Self Similar Network Traffic
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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.

Implications for Network Performance (1/3)

Comparison of Self Similar Models to “Standard” Models

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<th>Self Similar Model</th>
<th>Standard Model</th>
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<td>Bursts have no natural length</td>
<td>Bursts are predictable</td>
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<td>Aggregation intensifies burstiness</td>
<td>Aggregation masks burstiness</td>
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<td>Burstiness at all time scales</td>
<td>Bursts only evident at small time scales</td>
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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

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