Advance Internet Satellite Extension Project

A Case Study of the Home and Garden Information Center

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The Advanced Internet Satellite Extension Project (AISEP) is a 3-year grant on the development and deployment of advanced internet services and technology over satellite infrastructures. The objective of the project is to help curb the growing and equally daunting challenge termed the 'digital divide.'

The term 'digital divide' is a bastardized and multidimensional term used to describe the differences based on race, gender, geography, economic status, or physical ability of people who do and people who lack access to – or the capability to use - modern information technology via personal computers and workstations. Digital divide threatens to deny minority students, professors, students from low-income families, and minority serving institutions the necessary skills to overcome, survive, and be successful in the information driven economy of the 21st century.

Strategically, it is of utmost importance that America begins the battle against the digital divide at the community level of our society. In three years, AISEP has developed and equipped a network of community Centers and facilities whose internet services and network capabilities are provided through satellite infrastructures. These Centers, called TAP sites, are located in rural and remote areas where the telecommunication infrastructure is either lacking or nonexistent due to economic or geographical reasons.

The College of Agriculture and Natural Resources at the University of Maryland received 3 Tachyon Access Point Satellite (TAP) dishes for high-speed internet connectivity as part of the NSF/ADEC project. A Tachyon satellite system was placed at the Home and Garden Information Center in Clarksville (HGIC) to help the AISEP project observe and study the integration of satellite devices within pre-existing networks and applications. This paper is a case study of the problems encountered at the Home and Garden Information Center as it integrated into its network satellite internet connections.

Research Methodology

Tests were conducted using different bandwidth testers available on the internet to corroborate and document the existence of any problem with the HGIC Tachyon system. Prof. Tom Dunigan, an adjunct professor at the University of Tennessee, Knoxville and a network scientist at the Oak Ridge National Laboratory, developed and designed the primary bandwidth tester using Java applets. Additional tests were performed using the bandwidth tester at www.dslreports.com and Tachyon's internal network tests to avoid the network variables incurred by the public internet.

Prof. Dunigan's applet tested inbound and outbound TCP bandwidth speeds from PC browsers to a web server located at the Oak Ridge National Laboratory. Each test takes about 10 seconds to complete. The server window size for the tester is 64 KB and it is assumed that the client's receiving window size is 32.767 KB. At the end of each test, the applet reports the throughput using the standard rule, window size=bandwidth * RTT. It is important to note that throughput can be affected by the client's and server's operating system's TCP window size as well as packet loss due to congestion. It is arguable that the Java applets' results are not accurate due to various network variables but nonetheless, the applet serves the project's objectives. The tests include real time variables such as network congestions, packet routing, and packet loss, which every internet surfer endures. As such, the results are more realistic in comparison to internal network tests where the environment and network variables are known and set to achieve the best results.

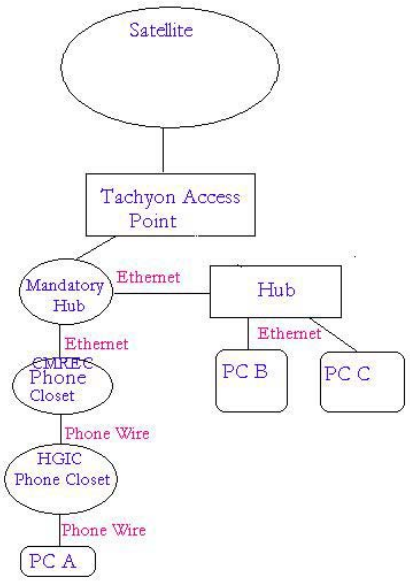
A Dell Pentium III computer was used for the series of tests. The PC operated on a Windows 2000 professional operation system. The processor runs a maximum speed of 600MHz and a bus speed of 100MHz. The Network card is a 3Com 3C18 Integrated Fast Ethernet Controller with a MAC address of 00:C0: 4F:0C: 88:64.

Home and Garden Information Center

The Home and Garden Information Center is an information outreach facility responsible for writing fact sheets, teaching manuals, distance learning of new agricultural products, and development of applied research projects. The Center helps farmers and gardeners increase yield

by providing timely information tips concerning their crops and farms through the normal media outreach and telephone. HGIC has three regional specialists on staff that support and train a cadre of horticultural consultants. The internet and technology growth across the state has led to an increase in the Center's audience and better use of its available resources. The Center has moved from responding to questions concerning plant diseases, pesticides, or drugs through the telephone to responding to these questions via emails. Based on the symptoms provided by callers, consultants search a database application on the web with a 56K dial-up cable modem. Rapid growth has spurred the HGIC's desire for better and faster internet connection but the enormous costs of an advanced internet connection created obstacles.

