Complex Systems and Networks

Prof. Yamir Moreno

Complex Systems and Networks Lab (COSNET),
Institute for Biocomputation and Physics of Complex Systems
& Department of Theoretical Physics
University of Zaragoza, Spain.

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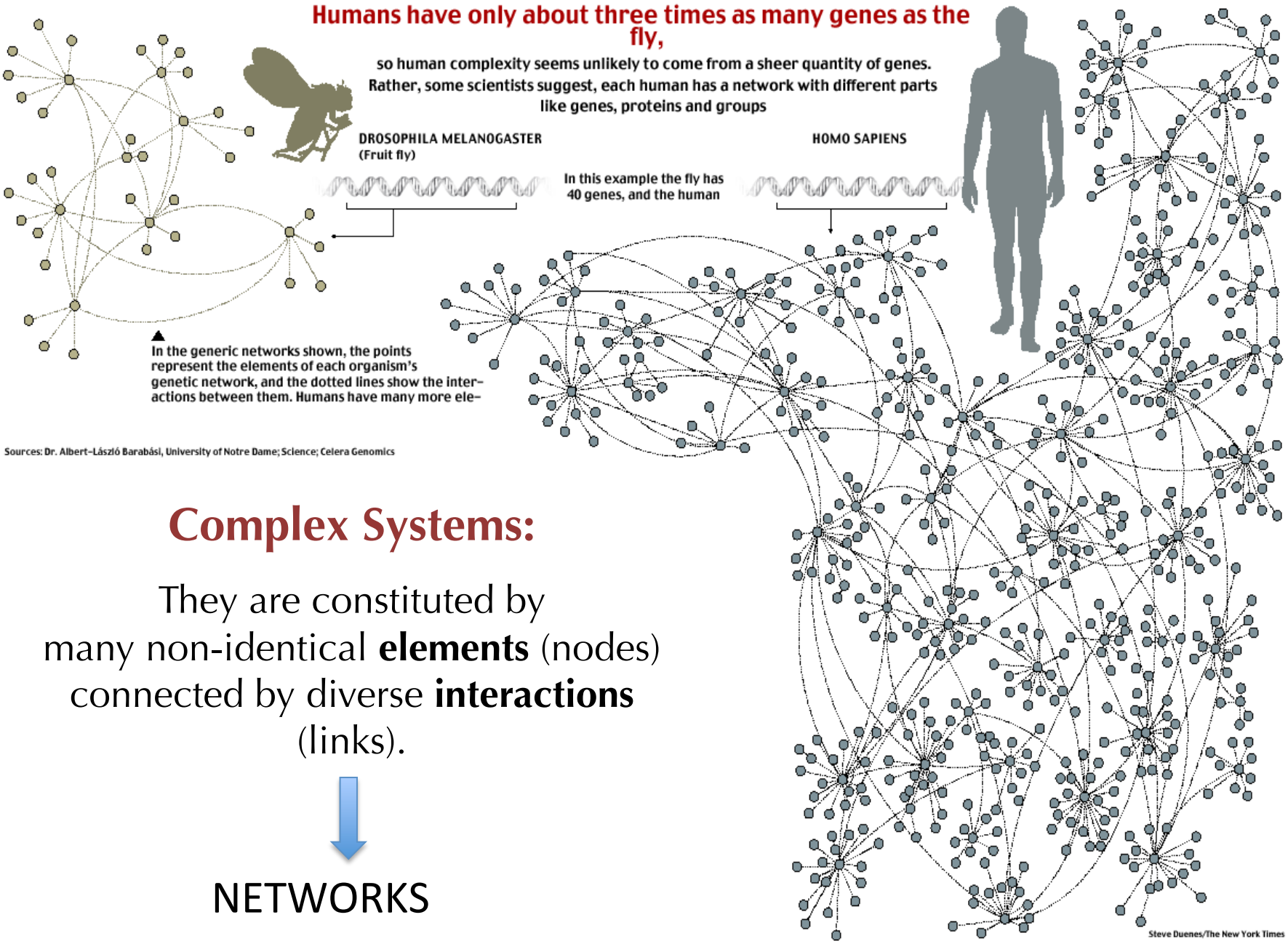


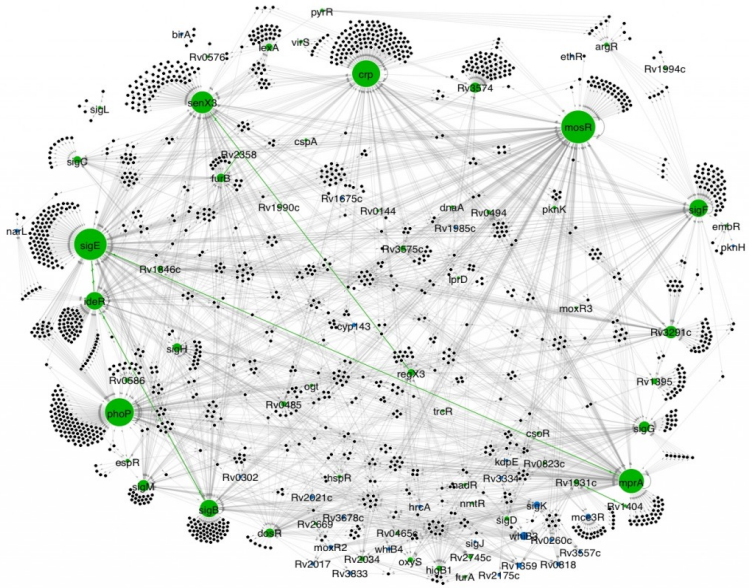
Complex Systems:

They are constituted by
many non-identical **elements** (nodes)
connected by diverse **interactions**
(links).

