Testing for GFR QoS Eligibility and ATM Frame-Based Statistics

Agilent Technologies Broadband Series Test System Application Note

Introduction

For the first time, manufacturers of GFR-capable switches and ATM Service Providers have a way to test conformance to this new ATM contract specification. The Agilent Technologies GFR Test Suite combines Guaranteed Frame Rate (GFR) testing capability, with extended frame-based performance metric calculations. With the ability to both analyze received streams for GFR contract conformance and generate GFR-eligible streams, the GFR Test Suite can test both shapers and policers alike. The GFR Test Suite also provides a series of frame-based performance measurements including frame latency, frame loss ratio and frame discard to paint a clearer picture of how the System Under Test (SUT) is behaving.

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GFR Service Category

What is GFR?

GFR is a new and unique service category that is designed to provide service guarantees at the AAL-5 frame level. The contract provides a guarantee of delivery up to the Minimum Cell Rate (MCR) and best effort delivery up to the Peak Cell Rate (PCR). GFR has been created to replace the Unspecified Bit Rate (UBR) and Available Bit Rate (ABR) service categories that are used for packed based LAN traffic.

The Unspecified Bit Rate (UBR) and Available Bit Rate (ABR) Problem

Limitations of the UBR Service Category:

- No performance guarantees
- Lacks intelligent congestion control
- Fairness of resource usage not guaranteed
- Selected cell discard ignores frame boundaries

Limitations of the ABR Service Category:

- Complicated inter-switch configuration
- Adverse interaction with TCP flow control
- Cell Policing ignores frame boundaries

GFR Better Than Best Effort

GFR defines the new traffic contract parameters Minimum Cell Rate (MCR) and Maximum Frame Size (MFS). GFR allows all frames up to the MCR to be guaranteed transmission with low cell loss ratio. All frames which fall above the MCR are transmitted up to an equal share of the available bandwidth of the system with no guarantee.

Improved Performance in IP/ATM Networks

The most commonly used ATM categories for IP traffic are UBR and ABR. However, the GFR service category has been developed specifically to manage IP QoS. by contrast, other service categories were designed for IP traffic being carried over ATM networks. The GFR Service category gives more emphasis to IP being carried over ATM networks. GFR will provide guaranteed throughput levels to IP traffic and will also deal with congestion in a much fairer way at the ATM (AAL-5) level. All the benefits provided by GFR at the ATM level are designed to improve performance at the IP level.

The GFR Test Suite

GFR Test Suite Analyzer

The Agilent Technologies GFR Test Suite Analyzer is the only application currently available that tests for GFR QoS Eligibility. It provides the user with a detailed report of the test result to help ascertain why the stream is or isn't eligible. It also provides a measure of the achieved cell rate for comparison with the contract, and supports scrambled O.191 Test Cell payloads. Traffic can be tested against the GFR traffic contract, and you can simultaneously test against CBR, VBR (1, 2 & 3) and UBR (1 & 2) contracts, using the same parameters to determine the best contract to use.

