IPv6 WEATHER REPORT

Measureable Internet QoE indicators

When attempting to measure the Internet QoE, we are faced with rather unexpected challenge – what is quality in the eyes of the end user?

In modern communications networks the question of QoE is still unresolved. There is a variety of available standardized measurement methodologies that are complex and rely mostly on end-to-end QoS metrics. The approaches are typically limited to automated observations of measurable performance parameters and application layer effects with appropriate inter-domain consolidations, resulting in QoE approximations. On the other hand, modeling and measuring true QoE is a complex task involving effects of subjective end user's perception and their communications context, and can therefore be observed only experimentally per each unique situation.

In order to simplify the QoE challenge, we have taken the approach of observing the main components of browsing through the Internet as the end user sees it. This resulted in the following QoE methodology.

Internet **availability**
- PING: lost ICMP packets [lost responses/sent requests]
- WEB: page availability [unreachable sites/sent requests]
- http DL/UL: availability [unfinished transfers/sent requests]

Internet **responsiveness/speed**
- PING: round trip time – RTT [s]
- WEB: page loading time [s]
- WEB: page loading speed [bit/s]
- http DL/UL: transfer time [s]
- http DL/UL: transfer speed [bit/s]

This QoE metric represents the Internet analogy to the typically encountered networking end-to-end QoS methodology. It's principal advantages are simplicity, re-usability of readily available methods and close similarity to recognized measurement and quality estimation procedures broadly used in telecommunications networks.

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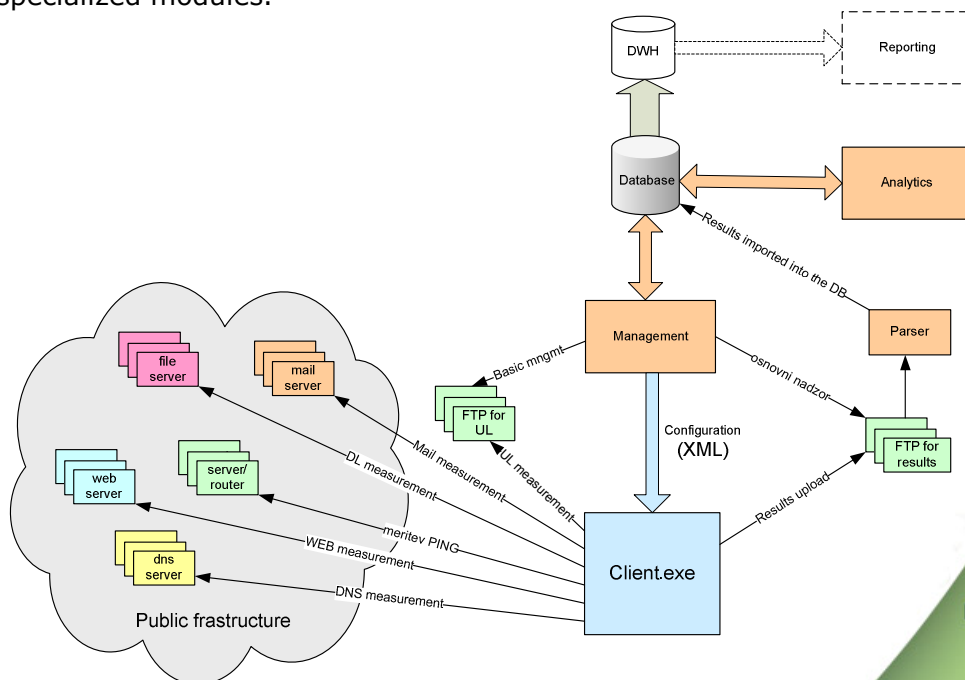
LTFE QoE measurement system

The LTFE QoE measurement system is a distributed agent-based solution for QoE measurements, reporting, analyzing and visualization within IP-based telco/provider networks.

