

# Global Next Generation Internet Initiatives

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## Abstract

Next generation Internet Initiatives are the research activities going on around the world towards developing the current Internet in terms of service and speed and launching a entirely new range of applications which will make use of these new opportunities, bringing wealth and knowledge to the entire world. This report surveys the research activities of global research networks working towards the development of the new services and applications. In this report second generation Internet initiatives like NGI, Internet2 and third generation Internet initiatives like SUPERNet and CANET3 have been described.

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# 1.Introduction

Internet is the major reason for the information revolution. Access to information on any subject is easy. Internet provides a forum for all to express their views. However, the internet is characterized by long delays, unacceptable disruptions , no quality of service, no realistic multimedia. Development of Internet and overcoming these hurdles are very important.

In order to provide a uniform service throughout the world and to integrate seamlessly with the present Internet research is going on throughout the world. Leading in this direction is the United States of America with its Next Generation Internet and Internet2 initiatives. Other countries like Canada, Japan, Singapore have also made steps towards a better Internet. Many continental networks like the CANET, TEN-155, APAN have evolved to improve the Internet. The Internet will become faster, cheaper and more efficient in the future. In this paper global research networks and their research activities have been surveyed.

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# 2.Global Internet Connectivity And Three Generations Of Internet

The Internet has reached the corners of the Earth. The Internet can be classified into three generations on the basis of the technology it uses and the applications it supports. Most of the Internet users use the first generation internet. But the inefficiency and congestion on this internet has become unacceptable to perform any research activities. The first generation Internet has the following features :

- Unreliable

- Uses IPv4
- No Quality of Service
- No assured Bandwidth
- Very low speeds

The second generation is a major step towards developing the Internet. This development which has so far been only in the research arena is moving to the implementation arena. The Second generation Internet adds quality of service, multimedia and other advanced services to the current Internet. The second generation internet initiatives are I2, NGI, CANet2 and other Asian networks. The chief characteristics of the second generation Internet initiatives are:

- Uses IPv6
- Multicast is provided
- QoS is provided

Third generation Internet provides all the advanced features at a very fast speed. The third generation Internet is mainly in the research stage. It involves many ambitious projects that are being done in the level of a local area network and are expected to be implemented in a global way. The third generation internet initiatives are the CANet3, SUPERNet. The chief characteristics of the third generation Internet are :

- Use of DWDM and other optical technologies
- Usage of optical layer routing and switching

This paper will deal mainly about the second generation and the third generation internet.

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## 3.Second Generation Internet Initiatives

The second generation initiatives which use IPv6, provide QoS are being developed independently and simultaneously throughout the world though at different speeds. The initiatives are classified based on the countries in which they are being implemented.

### 3.1North America

North America has been leading the world in research activities in the development of the next generation internet. In North America, USA has initiated the NGI and the Internet2 and in Canada CANet has been developed.

#### 3.1.1USA

USA has been leading the world in changing the dimensions of the Internet. Both from the part of the Government and the research and education institutions a thrust towards better connectivity has been very much emphasized mainly due to the congestion in the present Internet, which makes any useful research impossible. The two major initiatives going on in the USA are the NGI and Internet2. The NGI -

Next Generation Internet is an initiative of the US Government. The Internet2 is developed by the UCAID – University Corporation of Advanced Internet Development which is a consortium of the Universities in the USA. The aim is to develop a parallel network along with the NGI.

### 3.1.1.1 NGI

The following government agencies are part of the NGI : DARPA,DOE,NASA,NIH, NIST and NSF. The aim of NGI is to develop two networks one of which is 100 times faster than the current internet connecting 100 institutions –Net1 and the other which is 1000 times faster than the current Internet, connecting 10 institutions - Net2. [ [ngi99](#) ]

- The Net1 consists of the following networks : vBNS, NREN, DREN,NISN, ESNET.
- The Net2 consists of the SUPERNet.

