Multifractal Fractional Sum--Difference Models for Internet Traffic

Abstract

Internet quality of service is strongly effected by packet queuing behavior, which in turn depends on the behavior of packet interarrival times. Thus, accurate modeling of packet interarrival times is essential for maintaining a high quality of service on the Internet. Packet interarrival times have been studied before, and some models have been put forward. However, the Fractional Sum--Difference model is unique in that it offers the first parsimonious model that is able to account for statistical phenomena and provide formulas for and insight into the behavior of Internet traffic packet interarrival times. This includes the behavior of multifractal plots, variance--time (VT) plots, and the autocorrelation function (acf), as well as time--scaling behavior.

The simplicity of the FSD model comes from its use of a non--linear, monotone transformation of the interarrival times to a simple Gaussian process. Specifically, the Gaussian process is a long--range dependent time series that is the sum of a component which is near fractional Brownian motion (fBm) and a Gaussian white noise vomponent. The transformation can be approximated by a logarithmic transformation, so that the untransformed interarrival times can be approximated as the product of the exponent of a near fBm component and the exponent of Gaussian white noise. The untransformed time series can be modeled as marginally Weibull, so that the FSD model has only four parameters: the mean of the untransformed interarrival times, a Weibull shape parameter for the untransformed interarrival times, a parameter indicating the relative size of the long--range dependent component of the Gaussian image, and a parameter measuring the strength of the long--range dependence (d, the Hurst parameter minus 0.5). The FSD model is highly accurate and has been validated by real--world data sets.