ICoSCIS Project

Scientific Computing in Interdisciplinary Sciences

1. Complex Systems

2. GRID computing

Panos Argyrakis

University of Thessaloniki

GREECE

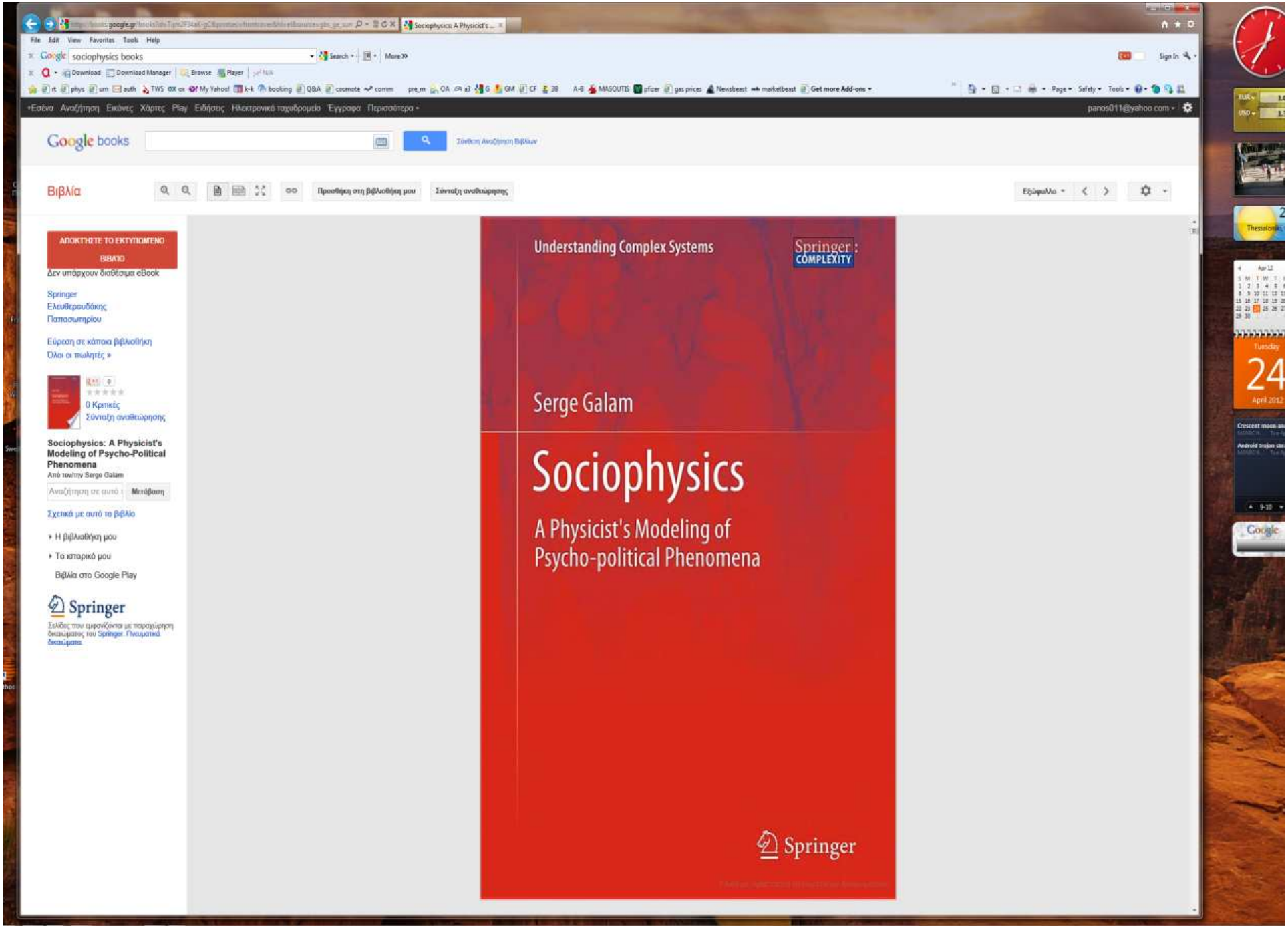
Interdisciplinary Sciences:

- Physics, Chemistry, Biology
- Mathematics, Computer Science
- Engineering
- Medical and Health Sciences

.....

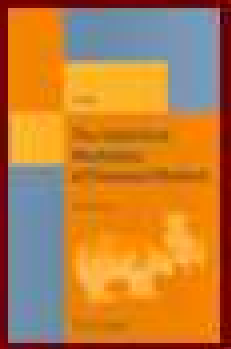
.....

- Economics ?
- Sociology?
- Linguistics


sociophysics books
Google books
Βιβλία
Understanding Complex Systems
Springer COMPLEXITY
Serge Galam
Sociophysics
A Physicist's Modeling of Psycho-political Phenomena
Springer

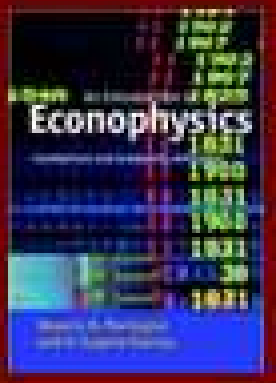
Textbooks in Econophysics

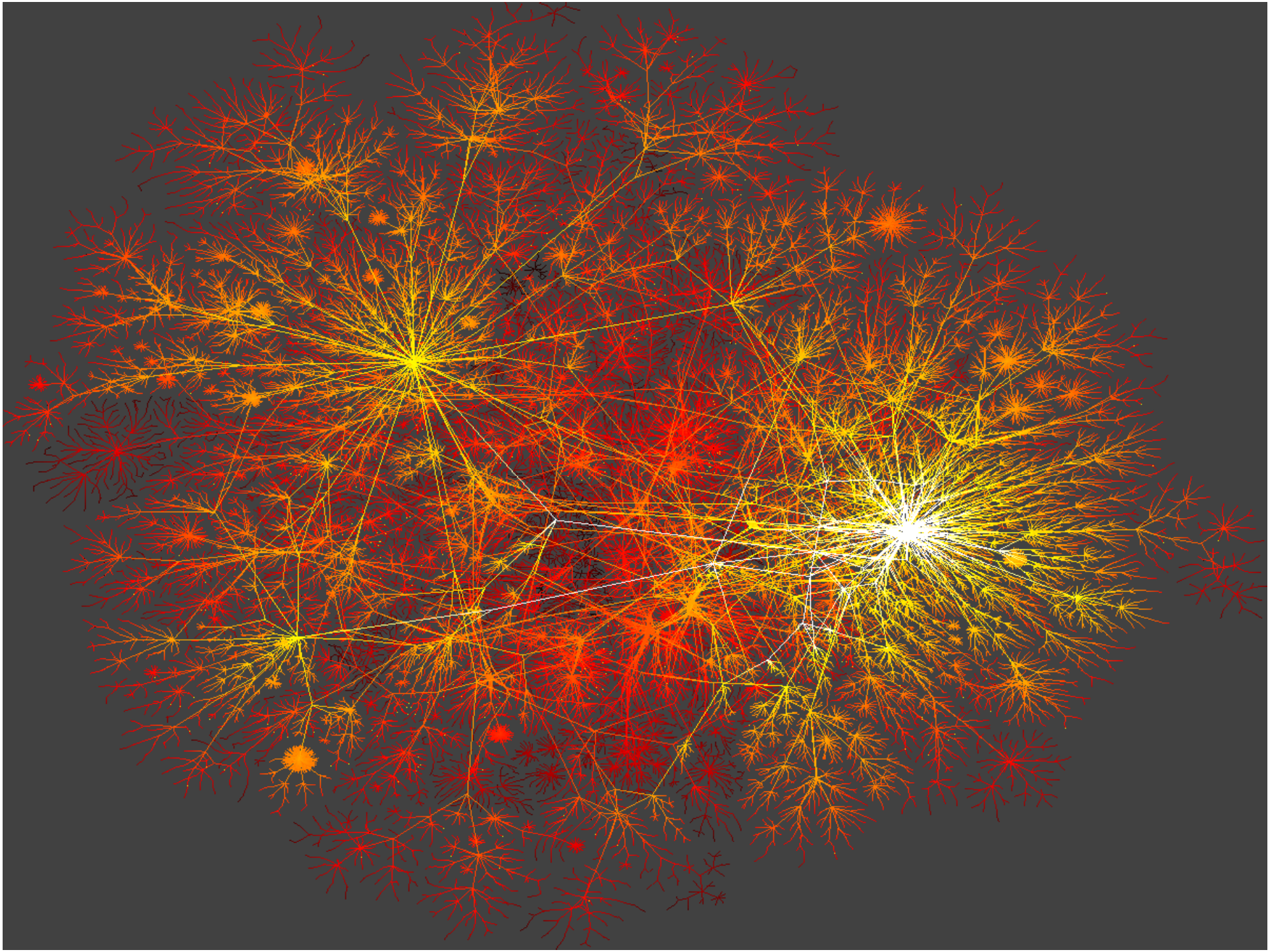
J.P. Bouchaud and M. Potters – Theory of Financial Risk and Derivative Pricing: from Statistical Physics to Risk Management, Cambridge University Press (2003)



J. Voit – The Statistical Mechanics of Financial Markets, Springer (2005)

R.N. Mantegna and H.E. Stanley – An Introduction to Econophysics: Correlations and Complexity in Finfinance, Cambridge University Press (2000)

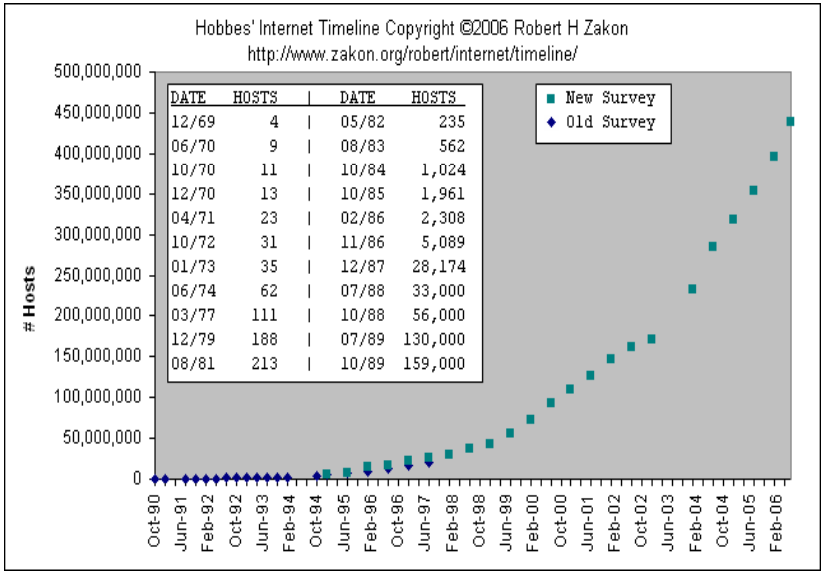




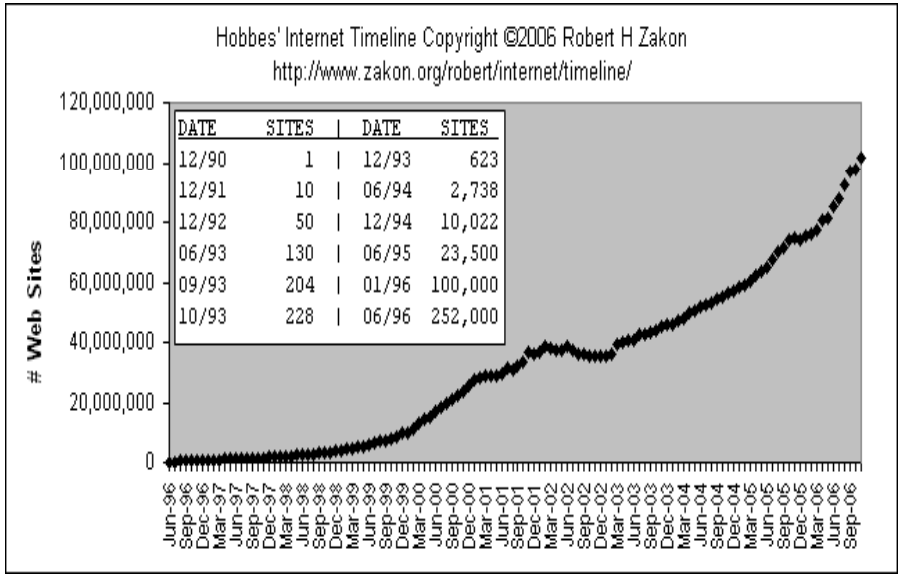
Internet and WWW explosive growth

1970 – 10 hosts
1990 – $1.75*10^5$ hosts
Now – $1.2*10^9$ hosts

1990 – 1 web site
1996 – 10^5 web sites
Now – 10^9 web sites



DATE	HOSTS	DATE	HOSTS
12/69	4	05/82	235
06/70	9	08/83	562
10/70	11	10/84	1,024
12/70	13	10/85	1,961
04/71	23	02/86	2,308
10/72	31	11/86	5,089
01/73	35	12/87	28,174
06/74	62	07/88	33,000
03/77	111	10/88	56,000
12/79	188	07/89	130,000
08/81	213	10/89	159,000



DATE	SITES	DATE	SITES
12/90	1	12/93	623
12/91	10	06/94	2,738
12/92	50	12/94	10,022
06/93	130	06/95	23,500
09/93	204	01/96	100,000
10/93	228	06/96	252,000

Internet

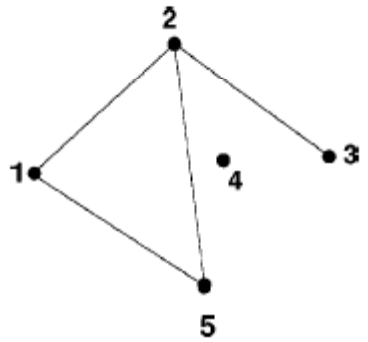
- Today >> 10^9 Connections
- What is its structure?
- How are new connections made?