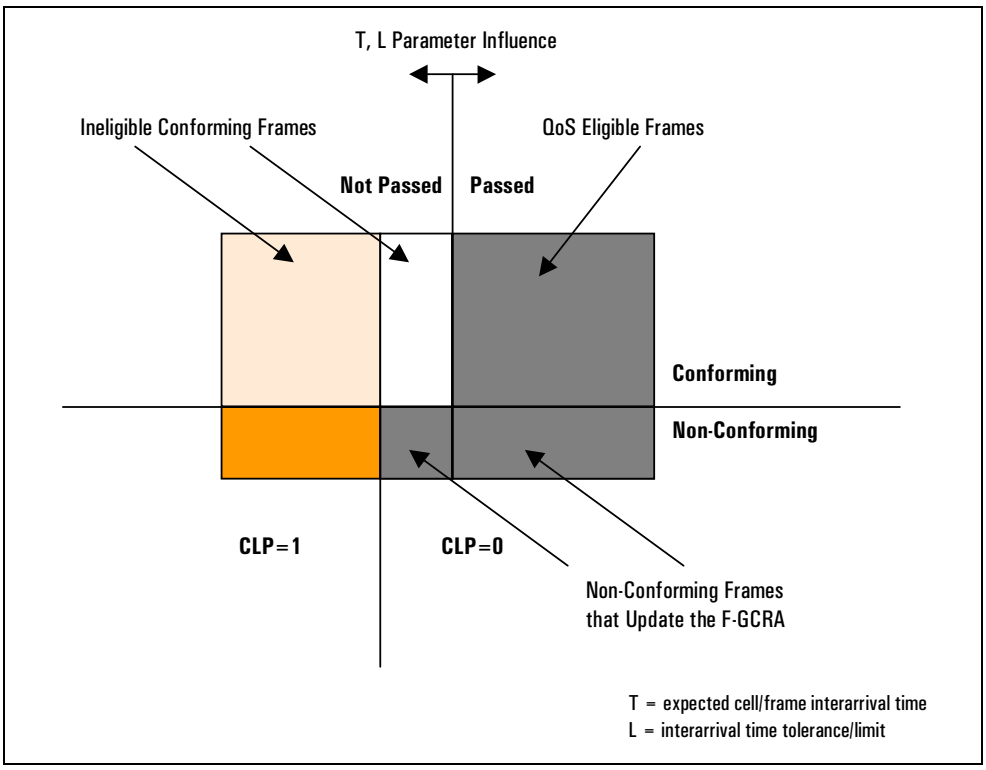

Figure 1: Classification of frames.

Conformance, F-GCRA, and Eligibility

For a frame to be deemed QoS Eligible, every cell must pass the cell conformance test and the frame must pass F-GCRA. The GFR Test Suite presents its results in three sections and provides detailed feedback to assist in determining why frames and cells have passed or failed.

Cell Conformance

All three parts of the conformance test must pass for a cell to be deemed conformant. The GFR Test Suite gives statistics on the number of cells and frames that have passed and failed each of these tests, and how many have passed the conformance test overall.

Reasons for failing conformance:

- Tagging occurring in the SUT
- Cell Inter-arrival times are too small
- Frame sizes exceeding the Maximum Frame Size (MFS)

F-GCRA

F-GCRA is a modified GCRA test that is used by the network to identify conforming frames that should be eligible for service guarantees. There are two reasons for a frame failing F-GCRA:

- The level of the "leaky bucket" could be above it's limit (determined by the contract parameters) or the first cell could have a CLP value of 1.
- Overflowing of the bucket occurs because of too many cells arriving at a high rate. For example:
  - Frame inter-arrival time being too short as compared to the contract
  - Traffic was sent at the PCR for longer than the MBS

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When the bucket overflows, subsequent frames will be rejected until the level drops below the limit again. If you are transmitting known traffic with all cells having a CLP equal to 0, then failing cells with a CLP equal to 1 can indicate:

- Tagging is taking place in the SUT suggesting that the traffic is being delivered to the SUT above MCR
- Marking may be occurring at the transmitter

GFR QoS Eligibility

The QoS Eligibility test then takes the results from the cell conformance and F-GCRA tests and combines them to calculate the number of frames that are eligible. The GFR Test Suite also calculates the cell rate of the analyzed traffic for comparison to the contracted MCR and PCR.

GFR and other frame-based statistics available in the analysis, as well as cell-based statistics such as inter-arrival time, bandwidth, cell delay variation. This allows you to perform both frame-based and cell-based analysis in the one test, without having to stop and restart the test equipment, which could result in invalid and misleading results.