The solution is designed as an automatic application-based multi-test tool for end user emulation. It consists of client-side, where measurements are taken with end user emulation (scenarios of end user activities involving use of several Internet services):

- Web browsing
- File transfer
- Delay measurements (ping RTT)
- Topology discovery (traceroute)

Layer 1 to layer 7 QoE effects are captured and transferred to server-side where QoE metric is stored in a database, and observed, analyzed and visualized using specialized modules.
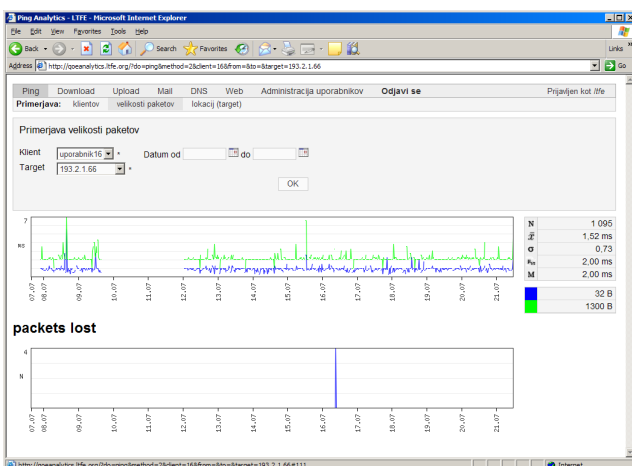

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A web-based user interface is available for analysis and visualization of captured QoE measurements. Reports can be generated and data can be exported to other systems.
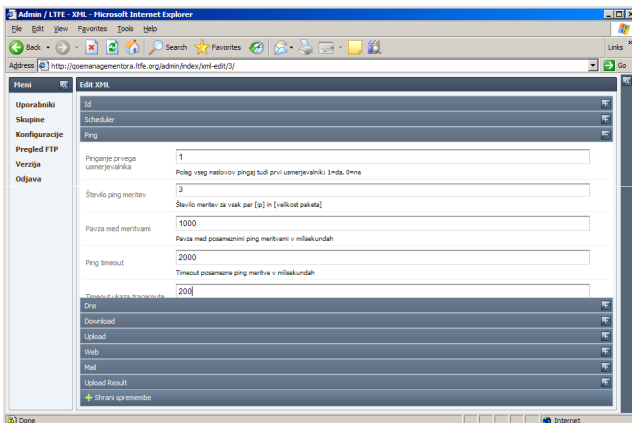
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LTFE QoE measurement system

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The solutions has a modular design. It is based on open source tools and components and is OS independent (support for Win XP/Vista, Linux).

Consisting of server-side and client-side, the client-side is a distributed network of agents (Python app) that emulate end-user's behavior on terminal and network equipment. Each agent can perform ping (RTT, lost packets) with variable payload sizes, traceroute (recording all hops), wget (complete page download with all included objects, recording the time, cumulative size and timed-out requests) and individual file download/upload over ftp (recording the time, file size). We support both IPv4 and IPv6. The client is available for PC and STB within a large installed user base (est.100.000 users).

The client-side is remotely controlled from a central management, analysis and visualization serve-side. Each agent periodically (before each measurement cycle) fetches a dynamically generated config file from the management server, performs any of the above measurements *in sequence* and uploads the results back to the server. Before each measurement, a traceroute is also performed so that possible path changes can be observed. Once the measurements are captured, the data is aggregated and parsed on the server-side, followed by data analysis and visualization using external and integrated tools.

Currently, we have ongoing projects and activities to upgrade and evolve the system in the following areas:

- Enhanced analytics and visualization using integrated modules (data mining, statistics, ontologies) and external tools (e.g. Matlab libraries)
- Portation of the agent to networking equipment (DSLAM, MSAN, router, home gateway)
- APIs for analyzed data exportation to management and provisioning systems

