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Future of telemedicine: Internet2 ?

ABSTRACT

Internet2 is a consortium being led by over 180 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies for tomorrow's Internet. The first basic principle of Internet2 is to ensure that Internet2 maintain an infrastructure flexible enough to work with current requirements, yet to be adaptable for future now-unknown needs and to provide a highway for higher bandwidth traffic using Internet Protocol version 6 (IPv6). The second basic principle of Internet2 is built up in the strategy of affordable communication named "common bearer service", which means a model of communicating from one connected node to any other connected node. One of the ways to ensure bandwidth, and keep it affordable for the institutions involved, is to establish what has come to be known as a gigapop ("gigabit capacity point of presence"). More or less, Internet2 is going to look very similar to the current Internet-data viewed in a Web browser, but so far, it is strictly being used as a pipeline to transfer data. According to the University Corporation for Advanced Internet Development, the minimum period of complete implementation of Internet2 is 24 months. Experience told us that the average period of establishing Internet as an every day practice is about 3 years (like in Yugoslavia, for example) which leads us to conclude that approximately 5 years is needed to implement new technology such as Internet2 in middle developed countries. Oncology, as one of the most complex domains of medicine and because of that a great user of telemedicine, is the most acceptable for the new technology such as Internet2. There is no doubt, that oncology will find the fastest way to join the Internet2 user society.

Key words: Internet2; Telemedicine; Computer communication networks; Telecommunication networks; Oncology

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INTRODUCTION

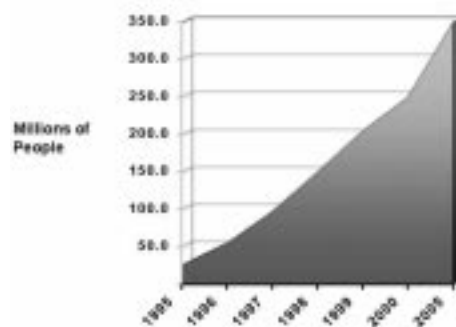
There are hardly any people from urban society who do not know what the Internet is and what the Internet services (e-mail, www, ftp,) are. But, the concept of Internet2 is not widely known by the educated part of population. What is really the concept of Internet2? Internet2 is a consortium being led by over 180 universities working in partnership with industry and government to develop and deploy advanced network applications and technologies, accelerating the creation of tomorrow's Internet. Practically, Internet2 is a collaboration

of over 130 United States universities, teamed up with industry and government, to develop advanced Internet technology and applications for high-end academic experimenting and research. Colleges and universities will use Internet2 to explore areas of instruction, research, and public service, such as learningware (software designed for classroom and distance learning), digital libraries, tele-immersion (such as telemedicine), and virtual laboratories. Eventually, the plan is that the technology will be available to everyone.

According to these facts, the primary goals of Internet2 are to:

- Create a leading edge network capability for the national research community
- Enable revolutionary Internet applications
- Ensure the rapid transfer of new network services and applications to the broader Internet community.

- Web, email, low-quality audio & video,
- Interconnect personal computers and servers,
- Applications adapt to underlying technology.



Graph 1. Number of people using Internet

The trend of number of people using Internet is presented in Graph 1.

- But, today's needs are more complex:
- Millions and millions of users
 - Less congestion
 - Multimedia

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WHY INTERNET2

- Basic characteristics of today's Internet are:
- Millions of users,



- Real time interaction, which Internet is not designed for. On the other side, only the Internet can accommodate explosive growth and enable convergence of information work, mass media, and human collaboration. These facts caused new concept called Internet2. Leadership of developing new concept, Internet2, is in hands of universities and there are several reasons for that, but the most important are:

- The Internet came from the academic community

- National Science Foundation's Network NSFNet (the scaled-up Internet)

- European Organization for Nuclear Research CERN (the WWW protocols)

- University of Illinois (the Web browser)

- Stanford University (the Internet protocols)

- Universities' research and education mission require an advanced Internet and have demonstrated they can develop it

Naturally, Internet2 corporate partners must back up the universities. Corporate partners are:

3Com, Advanced Network & Services, Alcatel, Ameritech, AT&T, Cabletron Systems, Cisco Systems, IBM, ITC Deltacom, Lucent Technologies, Marconi, WorldCom, Microsoft, Newbridge Networks, Netcom Systems, Nortel Networks, Qwest Communications, SBC Communications, WCI Cable.

This list of companies guarantees not only financial success of the concept of Internet2, but technological support as well.