Answer:

- We have to see how it all started

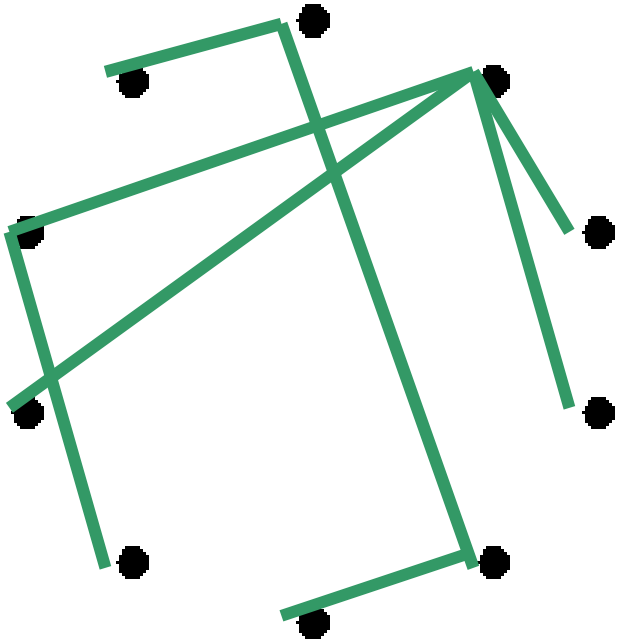
Network → Graph

- We have two (2) kinds of entities:
  - Nodes
  - Connections, synapses, edges



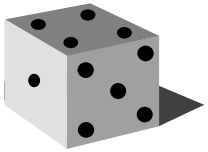
- could be a simple graph or a complex one (Complex systems)

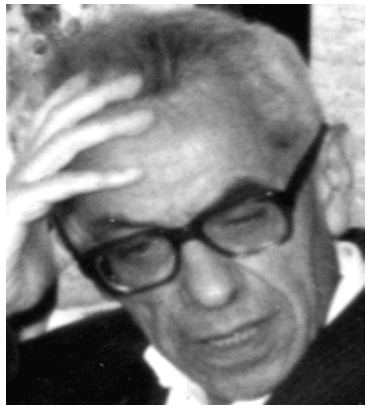
The model of Erdös-Rényi (1960)



Connections with probability p
p=1/6
N=10

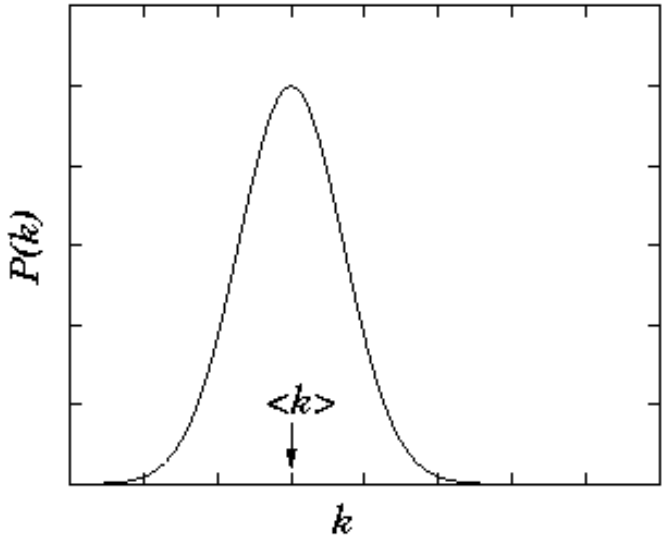
$\langle k \rangle \sim 1.5$





Pál Erdös (1913-1996)

Poisson distribution



k=number of connections that a node has
P(k)= distribution of k

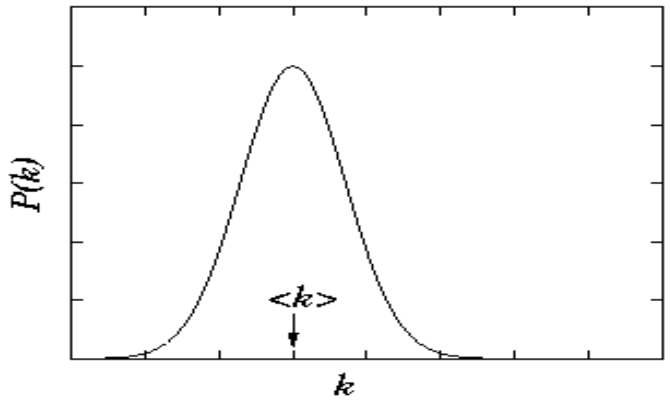
Structure of the Internet:

All new nodes are randomly connected.

No higher Government to dictate the connectivity in the Internet.

THUS:

One would expect a Normal distribution (Gauss/Poisson).



k=number of connections that a node has

P(k)= distribution of k

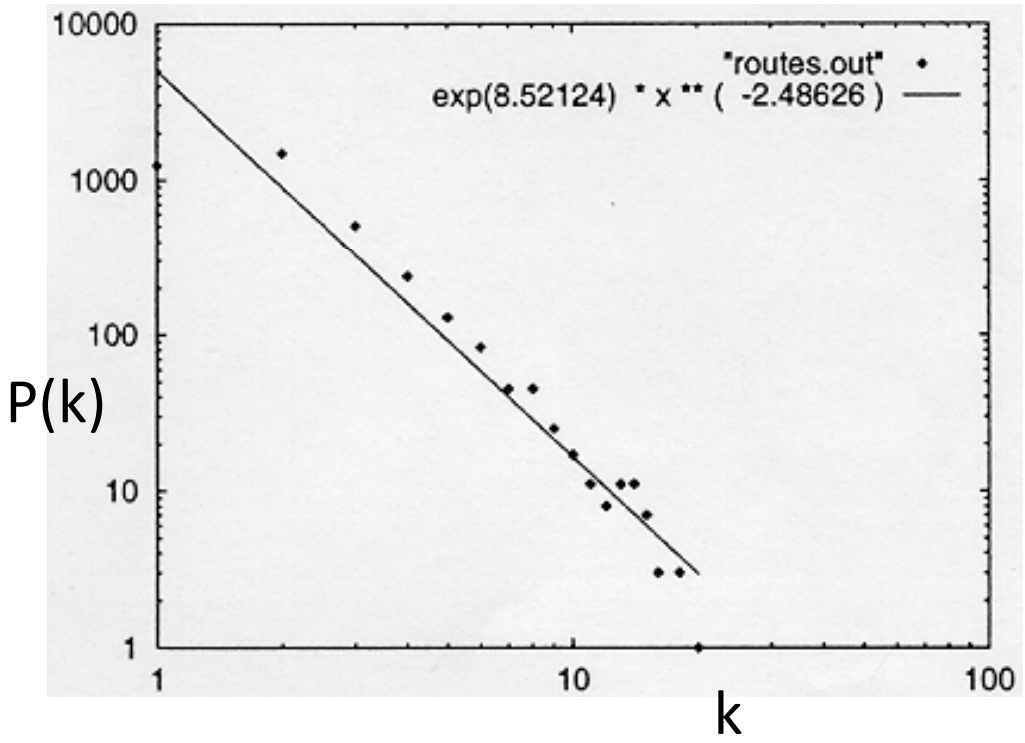
INTERNET BACKBONE

Nodes: computers, routers

Links: physical lines

$$P(k) \sim k^{-\gamma}$$

k=number of connections that a node has
P(k)= distribution of k

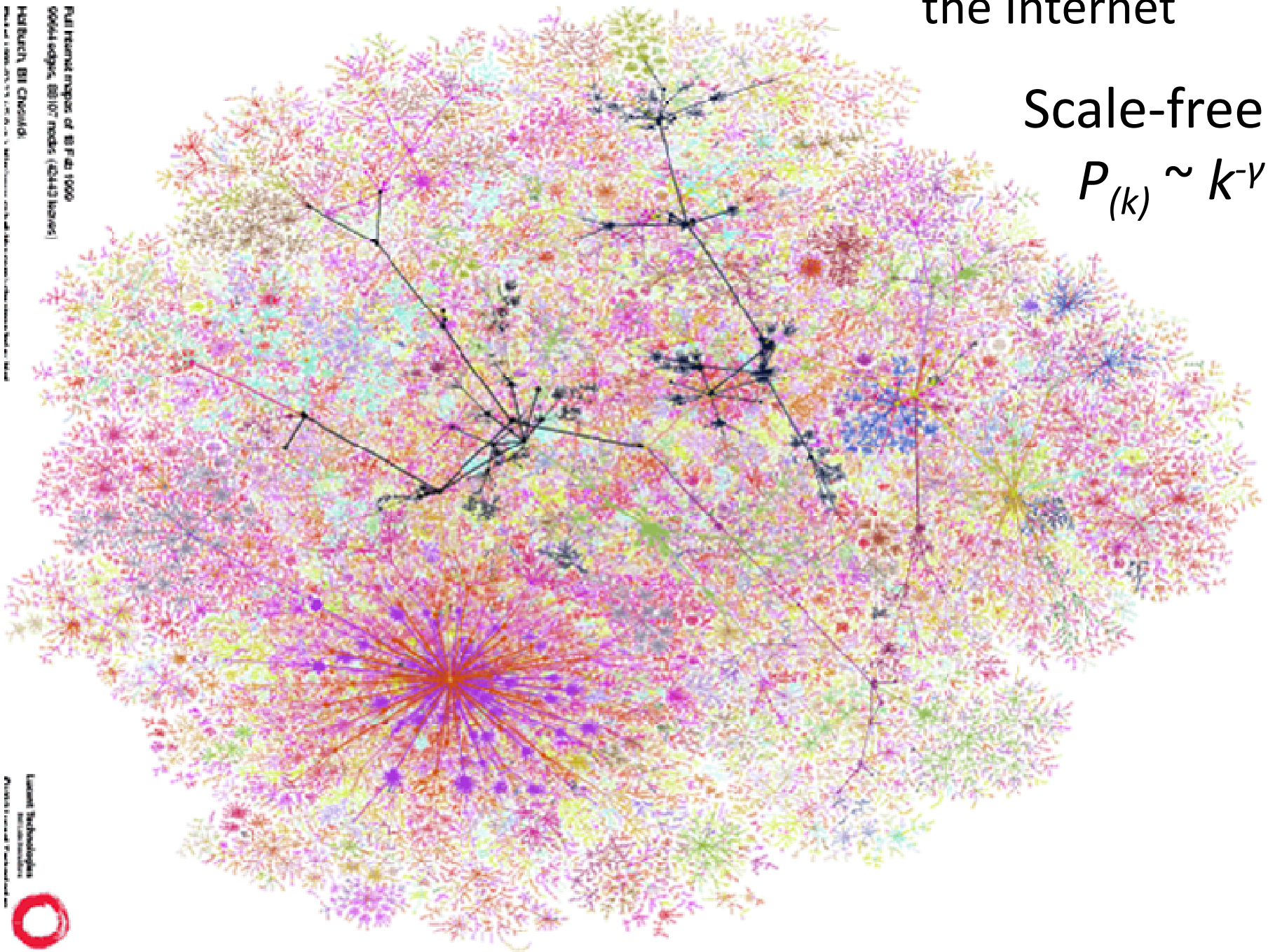


(Faloutsos, Faloutsos and Faloutsos, 1997)

