Reference Materials

Information Technology in Education Project

The Next Generation Internet – Internet2

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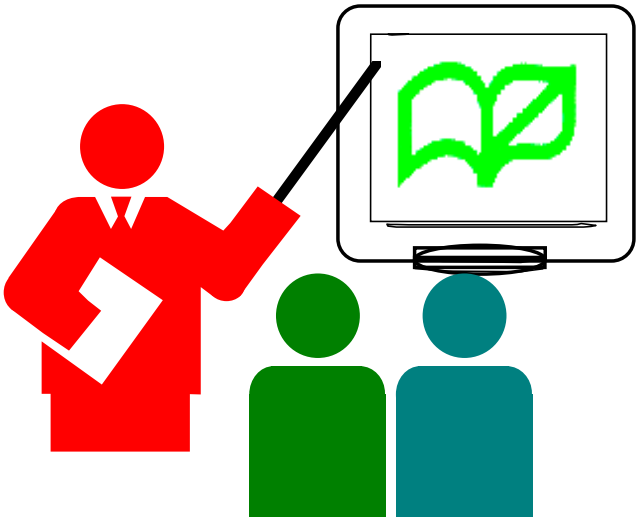

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The Next Generation Internet – Internet2

What would you expect from the next generation Internet? Will it be a faster network? In fact, most of the researchers who study the next generation Internet put their focus on the improvement of the current Internet (I1) instead of pursuing for a higher speed only.

About this document:

This paper explains the limitations encountering by the current Internet I1; the proposed solutions; and an introduction of the new Internet I2.

Problems Encountered by the Current Internet

The current widely used Internet, the I1 was developed under the sponsorship of the Department of Defense to connect different types of networks. With the recent explosive growth of Internet users, I1 has encountered the following problems:

- Insufficient IP addresses;
- Lack of data packet priority;
- Lack of built-in security; and
- Lack of multicast.

Insufficient IP Addresses

Every device (e.g. server or workstation) connecting to the Internet must be assigned with an IP address. The I1 is using a 32-bit addressing scheme (or a four-byte addressing scheme) to represent an Internet address. Hence, a maximum of 4,294,967,296 hosts can be connected together. It is obvious that this total number of IP address is insufficient to cater for the growing need of web enabled electronic devices such as the intelligent appliances (intelligent refrigerator, TV, mobile phone, or even microwave ovens). IP address exhaustion is thus foreseeable in the near future.

In Asia Pacific, the impact of the IPv4 (Internet Protocol version 4, the current version of IP) shortage has become more obvious, and APNIC, the Regional Internet Registry for the Asia Pacific region is under great pressure for allocating IPv4 addresses. To get round the problem, DHCP and NAT are used in the meantime.

Dynamic Host Configuration Protocol (DHCP)

DHCP is a technique that assigns temporary shared IP addresses to transient nodes from a pool of limited IP addresses. Most ISP (Internet Service Provider) uses DHCP technique to assign IP addresses by sharing a limited number of IP addresses to a large number of clients. The ISP assumes that not all clients are connecting to the system at the same time. Hence, when a client logouts from the network, the assigned IP address can be released and could be used by the next client.

However, the shared IP address approach does not work for applications that need static IP address. Therefore, the approach is just a work around and it is not a solution to the problem.

Network Address Translation (NAT)

Most schools have already used NAT technology in their Internet connections. This approach allows schools to use one set of IP addresses for internal traffic and a second set of address (usually assigned by ISP) for external traffic. A NAT device is used to connect the internal network to the Internet and through IP address translations to enable the public host to communicate with the internal workstations. However, the solution of NAT is not applicable to a public accessible host such as mail server and web server. These application servers are usually needed to assign with static IP addresses.

Lack of Data Packet Priority

As IP network transmits data packets along all available shortest routes, transmission error or delay may happen.

For those primary applications in I1 such as file transfer among computers, e-mail communication and remote access service, the transmission delay is hardly noticed by the end users and thus the impact is small.