Summarizing these aspects, Internet2 should not be a production network meant to conduct commerce and academic business nor should it be an experimental network reserved for researchers: Internet2 must accommodate the needs of a diverse academic community to learn, teach, conduct business, and support research in many disciplines.

INTERNET2 BASIC PRINCIPLES

How does Internet2 work?

The first basic principle of Internet2 is to ensure that Internet2 maintain an infrastructure flexible enough to work with current requirements, yet to be adaptable for future now-unknown needs. The Internet2 network design, which will remain compatible with the current Internet, will provide a highway for higher bandwidth traffic. Internet2 uses Internet Protocol version 6 (IPv6) instead of the current Internet Protocol (IPv4). IPv6 uses a different package scheme, the advantage of which is that it incorporates native multi-casting, high reliability, and high capacity. IPv6 will allow applications requiring high bandwidth to coexist with each other simultaneously. Because IPv6 users are able to send one content packet to many locations-instead of the current method of

sending many packets to many locations-and/or send data with guaranteed delivery and performance. Real-time data can now be utilized in real time. This means, for example, that a physician at the Doheny Eye Institute in Los Angeles can perform a retinal exam on a patient who is hooked up to a machine in rural San Joaquin, California. This example can almost be realized on today's Internet, but, in the final analysis, it demands a quality of service that cannot be extracted from today's Internet. The quality of service sometimes may depend solely on the high-probability availability of raw bandwidth, but it often depends on the availability of differentiated network services designed, for example, to insure against problems of latency in delivering 30-frames-per-second (fps), synchronized video from distant server to personal computer. Unlike today's Internet, 30 fps can be guaranteed over Internet2-no jerkiness, no delays, and no frames dropping out. As a proof for this state, a good experience with transmission of live laparoscopic surgery over Internet2 can be used (1). The scheme of Internet2 network architecture is presented in Figure 1.

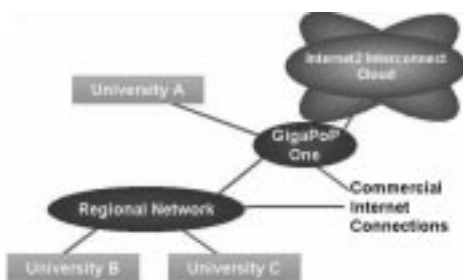


Figure 1. Internet2 network architecture

The second basic principle is built up in the strategy of affordable communication named "common bearer service", which means model of communicating from one connected node to any other connected node. One of the ways to ensure bandwidth, and keep it affordable for the institutions involved, is to establish what has come to be known as a gigapop, which stands for "gigabit capacity point of presence". According to University Corporation for Advanced Internet Development (UCAID), a gigapop is a high-capacity, state-of-the-art interconnection point where Internet2 participants can exchange advanced services traffic with other Internet2 participants. Campuses in a geographic region will join together to acquire a variety of Internet services at a regional gigapop. This is a great advantage, because it means that instead of each institution having to build their own high bandwidth networks between each other, they can build a connection just to the gigapop, which is already connected to other member institutions. Also, the consortium that manages Internet2 will be responsible for building, maintaining, and, if necessary, fixing the connections between gigapops. By using this method, nothing really changes for the end user, and the institution can guarantee delivery

of high bandwidth data while only bearing the cost of connecting to their gigapop. The scheme of Internet2 GigaPoPs is presented in Figure 2.

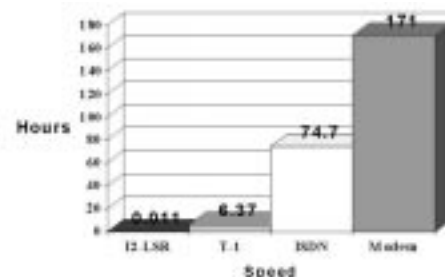


Figure 2. Internet GigaPoPs (situation in March 2000 in the USA)

How fast is Internet2?

A standard 10Base T Ethernet card, the kind that is in most LAN-connected computers, transfers data at 10 megabits per second. 100Base T Ethernet cards are available to transfer data at 100 megabits per second. Internet2 Ethernet card transfer rates are in the gigabits. Comparison of the Internet2 Land Speed Record downloaded "The Matrix" DVD is presented in Graph 2.

How can someone get in?



Graph 2. Comparison of the Internet2 Land Speed Record downloaded "The Matrix" DVD

At this point, the one who want to get in, must be a member in order to use Internet2, which means to be a part of a university, a non-profit organization involved in networking, or a corporation interested in developing Internet2. Of course, he has to be able to bear the financial investment required to provide onsite facilities. (2-23)

When Internet2 is going to be available to the rest of us?

