INTERNATIONAL JOURNAL OF NETWORK MANAGEMENT
Int. J. Network Mgmt 2005; **15**: 411–419
Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/nem.582

A measurement study of network efficiency for TWAREN IPv6 backbone

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The Advanced Research and Education Network (TWAREN) was established by the National Centre for High-Performance Computing. It provides advanced research and education in Taiwan. TWAREN supports the IPv4 and IPv6 protocols. This paper analyses network efficiency under the IPv6 structures. The TWAREN test will focus on the traffic issue for all fixed-size packets. The purpose of this test is to determine packet loss under the maximum packet transfer situation. We measure the network throughput under the maximum speed and the latency associated with each packet. Using that information, we in turn derive the needed data on IPv6 TCP/UDP bandwidth and packet loss under the TWAREN structure.

Introduction

A shortage of IPv4 address space has become apparent with the increasing number of Internet users, particularly in Europe and Asia. The new IPv6 technology was therefore developed and evolved to deal with the traffic issue. TWAREN, as shown in Figure 1, was fully deployed in December 2003. It has established greater than a 20 GB backbone bandwidth within Taiwan, especially for research and education purposes. A TWAREN project was proposed and implemented between two college campuses using Cisco network apparatus. The main purpose of this project is to analyse network efficiency under the IPv6 structures.[1]

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Among the entire network test instruments available, free software, Iperf,[2] was selected for its usage and budget consideration. Iperf is capable of measuring the maximum TCP network bandwidth and finding the network efficiency by setting and tuning the variables involved. Network information, including bandwidth, delay jitter and diagram loss, can be revealed.

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Contract/grant sponsor: National Centre for High-Performance Computing

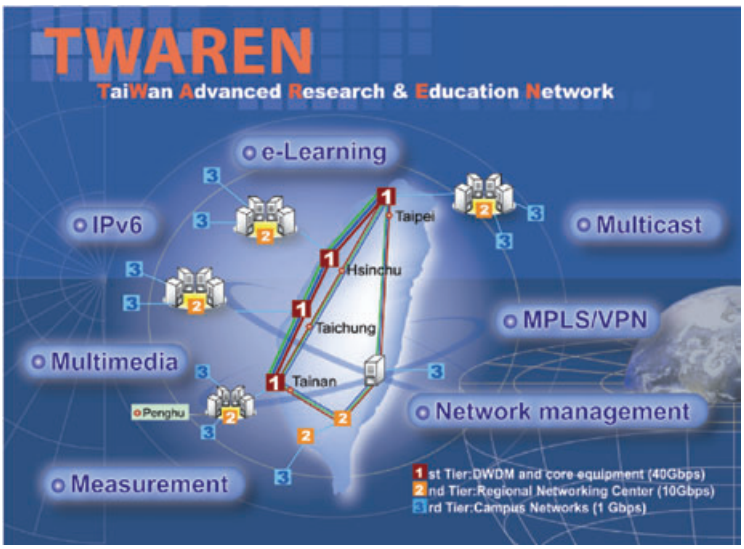

Figure 1. TWAREN topology

We make the following contributions:

- We share our test data on a web site with the National Centre for High-Performance Computing. Readers can reference the URL at http://www.ndhu.edu.tw/~yin/IPv6/.
- We performed bandwidth measurement, delay jitter and diagram loss. We conducted experiments to evaluate, measure and optimize IPv4/IPv6 UDP, TCP and RTT transmission performance using a TWAREN backbone.

The TWAREN test focuses on traffic issues for all fixed-size packets. The test determines packet loss under maximum packet transfer conditions. Network throughput is measured under the maximum speed and latency associated with each packet. Using that information, we will in turn derive the needed data for IPv6 TCP/UDP bandwidth and packet loss under the TWAREN structure.

The rest of this paper is organized as follows. The second section introduces the test instrument and methodology. The third section examines the proposed test data and simulation results. Conclusions are drawn in the fourth Section.

