Assignment 1 for CSE232

Notes on Existing Networks

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Abstract :

This assignment explores the evolution and impact of the Internet, beginning with its historical development from early communication networks to its current global status. It covers the establishment of ERNet in India, detailing its role in improving connectivity for educational and research institutions. The note also examines the Local Area Network (LAN) at IIITD, focusing on how it supports internal communication and connects to global networks. Finally, it proposes an innovative future application, highlighting emerging technologies and their potential to address current challenges or create new opportunities.

1 The History of the Internet

The Internet started as a simple experiment to help the U.S. government institutions to share information more efficiently. In the late 1950s, after the Soviet Union launched Sputnik into orbit, and the Cold War became more intense, fears in the U.S. grew that the Soviets might target and attack the country's telephone networks, which could disrupt and may even cripple long-distance communication forever. Also, at the time, computers were bulky, stationary machines, and the only way to transfer data between two computer systems was by mailing magnetic tapes, a method that was slow, inconvenient, and impractical for transferring large amounts of data over longer distances. These challenges necessitated finding a better way to communicate across the country.

A scientist at ARPA (Advanced Research Projects Agency Network) by the name of J.C.R. Licklider proposed a "intergalactic network" of interconnected computers as a solution to this issue in 1962. Government officials could stay in contact with each other even if the Soviets destroyed the telephone network thanks to such a network.

This need eventually led to the creation of ARPANET, short for the Advanced Research Projects Agency Network, the earliest precursor of the modern Internet. The use of ARPANET was initially only reserved for academic and research institutions connected to the U.S. Department of Defence. While the network was a big success, it was still only available to a small group of users and was not widely available. The creation of ARPANET, however, marked the beginning of the Internet as we know it today. Eventually, it would further evolve through different phases driven by major technological advances over decades.

Probably the most important technological development was the concept of packet switching, evolved in the early 1960s. At that time, the world relied on telephone networks that used circuit switching, which worked well for voice calls but wasn't great for the kind of data traffic generated by computers. Packet switching, a more efficient way to send data, was explored by researchers like Leonard Kleinrock at MIT and, separately, by Paul Baran at the Rand Institute and Donald Davies and Roger Scantlebury in England. Welsh Scientist Donald Davies pioneered the creation of packet switching. In packet switching, Data is sent to its destination after being divided into blocks, or packets, via packet switching. Each packet can then travel its own path from one location to another. Had packet switching not been implemented, the computer networks at the time would have been as open to hostile attacks as the phone system were. Their work set the stage for modern networking, and in 1969, ARPANET became the first packet-switched network, connecting four nodes : UCLA, Stanford Research Institute, UC Santa Barbara, and the University of Utah. By 1972, ARPANET had expanded to 15 nodes, and Ray Tomlinson introduced the first email program.

Only four computers were linked to the Arpanet by the end of 1969, but during the 1970s, the network's size gradually increased. It added the University of Hawaii's ALOHAnet in 1972, and the Norwegian Seismic Array and University College in London networks followed a year later. But as the number of packet-switched computer networks increased, it became harder for them to come together to form a single global "internet".

By creating a way for every computer on every mini-network in the globe to speak with every other computer, computer scientist Vinton Cerf started to tackle this problem in the middle of the 1970s. He dubbed his creation TCP, or "Transmission Control Protocol".Subsequently, he included "Internet Protocol," another protocol. These days, we refer to these by their abbreviation, TCP/IP. As "the 'handshake' that introduces distant and different computers to each other in a virtual space," one writer puts Cerf's protocol. Moreover, the fact that commercial networks also started to spring up, like Telenet and Cyclades, further extended the potential of computer networking. A very important milestone in the history of the internet was reached with the creation of TCP/IP protocols. In these protocols, data delivery was clearly separated from data forwarding. TCP/IP became a major foundation of the Internet.

In the 1980s, the Internet continued to grow even more rapidly ; this was evidenced by the fact that by the end of the decade, more than 100,000 computers connected to the net. This growth resulted partly from connections between many of the universities using networks like BITNET, CSNET, NSFNET, and many others.

