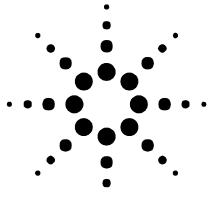# Testing ATM Signalling Performance

Agilent Technologies Broadband Series Test System
Application Note

Introduction

Early ATM switch implementations employed Permanent Virtual Connections (PVCs), between communicating endpoints. Switched Virtual Connections (SVCs), controlled by high speed signalling protocols are now widely-available, allowing endpoint connections to be set up and disconnected dynamically.

For ATM to be a viable transport medium, these connections must be established at very high speeds, and may include both point-to-point and point-to-multipoint configurations.

Verifying SVC performance will be critical to the future of ATM networking solutions. To achieve the required performance levels, switch architectures are changing from centralized to distributed call processing models. It is vital that these switches be performance tested with a high rate of the types of SVC calls which cause real world load conditions.

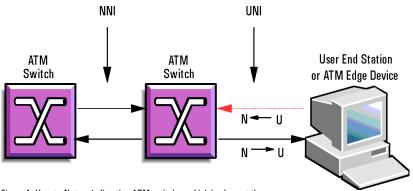**Agilent Technologies**
Innovating the HP Way

Figure 1: User-to-Network direction ATM switches which implement the signalling protocols at the User-Network Interface (UNI).

Performance testing is a very different task than functional or conformance testing, and thus requires a different analysis approach. You aren't just testing that the switch responds properly to all different types of signalling test traffic. Rather you are testing that the switch handles very large amounts of signalling test traffic that is sent in different ways across different ports to stress the switch in a real world fashion.
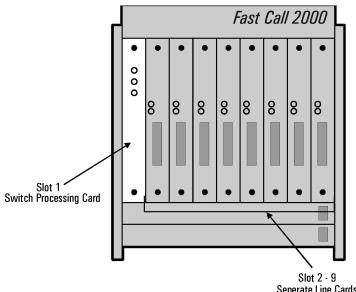
To perform this critical new testing in the best possible way, the signalling performance analyzer must be fast and flexible in terms of its number and types of ports, and have the ability to connect into different types of networks. The analyzer also needs to be flexible in terms of its use model and feature set, so that many different real world test scenarios can be created.

The UNI is the interface between the user or end station and an edge switch in the ATM network. The NNI is the interface between ATM switches. This solution note will discuss the key issues involved in the performance testing of ATM switches which implement the signalling protocols at the User-Network Interface (UNI); specifically in the User-to-Network direction, as shown in Figure 1.

Optimizing Performance Through Testing

Many ATM switch vendors have implemented UNI signalling in their switches and are now trying to improve the signalling performance. Initial implementations of UNI often don't achieve a high rate of SVC calls per second or the ability to handle a large number of open calls. This means that even if each SVC is setup to handle a fairly large amount of traffic, the total amount of traffic that the switch can handle (based on the total number of SVC's that can be setup and maintained) will be less than ideal. This translates into a higher cost in terms of dollars/Mbps, which makes the switch less competitive.

Switches need to be able to handle increasingly high numbers of calls per second per port and total open calls per port. They also need to make sure that the processing of the signalling protocols does not interfere with other lower layer functions that the switch needs to perform. To achieve this balance many switch vendors are trying new architectures, such as distributed processing models.

Fast Call 2000

Slot 1
Switch Processing Card

Slot 2 - 9
Seperate Line Cards
(Each with its own signaling CPU)

Figure 2: A switch implemented as a rack that takes multiple line cards, each with one or more ports and its own CPU to run the signalling. software

A switch may be implemented as a rack that takes multiple line cards, each with one or more ports and its own CPU to run the signalling software, as illustrated in Figure 2.

No matter what switch architectures are used, satisfactory performance levels must be attained and maintained under real world operating conditions. While functional and conformance testing verifies the operation of individual ports it may not guarantee overall performance in the installed network where a high level of signalling activity may occur on every port of the switch.

To guarantee real world performance, the switch must be stressed by generating a variety of SVC call profiles and measuring call processing performance metrics simultaneously on multiple ports. The ideal scenario requires all switch ports to be tested simultaneously.

Testing switches by simulating a real world multiport test scenario will provide the answer to these important performance questions:

• At what level of calls per second does my switch start taking longer to setup calls?

• At what number of total open calls does my switch start to reject calls?

• How long does it take my switch to setup or clear a large number of calls?

• How does my switch's signalling performance vary with differentcall setup parameters (e.g. a different requested cell rate, traffic type, etc.)?

