Bell Labs DARPA Project

Part I

PackMime Traffic Modeling

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Part II

Algorithms for MPLS Traffic Engineering

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PackMime Traffic Modeling

Goals

- simulation
- bandwidth allocation

Criteria

- validity: through extensive analysis of data, demonstrate synthetic traffic emulates statistics of live traffic
- simplicity: parsimonious models
- fast simulation: single-thread generation for any traffic load c, modeling changing statistical properties as c changes

PackMime FSD

- generation of packet arrivals and sizes

PackMime HTTP

- generation of HTTP 1.0/1.1 source traffic requests
- architecture for integration with transport layer

PackMime FSD

Fractional Sum-Difference (FSD) models for generation of packet arrivals and sizes arriving for transmission on a link

Previous Work

Fractional Brownian motion

- models are self-similar and Gaussian
- validity: Internet traffic is not in general self-similar or Gaussian

Traffic is multifractal

- Riedi and Vehel, Multifractal Properties of TCP Traffic: A Numerical Study, 1997
- complex nonlinear structure

Statistical properties of inter-arrivals and sizes change with traffic load c

- Cao, Cleveland, Lin, and Sun, Internet Traffic Tends *Toward* Poisson and Independent as the Load Increases, 2002
- arrivals tend toward Poisson
- sizes tend toward independence

Can we find simple, valid models that
1. reproduce multifractal behavior
2. account for changing statistical properties with c
3. allow fast computation

FSD Models

FSD Models

THE TRICK IS TRANSFORMATION

Let t_k for $k = 1, 2, \ldots$ be a packet size time series or a packet inter-arrival time series for traffic load c

Discovery: monotone transformation, T_c, of t_k changes the time series into a very simple gaussian (linear) process

$$z_k = T_c(t_k)$$

$\uparrow$ gaussian

$\uparrow$ multi-fractal

$$z_u = (I - B)^{-0.41}(\epsilon_u + \epsilon_{u-1}) + n_u$$

$$t_k = T_c^{-1}(z_k)$$

ϵ_u and n_u are white noise series with means 0 and variances $\sigma_c^2(\epsilon)$ and $\sigma_c^2(n)$

T_c^{-1} = Marginal(Inverse-of-Gaussian(•))

$$Bw_u = w_{u-1}$$

Sizes: marginal does not change with c

$\sigma_c^2(\epsilon) \to 0$ with c

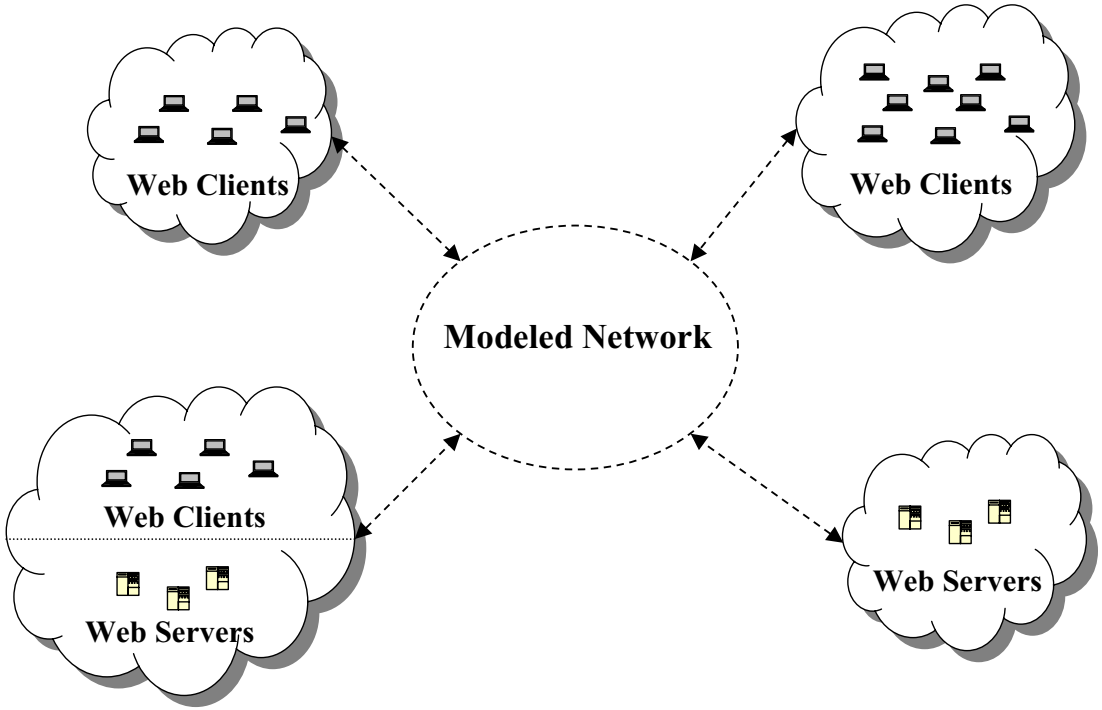
Inter-arrivals: Weibull $\to$ exponential with c

PackMime HTTP: Modeled Variables and Architecture

Source traffic generation of HTTP 1.0 and 1.1 requests and architecture for interaction with transport layer and a modeled network

Client
request arrival time
request file size
roundtrip time
bottleneck link speed
packet loss

Server
delay
response file size
roundtrip time
bottleneck link speed
packet loss



HTTP Source Traffic Modeling

PackMime HTTP

J. Cao, W. S. Cleveland, Y. Gao, K. Jeffay, F. D. Smith, and M. Weigle, Stochastic Models for Generating Synthetic HTTP Source Traffic , IEEE Infocom, 2004.

Modeling building and validation

- packet traces from UNC and Bell Labs

Other Work

Source traffic modeling

- generally neglected

HTTP source traffic modeling

- classical work: Crovella et al. and Mah are page based-models for Web server workloads
- empirical modeling of Jeffay et al.

PackMime FSD and PackMime HTTP: Status

Modeling and validation (completed)

Standalone C code for generation (completed but needs optimization)

Technology transfer (in progress)

- LBL: ns-2
- Univ. of Illinois: JavaSim
- Georgia Tech: GTNetS