Development of CX750A Network emulator

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[Summary] We developed the CX750A Network Emulator as a test tool to evaluate a wide variety of network devices, following the recent explosive growth of network applications. It allows the user to emulate a complex, large network environment on one PC for testing network devices to improve product quality and cut labor costs.

1 Introduction

Following the explosive growth and spread of the Internet in the 1990s, related hardware and services have become increasingly inexpensive and today anyone can use and configure a high-speed network environment for little cost. This trend is expected to continue and grow in the future and both the business and personal worlds are experiencing an upsurge of networking as well as the appearance of new network appliances and services. In response, new standards are being developed and high-performance, multi-function development tools and instruments are becoming widespread in the rush to design and deploy networks and services as fast as possible.

However, on-site testing and evaluation of these network appliances not only requires tests of communications functions but also requires comprehensive testing and evaluation of the various phenomena occurring in complex network environments.

At present, every stage from development through to testing and evaluation is handled by a few expert engineers with high-level skills and knowledge who mostly configure their own network testing tools. However, with the explosive growth of networks, the diversifying range of instruments with communications functions is outstripping the ability to produce sufficient numbers of expert engineers with the skills and knowledge to evaluate them and there is an urgent need for a simpler network configuration, test, and evaluation solution. We developed the CX750A Network Emulator to meet this need.

2 Development Concept

2.1 Technical Requirements

There are already various network appliance evaluation and test tools. However, since existing tools do not cover every application and purpose, many users create their own unique test tools, resulting in the following problems and requirements:

- Most current test tools place heavy emphasis on load testing and although this is useful for evaluating the performance of the test target equipment, in most cases easy and responsive detailed protocol tests are not supported.
- Most of the self-developed tools use OSS and UNIX operating systems, such as Linux and BSD, with easily revised protocol stack processing. However, such tools make sophisticated operations difficult, and adding new functions and protocols requires high-level programming skills and fast support is difficult.
- Generally, configuring a test environment for network equipment usually requires a lot of equipment, such as a host computer and server. Their operation requires complex and difficult connections and settings depending on the test objectives.
- In systems prioritizing normal operations, it can be difficult to generate error and quasi-normal conditions. Moreover, auto-testing using tracking with other network equipment requires high-level specialist knowledge and deep understanding of the specification of each piece of equipment and supported network protocols.

2.2 Development Concept

We developed the CX750A Network Emulator based on the following concepts to solve the above-described issues and requirements.

(1) Easily Configure Network Environment

By emulating a multinode network with specific features on a Windows PC, eliminate difficult procedures such as setting up and connecting various pieces of equipment to operate in accordance with standards without changing settings to easily and quickly configure a test environment.

(2) Intentionally Achieve Specific Conditions

Provide separate network nodes on the emulator, and a user-defined method for defining and changing task sequences to intentionally create abnormal and quasi-normal conditions, which are hard to generate on actual equipment, and to support detailed protocol tests.

(3) Emulate Real Network Environment

Irrespective of the operation platform, configure a multinode network with various unique IP and Ethernet addresses to emulate a real network environment.

3 Key Design Points

3.1 Software Structure

Figure 1 shows the software configuration for the virtual nodes provided by the CX750A Network Emulator. In this development, the protocol processing modules above the data link layer are designed to operate independently of the standard Windows protocol stack. Moreover, each virtual node on the network is completely independent and different MAC addresses can be set for each virtual node.

The virtual node Application part can define network appliance communications operations and a Communication Library layer is designed to offer complex message formats and TRx timings just by calling functions using an API.

As a result, user-unique protocols can be supported and error conditions that are hard to create on an actual server can be created easily.

3.2 Scenarios

One of the general scripting languages Lua is used as the scenario script. In addition to having advantages of fast operation speed, high portability, and easy embedding, Lua offers the major feature of a lightweight execution environment. By using Lua, up to 256 scenarios can be executed simultaneously. Additionally, the contents of communications sequences and Tx messages can be changed using parameter settings as can Rx message evaluation standards to facilitate description of various tests.

The scenario API executed at the Communication Library layer is designed to cover both the IPv4 and IPv6 protocol controls; IPv4 operation scenarios can be used for IPv6 tests without revisions. As a consequence, the test environment can be easily ported and test cases can be expanded when introducing IPv6 network appliances.

3.4 Protocol Stack

Emulation of large-scale, complex network environments requires simultaneous and parallel operation of multiple virtual nodes and this is achieved using the µIP protocol stack in OSS as a virtual node protocol stack. As well as adding this unique µIP revision, we also achieved a network appliance test function.

