

[TEMS™ PRODUCTS]

TEMS™ AUTOMATIC AUTONOMOUS NETWORK MONITORING SYSTEM



GAIN CONTROL OF YOUR NETWORK'S QUALITY

Mobile network operators must receive continuous feedback on a live network's quality of service (QoS), see the impact of optimization efforts on a regular basis, and have an accurate means of **measuring quality as perceived by subscribers.**

TEMS Automatic provides an autonomous system that uses test probes to:

- Continuously monitor and measure a live network's QoS (as well as that of their competitors)
- Collect accurate quality measurements as perceived by subscribers
- Transfer that performance and measurement data back to a central server for efficient analysis and report generation



HOW DOES AN OPERATOR KEEP CUSTOMERS SATISFIED?

In the competitive mobile Internet environment, delivering quality of service (QoS) is the key. Good QoS can make the difference between a satisfied subscriber and a former subscriber. Operators must take control of network quality. To best manage this, the operator must receive continuous feedback on the live network's QoS, see the impact of optimization efforts on a regular basis, and have an accurate means of measuring quality as perceived by subscribers.

In an effort to fulfill these requirements, operators have various traditional channels for gathering information. One channel is the collection of "fixed side" data, from the operations support system/network management system (OSS/NMS). This data is necessary but is generally used only for statistical analysis; without detailed processing, OSS data is limited when it comes to QoS evaluation and the end user's experience.

Another source of network information comes from the operator's own customer care department. While this is certainly a valuable source of data about network problems, it, too, is limited. Relatively few subscribers will call a customer care center when they are having problems. The rest may not complain, but they will be more likely to switch to a competitor. In addition, these disgruntled subscribers can spread negative word-of-mouth information regarding your network.

Yet another way that network operators have traditionally obtained network data is through manual drive tests. Drive testing provides a wealth of valuable information, but is limited by time and resources. Drive tests are usually performed on a set schedule, during regular working hours. They are not always performed when the need is greatest, at times like rush hours and weekends. In addition, manual test tools do not conduct end-to-end measurements. Although they are perfectly suited for troubleshooting and optimization, manual tests do not collect enough to deliver statistically reliable data.

TEMS Automatic, however, exceeds the limitations of any other method. It is an autonomous system that uses test probes to collect network information which is transferred back to a central server for analysis and report generation.

An end-to-end solution, it employs handsets making calls over the air interface, so that it can test from a subscriber's perspective automatically.

By working over the entire network area, 24 hours a day, seven days a week, it gives statistically reliable data as well as QoS information. It tests your network and your competitors' networks, giving fair and accurate comparisons.

STREAMLINED OPERATIONS AND IMPROVED QoS

TEMS Automatic assesses network quality from a subscriber's perspective by performing true end-to-end testing of both voice and data services. It is a complete solution, offering effective quality monitoring and troubleshooting, while also enabling operators to discover network weaknesses and implement corrections efficiently and thoroughly. TEMS Automatic has developed a comprehensive multi-technology platform that supports GSM/GPRS/EDGE, WCDMA R99, dual carrier HSPA+, and LTE.

TEMS Automatic helps operators to:

- **Increase revenue** – Problems can be located and fixed before they start affecting customers, thus improving customer satisfaction and reducing churn. Fewer blocked and dropped calls mean more call time and higher earnings. A high QoS also helps attract new subscribers.
- **Increase efficiency** – Because it is autonomous, TEMS Automatic is very cost- and staff-efficient, providing a comprehensive and continuously updated overview of network quality.
- **Optimize investments** – A wireless telecom network represents a huge capital outlay. The network needs to be optimized to bring the best possible return. TEMS Automatic furnishes the data needed to make wise investment decisions.