• How well does my switch respond to certain requests while under load (e.g. ILMI Coldstart, Layer 3 RESTART, etc.)?

• How does my switch perform now that it supports a new signalling protocol variant?

Are there any hotspots in the signalling performance of my switch?

• Will my switch recover from an excessive signalling load on multiple ports?

• Which switch meets my performance requirements?
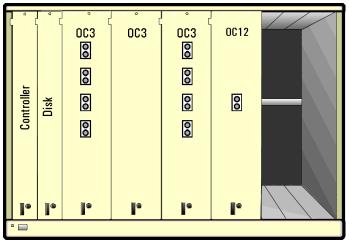

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Figure 3: Hardware configuratoin for signalling performance test system with balance of multiple ports per test system and high signalling performance per port.

As new architectures or software implementations are developed, the test cases must be repeated to ensure specified performance is being maintained. Regression testing using a multiport performance analysis tool guarantees reliable performance to existing customers and demonstrates performance levels to potential new customers.

Purchasers of ATM switches need to be certain that their network designs deliver the expected network performance. They also have to verify the performance of new switches or newer, faster versions of the same switches to ensure a successful network upgrade. Acceptance testing also requires a multiport performance analysis tool.

System test, regression test and acceptance test procedures are necessary to ensure performance in ATM switches and networks. These testing procedures require a multiport signalling performance test solution. Agilent Technologies can offer such a solution.

Performance Analysis Requirements

Testing the limits of a switch's performance is a very different task than testing its functionality or conformance to standards. Typically the switch is already developed, functioning and conforming to standards, but its performance under load conditions is yet to be characterized.

Cost and time-effective performance testing requires attention to a number of elements of the test procedures:

- The testing will require a balance between high performance stressing of individual ports and simultaneous background stressing of multiple ports.

- The testing approach must allow for extendable port capacity and signalling capacity to accommodate testing of different sizes of switches. Simply adding interfaces without adding more signalling horsepower will dilute the performance available to an individual port. A flexible system of high performance multiport modules, each with its own signalling CPU, ensures that many ports can be tested with adequate performance on each port.

- Realistic SVC signalling load profiles must be generated on multiple ports in order to simulate an actual network installation.
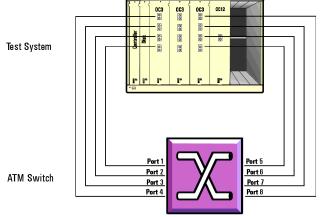
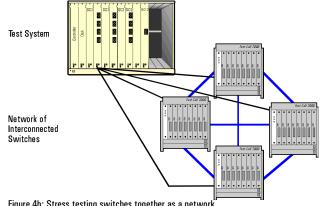Figure 4a: Stress testing switches individually.

Figure 4b: Stress testing switches together as a network.

- Correlated multiport performance metrics must be measured on all ports to get a true indication of how the switch performs under signalling load. If measurements are taken on only a single port then critical metrics can be missed because there is no guarantee that the selected port is the one that was affected.
- The test cases must be automated so that they are easily and reliably repeated every time the testing is performed.

Agilent will offer a new suite of products for the Broadband Series Test System (BSTS) that focuses specifically on multiport signalling performance testing of ATM switches.

The following sections describe some of the features and facilities that must be part of a signalling performance test system in order for it to provide real world tests while at the same time being flexible and easy to use.

3.1 Flexible Hardware Architecture and Extendable Port Capacity
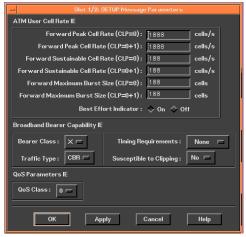
The ideal performance test system should be very flexible in terms of its configuration and suitability for different types of networks.
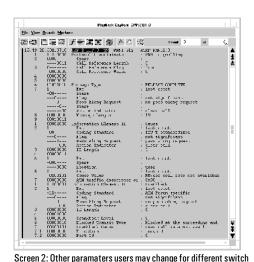
It should accommodate a number of ports that differ in both quantity and type. To achieve a balance of multiple ports per test system and high signalling performance per port, the signalling performance test system should have a hardware configuration similar to that shown in Figure 3. Note that the overall system is a rack that can hold multiple hardware modules.

Performance testing may involve a few ports on a single switch or many ports on a simulated network configuration. Port density within the test equipment rack becomes important. To accommodate the various test cases port capacity should be easily extended and configured, which

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Screen 1: Signalling load test system needs to give the user control over a minimum number of elements of the SETUP messsage.

