The Third-Generation HP ATM Tester

Breaking away from the traditional bounds of transmission and protocol analyzers, the HP E5200A broadband service analyzer redefines the way in which the interactions between protocol layers at multiple points in the network are analyzed and presented, leading to the new concept of service analysis.

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The HP E5200A broadband service analyzer (Fig. 1) is Hewlett-Packard's third generation of ATM test equipment, focusing in particular on the analysis needs of ATM service deployment.

Fig. 1. *The HP E5200A broadband service analyzer implements the new concept of service analysis, incorporating hardware, software, and usability advances aimed specifically at testing ATM services.*

HP's first-generation tester was called the Series 90. It combined extensive SDH/SONET transmission test capability with the world's first ATM test capability. The addition of higher-layer protocol testing and more complex ATM conformance testing resulted in the second-generation HP tester called the Broadband Series Test System (BSTS). The BSTS has been involved in almost every major ATM field trial around the world.

Now that ATM is progressing from the early field trial phase into the deployment of revenue generating services, the requirements for ATM test equipment have changed. To meet these requirements, HP's Australian Telecommunications Operation has developed the concept of *service analysis*. The HP E5200A broadband service analyzer implements the service analysis concept, incorporating hardware, software, and usability advances aimed specifically at testing ATM services.

Market Evolution in ATM Testing

HP has been developing test equipment for ATM since this technology first started to gain acceptance in Europe in the mid-1980s (see Fig. 2). It was at this point that the industry started to see the potential for an integrated public broadband network infrastructure, the Broadband Integrated Services Digital Network (B-ISDN).

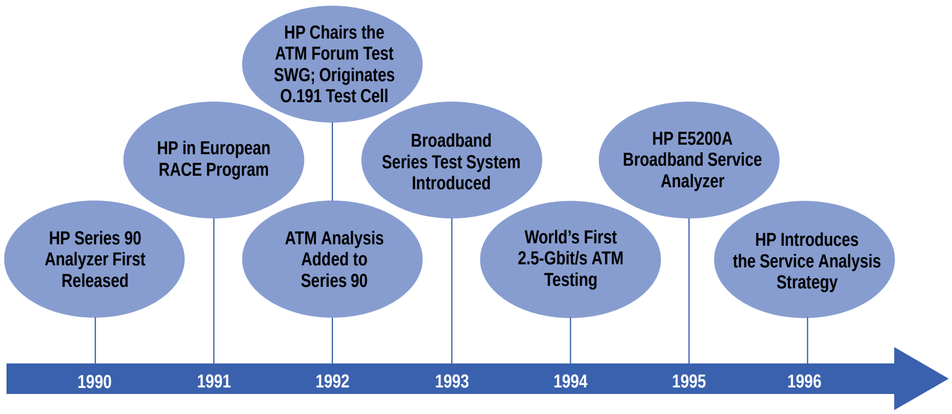

Fig. 2. *HP involvement in broadband and ATM testing.*

HP first became involved in ATM testing in 1988 when a team from the HP Queensferry Telecommunications Division (QTD) in Scotland joined a European Community research program called RACE (Research into Advanced Communications in Europe). The team joined a RACE project called PARASOL, which was a precompetitive collaboration between HP and research teams from a number of other European organizations. These organizations included a cross section of public telephone service providers, network equipment manufacturers, universities, and specialist software houses. The primary goal of the project was to research the test and measurement requirements of B-ISDN equipment and networks being developed by other RACE projects, and develop a test tool to support this work and verify its operation. A great deal of knowledge and experience was gained by all parties and a prototype product fulfilling these needs was developed and used successfully.

By the end of the PARASOL project in 1992, however, it had become obvious that ATM was gaining worldwide acceptance. The ATM Forum was forming and a competitive ATM marketplace was taking shape. This made continued collaboration unfeasible for HP. Therefore, in late 1992, HP's Australian Telecom Operation (ATO) launched the world's first commercial ATM test equipment, the HP 75000 ATM Series 90. This tester was based on the highly successful Series 90 SONET/SDH R&D testers and primarily allowed physical layer and ATM layer testing at OC-3/STM-1 rates, followed soon after by DS3. The Series 90 is essentially a transmission system tester with detailed SDH/SONET overhead test features. Subsequent ATM developments added concatenated payload capability at OC-12c/STM-4c rates and, more recently, OC-48c/STM-16c rates, making the ATM Series 90 the world's only real-time ATM tester at 2.488 Gbits/s.