TEMS Automatic completes the information picture

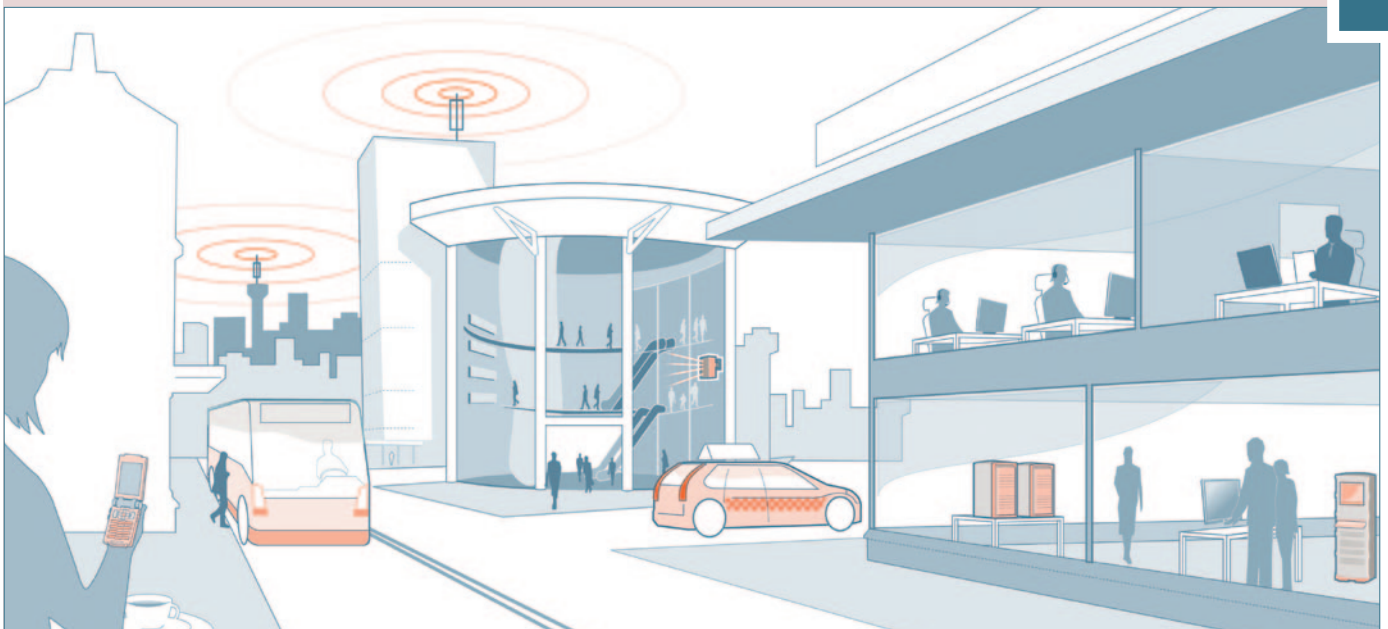
NEAR-REAL-TIME DELIVERY OF DETAILED NETWORK DATA

For true end-to-end testing of wireless networks, discover the autonomous network monitoring solution TEMS Automatic.

TEMS Automatic is an autonomous system that uses in-vehicle, fixed location, or handheld test probes. It sends network information back via the air interface to a central server for analysis and report generation.

What do you get with TEMS Automatic?

- Insight into the end user's perception of the network, thanks to measurements taken in the air interface rather than in network nodes (where other monitoring tools are used). A faithful measure of the end-to-end quality is obtained both for voice and data services.
- 24/7 measurements – without the cost of 24/7 staff. Every corner of the network is probed around the clock by autonomous data collecting units. The state of the network as perceived by subscribers can be fed back to technicians and modified at a pace approaching real-time control.
- Automated measurements – in the truest sense of the word. Not only test calls and measurements, but also data uploading and system configuration are carried out automatically. This enables rapid feedback on the state of the network – almost in real time – to the entire organization, all the way from management to RF engineers in the field.
- Analysis and benchmarking with the aid of map, chart, and spreadsheet presentations of high-level statistics as well as individual routes. Operators, networks, or geographical areas can be benchmarked with respect to user-selected performance parameters. TEMS Automatic data can serve as input to statistical reports produced by reporting solutions supporting Microsoft® OLAP and Microsoft® SQL Server, such as Microsoft® Excel and Microsoft® Reporting service.



MEETING NEEDS THROUGHOUT YOUR ORGANIZATION

The vast amount of network data available from TEMS Automatic gives the operator the key to maintaining and improving network quality. TEMS Automatic analyzes collected data and presents the results in reports and presentations. These show where services are unsatisfactory, allowing operators to locate and fix problems before they start affecting subscribers.