Screen 2: Other paramaters users may change for different switch implementations.

is easy using this model. Each module should have its own processor capable of generating a very high rate of calls per second while simultaneously responding to incoming calls and taking detailed measurements. Each module should be capable of generating calls over any number of its ports, from one to all, allowing for an extremely high rate of calls per second per port if only one port is chosen. The same module should also be able to operate over different physical interfaces, perhaps allowing four OC-3c or STM-1 ports or one OC-12c or STM-4 port.

3.2 Extendable Network Connectivity

Real ATM networks are typically made up of interconnected switches. In addition to stress testing switches individually, as is shown in Figure 4a, the test engineer needs to stress multiple switches together as a network as is shown in Figure 4b.

By connecting the test system to a network of switches the test engineer can verify that under load the switches correctly make calls through the network to the destination systems. To accomplish this, the test system needs to be able to connect to multiple ports of the System Under Test (SUT) and emulate multiple end stations sending traffic into the ATM network.

The test system also needs the right balance of per-port control and configuration settings since different ports can be connected to different switches, each of which can have a different configuration and exhibit different behavior.

To minimize test development time, test configurations that have been saved for one port in the system must be able to be re-used on new ports that have been subsequently added to the system.

3.3 Realistic SVC Signalling Load Profile Generation

Regardless of the type of physical interface or number of ports, the test engineer needs to be able to generate realistic signalling load profiles. This will involve control of the following elements of signalling generation.

• Different versions of the UNI

• Different SETUP parameters

• Large numbers of end-station addresses

• ILMI to facilitate address registration

• Different call initiation profiles, duration and open call limits

• Per-port settings

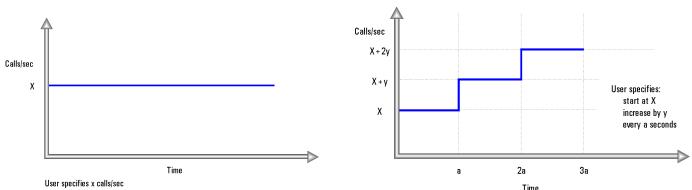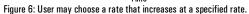Each of the above capabilities will now be examined in further detail.

Calls/sec

X

Time

User specifies x calls/sec

Figure 5: User may choose a rate that is contant.

Calls/sec

X + 2y

X + y

X

a   2a   3a

Time

User specifies:
start at X
increase by y
every a seconds

Figure 6: User may choose a rate that increases at a specified rate.

3.3.1 Different Versions of the UNI

Different protocol versions of the signalling test traffic will need to be generated-at least UNI 3.0, 3.1, 4.0 or Q.2931. Regardless of the protocol chosen, the test methodology should be the same. Since at this stage the user is not concerned with conformance testing, the user should not have to make significant changes to the test configuration to execute performance tests using different protocols. The user should simply be able to choose the protocol of interest, and then run the same test.

3.3.2 Different SETUP Parameters

SVCs are established to set up a path that will transfer ATM cell traffic. It is not enough to test that a switch can handle a high level signalling activity requesting the same type of cell traffic connection. The test engineer needs to generate a high volume of the most common types traffic requests on switched virtual circuits (SVCs).

The signalling SETUP message contains the traffic descriptor, a specification of the type of traffic that will be sent over the requested SVC. The signalling load test system needs to give the user control over a minimum number of elements of the SETUP message, as shown in Screen

1. This will allow stressing of the switch's capacity to accept or deny call setups as traffic conditions change.
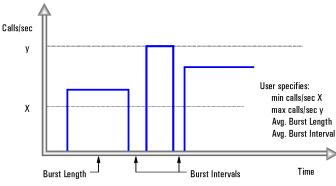
It may also be necessary to change other parameters for different switch implementations. As a minimum, the user should be allowed to change parameters shown in Screen 2 to assure that the analyzer can interoperate with the SUT.

3.3.3 Large Numbers of End-station Addresses

Connections must be established between source and destination addresses in any of the common destination formats. To emulate this traffic the test analyst must be able to specify source and destination addresses in various formats-at least the Network Service Access Point Data Country Code (NSAP DCC), the Network Service Access Point International Code Designator (NSAP ICD), plus the NSAP E.164 and E.164 Native formats.

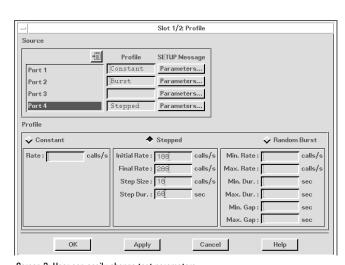The more addresses there are, the more completely the analyzer will stress the

Broadband Series Test System

Figure 7: User may choose a rate that increases in random bursts within some specified range.