The ATM Series 90 was a great success, helping HP to build strong global relationships with key ATM customers. It soon became clear, however, that with the speed of technological developments in ATM, there was a strong requirement for features beyond those that the Series 90 could support. HP's Idacom Telecom Operation (ITO) in Canada had been developing WAN testers for the X.25, Frame Relay, and SMDS standards. With ATM also being their next step, it was decided to combine ITO's higher-layer protocol expertise with ATO's expertise in ATM transport and develop a dedicated and extremely powerful ATM tester. The resultant Broadband Series Test System (BSTS) was a success in the R&D ATM test market from late 1993, gaining universal acceptance as the reference tester for ATM developments with almost every telecom operator and network equipment manufacturer throughout the world. Today, the BSTS continues to lead the way in R&D ATM test with support added for conformance test suites and now MPEG-2 video over ATM.

With ATM starting to move out of the R&D lab to early field trials and carriers throughout the world announcing plans for commercial ATM deployment, HP again saw the need to develop test equipment targeted directly at this new phase of the ATM life cycle. ATM features have been added by the HP Queensferry Telecom Operation (QTO) and the HP Cerjac Telecom Operation (CTO) to their transmission test instruments for use in installation and maintenance of the core network infrastructure, and the HP Colorado Communications Operation (CCO) has added ATM to their advisors for LAN/WAN interworking.

To address the speed and complexity of ATM service deployment fully, however, it was felt necessary to break away from the traditional bounds of transmission and protocol analyzers. By redefining the way in which the interactions between protocol layers at multiple points in the network are analyzed and presented, the concept of service analysis was born. It is this initiative that has led to the HP E5200A broadband service analyzer, the third generation of ATM test equipment from the ATO and HP.

Defining the HP Broadband Service Analyzer

As explained in the accompanying articles, the HP E5200A broadband service analyzer has pioneered several technical advances within Hewlett-Packard. It has also pioneered some key strategy and process initiatives, particularly in the area of direct customer involvement in the early stages of product definition. By targeting specific strategically important customers through intimately involving their HP sales engineers in the product's definition and development, it has been possible to build very strong relationships between customers, field, and factory and to ensure that a common understanding of the issues exists throughout. As described in ***Article 14***, graphical user interfaces for ATM service analysis were extensively usability tested on real users, whose feedback helped significantly to shape the design and gave them a feeling of real ownership in the final product.

What Is Service Analysis?

Broadband networks are complex to manage. To provide customers with the quality of service they expect, ATM service providers need to understand the interaction between services, protocol layers, and equipment. Service analysis allows service providers to manage the end-to-end quality of broadband services effectively by showing the important interactions between the elements of the service, such as location dependencies, protocol layer interactions, service interference, and element interoperability.

The need for service analysis is best understood by looking at a few examples.

Example 1: Flow control across protocol layers. Consider an application in which two LANs (TCP/IP) located in different cities are interconnected by a WAN technology (Frame Relay) which is in turn interconnected by a high-speed ATM backbone. In this situation, there will be three completely independent flow control mechanisms operating at the TCP/IP, Frame Relay, and ATM layers (Fig. 3). If the customer were to complain about low throughput, it would be impossible to find the cause of the problem without observing all protocol layers and the way their flow control mechanisms interact.

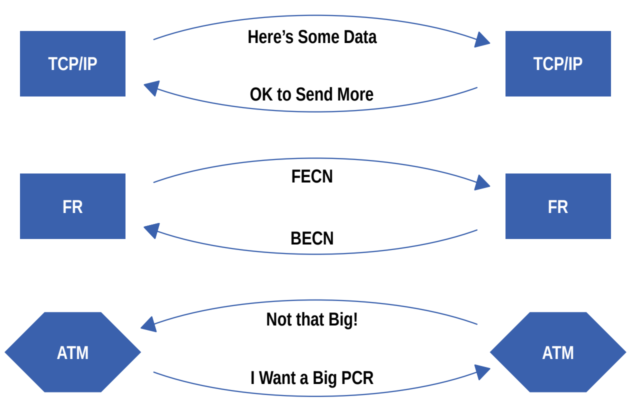

Fig. 3. *Flow control across protocol layers. PCR stands for peak cell rate.*

Example 2: MPEG video and ATM traffic policing. MPEG video over ATM presents special testing problems, particularly when interactions with TCP/IP are involved. Excessively bursty traffic introduced by layer interaction causes PCR (peak cell rate) violations, which when policed at the ATM layer cause video to freeze (Fig. 4).