To analyze problem areas, operators can choose to use TEMS™ Presentation to access TEMS Automatic data, TEMS™ Investigation data, or TEMS™ Pocket data, and to present it graphically as statistics in routes or in plots/bins of any shape. This makes it easy to see the network's QoS, while also allowing operators to find the cause of any problem. All measurements and events (radio parameters, signaling, etc.) of each single conversation, from call setup to call end, can be presented on a map, in a spreadsheet, in line charts, and in information windows. All views are linked together for maximum benefit.

TEMS Automatic benefits all levels of the operator's organization. Reports and other information can be distributed throughout the organization to show in detail what the current network situation looks like.

- **Managers** are able to supervise the organization's processes and the services they offer. They can keep track of key performance indicators (KPIs), including speech quality targets, by studying reports automatically distilled from measurement data at user-specified times. They are aided in making decisions on investments and organizational improvements. By getting a tighter grip on end-to-end voice and data quality, the company is in a better position to offer customers reliable service level agreements. TEMS Automatic results can also give managers an indirect view of their own workforce's performance.
- **Network planners** learn about places with recurrent problems by requesting statistics confined to specific areas. This helps them reveal deficiencies in their layout or the underlying theoretical models, and provides input for improvements. As a result they are able to boost network utilization and get maximum mileage out of the existing network before new investments are made.

- **Optimizers** are notified of all sorts of local malfunctions (weak signal reception, bad C/I, low data throughput, etc.), prompting them to try out various adjustments to the network configuration. For more intricate problems and in-depth analyses, a post-processing solution like TEMS™ Discovery is an indispensable complement.
- **Marketing staff** can extract statistics on coverage, services, and customer usage, thus furnishing the basis for precisely targeted advertising campaigns.
- **Customer care representatives** can view reports that give them an idea of which problems occur in the network in various areas. They can understand coverage and available services as well. All of this information can be used to better answer customer questions and address concerns.
- **Network operations staff** can monitor network services and receive SNMP alarms for non-working services.

Because TEMS Automatic relies upon device-based measurements, it truly tests from the user's perspective. It monitors the radio interface, and conducts end-to-end voice and data testing. It is unattended and operated remotely, freeing operations personnel from routine drive testing while providing more network data than directed drive tests can. It provides multi-technology support in a single platform, and can test competitors' networks along with the operator's network, for accurate comparison.

TEMS Automatic is designed to collect huge amounts of data from the network with minimal human effort. The system is objective, and collects and reveals network quality independently, no matter who the infrastructure provider(s) may be. A variety of test units, including mobile remote test units (RTUs), handheld test units, and fixed RTUs, are deployed throughout the network to place test calls that simulate the end user's experience.

These test units perform network testing automatically, according to flexible, user-defined measurement orders. Air interface data is recorded and sent to the central server over the data channel.

AUTONOMOUS NETWORK MONITORING

Positioned data

A Global Positioning System (GPS) receiver is integrated in the test units. It captures location during measurements, allowing data to be geographically positioned in map views.

Quality measurements

TEMS Automatic measures uplink and downlink voice and data services end-to-end from the user's perspective. This gives operators control over the quality they offer, as well as the ability to track down network weak spots. Measuring KPIs allows impartial comparison of different networks. Together with these KPI measurements, the system also supplies in-depth technical measurements that give a perfect foundation for analysis and problem solving.

Data quality

Data service performance measurements are performed on the air interface layers (RLC/LLC), and in the application layer (TCP), by measuring industry-standard KPIs. These KPIs include setup/send/receive timers and the various data throughput rates at which services have been transferred over the network. Typical services that are used for data testing include FTP, HTTP, and SMS, as well as new services such as video streaming/mobile TV, MMS, and WAP.

VSQI

The Video Streaming Quality Index (VSQI) is a non-reference method for video streaming quality assessment. VSQI is based on the quality of the encoded (compressed) signal prior to transmission, the amount of initial delay, and the subsequent interruptions during playback of the video sequence; that is, the time required for initial buffering and the incidence of rebuffering. It also takes into account the amount of packet loss at the application level (in other words, in the video streaming client). VSQI is expressed in the MOS scale.

Speech quality

TEMS Automatic offers functionality for advanced speech quality assessment by testing mobile-to-mobile or mobile-to-fixed networks.

