Use of IEEE 802.X Standards in the Bottle-Net WANulator

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Abstract – **The Bottle-Net WANulator is an inexpensive and self-contained Wide Area Network (WAN) simulator designed to replace WAN links in order to accurately simulate the limited bandwidth and increased latency characteristics of various WAN technologies. These traffic shaping algorithms are configurable by a user interface on the device itself, without the need for an external PC to make configuration changes. The device houses two Ethernet ports which allow traffic to pass between two Ethernet segments, just as in a bridge. The menu configuration allows setting bandwidth and latency for each direction of network traffic, as in an asynchronous network connection. This functionality allows for a technician to setup a WAN simulation scenario to see how various applications perform over slower network connections. The technician will then be able to determine the ideal link speed that should be purchased for any specific situation that involves a WAN link. The IEEE standards that were considered in the development of the Bottle-Net WANulator are IEEE 802.3i, IEEE 802.3u, IEEE 802.1D, and IEEE 802.3x.**

Index Terms – **802.X, Ethernet, WAN simulation, Bottle-Net WANulator**

I. INTRODUCTION

At most small-to-medium businesses (SMB), purchasing a Wide Area Network (WAN) is a large portion of the Information Technology budget. WANs are used to connect networks that are separated by long distances to allow for use by a variety of applications. Saddled with high costs, long-term contracts, and early termination fees, selecting a proper WAN link for a company's specific needs can be challenging.

With the rapid growth of the SMB market and ever changing types of WAN links offered to these businesses, there is a serious need for help in this area of IT management. Thus, the development of a WAN simulator, or WANulator, would allow companies to simulate WAN links prior to signing long-term contracts. With this capability, simulation of long-distance WAN links to remote offices can be done in a non-production environment.

The goal of the Bottle-Net WANulator project was to build an inexpensive and self-contained WAN simulator. This WANulator has the capability of simulating an operational WAN connection by inserting artificial latency and limiting the bandwidth between network devices in an experimental environment. The results are not only useful to IT professionals who are selecting a WAN technology, but it also allows network users to provide input prior to actual deployment. This consequently saves companies money as they will not buy an overly expensive WAN link that is never fully utilized. It also protects against installing an inadequate WAN link that prevents the essential applications from performing as desired. In either situation, the WANulator allows an IT professional to determine the ideal or minimum link speed that should be purchased for any specific situation.

A WANulator also provides the opportunity for upper management to be included in the evaluation of various WAN technologies by allowing them to see the effects of lower bandwidth, higher latency links on their applications. The management will then be able to make an educated decision on which WAN technology to deploy, lifting this burden from IT staff.

The WANulator seen in Fig. 1 houses two Ethernet ports and can pass traffic between any two Ethernet segments. This allows more than just two workstations to be connected to the device. For example, a server may be attached to one port, and an Ethernet switch may be connected to the other. Since numerous nodes could be connected to the switch, this would allow the simulation of many nodes trying to utilize a WAN link to access a remote server. This is an excellent way to determine the performance of a particular or multiple applications running over a low speed link.
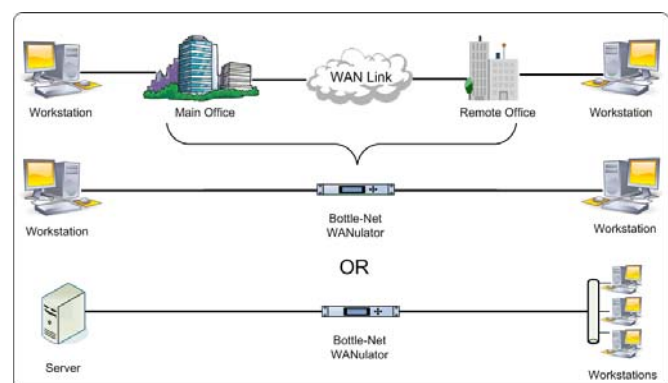
Fig. 1 – Overview

The communication between the two Ethernet ports of the device can be configured asynchronously. This feature more effectively recreates WAN links such as cable modems and DSL lines, due to the difference in both download and upload speeds.

II. PROJECT PROCEDURE

The first phase of the Bottle-Net project was the development of the WANulator concept. In this initial phase, issues such as need and market viability were addressed. Once it was determined that there was a market for a WANulator, the issue of how to create the device was considered. There were several technologies considered, but after much research and interaction with industry, there was only one configuration deemed suitable: a device with Ethernet ports, acting as a network bridge, configured to add artificial latency and limit bandwidth.

Following the device specification determination, the next phase of development focused on designing a product that would work as specified, be able to be completed within the time allotted and be at a price point that the market would accept. The design that was created utilized a combination of off the shelf and custom built components, and both open source and custom software. For the hardware, a Technologic Systems TS-7370 SBC was selected to perform the bridging, latency injection, and bandwidth control. This board utilized a customized version of Linux. Using the built in kernel support for network bridging created an efficient foundation for the device. To limit the bandwidth, a Token Bucket Filter was applied to the traffic, creating a bridge that connects two Ethernets, but limits the bandwidth between them. After adding a delay to the traffic leaving each interface, a fully-functional WANulator was created.

