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Testability in the NGN

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Abstract:

This paper is a part of series of white papers addressing the management network implementation in MSF networks. The testability of NGNs and their components is addressed in a context of the performance and fault management functional areas of TMN. Overview and comparison of management functions of element management layer and network elements in PSTN, IP-based, and Hybrid networks are discussed. Performance monitoring methods and performance measurements matrices are shown for the end-to-end calls.

End-to-end performance monitoring on signaling and bearer links and interworking between service and transport providers' domains are the most complicated and needed areas of a new management network's paradigm. MSF logical and physical architectures of a management network should be addressed in future documents.

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"*That which is monitored improves.*"
- Source unknown

"When you can measure what you are talking about and express it in numbers, you know something about it."
- Lord Kelvin

1 Introduction

Next Generation Networks (NGNs) are rapidly evolving to provide multi-service networking over packet-switched networks and require internetworking architectures and scenarios to allow internetworking with circuit-switched networks and between different physical and logical layers. Integration of different telecommunication technologies, local and long distance services, cable and phone, voice, video and data requires an integrated network management system that is standard-based and capable of managing the diverse network technologies. To address the hybrid nature of NGN, ITU-T defined such networks as Hybrid Switched Circuit/Packet Networks (HCPN).

The approach taken by the standards' community toward network management is to extend the employed management paradigms to manage HCPN. One of the most promising considerations for HCPN management is the extension of Telecommunication Management Network concepts. The challenge here is to apply an inherently hierarchical TMN architecture to a connectionless nature of IP networks.

The following areas should be addressed:

- Performance and fault management recommendations for IP- based networks.
- Interworking functions between IP-based networks owned by different operators.
- Performance objectives and procedures for IP-based and hybrid networks.
- End-to-end service and physical layers performance measurements.

The testability of HCPN is viewed in a context of management networks. The IEEE 90 Dictionary defines testability as:

> "The degree to which a system or component facilitates the establishment of test criteria and the performance of tests to determine whether those criteria have been met."

This white paper outlines the place of test criteria and the performance of tests in a management network. Performance and Fault management functional areas are the areas applicable for the evaluation of testability.

1.1 Telecommunication Management Network Overview

Telecommunications Management Network is the ITU-T set of standards for telecommunications network and was developed to provide common ground for developing and servicing PSTN networks. As it is defined by ITU, "TMN is conceptually a separate network that interfaces a telecommunication networks at several different points to send/receive information to/from it and to control its operations."

TMN definitions are organized into the functional, physical, and logical architectures.

1. The general relationship of TMN to managed networks could be depicted as follows:

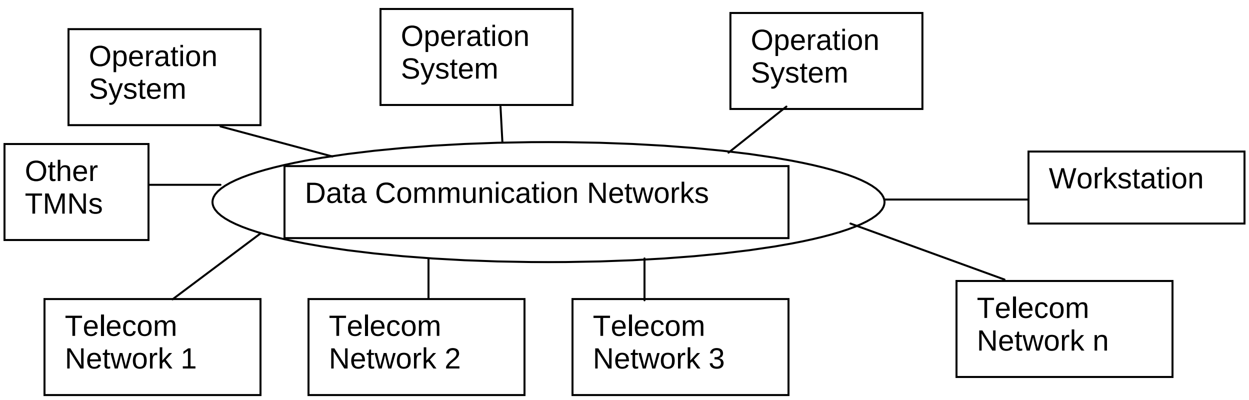

Figure 1. The general relationship of TMN to managed networks

A TMN consists of a set of operation systems, a data communication network, and interfaces to telecom networks under management. OSs implement management functions, and the data communication network provides transmission of monitor and control data between OSs and networks. Each of the telecom networks is comprised of a variety of equipment and interfaces.

2. TMN Functional Architecture

TMN consists of a set of functional blocks, a set of reference points, Management Application Functions (MAF), and Management Function Sets and Management Functions. A functional block is a logical entity that performs a prescribed management function. A reference point separates a pair of functional blocks, and two functional blocks must communicate via a reference point. One or more functional components make a functional block.

TMN management functions are broken down into five functional blocks:

- Operation system function (OSF) block. Provides core services for TMN.
- Network element function (NEF) block. Presents a view of the managed network elements to the OSF, and provides network elements with management.
- Workstation function (WSF) block. Supports the interaction between a human user and the OSF.
- Mediation function (MF) block. Manages communications between NEF and OSF. There are differences in vendors' implementations of NEF and OSF, and a mediation function is needed.
- Q-adaptor function (QAF) block. QAF provides a translation capability to connect a proprietary NEF or OSF to TMN, or non-TMN network element to a TMN.

