COMPUTER NETWORKS (CSE232) ASSIGNMENT 1

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A) History of Computer Networking and the Internet

Packet switching development: (1961-1972)

- **Packet Switching Invention:** By Leonard Kleinrock of MIT, Paul Baran of the Rand Institute, and Donald Davies/Roger Scantlebury of the National Physical Laboratory, England, laid the basis of today's Internet.
- **ARPAnet**: First Packet Switched Network by ARPA grew to 15 nodes in 1972. Key applications like Email were developed during this time.
- **First Experiment on Networked Computers**: The first experiment on wide-area computer networking was conducted in 1965 by Lawrence G. Roberts and Thomas Merrill. They connected a TX-2 computer in Massachusetts with a Q-32 in California using a low-speed, dial-up telephone line.

Proprietary Networks and Internetworking: (1972-1980)

- **Standalone Networks**: ALOHANet, DARPA's packet-satellite/ radio networks, Telenet, Cyclades, Tymnet, and IBM's SNA.
- **Internetting Concept**: Vinton Cerf and Robert Kahn designed TCP, UDP and IP to internetwork different networks.
- **X.25 Standard**: Way back in 1976, a standard for packet-switched communication over public networks was developed, influencing future networking technologies.

A Proliferation of Networks: (1980-1990)

- **University Networks**: BITNET, CSNET, and NSFNET connected many universities and research centres.
- **TCP/IP Standardisation**: Adopted formally on January 1, 1983, which replaced NCP.
- **DNS Development**: Human-readable Internet names are now possible.
- **Minitel in France**: A successful data networking project offering a variety of services.
- **EUNet**: Launched in 1982, EUNet provided email and Usenet services across European countries, expanding global connectivity.

The Explosion of the Internet: (1990s)

- **World Wide Web**: Invented by Tim Berners Lee, 1989-1991 led to growth in Web-based applications in Search Engines, e-commerce, and Social Networks.
- **Web Browsers**: GUI Browsers from Mosaic Netscape, Popularised the Web
- **Key Applications**: Email, web browsing, Instant Messaging, and peer-to-peer file sharing became the major Internet applications.
- **Financial Boom and Bust**: Many Internet start-ups went public, leading to a market crash in 2000-2001, but key companies like Microsoft, Cisco, Yahoo, eBay, Google, and Amazon did very well.
- **Search Engine Wars:** The '90s were filled with high-praised contests amongst search engines like AltaVista, Lycos, Yahoo, and later Google. These companies fought for a prime position in shaping how information is retrieved over the Internet today.

The New Millennium:

- **Broadband and Video Applications**: Cable modems, DSL, and fibre enabled services like YouTube, Netflix, and video conferencing.
- **Wireless Networks**: High-speed WiFi and 4G networks that enabled constant connectivity and location-specific apps like Yelp and Tinder.
- **Social Networks**: Facebook, Instagram, and Twitter built big networks of users and APIs for new apps.
- **Private Networks**: Google, Microsoft, amongst others, built private networks to improve the speeds of their services.
- **Cloud Computing**: Amazon EC2, Google's Application Engine, Microsoft Azure etc. provided scaled environments and high-performance networks.
- **The Mobile Revolution**: The introduction of the smartphone, in particular the iPhone in 2007, rewrote the landscape of the Internet and created mobile computing as a dominant means of personal and business communications.

(Source: Jim Kurose, Keith Ross: Computer Networking: A Top Down Approach, Pearson India, 7th Ed)

B) The development of ERNet in India

Initiation and Objectives: ERNET was initiated in the year 1986 by the Department of Electronics, now DeitY, with support from the UN Development Program. This project had the prime objective of linking all the premier institutions in India, such as IISc, the National Centre for Software Technology, and the five IITs, so as to provide an ideal setting for collaborative research and development in the area of computer networking.