UCAID predicts that the number of Internet2 academic members will grow significantly during the next six months. Over the following 12 months, it is expected that most Internet2 members to upgrade at least their campus backbones, most gigapops to become operational, and connections among Internet2 members and gigapops to be working. Within about 24 months of project inception, they expect teachers and researchers on Internet2

campuses to have routine access to Internet2 network service for their network-based applications.

The commercial transition will happen very quickly because companies like AT&T, Sprint, and MCI have been watching the progress closely, and can create their own backbone based on the UCAID model. They are likely to use the gigapop approach and sell similar services to downstream providers. And, because Internet2 is designed to take advantage of existing "off-the-shelf" technology, switch and router makers, like Cisco Systems, will continue to push the capabilities of their products and make them available to the private sector.

It is hoped that this will then invite competition into the network market to keep the costs down and quality of service high.

Similarly to the current Internet, money is the great motivator needed to push the Internet2 envelope. Even in an academic environment, institutions have to pony up serious capital (or win significant grants) before they can really test Internet2's capabilities. Once commercial companies create their own backbones and start offering service to the public, things are going to get interesting. Just like the current Internet, it is the individual developers working on their home computers who will figure out ways to push the medium.

What does Internet2 look like, or what is it going to look like?

Chances are, Internet2 is going to look very similar to the current Internet-at first. Data will be viewed in a Web browser, just like it is now. At this point, development on Internet2 is in its infancy. So far, it is strictly being used as a pipeline to transfer data. It is expected that Internet2 developers are planning to upgrade outdated technology like email. Things like improved Web searching and guaranteed email delivery and tracing must be part of the Internet2 design core.

Eventually, the line between television and the Internet will become blurred. It is likely that all media will be delivered over Internet2. For the end user, that means seamless access to unlimited information and/or your favorite TV show. Users will not be able to tell that the content they are viewing is coming across the Internet2 backbone instead of the Internet network.

Oncology, Telemedicine and Internet2-how close are they connected?

One of Internet2 focus areas is advanced application such as:

- Distributed computation
- Virtual laboratories
- Digital libraries
- Distributed learning
- Digital video
- Tele-immersion
- All of the above in combination

Most of these items can be found in application aspects of telemedicine. Because of that, development of these focus areas of Internet2 is automatically development of telemedicine itself. This fact will help to answer the question asked in this title, by giving the several examples. The most interesting application aspects for medicine, better to say, for telemedicine, are real-time accesses to remote instruments (basic for telesurgery for example). There are many projects with these titles such as at University of Pittsburgh, Pittsburgh Supercomputing Center, called 3-D Brain Mapping, at University of North Carolina, Chapel Hill, called Distributed nanoManipulator and at University of Illinois, Chicago, called Shared virtual reality -Virtual Temporal Bone.

But the problem with telemedicine is that its preparation costs very much. The concept of Internet2 just offers solution for this. The investments by universities in Internet2, coupled with the efforts of industry and government, are helping to develop technologies such as IPv6, multicasting, and Quality-of-Service that will enable a new generation of Internet applications, benefiting all sectors of the society, especially medicine and oncology as its important part. The wisdom of this approach to network research has been proven by the rise of today's Internet from the academic and federal research networks of the 1980s. Internet2 will replicate this success for the new millennium by relying on the university community for pre-commercial development. (24-33)

Oncology, as one of the most complex domains of medicine and because of that, a great user of telemedicine, is the most acceptable for new technology such as Internet2. There is no doubt, that oncology will find the fastest way to join the Internet2 user society.

CONCLUSION

The concept of Internet2 is geographically located in the United States of America and driven by American universities and companies. However, all other countries, Yugoslavia as well, are interested in implementing this concept as soon as possible, because of its financial and technological justification. According to the UCAID, the minimum period of complete implementation of Internet2 is 24 months. The experience told us that the average period of establishing Internet as an every-day practice is about 3 years (like in Yugoslavia, for example) which leads us to conclude that approximately 5 years are needed to implement new technology such as Internet2 in middle developed countries.

In the meantime, Yugoslavia and its medicine, specially oncology, has enough time to prepare for this new technology which will finally bring the telemedicine in every-day practice in a new, better way.

On the other side, the government should provide good environment for investments in medicine and technology which is the first step in building telemedicine. Serbia has engineers and physicians, knowledge and good will for implementing new technology in medicine (oncology), only the better organization and coordination between experts in medicine and telecommunication is needed to successfully finish this project.

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