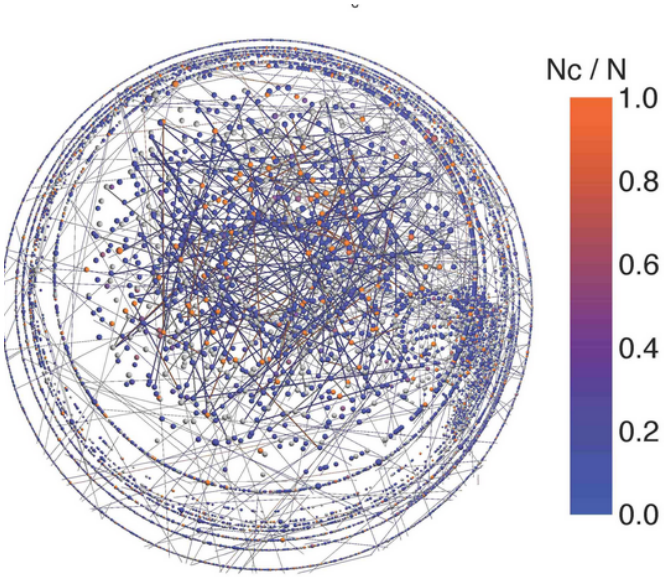
NETWORKS

@ Cosnet_Lab Images

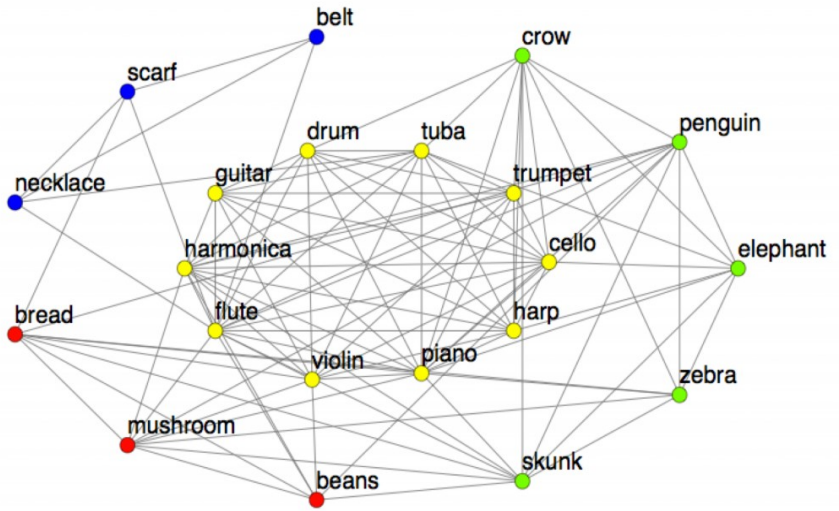
Biological Network *Mtb*



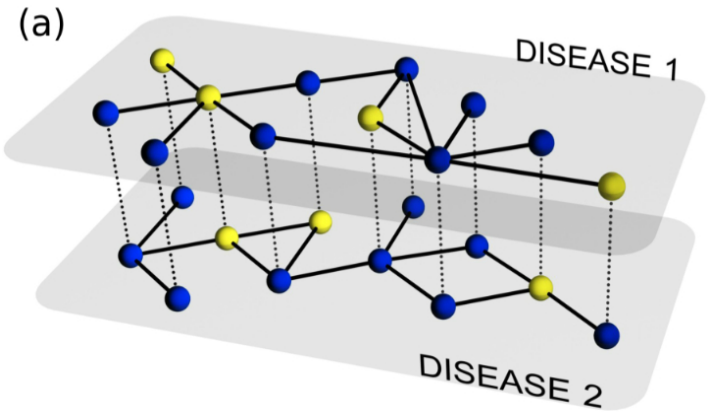
Online Social Network



Semantic Network

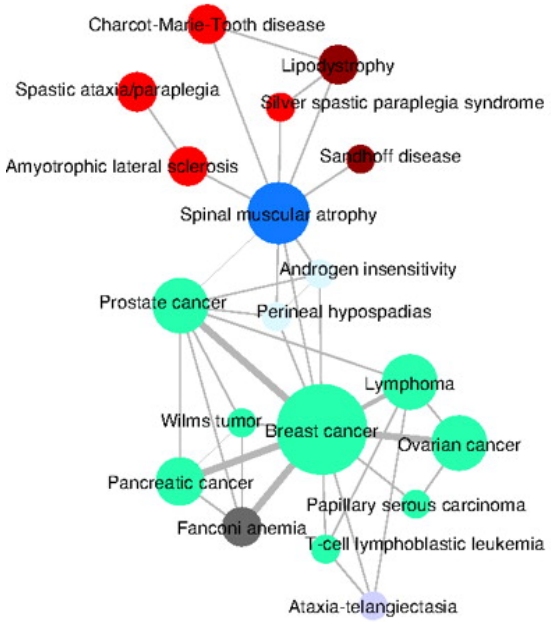


Multiscale-diseases Network (TB-HIV)

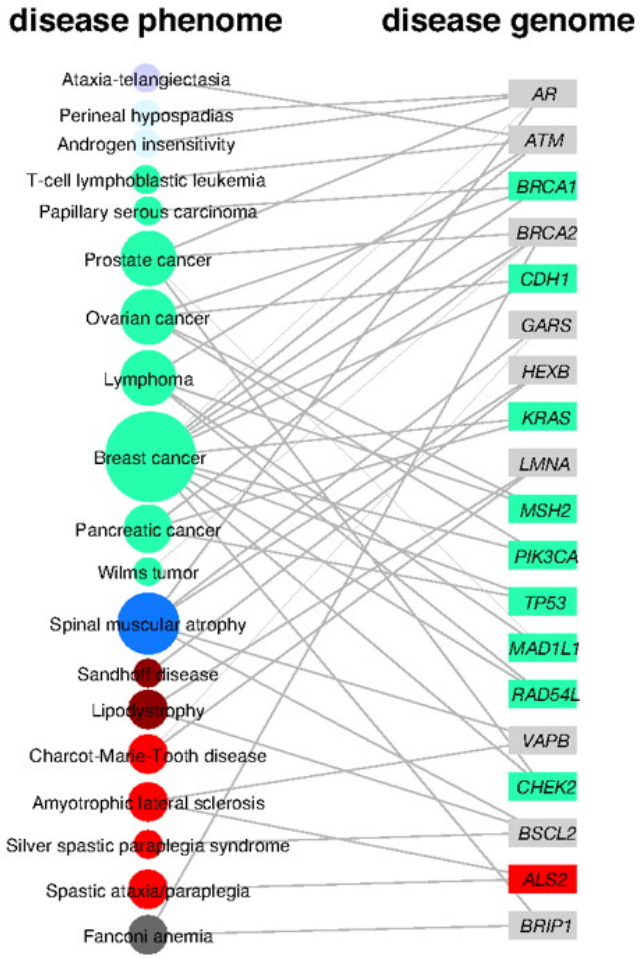


GENE NETWORK – DISEASE NETWORK

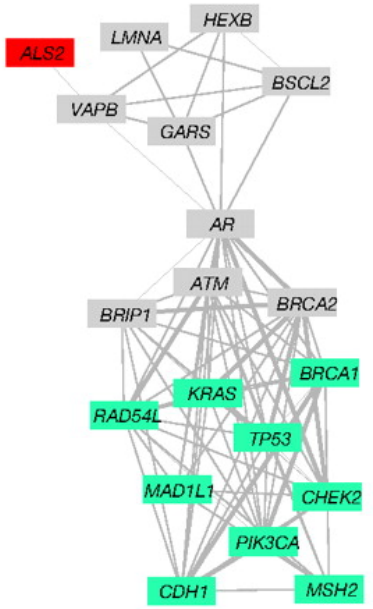
Human Disease Network (HDN)