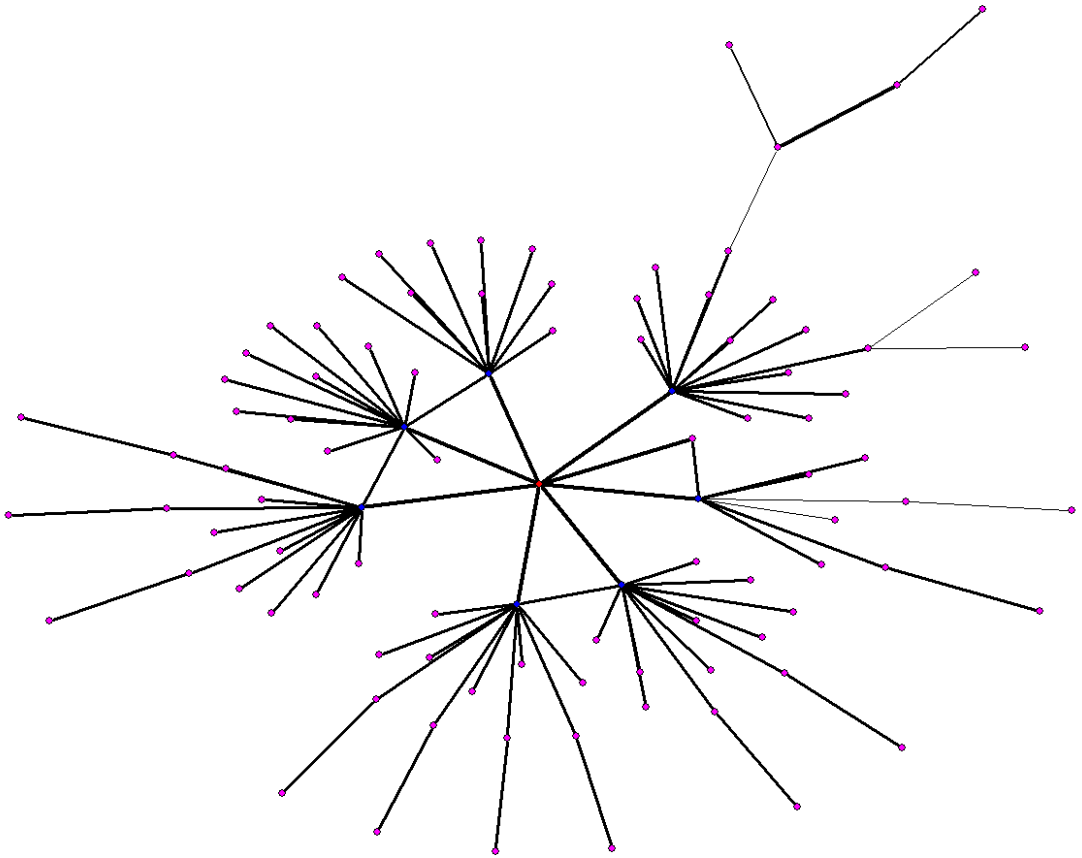
the Internet

Scale-free

$P_{(k)} \sim k^{-\gamma}$



Network Backbone at University of Thessaloniki

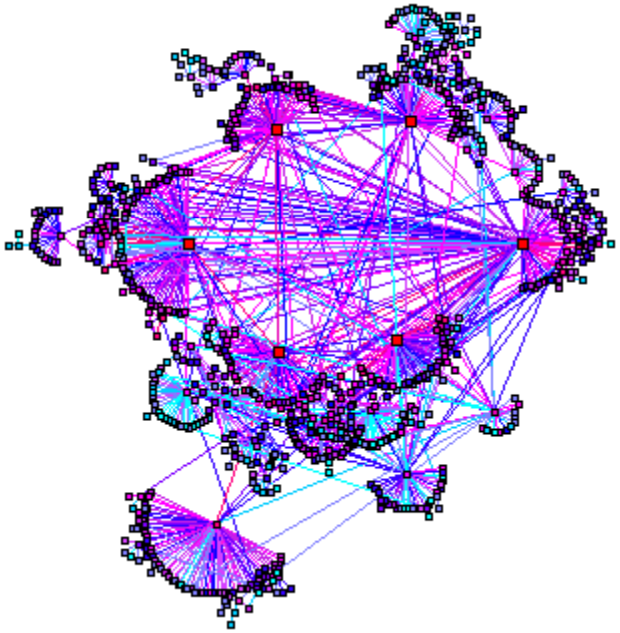


World Wide Web

Nodes: WWW documents

Links: URL links

800 million documents (S. Lawrence, 1999)

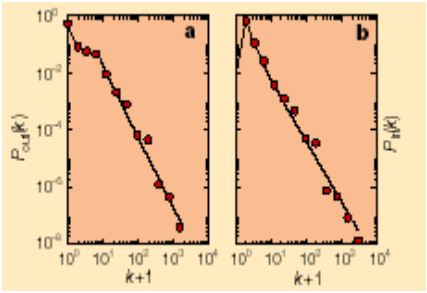


ROBOT: collects all URL's found in a document and follows them recursively

R. Albert, H. Jeong, A-L Barabasi, Nature, 401 130 (1999)

WWW

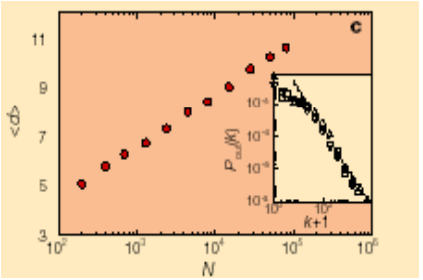
It has a power-law



Diameter of WWW:

<d>=0.35 + 2.06 logN

Av N=$8x10^8$ → <d>=18.59



Communication networks

The Earth is developing an electronic nervous system, a network with diverse nodes and links are

-computers

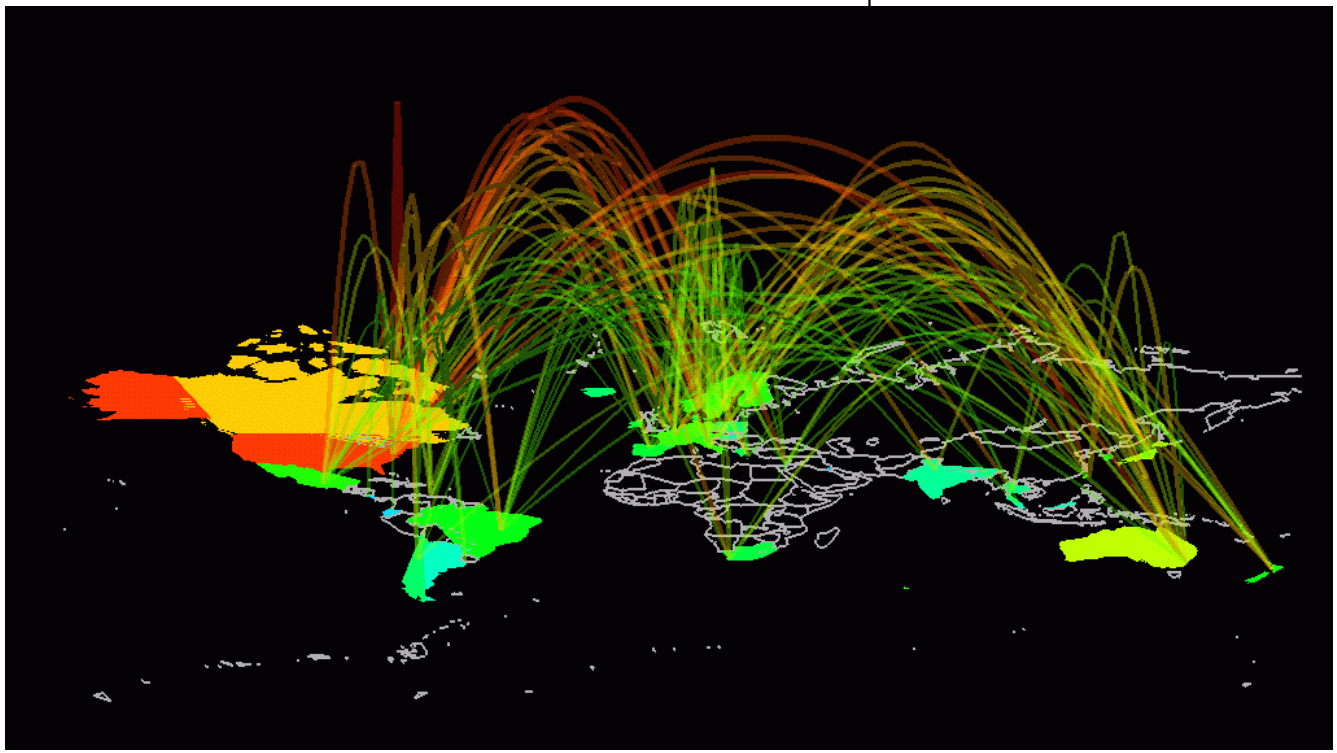
-routers

-satellites

-phone lines

-TV cables

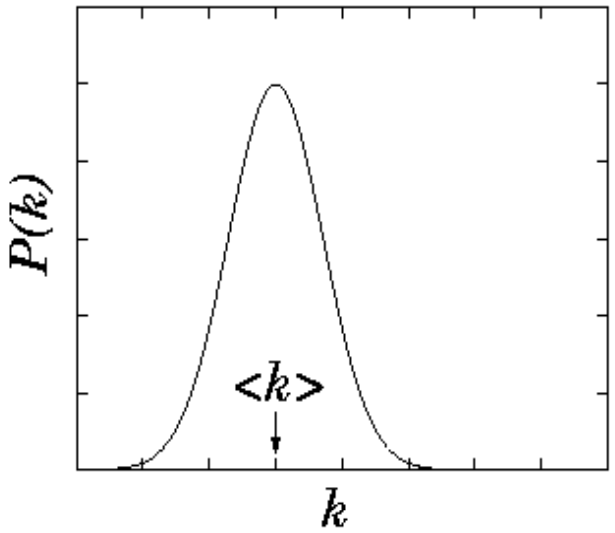
-EM waves



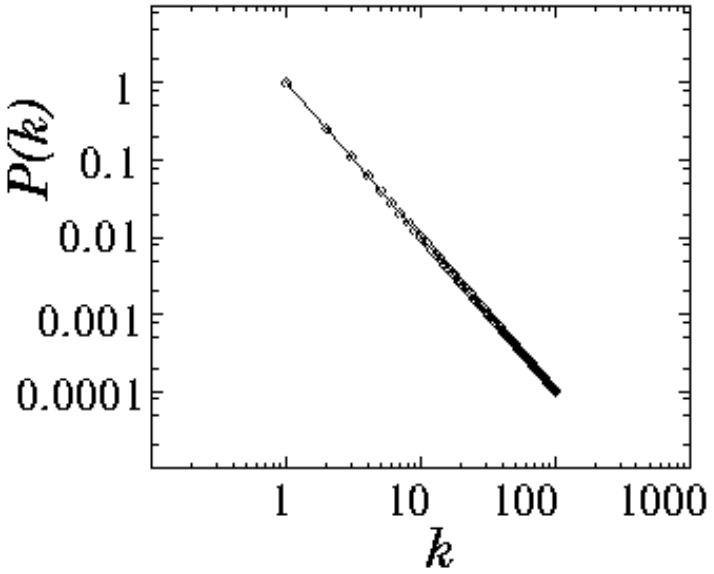
Communication networks: Many non-identical components with diverse connections between them.

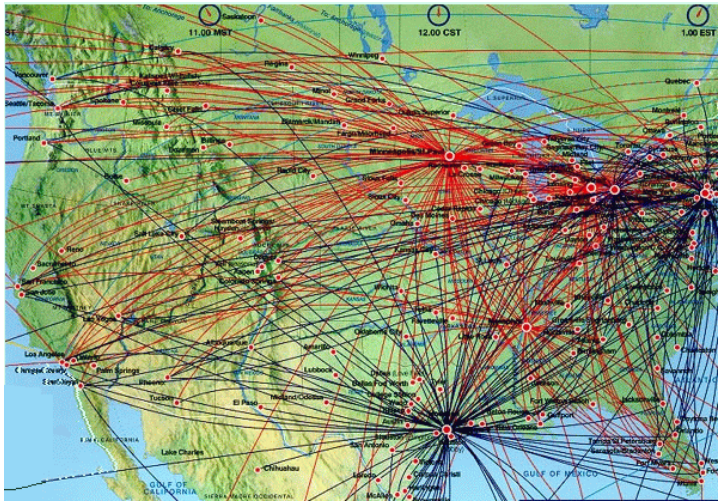
What does it mean?

Poisson distribution



Power-law distribution





Exponential Network

Scale-free Network

Society

Nodes: individuals

Links: social relationship
(family/work/friendship/etc.)

S. Milgram (1967)

John Guare

How many (n) connections are needed so that an individual is connected with any other person in the world?
N=6 billion people

Result: n~6

Conclusion: We live in a small world
Six Degrees of Separation!!

http://www.facebook.com/ Welcome to Facebook - Lo...

Edit View Favorites Tools Help

Google facebook Search More

Download Download Manager Browse Player N/A

rt phys um auth TWS ox ox My Yahoo! k-k booking Q&A cosmote comm pre_m OA a3 G GM CF 3B A-B MASOUTIS pfizer gas prices Newsbeast marketbeast Get more Add-ons Welcome to the UM Wirel...

facebook

Email Password Log In

Keep me logged in Forgot your password?

Facebook helps you connect and share with the people in your life.

Sign Up

It's free and always will be.

First Name:

Last Name:

Your Email:

Re-enter Email:

New Password:

I am: Select Sex:

Birthday: Month: Day: Year:

Why do I need to provide my birthday?

By clicking Sign Up, you agree to our Terms and that you have read and understand our Data Use Policy.

Sign Up

Create a Page for a celebrity, band or business.

English (US) Ελληνικά Español Português (Brasil) Français (France) Deutsch Italiano العربية हिन्दी 中文(简体) ...