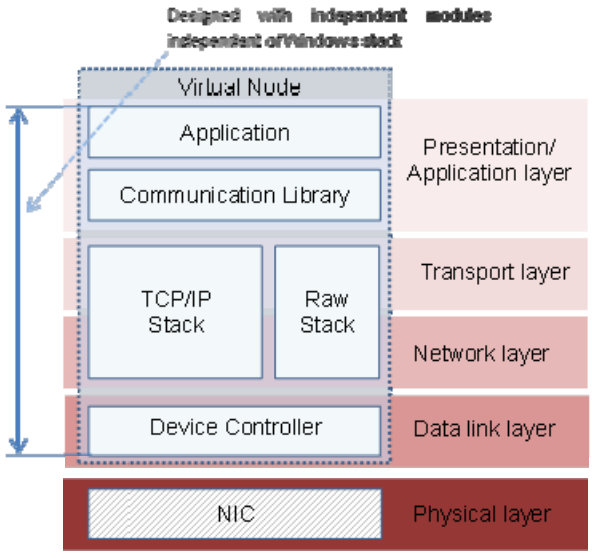

Figure 1 Software block diagram

Emulation of network appliance communications not only performs application protocol communications using TCP/UDP but also requires knowledge of ARP response processing and TCP negotiation processing, etc. Defining these processings for all scenarios not only requires high-level skills and knowledge of networks but also tends to greatly inflate scenario sizes. To solve these problems, we developed a unique TCP/IP protocol stack with layer-3 and layer-4 communication protocol functions.

In addition, since the Ethernet Frame TRx level must be defined depending on the test contents, we also developed a Raw Stack that never operates autonomously using TCP/IP, making it possible to send and receive Ethernet Frames directly.

These protocol stacks are designed for separate deployment at each virtual node, and as a result, each virtual node can operate and communicate independently with no mutual impact on or from other nodes. To ensure that the key lightweight feature of µIP remains unaffected while supporting basic performance for up to 100 virtual nodes, protocol stacks for both IPv4 and IPv6 are installed on the Windows PC. This offers flexible support for mixed IPv4 and IPv6 test network environments.

In addition, this protocol stack supports the IPv6 Core Protocols Specification requirements of the "IPv6 Ready Logo" and can be used to confirm that the test device has the required basic performance.

3.5 Server Emulation

In a general network environment, the required services are provided as service components. To deploy various types of server on a test network, we designed this system to deploy service components using easy mouse operations. Currently, we offer DHCP, DHCPv6, DNS, HTTP, and PPPoE server service components with further additions and extensions planned in the future. Moreover, we have given consideration to future addition of end-user-defined service components by adding support for provision of add-in service components without revising the software itself.

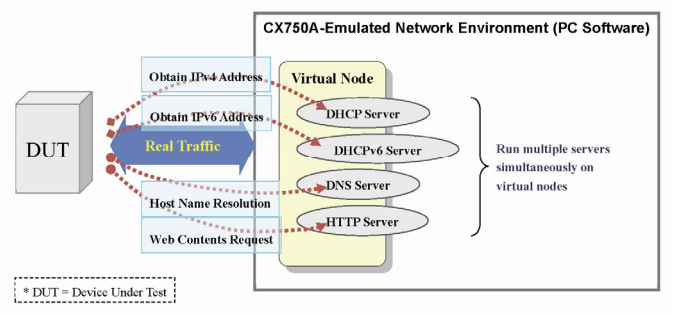

Figure 2 Implemented service components

3.6 VLAN Tagging Support

VLAN-tagged frames can be sent and received to set different VLAN IDs at each virtual node and VLAN-tagged frames with different VLAN IDs can be sent from each virtual node.

The physical interface can also be expanded by putting this function to practical use. As described previously, a different MAC address can be assigned to each virtual node, so all network nodes can operate fully independently. However, since there is only one physical interface on a normal PC, there is a limit on the number even if increased. Even when emulating several tens of nodes, all frames have to be sent out via the limited number of physical interfaces. For example, when testing a relay device with many physical layers, such as a router or L2 switch, sometimes it may be necessary to send frames separately from each of the multiple ports. In this type of case, using both a switch supporting VLAN tags with the VLAN tagging function supports physical sending of frames to multiple ports.

Figure 3 shows a diagram of VLAN tagging. Each virtual node sends VLAN-tagged frames with different IDs, and a switch supporting VLAN tagging forwards frames from different ports for each VLAN ID, eliminating the limit of physical control.