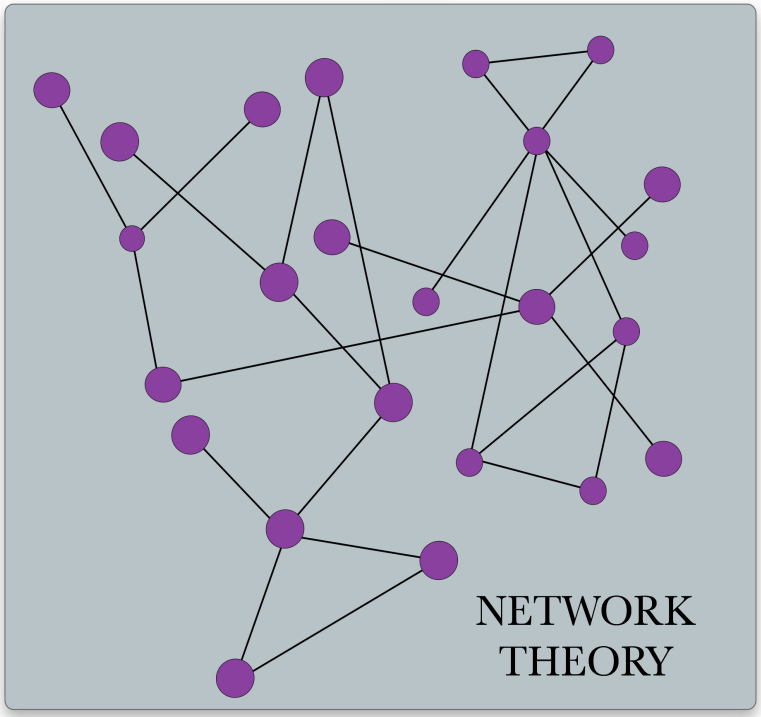
DISEASOME



Disease Gene Network (DGN)



Goh, Cusick, Valle, Childs, Vidal & Barabási, PNAS (2007)



- **Networks are ubiquitous in nature** and everything around us is connected.

- Networks are made up of **nodes** and **links**

- The **connectivity or degree** of a particular node is the number of other nodes it is linked to.

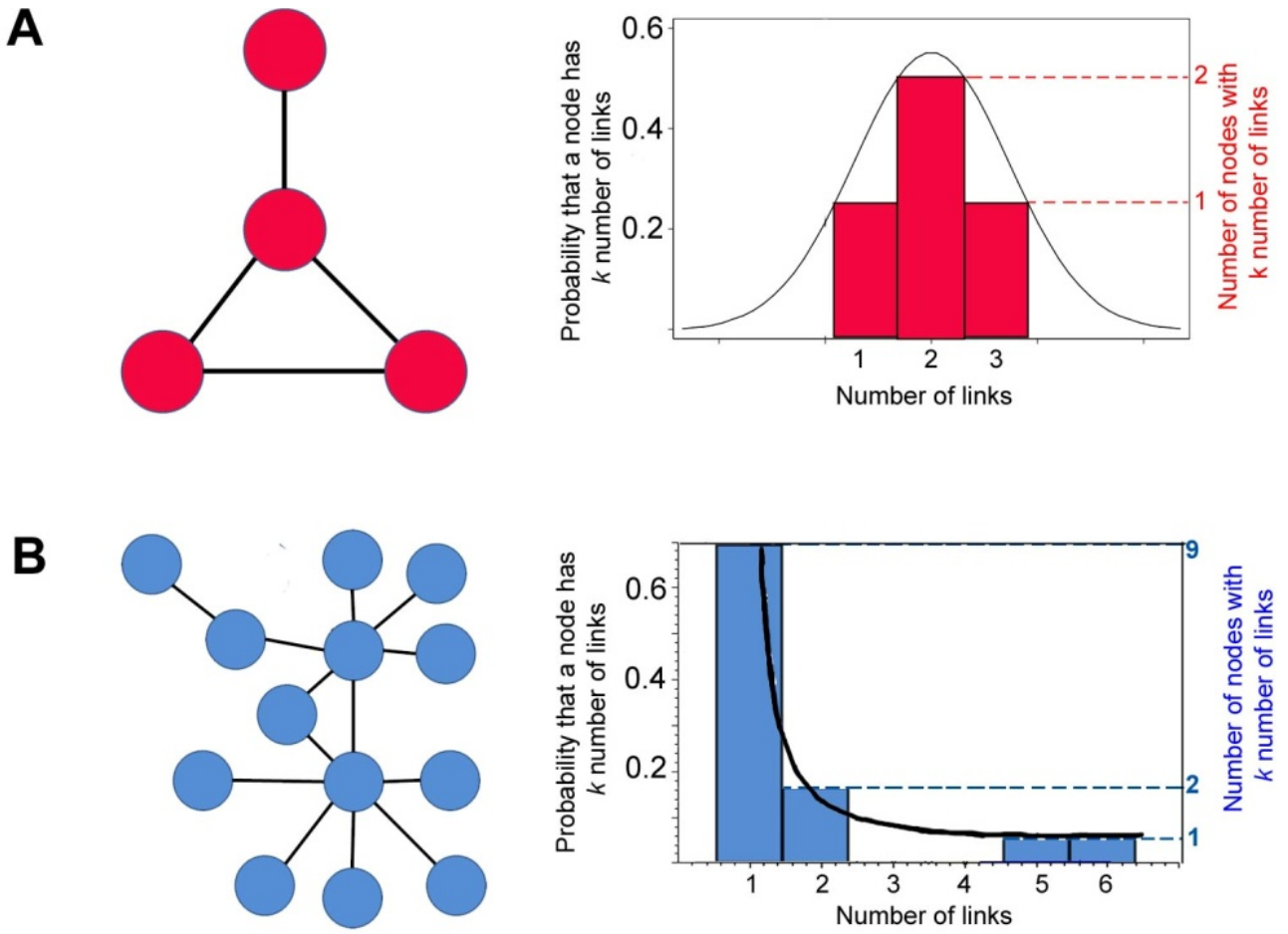
- There are **2 types of networks**:

Homogeneous Networks &
Heterogeneous Networks

Components: nodes, vertices

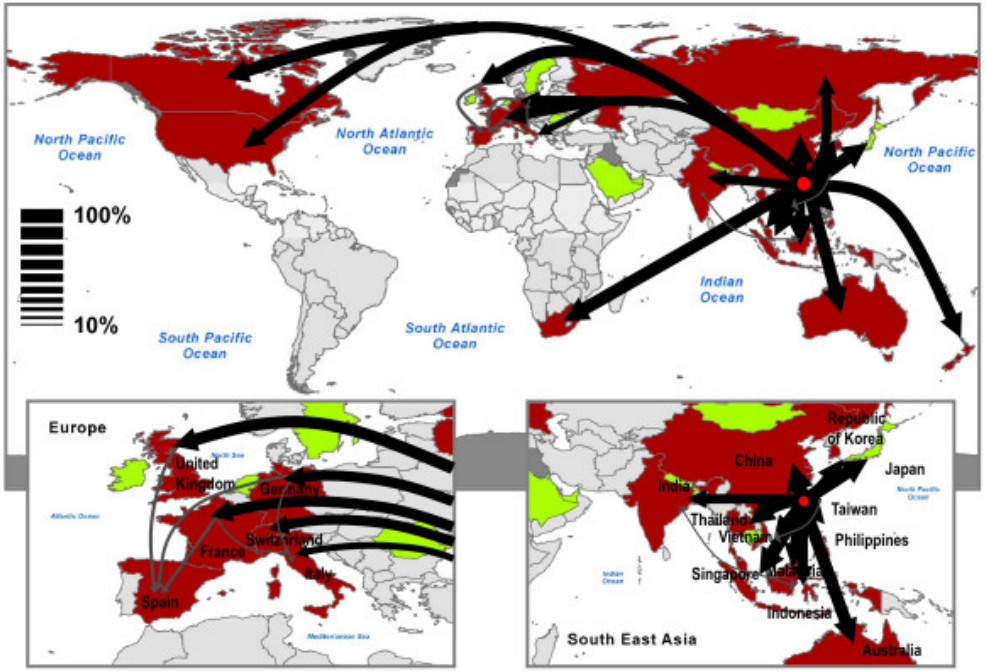
Interactions: links, edges

System: Network, graph



Networks and their corresponding graphs. **(A) Random network** shows a normal distribution and **(B) Scale-free network** shows a power-law distribution when their number or fraction of nodes with different number of links are plotted.

