IP Quality Monitor (IQM) is a hardware and software system intended for measurement, monitoring and management of the IP quality parameters. IQM takes into account different classes of service and zone structure of IP network. The IQM system could monitor the number of networks with various requirements for quality parameters. Quality monitoring policies can be applied individually to each test, or to zone-to-zone directions. In addition it is possible to deploy distributed monitoring with number of remote management domains.

The traditional approach is applied to the quality parameters measurement: specialized network devices (probes) are placed on the key network nodes. Program agents are running on the probes. In the automatic mode (scheduled or on demand) agents send a number of test packets to peer agents and measure parameters of their delivery: loss, delay, variations of delay and also channel capacity. The received information is processed and stored in text files, and then passed to higher level — to the core system for statistical processing and analysis. Measuring the quality parameters on certain parts of IP network will facilitate further process of a network problems troubleshooting. Thus, for example, it is possible to carry out quality management on one of the most problematic divisions of a network — on the last miles. Quality assurance includes the analysis of following parameters: IP packet loss, round-trip delay time, jitter (packet delay variations), available bandwidth (channel capacity). Measurement of these parameters can be made in different classes of service, for example: standard, premium and real-time. It is possible to take into account the zone structure of an IP network. This approach permits quality management in zone-to-zone directions instead of point-to-point.

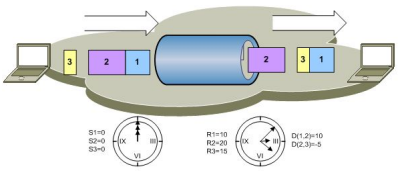
Packet loss can be influenced by a number of factors, including signal degradation over the network medium, overloaded network links, corrupted packets rejected in-transit, faulty networking hardware, faulty network drivers or normal routing routines. Packet loss is calculated as a ratio of lost packets to the total number of packets sent over the IP network in specified direction.

Round-trip delay time (RTD — round-trip delay time, RTT — round-trip time, RTL — round-trip latency) is the time required for a packet to travel from a specific source to a specific destination and back again.

Jitter (Jitter, IPDV — IP Packet Delay Variation, PDV — packet delay variation). In IP networks, jitter is the variation in the delay of the packets. IP Packet Delay Variation is defined in RFC 3393 as a difference of the one way delays of selected packets. Let's designate R as time when packet was sent, and S as delivery time. Than PDV value for i-packet and j-packet could be calculated as:

$$D_{i,j} = (R_j - R_i) - (S_j - S_i) = (R_j - S_j) - (R_i - S_i).$$

The figure illustrates how the PDV occures due to irregularity of IP packets delivery:



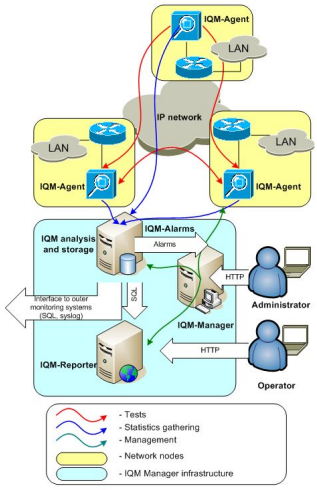
RFC 3550 defines incremental approach for calculation of PDV:

$$J_i = J_{i-1} + (|D_{i-1,i}| - J_{i-1})/16$$

This method is used by IQM agents for jitter measurement.

Bandwidth is value which is calculated by IQM as a function of packet delivery speed on the reception agent.

The following figure depicts the main components of IQM system.



From the technical point of view, IP Quality Monitor consists of two basic elements: agents of quality parameters measurement (IQMA) and management system (IQMM).

Agents of quality parameters measurement (IQMA) are hardware-software systems. IQMA make automated measurements of IP quality parameters themselves.

Agents can operate in two modes:

- **active** mode in which agent initiates test session using local scheduler or by the on-demand request

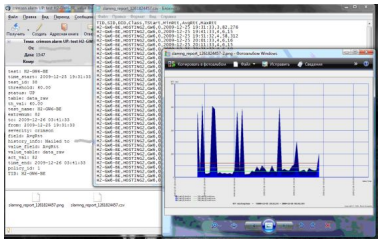
- **passive** mode in which agent receives test requests from other agents operating in active mode

Agents could work in both modes simultaneously. Besides, it is possible to use various network devices (such as routers, switches, servers) with UDP Echo service running as the passive agents.