Complexity

GFR is a very complex service guarantee with many parameters and many tests for the traffic to pass to be deemed QoS Eligible. During this testing the GFR Test Suite provides you with more than 35 different cell and frame-based statistics to assist in the analysis. These include:

Cell Based

- CLP conformance count
- MFS conformance count
- GCRA conformance count

Frame Based

- QoS Eligible/Ineligible frame counts
- Frame Discard counts (EPD and PPD)
- Frame Throughput

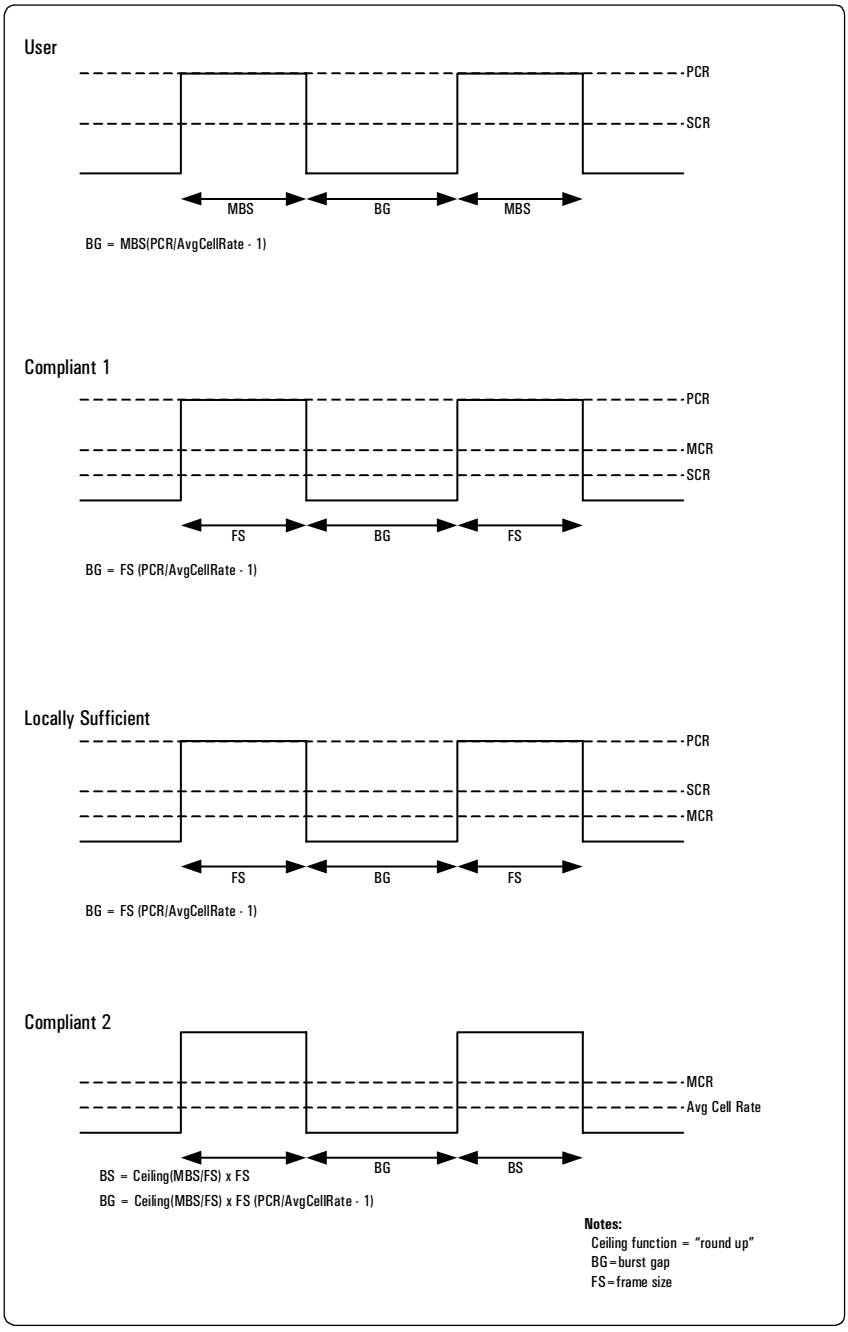

Figure 2: Mapping GFR to the VBR non-real-time stream.

