Terrorizing Complex Systems

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Terrorizing Complex Systems

Modern Life:

Ever more technological

Ever more interconnected

Ever more diverse

Symptoms:

Increased size and sophistication of systems and processes

Increased interdependence and contingency (globalization, just-in-time)

Increased social and psychological stress

Consequence:

Vulnerable to destabilization and catastrophic loss

More real than we'd like

Long-Term Capital Management:

Had the failure of LTCM triggered the seizing up of markets, substantial damage could have been inflicted on many market participants, including some not directly involved with the firm, and could have potentially impaired the economies of many nations, including our own.

Alan Greenspan (1998)

Internet Route Flapping:

Through-put and control protocol traffic at odds

Iraq:

``The tipping point long anticipated by President George W. Bush may have finally been achieved Wednesday morning as thousands of jubilant Iraqis took to the streets to mark the beginning of the end of Saddam Hussein's 24-year tyrannical rule of terror.”

LONDON, April 9 (UPI)

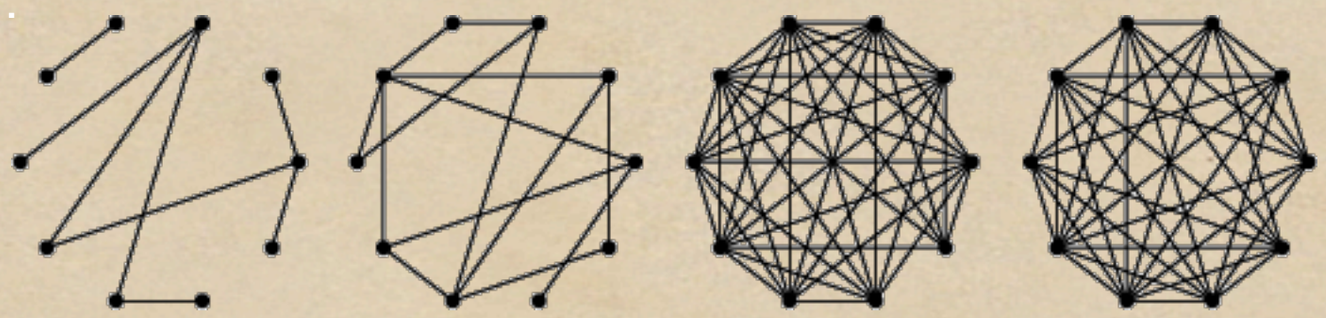
Modern life is more complex, but in what sense?