But why is it important?

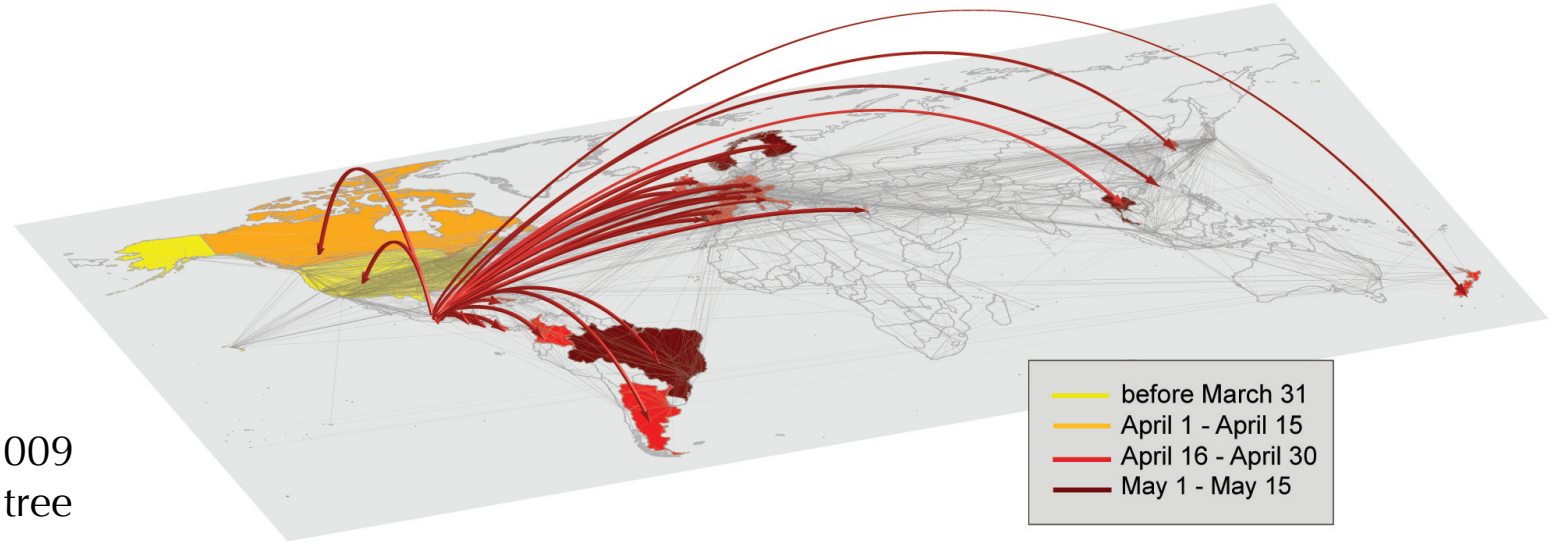


Can we predict the evolution of an epidemic outbreak as we do in weather forecasting?

Why is it difficult? What has changed?

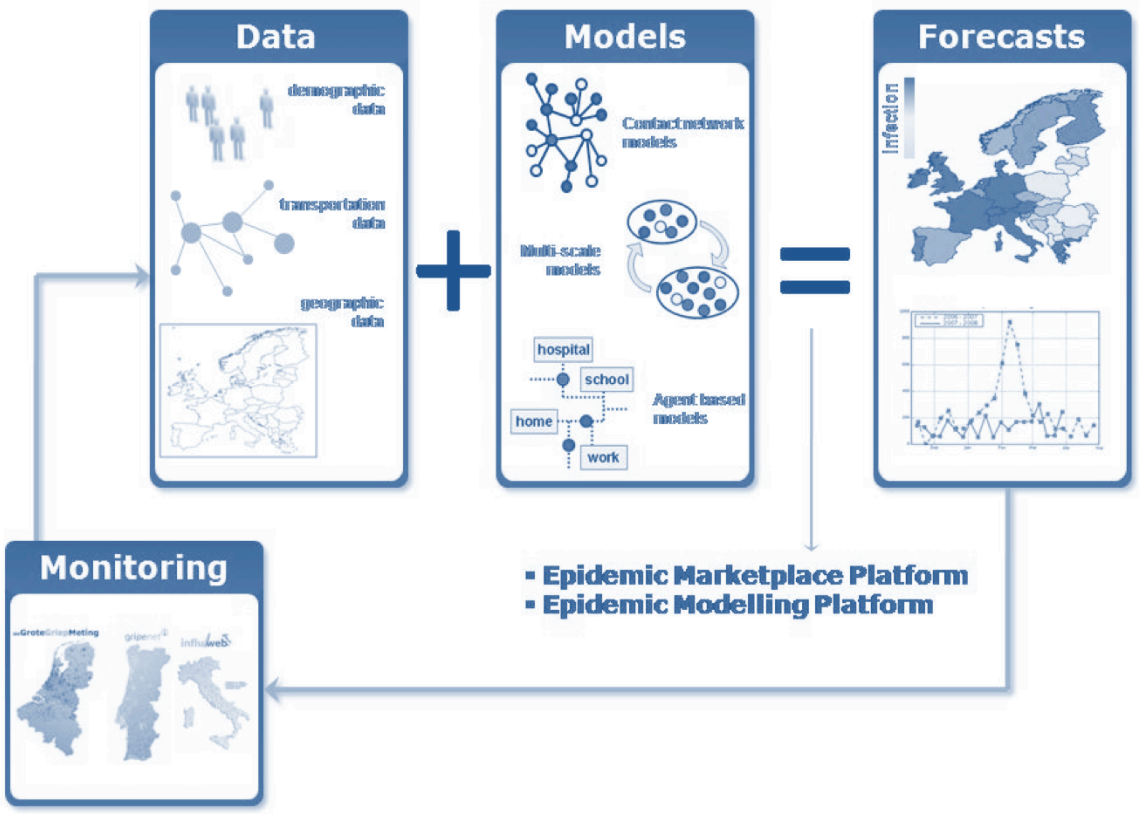
Black Death, Europe, Sicily, 1347

Spread of the Black Death. Spread by merchants and travelers, the plague killed more than a third of Europe's population within five years.

