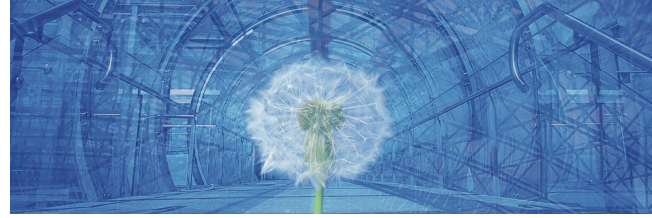# highstreet
Network Simulation

Service Flyer

OVERVIEW

Testing applications over real networks is often quite time-consuming and may easily lead to prohibitive effort. Therefore, tests are often limited to a few representative scenarios. For reaching sufficient "test" coverage, network simulation has become the method of choice. Moreover, simulation tools can be provided long before corresponding equipment and applications become available, thus making simulation an integral part of the product and network development process.

Some applications like IP-TV are extremely sensitive to packet loss. Others, like timing-over-packet, tolerate only a few hundred microseconds of packet delay variation. Consequently, network components like network transport equipment and transmission links have to be modelled at unprecedented accuracy. With their in-depth understanding of the transmission media and their long experience in the design of packet and circuit switching equipment, the experts of highstreet technologies are able to provide network impairment models at the precision required by the most demanding applications.

With the proliferation of multi-gigabit interfaces ever more packets have to be simulated. Per-packet simulation, however, does not scale with the network size. Within a joint research project, the Institute of Computer Science at the Freie Universität Berlin and highstreet technologies have developed a new simulation paradigm allowing simulating even largest networks in reasonable time. Comparatively small subnetworks are simulated on a per-packet basis the results of which are statistically modelled by phase-type distributions. These statistical sub-models are then combined to represent large networks. Also measurement results obtained from lab tests or field trials can be statistically modelled and flexibly integrated into end-to-end network simulations.

Network Modelling

The accurate modelling of transmission links and network elements is an indispensable prerequisite for high precision network simulation. Therefore, the highstreet Network Simulation Service starts with the development of exact impairment models for all network entities. The more challenging the applications are in terms of QoS the more accurate the network impairment models have to be. highstreet technologies is able to provide such accurate network impairment models for DSL, GPON, Microwave Radio, PDH, SDH, ATM, Carrier Ethernet, MPLS, and IP. Other transmission and switching technologies can be modelled on request. The figure below shows a packet delay model of a Carrier Ethernet switch as it is required for simulating the performance of timing-over-packet.
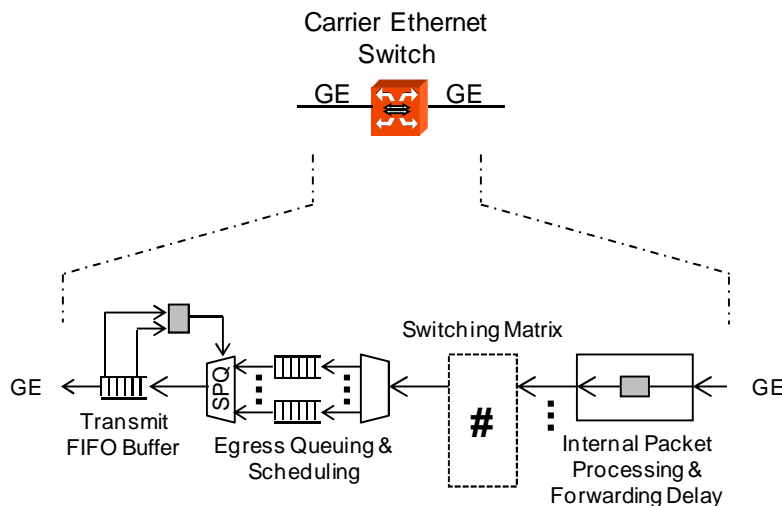
Delay model of a Carrier Ethernet switch