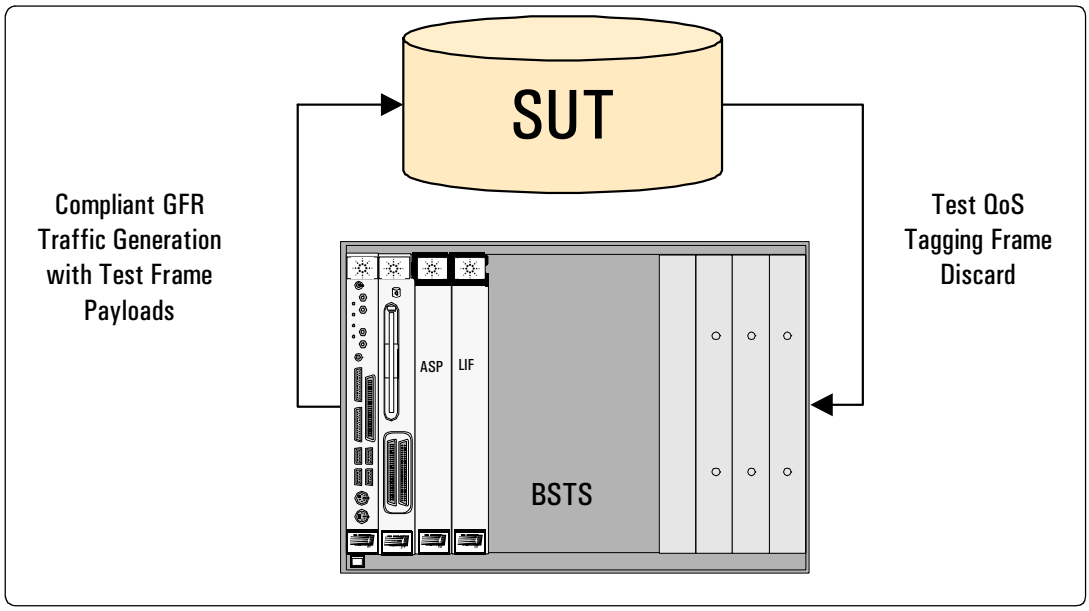

Figure 3: The GFR Test Suite Analyzer is then invoked with a receive contract that can be the same as or different to the transmit traffic contract for the analysis.

GFR Test Suite Tx/Rx Wizard

The GFR Test Suite Tx/Rx Wizard (Wizard) is a flexible and powerful tool for the testing of GFR policing and shaping. It works with either the ASP (E1607A/E1609A) or the CPP (E4209A/E4209B). The Wizard allows you to specify a transmit traffic contract which can then be mapped to one of three predefined profiles:

- **'Compliant 1'** is both eligible and conformant with uniformly spaced frames of equal size at 1 frame/burst with a mean cell rate below MCR
- **'Compliant 2'** is both eligible and conformant with M frames/burst separated by quiescent periods, such that the mean cell rate is below MCR. M = ceiling(MBS/FS). This forces the bucket level to it maximum possible level. The bucket may overflow as long as the first cell of a frame is received before the bucket overflows
- **'Locally Sufficient'** has uniformly spaced frames of equal size, with a mean cell rate above MCR (ineligible but conformant) to test that at least MCR is delivered by the SUT
- **'User Values'** has user parameters mapped directly (without manipulation) to a base GFR profile

A background traffic stream can also be added to load the SUT for stress testing. Note that background loading should not be used if you are attempting to determine an exact MFBS value (as specified in AF-TEST-TM-0131.000).

The GFR Test Suite Analyzer is then invoked with a receive contract that can be the same as, or different from the transmit traffic contract. The maximum number of cells to capture and process, as well as a receive timeout, can also be specified. The timeout is used to stop capture if the number of cells has not been reached within the time limit. This allows the system to return from the test, in the case of a mis-configured network or network error.