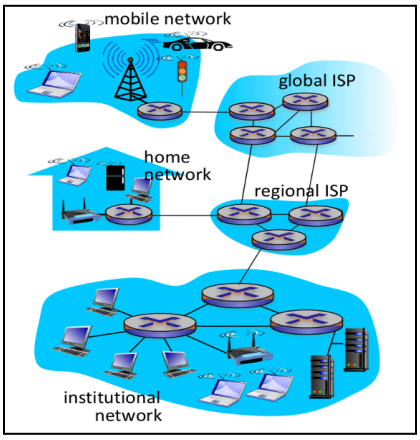
Early Developments: The first attempts were to develop a LAN at each of these institutions and, subsequently, to connect these LANs at the institutions under a WAN (Wide Area Network) environment, thereby forming an inter-institutional connectivity. ERNET introduced email services in India using the Unix to Unix Copy Protocol (UUCP), a predecessor to the currently used TCP/IP, thus helping Indian researchers to connect with their peers around the world. Setting up an email server was a breakthrough since it was a first-of-its-kind in the country, and laying the groundwork was an arduous task, involving laying more than a kilometre of Ethernet cables, some of them running underground, that connected the systems in different departments.

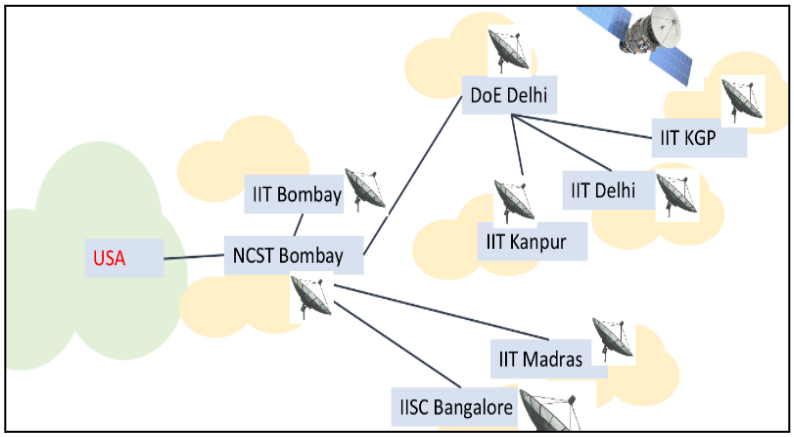
ISP Evolution: By 1992, ERNET had evolved into India's first Internet Service Provider, offering Internet access to universities. In 1995, this service was being offered to the general public in conjunction with VSNL (now Tata Communications).

"Official" Success of ERNET in India and its transition to ERNET India: In 1997, the final project review was done and the expert panel concluded that the project was a success, with UNDP praising the project as one of the most successful initiatives it had funded. ERNET turned into ERNET India in 1998—an autonomous society under DeitY.

Results: ERNET connected the country with internet connectivity, trained a generation of networking professionals, and laid the foundation for many more technological advancements in times to come. It significantly contributed to India's technological infrastructure and expertise in networking. Currently, ERNET India serves more than 1300 Institutions across the country and apart from providing Internet services, it also provides consultancy, project management and value added services like web hosting and email services.

(Source: ERNet, Research Matters, FactorDaily, Wikipedia, Lecture 1: Introduction, Lecture 2: Internet Architecture)





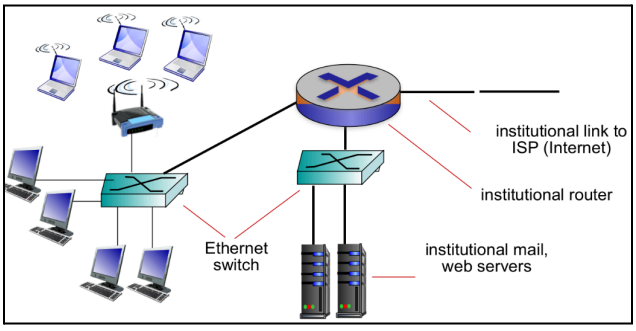
C) IIITD LAN, and how it connects to the rest of the world