Application Analysis

The performance of applications and thus the user experience strongly depends on the bandwidth and the QoS provided by the network. highstreet technologies analyzes the sensitivity of applications like web browsing, file download, VoIP, video conferencing, interactive gaming, IP-TV inlc. HDTV and 3D-TV, timing-over-packet, and circuit emulation. Detailed reports are provided describing how the applications react on e.g. bandwidth fluctuations, packet loss, packet transfer delay, and packet delay variation. Different application parameter settings are investigated. For example, the figure below illustrates the impact of packet loss and round trip time (RTT) on the throughput of TCP-Tahoe over an 14.4 / 2.8 Mbit/s HSPA radio access network.
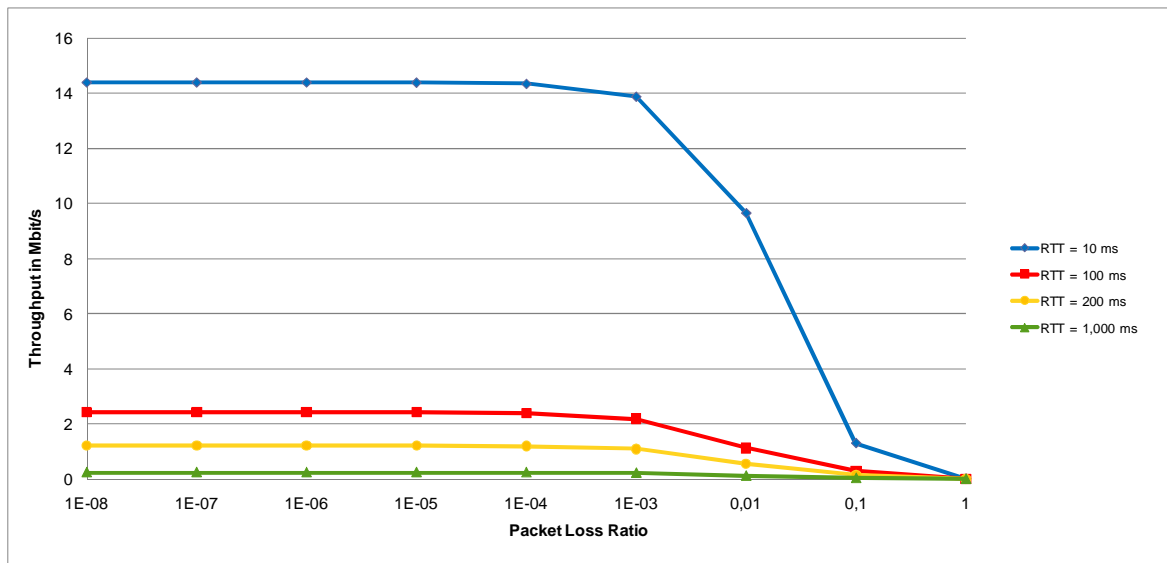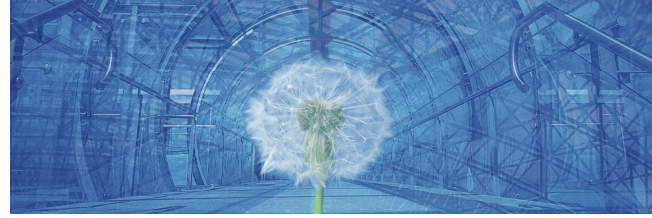
Data throughput of TCP-Tahoe over an HSPA radio access network
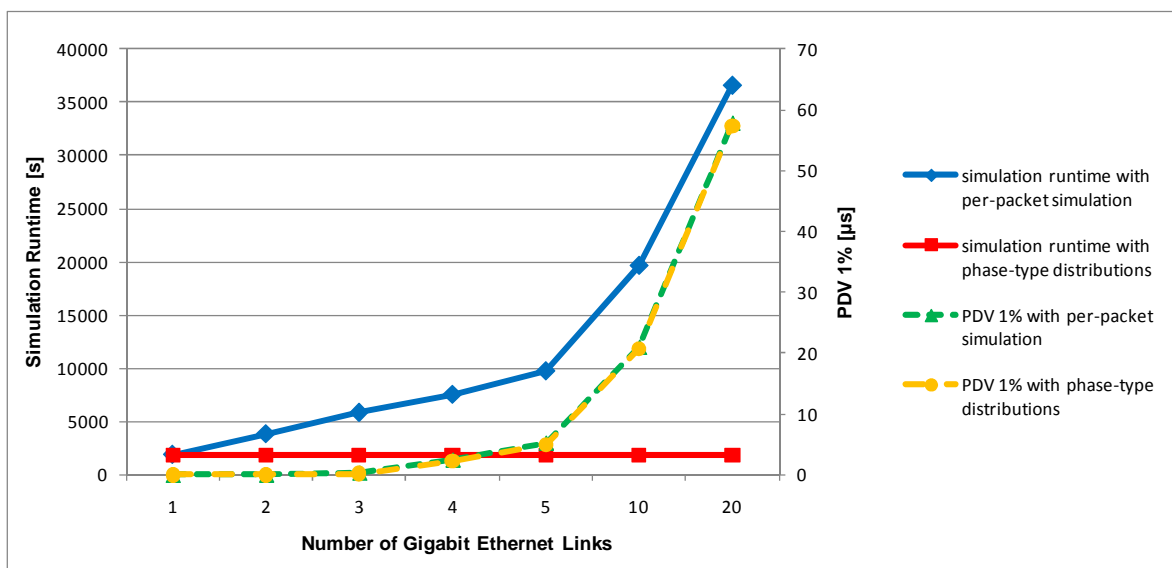
Network Simulation

