Self Similar Network Traffic

present by Carl Minton

Agenda

- Definition of self similarity
- Quantifying self similarity
- Self similarity of network traffic
- Implications for network performance
- Pointers for more information

Definition of Self Similarity

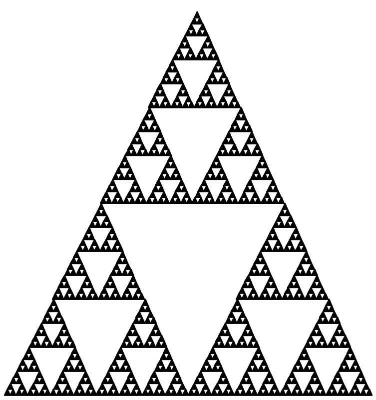
Self Similarity:

- self similar structures are “scale invariant”
- example: Sierpinski gasket
- as you “zoom in” the structure appears the same

Self Affinity, or statistically Self Similarity

- akin to self similarity
- “zooming in” yields a random process with similar statistical properties

Self Similar and Self Affine structures are both fractals



Quantifying Self Similarity

Hurst Parameter

- Developed by Harold Hurst in 1965 while studying fluid storage
- Rescaled range *R/S* is essentially a measure of the range divided by the sample standard deviation for a given duration, *t*, of the process
- $R/S = t^H$ for large t; where H is the Hurst parameter
- White noise has H = 0
- Measures long term dependence of the process
- A metric of a stochastic process of infinite extent
- Since it is a parameter of infinite series, it must be estimated for a trace of finite length
- Several methods exist for estimate

Self Similarity of Network Traffic (1/2)

Leland, et al., showed that Ethernet traffic exhibited self similar properties.

Study was of a network trace over the period from August 1989 to February 1992

Estimated the Hurst parameter around 0.8

Implications:

- long range dependence of traffic
- correlation over varying time scales
- self similar nature of traffic
- standard models were not accurate at depicting the nature of traffic

Self Similarity of Network Traffic (2/2)

see Figure 4 of Leland, et al.

Taken from Leland, et al.

Implications for Network Performance (1/3)

Comparison of Self Similar Models to “Standard” Models

Self Similar Model	**Standard Model** (Poisson, MMPP)
Bursts have no natural length	Bursts are predicable
Aggregation intensifies burstiness	Aggregation masks burstiness
Burstiness at all time scales	Bursts only evident at small time scales

Implications for Network Performance (2/3)

During periods of network congestion, congestion is persistent and losses can be high

- due to multifrequency trends within traffic, spike could appear on top of a number of shorter frequency upward trends
- aggregate effects of multiple trends within traffic
- larger buffers do not prevent losses

Periods of congestion are more difficult to predict

- since traffic is burst, with highly variable burst lengths, prediction is difficult

Congestion recovery is as important, if not more so, than congestion avoidance.

Implications for Network Performance (3/3)

Example: ATM CAC (Call Admission Control)

Goal: to admit calls to the network based on quality of service (QoS) constraints

Peak-rate allocation: admit calls until the sum of their peak rates equals the link capacity

Statistical multiplexing: admit calls based on expects levels of traffic

- attempt to guarantee a loss rate
- undermined by “statistical gain”, or independent sources transmitting peak rates simultaneously

Self similar traffic models undermine the notion of a low probability of a “statistical gain”

For Further Information

About Self Similarity

- Mandelbrot, B, *The Fractal Geometry of Nature*, W. H. Freeman and Company, New York, 1983
- Schroeder, Manfred, *Fractals, Chaos, Power Laws*, W. H. Freeman and Company, New York, 1991

About Self Similar Traffic

- Leland, W., et al, “On the Self-Similar Nature of Ethernet Traffic (Extended Version)”, IEEE/ACM Transactions on Networking, February 1994

About the Implications of Self Similar Traffic

- Leland, W. and Fowler, H., “Local Area Network Traffic Characteristics, with Implications for Broadband Congestion Management”, IEEE JSAC, September 1991
- Michiel, H. and Laevens, K., “Teletraffic Engineering in a Broad-Band Era”, Proceedings of the IEEE, December 1997