Two definitions

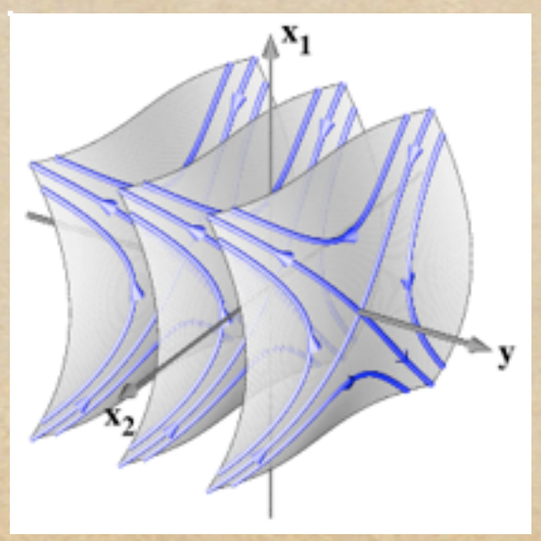
- Complication
- Structure

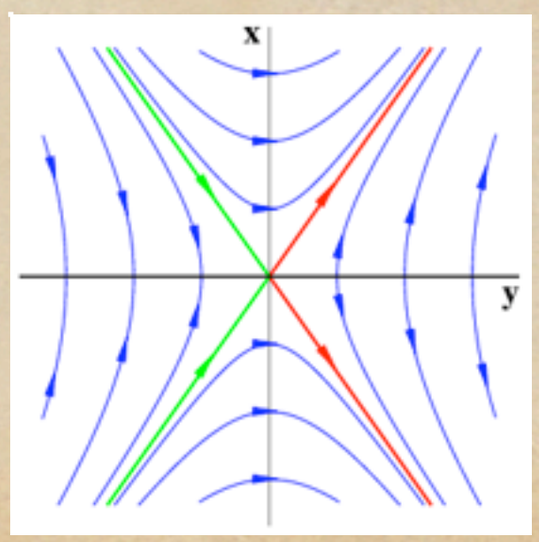
Complication

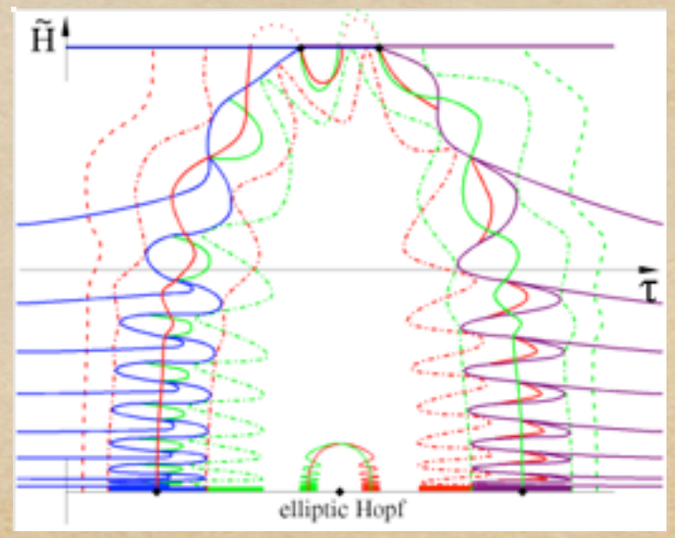
in Connectivity: Random Graphs



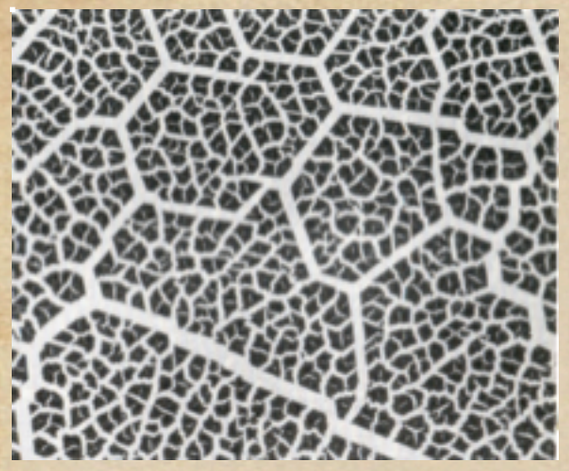
in Time: Intrinsic unpredictability (chaos)