Agents do not provide complex processing of the measured parameters, they just pass data in practically unchanged form to the IQMM — core statistical analysis subsystem.

IQMM management system includes following functional elements:

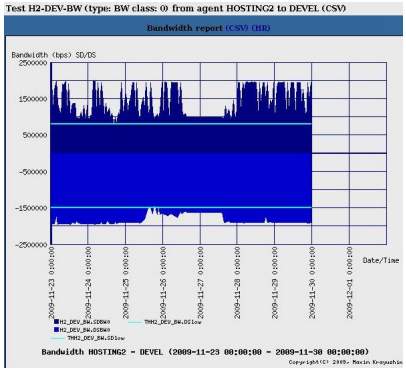
The **statistical analysis subsystem** provides processing and storage of statistical data. The subsystem receives and processes quality measurements data from agents, aggregates it, transforms to the optimal form for storage, saves in a SQL database. IQMM carries out the data validation and asserton, generates alarms by means of sending e-mail with the corresponding report in case of problems, and logs events to syslog or database.

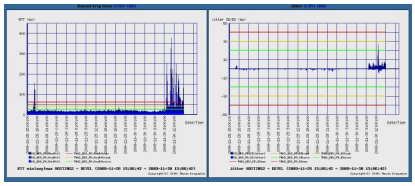


E-mail notification contains brief information about violation, the illustrative graph and data table.

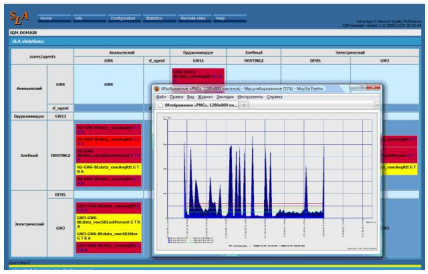
The **IQM reporter** is the information subsystem with GUI part based on the Web. Reporter. It allows to browse the quality parameters reports, including historical reports of the managed parameters, the aggregated statistics, statistics of violations, dashboards, SLA-reports.

Besides direct browsing of statistical data, the interface supports "health boards" or "dashboards". These are the auto-refreshing pages with the summary information about all violations occurred on the managed network. In case the accident occurred in a certain time window, the alarm signal is lighted. Operator could go to the detailed statistics page for carrying out of the detailed analysis of the problem occurred. For the user convenience it is possible to download reports as high resolution graphs and Excel-compatible tables.

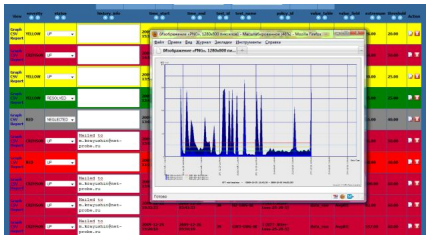




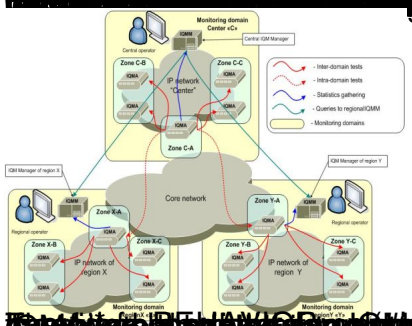
Historical reports.



Dashboard displays violation alarms in one summary table.



The alarms tool allows to carry out the analysis of received violations alarms, to remove or change the alarms status. Importance of a signal is defined by color which coincides with value of a field of alarm severity. The alarm can be ignored or canceled by changing the status of an alarm.



-Sberbank (According to *The Banker* magazine, as of 1 July 2010, Sberbank was ranked 43th in the world in terms of Tier 1 capital)

- ***FSUE Morsviazsputnik*** (the Russian licensed service provider of Inmarsat mobile satellite communications)