hTK-Legend Test Framework
Load & Stress component

Whitepaper

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Executive Summary

Increasing amount of mobile and network communication brings stability, reliability and efficiency of associated services on top of public and companies interests. Events like New Year's Eve and voting on popular TV pop star singing contests cause steep traffic peaks and require powerful infrastructure and related systems. Concurency and continuous innovation of technologies bring urgent need of introducing new functionalities faster and more reliable then ever before. These circumstances force service providers to optimize their network structure and resources, test and prepare systems for high load as well as for new features for everyday usage.

To be able to collect information about current system status and make strategic decisions to improve service quality and efficiency, necessity to simulate different traffic scenarios becomes much more important and tests of new features and system performance are crucial part of services deployment and maintenance. These tests require simulation of traffic scenario close to real conditions with the ability to identify and examine test results.

henkel-TK GmbH provides a traffic generator software with unique possibility to test performance, functionality, features and reliability of service providers systems with many different protocols and application simulating real traffic conditions. The range of services provided by henkel-TK GmbH covers from consultancy and support to training and fully customized on-site testing with presence of henkel-TK GmbH engineer.

Introduction

The hTK-Legend Test Framework Load & Stress component is a powerful traffic generation system developed with intensive usage of multi-threading and multiprocessing. It is deployed on Unix based systems in different fields of application where protocols are used to transfer data, for example core network for telecommunication services (SMS, MMS, GPRS, LTE, SIP) or Internet related services networks (HTTP, IMAP, DNS, LDAP). Its application spectrum covers the whole range from systems using single protocol up to the simulation of complete network elements with corresponding call flows.

By providing real-time graphs and storing counters of running tests in regular intervals, hTK-Legend Test Framework Load & Stress component detects message loss and improper behavior of tested system during failure state like protocol errors, abortions or hardware issues and can be therefore used to identify and simulate conditions which lead to these situations.

Key features of Load & Stress component:

- real-time control and monitor of test execution
- real-time load change without traffic interruption
- real-time collect and store test results in SQLite database format
- schedule tests execution and actions, for example test start and stop or load change
- full support for multi user environment
- graphical user interface (GUI) to manage tests and export results
- export results to csv and xlsx formats
- support for different protocols running at the same time on single machine
- simulation of different network elements with different protocols
- simulation of complete networks with close to reality parameters
- efficient usage of resources on traffic generator host system
- excellent stability and perfomance under heavy conditions
- stable API for easy and reliable integration into customer environment

Supported protocols and protocol stacks

The Load & Stress component supports several protocols and protocol stacks as well as simulation of functions and whole systems. The component is constantly enhanced by new implementations. The following sections introduce currently available implementations.

Mobile 5G

Table 1. Mobile 5G

Function	Emulated System	Interface	Protocol
SMS - Short Message Service	IP SM Gateway		
SBC / VoLTE call	PGW	Gm	SIP
		Gx	Diameter
	eMSC	Mb	RTP
MME	eNodeB	S1-MME	S1-AP
	SGW	S11	GTP-C
	HSS/HLR	S6a	Diameter
SGSN	SGW	S4	GTP-C
	MME	S3	GTP-C
NodeB	SGW	S12	GTP-U
	SGW	S1-U	GTP-U
SGW	PGW	S5	GTP-C
	PGW	S8	GTP-C
HSS/HLR	MME	S6a	Diameter
PCRF	PGW	Gx	SIP
	SBC	Rx	Diameter
	UR		LDAP
CSCF	SBC	Mw	SIP / SDP
WiFi UE	ePDG	SWn	IPsec 7
AAA	HSS	SWx	Diameter
	PGW	S6b	Diameter
	ePDG	SWm	Diameter

