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Experiences with the Design of B-ISDN Integrated Test System(BITS)

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Abstract

To ensure interoperability between network components, a test system is understood as a useful facility to test and validate the developed system. In this paper, we deal with design and implementation of the B-ISDN Integrated Test System(BITS). The BITS is composed of functions for conformance and interoperability testing, call simulation and protocol monitoring. The BITS is a flexible test platform for B-ISDN protocol testing. The test configuration of the BITS can be easily and efficiently prepared for testing B-ISDN protocol implementations in a real networking world. This paper presents experiences with the design of BITS, especially the tester architecture, the development of test suites for the B-ISDN signalling protocol, and its application to B-NT system developed by ETRI.

Keywords

B-ISDN, ATM, Protocol Tester, Conformance Test

1 INTRODUCTION

In order to verify implementations during the development stage, it is important that the protocol testing is performed in a proper way using appropriate tools. The framework for conformance testing was standardized in ISO/IEC JTC1 to verify the product's compliance with the specifications.

In this paper, we introduce "B-ISDN Integrated Test System(BITS)", which is a useful tool for the validation of the prototype during ATM technology development as well as for the

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performance evaluation of B-ISDN products. The BITS is composed of functions for conformance and interoperability testing, call simulation, and protocol monitoring. The BITS is designed so that test configurations are easily and efficiently prepared for testing B-ISDN User Network Interface implementations in a real networking world. The development of BITS has been carried out by ETRI, as a part of the Network Test Bed(NTB) project, which is one of the nation-wide governmental project named "HAN/B-ISDN".

The HAN/B-ISDN project is composed of four research areas : network technology, switching technology, transmission technology, and terminal technology. The entire research project is divided into 11 different research project units and is being carried out by several research organizations, universities and manufacturers. The main goal of the NTB project unit is to test the performance of various communication systems that will be developed by several project teams and to evaluate conformance, and interoperability. Protocols might be implemented incorrectly because of the wrong interpretation of standards and misuses of many options. Therefore, a clear verification process is necessary to ensure the interoperability among network components. It seems to be efficient that the development of the testing methodology, the test suites on various kinds of protocols, and the testers are made in early development stage of each network component.

2 DESIGN OF BITS

The design concept of this system is based on a modular structure, with loosely coupled interconnection between the test control part and the test connection part. Thus, the establishment of one's own development and the test environment are allowed. Modular structure introduces overload for a simple system, but upgrades and changes the system functions effectively. Loosely coupled interconnection between the test control part and the test connection part is appropriately applied to the configuration of various test networks. We constructed our own development and test environment. The test control part is named as the "Test Host System(THS)", which is implemented on the same general UNIX workstation as one is used for the development environment in order to make both environments alike. Because of several ATM connection interfaces, it is possible to test the THS itself without another Implementation Under Test(IUT). The test connection part is named as "Test Satellite(TS)", consists of one MVME 147, two ATM Boards, and one PHY with two STM-1 ports. In the near future, multiparty testing will be available.

2.1 System Architecture

The BITS is composed of a Test Host System(THS) and several Test Satellite(TS)s as shown in Figure 1. The THS communicates with the TSs via Ethernet.

2.2 System Functions

The THS has higher layers than the AAL layer on general workstation and the TS has three layers(STM-1 Physical, ATM, AAL 5). For logical connection, the Test Satellite Function(TSF) of the TS uses interprocess communication, frame control, and distribution

function of two STM-1 ports. The Message Distribution Function(MDF) in THS executes the message distribution function for the interprocess communication and other application processes. Among the application processes of THS, process for the call simulation and the conformance tests of Q.2931 and Q.SAAL will be used for various test purposes and applied to various types of configuration. Figure 2 shows the functional architecture of BITS.