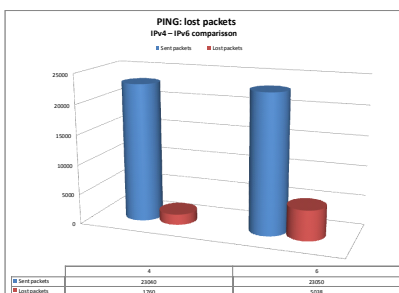## LTFE TestCenter
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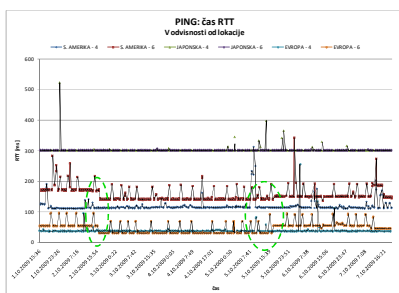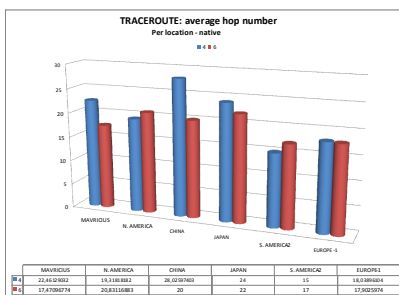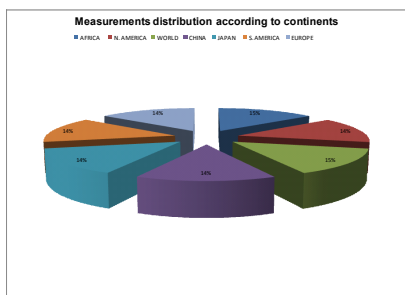
Internet QoE weather report

Internet QoE weather report is an ongoing project, dedicated to observations of effects of Internet transitioning to IPv6 on QoE.

This experiment is focused on measurements of Internet QoE, and detailed analyses and trend observations from the viewpoint of transitioning the Internet to the Internet Protocol version 6 (IPv6).

The LTFE QoE measurement system is used for the project. End-user behavior scenarios are generated using QoE methodology and metrics using delay measurements (ping), topology observations (traceroute), web browsing (wget), and file transfer activities (FTP DL/UL).

The QoE measurements are captured using dedicated measurements probes (LTFE QoE measurement system client-side agents) that are distributed in the access networks and core IPv4 and IPv6 backbones.

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Internet QoE weather report

Example configuration and Internet QoE weather report results

Internet QoE weather observations over IPv4/IPv6 backbone (Arnes, Metulj, Geant, …) and various access mechanisms (native IPv4/IPv6 dual stack, 3 IPv6 tunnels) in Slovenia.

User behavior scenario configuration

ping
- 5 measurements in a packet (average RTT and packet loss)
- packet size 32 octets and 1300 octets
- 1s measurment pause, measurement timeout 2s
- IPv4 or IPv6 addresses (no domain resolving)

web browsing
- open source wget, Mozilla/5.0 user agent (compatible)
- page-requisites function uploads all files available on the web page
- IPv4 and/or IPv6 domain resolving
- Issues: www.ripe.net (IPv4 and IPv6) vs. google.com (v4) & ipv6.google.com (v6)

download
- transfer of a single file over IPv4 and IPv6
- open source wget tool

upload
- transfer of a single file to FTP server over IPv4 and IPv6
- variable size (10 to 100 M, depends on connection speed)
- FTP server on UL Faculty of Electrical Engineering
- Pythonu-based client implementation based on ftplib module

traceroute
- executed along each measurement
- based on traceroute system tool

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Internet QoE weather report

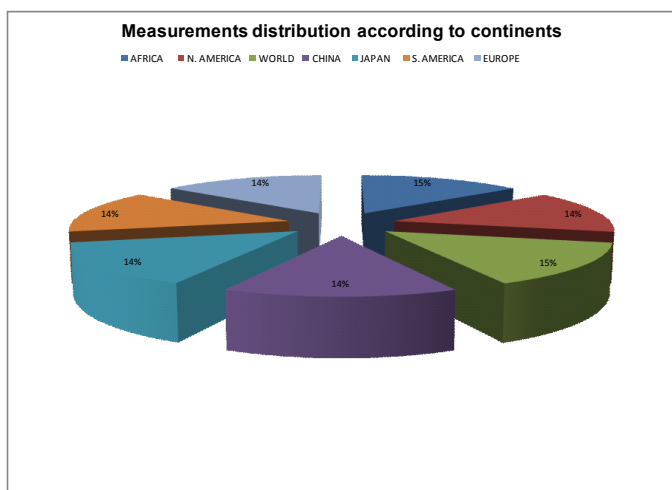**Example configuration and Internet QoE weather report results**