- The IIIT-Delhi campus uses state-of-the-art technology to meet the Institute's computing and communication needs. It has a fast, reliable and rugged Computer Network of more than 500 nodes.
- The Local Area Network (LAN) at IIIT-Delhi extends to all the hostels, faculty blocks, administrative blocks, the library, and classrooms via a 10-gigabit fiber backbone network.
- These architectures do not lag in speed, and it offers 1 Gbps access at the end user. The network resources are highly available, and the network resources are assured of continuous connection through a dedicated LAN connection available in every hostel room.
- The leased line by the National Knowledge Network is saving the campus with the speed of 1 Gbps, which is resilient and fast in matters of data transfer. It is also supported by a fail-over of 100 Mbps to remain connected in case any problem arises in the mainline.
- The wired connections are also complemented by a wireless network of 129 access points that provide an enormous amount of Wi-Fi coverage throughout the campus.
- Moreover, IIIT-Delhi has one commissioned data centre hosting 40 servers and 45.3 TB of network unified storage, supported by redundant UPS systems for continuous operation.

- The institute also has its own IPv4 and IPv6 address blocks. IP telephony is implemented across the campus with support for analog and IP phones.
- IIITD provides DHCP services within all its VLANs to allow clients to automatically configure their IP addresses in their MAC addresses. Devices with which an installation is done on campus must have MAC addresses of their devices submitted to the IT Department. However, the use of static IPs or installation of a DHCP server without express permission from the IT Department is not allowed within the IIITD VLANs, as it may disrupt normal operations.
- The access to the services on every port is open and made available through NAT implemented on the IIITD firewall. VPN connectivity for most of the common protocols is also enabled at the firewall. Regular logging is done to ensure safety.
- It is strictly forbidden to link in other ISP networks into the IIITD LAN without explicit permission from the IT Department. If allowed, due to research or operational necessity, it is the absolute responsibility of the faculty in charge to completely firewall the outside network from the IIITD VLAN for both inward and outward connections.
- In the academic area and student hostels, no Wi-Fi routers can be installed without prior explicit permission from the IT Department. Users are required to connect through the authorised list of IIITD Wi-Fi SSIDs for Wi-Fi Access

The IIIT-Delhi campus connectivity infrastructure is crafted in a manner that ensures establishing a robust connectivity bridging on-campus computers and the far-reaching Internet, thus facilitating applications of research, education, and global communication.

(Source: IT Infrastructure, IIIT Delhi, Lecture 2: Internet Architecture, Student Handbook, IIITD Internet Usage & Privacy Policy)



Virtual and Augmented Reality Networking

Virtual reality is an emerging technology that presents a computer-generated simulation of an environment that can be interacted with somehow in the apparent real-time way. Since then, the sphere of the implementation of this technology has significantly expanded. With increased maturity, however, the overall feasibility of virtual reality for educational use increased as well. However, with such a fast pace at which the technology is developing, the educational field is facing problems when it comes to keeping up with the steps of evolution; hence, we believe that the implementation of VR in education will be revolutionary and help provide the means of education to all, even to students based in remote areas.

Wireless networks play an important role in making VR much more accessible and effective for educational setups. Though such networks provide normal infrastructure for seamless connections, still a host of other educational benefits can be derived from it, far beyond the traditional classroom-based learning methodology. This is how wireless networking can help facilitate VR in education:

1. Eliminating Physical Constraints: Wireless networks eliminate the need for clumsy connections bound by wires and enable students to immerse themselves in VR without being tethered physically to one place. This flexibility is more than favourable to disciplines that require participation and physical activity within the discipline, such as physical education, architecture, and vocational training.