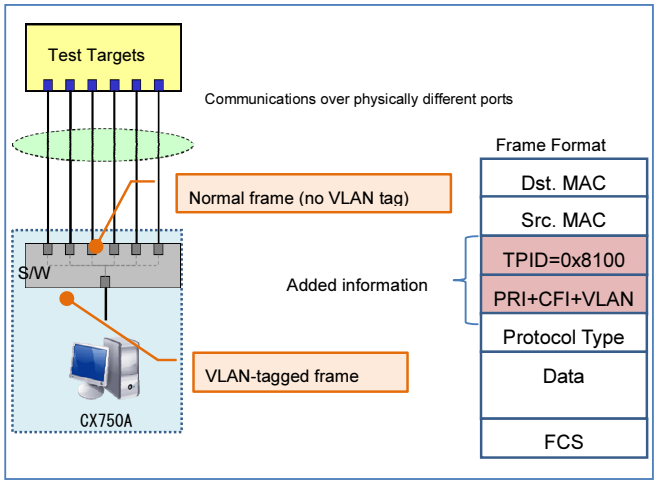

Figure 3 Application of VLAN tag

Number of Virtual Nodes	100 max.
Types of Virtual Node	IPv4, IPv6, RAW
Protocol Emulation	ARP, IPv4, IPv6, ICMP, ICMPv6, DHCP Client, DHCPv6 Client, TCP, UDP
Server Emulation	DHCP, DHCPv6, DNS, HTTP, PPPoE
Other Functions	Continuous Test Multiplex Node

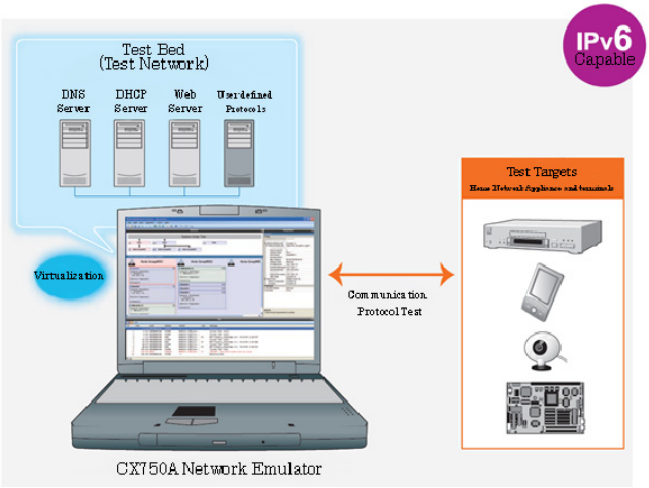

Figure 4 Summary of CX750A

4 Functions

4.1 Outline

The CX750A Network Emulator is software for emulating network appliances and networks when testing the network connection performance of various electronic devices, such as home network appliance and terminals. Figure 4 outlines the network emulator and the key specifications are listed in the following table.

4.2 Summary of GUI Screen

Figure 5 shows a general view of the GUI screen. The test network is configured by arranging virtual network nodes (virtual nodes) on the GUI screen to create and operate a realistic test network environment on a single PC.

4.3 Construction of Virtual Network Environment

Multiple, autonomously operating virtual nodes can be arranged on the virtual network and each node can emulate running communication applications and services using virtual stacks. Figure 6 compares the services offered by an actual network and this virtual network software.