Mobile 4G

Table 2. Mobile 4G

Function	Emulated System	Interface	Protocol
MME	eNodeB	S1-MME	S1-AP
	SGW	S11	GTP-C
	HSS/HLR	S6a	Diameter
SGSN	SGW	S4	GTP-C
	MME	S3	GTP-C
NodeB	SGW	S12	GTP-U
	SGW	S1-U	GTP-U
SGW	PGW	S5	GTP-C
	PGW	S8	GTP-C
HSS/HLR	MME	S6a	Diameter
PCRF	PGW	Gx	SIP
	SBC	Rx	Diameter
	UR		LDAP
CSCF	SBC	Mw	SIP / SDP
WiFi UE	ePDG	SWn	IPsec 7
AAA	HSS	SWx	Diameter
	PGW	S6b	Diameter
	ePDG	SWm	Diameter

Mobile 3G

Table 3. Mobile 3G

Function	Emulated System	Interface	Protocol
Node-B	RNC	Iub	ALCAP/NBAP
RNC	Node-B	Iub	ALCAP/NBAP
	SGSN	Iu-PS	GMM/SM/GSMS/SS - GTP-U
	MSC	Iu-CS	ALCAP - GMM/CC/ SMS/SS
SGSN	RNC	Iu-PS	GMM/SM/GSMS/SS - GTP-U
	GGSN	Gn	GTP-C - GTP-U
	MSC	Gs	BSSAP+
	SMSC	Gd	GSM/MAP
	HLR	Gc	GSM/MAP
MSC	RNC	Iu-CS	ALCAP - GMM/CC/ SMS/SS
	SGSN	Gs	BSSAP+
	HLR	D	GSM/MAP
	SMSC	E	GSM/MAP
	GMSC	E	GSM/MAP - ISUP
SMSC	MSC	E	GSM/MAP
	SGSN	Gd	GSM/MAP
GGSN	SGSN	Gn	GTP-C - GTP-U
	network	Gi	IP
	HLR	Gc	GSM/MAP

Mobile 1G/2G - GSM

Table 4. Mobile 1G/2G - GSM

Function	Emulated System	Interface	Protocol
BSC	MSC	A	BSSAP
	SGSN	Gb	GMM/SM SNDCP - LLC - BSSGP
SGSN	GGSN	Gn	GTP
	BSC	Gb	GMM/SM SNDCP - LLC - BSSGP
	HLR	Gr	GSM/MAP
	MSC	Gs	BSSAP+
GGSN	SGSN	Gn	GTP
	Border GGSN	Gp	GTP
	HLR	Gc	GSM/MAP
	IP Network	Gi	IP (Payload of GTP-U)
MSC	BSC	A	BSSAP
	SMSC	E	GSM/MAP
	EIR	F	GSM/MAP
HLR	MSC	D	GSM/MAP
	GGSN	Gc	GSM/MAP
	SGSN	Gr	GSM/MAP
SMSC	SGSN	Gd	GSM/MAP
	MSC	E	GSM/MAP
MMSC	GGSN	Gi	MM1
	SGSN	Gn	MM1/GTP
	BSC	Gb	GMM/SM SNDCP - LLC - BSSGP

Mobile - ANSI

Table 5. Mobile - ANSI

Function	Emulated System	Interface	Protocol
SMSC	Network - CDMA		IS637/IS41
	Network - TDMA		IS637/IS41

PSTN - Fixed network

Table 6. PSTN - Fixed network

Function	Emulated System	Interface	Protocol
Analog Subscriber	Fixed Network Switch	Analog Line	Analog
Fixed Network Switch	Analog Subscriber	Analog Line	Analog
ISDN Subscriber	Fixed Network Switch	Deutsche Telekom	1TR6
		ETSI	EDSS1
Fixed Network Switch	ISDN Subscriber	Deutsche Telekom	1TR6
		ETSI	EDSS1
Fixed Network Switch	Fixed Network Switch	ISDN User Part	ITU-T Q.76x
Service Switching Point	Service Control Point	Intelligent Network	ETSI EN 301 668-1
Service Control Point	Service Switching Point	Intelligent Network	ETSI EN 301 668-1