#### vBNS

The principle behind the vBNS-Very high speed Backbone Network Service is faster internet. It connects 104 institutions. It has 16 peer networks through NGIX[[ngix99](#)] – NGI exchanges. A full mesh of statically linked Unspecified Bit Rate (UBR) - Permanent Virtual Paths (PVPs) interconnect the 12 nodes of the vBNS. The current maximum speed achieved is OC-48c on Jan 1999. The project areas in which vBNS is being used are IPv6, performance measurement and QoS. [[vbns99](#)] [[jamison98](#)]

#### NREN

The NREN-National Research and Educational Networks connects 5 of 8 (as of summer 1999 ) NASA centers and research centers of leading corporations at 155 Mbps. The network access is provided through routed Fiber Distributed Data Interface (FDDI) and ATM User Network Interface (UNI). Both the router and the ATM switch support IP over ATM It helps the High Performance Computing and Communications Program community of the NASA. The research areas are IPv6 , multicast, Quality of Service,performance measurement, security and network management tools. Fundamentally the network is used for NASA's research purposes apart from the above mentioned research activities. [[nren99](#)]

#### DREN

The DOD's HPC-High Performance Computing center and the WIDE center are linked together with the above networks. Interoperable IP and ATM service are provided. Of the more than 60 sites of DREN around 25 are ATM and the rest are IP sites. They are primarily used for research in the defense arena. The maximum speed as of November 1998 is OC-3 and in the future it is expected to go upto OC-48.[[dren99](#)]

#### NISN

NISN is the NASA integrated services network. It is a single integrated network project aiming to replace many individual NASA networks and brings them under one organization. This is primarily for the operations of the NASA. The expected connection speed in December 1999 is OC-3. The networks being integrated are

- PSCN - Program Support Communications Network

- Nascom - NASA Communications Network
- NI - NASA Internet (formerly NSI - NASA Science Internet)
- AEROnet- Aeronautics Network
- EBnet - Earth Observation Data Information System (EOSDIS) Backbone Network

[\[nism99\]](#)

## **ESNET**

The Energy Sciences network is an international scientific collaborative network. It is an ATM backbone network. It is one of the major networks that interconnect the American networks and the Asian and European networks. The latest speed achieved by the ESnet is OC-12. The research activities of the ESnet are IPv6 , 6Bone Backbone Participation , Class Based Queuing (CBQ), Quality of Service (QoS) and Virtual Networks. [\[esnet99\]](#)

## **NLANR**

The chief purpose of the NLANR - national lab for advanced networking research, is to actively further research in the NSF's High Performance Connections sites and vBNS and other similar HPNSP (high-performance network service providers). It is also involved in IRcache which is actively involved in web caching activities. It consists of Applications/User Support, Engineering Services and Measurement and Analysis. [\[nlanr99\]](#)

## **MREN**

Metropolitan research and educational network is a consortium of many Universities and National Research Institutions. The maximum speed expected is OC-12c. It is a star topology network and hence has many advantages and provides full cell switching between the network sites. The research activities involved in the MREN include RSVP, advanced GigaPOP technology, QoS among many others. [\[mren99\]](#)

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### **3.1.1.2 Internet2**

Internet2 [i299] is development led by US universities and runs parallel to the NGI of the US government and is developed by the UCAID - University Corporation for Advanced Internet Development. The Internet2 consists of five major areas of research and development :

## **QBone**

QoS over IP for IP differentiated services - DiffServ. The DiffServ architecture consists of Bandwidth Brokers, Core routers, Leaf routers, Ingress Edge Router and Egress Edge Router. The QBone first attempts to build a interdomain testbed infrastructure and then support intradomain capabilities.

[\[teitelbaum99\]](#)

## **I2DVN**

The Internet2 Digital Video Network is the meeting point of many digital video initiatives. The research activities involve live transmission of video, video conferencing and video-on-demand.

## **I2DSI**

The Internet2 Distributed Storage Initiative involves the development of reliable, scalable storage infrastructure in order to maximize the benefits of the advanced networks like vBNS and Abilene. It replicates hosting services for internet content and applications. It provides predetermined services and predetermined costs without the end user being aware of it. [\[beck98\]](#)

## **Abilene**

The aim of Abilene is building a smarter internet. The present Abilene network consists of 25 GigaPOPs. The maximum speed achieved so far is OC-48 among GigaPOPs[\[gigapop99\]](#). The Abilene network runs IP over SONET without ATM. The connection is done by means of either Core consisting of a set of Router Nodes connected to each other with Interior Circuits (Core Architecture) or an Abilene Connector, connecting to a Router Node, consisting of a set of Access Circuits (Access Architecture). The chief aim of the Abilene is high reliability Low latency, multicast, quality of service, and measurements.