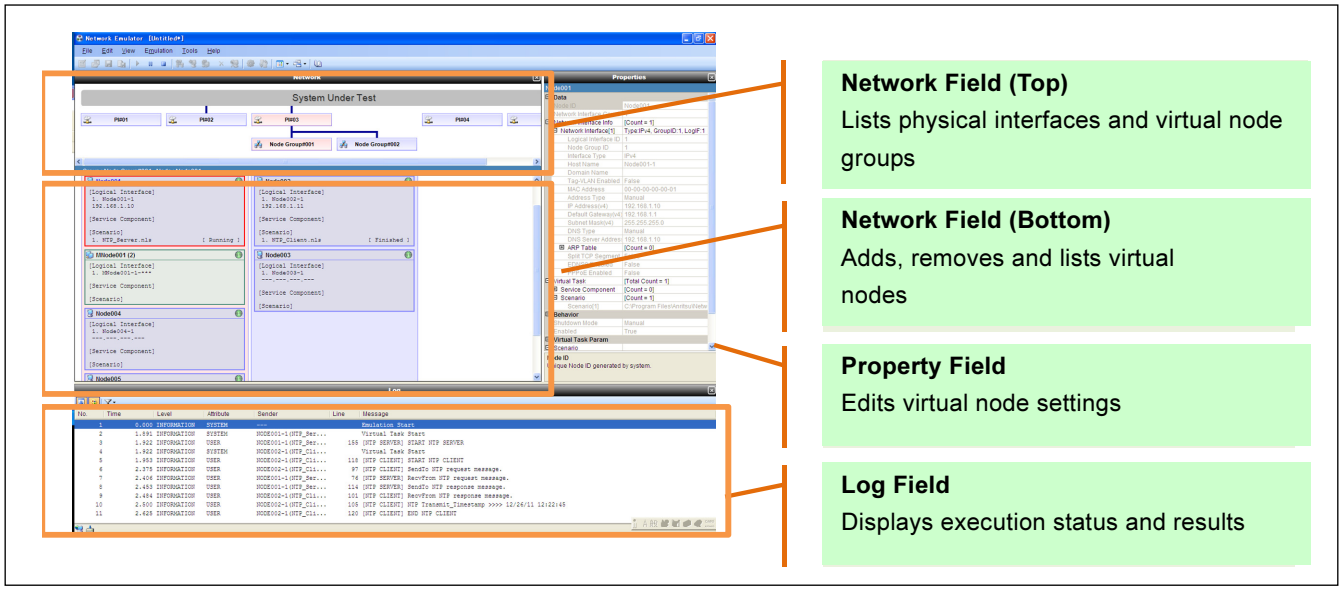

Figure 5 GUI

4.4 Basic Service

Actual network environments usually offer standard services such as ARP, ICMP, DHCP, DNS, etc. Consequently, this system is designed to support configuration of a test environment emulating these services using simple operations.

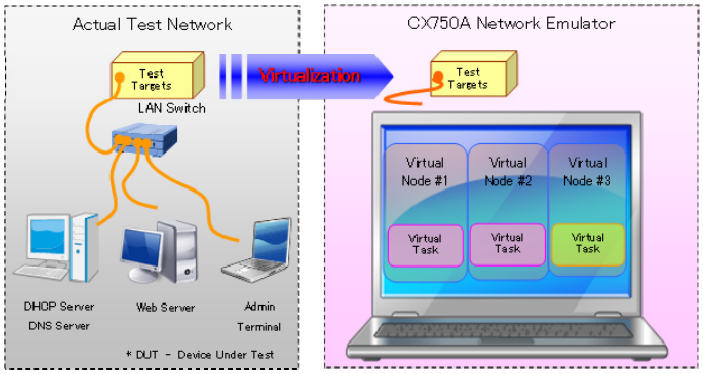

Figure 6 Construction of virtual network environment

4.5 Testing with Scenarios

The CX750A Network Emulator has functions for defining and executing application and protocol test sequences. They can be used to intentionally generate operations and conditions that can be hard to create on a network with actual devices as well as to execute multiple asynchronous scenarios at the same time.

4.6 Continuous Test

This function runs a large number of test sequences continuously. This makes it possible to test different network configurations, such as IPv4 and IPv6 connections efficiently.

5 Applications

5.1 Home Network Appliance Communications Tests

Many of today's household appliances, such as digital televisions, video recorders and players, games, and mobile terminals, have network functions and their numbers are not only expected to increase even further in the future but they will also offer higher functions and more diverse services.

Electronic devices with these built-in diverse network functions will undoubtedly require connection compatibility verification and confirmation tests. The CX750A Network Emulator is a cost-effective solution for defining the sequences required for testing these diverse communications as well as the great variety of devices to be tested.

5.2 SIP Terminal Tests

For SIP testing, there are already a wide variety of products such as test tools and measurement solutions covering a diverse range, such as traffic tests, voice quality tests, signalling tests, etc. However, a single test tool that can cover basic calling, information registration, congestion notification, emergency warnings, etc., for VoIP phones would be difficult to find.

Since the CX750A Network Emulator has built-in server functions (service components), including DHCP and DNS, as standard features, plus features for easy execution of comprehensive test cases using combinations of scenarios (scripts), it is the ideal test tool for evaluating VoIP phones, home routers, gateways, etc. Furthermore, it is also designed to support E-terminal verification tests, assuring high cost-performance well into the future.