Facebook © 2012 · English (US)

Mobile · Find Friends · Badges · People · Pages · About · Advertising · Create a Page · Developers · Careers · Privacy · Terms · Help

Facebook:

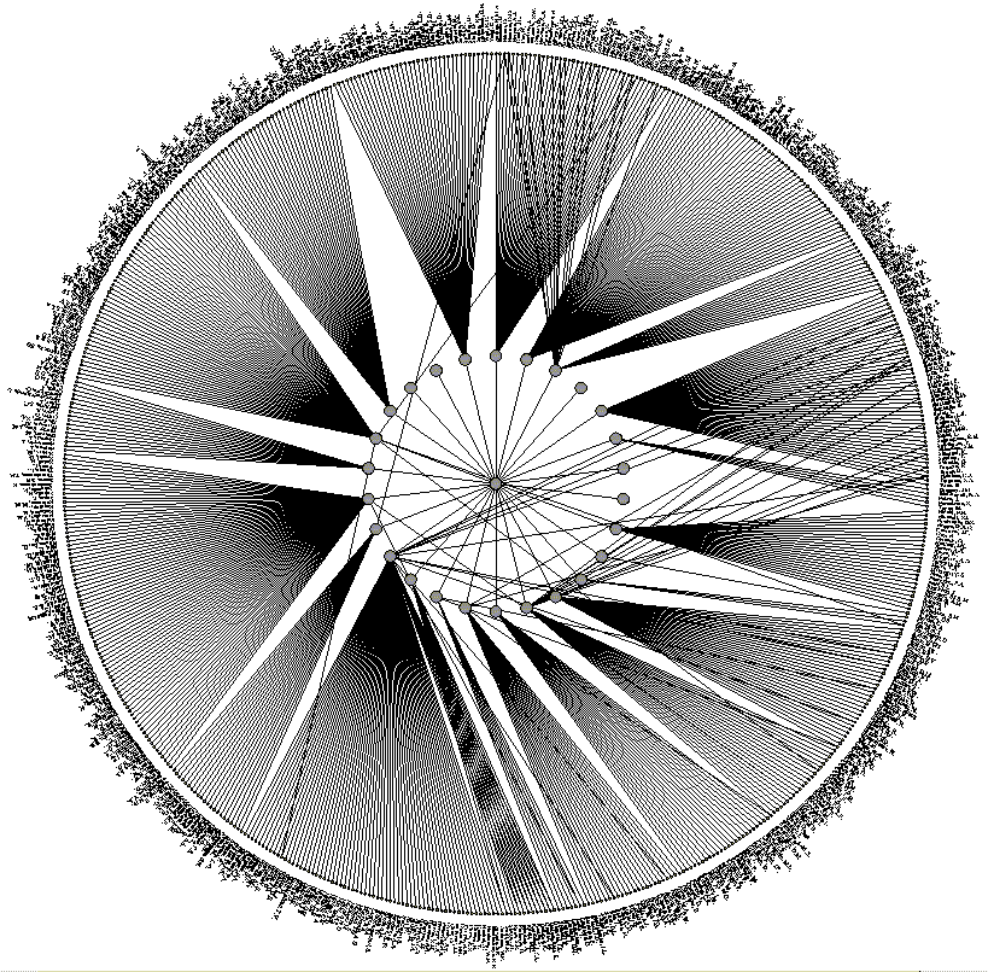
- 700,000,000 registered users
- 50,000,000 active users
- 5,000,000 generate 95% of traffic

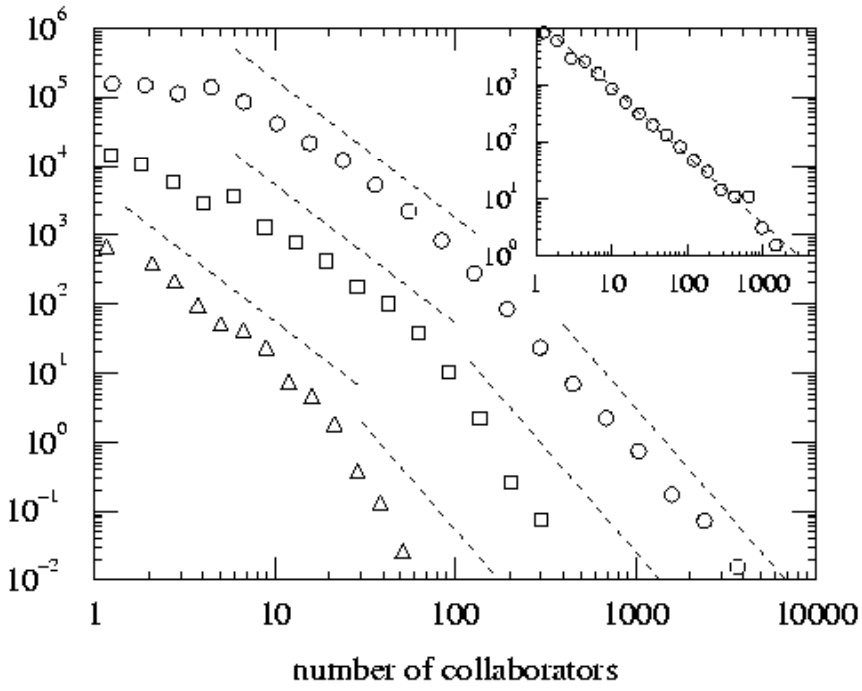
Questions to answer:

- How many people communicate with how many?
- How many connections that each person have?
- How frequently does he communicate with others?
- How long time does the communication last?

SCIENCE COAUTHORSHIP

Nodes: scientist (authors)
Links: write paper together





(Newman, 2000, H. Jeong et al 2001)

SCIENCE CITATION INDEX

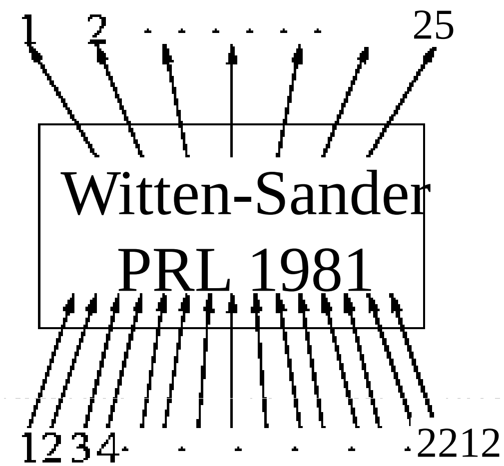
1,000 Most Cited Physicists, 1981-June 1997

Out of over 500,000 Examined

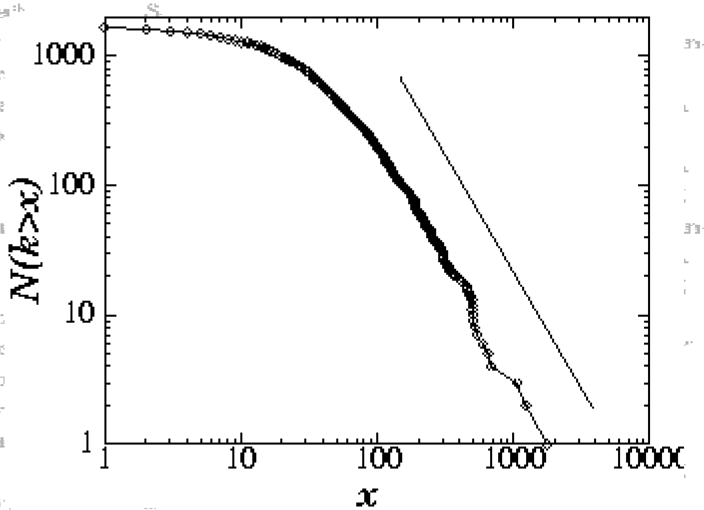
(see http://www.ssi.nrel.gov)

Nodes: papers

Links: citations



1736 PRL papers (1988)



$P(k) \sim k^{-\gamma}$

$(\gamma = 3)$

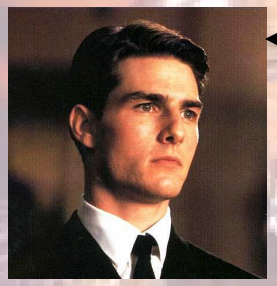
(S. Redner, 1998)

* citation total may be skewed because of multiple authors with the same name

ACTOR CONNECTIVITIES

Nodes: actors
cast jointly

Links:



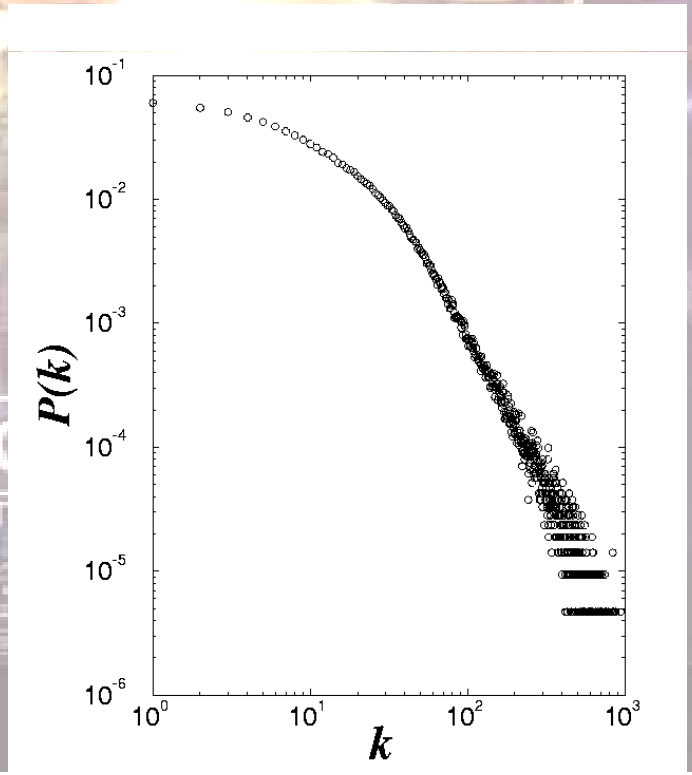
Days of Thunder (1990)
Far and Away (1992)
Eyes Wide Shut (1999)

N = 212,250 actors

$\langle k \rangle = 28.78$

$P(k) \sim k^{-\gamma}$

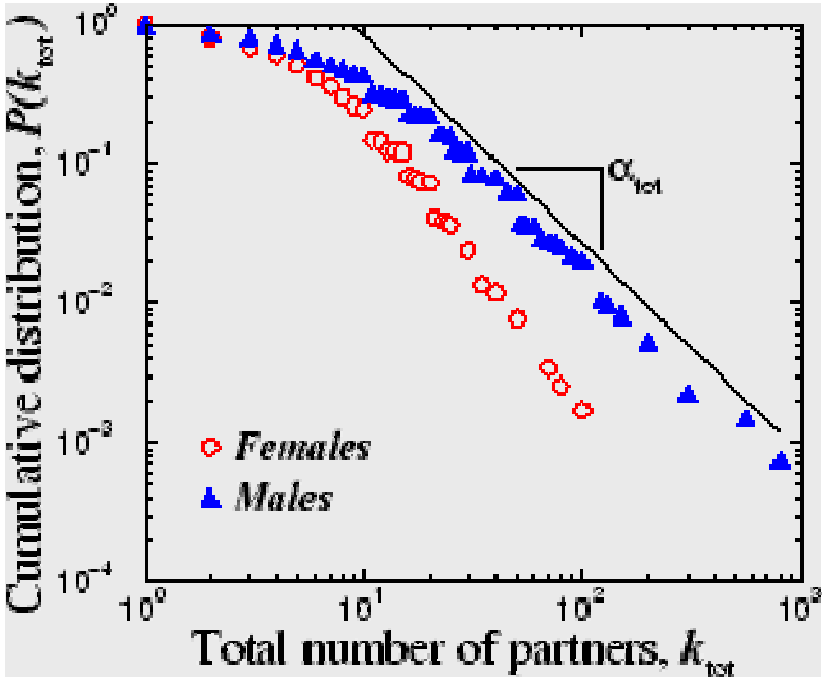
$\gamma = 2.3$



Sex-web

Nodes: people (Females; Males)

Links: sexual relationships



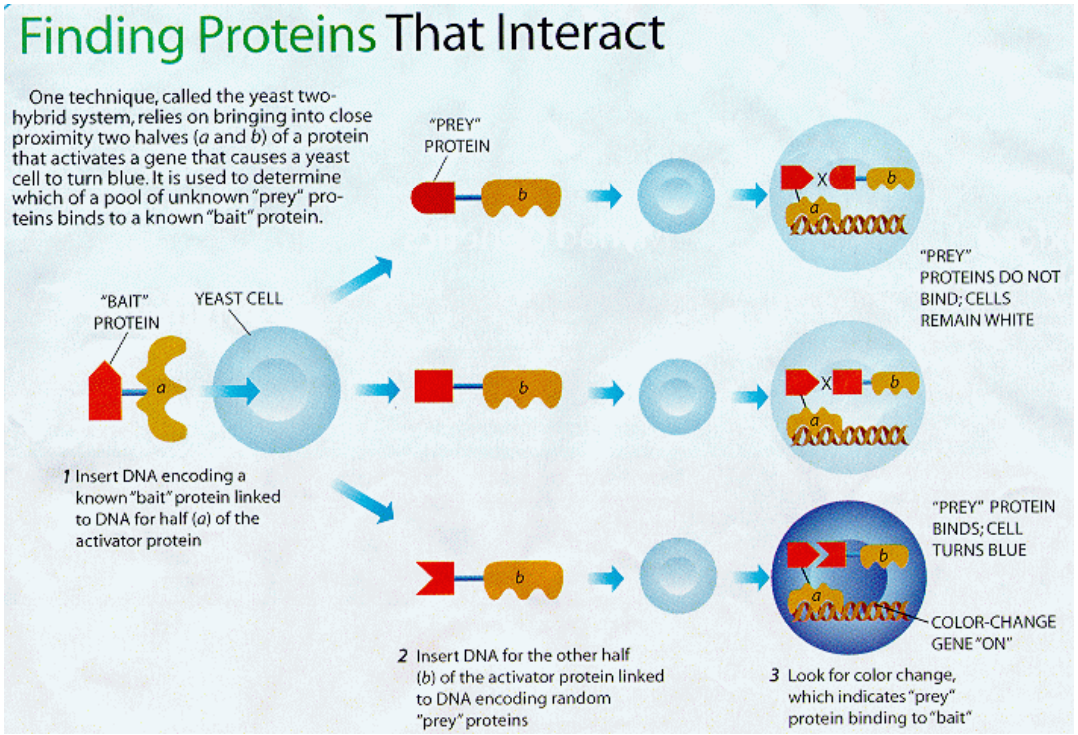
4781 Swedes; 18-74;
59% response rate.