HGIC has a simple network architecture. There are two buildings at the Center and the Tachyon Access Point satellite system is placed in the CMREC building. A mandatory hub is connected to the TAP box where two Ethernet cables extend out. One of the Ethernet cables connects into another hub and then to two PC's. The second Ethernet cable out of the mandatory hub is the link to the HGIC building. The links runs on the phone wire into the HGIC building where it connects into another hub and then to a PC. Below is a pictorial representation of the Network.



The Home and Garden Center uniquely matches the capabilities of the emerging satellite internet technology because HGIC is located in a rural area with minimal telecommunication technology available to the community. The Center serves as a distance-learning Center to an audience that is an integral part of the project. Prior to the satellite internet connection, the Center possessed an ISDN cable connection running on a 56K dial-up cable modem. Since the speed of an ISDN connection is inversely proportional to the number of consultants on the system, the ISDN cable connection hindered the HGIC consultants by increasing the upload time of emails and their database query time. A Tachyon Access Point system was placed at HGIC since the satellite system was capable of delivering better and faster internet speed to the Center and above all the satellite connection was more cost effective when compared to T1 connections. The satellite does not require additional burdens of rewiring the old building like a T1 connection would require. A key functionality of the satellite technology is its standard compliance and its ability to conquer geographic hindrances. The TAP technology adapts and fits into any subscribers preexisting network and it is not hindered by the facility's geographic location.

TAP Technology

The TAP technology consists of three components: TAP Outdoor Unit (ODU), Tachyon Network Server (TNS), and the Subscriber's LAN. The Outdoor Unit is a mounted satellite antenna that also includes an Upconverter Power Amplifier (UPA), Ortho-Mode Transducer, Low Noise Block Downconverter, and Transmit/receive filter. The Tachyon Access Point is a PC that translates satellite signals to and from IP packets for the subscriber's LAN. When a user requests data from the internet, the request is first sent to the TNS. The network server converts the data request into a L-band signal and the signal is sent to the UPA where the signal is amplified and transmitted to one of Tachyon's geosynchronous satellites orbiting the Earth. The receiving satellite retransmits the signal to the Gateway in San Diego for processing and forwarding to the public Internet. According to Info World Magazine Test Center, the Tachyon technology suffers a 500 ms latency problem, which may seem like eternity in comparison to the 20 ms latency of a landline circuit. Nevertheless, exchanges between computers are not affected.

Tachyon uses Time Division Multiplexing (TDM) for the transmission of its data. The transmission of data is dependent on frames. A frame is like a vehicle that carries data to its destination and has a finite capacity. When transferring data larger than the capacity of a frame, some data has to wait depending on which multiplexing technology is used. Frames can be organized using frequency, time or code division. Frequency division multiplexing assigns each frame a frequency domain to carry its data; similarly code division multiplexing uses a related concept. Tachyon uses the time based TDM technology. For example, suppose we are at a TDM regulated cocktail party that allows one person to speak at a time, and then the next person speaks for a fixed period of time, and so on until every one has had their chance to speak. The pattern then revolves. The idea is to split the time into frames and then further divide the frames into time slots. Each receiving or sending node has an assigned time slot. Using TDM, the TAP system communicates with the geosynchronous satellite. Satellite latency is a byproduct of the time it takes a node to wait for its next turn. The transmission rate of the frame is equal to the product of the number of bits in a frame and the frame rate.

Data Gathered

The first bandwidth tests revealed the satellite system was performing below par. The Internet Explorer browser took 12 seconds to download a 300K PDF file while the HGIC's ISDN connection took 41 seconds. Furthermore, the browser was unable to download video files as it often lost most of the video packets. Below are some of the data collected to indicate the existence of a slow Internet connection at the Center.

Legend

- Site: The server where the bandwidth tester is located.
- Initial Guess: The applets make an initial guess of the type of connection based on certain variables before the tests begin.
- Final Estimate: the applet estimates the connection speed based on the standard formula.
- Max. Exp. Bandwidth: This is the maximum bandwidth used during the tests.
- RTT: The average round trip time between the server and the PC. The time it takes for a data packet to be acknowledged from the receiver.

- Upload time (Size/time): The time it takes the PC to upload a file to the server.
- Download Time: The time it takes the PC to receive a file from the server.