Reference points define service boundaries between two management function blocks and identify the management information passing between functional blocks. While a reference point is a logical entity, its implementation becomes an interface. Five classes of reference points are specified in the TMN framework:

- "q" class consists of:
    - qx
    - Q3
- "f" class
- "x" class
- two non-TMN points, g point and m point.

Q3 is the only interface that has a substantial number of specifications and has been widely implemented. X-class reference points are used for interfaces between different management networks.

3. TMN Physical Architecture

The TMN physical architecture, as for any network, is defined in terms of various nodes in the network and the communication interfaces between the nodes. A node can be a hardware system, a software application, or a combination of the two. Many kinds of nodes could be used in TMN. One of our interests is a mediation node, which provides interfaces between non-TMN and TMN functions. Many vendors do not fully support TMN and use proprietary management interfaces. A mediation device or Q Adaptor is specified to support such interfaces. Figure 1 diagram, "The general relationship of TMN to managed networks," represents the simplified TMN physical architecture.

4. TMN Logical Layered Architecture

TMN addresses five functional areas and five logical management layers.

The logical management layers structure the management functionality into groupings named “logical layers” and describe the relationship between layers. This concept is known by its application to OSI’s network architecture. The TMN architecture places OSF functional blocks into the following layers:

- Business Management Layer (B-OS)
- Service Management Layer (S – OS)
- Network Management Layer (N-OS)
- Element Management Layer (E-OS)
- Network Element Layer (NEF). This layer is the ultimate destination of TMN and does not have OS associated.

Where possible, a recommended assignment to a logical layer is provided in TMN for each functional block.

Five functional areas are the generic and specialized TMN management function sets. Following the framework of groups operations, administration, and maintenance (QA&M) function, the function sets are classified in ITU-T M.3010 into five Management Functional Areas:

- Performance Management
- Fault Management
- Configuration Management
- Accounting Management
- Security Management

The testability requirements for HCPN fit into the Performance and Fault Management functionality of TMN.

1.2 TMN Performance Management

Performance Management area provides functions to evaluate and report upon the behavior of telecommunication equipment and the effectiveness of the network and network elements. Its role is to gather and analyze statistical data for monitoring and to control the status and quality of the network.

Performance Management area includes the following function set groups:

- Performance Quality Assurance
- Performance Monitoring
- Performance Control
- Performance Analysis

Performance Quality Assurance, Performance Analysis, and to a great extent, Performance Control will be reviewed in the MSF White Paper (msf2004.241.00) "Service Assurance in NGN."

1.2.1 Performance Monitoring

Performance Monitoring involves the continuous collection of data concerning the performance of NE. Performance monitoring should be designed to measure the overall network quality by using monitored parameters and comparing them with the predefined threshold. Also, the degradation of group of parameters could provide additional information for analysis and control.

Performance Monitoring includes the following function sets:

- Policy function set
  This set establishes values of threshold settings and schedules for data collection for specific kinds of circuits/connections.
- Event correlation and filtering function set
  This set provides access to information concerning identified root causes based on policy-defined events
- Data aggregation and trending function set
  This set provides access to aggregated and correlated end-to-end current and history performance monitoring information. This set should provide tracking and detection of network faults and impairments in different sections of network or between networks under the management. This function set is one of the most complicated performance monitoring functions sets. PSTN to IP signaling integrity and monitoring is the issue, which has not yet been properly resolved.
- Circuit or connection specific data collection function set
  This set collects information across different NEs. The information collected is the input into the Data aggregation and trending functional set
- Traffic status function set
  This set provides current traffic status information. Service availability, status of controls, congestion status, identity of signaling path, etc. are examples of TMN requirements.
- Traffic performance monitoring function set
  This set reports current performance measurements of the traffic that has been offered and carried by NEs.
- NEs threshold crossing alert processing function set
  This set provides access to the root cause events as inferred by an event correlation process.

- NEs trend analysis function set
  This set reports the trends detected by processing the historical data of NEs
- Performance monitoring data accumulation function set
  This set includes reporting of processed and raw performance monitoring data.
- Detection, counting, storage, and reporting function set
  This set supports the reporting of results of the continuous detection, collection, and reporting of performance primitives, i.e. data or measurements, associated with a transmission, traffic, or service entity. Storage implies that performance registers within NE are readable or demand without resetting the count. Reporting implies that NEs report any performance parameters on demand, as well as report periodically via scheduling.

A good practical presentation of the model for performance monitoring implementation is provided in ITU-T Recommendation Q.822. This model focuses on the performance data collection process and the managed object classes used to represent performance data. This approach will be used in incoming white papers for the testability in MSF networks.

1.2.2 Performance Control

Performance Management Control supports the transfer of information to control the operation of the network in the area of Performance Management. For network traffic management, this includes the application of traffic controls that affect the routing of traffic and processing of calls. For transport performance monitoring, this group includes the setting of thresholds and data analysis algorithms and the collection of performance data, but has no direct effect on the managed network.