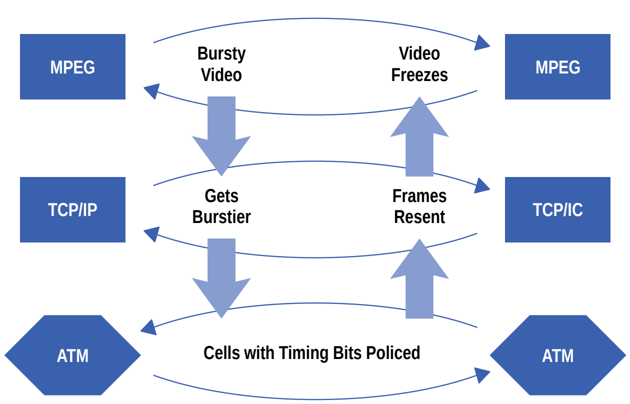

Fig. 4. *MPEG video and ATM traffic policing.*

Example 3: Bit error multiplication and cell loss tyranny. Consider a simple FDDI interconnect service running over an ATM backbone. Because error correction is handled by the higher protocol layers, data services are especially sensitive to cell loss. In this example (Fig. 5), two bit errors in the physical (transport) layer cause an ATM cell to be discarded. This in turn causes an entire 8000-byte FDDI frame to be retransmitted. The net effect is that two bit errors cause an additional 167 cells to be transmitted. In a usage billing scenario, this becomes very expensive. This effect, also known as *cell loss tyranny*, can result in a downward performance spiral. As frame retransmissions increase, ATM layer congestion may occur, causing more cells to be lost and frame retransmissions to increase even further. To isolate the cause of high frame retransmission rates, testing must be performed across all protocol layers.

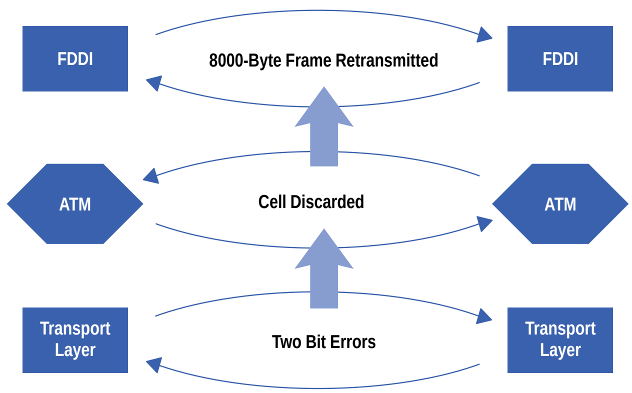

Fig. 5. *Bit error multiplication and cell loss tyranny.*

HP E5200A Broadband Service Analyzer Overview

The HP E5200A broadband service analyzer is a powerful and flexible tool designed to:

- Assist ATM equipment and service installation
- Minimize troubleshooting time
- Assist in meeting service delivery requirements
- Test the interworking of broadband services
- Help manage the performance of broadband networks
- Assist in guaranteeing end-to-end quality of service.

The broadband service analyzer puts users in control by providing service-focused measurements. It allows users to deal with the practical realities of building, operating, and managing broadband networks and to achieve end-to-end service quality. By using the broadband service analyzer, users can be confident that a customer's services are operating reliably and that they can manage the services to maintain a high level of performance and reliability.

The test capabilities provide the information needed to determine the health of a network at all layers of the ATM protocol stack, from the physical layer right through to the AAL (ATM adaptation layer) and above. It can decode LAN protocols running directly over ATM or running over ATM via Frame Relay. It can quickly determine how a customer's services are performing.