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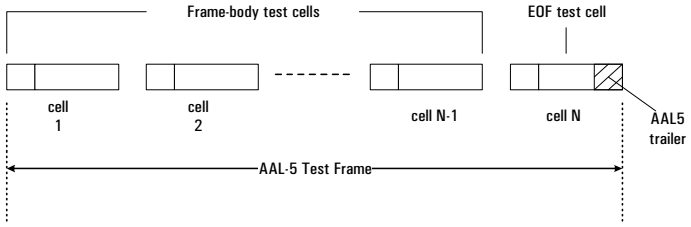
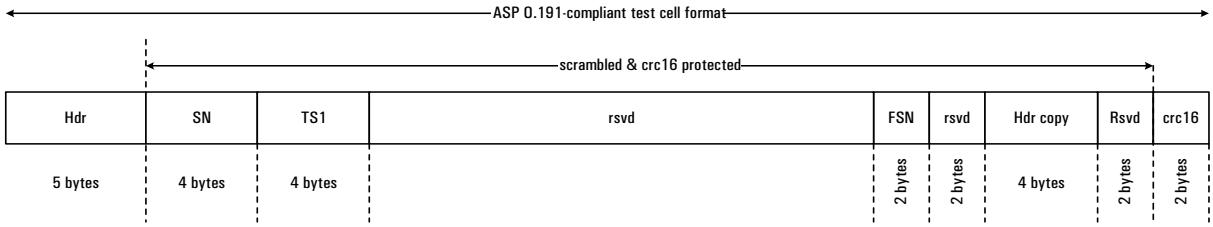
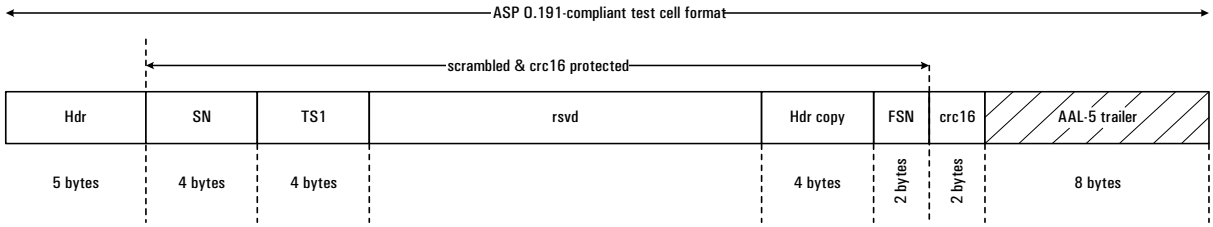
E1607A/E1609A ATM Stream Processor - AAL-5 Test Frame Format



Frame-Body Test Cell



End-of-Frame Test Cell



Field	Description
Hdr	ATM cell header
SN	O.191-conformant test cell sequence number (32 bits)
TS1	O.191-conformant test cell transmit timestamp (32-bits, counts units of 10ns)
Rsvd	Reserved
UN	O.191 conformant Unused octets
FSN	Test Frame Sequence number (conforms to draft ATM-Forum Test Frame specification)
TS2	Test Cell loopback transmit timestamp (O.191 format) (not used by ASP)
P	PPC - Proprietary Payload Control
T	O.191 conformant TCPT (Test Cell Payload Type) field
crc16	O.191 conformant test cell CRC-16 payload integrity check

Figure 5: E1607/1609 ATM stream processor - test frame format.

ATM Stream Processor Benefits

When used with the CPP, the GFR Test Suite provides basic GFR test capabilities. Please refer to the "GFR Capabilities" table. Although the GFR Test Suite is compatible with both the E1607A/E1609A Agilent ATM Stream Processor (ASP) and the E4209A/B Cell protocol Processor (CPP) there are certain benefits associated with using the ASP. The ASP has the capability of transmitting O.191-like AAL-5 Test Frames and Cells that contain extra information (FSN, CSN, TS2, Header Copy) allowing extended frame performance measurements to be made. Scrambling of cell payloads is also provided to make the transmit stream behave as a PRBS.

