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: preferential 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?