Data Protocols on Mobile and Fixed networks

Table 7. Data Protocols on Mobile and Fixed networks

Function	Emulated System	Protocol
Web Server	Web Client	HTTP / HTTPS
	Web Server	
FTP Server	FTP Client	FTP / FTPS
	FTP Server	
SSL Server	SSL Client	SSLv1 / SSLv2 / SSLv3 / TLSv1.1 / TLSv1.2 / TLSv1.3
	SSL Server	
DNS Server	DNS Client	DNS
	DNS Server	
Mail Server	IMAP Client	IMAPv3 / IMAPv4
	IMAP Server	
	POP Client	POP3
	POP Server	
	SMTP Client	SMTP
	SMTP Server	

Connection examples

Figure 1. Email traffic simulation for e-mail server with hTK-Legend Test Framework

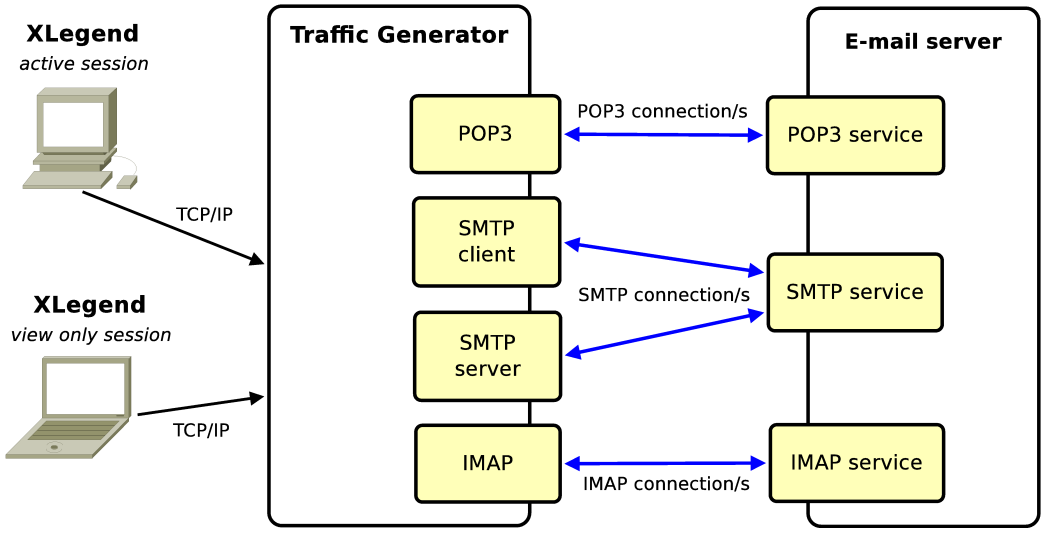


Figure 1, “Email traffic simulation for e-mail server with hTK-Legend Test Framework” shows connection between Traffic Generator and email server using 3 different protocols (POP3, IMAP, SMTP). Traffic Generator sends e-mail traffic on all protocols and simulates SMTP server in internet for emails relayed by email server. There are two connections by XLegend GUI, control session to manage the running tests and view session to observe overall activity.