The network impairment models of transmission links and switching equipment are combined to complete transport networks. The end-to-end behaviour is then simulated under various network and load conditions. The packet transfer delay over a typical Carrier Ethernet switch, as it has been simulated for assessing the performance of timing-over-packet, is displayed hereafter.
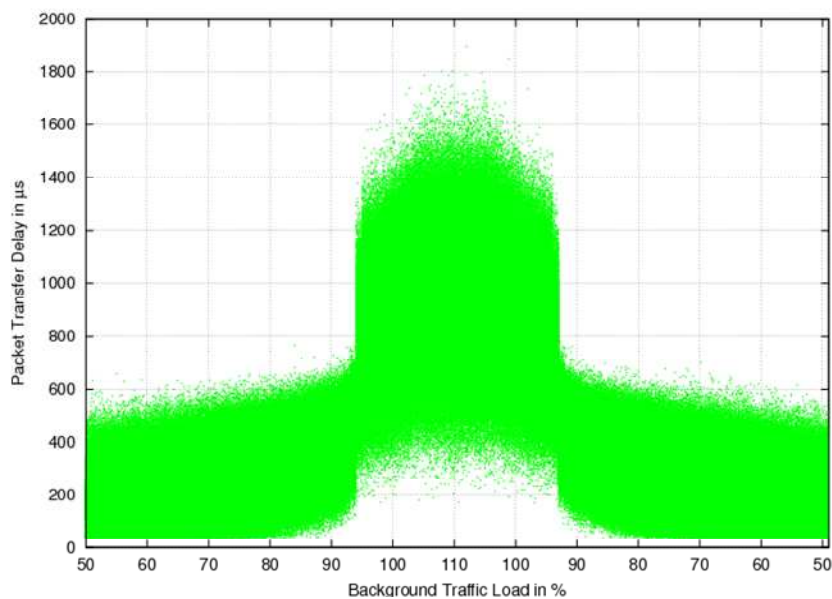
**Packet transfer delay over 5 FE interfaces of typical Carrier Ethernet switches**
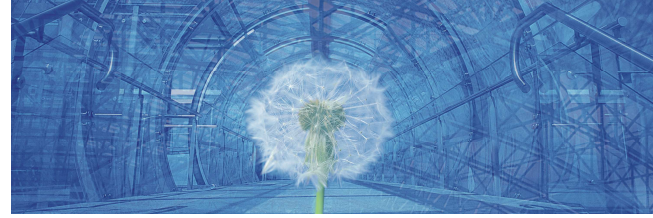
Although highstreet technologies disposes of multi-processor machines and supercomputing facilities, per-packet simulation would lead to inacceptable simulation times in large networks. In such situations, highstreet technologies applies a new simulation paradigm. The end-to-end network is decomposed into sub-networks that can be simulated in reasonable time. The results of these sub-network simulations are characterized by appropriate statistical models employing phase-type distributions. These can then be combined to obtain the end-to-end network behaviour. The diagram below highlights simulation runtime reduction attainable by the use of phase-type distributions and the nonetheless high accuracy.