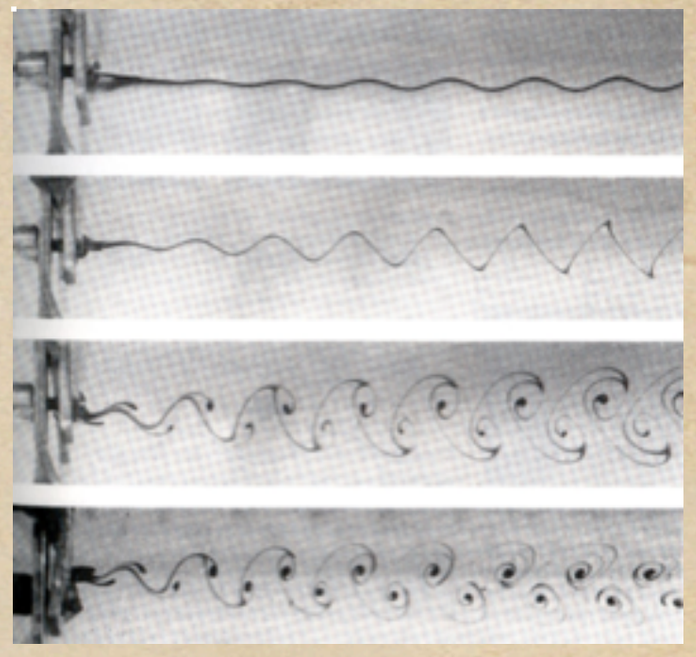


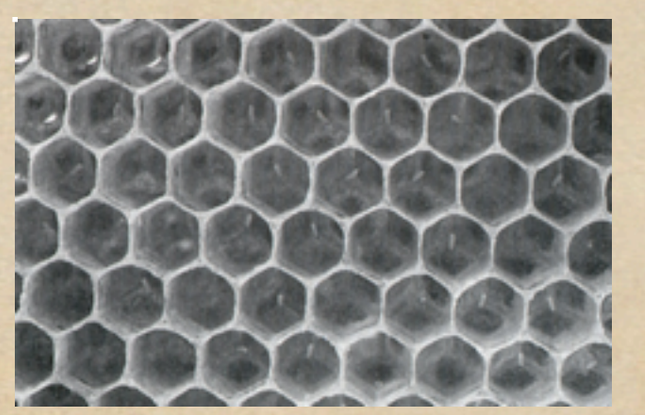




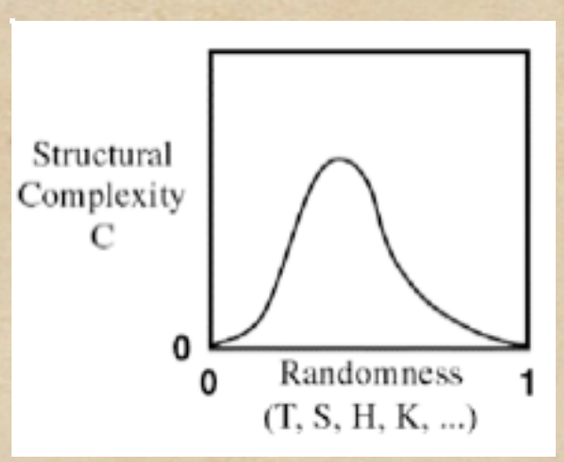
Structure





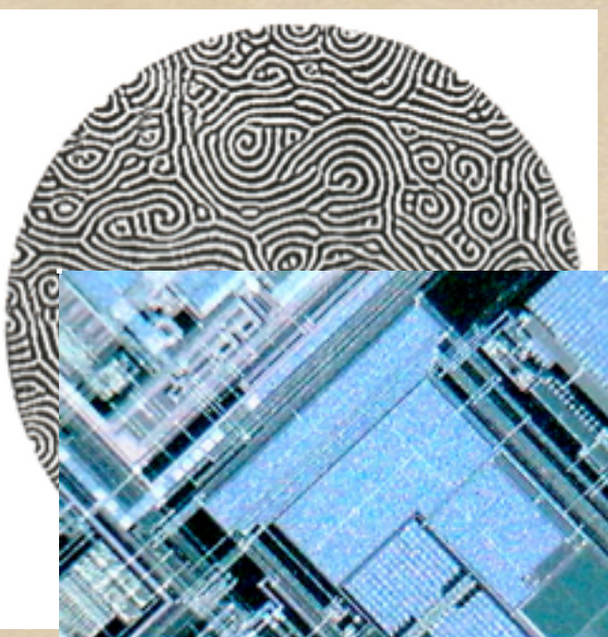


Complication versus Structure



Boredom

Delight



Confusion

Variatio Delectat

What are Networks?

To say a system is a network calls attention to

its architecture

Study of networks is a study of structure & organization

What's old:

Time-worn problem of "pattern"

What's new:

Mathematics: dynamics, complexity, ...

Tools: simulation, visualization, automated experiment

Openness to re-think current approaches

SFI Network Dynamics Program

(discuss.santafe.edu/dynamics)

Funded by Intel, an SFI Business Network Member

Theory Agenda:

- Network structure: mean path, clustering, degree distribution, betweenness
- Dynamics **on** networks: synchronization, emergence of patterns
- Dynamics **of** networks: perferential attachment, scale-free networks
- Self-adapting networks

Applications:

Ecology: food webs, allometric scaling

Internet and web: structure, dynamics, and growth

Social systems: scientific collaboration networks

Neural networks: intrinsic computation versus architecture

Epidemiology: spread of disease

...

Vulnerability of Large-Scale Complex Systems

- Stability & robustness
- Control
- Pattern discovery
- Right-sized?
- Right architected?
- Right dynamics?