Figure 2. SS7/SIGTRAN network simulation for SMSC with hTK-Legend Test Framework

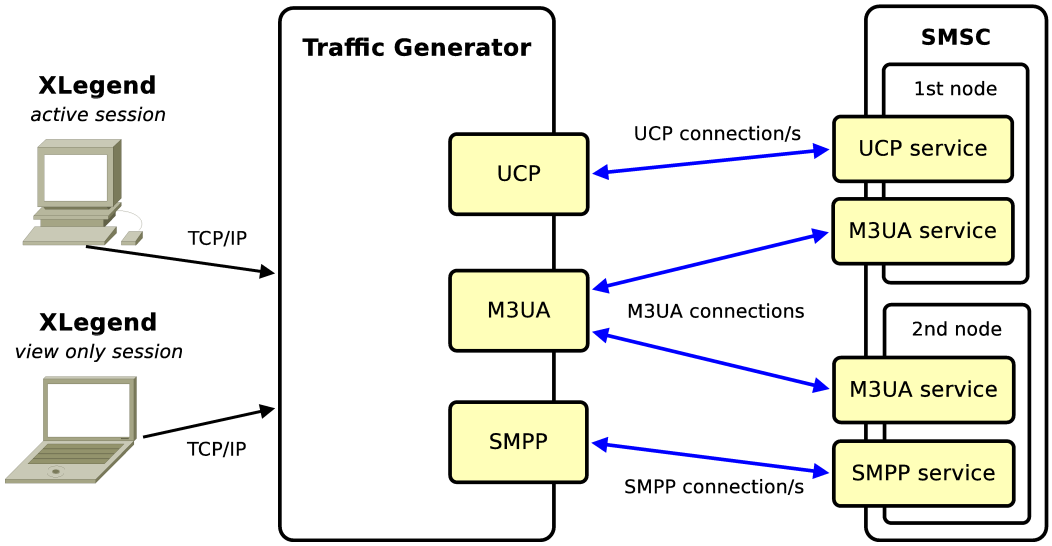


Figure 2, “SS7/SIGTRAN network simulation for SMSC with hTK-Legend Test Framework” shows connection between Traffic Generator and 2-node SMSC using 3 different protocols (M3UA, UCP, SMPP). hTK-Legend Traffic Generator generates and accepts SMS messages to and from SMSC on all protocols and simulates HLR function on M3UA connections.

Performance

High performance and stability are key advantages of Load & Stress component, as from very beginning its development is focused on fully stable and powerful design with various options and functions available. Thanks to this approach the Traffic Generator is able to simulate traffic flows for different protocols and by combination of these to provide full environment for testing of single product or complete network (like SMSC, MMSC, e-mail or AAA) - for example as shown above in Figure 2, “SS7/SIGTRAN network simulation for SMSC with hTK-Legend Test Framework” the Traffic Generator provides simulation of SS7 network and Large Account connections and allows to test SMS Center in various situations and traffic scenarios.

None of finished implementations in customer environment hit the Load & Stress component performance limits, so to provide approximate overview of the performance, henkel-TK GmbH made local tests in own test lab.

Local tests in henkel-TK GmbH laboratory

Test description for SUA/SCTP/IP connection

henkel-TK Test Framework simulated both client and server side connected over localhost interface by SUA/SCTP/IP protocols interface. Basic SMS messages have been sent and accepted by the same traffic generator system and whole load test was controlled by GUI running on external system.

Basic SMS message is described as 1 SMS sent and delivered over a pair of TCAP-Begin and TCAP-End transactions. TCAP-Begin packet contains Dialogue Portion and Component Portion with a MAP Invoke Operation Forward Short Message containing short message text. The short message had a randomly distributed length between 10 and 160 characters. TCAP-End packet contains Dialogue Portion and Component Portion with the MAP Return Result for the Forward short message.

Test results for SUA/SCTP/IP connection

The test results are presented as Transactions Per Second (TPS), each TPS unit represents a full transaction of TCAP-Begin and corresponding TCAP-End, with measured CPU usage in percentage for every of tested systems.

- **MacBook 13" – 30.000 TPS – CPU usage 50%**

  hardware specification: Intel® Core2™ T7400 @ 2.16GHz / 1GB RAM / OS: Fedora Core 6, kernel version 2.6.20-1.2962.fc6

  30.000 TPS represents 10.000 basic SMS/sec over simulated SS7 network as shown in Figure 2, “SS7/SIGTRAN network simulation for SMSC with hTK-Legend Test Framework”

