Percentiles calculation of the IP packet delay distribution function

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Two parameters of the QoS

Quality of service in the IP-networks is standardized by several indices. There are two values related to the delay of the IP-packets between user-network interfaces in the list of the quality of service indices:

- IP Packet Transfer Delay (IPTD);
- IP Packet Delay Variation (IPDV).

IPDV is a difference between 0,999 quantile of the IP-packets delay distribution function and minimal transfer time of the IP-packets.

Additional network performance parameters

In ITU-T Recommendation Y.1543 other delay variation percentiles are proposed as performance attributes:

•90th percentile – DV90.

•99th percentile – DV99.

By taking multiple percentile readings and a minimum delay reading, the distribution of delays can be better understood .

Quantile estimation method according to recommendation Y.1541 (1)

$$\gamma(i) = 6\frac{x_P - \frac{t_P(i) - \bar{t}_B(i)}{\sigma_B(i)}}{1-(x_P)^2}, \quad \omega(i) = \gamma(i)[\sigma_B(i)]^3$$

$\bar{t}_B(i)$ – mean value of delay on i-th stage

$\sigma_B(i)$ – mean square value

$t_P(i)$ – p-quantile

x_P – p-quantile on conditions that studied random variable is a normal variate

Quantile estimation method according to recommendation Y.1541 (2)

It is assumed that delay values on each stage are mutually independent

$$\bar{t}_B = \sum_{i=1}^{N} \bar{t}_B(i), \quad \sigma_B^2 = \sum_{i=1}^{N} \sigma_B^2(i)$$

$$\gamma = \frac{\sum_{i=1}^{N} \omega(i)}{[\sigma_B]^3} \qquad t_P = \bar{t}_B + \sigma_B \left\{ x_P - \frac{\gamma\left[1-(x_P)^2\right]}{6} \right\}$$

In the examples included in the ITU method, all calculations are made for the value $p = 0.999$. This probability was chosen by ITU for the standardization of the quantile of IP packets delay distribution between user-network interfaces.

Quantile estimation for the exponential distribution

For N-stage model consisting of M/M/1 queuing system models with identical parameters (mean arrival rate λ and mean service rate μ), delay distribution function is defined by the following expression:

$$S(t) = 1 - e^{-(\mu-\lambda)t} \sum_{j=0}^{N-1} \frac{[(\mu-\lambda)\cdot t]^{N-j-1}}{(N-j-1)!}$$

From this expression quantiles of the delay distribution function can be numerically evaluated.

Quantile estimation for 3 phases

	$\rho=(0,2..0,4)$	$\rho=(0,4..0,6)$	$\rho=(0,6..0,8)$
$x_{p=0,9}$	0,015	0,014	0,011
$x_{p=0,99}$	0,012	0,012	0,011
$x_{p=0,999}$	0,007	0,009	0,015

Quantile estimation for 5 phases

	ρ=(0,2..0,4)	ρ=(0,4..0,6)	ρ=(0,6..0,8)
$x_{p=0,9}$	0,013	0,013	0,012
$x_{p=0,99}$	0,011	0,011	0,012
$x_{p=0,999}$	0,006	0,007	0,011

Quantile estimation for 7 phases

	$\rho=(0{,}2..0{,}4)$	$\rho=(0{,}4..0{,}6)$	$\rho=(0{,}6..0{,}8)$
$x_{p=0,9}$	0,011	0,011	0,011
$x_{p=0,99}$	0,010	0,010	0,010
$x_{p=0,999}$	0,005	0,005	0,008

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Thank you for your attention

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