NSFNET also became a backbone of the internet along the way. A big change came in 1983 when TCP/IP took over from an older system called NCP. This was a consequential development. Also, at the same time, the Domain Name System (DNS) was developed, which facilitated surfing and navigation through the internet.

The 1990s was the decade of transformation for the Internet. The ARPANET was put out of use, and fledgling commercial ISPs started to take form. But perhaps the most innovative creation during those years was the World Wide Web, developed by Tim Berners-Lee at CERN between 1989 and 1991. The Web swept the Internet into homes and businesses and enabled new applications such as search, e-commerce, and social networking. By the mid-1990s, the internet had become a household platform and was more popular than ever before, with browsers like Netscape simplifying "surfing" on the Internet. At about this time, many applications, like email, Web browsing, instant messaging, and peer-to-peer file sharing, started gaining popularity. The Internet, as it entered the 2000s, kept changing at an incredible pace. The arrival of broadband, dissemination of WiFi and 4G networks, and massive growth in cloud computing gave fillip to it. Social media sites such as Facebook, Instagram, and Twitter started to make their presence felt in the beginning of 2000 and changed the way people used to communicate, generate content, and share it. By 2005, Online social media networks were being used by more and more teenagers. By around 2015, more people accessed the internet from smartphones than from other kinds of computers. By the 2020s, enterprises like OpenAI, Google, Microsoft, amongst others, made advanced AI systems accessible to the public. The story of the Internet is, in many ways, a story of dynamism and evolution. It started as just a research project and grew to what none of its creators ever imagined. The internet today is such a large network, covering almost the whole globe, all continents, and interconnects people numbering billions with each other all the way. It has changed our life, the way we work and how we communicate with people.

2 The development of ERNet in India

2.1 History

ERNET India, or Education and Research Network of India, is an autonomous society under the Ministry of Electronics & Information Technology, Government of India. Its members are chosen from premier academic and research institutions across India, government organizations, and research bodies. It is a non-profit organization that brought the internet to India in 1986 with funding support from the Government of India and the United Nations Development Program. The organization's vision was to advance Indian research and education by providing state-of-the-art communication infrastructure and enabling nationwide access to information sources and international databases.

The project was initiated to cater to the need for an efficient, economical, and effective way to share information and resources among various research and educational institutions in the country. It initially connected five major cities—Delhi, Mumbai, Kolkata, Chennai, and Bangalore—and in its first avatar, ERNET involved eight premier institutions as participants, including the Indian Institute of Science (IISc), National Centre for Software Technology, five Indian Institutes of Technology (IITs), and the Department of Electronics (DoE). Its first task was to set up a Local Area Network (LAN) and then connect the LANs of various institutions using a Wide Area Network (WAN).

2.2 Architecture

ERNET is based on the TCP/IP (Transmission Control Protocol/Internet Protocol) protocol. ERNIC provides Internet Protocol (IP) address space (both IPv4 and IPv6) and in-addr.arpa domain delegations to its customers. The various activities performed by ERNIC include :

— Allocating IPs to various Points of Presence (PoPs) and users (terrestrial as well as SAT-WAN).
— Collecting information about administrative and technical contact persons from each customer location and creating NIC handles for them.
— Updating information about `inetnum` objects (the range of IP address space described by the object) in the APNIC database.
— Coordinating with various PoPs for creating reverse DNS zones on name servers and registering the reverse domains with APNIC.
— Taking appropriate actions on complaints received regarding any illegal usage of internet resources.

2.3 Services

ERNET provides access services, application services, hosting services, and operations support services.

— Application services include email hosting, domain registration, and MPLS VPN.
— IT consultancy and project management services for the establishment of IT infrastructure and converged network projects.

2.4 Projects

ERNET has several ongoing and past projects. Here are a few examples :

— **Virtual Classroom :** ERNET India implemented and operated smart virtual classroom facilities in 3204 government-owned/controlled schools as part of the Digital India initiative.
— **High-Speed Network Connectivity :** A "Free Space Optics Communication Technology (FSOC)" based link was established between Kohima Science College and Kohima Secretariat, Nagaland.