However, for those interactive and multimedia applications such as video-on-demand, video conferencing or other high bandwidth-demanding services, transmission delay causes jitter in the transmitted video stream which leads to choppiness in the output as well as possible loss of synchronization for phase sensitive streams. Thus, the transmission of real time applications through I1 mostly is unsatisfactory.

Lack of Built-in Security

Privacy and Internet Security are hot topics in today's Internet world. In fact, I1 protocol itself does not have any built-in security features.

The current system can be improved by adding additional security modules such as IPSec (IP Security). However, this approach demands both the sending and receiving devices to be equipped with the IPSec in order to have encrypted communication and mutual authentication.

Lack of Multicast

I1 is originally designed for one-to-one communication (i.e. the unicasting) and one-to-all communication (i.e. broadcasting), but not multicasting (i.e. one-to-many). Multicasting is the trend of delivering content to a selected group of receivers. In I1, this requirement is fulfilled by a series of repeated unicast process, which consumes a huge portion of bandwidth in delivering content to the selected group of receivers.

The Ideal Future Internet

The Internet is becoming an indispensable part of our daily life. More and more advanced and bandwidth demanding applications will be run on this platform. The ideal next generation Internet should be able to:

- solve the deficiencies of the existing Internet (I1); and
- allow the rapid transfer of new network services and applications to the public.

Extended Address Architecture

Since more and more devices and intelligent electrical appliances would be connected to the Internet, the IP address of the next generation Internet should be further extended. According to the latest development, academic and market practitioners are now proposing a new version of IP address scheme, IPV6, to increase the addressing spaces.

Quality of Service (QoS)

Regarding the packet delay issue, to increase the bandwidth by upgrading only the backbone of the Internet is not a long-term solution. It is because the pace of increasing the network bandwidth is not able to meet the ever-increasing bandwidth demanding applications.

Quality of Service, QoS, means to assign priority to each IP data packet regardless of whether it is data, voice or video packet. With the introduction of the QoS feature, data stream and control signal stream can be transmitted under the same media but with different priority. Thus, real-time high bandwidth demanding applications, such as video-on-demand can be entertained and guaranteed to receive a high-quality service in the following aspects:

- Constant bit rate
- Latency
- Throughput
- Scheduled capacity
- Error rate

Encryption

The transmission protocol of the next generation Internet should have built-in security feature to cater for authentication and encryption. Each packet will contain security information in its header so as to enable the receiver to know the sender. The data packet will also be encrypted so

that only the desired receiver can decrypt and resemble the original message.

With this security feature, it is safer for users to perform activity like electronic banking or electronic commerce on the Internet. The risk of the submitted data being hacked can be reduced.

True multicast

The new addressing scheme will allow user to specify a group of receiving users. A data packet destined for a multicast address will reach all users belonging to the multicast group.

The true multicast feature greatly reduces the demand of bandwidth and thus enables the development of web TV as well as group video conferencing.

Enhanced backbone

In order to provide a higher-speed Internet, the backbone of the new Internet should reach at least 1Gbps to cater for the future advance applications.

Internet2

Internet2 is a consortium being led by 200 US universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet or ***the next generation Internet***. Internet2 is recreating the partnership among academia, industry and government that fostered today's Internet in its infancy.

One of the major components of the Internet2 is GigaPoPs. A number of GigaPoPs would have to be set up; each acts as a regional high-performance aggregation point for all participants. The connections between these GigaPoPs are of very high speed and low-delay backbone network. Each participant in Internet2 will be connected by some means to these GigaPoPs at a variety of capacities ranging from a fractional of 45 Mbps to as high as 622 Mbps.

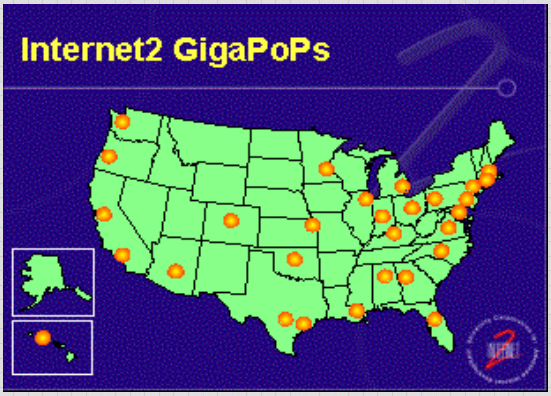
In Hong Kong, a link to Internet2 from Joint Universities Computer Centre (JUCC) has been established and put into production on 21 October 2002. The bandwidth of the link is 45Mbps.