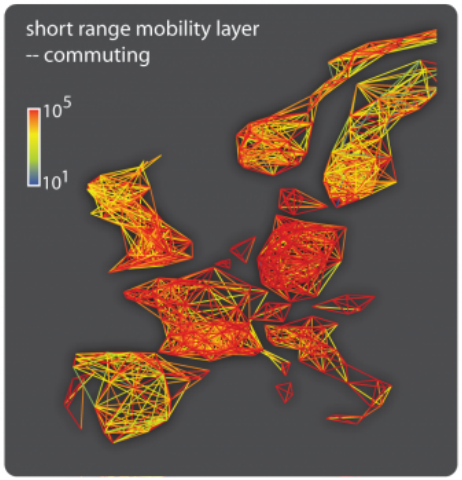


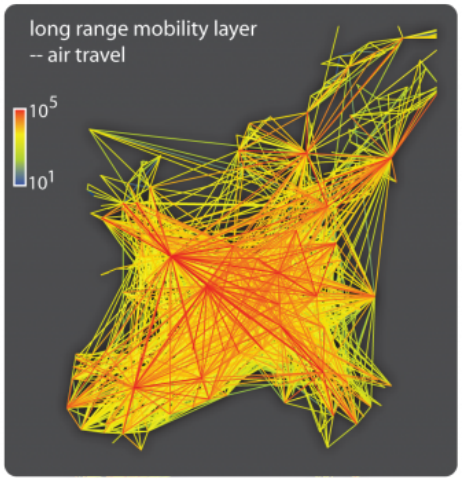
H1N1/ 2009
Invasion tree


FLIGHT
zh
aw
TECHNORAMA



What do we need?





Citizen science and volunteering

Influenzanet

Gripenet.es

Newsletters
Popular science
Historical background
Analysis of scientific methods, etc.