Screen 3: User can easily change test paramaters.

Screen 4: User can vary the number of calls per second, in conjunction with the duration, and other parameters over time.

routing tables of the SUT. Each port on the analyzer will have an address that will be used as the source address for calls, and each source address should be able to make calls to a large number of destination addresses. In addition, there should be some randomness in the system so that the same addresses are not always sent in the same order all the time. Again, this is important to emulate real world conditions.

3.3.4 ILMI to Facilitate Address Registration

The local (source) addresses for all the ports on the analyzer will need to be configured in the switch or switches to be tested, so that they can route appropriately. The Integrated Local Management Interface (ILMI) makes this process easier as the user can just configure addresses on the analyzer and use ILMI to exchange this information with the switch.
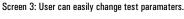
In typical scenarios, this process is performed once at the start of the test, which requires the user to have manual control over this capability.
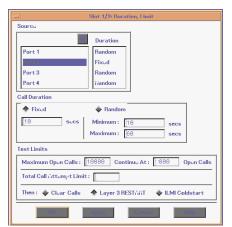
3.3.5 Different Call Initiation Profiles, Call Duration and Open Call Limits

Once addresses are specified, the user needs to be able to vary the rate at which calls are made into the SUT over time. This will emulate end stations that send different levels of signalling traffic into

the network as they run different applications. The user should be able to choose a call rate that is constant (a fixed rate of calls per second), increasing at some specified rate (or stepped), or in random bursts within some specified range. These three cases are shown in Figures 5, 6 and 7.

In the random case, control over the time between bursts is also important. Control over the length of each call, (i.e. how long the call stays open before the test system releases it) should also be configurable, and both fixed and random call durations should be allowed. The number of calls per second, in conjunction with the duration; the maximum number of open calls; and the overall duration of the test determine how the number of open calls varies over time. The user should easily be able to change these test parameters as shown in Screens 3 and 4.

Figure 8 illustrates how these parameters work together to affect the total number of open calls over time. One more parameter can greatly increase the range of control over open calls, and thus the overall usefulness of the system. An upper and lower limit on the total number of open calls allows the test system to cycle repeatedly between an upper and lower boundary. When upper and lower open call limits work in conjunction with the call rate and call duration, very
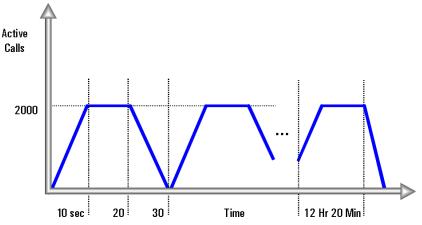
Figure 9: Total number of open calls to cycle over time. When upper and lower open call limits work in conjunction with the call rate and call duration, very flexible real-world behavior is achieved.
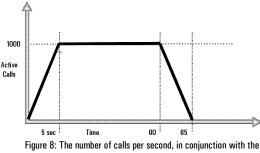

Figure 8: The number of calls per second, in conjunction with the duration; the maximum number of open calls; and the overall duration of the test determine how the number of open calls varies over time.

flexible real-world behavior is achieved. Figure 9 shows how these parameters allow the total number of open calls to cycle over time.

This degree of flexible call profile control is necessary if hotspots in switch signalling performance are to be identified. A variety of test cases can be devised to establish the limits of performance.

3.3.6 Per-port Settings

In real-world traffic conditions all ports attached to a switch will not behave the same way. Each switch port will be attached to a different end station or to another switch which handles calls from many end stations. Every end station will be sending traffic according to its own network needs, with different call rates, length of calls, and so on. Therefore the analyzer should allow most of the above test parameters to vary on a per-port basis to emulate the real world. This will make for a realistic mix of different traffic on different ports over time.

3.4 Correlated Multiport Performance Metrics

For different scenarios, different measurements are required. For example, when the user wants to know how the total number of open calls affects the switch's average call setup

time, those measurements should be taken for that test and others will not be required. There should be a wide breadth of statistics and events available for the user to choose the relevant metrics for an individual test. Some examples of typical statistics and events are shown in Figure 10.
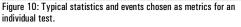
Measurements should also be taken such that it is possible to correlate various statistics, errors and events against each other over time. This will provide the user with key information about exactly what was happening on the SUT when the error occurred or the performance dropped off. For example, with some of the above statistics and events selected and logged over time, the user could produce graphs similar to those shown in Figure 11 to give a much clearer indication of performance variations.
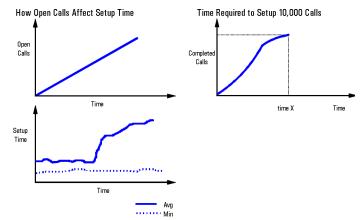
When the measured performance metrics indicate a performance problem it will be necessary to revert to functional testing to establish the exact cause of the problem. For example, under certain