- **Desktop PC – 50.000 TPS – CPU usage 60%**

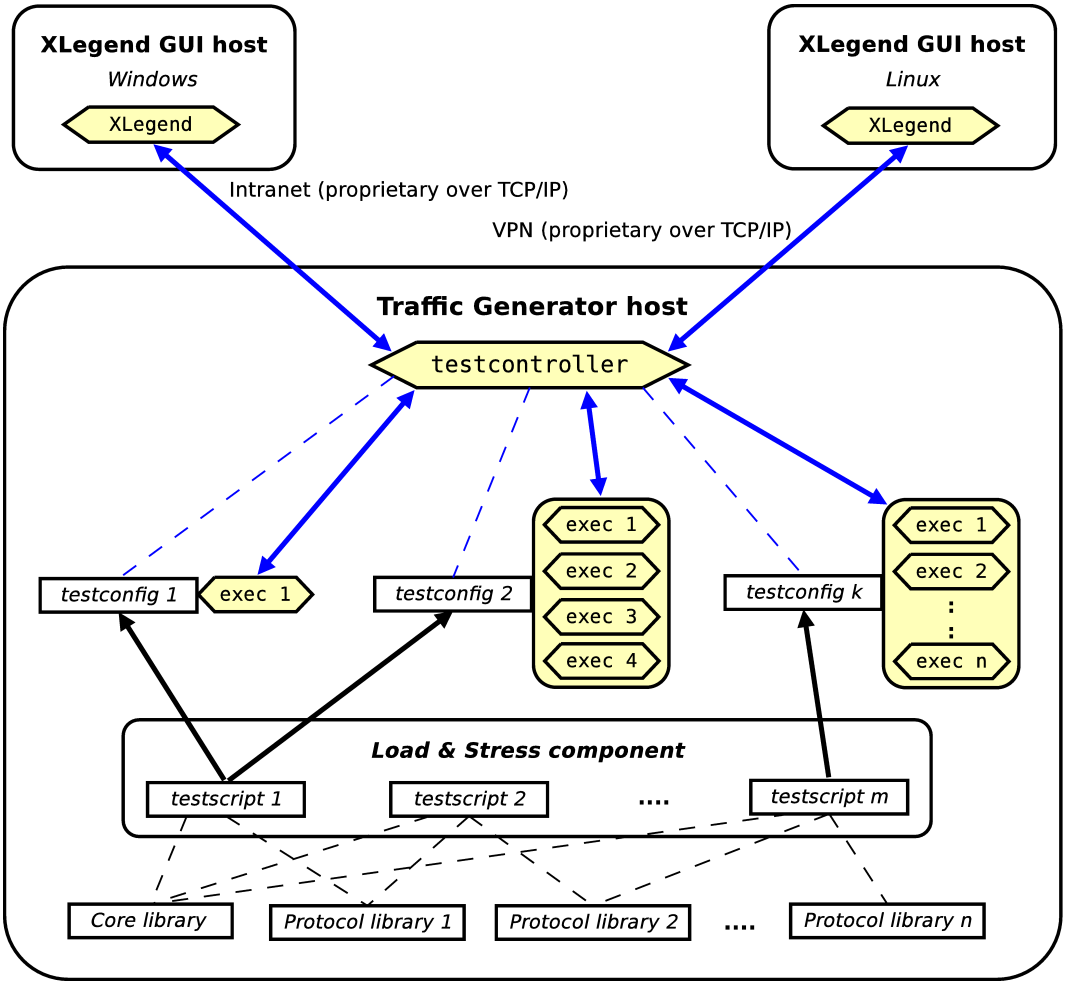
  hardware specification: AMD® Athlon64™ X2 Dual Core 5200+ @ 2.6GHz / 4GB RAM / OS: Fedora Core 6, kernel version 2.6.20-1.2962.fc6

  50.000 TPS represents 17.000 basic SMS/sec over simulated SS7 network as shown in Figure 2, “SS7/SIGTRAN network simulation for SMSC with hTK-Legend Test Framework”

Architecture

An abstract overview of the hTK-Legend Test Framework architecture with Load & Stress component is shown below in Figure 3, “hTK-Legend Test Framework architecture”.

Figure 3. hTK-Legend Test Framework architecture



The hTK-Legend Test Framework is built using a modular design architecture with a lot of different possibilities for usage and expansion. Load & Stress component main development goal is high and stable performance even under heavy duty conditions. For this reason the control GUI software module called XLegend and the Traffic Generator processes are completely separated and shall be hosted by different machines. Both components communicate via a proprietary protocol on top of TCP/IP. This communication is fully encrypted and connection is initiated from XLegend towards to Traffic Generator host listening on TCP port 9199. This secured setup is therefore suitable for connections over the Internet, in networks like intranet or VPN and also for tunnel established on top of SSH connection.