## **3.1.2CANADA**

Canada has been playing a significant role in the development of the Internet. Canadian networking infrastructure started in a major way with CANET, NTN and the current second generation CA\*net2. The CANARIE Inc. played a major role in most of the Canadian initiatives.

## **CANET2**

The ARDNOC- Advanced Research and Development Network Operations Center maintains the Canadian network infrastructure. The ARDNOC is also a research oriented institution involved in IP Telephony, Multicasting, and Video Conferencing. The CANET2 is a development parallel to the next generation internet of USA. It consists of 15 GigaPOPs and regional advanced networks (RANs). [\[canet99\]](#)

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## **3.2Europe**

In Europe a internet connecting the networks of all the nations first was initiated in the form of the TEN-34 which was replaced by the TEN-155. There are other networks connecting other regions of Europe which include the Nordunet connecting the Nordic nations , the MIRnet which connects the USA and the Russia.

### 3.2.1 TEN-155

TEN-155 is the pan-European research network. It acts as the current backbone for the European internet. The backbone consists of SDH circuits with ATM overlay. The maximum speed achieved is 155 Mbps. TEN-155 provides QoS in the form of Managed bandwidth services and it implements VPN-virtual private network with committed bandwidth between national research networks. It plays a major role in research activities of the European research community. [[ten99](#)]

### 3.2.2 TERENA

The TERENA - Trans European Research and Education Networking Association is involved in advancing networking infrastructure in Europe. The current major research projects are creation of an automated indexing system for information recovery and Computer Security. [[terena99](#)]

The following task forces are involved in research.

- TF-CACHE- The principle behind this task force is that the efficient caching mechanism can significantly improve the performance of the Internet. It aims to develop an organized caching mechanism for the entire Europe.
- TF-TANT – This task force determines the suitability of advanced networking infrastructure for the European networking research community.
- TF-STREAM – This task force aims in co-ordination of efforts in streaming media technology.

### 3.2.3 DANTE

The DANTE - Delivery of Advanced Network Technology to Europe Ltd. was set up by the ENRN-European national research networks to promote research interaction among the European researchers. DANTE and TERENA are involved jointly in many projects. [[dante99](#)]

The chief of the activities of DANTE include the QUANTUM project and the Q-MED project.

QUANTUM Project – This project aims in providing a uniform 155 Mbps connection to the entire Europe.

Q-MED Project – It aims to provide a connection from the national research networks of Israel and Cyprus to TEN-155.

CAPE Project – This project aims to interconnect the APAN with the Ten-155 directly.

### 3.2.4 European National Research Networks

ACOnet - Austrian Academic Computer Network in Austria

ARNES - Academic and Research Network of Slovenia in Slovenia

BELNET – Belgian Research Network in Belgium

CESnet in the Czech Republic

CYNET in Cyprus

DFN in Germany

EENet - Estonian Educational and Research Network in Estonia

GARR – Italian Academic and Research Network in Italy

GRNET - Greek Research and Technology Network in Greece



HEAnet – Ireland’s Academic and Research Networking Ireland

HUNGARNET in Hungary

IUCC - Israel InterUniversity Computation Center in Israel

LATNET – Latvian Network in Latvia

LITNET – Lithuanian Network in Lithuania

NASK - Polish Internet Operator in Poland

NORDUnet in the Nordic countries

DENet - Denmark Network (Denmark),

FUNET - Finnish University and Research Network (Finland),

ISnet - Icelandic network (Iceland),

UNINETT -Norwegian academic network for research and education(Norway),

SUNET - Swedish University Network (Sweden)

POL-34 -Polish Scientific Broadband Network in Poland

RCCN - Portuguese Network in Portugal

RESTENA -National Network for Education and Research in Luxembourg

RedIRIS-National Research Network in Spain

RENATER -Research Network in France

RUCC - Romanian National Network in Romania

SANET -Slovakian Network in Slovakia

SURFnet - National Computer Network in the Netherlands

SWITCH - Switzerland National Network in Switzerland

UKERNA/JANET/SuperJANET1,2,3,4 in the UK

MIRNET is a 6Mbps link between USA and Russia running on ATM for research collaboration between scientists in USA and Russia.

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## 3.3Asia

In Asia the countries doing research in the next generation internet have joined together to form many consortiums among themselves and with other countries in the pacific rim. These include APAN, APII and AJNC. The various countries involved are Japan, Korea, China, Malaysia, Singapore, Taiwan, Thailand and a host of other countries.

