Emerging Technologies

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Abstract

Phenomenal advancements have taken place in the field of Information and communication technologies in the last decade. Spectacular and innovative changes are expected to take place in these fields in coming decade. Networking technologies are going through a sea change. This paper enumerates the likely networking technologies which are emerging, particularly WLANs. Most of the personal communication in the country will be through cellular/ mobile technologies, which are also covered in the paper. Impact of mobile communication on possible wireless libraries is brought out. Economic and social changes are bound to give a fillip to online or e-education using Web based technologies. The need for correlation and comparison of data from distributed sources is giving rise to new discipline of virtual data warehousing. These topics too are briefly covered in this paper.

Keywords : Backbone network, Access network, optical wireless, e-education, virtual data warehousing.

0. Introduction

This is the era of Information and Communication technologies. Information explosion has necessitated the need to devise new means for transporting huge information over long distances in shortest possible time. Newer networking technologies are emerging. To accommodate bigger bandwidths, there is a visible shift from Radio frequency spectrum to optical frequencies. Wireless/ mobile communication is fast coming into vogue. The day is not far when students, using their PDAs or laptops will be accessing library databases giving rise to wireless libraries. As Internet reaches the corners of the country, e-education using Web based technologies will play a vital role in educating the masses, who do not attend formal schools or colleges. The concept of data warehousing and data mining is fast changing and soon there will be virtual data warehouses.

1. Network Technologies

There is world wide demand for broadband communications, which is ever increasing at a fast rate. A data communication network basically consists of two main components viz. i) Wide Area Network (WAN) and ii) Local Area Network (LAN). These two networks are distinguishable from each other by the physical area they encompass. A WAN is used for inter-city, inter-country or inter-continental communication. On the other hand, a LAN is used for connecting computers in a building, a university campus i.e. over a comparatively smaller area. Inter-continental traffic is carried either through satellite links or through under sea submarine cables. In this paper, I am limiting the discussion to emerging technologies for communication within a country like ours.

A wide area network can be established through i) satellite communication, ii) terrestrial communication or iii) a mix of these two. Satellite communication is best suited for remote and inaccessible locations and has many plus points. But its biggest draw back is its inability to sustain very high data rates. Due to technological advancements, VSATs having high data rate capabilities are coming in market, but the main limiting factor is the non availability of sufficient satellite transponder capacity. Another problem with satellite networks is " Latency". A one hop network has a latency of about 240 ms. More than 100 ms of

latency makes it difficult for e-scientists to do interactive visualization, simulation steering and collaboration. (1). Better option for very high data speeds is use of terrestrial optical fibre network.

For such a network, main elements are:

1. Backbone Network
2. Access Network

Backbone switches and routers are also important elements of a network, but they are not being discussed in this paper.

1.1 Backbone Network

A backbone network is the national transport network connecting various towns and cities in the country. India already has an extensive fibre based backbone network, mostly belonging to Bharat Sanchar Nigam Limited (BSNL). Many private companies have also started establishing their own fibre networks. Presently these networks are using Synchronous Digital Hierarchy (SDH) and or Wavelength Division Multiplexing (WDM) technologies. WDM products are still quite expensive though their costs are likely to come down by a factor of three in next few years. WDM technology multiplies the capacity of fibre by 10 to 40 times or even more. But since so much capacity is not required in the country today, most operators have postponed using it. SDH technology provides communication typically at 2.4 Gbps on a fibre, though 10 Gbps communication has now started to be used.(2).

In future, when the demand grows, Dense Wavelength Division Multiplexing (DWDM) technology can be adopted which will enable a single fibre to carry Tbps of information.

1.2 Access Network

Wireless local area networking has taken the world by storm. Wireless local area networks (WLANs) have quickly become extremely popular. People are avoiding expenses and delays associated with wired networks. The IEEE 802.11 series of standards define WLANs. They are providing increasingly higher access speeds with each generation. Initially wireless stations had a top speed of about 1 Mbps; today, wireless stations have a top speed of 54 Mbps. (3). Security is a major problem with WLANs. Anyone with a radio receiver can eavesdrop on a WLAN and similarly anyone with a transmitter can send messages to a WLAN. The IEEE 802.11 standard defines a data confidentiality mechanism known as Wireless Equivalent Privacy (WEP). Encryption mechanism is used in WEP but still it is not found foolproof yet. It was the establishment of the 802.11b standard by the IEEE that set the stage for mass market development of WLANs. A consortium of manufacturers renamed 802.11b as “Wi-Fi” (for wireless fidelity). (4). Another wireless networking standard that has received a great deal of publicity is Bluetooth. Bluetooth, like 802.11b networks, operates at a frequency of 2.4 GHz.The problem with using Bluetooth is its limited physical range and bandwidth, about 30 feet with a bandwidth of 2 Mbps. (In contrast, 802.11b has a range of 300 feet with a bandwidth of 11 Mbps.) Bluetooth has been designed primarily to connect various wireless devices together such as allowing your PDA to synchronise with your laptop or cell phone. Bluetooth is suitable for many applications but not for data networking purposes such as surfing the World Wide Web or accessing large files.(5).