— **E-learning Centres :** Integrated LANs for e-learning centres at schools.
— **LiFi Experimental Testbed :** Light Fidelity (LiFi) is emerging as a complementary technique using intensity-modulating LED lights to realize networked wireless systems—a light-based WiFi.
— **Vocational Centers :** Proposed to implement vocational centres in 100 locations across the country. Spastics and physically impaired children are also covered in this phase.
— **ICT Centres :** Information & Communication Technologies (ICT) centres in approximately 247 schools located in rural areas of Ajmer/Jaipur in Rajasthan, with the objective of delivering state-of-the-art ICT infrastructure models in schools for future replication.
— **E-learning Collections :** Digitization projects of free-to-read searchable collections of about 1 million books funded by the Indian Department of IT.
— **CIV-VV :** The project facilitates various services such as e-mail, access to various socio-economic databases, e-newspapers, e-procurement, grievance redressal, and weather information.

2.5 Present

ERNET India has its headquarters at Electronics Niketan, New Delhi, and its regional centre at the Innovation Centre, Society for Innovation and Development (SID), in the Indian Institute of Science campus (IISc). The services of ERNET are being used by 80,000 users from 700 organizations representing various R&D labs and thousands of academic institutions in various sectors, namely health, agriculture, higher education, schools, and science & technology. It provides web accessibility services, campus Wi-Fi services, and connectivity to various institutions in the country and has built up national capabilities in the area of networking, especially in protocol software engineering. ERNET India serves in the areas of ICT project consultations, terrestrial and VSAT networks, domain registration for education & research institutions, web hosting services, setting up smart virtual classrooms/digital classrooms, including high-resolution e-classrooms for medical colleges/hospitals, and Eduroam services for educational institutions. The ERNET network uses AS number 2697 and for BGP peering with external networks.

3 IIIT-D LAN & How it Connects to Rest of World

LAN

Local Area Network (LAN) refers to the collection of devices connected together in one physical location like an office, building, institution, etc. IIIT Delhi's LAN network provides connectivity to the entire campus due to its advanced network infrastructure.

Network Backbone

The redundant 10-gigabit fiber backbone network ensures rapid data transfer across all campus areas, including hostels, faculty blocks, administrative block, library, classrooms, and residences.

Reason : The redundancy in the backbones helps to ensure that there is no interruption in network service. If any link or component fails, another takes over to ensure no fault or failure to the transmission. The 10-gigabit fiber optic connections provide enough bandwidth to support the vast data transfer required for academic and research activities.

Access Layer

The access layer consists of layer 2 and 3 switches providing 1 Gbps connectivity to end-users, enabling high bandwidth availability up to individual network points. Layer 2 switches manage data within the same network segment using MAC addresses, improving performance by reducing traffic. Layer 3 switches use IP addresses to route data between different segments for efficient communication across the network. This setup ensures a high-speed and reliable network for both students and faculty.

Wireless Network

The extensive wired network is complemented by a wireless network with more than 200 access points across the campus to ensure connectivity. However, some areas, like the sports ground, still lack Wi-Fi coverage, which is a drawback of the wireless network.

Internet Access

The institute has high-speed internet connectivity via a 1Gbps leased line from the National Knowledge Network (NKN). A 100Mbps backup line is available to ensure continuous internet availability in case the NKN line fails.

Data Center

IIIT Delhi has its own Data Center, which includes over 40 servers and a network unified storage system with a 45.3 TB capacity. The data center is powered by redundant UPS backup to ensure maximum uptime. All servers are connected to the Internet using public IPs.

Software

The institute primarily focuses on using free operating systems like Ubuntu, but it also has licenses for Microsoft Windows, RHEL, and Microsoft Office to meet various requirements.

IP Telephony

The campus has IP telephony, featuring 115 IP phones and over 100 analog phones.

VPN Access

A VPN service is provided to allow access to IIIT Delhi IT resources from outside the campus through an application called FortiClient VPN. IIIT Delhi has its own /24 public IPv4 address block and a /48 IPv6 address block. The institute is actively working towards becoming an IPv6-enabled campus.

Network Security

User Authentication : Access to the network requires authentication. Students use a firewall login for internet access, while faculty and staff have different access mechanisms.