### 3.3.1 APAN

APAN-Asia Pacific Advanced Network is a consortium of many networks in the Asia Pacific region. The main exchange points for the APAN are located in Tokyo, Singapore and Seoul. The main function for the exchange points are to transfer ATM cells. All APAN members operate APs- Access Points at their own boundaries and connect individually to other global networks. The APAN research involves the following working groups Cache, IPv6, Multicast, Measurement, Multimedia, Satellite Internet, Security, Network design,Television and QoS.[[apan99](#)]

### 3.3.2 APII

APII -Asia Pacific Information Infrastructure – is a testbed which involves Korea, China, Japan and



Singapore. Its aim is to connect the national testbeds developed in the individual countries. The speeds are modest in the range of 2 Mbps. The research areas are Performance Measurement, Mbone establishment, RSVP Backbone Establishment, Network Management and long distance applications. [[apii99](#)]

### 3.3.3 Singapore

SingAREN [[singaren99](#)]

SingAREN - Singapore Research and Education Network is connected to the APAN, STARTAP. The maximum speed achieved so far is 622 Mbps. It uses ATM as its current transport technology. The technology groups are Multicast Tele-Traffic technology groups. It is involved in many research areas which includes many long distance applications, video services and QoS. [[ng98](#)] [[ngoh98](#)]

### 3.3.4 Japan

IMNET [[imnet99](#)]

IMNET – Inter Ministry Research Information Network is the research network for many government agencies. The research involved are electronic navigation, national aerospace, geographical survey, communications research and space program development.

MAFFIN [[maffin99](#)]

MAFFIN - Ministry of Agriculture, Forestry and Fisheries Research Network deals with global disaster warning systems.

SINET [[sinet99](#)]

SINET – Science Information Network. This network is connected at 10 Mbps to TEN-155 and at 150 Mbps to USA. This is the research network operated by NACSIS for the government universities.

WIDE [[wide99](#)]

WIDE – Widely Integrated Distributed Environment aims to establish large-scale distributed computing environment. The areas involved are in multicasting, QoS and in multifarious areas.

JAIRC [[jairc99](#)]

JAIRC - Japan Advanced Internet Research Consortium is a consortium of various research networks in Japan. It is connected to vBNS and Abilene at 70 Mbps. The chief among them is the Cyber Kansai Project. The major research areas are Internet broadcasting and video archive services.

NACSIS [[nacsis99](#)]

NACSIS - National Center for Science Information Systems : The research activities involved are in the field of video transmission, distributed architecture, databases and image processing.

### 3.3.5 Korea

KREN [[kren99](#)] (Korean)

Korea Education Network

PUBNET [[pubnet99](#)] (Korean)

Korea Public Sector Network for Internet

KREONet [[kreonet99](#)] (Korean)

Korea Research Environment Open Network

### 3.3.6 China

CERNET [[cernet99](#)]

China Education and Research Network has been established for development of national infrastructure.

CASNET [[casnet99](#)] (Chinese)

China Academy of Science Network

Nsfcnet [[nsfcnet99](#)]

Natural Science Foundation of China Network which aims to develop the China's first very high speed network for research purposes.

Cstnet [[Cstnet99](#)] (Chinese)

China Science and Technology network.

### 3.3.7 Hongkong

HARNET [[harnet99](#)]

Hong Kong Academic and Research NETwork – is a network for the research activities of eight tertiary institutions maintained by the Joint University Computer Center.

### 3.3.8 Malaysia

TEMAN [[teman99](#)]

Testbed Environment for Malaysian Multimedia Applications and Networking. The current maximum speed achieved is 155 Mbps. This research network is involved in Multimedia applications, Performance measurement.

### 3.3.9 Taiwan

TANET [[tanet99](#)]

Taiwan Academic Network is the research network developed by the National Center for High Performance Computing of Taiwan. The maximum speed achieved so far is 622 Mbps. The research projects going on are the FX-net Application System – a global weather monitoring system and telemedicine.

### 3.3.10 Thailand

THAISARN [[thaisarn99](#)]

Thai Social/Scientific, Academic and Research Network is the research network providing internet service to Thailand and simultaneously implementing hierarchical cache services by setting up cache/proxy servers at every organizational level. A total 112 Mbps of international bandwidth has been established.