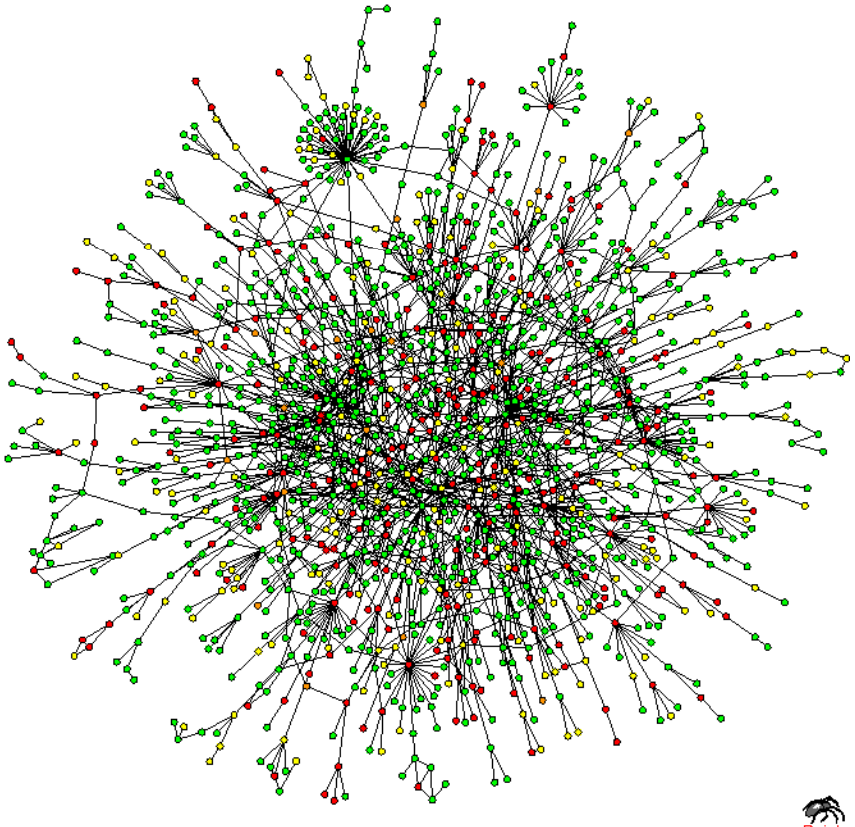
Liljeros et al. Nature 2001

Yeast protein network

Nodes: proteins

Links: physical interactions (binding)



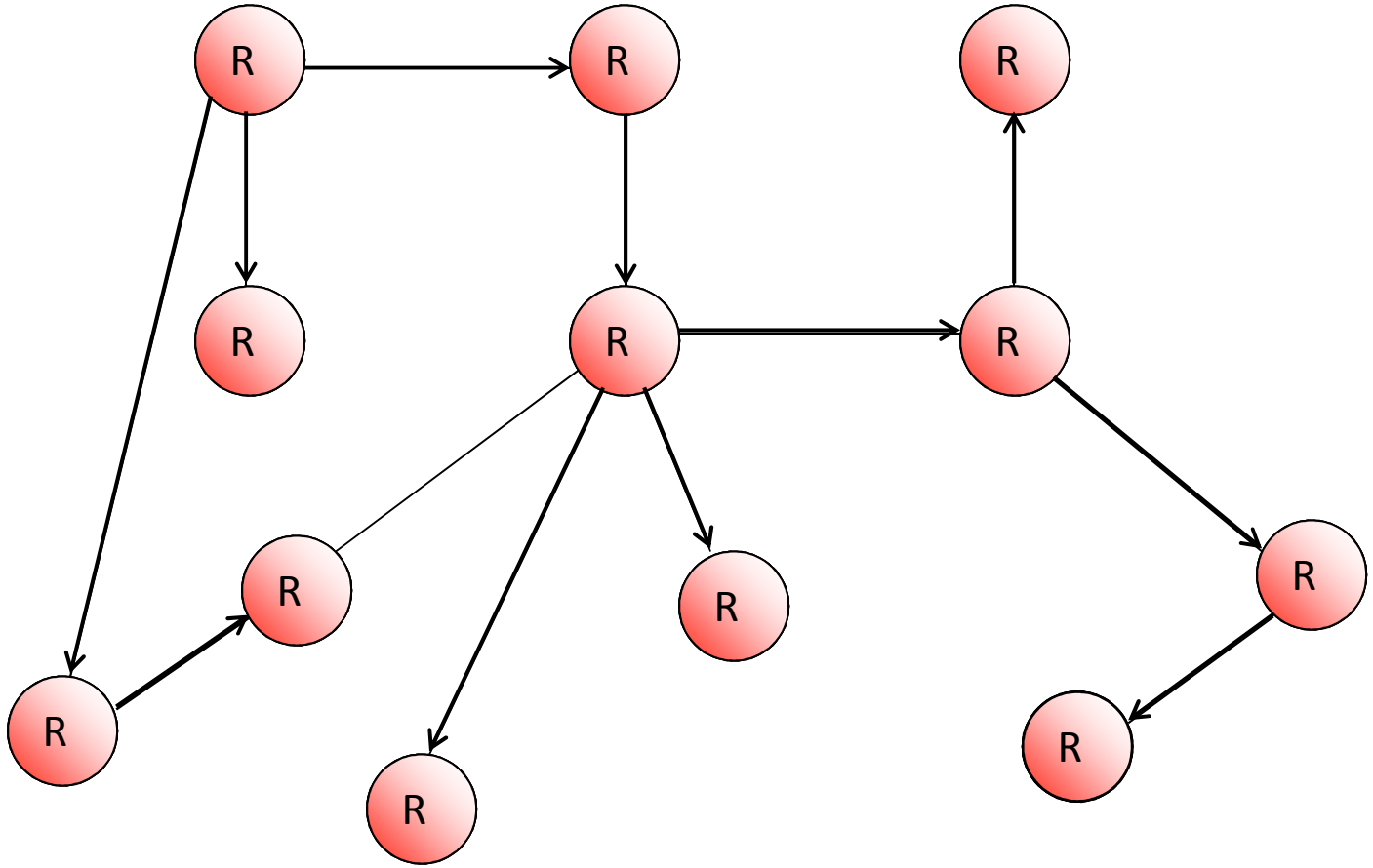


P. Uetz, *et al.* *Nature* **403**, 623-7 (2000).

Real-world phenomena to study

- *Crowd behavior*: strategies to evacuate people and stop panic.
- *Search strategies*: efficient networks for searching objects and people.
- *Traffic flow*: optimization of collective flow.
- *Dynamics of collaboration*: human relationship networks such as collaboration, opinion propagation and email networks.
- *Spread of epidemics*: efficient immunization strategies.
- *Bullying:* networks of harassment in peer groups
- *Patterns in economics and finance*: dynamic patterns in other disciplines, such as Economics and Finance, and Environmental networks.

SIR



S Susceptible

I Infected

R Recovered (or Removed)

What is Econophysics?

" Econophysics is the application of typical methods from physics to the study of the financial markets, seen as a complex system."

H. E. Stanley, Boston University, Boltzmann Medal 2004:

"For his influential contribution to several areas of statistical physics…"

Physica A, Vol. 285, p. 1 (2000)

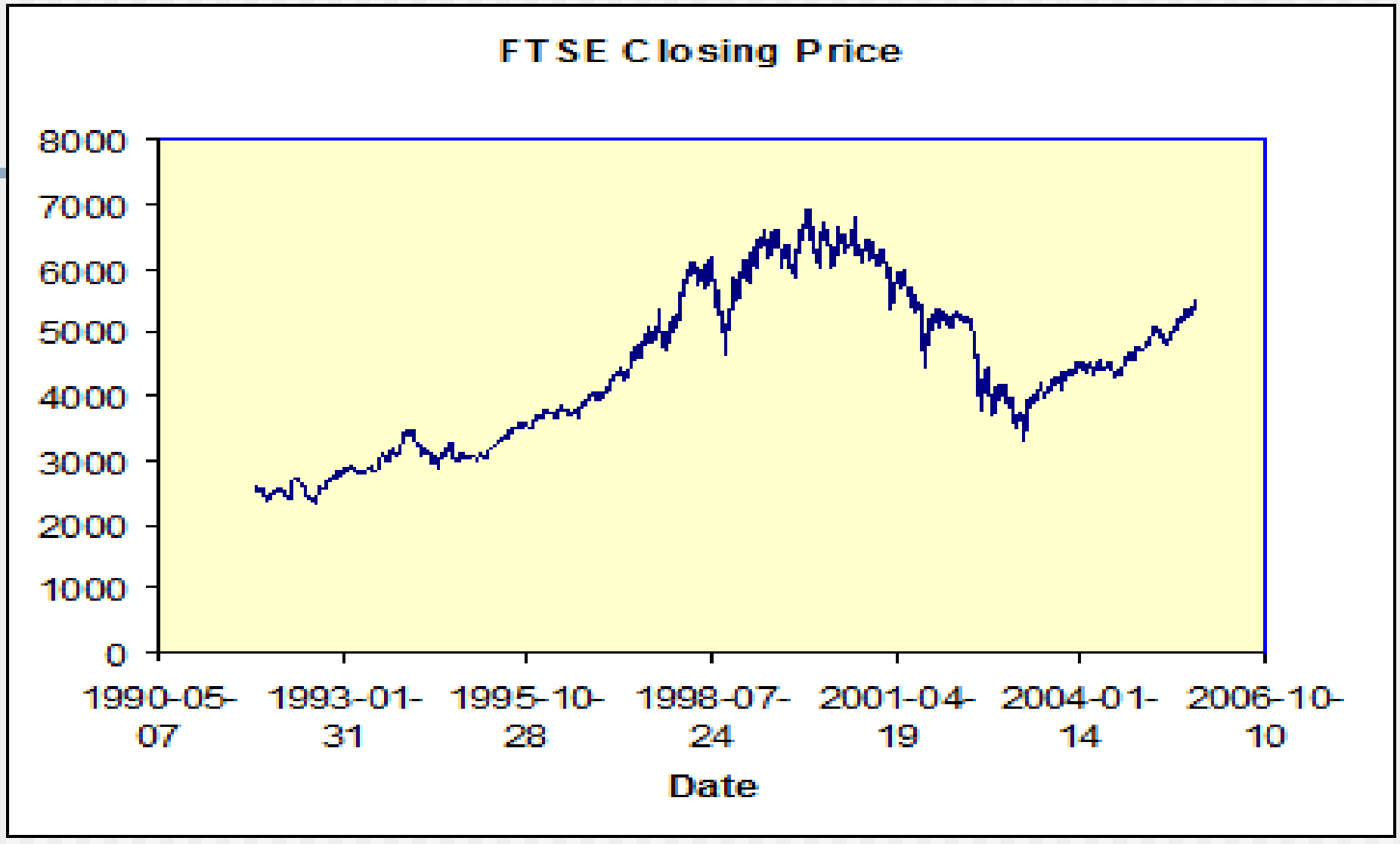
Exotic statistical physics with applications to biology, medicine and economics.

However…it is nothing really that new!

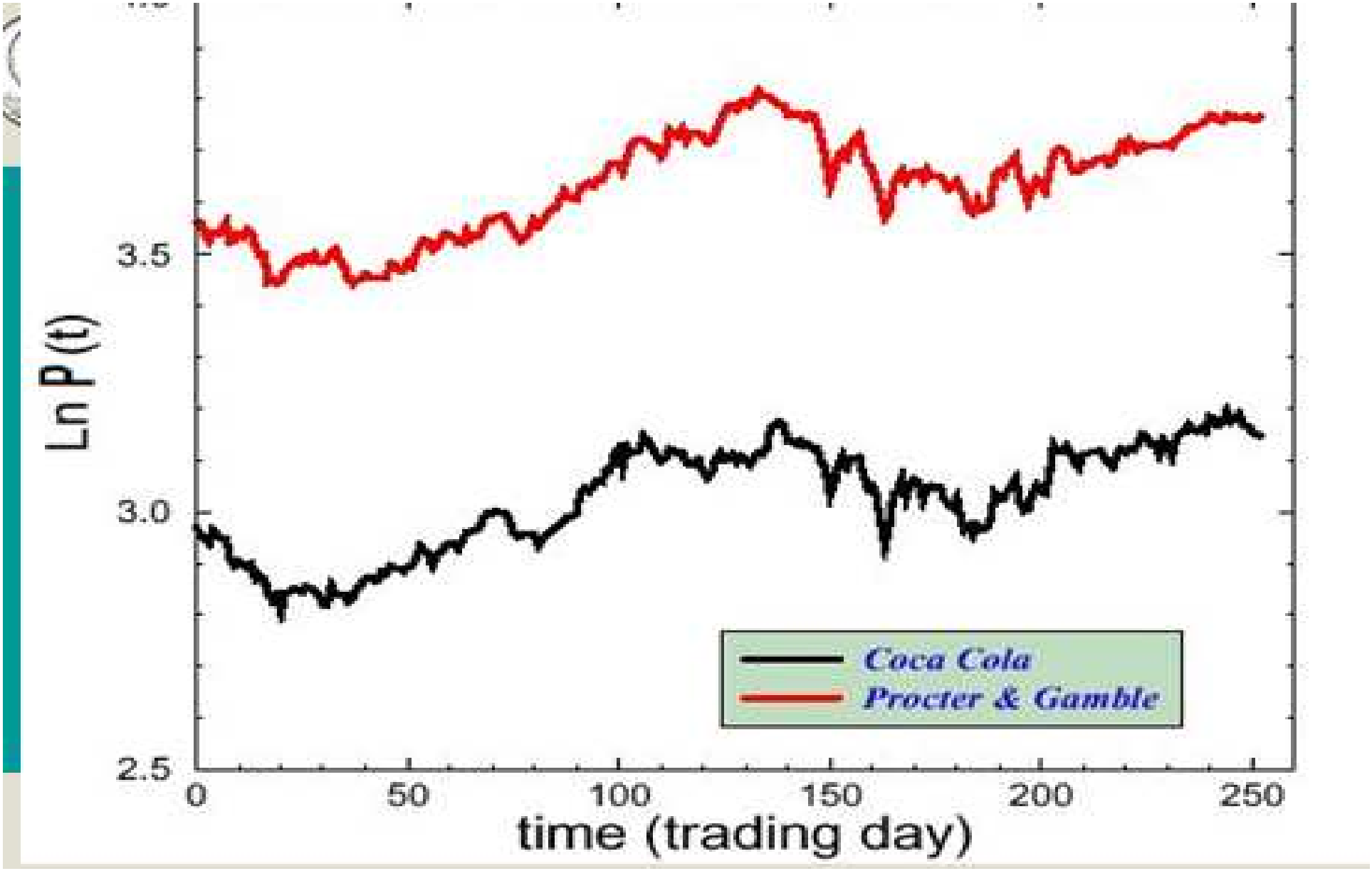
E. Majorana, ***Scientia***, Vol. 36, 58 (1942)

"On the value of the statistical laws in physics and in social sciences."