1.3 Fault Management

Fault Management functions enable the detection, isolation, and correction of abnormal conditions in the network. The ultimate goal of fault management is to minimize the impact of faults on the services with a minimum amount of interference to normal network operation. The fault management process could be modeled as five groups of functional sets:

- Reliability, Availability, and Survivability (RAS) Quality Assurance
- Alarm Surveillance
  This group monitors NE failures in near-real time. When such failure occurs, NE makes an indication available.
- Fault Localization

If the initial failure information is insufficient for fault localization, it has to be augmented with additional information. Specific routines employ internal or external test systems and can be controlled by TMN

- Fault Correction
- Testing (described in section 1.3.1 below)
- Trouble Administration

1.3.1 Testing Functional Set Group

Testing management could be broken down into service, network, and network element levels.

The task of service management layer testing includes determining the testing strategy and designing a service feature combination for testing in order to determine whether a service feature or a set of service features is working properly.

There are several steps involved in testing at the network management layer:

- A systematic test of segments of a circuit is arranged to determine which segment caused the fault.
- An appropriate test suite is selected for the test required
- Results from each segment test are correlated and reconciled if necessary to derive an overall conclusion.

As for the service-level testing, few standards exist for network-level testing. Most standards were developed for testing management of the network element layer.

1.3.2 Testing Functional Sets

TMN specifies two ways of testing. In one, a TMN requests NE to carry out analysis. NE executes processing, and the results are automatically reported to the TMN, either immediately or on a delayed basis.

In another method, a TMN requests that the NE provide access to the circuit or equipment of interest. TMN collects the needed data.

Testing includes the following function sets:

- Test point policy function set
  This set manages tables that define the conditions for providing test access at various points along a circuit.
- Service test function set

This set provides testing of a service feature or set of service features, and requests an agent to test a service to ensure that it is available for operation. The agent sends a report with the results of the testing.

- Circuit selection, test correlation and fault location function set
  This set supports requests for test on an end-to-end circuit and supports the return of test results
- Selection of test suite function set
  This set supports requests that a specific part of a circuit be tested and supports the return of results.
- Test access network control and recovery function set
  This set provides for setting up a suite of tests on a specific part of a circuit, determining the configuration of the appropriate test access points, and sending the appropriate commands.
- Test access configuration function set
  This set provides for setting up configuration of tests access arrangements and access to status information. It also supports management functions: “Connect test access,” “Change access mode,” and “Release test access.”
- Test circuit configuration function set
  This set provides for setting up configuration of tests access arrangements and access to status information. It also supports such management functions as: “Interexchange pairs,” “Change leads,” “Change Terminate test and Leave Status,” etc.
- NEs test control function set
  This set provides for controlling the performance of a test or a suite of tests. It also supports such management’s functions as: “Control analog test signal,” “Connect and disconnect monitor/talk link,” “Test digital loopbacks,” “Terminate test measurement,” etc.
- Results and status reporting function set
- Test access path management function set
  This set provides management of Test Access Points (TAP) resources, and test resources such as signal generators and receivers. It also supports such management functions as: “TAP loopback test,” “Restore TAP in service,” “Request TAP status,” etc.
- Test access function set
  This set supports requests for test access to a path or circuit supported by NE. Test access may involve removing the path or circuit from service.

2 IP Network Management Architectures

In its simplest form, the existing IP-based management architecture can be described as management protocols providing for the exchange of messages, which convey management information between the managed elements and the management stations (IETF RFC 1901). In IP-based management, the management station does not always have as clear a distinction between EMS and NMS as is typically found in TMN-based networks. The term “mid-level manager” is often used to indicate the case where there is a management station acting as an intermediary between another management station and a managed element.

While management is not always formally discussed in terms of Fault, Configuration, Accounting, Performance and Security (FCAPS), these areas are all present in varying degrees. Given the connectionless nature of IP routing, monitoring functions have historically placed more emphasis on performance management compared with other functions. Other areas, such as alarm management, have received more attention in recent years, though. SNMP and RMON are the directions where IETF put their efforts for defining distributed network management platform. Below are the short overviews of SNMP and RMON.

2.1 SNMP

IETF RFC 3411 defines an SNMP management system as containing:

- several (potentially many) nodes, each with an SNMP entity containing command responder and notification originator applications which have access to management instrumentation (traditionally called agents);
- at least one SNMP entity containing command generator and/or notification receiver applications (traditionally called a manager); and
- a management protocol, used to convey management information between the SNMP entities.

RFC 3411 defines managed elements as devices such as hosts, routers, terminal servers, etc., which are monitored and controlled via access to their management information.

SNMPv1 defines the following protocol operations: get, get-next, set and trap and allows for many simple data types based on integer and strings. SNMPv2c added get-bulk and 64-bit counters, and changed the PDU format. SNMPv3 added security and introduced new terminology. Also, more performance measurement matrixes and alarm MIBs were specified recently in SNMP3.

Management information consists of "managed objects" which are individual data items, e.g., integers and strings, defined using the Structure of Management Information (SMI). These are accessed via a virtual information store, termed the Management Information Base (MIB). The scope of the MIB is typically one managed entity. Managed objects are organized into simple groups or into tables.

2.2 RMON

RMON extends the capabilities of SNMP to larger IP-based networks. RMON is a specification of a special-purpose MIB, and it uses the underlying SNMP. RMON also specifies a dedicated management entity, acting in an agent role, to collect and manage an RMON MIB. This dedicated management entity, along with a network device (if needed) is called a remote monitor or probe. Usually, it is a software agent installed on a network element. A probe monitors the health and behavior of a segment of a network, reducing the burden on the management station.