Per-packet Simulation vs. Phase-type Distributions – Simulation Runtime and Accuracy

If parts of the network cannot be modelled for whatsoever reason it is possible to analyze measurement data and create statistical models for these parts of the network. These statistical models can be seamlessly integrated into end-to-end network simulation.
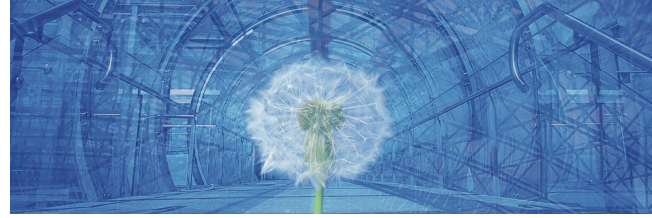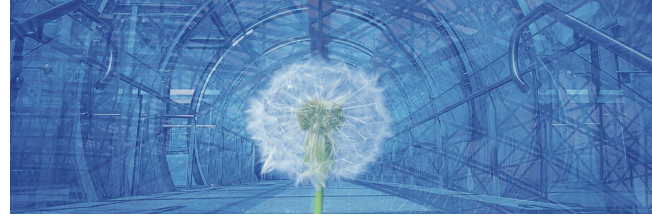
Network Optimization and Application Tuning

Both networks and applications offer parameter sets via which their behaviour can be influenced. After having assessed the performance of the applications by simulating the network behaviour highstreet technologies elaborates proposals for network parameter settings that optimize the performance of the predominant applications. The next figure shows how highstreet technologies optimized the parameters of a Carrier Ethernet switch for low packet delay variation, thus enabling timing-over-packet. Similarly, also the applications are tuned for the underlying network.
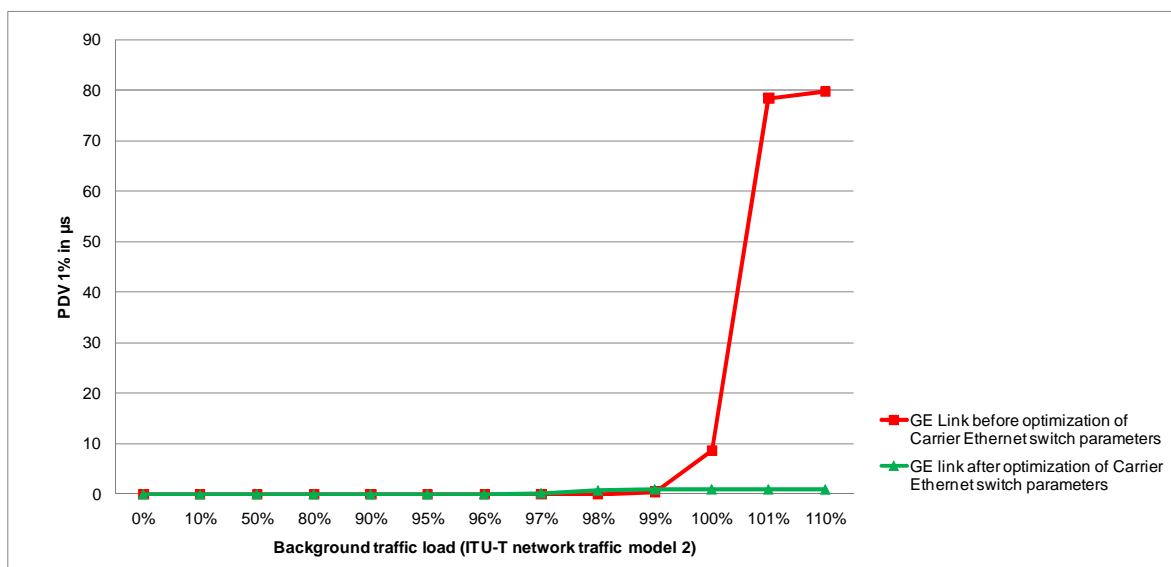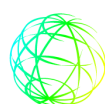

Optimization of parameter settings of a Carrier Ethernet switch

SUMMARY

The table below summarizes the highstreet Network Simulation Packages and the corresponding deliverables.

Network Simulation Package	Deliverables
Network Modelling	Network models for all transmission links and switching equipment List of network parameters impacting the behaviour
Application Analysis	Qualitative and quantitative analysis of how the performance of the respective application is impacted by the network behaviour List of application parameters impacting the performance
Network Simulation	Qualitative and quantitative report on the key network performance indicators under different network and load conditions
Network Optimization and Application Tuning	List of network parameter settings optimizing the performance of the predominant applications running over the network List of application parameter settings tuning the performance of the applications to the given network characteristics