The Traffic Generator consists of a control engine called testcontroller, core library, protocol libraries and testconfigs. Load & Stress component consist of testscripts developed for load and stress tests with simulated traffic. The libraries offer their functionality as APIs to these testscripts and every testscript provides a set of parameters configurable during creation and modification of test configuration, called testconfig. I.e. every testconfig is associated with exactly one testscript from Load & Stress component but every testscript can be referenced by several testconfigs.

Besides the testscript parameter values a testconfig also defines the number of instances i.e. execs of its associated testscript. Starting multiple processes of a single testscript may be necessary for configuration or performance reasons.

Results produced by running execs are communicated to connected XLegends via the testcontroller process and are also written to a file system mounted on the Traffic Generator host.

Control and management of the Traffic Generator i.e. the testcontroller, testconfigs and results is performed using the XLegend - graphical user interface part of Test Framework.

To execute tests using the hTK-Legend Test Framework it is necessary to have a CodeMeter USB stick with valid license connected to the Traffic Generator host.

Testcontroller

The testcontroller is the central process running on the Traffic Generator host, see Figure 3, “hTK-Legend Test Framework architecture”. Its most important tasks and features are listed below:

- Controls and monitors test execution
- Manages scheduled activities for testconfigs (e.g. start, stop or change the traffic load)
- Supports multi user environment
- Manage connections and data transfer to and from one or more XLegends

Load & Stress component

The Load & Stress component consist of testscripts, these as executables generate traffic to send and receive messages to and from the System Under Test. Efficient utilization of resources on Traffic Generator host is achieved by intensive usage of multi-threading and multi-processing techniques during Load & Stress component development. Key features are listed below:

- Developed in the C programming language
- Collects and stores test results in SQLite database format
- Different testscript executables can run in parallel
- Highly configurable via parameters (e.g. number ranges, delays for responses, response error codes definition and rate/amount) used in testconfigs
- Support protocols and simulate network elements (e.g. SMSC, MMSC, HLR)

XLegend

The XLegend controls, manages and monitors the tests on Traffic Generator. The following list provides few examples of its rich functionality:

- Provides interface to load, start and stop tests, to define the load amount and schedule these actions
- Supports editing of test configurations, testconfigs
- Supports creation and modification of load profiles
- Provides real-time online and offline graphs of selected testconfig counters
- Provides test result convertion function to csv
- Provides sophisticated wizard to create customized xlsx files (Open Office XML/new Microsoft Excel format) from test results

Result-Portal

The Result-Portal is optionally available for the Load & Stress component. Dedicated hardware for the Result-Portal is recommended. Key features are listed below:

- uses labels for easy navigation in results and archive
- automated conversion of results to xlsx format with attached template
- web-based front-end with user access based on privileges
- configurable result reports sent via e-mail
- protected by CodeMeter USB stick with Result-Portal license

Screenshots of XLegend

Following figures show screenshots of the XLegend main window for Load & Stress component, the online and offline plotting windows.