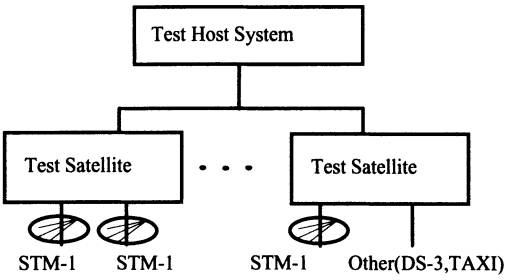
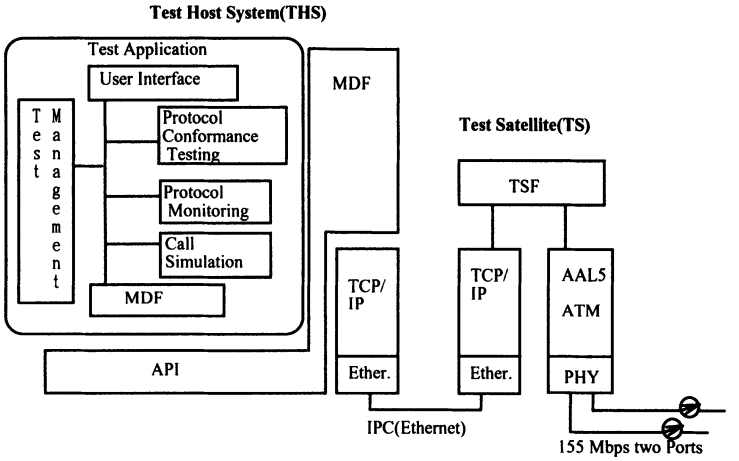


Figure 1 System Configuration Diagram of BITS.



API : Application Programming Interface
TSF : Test Satellite Function
TS : Test Satellite
MDF : Message Distribution Function
THS :Test Host System

Figure 2 Functional Architecture of BITS.

The BITS has the following functions :

- Protocol Monitoring

One basic function of BITS is protocol monitoring implemented by intercepting signals between the BITS and the System Under Test(SUT) or between two SUTs.

- Protocol Conformance Testing
  The conformance testing consists of verifying processes that B-ISDN User-Network Interface Products comply with B-ISDN specifications, performed by a tester. In addition the protocol and the test suite for Q.2931 and Q.SAAL Layer are implemented in BITS.
- Call Simulation
  In order to test the call processing capability of an IUT, we generate the call establishment for testing and assure that the data transfer is completed via the ATM connection. The BITS call simulation function consists of file transfer/receive, frame generation/analysis, and call connection/release.
- Test Management
  The protocol functions of BITS is the realization of the B-ISDN User Network Interface Protocol, the connection handling and the traffic management. The test application process of THS performs conformance testing, call simulation, and protocol monitoring of Q.2931 and Q.SAAL. Simulation procedures and scenario handler are controlled and managed by user control commands.

3 SYSTEM IMPLEMENTATION

3.1 Hardware Implementation

As mentioned before BITS is composed of a THS and several TSs. In this section, we describe the hardware configuration of the TS. Figure 3 shows the hardware block diagram of the TSs. Several hardware block units are divided into two units, Test Control Unit and Test Circuit Unit. The functions of hardware block units are as follows.

The Test Control Unit consists of the Ethernet Interface Unit for Ethernet interface with THS and the Central Processing Unit for test function processing of TS.

In the Test Circuit Unit, most of the processing units were implemented using Field Programmable Gate Array(FPGA). The Physical Interface Unit was designed for different physical interfaces. In order to capture the physical layer data stream without disturbing the communication between BITS and the SUT, Physical Interface Unit receives/transfers the optical signals from/to the SUT and converts them into/from the electrical signals. The traffic Processing Unit generates cells by software. Therefore, the traffic rate is restricted to 1Mbps, and it will be constructed by hardware for supporting 155Mbps rate later on. The debugging for the hardware development is done by a logic analyzer and a digital signal analyzer. Most of the block diagram was designed using Workview of Viewlogic company. The system has its own diagnostic function as a loopback test at the board and system level.