System Configuration

The service analyzer consists of four major elements:

- An intelligent base unit that houses the measurement system hardware and software
- A choice of interchangeable line interface modules (interface pods)
- A choice of applications that support analysis of higher-layer protocols and remote testing
- An X display terminal such as a notebook PC or a UNIX® workstation.

The service analyzer can be expanded and updated in the field as new applications are developed. The compact size of the unit means that it can easily be carried onto an aircraft as hand luggage.

Hardware Architecture

The broadband service analyzer's main hardware processing comes from 17 Xilinx XC4013 FPGAs incorporating approximately 221,000 gates. Three i960 RISC processors are used to control the statistics processing, protocol processing, and display graphics and a 500-Mbyte hard disk drive is included. The major functional components are shown in Fig. 6.

The line interface pods contain the line interface circuitry for each interface with capabilities for hot insertion and autoconfiguration. Line interface pods provide physical layer transmit and receive functions and test capability.

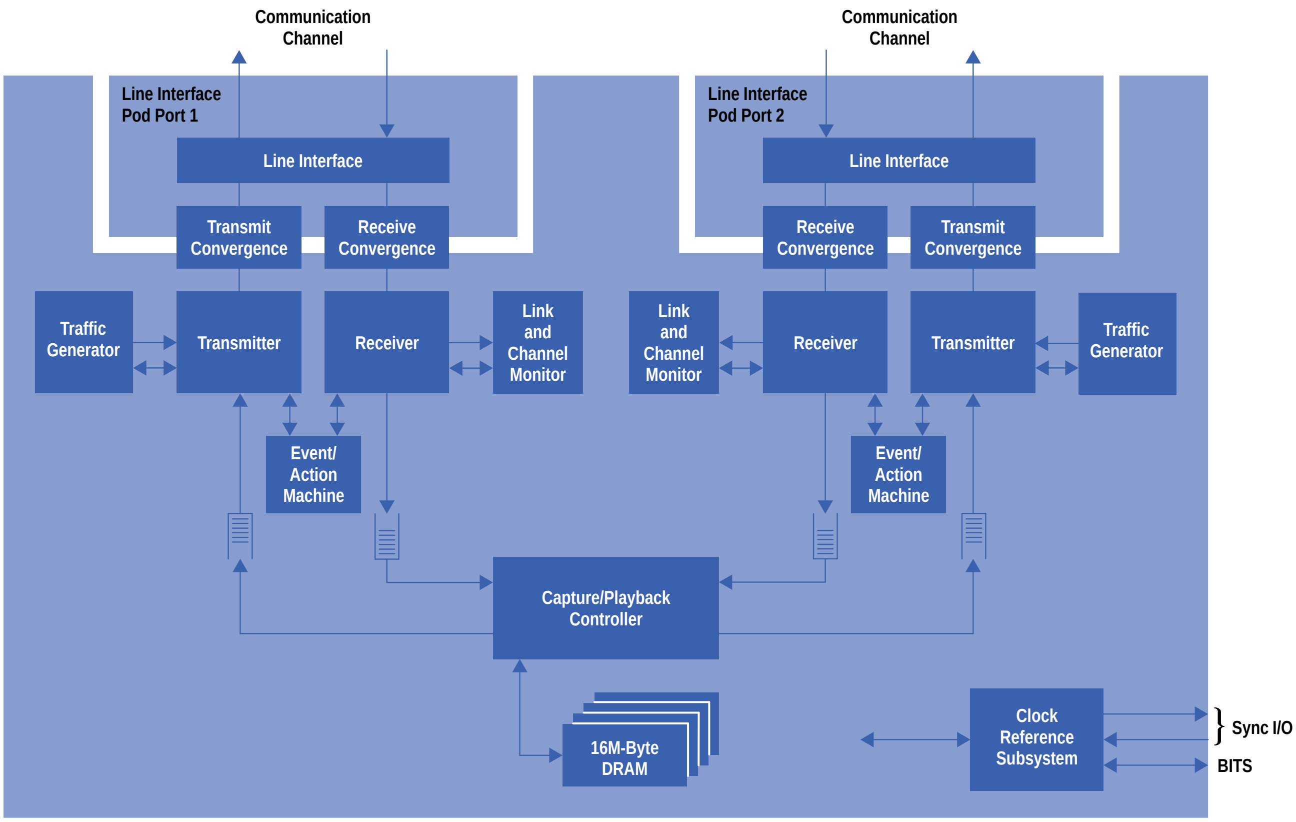

Fig. 6. *Broadband service analyzer hardware architecture.*

The three CPUs are on the main CPU card. The graphics CPU responsibilities include running the X-Windows host via the LAN interface, handling I/O, and interfacing to the hard disk drive. The protocol CPU interfaces with the instrument hardware, controlling the transmit and receive functions for both ports and performing higher-layer processing of the data. The statistics CPU performs the real-time measurements for the link and channel monitors of both ports.

The capture/playback subsystem controls the 16M bytes of DRAM, partitioning it between the two ports as required, adding receive timestamps, and controlling transmit playback.

The traffic generator controls the traffic simulator and the alarm and error simulator functionality. A transmit cell sequence can contain up to 1500 cells.