The results analysis and visualization is given based on the captured QoE measurements for configured end user behaviors over IPv6 and IPv4 networks using statistical methods and observations. Comparative visualizations capture the key differences between IPv6 and IPv6 QoE experience.

The following QoE viewpoints have been observed:
- Measurements distribution over the world
- How far is the Internet in terms of delay?
- Availability (general and per access type)
- Speed (per access and per location)

Measurements distribution over the world

Client-side was configured to test the Internet using well distributed sites over the continents.

Measurements distribution according to continents
■ AFRICA ■ N. AMERICA ■ WORLD ■ CHINA ■ JAPAN ■ S. AMERICA ■ EUROPE

15% 14% 15% 14% 14% 14% 14%

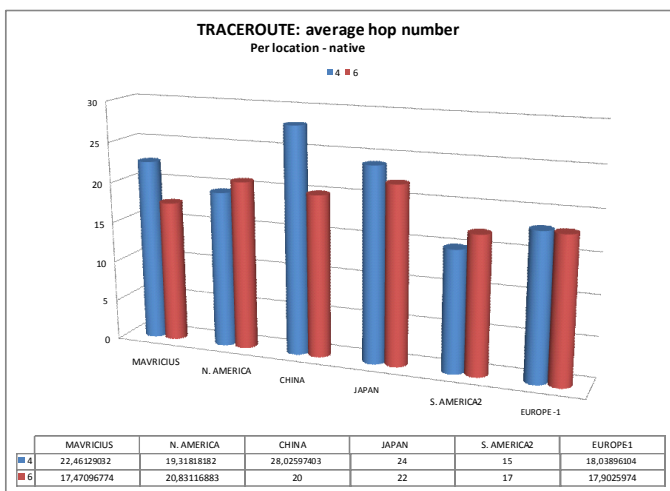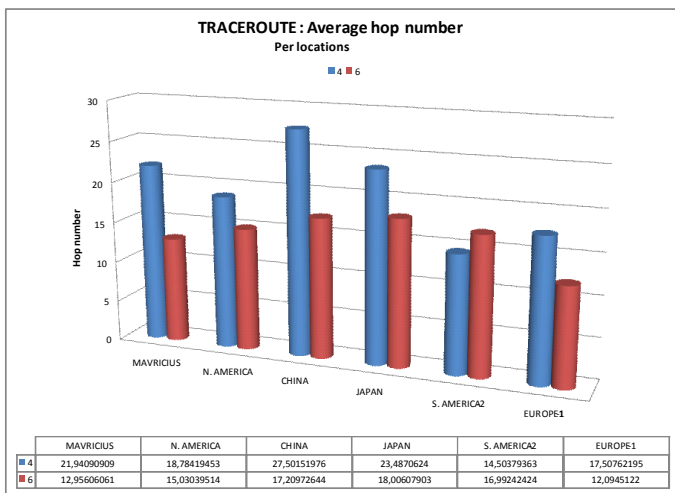# LTFE TestCenter
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How far is the Internet in terms of delay

Results on average hop number using traceroute topology discovery technique.