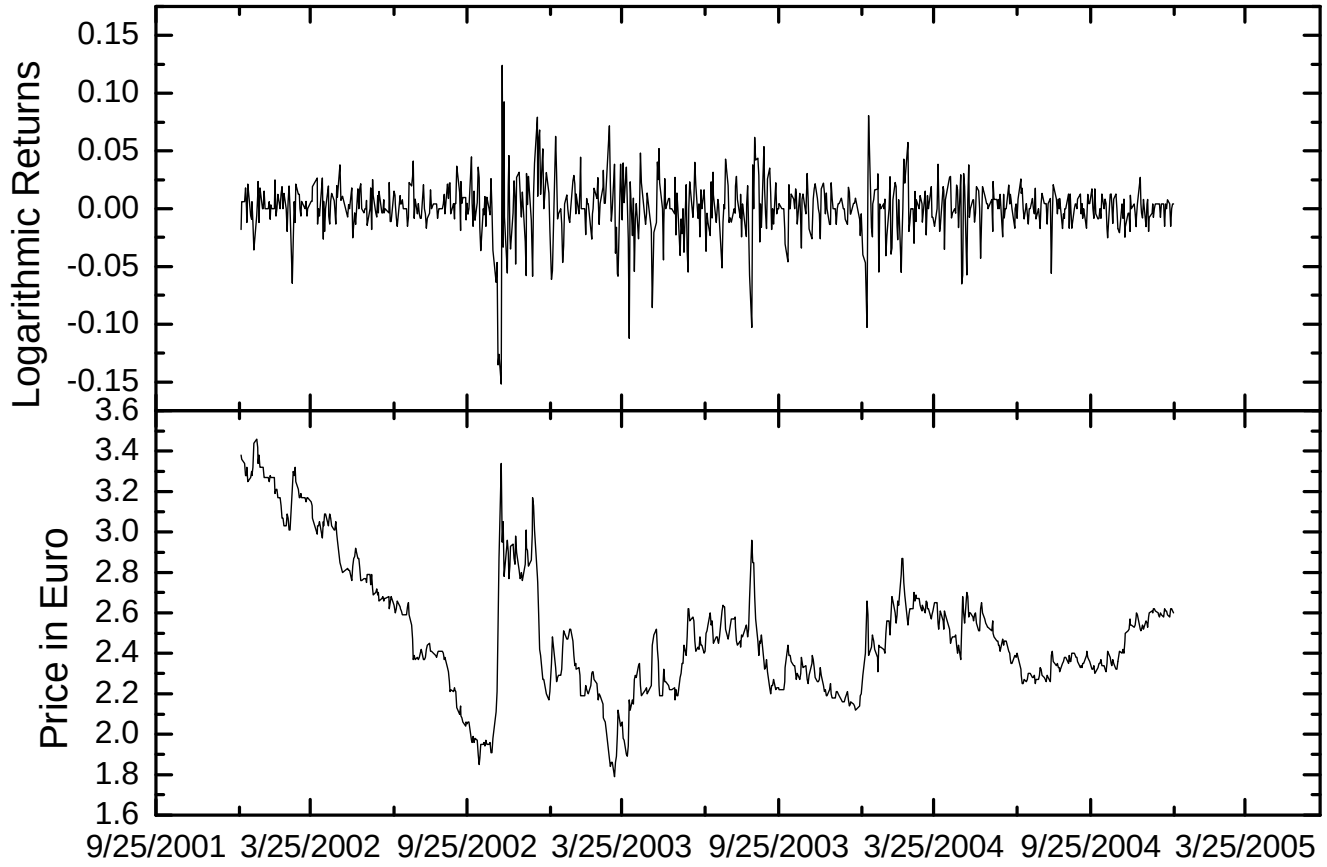
Time series


FTSE Closing Price
8000
7000
6000
5000
4000
3000
2000
1000
0
1990-05-07
1993-01-31
1995-10-28
1998-07-24
2001-04-19
2004-01-14
2006-10-10
Date

Stock price changes



Financial Time Series

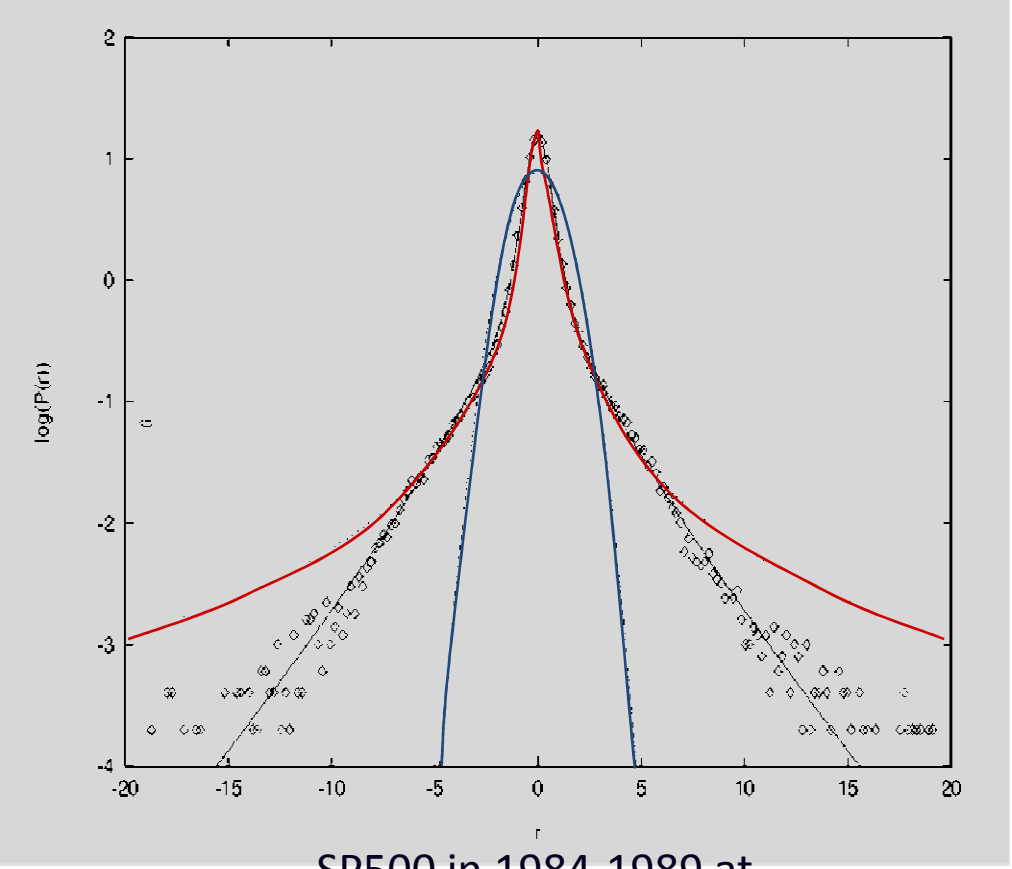


If not Gaussian then what?

Small to intermediate δp :
Pareto-Levy distribution with a power-law tail $1+\mu \approx 2.4$ (Mandelbrot, 1963).

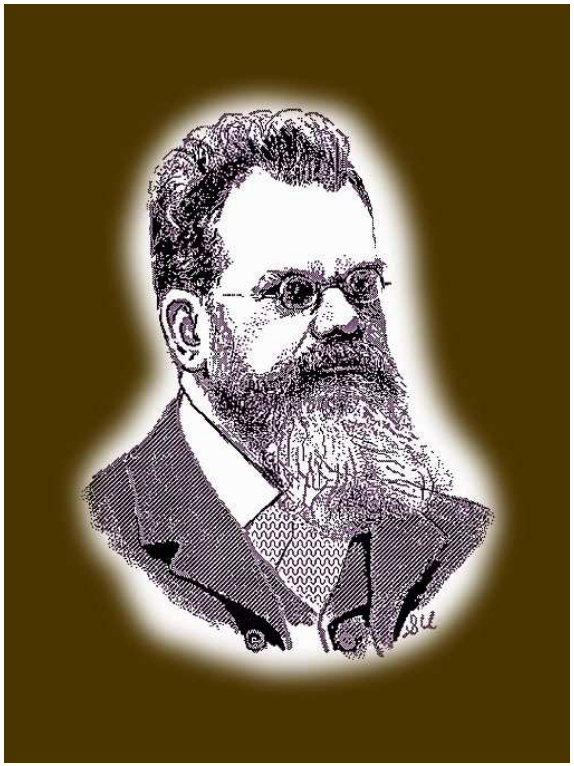
- It is a stationary pdf for the sum of random variables with diverging second moment:
  $\Rightarrow \int \delta p^{-(1+\mu)}\, \delta p^2\, d\, \delta p = \infty$
- non-random walk exponent in p vs. t
  $\langle |p(t)-p(0)| \rangle \sim t^{1/\mu}$

From Mantegna,Stanley, Nature (1995)



SP500 in 1984-1989 at
1 min resolution
(1.5mln data points)

Boltzmann-Gibbs versus Pareto distribution



Ludwig Boltzmann (1844-1906)

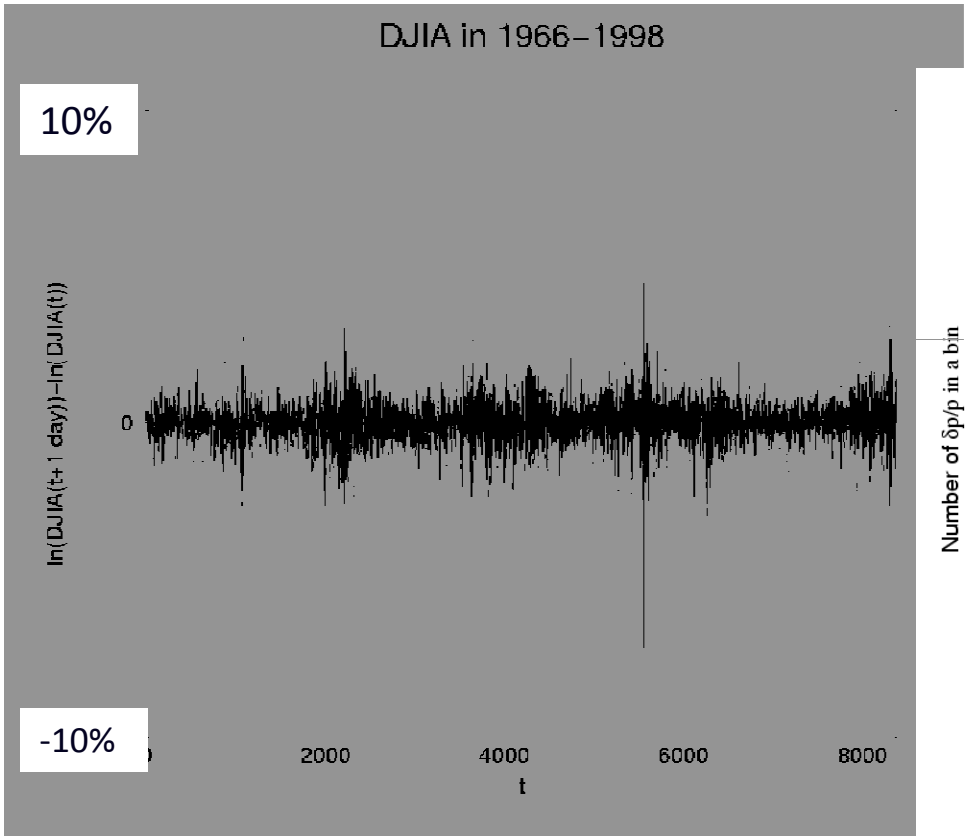
Vilfredo Pareto (1848-1923)