The next phase was of great importance to the market viability of the device. It was this phase of development that focused on the end user experience. The specifications defined that the device must be compact, portable and completely self-contained. In order to meet these objectives, the Bottle-Net WANulator was designed with a front-panel display for configuration. This was accomplished through a custom user interface board. Utilizing a PIC24H32 processor, the board interfaced to the TS-7370 through the PC/104 bus and provided the end user with an intuitive LCD menu for configuration.

The project was concluded with phases of construction, testing and documentation. At the completion of the project, a fully-functional, working prototype was presented with a comprehensive test plan. Accompanying the prototype was the complete intellectual property package containing all designs, schematics, software code, user manuals, and test results.

III. IEEE STANDARDS CONSIDERED

In order to accomplish the goal of building the Bottle-Net WANulator, several IEEE standards were considered. More specifically, 802.1D, 802.3x, 802.3u, and 802.3i standards were all evaluated for the Bottle-Net WANulator.

A. IEEE 802.1D - Bridging

The first decision to be made, however, was to determine the network role of the device. After much research and discussion, it was decided that the Bottle-Net WANulator should act as a network bridge rather than as a router. This was a significant specification. By having the device operate at the Data Link layer of the Open Systems Interconnection basic reference model (Fig.2 - OSI Model), the Bottle-Net WANulator can operate with a wide range of common networking protocols such as Internet Protocol (IP) and Internetwork Packet Exchange (IPX). The Ethernet bridging that will be performed is based on IEEE 802.1D Bridging.
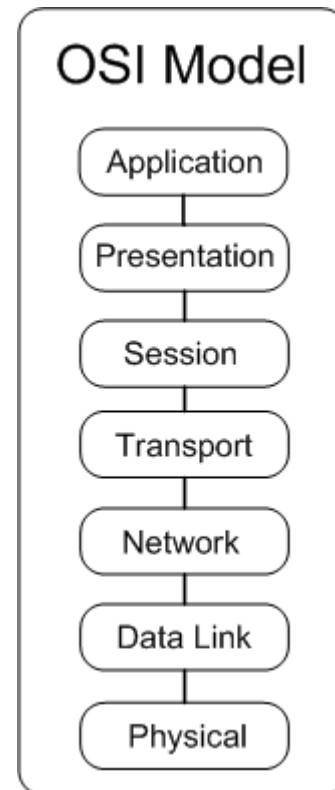

Fig. 2 – OSI Model

The IEEE 802.1D standard defines Media Access Control (MAC) Bridges for local and metropolitan area networks. This standard allows for Local Area Networks (LANs) to be connected together using a MAC bridge. With a bridge, nodes can communicate as if they were operating on the same LAN, even if they are not. The MAC bridge operates at the first and second layers of the OSI model, which are the Physical and Data Link layers respectively. The MAC bridge does not evaluate higher level packets, but instead only at Ethernet frame level.

For connectivity, the MAC Bridge uses port states on each physical port on the bridge to determine how to forward frames. The port state manages whether or not the bridge will

that do not support flow control. In order to keep the device as universal in application as possible, the decision was made to limit bandwidth internally, rather than rate limit the interfaces.

C. IEEE 802.3i & 802.3u – 10BASE-T and 100BASE-TX

The Bottle-Net WANulator has two 10/100 Ethernet interfaces. They conform to IEEE 802.3i 10BASE-T and IEEE 802.3u 100BASE-TX standards. The 802.3i standard is for transmission of 10 Mbps over twisted pair cabling, or 10BASE-T, and 802.3u refers to 100BASE-TX, or Fast Ethernet (100Mbps). Since the device will be communicating through two RJ-45 Ethernet ports, it is obvious that these standards are followed to avoid conflicts with existing infrastructure. The requirement to follow these standards was a matter of reality. In order to properly simulate WAN links, the Bottle-Net WANulator needed to follow the standard that would be found in virtually all networking environments, from large businesses down to small home networks. By incorporating both standards into the device, Ethernet compatibility is guaranteed.

IV. CONCLUSION

While the concept of reducing network performance may not seem on the surface to be a desirable goal, the Bottle-Net WANulator fills a void in the computer networking industry. Through sound design, implementation, and testing, it creates a new use for common and established standards. The Bottle-Net WANulator project has produced a fully-functional, working prototype.

It is the goal of the development team to continue pursuing further development into a marketable product. Currently being considered is a provisional patent on the unique implementation of the bandwidth reduction algorithm that is used to limit bandwidth accurately. The current prototype will be redesigned to fit an enclosure that can be easily mass produced. It is also important to protect the internal software from unauthorized duplication. Once this has been achieved, WANulators will be made available to a limited group. The first recipients of the Bottle-Net WANulator will be asked to provide feedback which will help in determining the next phase of commercialization. The initial users will provide valuable information which may warrant another redesign to add more features, leading to enhanced success in the marketplace. Once the feature-set has been finalized, commercialization can become a reality.