The following RMON goals are stated in IETF RFCs:

- Off line operations
- Proactive monitoring
- Problem detection and reporting
- Value-added data
- Multiple managers support

In summary, an RMON system consists of:

- Management station (same as in SNMP)
- Set of RMON probes
- Management protocol identical to the one used in the existing SNMP management systems

2.3 IP-Based Networks Performance Objectives

One of the tasks of performance management definition efforts is to address performance objectives and limits of IP networks in an environment where multiple IP networks belong to different operators. This could be done regardless of the transport technology and the higher level of implementation over IP. ITU-T Recommendation M.2301 defines this objectives and limits. The reference model is based on the concept of IP Operator Domains (IPODs) and their interconnection links. An IPOD consists of one or more Autonomous Systems (ASs) and their interconnection links. The recommendations are applicable to performance of fixed access links, whose routing does not change. It should be noted that dial-up access links, end-customer owned portions, and MPLS network performance is for further study.

ITU-T Y.1540 provides a general framework for applying these limits. Guidelines for the methods and procedures for applying the reference values of measurements in provisioning and maintenance are given in ITU-T M.2301. Assumptions used in the Recommendation use the following principals:

- It is desirable to do in-service, continuous measurements. In some cases, out-of-service measurements may be necessary
- Performance limits of IP flows are independent of the supporting transport, but the allocation to network sections may be dependent on the transport medium used.

3 Integrated Management of HCPN

As a continued work on a series of Recommendations defining the TMN paradigm for HCPN, ITU-T M.3017 proposed a framework for the integrated management of these networks.

Two kinds of networks are specified for the management: technology specific network (TSN) and multi-technology networks (MTN). TSN is a single-layer network, which is concerned with only one technology, e.g. IP, ATN, SDH or Optical network. MT composes several interacting TSNs belonging to the same operator.

Integrated Network Management System (INMS) is defined as a managing system to perform the integrated management of MTN. Also, Technology-Specific Network Management System (TS-NMS) specified for TSN. TS-NMS relates to IMNS by providing the management information to it.

Below is an example of logical layer architecture option 1 from ITU-T recommendation M.3017.

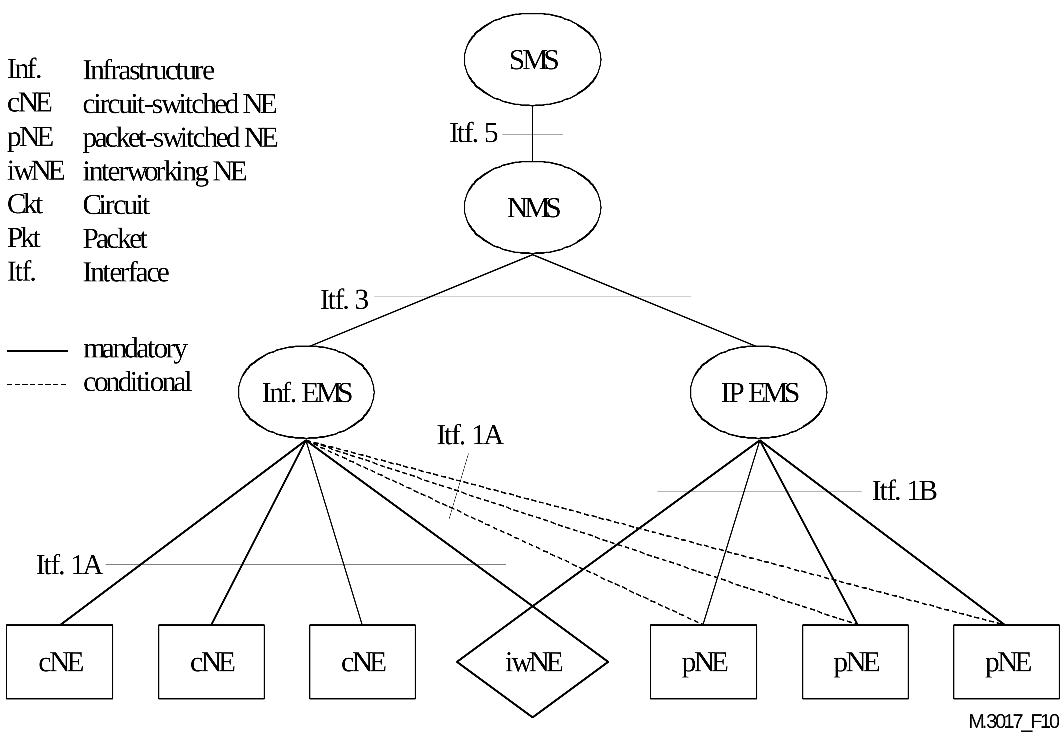

Figure 2 Integrated management of HCPNs option 1 M.3017

It should be noted that the intention of IMNS implementation is more on interworking between TSNs, while the management information moving between layers could be adapted from TMN. INMS is specified as more of an integrated network management layer OS for managing relations between TSNs.

The information model of INMS, as it is defined today, differs from the definition of functional areas defined for TMN. IMNS provides the integrated management of:

- Performance
- Fault
- Topology
- Configuration

While there could be the changes in specifications and definitions, it is sufficient to assume that IMNS Performance and Fault Management information functions could be mapped from Performance and Fault management functional areas of TMN.