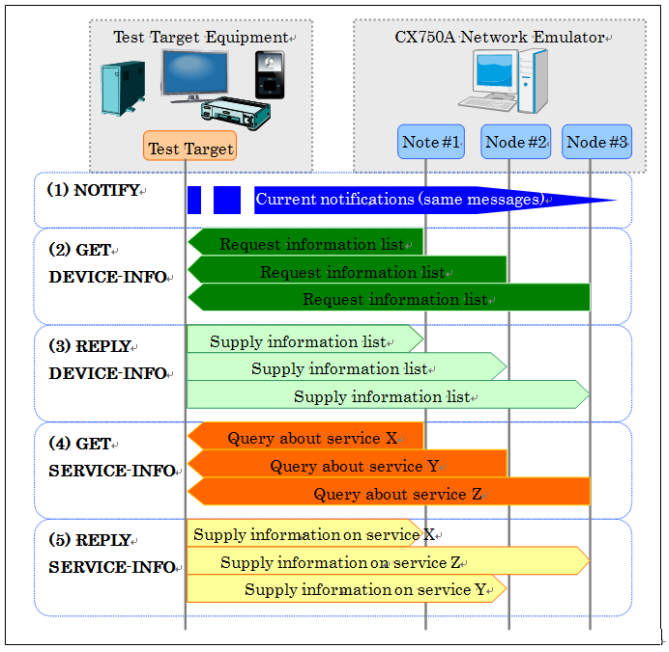

Figure 7 Application to home network appliance

5.3 IPv6 Tests

Standards bodies and organizations have established verification programs specifying IPv6 conformance test items and measurement tools to assure compatibility between devices. However, their main objective is to verify compliance and compatibility of the protocol stacks in each

device rather than to conduct thorough separate investigations of each device type.

Since the CX750A Network Emulator incorporates built-in DHCPv6 and IPv6 DNS servers as standard virtual nodes, it is easy to configure an IPv6 test network without concerns about installing and setting servers. Furthermore, the network is easily administered and reconfigured because data on the entire network setup can be saved to a configuration file.

6 Summary

We have developed a network emulator running on a Windows PC for emulating a network appliance test environment. It can reproduce a variety of complex, large-scale networks such as building networks, and can also reproduce error status operations on IPv6 networks, making it the ideal cost-effective test tool for improving customers network equipment quality while cutting testing costs. With the coming widespread deployment of LTE and cloud services, both network data traffic and power consumption are expected to increase explosively; the CX750A can help network designers minimize power consumption and thereby play a role in reducing global warming emissions.

We intend to continue expanding the functions of this software emulator as well as its application range in the lineup of Anritsu measurement solutions.

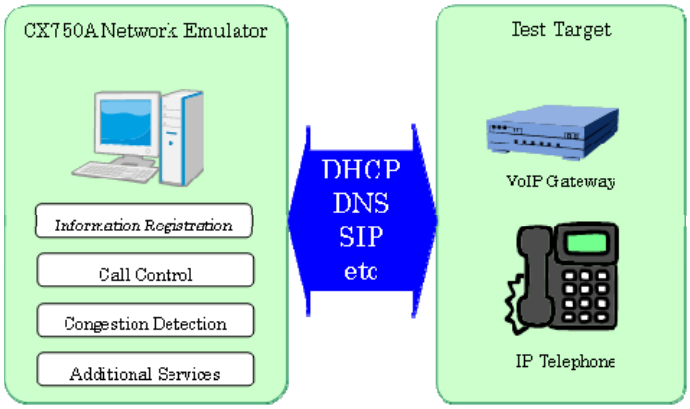

Figure 8 Application to SIP devices

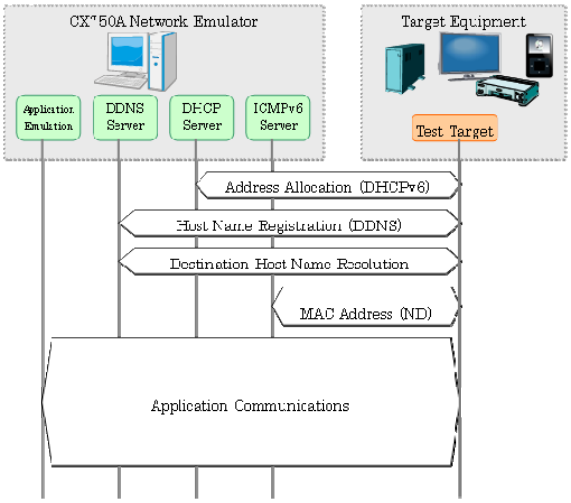

Figure 9 Application to IPv6 devices.

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