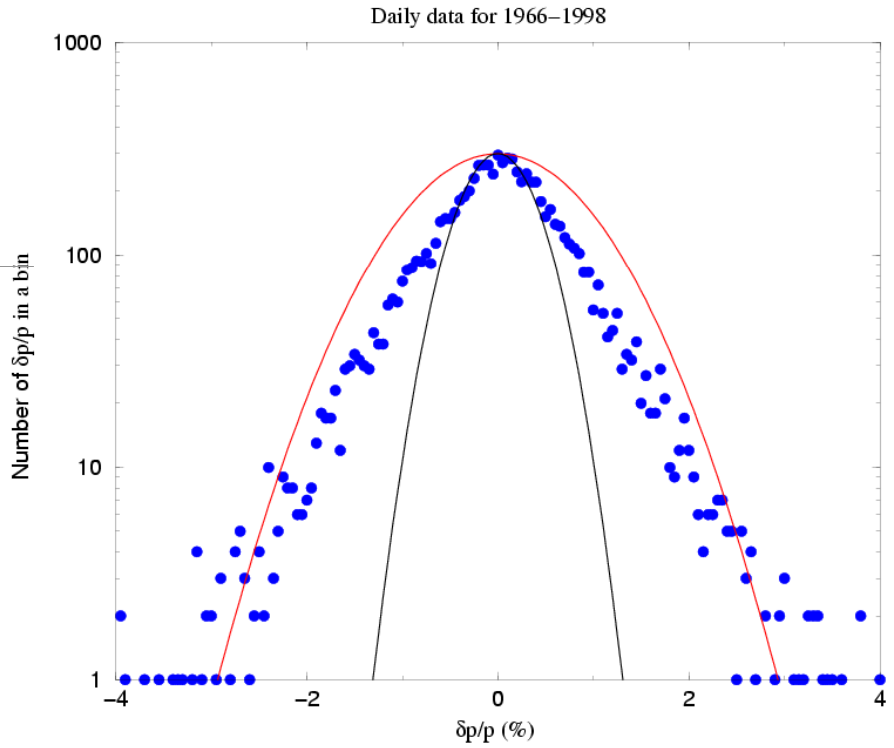
Boltzmann-Gibbs probability distribution $P(\varepsilon)\sim\exp(\varepsilon/T)$, where ε is energy, and $T=\langle\varepsilon\rangle$ is temperature.

Pareto probability distribution $P(r)\sim r^{-(\alpha+1)}$ of income r.

An analogy between the distributions of energy ε and money m or income r

Quick experiment: free data from www.nyse.com/marketinfo/nysestatistics.html





In a gaussian world the probability of the October 1987 crash would be 10^{-135}!

Athens Stock Exchange: Alpha Bank

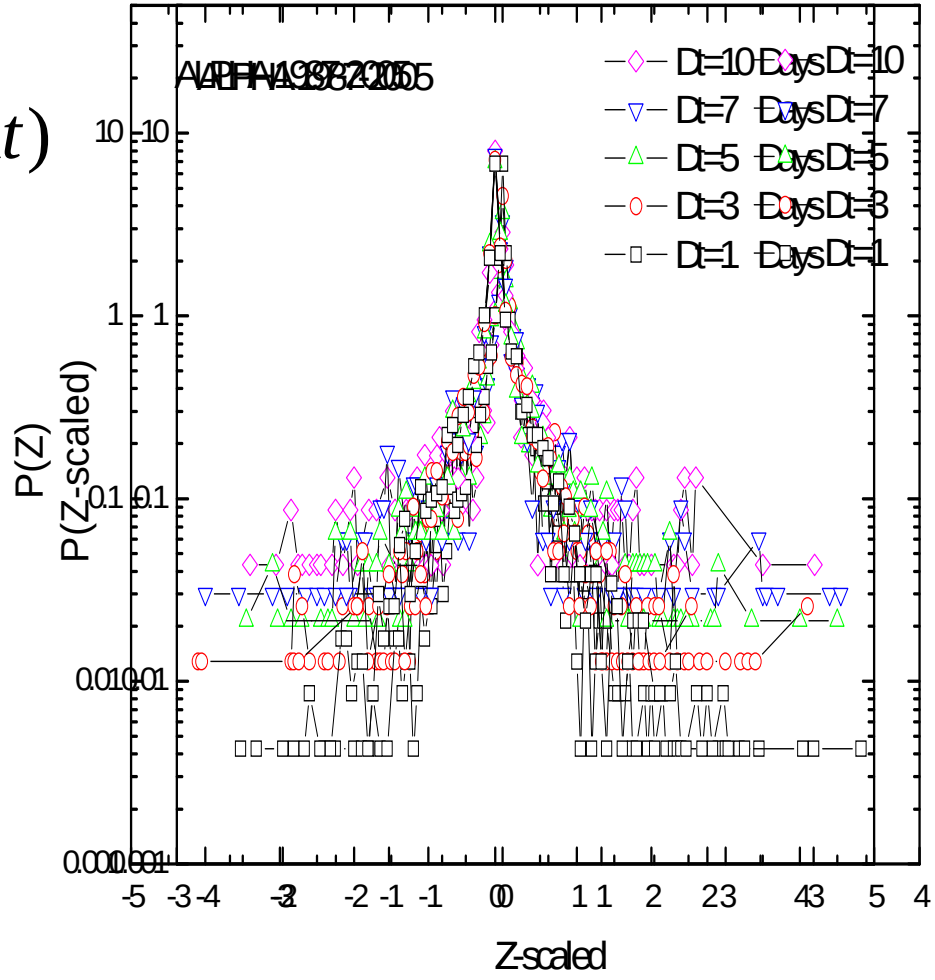
$$Z(t) = LogP(t) - LogP(t - \Delta t)$$

- Mantegna - Stanley

$$Z_s = Z / [(\Delta t)^{1/\alpha}],$$

$$P_s[Z_s] = (\Delta t)^{1/\alpha} P_{L,\alpha}[Z]$$

$$a = 1.43$$



Rare events:

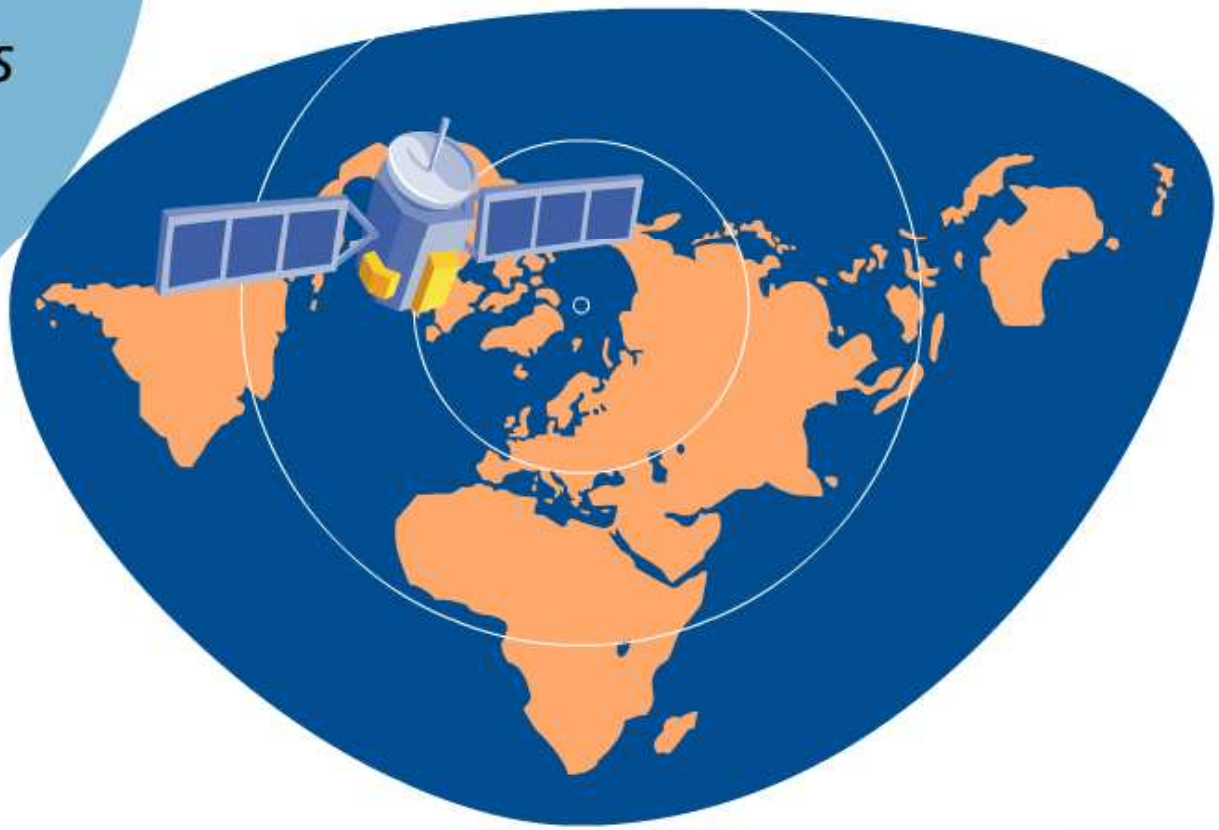
- Why do Financial Stock Markets crash?
- What are the bubbles?
- Can we predict such events?
- Can we find some pre-cursor activity?

What is the Grid?

If you look at our world today you will see a lot of computers, up to several million!

What is the Grid?

... but also data storage elements and instruments such as meteorological sensors and satellites.



What is the Grid?

Most of them are connected to the ***Internet****, a large-scale computer network.*

What is the Grid?

*Thanks to the **World Wide Web**, a service built on top of the Internet, these computers can **share information.***

What is the Grid?

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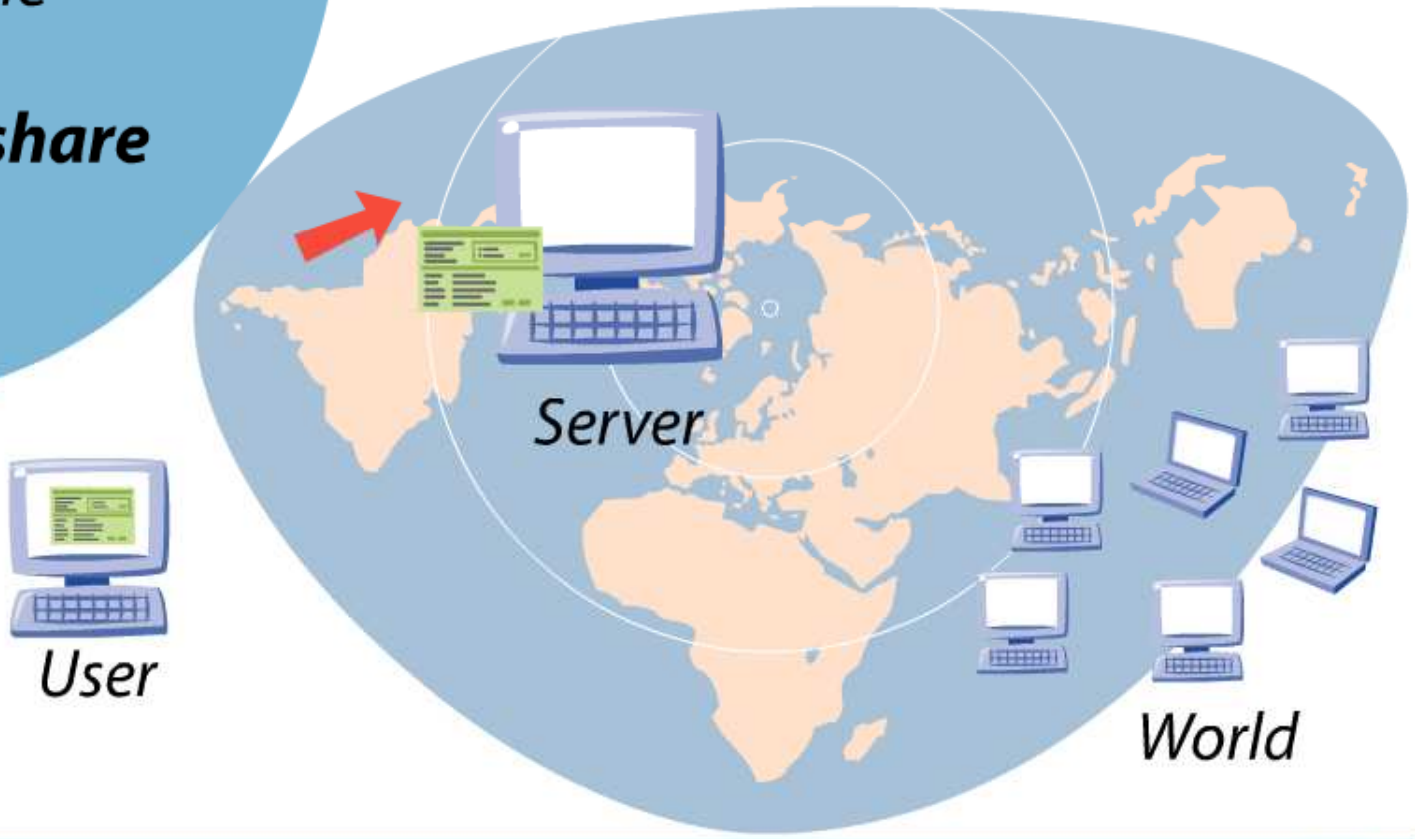

What is the Grid?