2. Scalability and Flexibility in Educational Settings: Wireless network infrastructures give unmatched scalability that helps educational institutions in scaling their VR installations without the problems associated with installing and maintaining large wired networks. Especially in large classrooms, lecture halls, or multi-room setups, many VR devices may be running at the same time. Another important aspect of wireless networking is that it is scalable and can help in making the scale-up of pilots of VR programs in schools and universities much easier and get more and more students access to modern tools of education.

3. Increased Learning Outcomes Through Immersion: In VR, students are exposed to educational content in very immersive ways, which also help in improving comprehension and retention. For example, medical students can practise surgical procedures in a virtual setting and gain practical experience without real exposure to actual practice. Such immersion, tied

with wireless connectivity, favours deeper learning and has the capability to enhance technical and soft skills in an advanced way.

4. Bridging the Educational Divide in Remote Areas: Perhaps one of the most revolutionary aspects of wireless networks in VR education is their ability to reach students in remote areas. For these students, educational resources that are traditional in nature, such as textbooks and in-person labs, are out of reach due to geographical, economic, or sometimes infrastructural limits. With the help of wireless networks, VR content can be delivered directly to the learners' homes or to centres in their communities, which gives them equal chances to learn.

5. Interactive and Collaborative Learning: Students from all over the world can now meet in a virtual classroom to take a course in environmental science, visit an ecosystem, and reciprocally teach their observations as one does in a physical classroom. It is the level of interactivity far surpassing anything afforded by more traditional online learning spaces, such as YouTube, which for all intents and purposes represents little more than simple passive consumption.

6. Support for Advanced Educational Technologies: The developed and newest wireless technologies, particularly Wi-Fi 6 and 5G, were extremely important in delivering the high data throughput and low latency that VR applications require. These technologies enable smooth and uninterrupted VR experience, which helps retain the level of immersion important for successful learning.

7. Cost-Effectiveness and Ease of Deployment: By making the deployment of VR in the educational setting easier and cheaper, the wireless networks have thus increased the chance of more and more schools and universities having VR labs set up faster with very little financial investment in total that is required for infrastructure and cabling.

Wireless networks drive the need for the integration of VR into the classroom, allowing mobility and scalability, and provide technological support in the measures required to offer students immersive experiences in interactive learning environments. Such networks are of critical importance in remote areas because they allow pupils to be able to access high-quality education in ways that were impossible before. Therefore, wireless-enabled VR has a tremendous potential to revolutionise the process of education, make it more engaging and effective through greater means of learning access; it can be more interactive and impactful, in general.

Steps to deploy VR in Education:

The following steps can help the educator ensure the VR content aligns with the curriculum and learning objectives:

Define learning objectives: Articulate clearly what specific learning objectives the VR experience is to address. It identifies knowledge, skills, or competencies students are expected to acquire or demonstrate with the help of a VR activity.

Curriculum integration:

Identify subject areas that are relevant so the VR content can be beneficial to student learning. Ensure that the VR activity links to the curriculum's scope and sequence.

Seek inexpensive solutions:

Find affordable VR hardware, or software platforms within your budget. Otherwise, more affordable than the most advanced settings in VR are also standalone VR headsets or mobile VR solutions.

Cooperate with academic institutions, technology companies, local communities to share resources or aggregate funds, or to solicit grants that can subsidise the financial expense that a school or university cannot afford on its own in creating VR for education.

Pilot testing:

Pilot testing can be done on a small scale by just a few learners or teachers before deploying the VR content at scale. One can observe if the VR indeed supports what was intended for the learning outcomes. Take feedback from the students about the same. Based on what comes out of pilot testing, make adjustments or modifications to that VR.

Ongoing reflection and iteration:

Keep reflecting on how effective the VR content is, whether it is well-matched to the curriculum, and how it can be improved or changed based on the feedback from students, educators, and others. In the context of making it relevant and effective as a support to the curriculum, VR content shall be updated and upgraded on an ongoing basis.

(Sources: Research Gate, MDPI, Immersionvr, HP)
