ANALYSIS CLASSICAL AND FRACTAL SERVICE SYSTEMS IN TELECOMMUNICATION NETWORK

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In the telecommunications network, switching node buffers are a critical resource for managing subscribers and network traffic. Research shows that in packet switching, network traffic is inherently self-similar or fractal. Fractal properties characterizing traffic typically include concepts such as slowly decaying dispersion and long-term dependency [1, 2].

Self-similarity traffic has a significant impact on the quality of communication and on queues in queuing systems. An adequate description of self-similar traffic in a telecommunications network is determined by probability distributions with heavy "tails." Currently, there are no general analytical results on queuing for self-similar traffic and the impact of self-similarity on service quality [3, 4].

When modeling self-similar traffic, it is necessary to reflect the presence of long-term dependencies in traffic paths and its pulsating (self-similar) structure on multiple time scales. Both of these effects can be modeled by a burst process. A burst implies a prolonged flow of data blocks, such as packets.

In practice, when modeling sources, the distribution OFF periods is often assumed to be exponential, while for ON periods the Pareto distribution is most often used. The probability density of the Pareto distribution is determined by the distribution function in the form [1, 2, 5]:

$$w(x) = P(x) = (\alpha \cdot \beta^{\alpha}) / x^{\alpha+1}, \ x \geq \beta \ , \beta > 0 , \ \alpha > 0 , \qquad (1)$$

where β is the boundary parameter that specifies the minimum value of the random variable x and is, in fact, a scale factor;

α is the shape parameter $1 < \alpha < 2$ and is expressed through the Hurst coefficient as follows: $\alpha = 3 - 2H$.

In addition to the mathematical expectation and variance, a useful characteristic of a random variable x in queue modeling is the square of its coefficient variation $C^2(x)$, where $x \in Pa(\alpha, \beta, H)$:

$$C^2(x) = (1-2H)/(3\text{-}2H) = 1/\alpha \cdot (\alpha - 2) . \qquad (2)$$

Variation coefficients (or more precisely, their squares) are a measure of the dispersion of values for request arrival intervals and service intervals.

The larger these coefficients, the larger the average queue length $L(\rho)$ should be expected for a fixed load ρ .

For the Pareto distribution, in the range of parameter values $1 < \alpha \leq 2$, both squares of the variation coefficients (intervals between arrivals and arrival durations) essentially tend to infinity, from which it follows that the values of the average queue length $L(\rho)$ should be expected to be significantly (many times) greater than for M|M|1.

In the general case, a telecommunication network node is considered as a QS of class G|G|1|m in a stationary operating mode. The main problem of designing buffers assystems of class G|G|1|m is posed as finding the dependence of the probability of losing a request P_n on the buffer size m:

$$P_n = f(m, H)\,, \quad m = 1, 2, 3, \ldots \;.$$

This will allow for any pre-set acceptable loss probability P* to determine the corresponding smallest acceptable buffer size m*

Thus, mathematical concepts such as self-similar random processes, long-term dependence, and heavy-tailed distributions have come into widespread use in the description and analysis of fractal traffic.

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