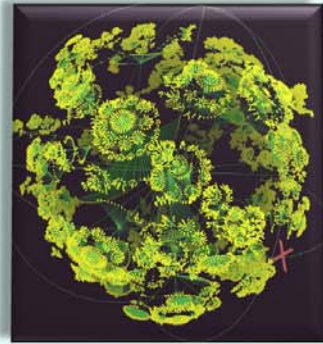


# Communication Networks

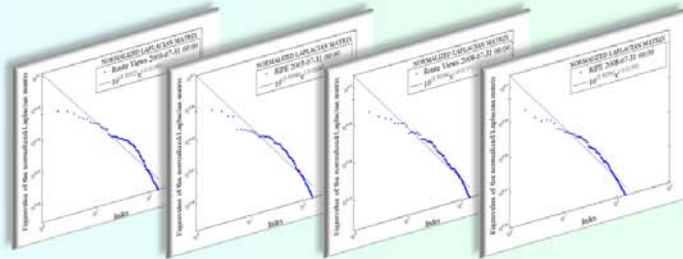
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## The Internet as a Complex Network



1hr (535,102 nodes and 601,678 links)

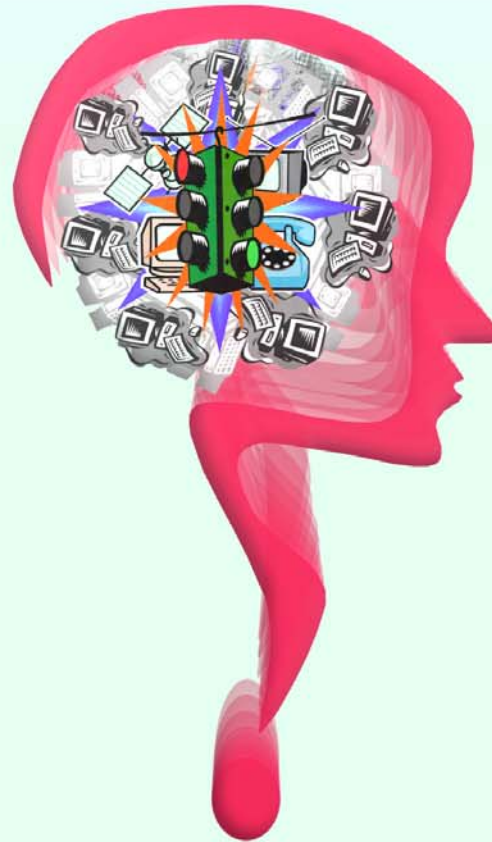
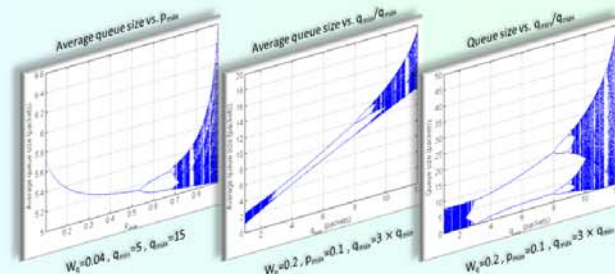


- The Internet topology is characterized by the presence of various power-laws.
- Plots of eigenvalues of the normalized Laplacian matrix show invariance regardless of the exponential growth of the Internet.

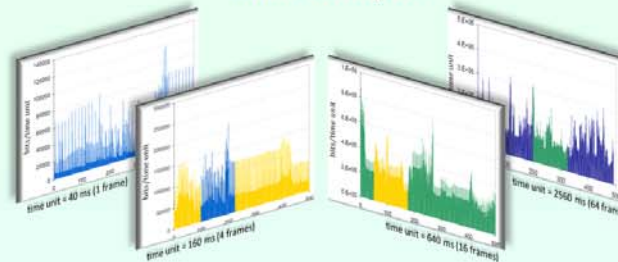
## Modeling the TCP Protocol with RED Algorithm

- Discrete dynamical model of TCP/RED:

$$\bar{q}_{k+1} = \begin{cases} (1 - w_q) \cdot \bar{q}_k + w_q \cdot \max\left(\frac{N \cdot K}{\sqrt{p_k}} - \frac{C \cdot d}{M}, 0\right) & \text{if } p_k \neq 0 \\ (1 - w_q) \cdot \bar{q}_k + w_q \cdot (rwnd \cdot N - \frac{C \cdot d}{M}) & \text{if } p_k = 0 \end{cases}$$

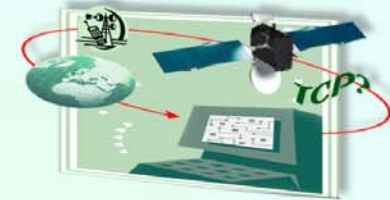


## Traffic Analysis



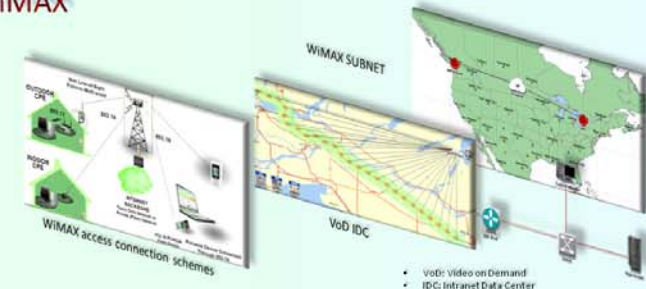
- MPEG video traces may be viewed on various time scales.
- The Internet traffic exhibits self-similar and fractal behavior.

## TCP for Heterogeneous Networks



- TCP is designed for wired networks where packet loss is mainly due to congestion. As an indicator of congestion, packet loss causes TCP to reduce its congestion window size and its throughput.
- In wireless networks, TCP packet loss is often caused by transmission errors and periodic disconnections due to frequent handoffs.
- Various enhancements of TCP congestion control algorithms have been proposed to improve TCP performance in wireless and satellite networks.

## WiMAX



- Worldwide Interoperability for Microwave Access embodies the IEEE 802.16 family of standards that provides fixed and mobile broadband access in the telecommunications landscape.
- Performance of mobile WiMAX networks for streaming video and audio content was evaluated using the OPNET simulation tool.

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