Table 1

Site	Test #	Initial Guess (Up/Down) kbs	Final Est. (Up/Down) kbps	Max. Exp Bandwidth kbs	RTT	Upload Size/time Kbytes/ msecs	Download Size/time Kbytes/msecs
http://sunbirdj.ccs.ornl.gov	1	217/413		2221	0.118		
	2	389	347/386	2361	0.111	50/4060	696/1420
	3	216/416		2259	0.116		
http://www.dslreport.com Mega Line, Ca	1	388	270/388				696/1430
	2	379	251/384			50/4120	696/1460
	3	384				50/4120	696/1460
http://www.dslreport.com Link Line, Ca.	1	388	303/385			50/4010	696/1430
http://whisper.cs.utk.edu	1	215/419		491	0.095		
	2	215/415		491	0.095		

* Some sites do not disclose all the necessary variables.

The test above was conducted from the HGIC building and the results indicated that the TAP was running an average speed of about 292 kbps on the upload while the download speed is about 385 kbps. In addition, the inconsistent upload speed is obvious from the data above. Though the results show that the satellite Internet connection was running about five to seven times faster than the average 56K connection, the consultants still complained of slow speed.

Another set of data was collected on Dec. 7, 2001. This time the tests were conducted under several conditions testing for any difference when more than one hub existed between the PCs and the TAP system. Below is a summary of the results.

Table 2

Building	Site A	Site B	Site C
CMREC	127/413	160/388	242/333
HGIC	72/414	71/359	58/373

The data above showed there was no significant speed difference concerning the number of hubs between the TAP and the subscriber's PC. On the other hand, there exist a 50 % speed degradation with the Internet connection in the HGIC building. The test revealed a possibility that the internal network was faulty and more importantly the link between the HGIC building and the CMREC building was creating a communication bottleneck.

Description of Problem

The satellite network architecture of the Home and Garden Information Center raised uncertainties because of the type of physical media used to link the HGIC and the CMREC buildings. A phone wire serves as the link between these two buildings. Phone wires are adequate for small network traffic. However, there is no information concerning the physical state and age of the wire. Thus, there is a good possibility that this phone line was installed several decades ago during the construction of the building. Furthermore, phone wires are controversial in any network because they create data collisions in the network. The end-to-end channel propagation delay of phone wires is very slow in comparison to the data transfer rate of the TAP system. There is the likelihood that data collision is the cause of the slow connections.

The HGIC overly uses dumb hubs. This use further corroborates the existence of data collisions in the network. Data collision is the simultaneous presence of signals from two or more nodes on a network. Collisions can occur when two nodes assume the network is idle and begin to propagate signals while another node is transmitting its data signals. The end result is both signals are corrupted and afterwards destroyed, increasing the time it takes a node to propagate its signals. Additionally, data collision is present because all the nodes in the network belong to the same collision domain. According to Prof. Shankar of the Computer Science Dept of the University of Maryland, collisions can significantly reduce the efficiency of a network.

Some have argued that the data packets piggyback ride on the public Internet might be a source of the slow speed connection for the Center. Without a doubt, the internet is subject to several circumstantial variables which suggest the premise that the minute time the data packets

lose in the Internet traffic might be adding up to a longer wait for the Internet user. When the time lost in the Internet traffic is combined with the satellite's latency, there is evidently a longer wait.

Proper configurations of applications help maximize the efficiency and speed of the application and its network. The configurations of several PCs internet browsers were improperly set. Satellite systems are time-sensitive devices that rely on internal application configurations to achieve maximum productivity. Because of the improper browser configuration the consultants were unable to reach committed speed rates. The facility was not using an extra feature of the TAP box. The TAP has a built in proxy-server that improves performance by intelligently caching frequently requested pages but some of the HGIC PCs were unable to exploit the proxy server since their configurations were improperly set. The goal of the Home and Garden Information Center perfectly matches the caching abilities of the TAP because the consultants are mostly accessing and requesting the same data from the same location.

Resolutions

HGIC replaced the hubs in the network with Ethernet Switches. Ethernet switches are high performance multi-interface bridges. Bridges unlike hubs are not physical level devices. A bridge operates on frames, examines the destination address of the incoming frame and forwards the frame to the interface that leads to its destination while hubs simply copy incoming packets to all its interfaces. With the installation of Ethernet switches, more computers could be added to the network with little or no collisions. The switches operate in full-duplex modes meaning they send and receive data frames simultaneously over the same interface. One advantage of using switches is that the hosts always sense idle channels and never experience collisions. The Home Garden Information Center also changed the physical media that linked the CMREC building with the HGIC building. A fiber optic cable was installed in between the two buildings. Fiber optic cables can propagate data at tremendous bit rates of up to tens or hundreds of gigabits per second. Fiber cables are also immune to electromagnetic interferences. The fiber cable will conduct better data transmission between the two buildings.