As seen on the diagram, the logical architecture of IMNS specifies four layers:

- Service Management
- Network Management
- Element Management
- Network Elements

As mentioned before, the major efforts of standards committees for IP network management are in areas of performance and fault management. To address these areas, the logical architectures used are focused on the integration of management functions on Network and Element Management layers.

4 Performance Monitoring Methods

There are two basic approaches to performance measurements. ITU-T defines them “intrusive” and “non-intrusive,” which equate to terms “active” and “passive” used by IETF.

Intrusive performance measurements are made by inserting some kind of specific flow interleaved with the normal traffic flow between two measurement points. It should be noted that intrusive methods impose additional traffic through the network. It is also important to consider the fact that when the normal traffic flow is low, the results of intrusive measurements could be invalid.

Non-intrusive performance measurements could be of two kinds. The performance could be assessed by collecting data from MIB of NE or by a probe connected to the network. The probe monitors traffic flow by connecting to NE mirror ports or by tapping to the link.

Non-intrusive measurement has the advantage of minimizing the impact on customer's traffic and testing every route through the network. It should be noted that non-intrusive measurement can realistically be done only within one server provider network, since it may be difficult or undesirable for one operator to access NE in another network. If so, results of measurements might be exchanged by connecting operators over a TMN X-interface.

Signaling Gateways, Media Gateways, and Media Gateway controllers are the functional elements performing the interconnections. These functional elements are combined under the name TIGIN Gateway in ITU-T Recommendation G.799. Also, in this recommendation a notion of General Switched Telephone Network (GSTN) introduced. GSTN includes ATM, PSTN, ISDN, wireless, and private networks.

Performance management in interconnected networks includes items such as facility and connection performance monitoring, congestion control, and traffic management.

ITU-T G.799 specifies performance management requirements for call quality monitoring and diagnostic capabilities and requirements for congestion control and traffic management.

Call quality requirements are based on the capability of a TIGIN Gateway to monitor and report on individual calls using RTCP XR Recommendations (RFC 3611). It is not clear yet if these Recommendations will be accepted by the industry.

Congestion control is addressed by TIGIN Gateway support for H.248 Congestion Handling Package. SS7 signaling management controls should be applied when internal signaling congestion is detected.

Overload controls, and traffic management for other signaling interfaces (MF, DTMF, CAS) are for further study.

4.1 Non-intrusive monitor access

The monitor access shall provide the ability to connect to a specific port/address/call and monitor one or both directions of an active call simultaneously (Figure 3). It shall be possible to monitor a specific port or connection within the TIGIN Gateway, allowing a port to be monitored before a call is active on the port. When an active call is placed on the port, the monitor shall remain active. The monitor access may provide either a TDM or an IP output and will depend on the actual implementation of the TIGIN Gateway.

In the non-intrusive monitoring case, there is no requirement that signaling be monitored.

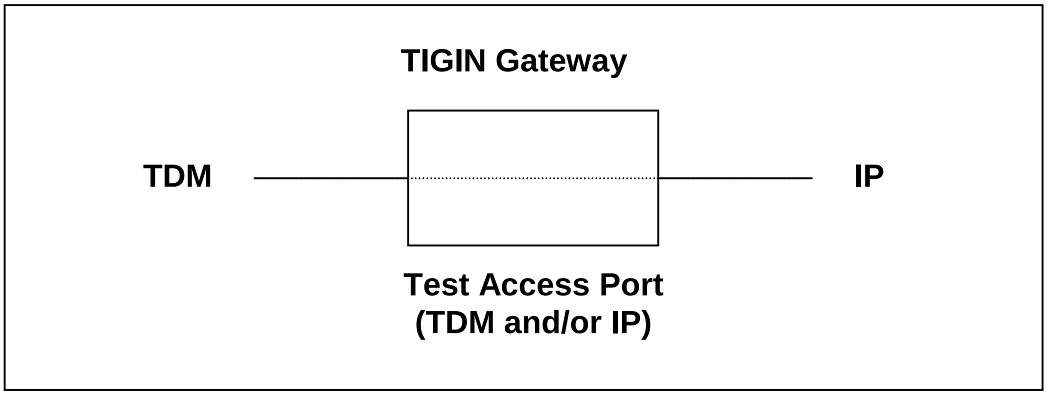

Figure 3 G.799.1/Y.1451.1 - Non-intrusive Monitor Access

4.2 Intrusive Monitor Access:

The intrusive test access shall allow test calls to be made in either direction. The intrusive test access shall allow the user to connect to a specific port/address and place a call to a destination either in the direction of the GSTN or the IP network. The intrusive test access may provide either/or a TDM or IP output and will depend on the actual implementation of the TIGIN Gateway.
In the case where the Test Access Port is TDM (e.g., Figure 4), a TDM/IP conversion function is required to access the IP data port or stream.
The specific point within the IP path where access is placed shall be the last IP point prior to any speech processing functions.