Citizen collaboration

Collection of reliable data at individual level

Information processing

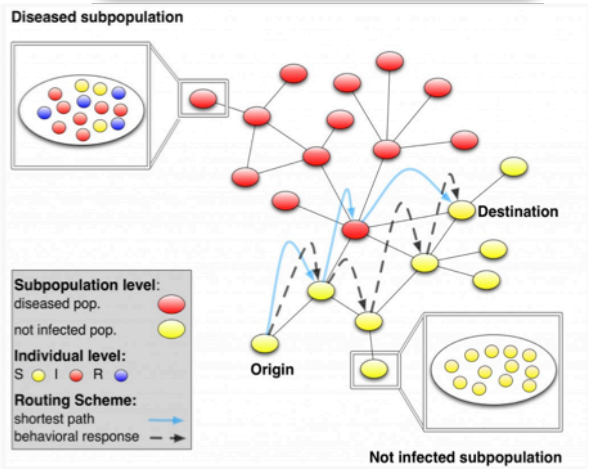
Mathematical & Epidemiological models

Prediction of the evolution of epidemic

Validation

Generating new scenarios

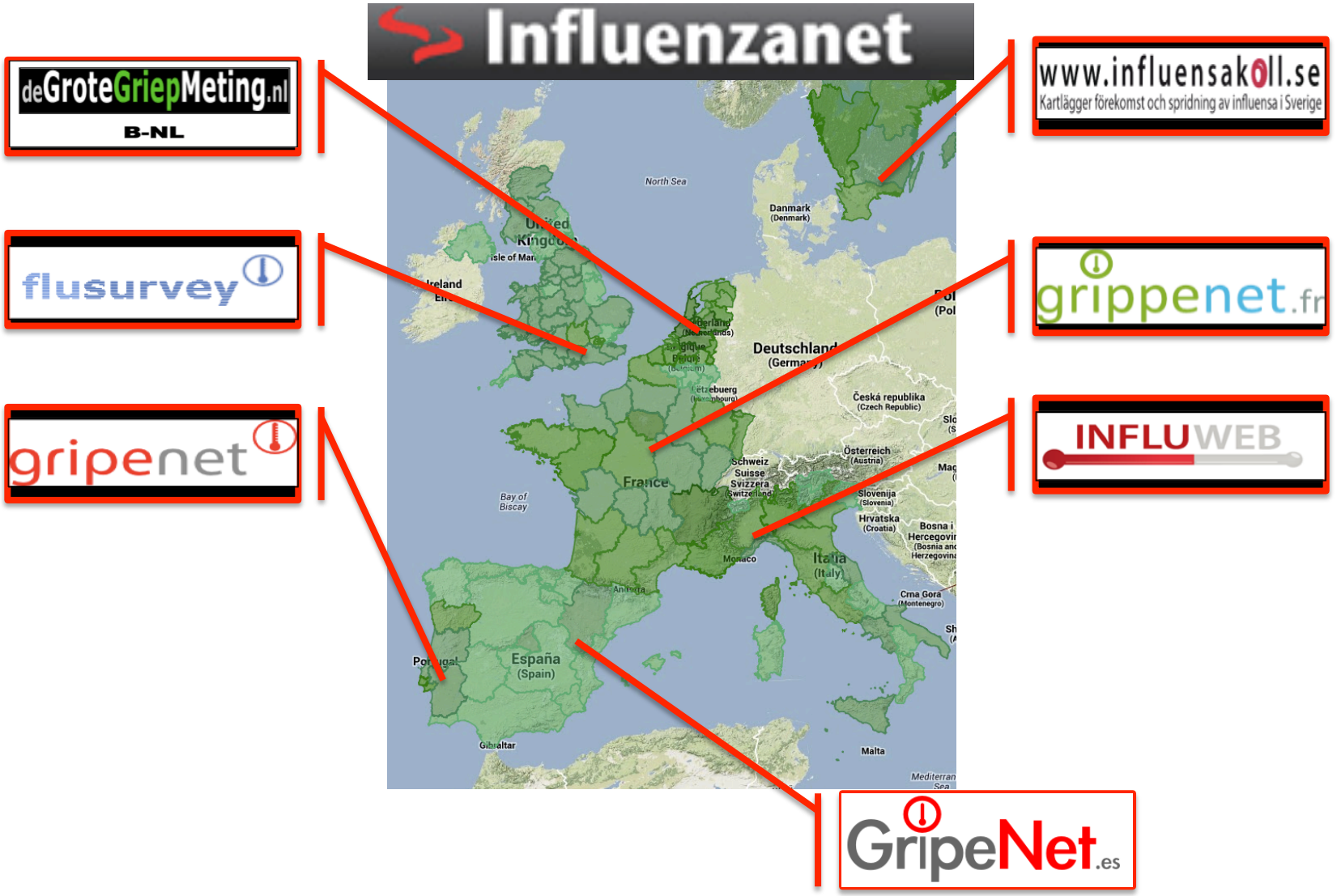
Data+ Models= Prediction



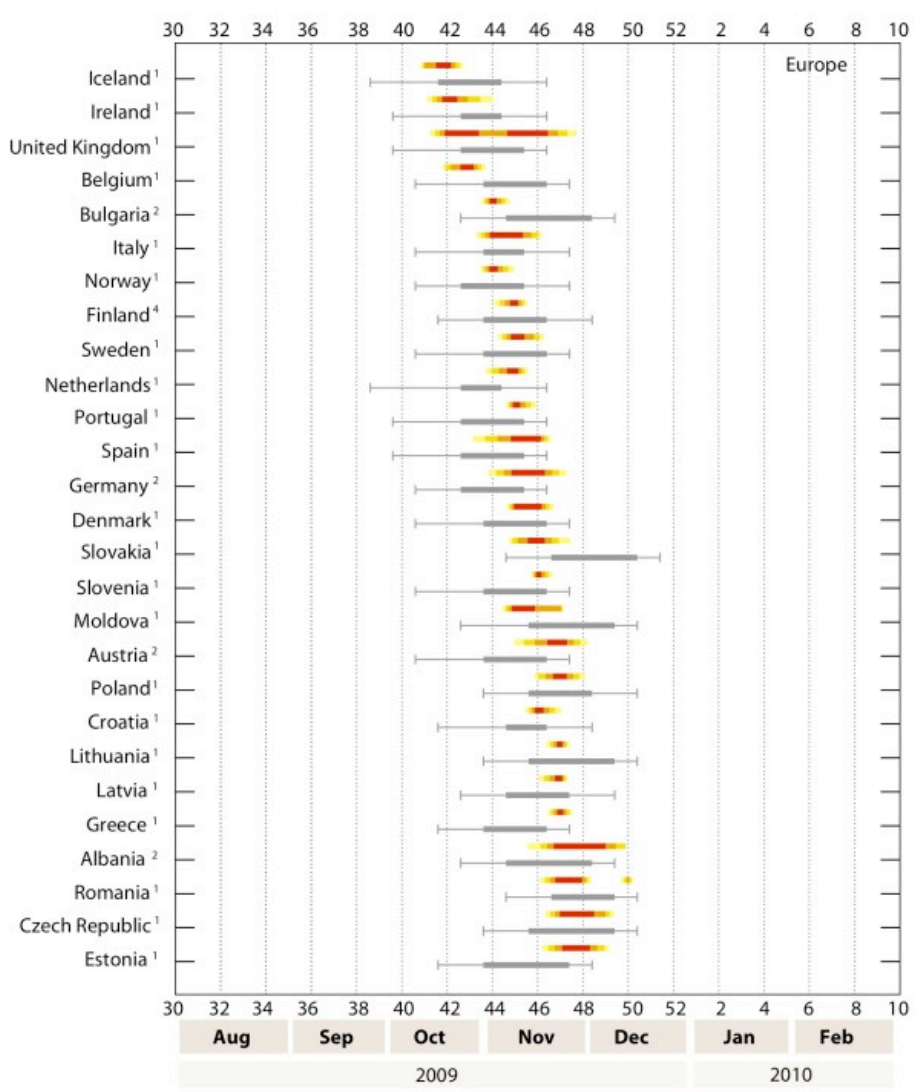
Surveillance & monitoring

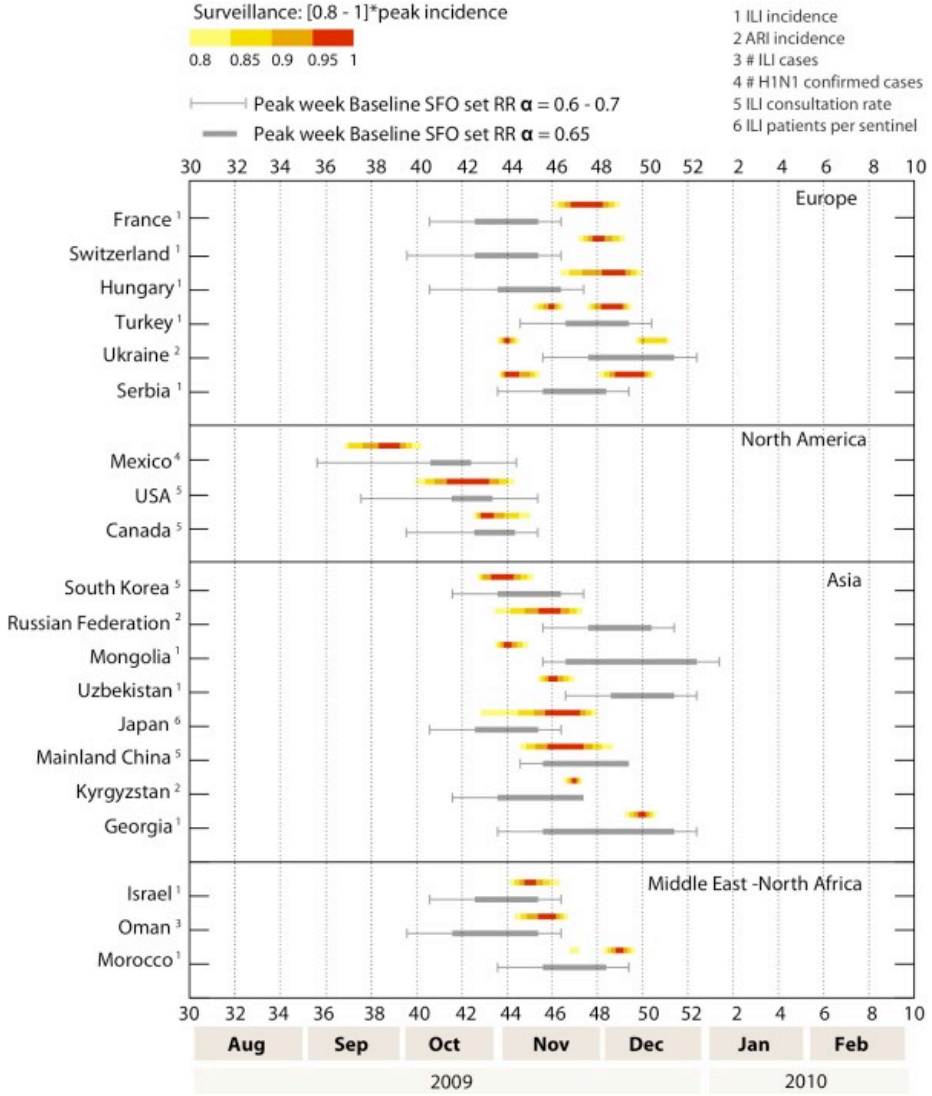
Important applications derived from the epidemiological study

