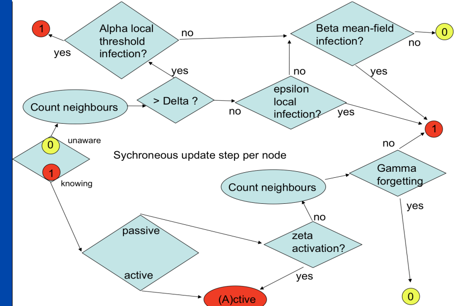
- local infection:
  - classical epidemics (linear, like a flu)
  - **threshold epidemics if $\Omega(x, t) \geq \Delta$**
- mean-field infection (e.g. by mass media)
- passive knowledge can become active knowledge
- active knowledge cannot be forgotten

Initial infection:

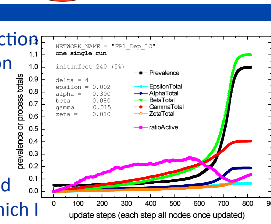
"seed group" of interconnected nodes

- done for each node
- synchronous update (no path dependence)
- runs until stagnation (nothing happens anymore)
- intermediate and end results are stored

Studied: dependence on initial infection



From 5% initial infection into 100% stagnation within 800 time steps ...



"Delta Δ" is the threshold of infected neighbours above which I am strongly susceptible to the (new) knowledge.

"End prevalence" is the average outcome of a single infection run.