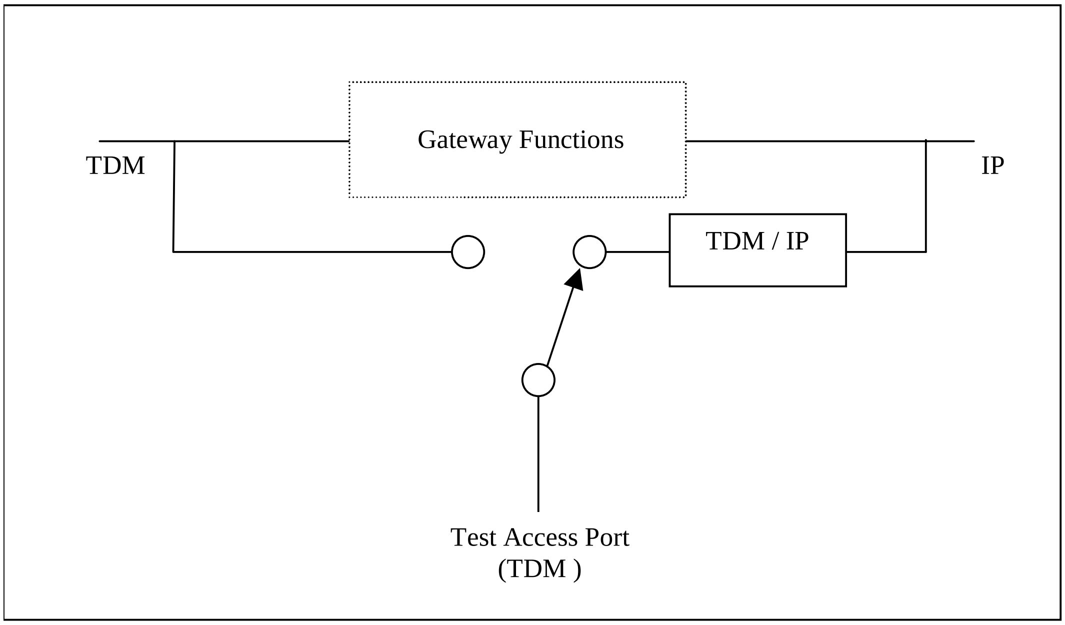

Figure 4 G.799.1/Y.1451.1 - Intrusive Test Access – TDM Test Access Port

In the case where the Test Access Port is IP (e.g., Figure 5), a TDM/IP conversion function is required to access the TDM data port or stream.
The specific point within the TDM path where access is placed shall be prior to any speech processing functions.

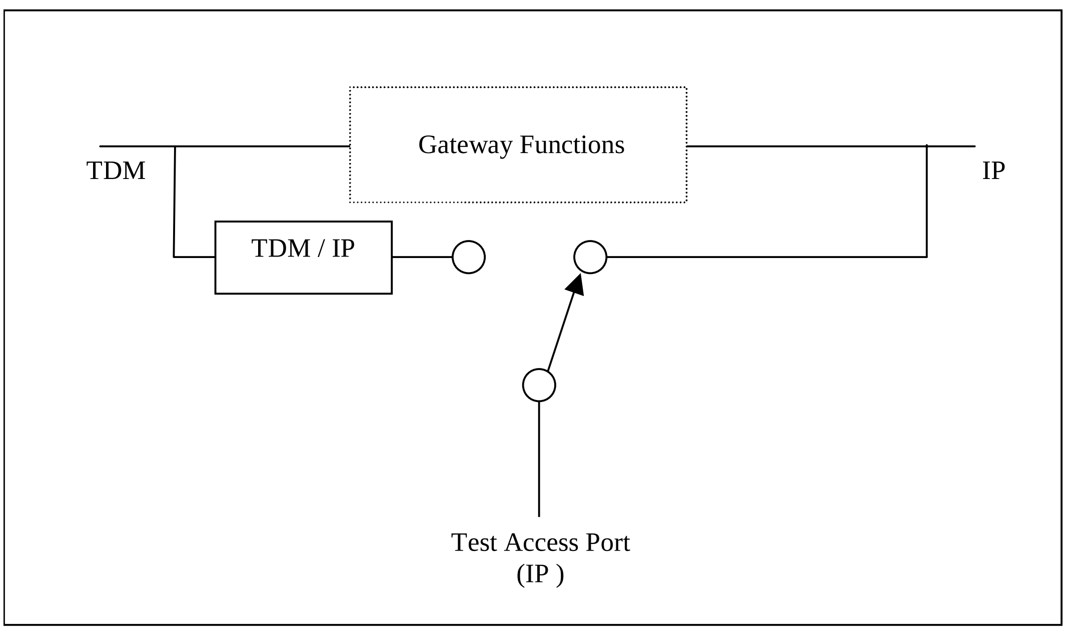

Figure 5 G.799.1/Y.1451.1 - Intrusive Test Access – IP Test Access Port

In the case of SS7 signalling arrangements, the signalling to set up calls is done via the H.248/Megaco path to the MGC.

The functions provided by the management system should not overlap with those provided by per-call control.

5 Measurements

5.1 Performance Measurements Matrices

Converged network performance matrix today is a combination of the existing PSTN performance measurement model, IP quality of service Matrix applied to RTP streams, and Speech quality intrusive and non-intrusive measurements. Standard organizations are still working on the testing methodology and quality of voice measurements for converged network. ITU-T and IETF generated a number of standards and recommendations, more for a voice path and less for a signaling path. ITU-T standard (working document Y.1530) will address Call Processing aspects of performance measurement, thus covering all parts of proposed converged network model.

The matrix data provided below is a set of measurements specified by ETSI, ITU-T, IETF, MSF, ATIS, and other standard committees for QoS in packet networks. ATM networks are not explicitly discussed in the paper, but most of measurements are applicable to them too.