## 3.4 Australia

### AARNET and AARNET 2

The Australian Academic and Research Network chiefly caters to the research needs of the Australian academic community. The research activities involved are in performance measurement, routing and caching and mirroring.[[aarnet99](#)]

### AJNC

AJNC - Australia Japan network link is a joint development of Australian and the Japanese governments. It operates at a speed of 1.5 Mbps with 768 kbps committed information rate.[[ajnc99](#)]

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# 4. Collaboration and Interconnection of Major Research Networks

## 4.1 CCIRN

The CCIRN - Coordinating Committee of Intercontinental Research Networking – provides a meeting place for all international networks to organize and implement a globally connected internet. The CCIRN consists of the following working groups Caching WG (inactive), Mbone WG, Measurement WG, Security WG and QoS WG. The Mbone WG is primarily concentrating on Multicast Border Gateway Protocol (MBGP) system. The other WGs are mainly involved in coordinating the research activities in other research networks around the world. [[ccirn99](#)]

## 4.2 OXYGEN

This is a major under-sea cable link project with a capacity of 2.56Tbits/sec on trans-oceanic segments. There are 76 countries involved in this project. The project's first phase is expected to be completed in 2003. The project is in the development stage. The chief feature of this project is nearly 90% of international telecommunications traffic is expected to be handled by this. There are to be three network management centers which will manage this network. The capacity of OXYGEN Network will be 320 Gbit/s per fiber pair. The long-haul links will each have eight fiber pairs at the maximum. Thus each of these links in the network will be capable of carrying 256 STM-64 traffic streams. [[oxygen99](#)]

## 4.3 STARTAP

STARTAP - Science Technology And Research Transit Access Point is being developed by the ANIR - Advanced Networking Infrastructure and Research division of the CISE - of NSF. STARTAP is developed to handle international vBNS connections. STARTAP is connected with the NAP [[nap99](#)] in Chicago and thus interconnects the world's major research and education networks. It is connected to APAN at 70 Mbps, to the CANet at 45 Mbps which will soon be upgraded to OC-3 speed. Further it is

also connected to MIRnet at 6Mbps, Nordunet at 45 Mbps, Singaren at 12 Mbps, SURFnet at 45 Mbps, TANET2 at 15 Mbps. vBNS at OC-12, NISN, NREN and ESNET at OC-3. [[startap99](#)]

## 4.4 TRANSPAC

TRANSPAC – Trans Pacific – is an initiative of the Indiana University to interconnect vBNS and Internet2 to the research networks in Asia through the STARTAP. The main research thrust of the TransPAC is in QBone. The TRANSPAC connects the APAN Tokyo-XP eXchange Point with STARTAP at 35 Mbps VBR-nrt. [[transpac99](#)]

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# 5. Third Generation Internet Initiatives

## 5.1 SUPERNet

SUPERNet is a wide area testbed which is composed of interoperating super-speed local networks. These networks are located in different corners of the USA and are connected by the HSCC. [[supernet99](#)]

- NTON II network – connects metropolitan areas on the west coast over four wavelengths, each with 10 Gbps capacity. It involves WDM, wavelength routing and optical amplification. It uses in-place commercial fiber. [[ntonc99](#)]
- HSCC (High Speed Connectivity Consortium) network connects cross-country sites and regional networks at 2.5 Gbps end-to-end. [[hsc99](#)]
- ONRAMP network involves advanced metropolitan area and regional access technologies. It aims to develop an integrated IP and WDM network. [[onramp99](#)]
- BOSSNET – Boston-South Optical Network – This network enables physical layer networking and communications experiments over multiple dark fibers. Its research activities involve developing the non-repeated optical network systems. [[bossnet99](#)]
- ATDNET (Advanced Technology Demonstration Network) testbed whose basis is multi-wavelength, reconfigurable optical networking technology. It is a SONET/ATM network testbed based on physical ring topology for SONET transport. It utilizes the technology developed by the MONET. [[atdnet99](#)]
- MONET – Multiwavelength Optical Networking testbed is the initiative of many corporations and US government agencies to develop transparent multiwavelength optical networking, which will serve as a forerunner of future national networks. Its main aim is to achieve high speed with minimum cost and to integrate base technologies with the latest technologies. [[monet99](#)]
- CAIRN – Collaborative Advanced Interagency Research Network testbed which facilitates collaborative research in new protocols and services such as RSVP, multicast, IPv6 and Integrated service models: packet scheduling and admission control. [[cairn99](#)]
- ABONE testbed, supporting Active Networking research which involves a large quasi-stable

virtual infrastructure to test the implementation of flexible active networks. [[abone99](#)]