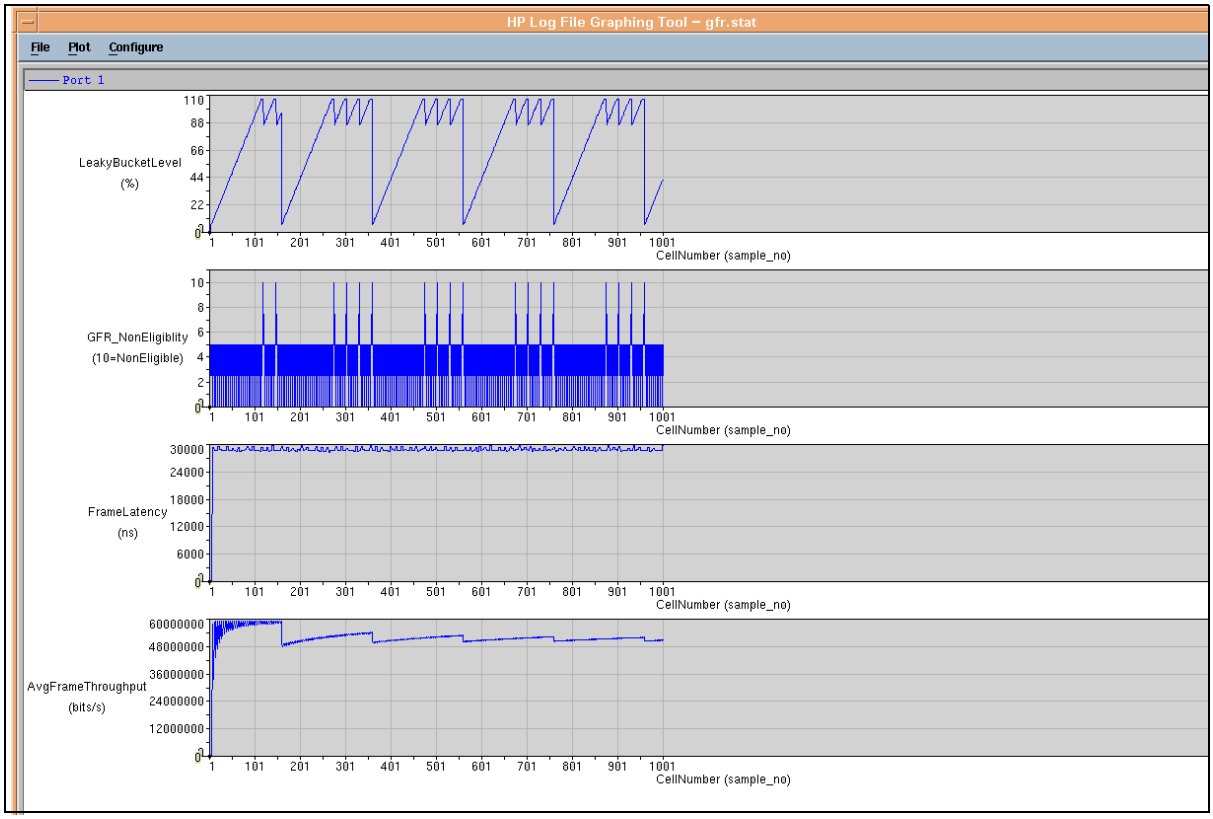


Figure 4: ASP test-cell & test-frame formats.

Benefits of the ASP

O.191

The O.191 test frames and cells are an accepted standard for measurement of ATM QoS. Service providers can use O.191 for performance benchmarking and vendor equipment evaluation. Vendors can utilize the cells and frames to ensure that their equipment will pass the tests performed by the service providers and meet their needs. Therefore by using the O.191 cells and frames you can be assured that you are meeting the set standards.

Scrambling

The benefits of the ASP supporting scrambling of cell payloads is two-fold. Firstly, by scrambling the traffic to create a PRBS this better stresses a switches hardware and uncovers "stuck bit" faults. Secondly this eliminates the need for separate PRBS testing.

Using the ATM Stream Processor

The Wizard has the capability of generating a graphable statistics file using the built-in LFGT utility. This presents the test results to you in an easy-to-analyze form. These graphs include the F-GCRA bucket level and other frame-based statistics, on a cell-by-cell basis for the length of the capture.

This allows you to see how the SUT was performing at different stages of the test, to gain a better understanding of its characteristics.

Output Files

Since there are many test parameters to be configured, the GFR Test Suite Tx/Rx Wizard provides a save/restore feature for these parameters. This allows for easy repetition of tests and templating for tests of similar setups. As with the CDTA Wizard, cell record files and graphable statistics files can also be generated for post-analysis viewing. The LFGT can be automatically launched to graph the statistics for you.