TRACEROUTE : Average hop number
Per locations

	MAVRICIUS	N. AMERICA	CHINA	JAPAN	S. AMERICA2	EUROPE1
4	21,94090909	18,78419453	27,50151976	23,4870624	14,50379363	17,50762195
6	12,95606061	15,03039514	17,20972644	18,00607903	16,99242424	12,0945122

TRACEROUTE: average hop number
Per location - native

	MAVRICIUS	N. AMERICA	CHINA	JAPAN	S. AMERICA2	EUROPE1
4	22,46129032	19,31818182	28,02597403	24	15	18,03896104
6	17,47096774	20,83116883	20	22	17	17,9025974

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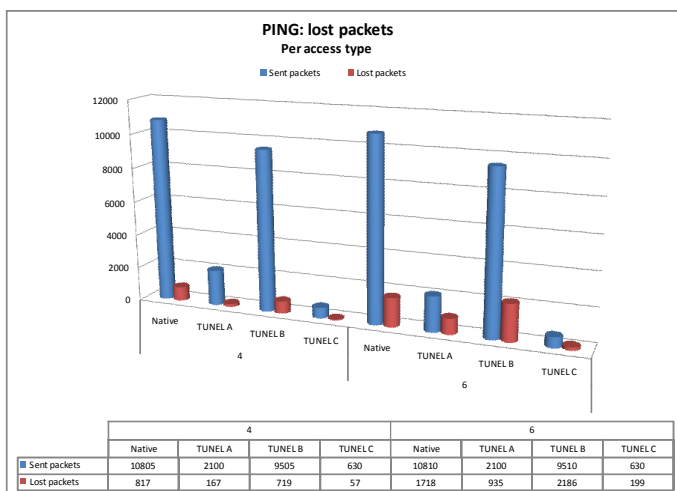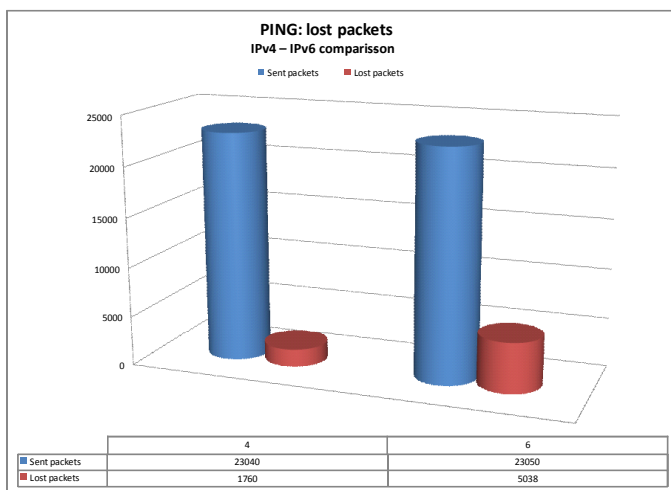Tel.: +386 (0)1 47 68 988
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Availability

Results on site availability by observing lost packets and average RTT. Comparisons are given for IPv6 vs. IPv4.

PING: lost packets
IPv4 – IPv6 comparisson

■ Sent packets   ■ Lost packets

	4	6
■ Sent packets	23040	23050
■ Lost packets	1760	5038

PING: lost packets
Per access type

■ Sent packets   ■ Lost packets

	4				6			
	Native	TUNEL A	TUNEL B	TUNEL C	Native	TUNEL A	TUNEL B	TUNEL C
■ Sent packets	10805	2100	9505	630	10810	2100	9510	630
■ Lost packets	817	167	719	57	1718	935	2186	199