Citizen Science and volunteering



Results: H1N1





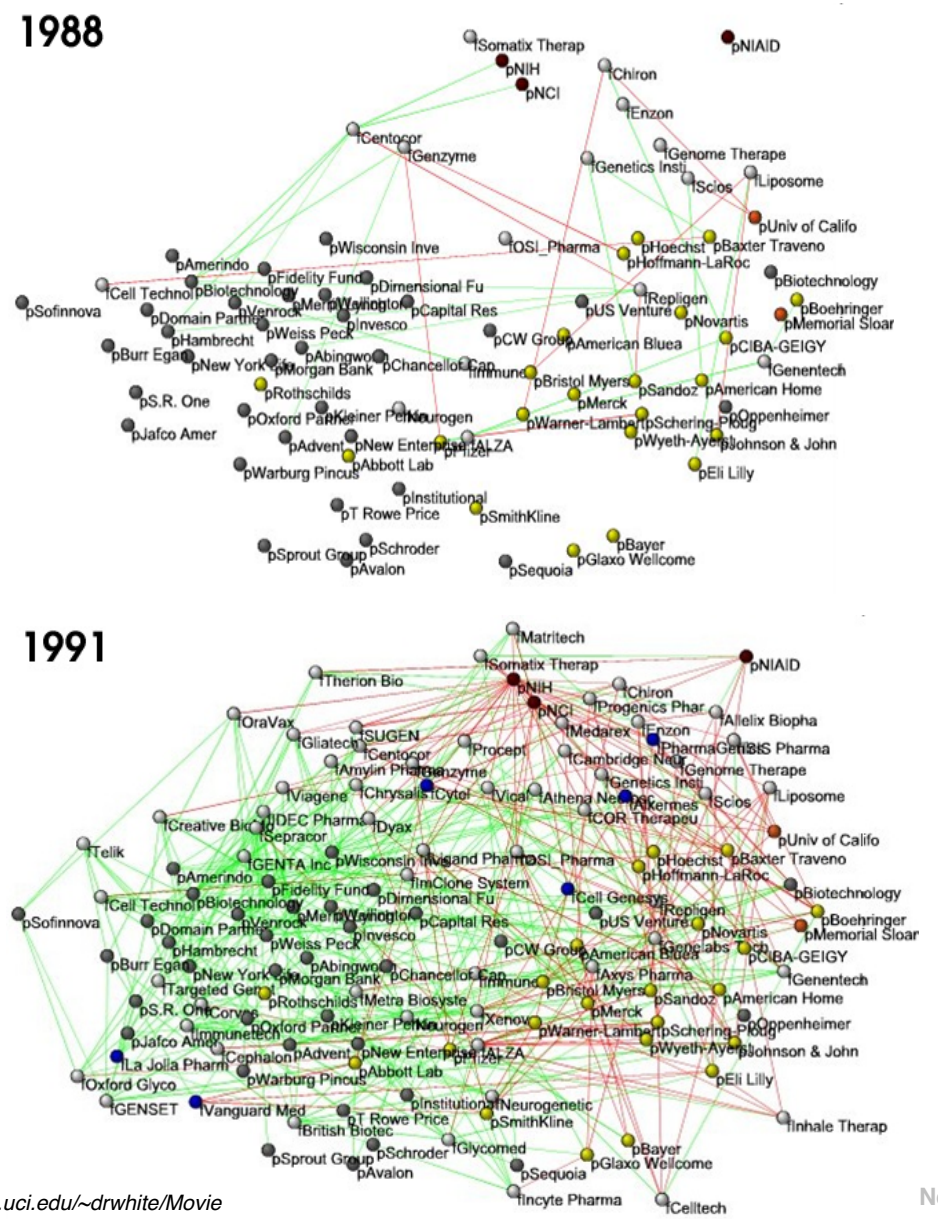
BUSINESS TIES IN US BIOTECH-INDUSTRY

Nodes:

- Companies
- Investment
- Pharma
- Research Labs
- Public
- Biotechnology

Links:

- Collaborations
- Financial
- R&D



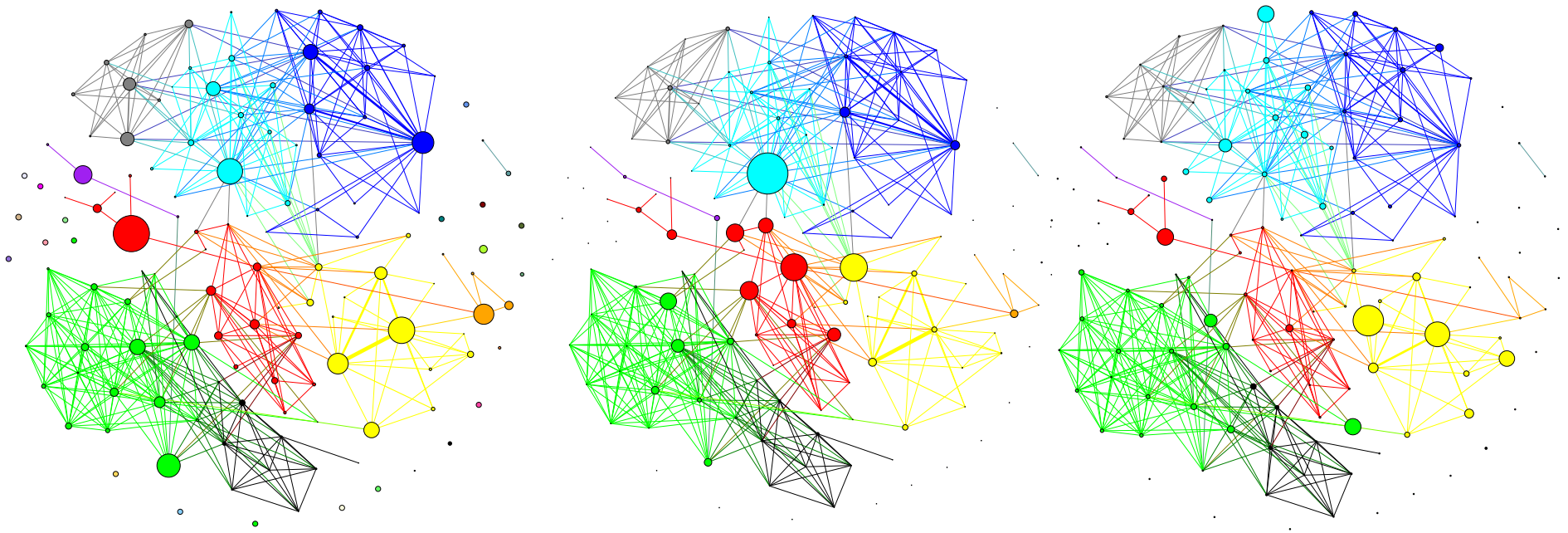
http://ecclectic.ss.uci.edu/~drwhite/Movie