- **POLQA** (Perceptual Objective Listening Quality Assessment) algorithm, standardized as ITU Recommendation P.863.

POLQA is measured in a mobile-to-mobile configuration (RTU to RTU, or RTU to Mobile Call Generator), and is used with NB (narrowband, 300-3400 Hz) or SWB (super-wideband, 50-14000 Hz) operational mode.

- **PESQ** (Perceptual Evaluation of Speech Quality) algorithm, standardized as ITU Recommendation P.862.1. PESQ is measured in a mobile-to-fixed configuration (RTU to Call Generator) as well as in a mobile-to-mobile configuration (RTU to RTU, or RTU to Mobile Call Generator¹).
- **SQI** (Speech Quality Index), an algorithm which uses radio link parameters to calculate the perceived speech quality on a radio channel. SQI values are based on bit error and frame erasure rates and their respective distributions, as well as handover events, DTX percentage, and the choice of speech codec. SQI is expressed in the MOS scale.

Both PESQ and POLQA are designed to mimic human speech perception. Throughout test calls, a speech sentence is played on the voice channel. The PESQ or POLQA algorithm computes a quality estimate by comparing the transmitted sentence with the undistorted reference, taking also the fixed-side equipment into account, providing scores calibrated to the MOS scale

For almost a decade, the intrusive perceptual solution for listening speech quality evaluation has been PESQ standard P.862 (along with P.862.1, 2, and 3). With the 3G network evolution towards all IP, particularly NGN (LTE/SAE-SON), ITU-T recognized the industry's immediate need for a new standard that would both improve current PESQ performance under certain specific network conditions and cover 3G network evolution for voice service: from traditional CS to VoIP and VoIP over IMS, from NB to WB and SWB, and from low codec rates to very low and adaptive codec rates. As a result, POLQA was developed.

PESQ and POLQA are both part of a larger package of audio quality measurements (AQM) that also includes echo delay and attenuation, speech path delay, volume level, and silent call detection, as well as it includes frequent audio quality measurements (AQMs). AQM gives quality scores with twice the frequency of PESQ or POLQA algorithm. This makes it easier to geographically pinpoint speech quality problems and to find the corresponding radio problem.

By using PESQ/POLQA and SQI together it is possible to detect non-radio problems that affect speech quality

(suggested by a good SQI and a bad PESQ/POLQA value occurring simultaneously).

PESQ is supported for mobile-to-mobile and mobile-to-fixed testing, and POLQA is supported for mobile-to-mobile testing.