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Statistics	Events
Elapsed Test Time	Test Started
Number of Calls Remaining in Test	Test Stopped
Attempted Call Rate	Test Paused
Actual Call Rate	Starting Post Test Script
Total Number of Attempted Calls	Test Call Attempts Limit Reached
Total Number of Connected Calls	Open Call Upper/Lower Limit Reached
Total Number of Failed Calls	All Calls Cleared
Total Number of Cleared Calls	Call Attempt Rate Set to X
Avg/Min/Max Setup Time	ILMI Registration Attempt
Avg/Min/Max Teardown Time	ILMI Registration Error
Inbound Calls Accepted	ILMI Coldstart Initiated/Received
Valid Setups Received	L2/L3/Physical Errors/Events
...	...

Figure 10: Typical statistics and events chosen as metrics for an individual test.

Figure 11: Statistics and events selected and logged over timegive a much clearer indication of performance variations.

performance stress conditions the switch may be generating non-conformant signalling messages. This will require detailed protocol analysis which is not provided by a multiport performance analysis tool.

The Broadband Series Test System allows functional test and load test tools to be used simultaneously. The advantage of this is that functional troubleshooting can be carried out more quickly when the measurements are correlated with the same signalling load that was used to uncover the problem.

3.5 Test Automation

To save the user time in re-running and customizing tests, it should be possible to control most aspects of a test without having to use the analyzer's graphical user interface (GUI) every time.

The performance test tool should have some kind of application programming interface (API) which allows the user to execute tests from a program or a script. The user should be able to use the GUI at first to specify a test and get it working. Thereafter, it should be possible to load the same test programmatically or via a script and run it, analyze results and do post-test analysis. This keeps the user from having to always sit in front of the display to run a test, and it make it easier for the user to customize tests and link different tests together.

Once a user has a working test that finds a performance problem, it is critical that they be able to verify that any changes that they make to address the problem actually work. Once a test is specified, it should be easy to save all the test parameters and any past test results. This should include some capability for saving the configuration of a test that spans multiple ports with different settings for different ports. Repeatability is the key here.

When the user wants to test a new switch or a new release it should be easy to re-run an existing test and compare the results against past results as a regression test. The test system should provide some kind of pass/fail result indication in this case. This is a tough problem, because like the measurements, the pass/fail criteria will differ for any given test scenario. The system needs to be flexible enough to allow the users to customize the analysis of the test measurements to fit their needs.

Conclusion

As SVCs have become more prevalent in ATM networks, higher performance of the SVC-related functions switch functions is required. Even after a switch is fully functional and conformant to standards, there is plenty of work to do to verify that it offers competitive SVC performance under real-world conditions.

Thus, performance testing is an important complement to functional and conformance testing functions, yet it demands unique capabilities from the analysis tool.

UNI signalling performance testing is a challenging new problem that requires a rigorous solution. Generating high rates of calls per second with flexible profiles, and maintaining many active SVCs across multiple ports is critical. And all this has to be done while simultaneously making the appropriate performance measurements. The ideal solution will balance breadth and depth of testing in a system that is quick and easy to use, but also adaptable to a wide variety of real-world scenarios.

Acronyms

API	Application Programming Interface
ATM	Asynchronous Transfer Mode
BSTS	Broadband Series Test System
CPU	Central Processing Unit
DCC	Data Country Code ATM address format
GUI	Graphical User Interface
ICD	International Code Designator ATM address format
ILMI	Integrated Local Management Interface
NNI	Network-to-Network Interface
NSAP DCC	Network Service Access Point Data Country Code
NSAP ICD	Network Service Access Point International Code Designator
OC-3	Optical Carrier 3 - 155 Mb/s
OC-12	Optical Carrier 12 - 622 Mb/s
PVC	Permanent Virtual Circuit
STM-1	Synchronous Transport Module 1 - 155 Mb/s (Europe)
STM-4	Synchronous Transport Module 4 - 622 Mb/s (Europe)
SVC	Switched Virtual Circuit
SUT	System Under Test
UNI	User-to-Network Interface

Broadband Series Test System

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:

- ATM traffic management and signalling
- Packet over SONET/SDH (POS)
- switch/router interworking and performance
- third generation wireless tesing
- 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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