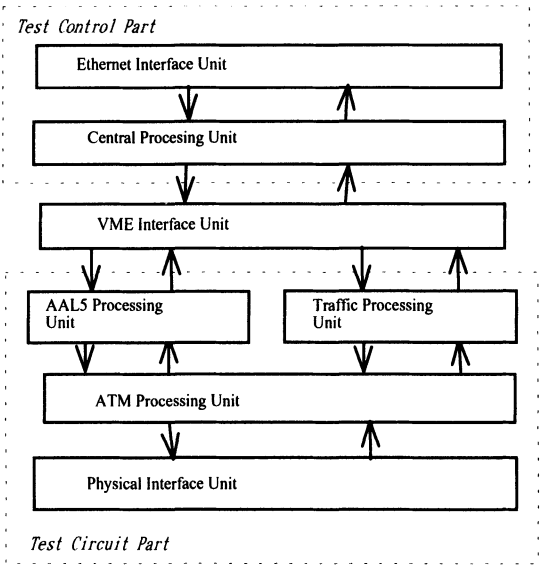


Figure 3 Hardware Block Diagram of a Test Satellite.

3.2 Software Implementation

The software of the BITS is divided into two softwares, one in the THS and the other in the TS. System interface uses TCP/IP for LANs. Software in the THS covers protocol conformance, event generation and analysis for the protocol conformance and interoperability testing in a UNIX system environment. Software for TS executes the test traffic generation and control. Functions for ATM interface control are implemented by using C language and are based on a real time operating system, VRTX. The operation method of the system, the interface type and the number of data for construction management will be determined when the TS downloads a program.

4 TEST EXPERIENCES WITH THE DESIGN OF B-ISDN SIGNALLING PROTOCOL

We have applied BITS to testing of Q.2931 and Q.SAAL. In this section, we explain the test suite of Q.2931 and Q.SAAL conformance testing and X/Motif based on the user interface of BITS. The purpose of testing is to check whether the functions of a System Under Test(SUT) operate normally or not. In order to apply BITS to the various test purposes, the system function and the size of BITS are made to be extendable.

4.1 Conformance Test Methods

Conformance testing, a stage of protocol engineering, includes determining whether a given protocol IUT conforms to the specifications. For this purpose, ISO is developing the OSI conformance testing methodology and framework, describing the various test architectures for different environments, test assessment and Abstract Test Suite(ATS) notation. The test methods designed in ISO/IEC 9646 are divided into two categories, the local and distributed test. The local test method has Upper Tester(UT) and Lower Tester(LT) which are required to access directly the upper boundary and the lower boundary of the IUT, respectively. The distributed test is classified into three kinds of test methods, which are Distributed, Coordinated, and Remote Single layer test method according to the number and the position of the PCO(Point of Control and Observation) and the Test Coordination Procedure(TCP). The Remote Single layer(RS) test method has only LT that is required to achieve the control and the observation of specified interactions.

In this paper, we have chosen the RS test method because it does not put a burden on the implementation, even though the test coverage of RS test method is relatively low. The RS test method is illustrated in Figure 4, the dotted lines indicating that only the desired effects of the TCP are described in the ATS and this test method is applicable to the B-ISDN signalling protocol.

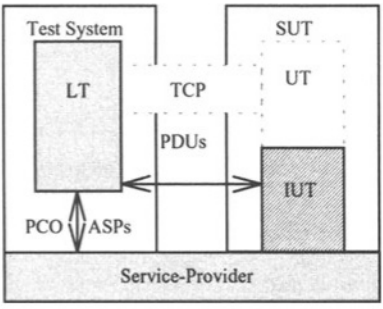


Figure 4 The Remote Single layer test method.