MAC Address Registration : All devices connecting to the network must have their MAC addresses registered with the IT Department.

Monitoring and Logging : The IT Department maintains logs of internet access for at least three months, as required by government regulations.

IIIT Delhi IT Team

The IT team maintains this high-speed, reliable network 24/7. They regularly upgrade the firewall to ensure stable connections and security. Last year, they shifted the servers in the data center to a renovated part of the installation to improve network speed and stability. Their ongoing efforts aim to provide state-of-the-art network infrastructure to IIIT Delhi students and faculty.

Conclusion

IIIT Delhi's LAN infrastructure showcases the institution's commitment to providing a world-class environment for education and research. The robust, high-speed network enables seamless communication, access to vast information resources, and supports advanced computational tasks. While there's always room for improvement, such as expanding Wi-Fi coverage to all areas of the campus, the current infrastructure positions IIIT Delhi as a leader in technology education and research.

4 New, Innovative & Useful Applications in Future

4.1 Global Seeding for Every Download

Seeding is a key notion in peer-to-peer (P2P) networks, such as torrents, as it helps to improve download speeds and reliability. Seeding makes a file more accessible by enabling users who have downloaded it to share it with others. A creative application might establish a Universal Seeding Network that increases the effectiveness of downloads on multiple platforms.

This program would incorporate the idea of seeding into every digital download, independent of the source or type of material. The system would enable users to automatically share (seed) files they download, be it a game, software update, or a large paper, with other users who are also downloading the same content. Everyone participating benefits from a speedier and more dependable download procedure as more users engage in seeding. This would shorten the time it takes to locate the ideal file to download from peer-to-peer networks like torrent.

4.2 Autonomous Distributed Service Networks (ADSN)

A network architecture that might build a self-managing platform for service delivery by utilizing machine learning (ML), artificial intelligence (AI), and other technologies. Establishing conditions that would allow services to be optimized autonomously and to grow without requiring human involvement.

Real-time service scaling should take into account the current network traffic and user needs. The network might anticipate demand spikes and then automatically assign resources to satisfy those needs by evaluating real-time data. For instance, if there is an unexpected rise in viewers during a live event, the ADSN may automatically handle it by providing more bandwidth without interfering with other network functions.

4.3 Distributed Personal Cloud Infrastructures

This can enable people to unite their different gadgets into a decentralized network, enabling them to establish their own personal cloud environments—similar to building your own server.

This network would operate independently of a central server or outside supplier, much like current cloud services. Rather, every device within the network would participate in the distribution, processing, and storing of data, increasing the overall system's security and resilience.

4.4 Next-Generation Streaming Platform with Adaptive Encoding and HEVC

The objective is to develop a video distribution system that optimizes according to user devices, network conditions, and content type.

Using HEVC and other cutting-edge codecs, this platform would dynamically select the optimal encoding parameters to give the best video quality at the lowest bitrates. Real-time network circumstances analysis by the system would allow it to modify the encoding process and guarantee buffer-free playing even on low-bandwidth connections.

4.5 Edge Computing in Real-Time for Smart Cities

By bringing data processing closer to the point of generation, edge computing lowers latency and uses less bandwidth. Edge computing may allow for the real-time processing of data from sensors, cameras, and Internet of Things (IoT) devices in smart cities. This would facilitate prompt decision-making in vital areas such as energy distribution, public safety, and traffic management. For instance, emergency services could react more quickly to situations picked up by surrounding sensors, or traffic lights could change in real-time in response to current traffic circumstances.

4.6 The Objective and Prospective Course of Self-Healing Network Architectures

The goal of self-healing network topologies is to create networks that are capable of automatically detecting, diagnosing, and correcting faults without the need for human intervention. These systems would combine advanced AI and machine learning with network management to use predictive analytics to spot potential issues and take prompt corrective action.

Building incredibly resilient networks that minimize disruptions and downtime and ensure continuous operation even in the face of attacks or failures is the aim of the future. Self-healing networks will increase the dependability and effectiveness of critical infrastructure, such as financial systems, cloud services, and telephony, by enabling adaptive, automatic solutions to emergent defects.

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