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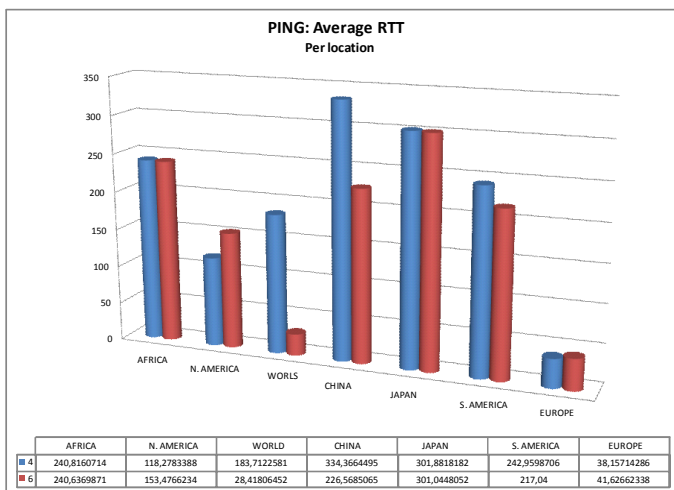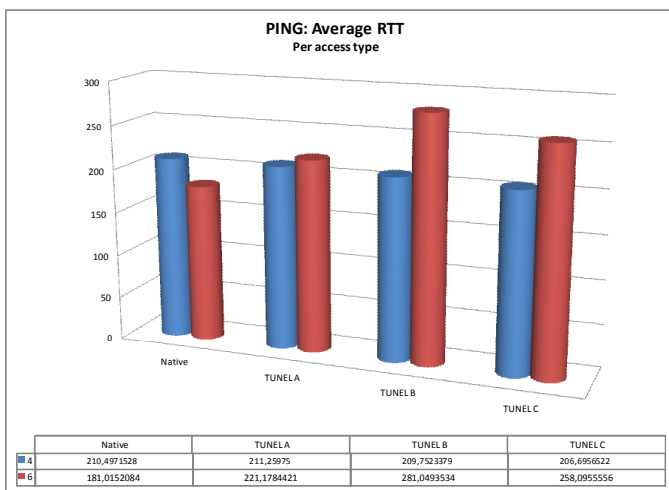
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Speed

Results on speed per access type and location. Comparison is given for IPv6 vs. Ipv4.

PING: Average RTT
Per access type

	Native	TUNEL A	TUNEL B	TUNEL C
4	210,4971528	211,25975	209,7523379	206,6956522
6	181,0152084	221,1784421	281,0493534	258,0955556

PING: Average RTT
Per location

|	AFRICA	N. AMERICA	WORLD	CHINA	JAPAN	S. AMERICA	EUROPE
4	240,8160714	118,2783388	183,7122581	334,3664495	301,8818182	242,9598706	38,15714286
6	240,6369871	153,4766234	28,41806452	226,5685065	301,0448052	217,04	41,62662338

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Speed

Results on speed per location. RTT measurements are displayed in time per different locations.

PING: čas RTT
V odvisnosti od lokacije
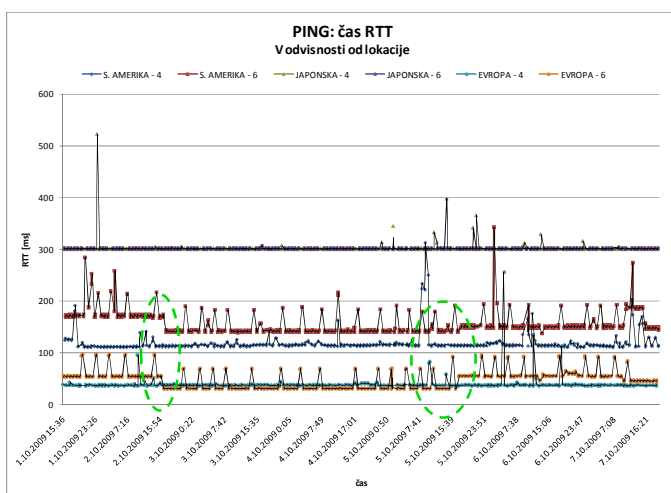
Conclusion

The results show that IPv6 is a mature service platform with comparable or even enhanced QoE experience (if native access is used). RTT can be increased and web response times can be much improved if IPv6 is used. Another important effect of IPv6 observed through the presented results is the fact, that the introduction of IPv6 is bringing some world locations and continents much nearer to the rest of the world (for example Africa).

The observed downsides are foremost the use of tunneling mechanisms. The results show that their side-effects are blurred and decreased IPv6 Internet performance by causing unavailability of web pages and decreasing responsiveness.

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