The reference model, data path, source, and destination designations used below are loosely taken from a variety of standards. Some of measurements are accompanied by the suggested reference values.

5.1.1 Reference Model

- Packet Flow
    - o Packet flow is traffic having the same Source, Destination, Class of Service, and Session Identification.
    - o Voice Signaling and Voice Media can be in one packet flow (CAS) or in different packet flows (CCS and Voice Packet Flow)
- QoS definitions and classes of services presented in this document are applicable primarily to Voice Packet Flow.
- Packet Flow is a basis for specifying and measuring Traffic Capacity for Capacity Agreement between a customer and a carrier.

5.1.2 Data Path

- End to end measurements for specified Source and Destination ends

- Measuring point position in regard to Network Segment (NS) been measured. Emphasis on measurements between IP and PSTN Network Segments
  - IP NS only
  - IP to PSTN NS
  - PSTN to IP NS
  - PSTN NS only
- Correlation of the call measurements at multiple points in the network to a specific test call
- Capture and correlation of the call measurements to live calls
- Signaling Path Measurements

5.1.3 Measurement Time

- Time period to collect samples (for voice it is advised to have min 10-20sec and max 2-5 min. One min is suggested for provision)
  - Sufficiently long to include enough packets of measured flow
  - Sufficiently long to reflect a period of typical usage or user evaluation
  - Sufficiently short to ensure a balance of acceptable performance. For example, impact of burst errors should not be lost if Time period is too long.
  - Sufficiently short to address practical specs of measuring unit (memory, power, performance, connection speed and methods)
- Absolute time of measurement occurrence
- Time between periods of collecting samples

5.1.4 Source and Destination Traffic characteristics

- Source Traffic Rate
- Source Traffic Pattern
- Presence of Different Traffic kinds (for example, voice and data)
- Packet sizes and fragmentation rules
  - For most cases, especially for delay measurements and for constant bit rate, a fixed size of packets should be used. 160
  - Information fields of 160 octets and 1500 octets are suggested. For bit error measurements, 1500 octets information field size is recommended.

5.1.5 Type of Measurements

- Against Classes of QoS
- In-Service
- Out-of- Service
  - Turn Up
  - Commissioning, Investigating “faults”

    - Maintenance
- Active or Intrusive Test Matrix.
    - Simulated Media Stream (ETSI)
    - Delay Variation
    - Packet Loss
    - Packet Loss Correlation
    - Packet Delay
- Non-Intrusive monitoring of media paths to determine customers QoS (ETSI)
    - Packet Loss
    - Packet Loss Correlation
    - Delay Variation
    - Bandwidth Utilization per flow/circuit
    - CPU load/performance
    - Audio Monitor for selected live calls
    - Recording and Playback of selected live calls

5.1.6 Measurements Results

- Absolute Values
- Averages
- Means
- Variances
    - Standard Deviations
    - Reference Points, e.g., Clock
    - Summarizing period (For example, Short – 1 min, Long – 1 Day)
- Statistical Analysis
    - Baselining
    - Threshold
    - Predictive
- Presenting results against pre-defined Service Level for a specific customer
- Presenting results against pre-defined Service Level for a specific flow/circuit

5.2 Voice Quality Measurements

5.2.1 RTP Performance Matrix

- One Way Transmission Time
    - Mean transmission time/ms
    - Min and Max transmission times/ms
- Round Trip Transmission Time
    - Mean round trip transmission time/ms

    - Min and Max transmission times/ms
- Jitter (Two Point Packet Delay Variation)
    - PDV is the difference in msbetween upper and lower percentiles on the packet delay distribution. Two PPDVs use two monitoring points. The measurement uses the difference between the inter-packet sending time and inter-packet arrival time.
    - Mean value in ms
    - Min and Max in ms
- One Point Packet Delay Variation
    - One Point PDV in ms uses one monitoring point. The measurement is based on the inter-packet arrival time.
    - Mean value in ms
    - Min and Max in ms
- Network Packet Loss
    - Percentage of packets lost at test point. Does not include losses due to the end-terminal equipment (codecs, buffers)
    - Total number of packets lost
    - Percentage of packets lost, including out of sequence packets which can not be used
- Effective Packet Loss
    - Percentage of packets lost as measured at the input of the speech codec, affecting the speech codec performance
    - Total number of packets lost
    - Packet loss distribution
- Packet Errors
    - Percentage of packets that fail CRC when received at a test point
    - Total number of errored packets
- Mis-sequenced Packets (Packets Out of Sequence)
    - Number of out of sequence packets at the receiving test point
- Voice Client Induced PDV
    - Inter-packet delay variations in ms as packets are transmitted onto the NS by a voice client.
- Packet Loss Correlation (Passive Monitoring, VQMON approach)
    - Average number of successive lost packets in a burst at a test point
    - Distribution of burst loss lengths
    - Markov loss model
- Examples of packet performance parameters mapping to overall/user-user parameters

5.2.2 Speech Quality Matrix

- Non-intrusive
    - E-Model (R-Value)
    - VQMON
    - 3SQM
- Intrusive

  - Mean One Way Delay (ETSI)
    - Time divided by two in ms for a test signal to go from near end test point, traverse the NS, get looped back at the far-end of NS, and arrive back.
    - Average of 10 delay measures or 90% of largest delay (whichever is greater)
  - PESQ
  - PSQM
  - MOS
- Advanced
  - Convergence parameters of echo cancellers
  - Double Talk
  - Echo
  - Signal Loss
  - Noise

5.2.3 *Call Measurements*

- Call Set Up Time
- Start Dial Signal Delay
  - Time in ms for the dial tone to audible after the phone in placed off-hook from the idle state
  - Percentage of calls with no dial tone
- Call Duration
  - Accuracy to 1ms
  - Percentage of premature releases
- Ring Duration
- Releases on Request
  - Connection is released when phone placed on-hook
- Call Termination Reason
- Echo in the voice path with up to 128ms tail
- Post Dial Delay
  - Time in ms between dialing the last digit and audible tone being heard at the originating end (usually ring back or engaged tone).