The world wide demand for broadband communications is met in many places by installed single mode fibre networks. However, there is still a significant “last mile” problem, which limits the availability of broad band Internet access. Fibre optic networks exist world wide. With implementation of dense

wavelength division multiplexing (DWDM), the information carrying capacity of fibre networks has increased enormously. At least 10 Tb/s capacity on a single fibre has been demonstrated as of early 2002.This would allow simultaneous allocation of 10 Mbps each to one million subscribers on a single fibre backbone. The problem is to provide these capacities to actual subscribers, who do not have direct fibre access to the network. . Presently most subscribers are provided wired access to the network since fibre comes to Basic telephone provider's/ ISP's station. Twisted pair wiring may give subscribers network access at rates from 128 kbps to 2.3 Mbps, and access through Digital subscriber Lines (DSL) is limited to about 144 kbps. Cable modems can provide access at about 30 Mbps, but since multiple subscribers share a cable, simultaneous usage by many subscribers drastically reduces the data rates available to each. This bridging problem could be solved by laying optical fibre to each subscriber, but it will involve huge investment which subscribers will not be willing to pay. Optical wireless provides an attractive solution to the " last mile" problem, particularly in densely populated areas. Optical wireless service can be provided on demand basis without expensive infrastructure. Optical transreceivers can be installed in windows or rooftops of buildings and can communicate with local communication node, about less than 300 m away. In case of many high rise apartments, this distance can be less than 100m. These distances are kept small to ensure reliability of optical connection between subscriber and the node. (6).

1.3 Optical Wireless vs. RF Wireless

Wireless connectivity can be achieved either by RF links or by optical wireless links. RF spectrum is becoming increasingly crowded and demand for bandwidth is ever growing. Inspite of allocation of bandwidth in several gigahertz region, subscribers get only modest bandwidth in densely populated areas. Limited frequencies are available for line of sight RF links. In directional microwave point-to-point links, there is interference due to vicinity of RF antennae and their side lobes. In RF broadcast mode, all subscribers within a cell have to share the available bandwidth, cells have to be made smaller, and their base station powers are limited to allow spectrum reuse in adjacent cells. It limits the size of the network and the number of users. Optical wireless systems can be made highly directional; there are no undesirable broadcast side lobes, which exist in the case with RF links. Equivalent sized apertures of a microwave signal at 2 GHz has a diffraction angle about 100,000 times larger than a laser operating at 1.55um. Diffraction angle quantifies the magnitude of diffraction for an aperture of a particular size (e.g. a microwave dish antenna or optical telescope used to direct a laser beam). Diffraction is the ability of electromagnetic radiation to leak around the edge of apertures/ antennae, and to provide energy in regions of space, where there should be shadow. Further, the high carrier frequency, which for a 1.55 um laser is almost 200THz, provides about 100,000 times more information carrying capacity than a 2 GHz microwave signal. Unlike RF link, the spill over or scattering, of light at the receiver location is virtually immune to interception by a third party, providing a high degree of security for the optical link. The safety of OW communications systems for human eye have been studied and they are well within safety standards. The atmosphere is not an ideal optical communication channel. The power collected by a receiver of a given diameter fluctuates, which can increase bit errors in a digital communication link. But these can be taken care by properly designing the link, by using large enough receiver so that all of a transmitted laser beam is collected and directed to a photodetector. (6).

1.4 Portable / Mobile Networking

Two significant events have taken place in the last decade. One is the use of personal computers in networking and the other is the growth and increasing sophistication of wireless telephony. In June 2002, the number of mobile phone users worldwide reached one billion mark. (7). After nearly 100 years India has 41 million wireline telephones, but in less than last 10 years the number of mobile phones has reached 10 million.(8). The first generation (1G) of cellular mobile standard evolved in 1970's with an aim to provide voice telephony to mobile users. Here, Frequency Modulation (FM) and Frequency

Division Multiple Access (FDMA) was predominantly adopted as the multiple-user access technique. With the focus shifting to digital communication, second generation (2G) standard evolved to provide global connectivity for voice, data and fax transmission. (9). Most of the present mobile communication networks in the country use 2G technologies. Time Division Multiple Access (TDMA) is used by the Global System Mobile (GSM) operators where as WLL operators use Code Division Multiple Access (CDMA). Transition from 2G to 3G technologies was planned in a phased manner with the intermediate stage called 2.5 G technology. Here General Packet Radio Service (GPRS) is used by GSM operators and improved CDMA standard is used by WLL operators. Technologies of the Internet and mobile telephony have now started to converge, bringing promises of a new era of portable networking. In May 2003, Japan had nearly 63 million mobile Internet users. Japan was the first country to offer consumers access to 3G wireless networks based on Wideband Code Division Multiple Access standard in October 2001. These 3G networks allow transmission speeds of upto 384 kbps, opening the way to advanced audiovisual capabilities. By 2006, there are plans to roll out fourth generation (4G) networks, which will be 10 times faster. (7).