4.2 Development of Abstract Test Suites(ATS) for Q.SAAL and Q.2931

We developed an abstract test suite for the protocol conformance testing, using the following procedures. First of all, we extract the test cases and the test purposes by analyzing the basic standards. Then we generated an Extended Finite State Machine(EFSM.) describing the control procedures of the protocol specifications. The test tool, Conformance Kit, developed by Netherlands PTT was used to get the raw level of the dynamic behavior part of the Abstract Test Suite(ATS). Finally we got the ATS, which was written in Tree and Tabular Combined Notation(TTCN) language, which is a language standardized by ISO for the specification of tests for communication. TTCN has been developed within the framework for ISO's test

methodology ISO/IEC 9646. The Test Suite comprises different test cases specified in TTCN which comes together with all the different necessary definitions and declarations. The above procedure was performed manually by considering nondeterministic problems, timer operation and data flow within the raw test suite. Table 1 shows the dynamic behavior of a sample test case for Q.2931 protocol of B-ISDN signalling protocol.

According to the above procedure, we obtained 161 test cases for Q.SAAL-UNI and 397 test cases for Q.2931 User-Side protocol in the Remote Single layer(RS) test method. We applied the same procedure to Q.2931 Network-Side protocol and obtained 420 test cases for the protocol based on the parallel test architecture.

Table 1 An Example of a Test Case Dynamic Behavior

Test Case Dynamic Behaviour					
Test Case Name : TC00001 **Test Group :** q2931_protocol/pt/N00/ **Objective :** NULL STATE TESTS. VALID TEST EVENTS. Ensure that on receipt of a valid SETUP message the IUT responds with a CALL PROCEEDING message and moves to the state 3. **Default :** general_default(0) **Comments :**					
Nr	**Label**	**Behaviour Description**	**Constraints reference**	**Verdict**	**Comments**
1		+ pr_U00			
2		L ! SETUP **START** T303MAX	SU1(0)		
3	L1	L ? CL_PRr CANCEL T303MAX	CPr1(1)	(PASS)	
4		+ cs_N03(0)			
5		+ po_U00(0)			
6		+ um(1)			
7		GOTO L1			
8		? **TIMEOUT** T303MAX		(FAIL)	
9		+ po_U00(0)			
10					

4.3 Development of an Excutable Test Suite(ETS) for Q.SAAL and Q.2931

In the case of protocol conformance testing, an ATS is not executed as it is in BITS. Note that the procedure of ATS to ETS translation is needed. For protocol conformance testing, the tester covers every transition of the protocol that is represented by an EFSM. We describe the construction of ETS in BITS. In order to achieve the test purpose, every test case of BITS is composed of the following parts : a preamble that drives IUT state into initial state, a test body that accomplishes the test purpose and checks the test results, and a postamble that drives the IUT state into the initial state after the protocol state transition. In the case of testing every transition, test cases will be classified into a valid, invalid, or inopportune test cases. According to the above procedure, the test result turns out to be "pass" or "fail".

Conformance test suite of Q.SAAL

Q.SAAL is the peer-to-peer protocol for the transfer of information and control by selective retransmission and flow control. This protocol is composed of a common part and a service specific part. The service specific part is called SSCS, which is divided into SSCOP and SSCF.

There are two state of IUT in the Q.SAAL conformance testing, one is the active IUT, which connects/releases the Q.SAAL layer, and the other is the passive IUT, in which the protocol tester connects/releases the Q.SAAL layer.

Conformance Test Suite of Q.2931

Q.2931 is the procedure for establishing, maintaining, and clearing of network connections at the B-ISDN User-Network interface. Q.2931 conformance testing verifies that a B-ISDN product complies with the B-ISDN specification. This protocol is composed of Q.2931 User-Side protocol and Q.2931 Network-Side protocol. Each side of the protocol has two states of IUT, Active IUT and Passive IUT. The former connects/releases the Q.2931 layer and for the latter case, the protocol tester connects/releases the Q.2931 layer.