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Frame Performance Measurements

Using the ASP's O.191 test frames extends the capabilities of the GFR Test Suite to deliver extended performance measurements on a frame-based level.

- **Frame Discard (FD)** detects if frames have been discarded by the SUT and how the discard has been implemented (EPD, PPD).
- **Frame Throughput (FTT)** allows testing for Peak throughput, loss-less throughput and full-load throughput metrics.
- **Frame Loss Ratio (FLR)** calculates the number and percentage of frames lost in the SUT. This can point to a lack of resources in the SUT among other problems.
- **Maximum Frame Burst Size (MFBS)** is a measure of the maximum number of frames that could be sent at the peak rate through the SUT without incurring loss.
- The **Frame Latency (FLY)** metric is measured in two ways, using First In Last Out (FILO) and Message In Message Out (MIMO) latency.
  - FILO latency is a measure of the user-perceived latency of the system. The user starts the measurement once the first bit of their frame has entered the SUT, but cannot use the frame until the last bit has been received.
  - MIMO latency is a measure of the latency introduced by the SUT. It is independent of frame input time, output transmission time, or other physical layer delays which FILO takes into account. By providing you with both measurements, you can see the SUT latency and also the effect of other network factors on the user's perceived latency.

These frame-based performance metrics give an overview of the SUT's QoS management capability. They can be utilized in checking or negotiating contracts with a service provider. A service provider can also use them to check that their equipment performs to the vendor's specification.

Applications

The applications of the GFR Test Suite fit into three main categories: GFR System Testing, Traffic Contract Verification, and Traffic Contract Optimization.

GFR System Testing

Testing Policing

To successfully test GFR Policing you require accurate generation of GFR traffic into the SUT. An analyzer at the receive side is required to test for QoS Eligibility, frame discard and tagging. The GFR test Suite provides both sets of functionality through the GFR Test Suite Tx/Rx Wizard.

Testing Shaping

To test GFR traffic shaping you need a receive side analyzer to test for QoS Eligibility. The GFR Test Suite Analyzer performs this task by analyzing against a user specified GFR contract. To test a system's shaping functionality you simply have to run the GFR Test Suite on the output of the system. This can be performed both in-service with real traffic, or out-of-service with test traffic.

Switch Testing

This is where the application is used to test that a GFR switch is handling traffic in a GFR-compliant manner. The application can further be used to measure performance of the switch. The GFR Test Suite can also be used to test an entire network of switches that are interconnected. This requires an entry and exit point from the network to be specified.

Traffic Contract Verification

Verification of Services by the provider

GFR Test Suite can be used to verify that the service being provided to customers is actually what they are paying for. This helps prevent difficulties with clients who think they are not being provide the correct service. The results can be shown to the user to verify a contract.

Verification of Services by the client

GFR Test Suite can also be used by clients to verify that they are receiving the service that they have paid for.

The two verifications tests can be performed in-service allowing the network to be tested at any time.

Traffic Contract Optimization

The graphed statistics include the F-GCRA updated leaky bucket levels as new frames arrive at the receiver. This graph is plotted with the current level as a percentage of the limit, so you can easily notice if the bucket over fills or always remains below the limit. This information can then be used to adjust MCR, PCR, MBS, MFS and CDVT to obtain your optimum contract.

Summary & Conclusions

GFR is a new frame-based ATM Service Category designed to assist in improving performance for AAL-5 traffic, such as IP. The Agilent Technologies GFR Test Suite provides a complete, powerful and flexible solution for testing your GFR enabled network, service or device.