C/I measurements

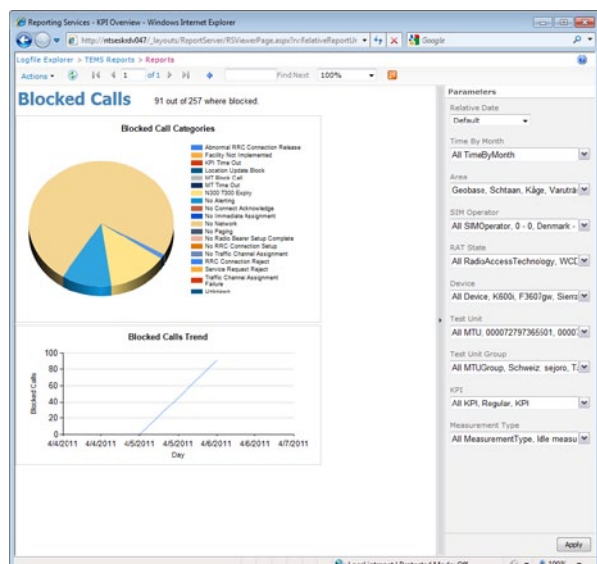
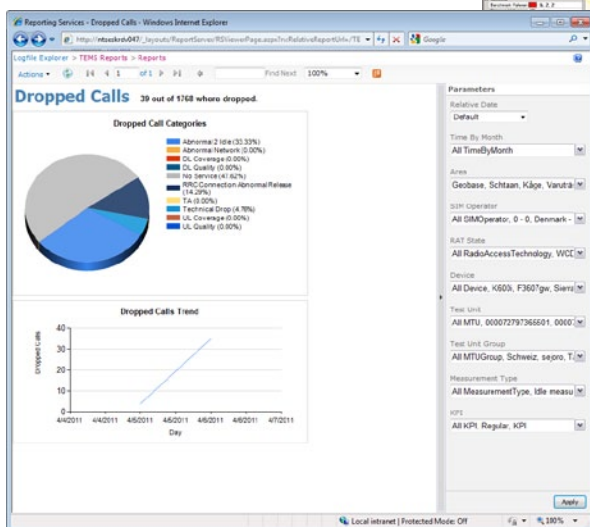
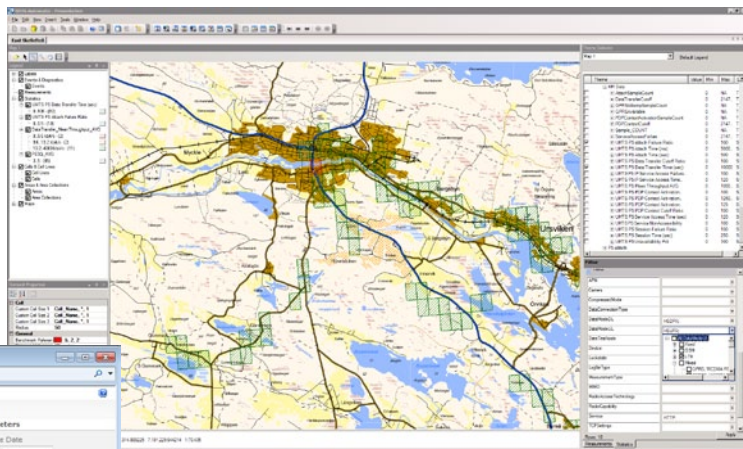
TEMS Automatic can also measure the carrier to interference (C/I) ratio, another important parameter when assessing radio network performance. C/I is the ratio between the signal strength of the current serving cell and the signal strength of interfering signal components. C/I is measured in real time in idle, dedicated, and packet mode, and can also be measured in frequency hopping networks.

The measured average C/I can be presented for each frequency used, and this data makes it possible to identify frequencies exposed to high levels of radio interference.

Frequency scanning

Using the handset, the RTU can perform both GSM and WCDMA scanning. In GSM scan mode, the handset can scan any channels including BSIC decoding. In WCDMA scan mode, the handset can perform CPICH scanning on up to 12 carriers (UARFCNs), as well as request layer 3 decoding. It is also possible to connect an external scanner and have the data uploaded via the RTU.

TEMS Automatic users can see the state of the network automatically, particularly with the optional reporting solutions like Microsoft® Reporting services.



TEMS Automatic provides the ability to:

- **Improve QoS**
 - By reporting quality trends that show the impact of optimization efforts on a daily, weekly, or monthly basis.
 - By providing continuous feedback on the QoS of the live network as experienced by subscribers, in regards to both speech quality and data services.
- **Reduce churn and increase revenue**
 - By detecting faults, capacity bottlenecks, and configuration problems immediately – before subscribers do.
- **Reduce costs**
 - By allowing field engineers to focus on planning, troubleshooting, and fixing errors rather than merely collecting data.
 - By minimizing the time it takes to create and distribute quality reports.

Location based services

Automated testing of location based services, such as verification of successful call attempts and accuracy of caller locations, is possible with TEMS Automatic. The solution facilitates cost reduction if compared with traditional manual drive testing. It also allows users to compare autonomous data with data retrieved from the operator's infrastructure. Users can plot the specific calls on a map or export the data for separate post-processing.

TEMS Automatic also supports wireless operators in verifying the accuracy of the location data and call success rates submitted to Public Safety Access Point (an emergency call center).

Scalability options

TEMS Automatic is completely scalable. From a single-server configuration to multiple servers supporting hundreds of RTUs, TEMS Automatic systems can expand to accommodate networks of any size.

Leading operators to success

TEMS Automatic is the industry-leading autonomous network monitoring solution. As a powerful automatic system, it provides operators with the information they need. Our worldwide presence attests to our focus on our customers' needs. Our technically advanced solution is proven and stable, and has been designed with the future in mind. It is able to grow and expand with the changes in the market. Our commitment is to help our customers improve their business and increase their competitiveness.



Two RTU-5Gs mounted with a UPS
(Uninterruptible Power Supply)