R&D and Organizational Networks

Scientific Production

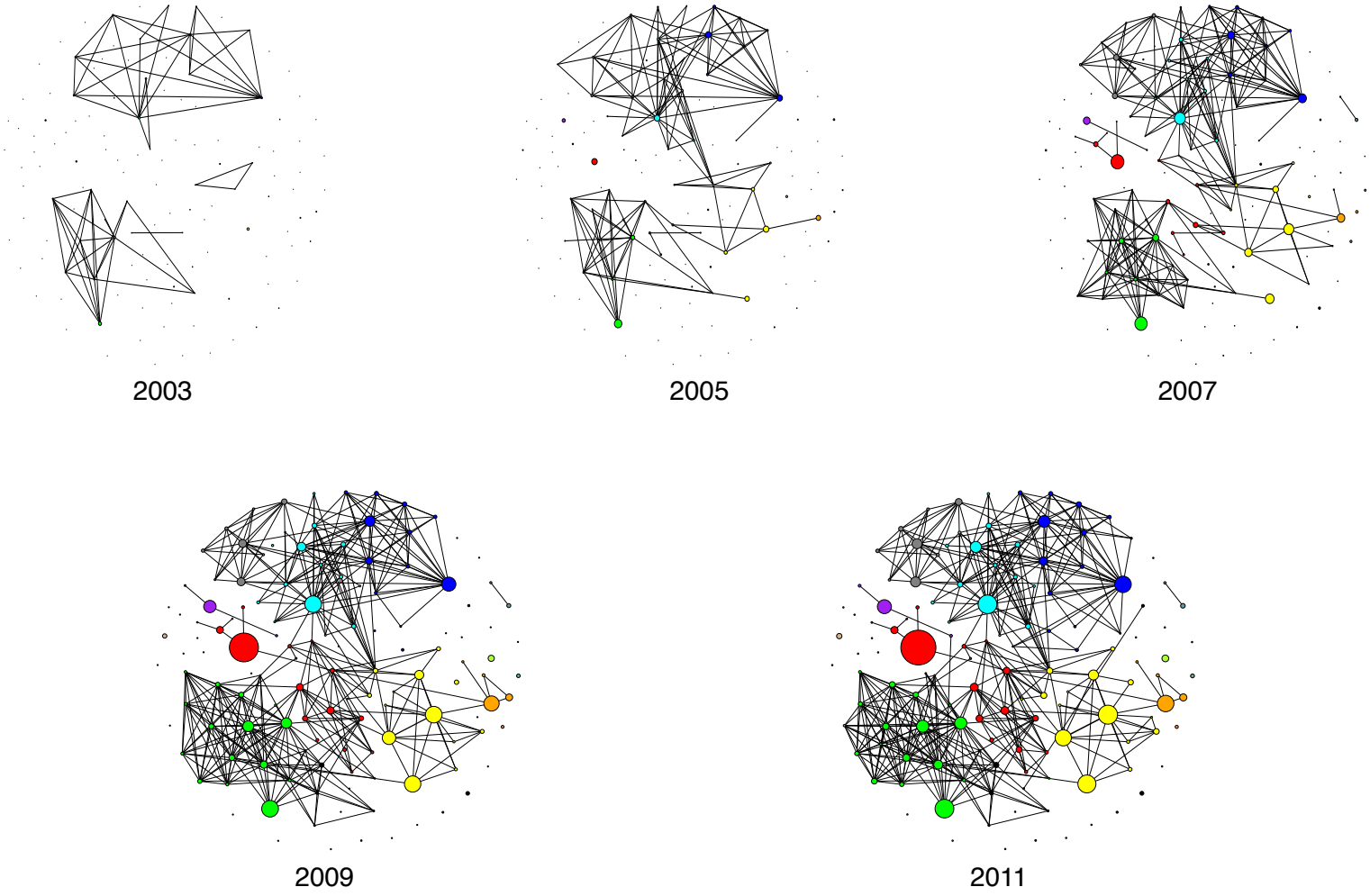
Centrality

Scientific Impact



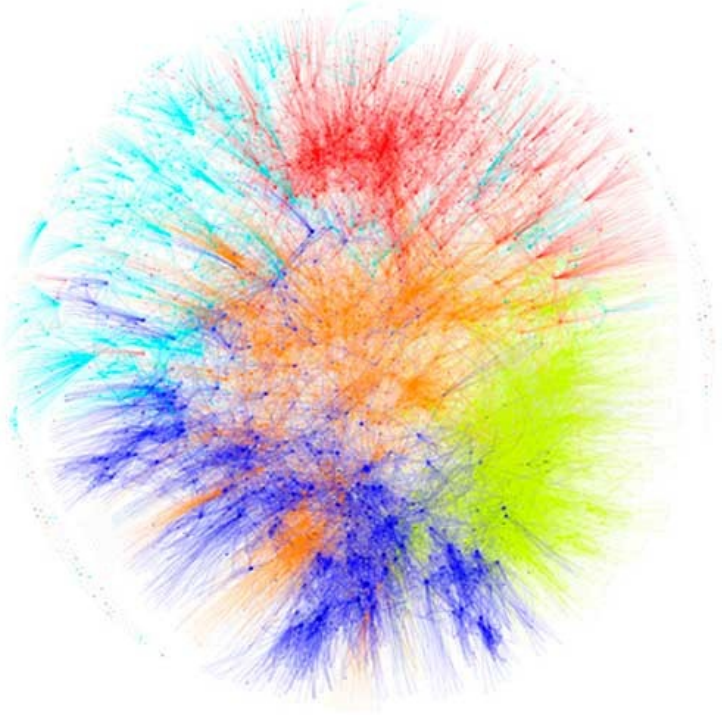
Collaboration Network @BIFI, 2003-2011. Nodes represent researchers from BIFI. Links are established whenever two authors have published a paper together. The size of the nodes is proportional to: the total number of papers in the period analyzed (scientific production); the betweenness centrality of the nodes -i.e., how often a node is in the shortest paths between other vertices- (centrality); and the average number of citations per paper (scientific impact). Colors stand for communities as given by a community detection algorithm. Source: ISI WoK. © J. Borge-Holthoefer & Y. Moreno.

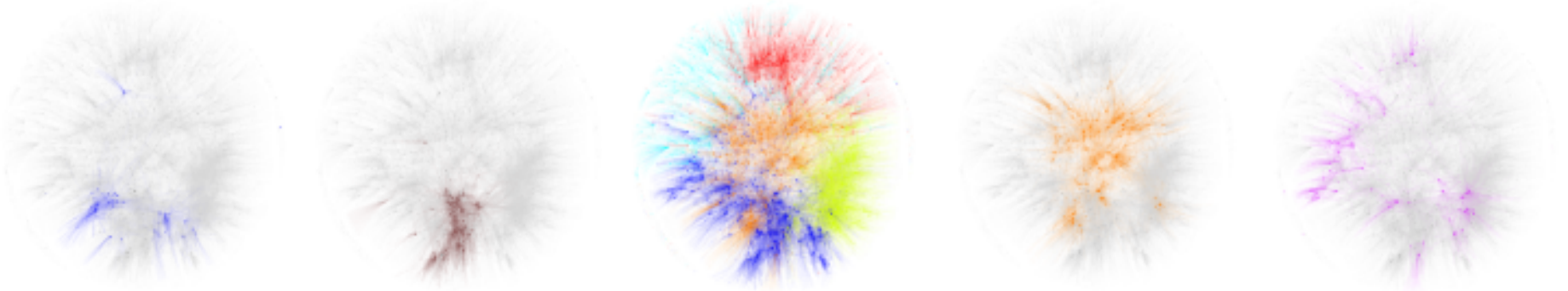
R&D and Organizational Networks



Evolution of the Collaboration Network @BIFI. Nodes represent researchers from BIFI. Links are established whenever two authors have published a paper together. The size of the nodes is proportional to the total number of papers in the period analyzed. © J. Borge-Holthoefer & Y. Moreno

Evolution of the scientific collaboration network, @BIFI





Main Conclusions:

- Complex systems cannot be fully understood by studying only their isolated constituents. *"The whole is more than the sum of its parts"*

- Understanding and modeling the structure of complex networks would lead to a better cottoning on their dynamical and functional behavior.

- To test the innovative tools and methods, and apply new methodologies and procedures in the analysis and design of complex systems.

- The findings and results obtained will deliver new insights in different scientific fields such as: Epidemiology, communication technologies, Biology at all levels (molecular, cellular) etc.

- It is important to foster a community of multidisciplinary scientists, who master the discipline of complex systems and use it for their daily research.

- Identify the best course of action to transfer the acquired knowledge from basic sciences to the application level. This is our goal.

Conclusions and Perspectives

- Complex systems cannot be fully understood by studying only their isolated constituents. *"The whole is more than the sum of its parts"*

- Understanding and modeling the structure of complex networks would lead to a better cottoning on their dynamical and functional behavior.

- This would also lead to new methodologies and procedures for the analysis and design of complex networked systems.

- It is important to foster a community of multidisciplinary scientists, who master the discipline of complex systems and use it for their daily research.

- Need of identifying the best course of action to transfer the acquired knowledge from basic sciences to the application level.