Testing Instrument and Methodology

This section provides a detailed description of our test instrument and methodology. Our test topology consists of a server-testing platform, core router, packet generator and sniffer.

—Test Instrument—

Most of the testing software used in our proposal was provided free except for the server. The hardware used was a Pentium 4 IBM PC with an Intel Gigabit Ethernet card for the server-testing platform. The operating system employed Fedora Core 2 Linux with Iperf and Ping6 as the software testing instruments. Iperf was used to collect the traffic traces for offline traffic analysis. Iperf free software was used to generate both IPv6 and IPv4 network packets to produce the transmission data list for TCP and UDP. It can also be used to measure the maximum TCP throughput, UDP bandwidth, UDP delay jitter and UDP packet loss. Ping6, another measuring instrument, can be used to obtain information on IPv6 round-trip time over an ICMPv6 packet.[3]

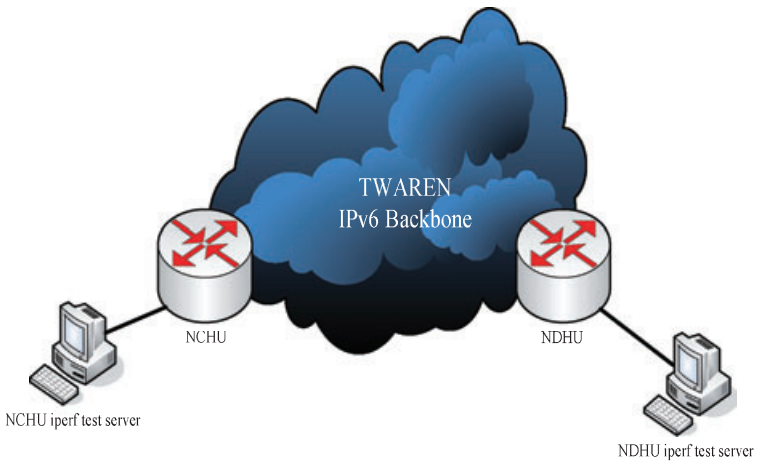

Figure 2. Network testing topology (NCHU: National Chung Hsing University; NDHU: National Dong Hwa University)

—Test Methodology—

This test focused on measuring IPv6 network efficiency over the TWAREN backbone by adopting the RFC 2544 definitions.[4] Under the fixed-size traffic packet situation, it first finds the maximum transmission rate under the presumption of no packet loss. It then derives the greatest throughput for IPv4/IPv6 under the TWAREN backbone. Figure 1 illustrates the test network structure.

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Two servers shown in Figure 2 were located at two separate campuses. Both servers embodied IPv4/IPv6 dual stack architectures and contained IPv4 and IPv6 addresses. The test procedure involved sending different-sized packets at different rates from one campus to another. The purpose was to measure the maximum IPv6 network efficiency by observing packet loss fluctuations between the two sides.[5]

An indirect mechanism was adopted for this test to avoid interference with the existing network at each campus, as shown in Figure 3. The test network was connected to a Cisco 3750 Layer 3 Switch under Giga-POP (point of presence with gigabit capacity).

In addition to the test on network efficiency over the two ends of TWAREN, The TWAREN test also included a server efficiency analysis. The goal was to determine the maximum number of packets transmitted between the two servers. To test the network efficiency, the two servers were directly connected through a Gigabit Ethernet (1000 BASE-T), and point-to-point analysis was conducted on the data packet transmission efficiency.

Testing Data

In this section we examine the IPv4/IPv6 efficiency performance testing by measuring the data on the servers and TWAREN backbone. Experiments were performed to evaluate the effect of the packet size and bandwidth throughput on active transport (UDP, TCP and RTT) traffic flows.

—Analytical Approach—

In our proposed measurement, the TWAREN backbone TCP, UDP and RTT efficiency performance was estimated using Iperf.

The bandwidth was calculated as follows:

$$\text{Bandwidth} = \frac{S(N-1)}{t_N - t_i} \quad (1)$$