5.2.4 *Call Analysis Ratios*

- Call Connection Performance
  - Network Effectiveness Ratio (NER)
  - Answer Seizure Ratio (ASR)
  - Call Completion Ratio (CCR)
  - Call Loss Ratio (CLR)
- Call Ratios
  - No Correlation
  - No Dial Tone
  - Congestion

- Busy
- Aborted

6 Summary

MSF solution for management of next generation multi-service networks could be addressed by adapting the Telecommunication Management Network paradigm. MSF Release 2 Architecture elements should include additional interface layer, which will communicate results of passive and active monitoring measurements to the higher functional levels of management. Such areas as Resource Management, QoS, Alarms, Measurements Matrices, and Service Level Agreement monitoring would be addressed from one solution compatible for both IP and PSTN networks.

7 Abbreviations

CAS	Channel Associated Signaling
CCS	Common Channel Signaling
DTMF	Dual Tone Multi- Frequency Signaling
EMS	Element Management System
FCAPS	Fault, Configuration, Accounting, Performance, and Security
GSTN	General Switched Telephone Network
HCPN	Hybrid Switched Circuit/Packet Networks
IMNS	Integrated Network Management System
IPOD	IP Operator Domain
MAF	Management Application Function
MEGACO	Media Gateway Control Protocol
MGC	Media Gateway Controller
MF	Multi-Frequency Signaling
MIB	Management Information Base
MOS	Mean Opinion Square
MPLS	Multi-Protocol Label Switching
MTN	Multi-Technology Specific Network
NE	Network Element
NEF	Network Element Function
NGN	Next Generation Networks
NMS	Network Management System
NS	Network Segment
PDU	Protocol Data Unit
PDV	Packet Delay Variance
PESQ	Perceptual Evaluation of Speech Quality
PSQM	Perceptual Speech Quality Measurement
RAS	Reliability, Availability, and Survivability
RMON	Remote Network Monitoring
RTCP XR	RTP Control Protocol Extended Reports
RTP	Real Time Protocol

SMI	Structure of Management Information
SNMP	Simple Network Management Protocol
SMS	Service Management System
TAP	Test Access Point
TDM	Time Division Multiplexing
TIGIN	Transport Equipment for Interconnection of GSTN and IP Networks
TMN	Telecommunication Management Network
TSN	Technology Specific Network
QAF	Q-Adaptor Function
QA&M	Operations, Administration, and Management
OS	Operation System
OSF	Operation System Function
WSF	Workstation Function

8 References

Wang H. Telecommunications Network Management, New York, McGraw-Hill, 1999

ITU-T Recommendations P.1010 (07/2004) Fundamental Voice Transmission Objectives for VoIP Terminals and Gateways

ITU-T Recommendations G.107 (03/2003) The E-Model, a computational model for use in transmission planning

ITU-T Recommendations G.799.1/Y1451.1 (06/2004) Functionality and Interface Specifications for GSTN Transport Network Equipment for Interconnecting GSTN and IP Networks

ITU-T Recommendations G.1020 (11/2003). Performance parameter definitions for quality of speech and other voiceband applications utilizing IP networks.

ITU-T Recommendations Y.1541 (05/2002) Network performance objectives for IP-based services

ITU-T Recommendations M2301 (07/2002) Performance objectives and procedures for provisioning and maintenance of IP-based networks

ITU-T Recommendations Q.822 (1994) Stage 1, stage 2 and stage 3 description for the Q3 interface - Performance management

ITU-T Recommendations M.3000 (02/2000) Overview of TMN Recommendations

ITU-T Recommendations G.809 (03/2003) Functional architecture of connectionless layer networks

ITU-T Recommendations M.3020 (02/2000) TMN interface specification methodology

ITU-T Recommendations M.3400 (02/2000) TMN management functions

ITU-T Recommendations M.3010 (02/2000) Principles for a telecommunications management network

ITU-T Recommendations M.3017 (06/2003) Framework for the integrated management of hybrid circuit/packet networks

ITU-T Recommendations Y.1530 (2001) Call processing performance for voice service in hybrid IP networks

IETF RFC 1901 (1996) Introduction to Community-based SNMPv2

IETF RFC 3411 (12/2002) An Architecture for Describing

Simple Network Management Protocol (SNMP) Management Frameworks

IETF RFC 2021 (1/1997) Remote Network Monitoring Management Information Base Version 2 using SMIv2

IETF RFC1889 (1/1996) RTP: A Transport Protocol for Real-time Applications

IETF RFC 3611 (11/2003) RTP Control Protocol Extended Reports (RTCP XR)

ETSI TR101 300 v2. (1999-2000) Telecommunications and Internet Protocol Harmonization over Networks (THIPHON): Description of technical issues.