Figure 4. XLegend main window

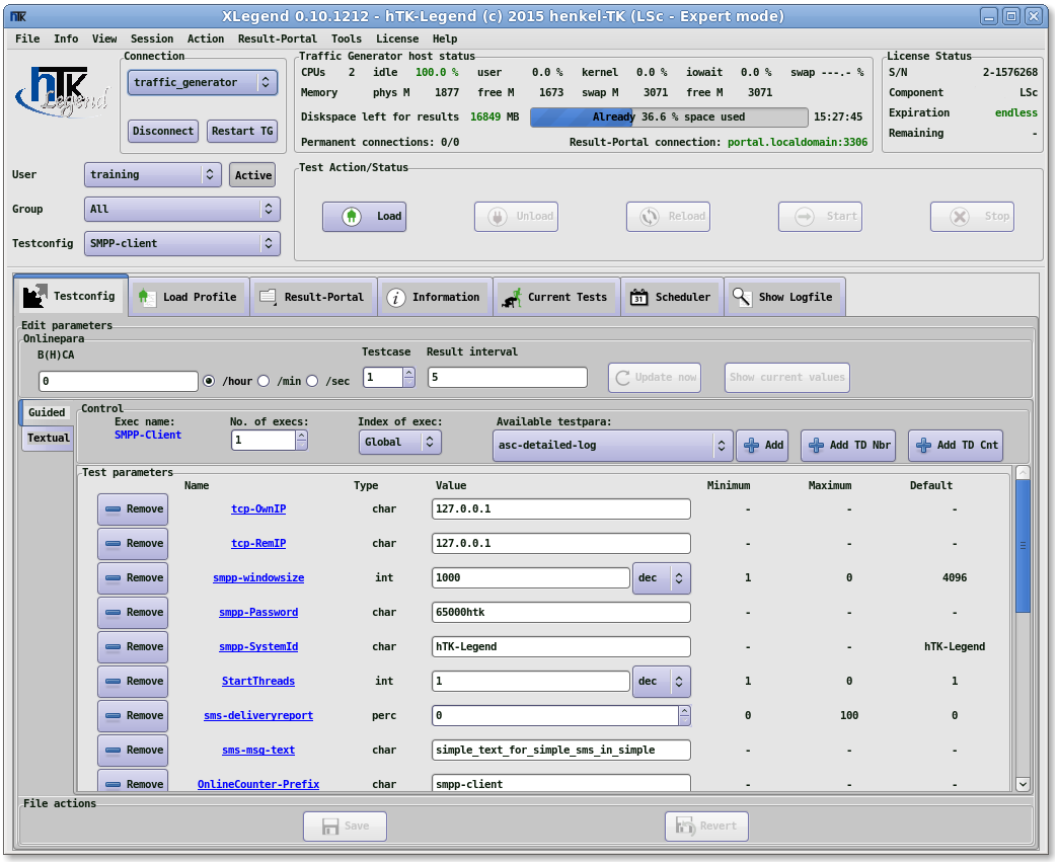


Figure 5. XLegend real time graphic window

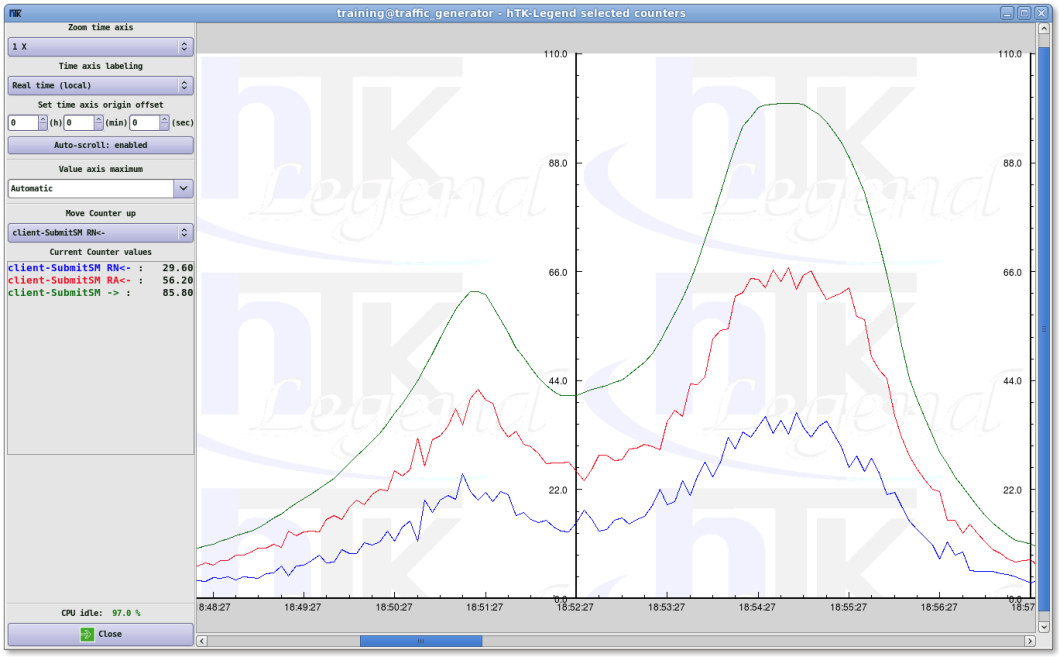


Figure 6. XLegend offline counters window