A Tachyon Network Engineer reconfigured the settings of applications like Internet Explorer and Netscape Navigator to take advantage of the TAP system proxy server. Since the consultants often access the same web page, Tachyon's caching technology will inevitably improve the response time for data requests. The in-built proxy server intelligently produces the most current version or the requested data because the system prefetches cached data. The proper reconfiguration of HGIC's PC will eventually help to maximize throughput of the Tachyon Access Point because both clients and servers are now synchronized to take advantage of the proxy-server.

The completion of the Abilene project led to rerouting HGIC's data request to take advantage of the Internet2 low data traffic. This change brought a higher level of satisfaction for the satellite connection. Dr Mary Malinoski, one of the Center's regional specialists, testified about the improved and faster Internet connection. Dr Malinoski tried downloading several broadband high-resolution movie trailers and she was impressed with the connection speed.

Internet2 is a progression from the present internet from the University Corporation for Advanced Internet Development (UCAID). UCAID is a not for profit consortium of universities and research institutions designed and developed to accelerate the diffusion of advanced internet technology. UCAID brings together institutions and resources from academia, industry, and government to develop new technologies and capabilities that can be deployed on the global Internet. The consortium aims to provide a higher level of Internet quality that is currently unavailable to new applications such as digital libraries and virtual laboratories. The present Internet is unable to provide the quality of service required by these applications because of problems like congestion and bandwidth. Nonetheless, it is important to note that the Internet2 does not intend to replace the Internet nor is it a separate physical layer. Instead, it aims to ensure that new applications can be rapidly deployed on the Internet and the next generation Internet.

The Abilene project is a backbone network for Internet2. The backbone network uses high performance IP routers, accessible to gigaPoPs in several dozen locations nationwide to support the Internet2 infrastructure. The long-range objective of Internet2 is to make advanced technological

developments and advances available on the global Internet and Abilene aids the Internet2 project by serving as a test bed for the new networking designs, and by publishing the interfaces that result from the project.

I2 is a significant development in the fight against digital divide. More especially, Internet 2 will make a huge difference in the connectivity of Minority Serving Institutions (MSI). At the Senate's Committee on Commerce, Science, and Transportation hearing on the National Telecommunications and Information Administration (NTIA) Digital Network Technology Program Act (S. 414), Dr. Juliet Garcia, President of University of Texas at Brownville and Texas Southmost College, called technological network advances for MSIs, HSUs, or HBCUs " a great leveler." She remarked that University of Texas at Austin has 146 books per student compared to 17 books per student combining University of Texas, Brownsville and Southernmost College, Brownsville. With an advanced Internet connection like the Internet2, the library will build in two years a digital collection of books that would otherwise take 10 years to build in print. Furthermore, the library can also have access to large digital libraries at bigger institutions and endowments.

Conclusion

The Internet is an innovative force that is improving the every day life of people all around the world. Americans are effecting business transactions or "Ebaying" with people they have never met. Simultaneously, the Internet is increasing the social and economic gap between the haves and the have-nots, and urban and rural life. Current reports show a reduction in the gap between the haves and the have-nots. Robert J. Samuelson, a political columnist for the Washington post, reported that digital divide is declining. According to the Census Bureau's latest survey, in 1997 only 37 percent of people in families with incomes from $15000 to $24,999 used computers at home or work. By September 2001, that proportion had improved to 47 percent. Among all racial and ethnic groups, Samuelson noted computer use was on the rise compared to rates from 1997: Asian Americans 71 percent (58 percent in 1997); blacks, 56 percent (44 percent); Hispanics, 49 percent (38 percent). Evidently, the Internet is becoming an integral part of the urban American life while rural America and the American Indian Nations continue to lag behind technologically due

to geographical and economic reasons. Data must travel through miles of cable to American homes but corporate America has refused to connect rural America. Satellite Internet connection has come to change the technological disparities for rural and underserved America.

This case study has shown that satellites are capable of matching and exceeding the expectations of landline connections. The HGIC Center now runs more than 20 PCs on satellite Internet Connection. The 500-millisecond latency may seem like eternity to the urban Internet surfer but lightning fast to the American Indian kid living in the reservation. Dr Monet of the American Tribal Colleges reported to the Senate's Science and Commerce committee that less than 50% of homes on reservations have telephones compared to 95% nationally. The technology cuts across all barriers that have hindered the technological and economic growth of the reservations and under served America since it is not hindered by remoteness or the physical connections. Satellite Internet technology is the way out of obscurity for reservations and underserved America and definitely a viable weapon against digital divide if one remembers that most of the United States' land mass is in outlying and rural areas.

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