The link and channel monitor performs real-time processing on up to 1024 different received channels on each port with determination of cell counts, AAL type detection, error statistics, and reassembly statistics.

The event/action machine provides trigger event detection and subsequent analyzer action control.

The clock subsystem provides the clock signals for the different elements of the analyzer. Clock sources that can be used include an internal Stratum 3 reference, a BITS source, or external I/O clock sync.

Software Architecture

The broadband service analyzer's software is designed with object-oriented techniques using managed objects (see ***Article 11***). While this increased the initial development time as new techniques were learned, the use of object-oriented technology will make it possible to add future enhancements and new applications much more efficiently and flexibly than if traditional software design had been used.

The software architecture (Fig. 7) is based around several distinct functional subsections:

- The application presentation subsystem provides the graphical user interface.
- The analyzer subsystem provides SMARTtests, the TCL (Tool Command Language) user scripting environment, and BSTS UPE (user programming environment) compatibility.
- The protocol support subsystem provides protocol analysis and PDU (protocol data unit) segmentation, reassembly, and filtering.
- The measurement and control subsystem provides control of the measurement hardware.

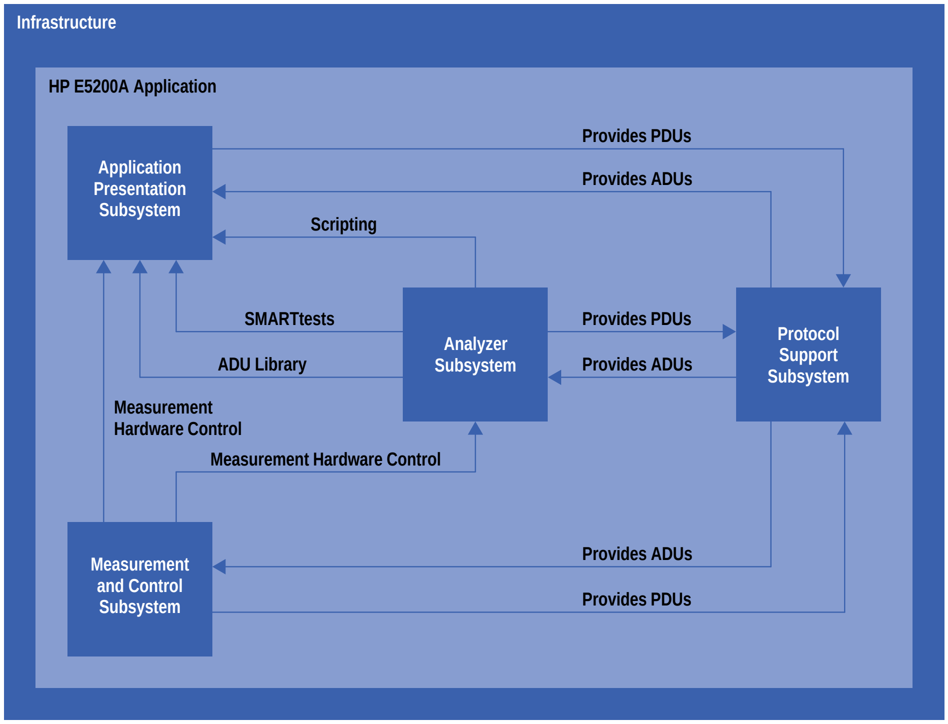

Fig. 7. *Broadband service analyzer software architecture. An ADU is an internal format container of PDUs (protocol data units) plus control information.*

The infrastructure is based on the VxWorks real-time operating system and includes elements to perform basic computing, platform services, operating support, and user interface services. The GUI is based on the X Window System, allowing control via the LAN connection from any X terminal.