4.4 Configuration of the Test System Interfaces

The test system Interfaces of BITS have been implemented as shown in Figure 5. A TS has two STM-1 interfaces for an IUT and one THS has several TSs with the dynamic allocation. In the near future, various types of physical interfaces(e.g. DS3 interface) will be available.

For the conformance testing and the call simulation of BITS, configured function of each application part establishes a specific application system. The User Interface supports a convenient interface for the functions of the system. The test application system of BITS has protocol monitoring and call simulator, and a conformance tester for basic interconnection and interoperability testing.

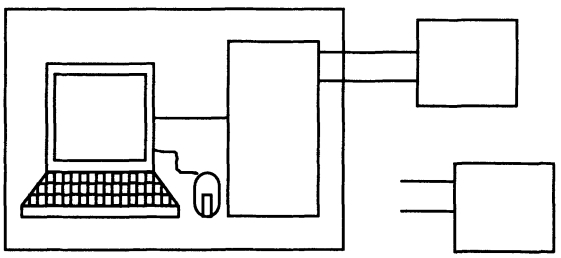


Figure 5 System Interfaces of BITS.

Figure 6 shows a simplified logical display of the BITS user interface. The entire window is composed of 3 frames and each frame is as follows.

Under the Test Environment Setup frame, the user determines the environment that will be

executed.. In the Mode Setup button, the test environment and protocol layer of protocol tester and IUT are determined. If the simulation environment is chosen, then testing will be performed inside the THS. If the test environment is the target environment, then the test will be performed through Ethernet to TS. In the Env. Reset button, entire application of BITS is terminated. The Q.2931 Service Request button determines service request environment for Q.2931. The Q.SAAL Service Request button determines service request environment for Q.SAAL.

Under the Conformance Test frame, each protocol and test case are selected, in order to drive test software of Q.2931 layer and Q.SAAL layer and the selected ETS(Executable Test Suite) will be executed. The Test Suite selection button determines the Q.2931 and Q.SAAL test case number and performs Q.2931 ETSs and Q.SAAL ETSs.

Under the Call Simulation, the frame provides a call simulation menu for selecting each file/frame/call function, and the selected function is performed.

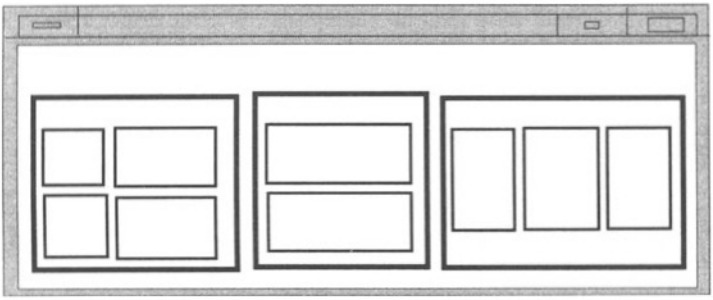


Figure 6 Display of the BITS User Interface.

5 CONCLUSIONS

In this paper, we described the design and implementation of a B-ISDN protocol tester to ensure interoperability between network components. The BITS is composed of functions for conformance testing, interoperability testing, call simulation, and protocol monitoring. The design concept of the BITS is that the test configurations can be easily and efficiently prepared for testing the B-ISDN User Network Interface implementations in a real networking world. This paper presented experiences with the design of BITS, especially its tester architecture and the development of test suite for the B-ISDN signalling protocol.

This system was used to test the Centralized Access Node System(CANS), which is one of the products of the HAN/B-ISDN project, and had been exhibited in ION'94. In the near future, we are going to test ATM switch, ATM-MSS(Metropolitan Area Network Switching System), Ethernet TA, Video TA and B-TE as components of Network Test Bed. So far, we have implemented the basic ETSs and full functions are being developed. We also have a plan to develop testing functions for UNI/NNI signalling release II, III for multi-party and multi-connection.

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