GigaPoPs

GigaPoP is the short name for "Gigabit Point of Presence", which is a network access point that supports data transfer rates of at least 1 Gbps. GigaPoP provides local traffic exchange and offers a variety of speed. It is:

- a Point of aggregation;
- a Point of policy implementation, like telecommunication regulation and AUP (Acceptable Use Policy) Portal; and
- a Point of Backbone uplink.

Currently, only a few GigaPoPs exist, and they are used primarily for accessing the Internet2. The number of GigaPoPs is likely to grow in the near future and each tends to substitute a regional network. Nowadays, there are 29 GigaPoPs for Internet2 in the U.S. Most of the GigaPoPs are resided in university computer centers, and only some are resided outside of universities.



Internet2 Applications

Internet2 can greatly improve today's Internet access performance. It facilitates new applications to be implemented that require good latency control, good jitter control, high bandwidth, and confine to a small group of users.

For example, Tele-immersion, a new telecommunication medium that unifies Virtual Reality and videoconferencing could enable students or teachers at geographically distributed sites to collaborate in real time in a shared,

simulated, hybrid environment as if they were in the same physical room.

Different kinds of point-to-point session could be set up such as school to school, expert to schools, expert to student teams, and expert to teachers. It allows students to manipulate a virtual object model beginning from the conceptual design up to the final product. Expert in other location could use the virtual model to answer the question. In such a way, physical and virtual environments appear united for both input and display. The combination offers a new paradigm for human communications and collaboration.

Other examples like remote music teaching, digital libraries, and virtual laboratories. More details can be found in the following websites:

http://k20.internet2.edu/

http://apps.internet2.edu/

It is expected that these interactive, individualized, accessible, flexible, and equalize across schools applications could improve the teaching and learning process.

Summary

This paper discusses the deficiencies of current Internet (I1) which hindered the development of advanced applications over the Internet. The next generation Internet, Internet 2 (I2), should have to solve the identified I1 deficiencies as well as to enhance I1 access performance. However, it should be noted that the development of I2 is not to replace the I1 but to supplement new features and functions on top of the current Internet.

Although Internet2 is not yet widely deployed in Hong Kong, it is worthwhile to note the progress of development of Internet2 in the foreign countries. We should get prepared as the technology will soon come to Hong Kong. Schools may benefit from the technology to have a more secure and efficient network for multi-media applications.

Project Stages

The development of Internet2 in the US and other countries is as follows:

Internet2 in US

In October 1996, 34 US research Universities committed to providing resources to work in network projects, to upgrade each campus network to a very high speed backbone network (vBNS) and to join them together.

In 1998, the Next Generation Internet (NGI) Program leading by the Federal Government, focusing on the needs of the Federal agency, was successfully completed.

I2 K20 Initiative

The I2 K20 Initiative will engage interested K-12 schools, community colleges and universities, libraries, and museums (and their government and corporate partners) in the development of partnerships and collaborations across a wide range of areas networks. The initiative is as follows:

- To focus on programmatic and content efforts that are likely to facilitate teaching, learning and access to education opportunities for the broad education community and its constituencies;
- To purse potential areas including advanced content repositories; advanced applications; middleware collaborations; advanced network services; broadband; and related research, evaluation and information sharing.

See its official web site at:

http://k20.internet2.edu/

Internet2 in Asia

It was found that some developed Asian countries had connected their Universities to the Internet2. For example:

- CERNET in mainland China
- The National Broadband Experimental Network (NBEN) in Taiwan;
- The Singapore Advanced Research and Education Network (SingAREN);
- Kansai GigaPOP Project in Japan;