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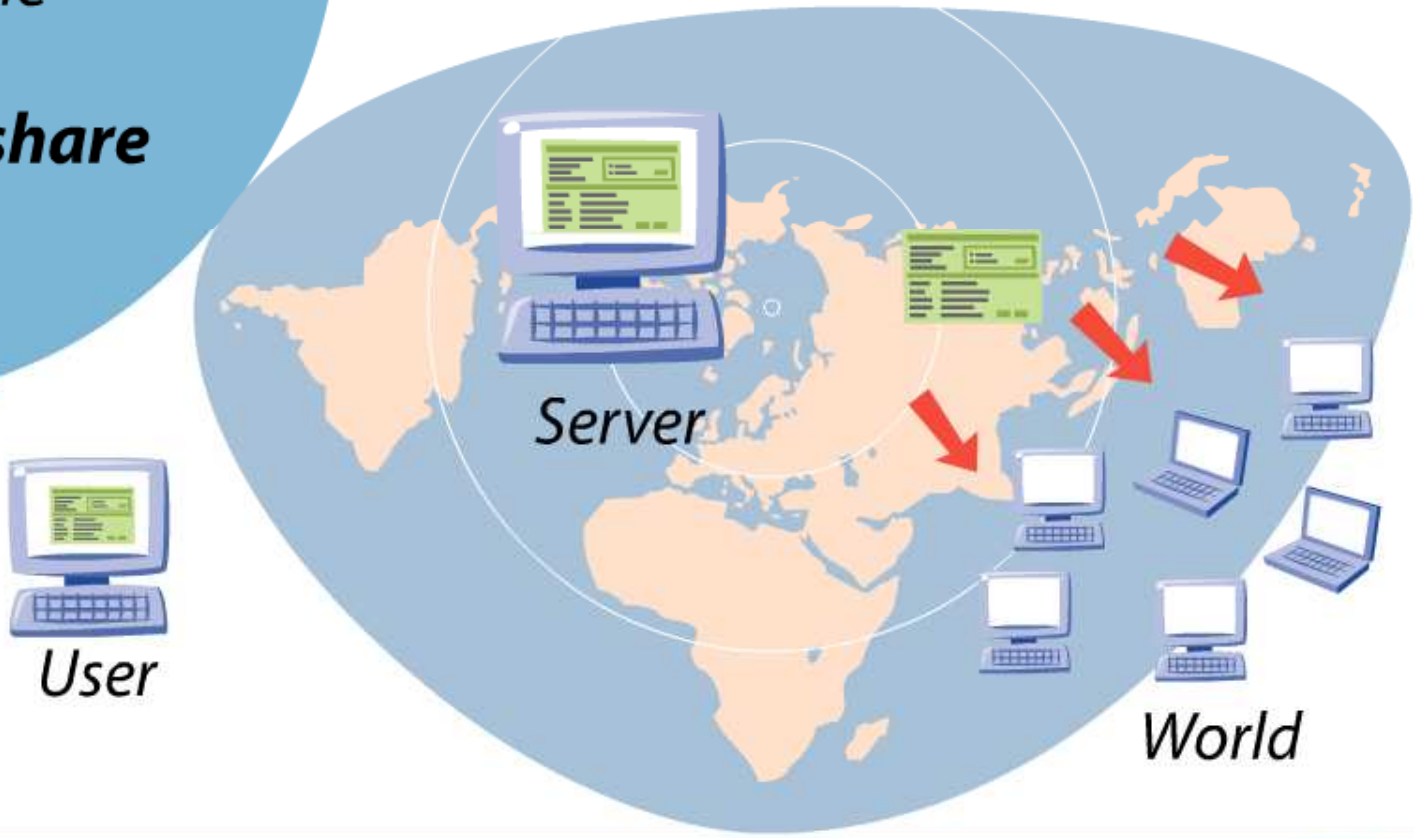


What is the Grid?

The Grid goes one step further!

What is the Grid?

Computers and instruments connected to the Grid share not ***only*** *information ...*

What is the Grid?

... but also ***computing power*** *and resources like* ***disk storage, databases*** *and* ***software applications.***

What is the Grid?

While one computer may take days to complete a complex calculation ...

What is the Grid?

... the Grid will make available hundreds of collaborative computers...

What is the Grid?

... to get the ***same result faster and more efficiently!***

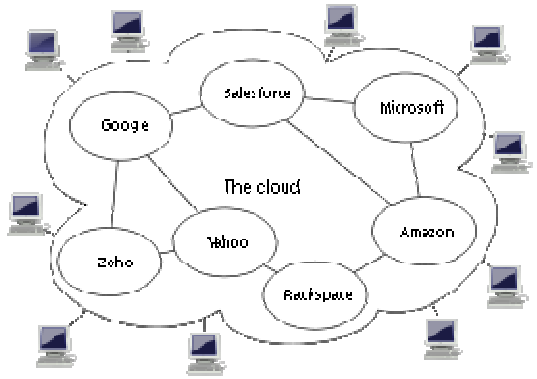
What is the Grid?

Once connected to the Grid, the user will see it as one large computer system, providing almost ***infinite computer power!***

computing nowadays is like…….

water, electricity, telephone, television

Cloud computing



Tools to attack the computational problem (the HPC case…)

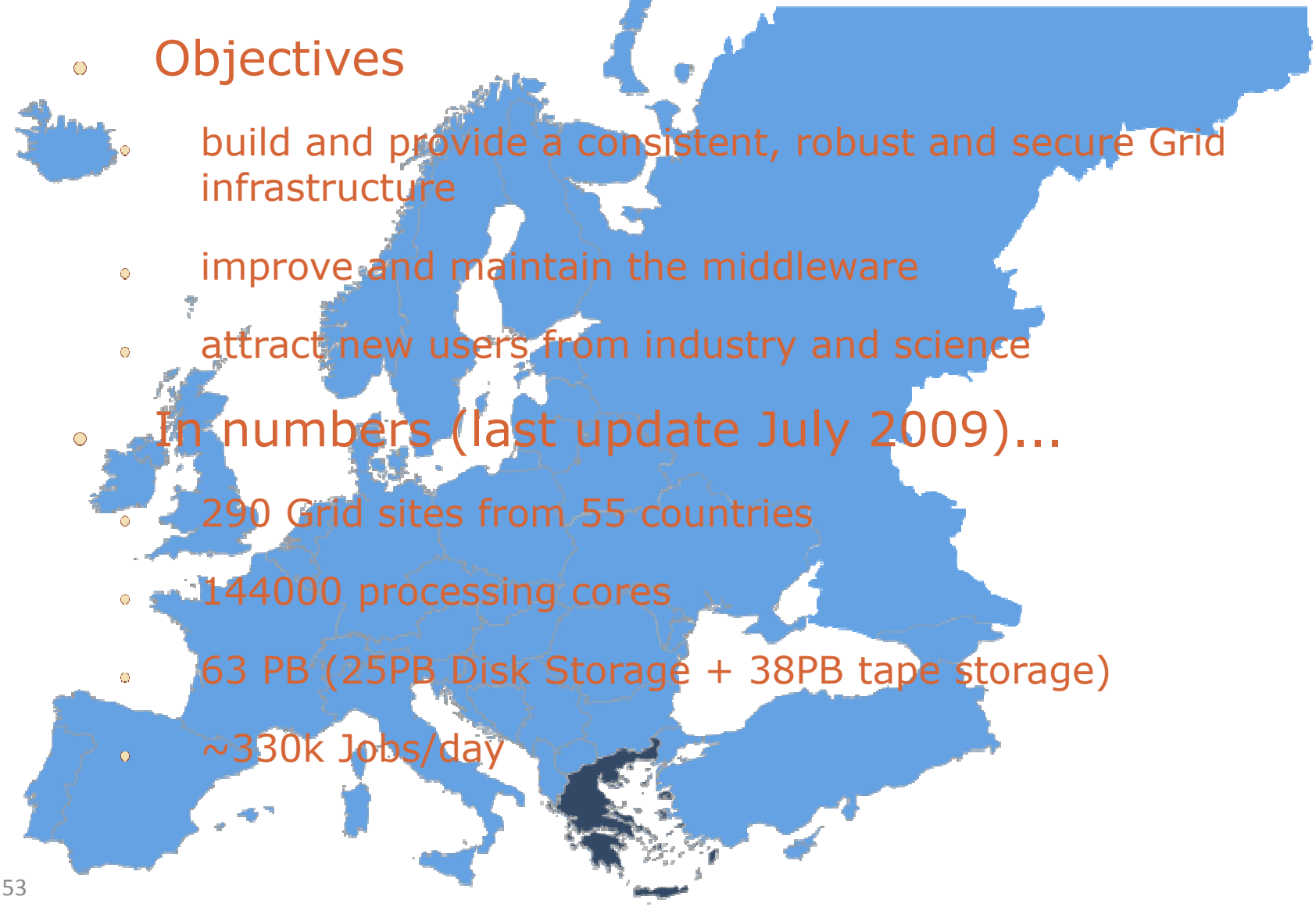
- Special hardware

SGI Altix FPGA
Blade servers

nVidia GPGPU

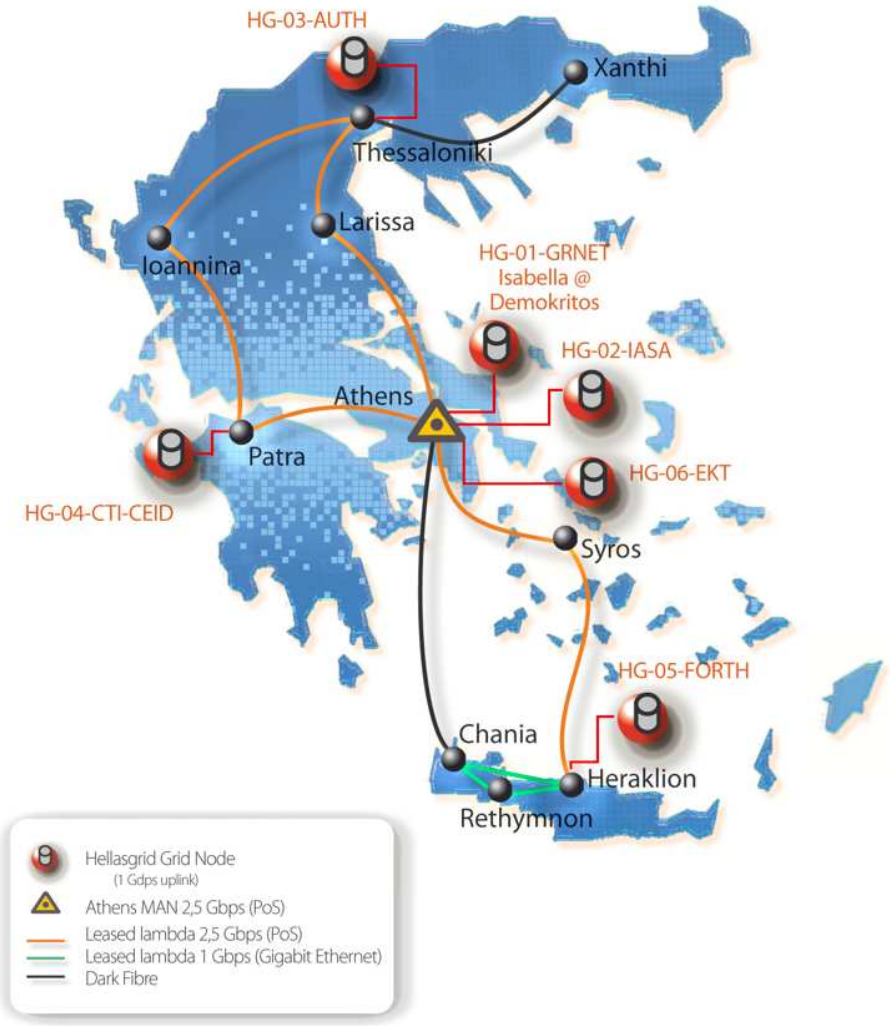
IBM Cell
(LANL Roadrunner)

European Grid Infrastructure



- Objectives
  - build and provide a consistent, robust and secure Grid infrastructure
  - improve and maintain the middleware
  - attract new users from industry and science
- In numbers (last update July 2009)...
  - 290 Grid sites from 55 countries
  - 144000 processing cores
  - 63 PB (25PB Disk Storage + 38PB tape storage)
  - ~330k Jobs/day

HellasGrid Overview



HellasGrid Infrastructure Overview		
	CPU Cores	Storage (TBs)
HG-01-GRNET	64	20
HG-02-IASA	120	4
HG-03-AUTH	120	4
HG-04-CTI-CEID	120	4
HG-05-FORTH	120	4
HG-06-EKT	628	12
GR-01-AUTH	136	29
GR-04-FORTH-ICS	10	-
GR-06-IASA	20	2
GR-07-UOI-HEPLAB	28	20
GR-09-UOA	10	2
GR-10-UOI	120	2
Total	**1496**	**103**

Grid Infrastructure @ A.U.Th.


120 CPUs Xeon 3.4GHz


34TB H.D. Storage
88 Xeon Cores 2.0GHz


4TB H.D. Storage


96 Intel Cores 2.4GHz
4TB H.D. Storage

ICoSCIS Project

- Build new GRID node in Blagoevgrad
- Connect Blagoevgrad node to the Bulgarian National Grid structure
- Enhance/improve the Thessaloniki node
- Bring the 2 communities together
- Provide all the necessary training