## 5.2 CANET3

This is the 3rd generation initiative of the ARDNOC in parallel with the CANET2. The aim to developing a Canadian optical internetwork with 10 GigaPOPs. CANET3 uses IP directly over DWDM – Dense Wavelength Division Multiplexing without the intervening ATM and SONET technologies. The network can reach upto 40Gbps in speed . The critical feature of CANET3 is the "link layer". A connection of dedicated wavelengths which uses upto 32 different colors of light through a single optical fiber. The network spans over Canada from the west coast to the east coast. This is a network primarily built for Internet traffic and not the voice traffic. [[canet99](#)]

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## 6.Summary

Internet is moving from its current scenario with poor service and performance to a next generation Internet with advanced features. In this paper, the next generation Internet initiatives throughout the world have been described and their salient features explained. The second generation internet initiatives like Next Generation Internet , Internet2, Asia Pacific Advanced Networks and TEN-155 have been described. The third generation internet initiatives which will be the Internet of the future like the SUPERNet and the CANET3 have been described. These next generation Internet initiatives will lead to a faster and more efficient Internet in the future.

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- 52.[onramp99]ONRAMP- <http://www.ll.mit.edu/AdvancedNetworks/ngi.html>
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## 8.List of Acronyms

- 1.AARNet - Australian Academic and Research Network
- 2.AJNC - Australia Japan network link
- 3.APAN Asia Pacific Advanced Network
- 4.APII - Asia Pacific Information Infrastructure
- 5.ARDNOOC- Advanced Research and Development Network Operations Center
- 6.CANET2 - Canadian Network
- 7.CCIRN - Coordinating Committee of Intercontinental Research Networking
- 8.DANTE - Delivery of Advanced Network Technology to Europe LTD
- 9.DARPA- Defense Advanced Research Projects Agency
- 10.DOE-Department Of Energy
- 11.DWDM - Dense Wavelength Division Multiplexing
- 12.GigaPOP GIGAbit Point Of Presence
- 13.I2DSI - Internet2 Digital Video Network
- 14.I2DVN Internet2 Digital Video Network
- 15.IMNET Inter Ministry Research Information Network
- 16.JAIRC - Japan Advanced Internet Research Consortium
- 17.MAFFIN- Ministry of Agriculture , Forestry and Fisheries Research Network.
- 18.MREN- Metropolitan Research and Educational Network
- 19.NACISIS - National Center for Science Information Systems
- 20.NAP Network Access Point
- 21.NASA- National Aeronautics and Space Administration
- 22.NGI - Next Generation Internet
- 23.NIH-National Institutes of Health

- 24.NISN- NASA Integrated Services Network
- 25.NIST - National Institute of Standards and Technology
- 26.NLANR - National Laboratory for Advanced Networking Research
- 27.NREN-National Research and Educational Network
- 28.NSF - National Science Foundation
- 29.QoS - Quality of Service
- 30.SINET Science Information Network
- 31.STARTAP - Science Technology And Research Transit Access Point
- 32.TERENA - Trans European Research and Education Networking Association
- 33.UCAID - University Corporation for Advanced Internet Development
- 34.VPN - Virtual Private Networks
- 35.WIDE - Widely Integrated Distributed Environment

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## 9.Appendix A - Glossary

- 1.NAP - Network Access Point - NAP is a meeting point of ISPs for the exchange of routing information and data packets. It is a ISO-OSI datalink layer interface.
- 2.GigaPOP - Gigabit Point of Presence - A GigaPOP is a regional data transfer center that efficiently transfers huge amount of data between regional, national and other networks. Because this "point of presence" (or POP) connects with the high-performance gigabit networks to transfer data, it is commonly referred to as a "GigaPOP". It is an exchange point like the NAP but it operates on the ISO-OSI network layer where the Internet Service Providers meet their customers. A GigaPOP performs aggregation of traffic and thus provides a better quality of service and multiple services with a single provider.
- 3.NGIX - Next Generation Internet eXchange points - These are the three high performance inter-exchange points for the NGI effort built in east coast, midwest and the west coast of US. The NGIX will support both IP and ATM level traffic exchange.

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Note: This paper is available on-line at <http://www.cis.ohio-state.edu/~jain/cis788-99/testbeds/index.html>