Broadband Service Analyzer Features

The analyzer's powerful real-time measurement system allows users to perform extensive real-time measurements and instantly get reports on the status of broadband services. Link and channel information is updated to determine:

- Active VPI/VCI channels
- AAL type and errors
- Network utilization
- Network errors
- Network alarms
- Cell counts.

Measurements can be correlated to identify important interactions between the layers of the broadband protocol stack and any interference between individual services on different ATM channels or on different ports.

Customers are geographically dispersed, and there is a need to be able to guarantee the end-to-end quality of their service. The distributed object measurement technology of the broadband service analyzer makes remote measurements a normal mode of operation. Coupled with the optional HP Broadband Launch Pad software application, access and management of multiple service analyzers distributed throughout the network is possible. This helps reduce the cost of managing broadband networks, improves the speed with which faults are isolated and repaired, and provides a single consistent set of tools for both remote and dispatched applications.

The service analyzer's graphical user interface can be used by people of all skill levels. The measurements made by the service analyzer are displayed so that they are easy to interpret. Users can quickly and easily see what is happening to a customer's service and make an informed decision on the appropriate action to take. Link and channel monitors guide users through the service analyzer's extensive monitoring capabilities, directing the user to the problem areas.

Testing Made Easy

Testing is made easy with the broadband service analyzer, as illustrated in Fig. 8. The user simply connects the service analyzer to a network and the link monitor immediately gives a summary of the health of the network. To look more closely, the user can select a channel monitor to obtain a graphically correlated view of the measurements relevant to a particular

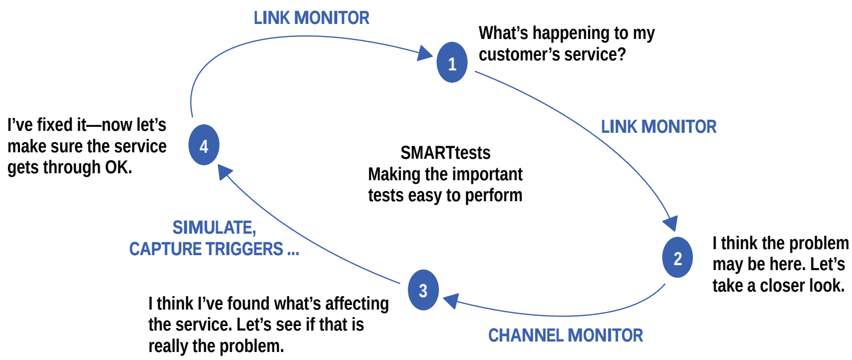

Fig. 8. *The HP E5200A link monitor, channel monitor, and SMARTtests support each other to simplify testing.*

channel. Users can immediately see whether service level problems are related to problems in the other layers of the protocol stack.

A range of predefined SMARTtests reduce the complexity of performing important tests such as cell loss and cell delay. Testing can be started rapidly with one or two clicks of the mouse. Users can also create their own tests by using the macro programming function of the service analyzer. This function provides a record/playback system that creates test programs by automatically recording the results of actions on the service analyzer.

The service analyzer's sophisticated traffic simulation and data capture systems enable users to inject data into the network to exercise the network' s capabilities, simulate specific problems, and then analyze the results as data is captured.

The service analyzer's flexibility is further enhanced by the wide range of interfaces its platform can support, including E1, E3, DS1/DS3, OC-3/STM-1, OC-12/STM-4, 6.3-Mbit/s, and 155-Mbit/s coaxial. Available immediately are OC-3/STM-1 single-mode and multimode optical, STM-1/STS-3c electrical, E3, and DS1/DS3 interfaces.

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