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GFR Capabilities Table

	ASP	CPP
GFR Testing	yes	yes
Received Test Frames	yes	yes
Transmit Test Frames	yes	no
Unscramble Test Frames	yes	yes
Generate Graphable Stats	yes	yes
Extended Frame Statistics	yes	no
Save/Restore Cell File	yes	yes
Save/Restore Test Configuration	yes	yes
Generate Background Traffic	yes	yes
Cell Rate Calculation	yes	yes

Available GFR and Frame-Based Statistics

Cell Based

Total cells processed

Transmitted cell count

CLP0 cell count

CLP1 cell count

Cell Conformance Test:

- CLP conformant & non-conformant
- MFS conformant & non-conformant
- GCRA conformant & non-conformant
- Overall conformant & non-conformant

Frame-Based

Total frames processed

Transmitted cell count

Cell/Frame Conformance Test

CLP conform & non-conformant

MFS conform & non-conformant

GCRA conform & non-conformant

Overall conform & non-conformant

F-GCRA Test:

- Pass F-GCRA
- Fail F-GCRA
  - Overflow bucket failure count
  - clp1 failure count
- Update F-GCRA
  - Passed
  - Non-conformant

Extended Frame Statistics:

- MFBS calculation
- Throughput calculation
- FLR calculation
- Application GoodPut
- Lost frames count
  - Total lost
  - Timed out
  - Dropped
  - Missing cell
  - EPD count
  - PPD count
- Latency calculations
  - FILO & MIMO latency
  - Minimum latency
  - Average latency
  - Maximum latency
  - Latency Histogram

Applicable Specifications

Specification	Reference	Relevance	Sections
ATM Forum Traffic Management Specification Version 4.1	AF-TM-0121.000	GFR Service Model Definition	2.1.6, 2.5, 4.3.3, 4.5.5, 4.5.6, 5.8, Annex B.5, Appendix VI
ATM Forum Performance Testing Specification	AF-TEST-TM-0131.000	Frame Based Performance Metrics	3, 4
ATM Forum Traffic Management Baseline Text Document	BTD-TM-01.02	Verification of GFR Service Guarantees	Appendix VII.3

Acronyms

AAL	ATM Adaption Layer
ABR	Available Bit Rate
ASP	ATM Stream Processor (E1607A/E1609A)
ATM	Asynchronous Transmission Mode
BG	Burst Gap
CDTA	Capture Data Traffic Analysis
CDVT	Cell Delay Variation Tolerance
CIA	Cell Inter-Arrival
CLP	Cell Loss Priority (allowed values of 0,1) - 0 indicates high priority - 1 indicates low priority
CoS	Class of Service
CPP	Cell Protocol Processor (E4209A)
CSN	Cell Sequence Number (order of cell in stream)
EPD	Entire Packet Discard
FS	Frame Size
FSN	Frame Sequence Number (order of frame in stream)
FD	Frame Discard
F-GCRA	Frame-based Guaranteed Cell Rate Algorithm
FILO	First In Last Out
FLC	Frame Loss Count
FLR	Frame Loss Ratio
FLY	Frame Latency
FTT	Frame Throughput
GFR	Guaranteed Frame Rate
IP	Internet Protocol
LAN	Local Area Network
LFGT	Log File Graphing Tool (Agilent Technologies)
Marking	Changing cell's CLP from 0 to 1 before transmitting
MBS	Maximum Burst Size
MCR	Minimum Cell Rate
MFBS	Maximum Frame Burst Size
MFS	Maximum Frame Size
MIMO	Message In Message Out
PCR	Peak Cell Rate
PPD	Partial Packet Discard
PRBS	Pseudo Random Binary Stream
QoS	Quality of Service
Rx	Receive
SUT	System Under Test
Tagging	Changing cell's CLP from 0 to 1 after transmitting
TS2	Transmit time stamp
Tx	Transmit
UBR	Unspecified Bit Rate

Broadband Series Test System

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Agilent Technologies Broadband Series Test System

The Agilent Technologies BSTS is the industry-standard ATM/BISDN test system for R&D engineering, product development, field trials and QA testing. The latest leading edge, innovative solutions help you lead the fast-packet revolution and reshape tomorrow's networks. It offers a wide range of applications:

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- Packet over SONET/SDH (POS)
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- complete, automated conformance testing

The BSTS is modular to grow with your testing needs. Because we build all BSTS products without shortcuts according to full specifications, you'll catch problems other test equipment may not detect.

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5980-0565E 05/00 Rev B

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