1.5 Wireless Libraries ?

Imagine a student coming out of his classroom and going to the library to find some books/ articles for a paper he intends to write. Going over to the study carrel, he opens his laptop and logs into the library network. Going to the library home page, he clicks on to the library OPAC. He carries out search for some books on his subject of interest and heads to the stack to get books on his topic currently available for loan. In the stacks, a library staff is taking books off the shelf and running some sort of a wand attached to a hand held computer over the inside of a book. He is doing inventory and shelf reading. A group of students are working on a class project and have their laptops out looking for magazine articles in the library databases. One student is using her Palm PDA and chatting with the reference librarian. She then walks to the stack to get a book suggested by the librarian, occasionally glancing at her PDA to confirm the call number. What is remarkable about this scenario? The students and the library worker are all using computing devices connected to the campus network and the Internet beyond. Yet there is not a wire in sight, no power cord, no network cable. All the individuals are completely mobile, empowered to consult network-based resources anytime they want, and from any place by a wireless network.

A wireless network enables a device to stay connected to wired network without a wire or a network cable. WLANs use access points to receive and transmit radio signals to and from user's computer or other devices. The user's device has a special card containing small radio transmitter and receiver. The access point is hard wired to the local area network (LAN) and via that to the Internet. WLANs allow users to roam without having to unplug a network cable from one jack and plug it into another. This is done by strategically locating access points to avoid breaks in coverage as the user moves around. Wireless devices can be put to good use by the library support and professional staff. They can use PDAs or laptops combined with bar code readers for shelf reading, inventory and other scanning. Wireless allows reference staff to roam around with full access to network and library resources. In fact, a wireless network does not stay wireless for ever. WLANs tend to eventually connect with the main campus network and the Internet through a wired connection somewhere along the line. So, while a wired network is necessary, a wireless network is a supplement. Wireless networks provide something wired ones can not: mobility. This mobility and the resulting flexibility it provides to the computer user are what make a wireless computing environment so attractive on campuses and in libraries. (5).

2. E-education

In this millennium, the technological advancements made in the last decade are creating new emphasis for educators on electronic information tools. Electronic means, like the Internet and Web, provide

educators new tools. Originally, the Internet was intended to be a network that would facilitate communication and collaboration among researchers and educators in universities, government agencies and industry. This is no longer the exclusive role of the Internet. Two growing roles of Internet are supporting electronic commerce and providing learning solutions for educational institutions. There are more people in the world than ever before who want education. This demand cannot be met simply by building more schools and training more teachers.

Electronic tools such as Internet support effective learning by allowing patrons to be self-directed, to learn at their own pace and to participate in diagnosing their own learning needs. Unlike traditional paper encyclopedias, electronic cyclopedias allow learners the opportunity to jump quickly from topic to topic in their quest to satisfy their informational and / or educational needs. Although traditional print cyclopedias also support this type of research, many learners consider clicking a hypertext link more inviting than switching between heavy and bulky encyclopedia volumes. The Internet allows learners to be in control of their pace (how much time they want to spend finding additional information).

Timing is very important for effective learning since students best utilize information when it is available at the time they are ready to learn. Some students learn best during the day while others learn best during the night. Students do not want their learning timings tied by educational bureaucracy. Internet technology can be designed to provide learners access to educational programmes and information twenty-four hours a day.

Another important aspect is that students are more engaged in the educational process when they are given the chance to be active, rather than passive, learners. Internet technology supports active learning through the use of diversified learning activities. With the right kind of equipment and instructional design, a student can actively learn by retrieving a full-text article, seeing a significant picture, hearing a song, participating in a real- time Internet chat, and participating in a teleconference. Using technologies such as Internet videoconferencing, exciting learning activities are emerging. Students who normally do not have an opportunity to communicate with peers across the globe can now access learning environments through the use of low-end, two way video and audio connections. In case of rural and remote students, Internet teleconferencing services help in reducing physical and mental isolation. (10).

The technology of the Web has greatly enriched distance learning, by providing content and interactive features that other distance learning methods lack. This technology provides:

- Expanded interaction with faculty through e-mail, bulletin boards, and multimedia lectures.
- Student to student interaction through e-mail, bulletin boards, and chat room discussions.
- Superior presentation through graphics, audio and video.
- Immediate access to course-related content such as lecture notes, readings, and links to relevant external sites.
- Interactive learning and assessment tools.

The Web environment is very rich-on TV course, CD-ROM, or traditional course can ever approach the resources at an instructor’s and student’s fingertips as in an online course. (11).

But in using Web technology for education, it is important to remember that evaluation of reliability, currency, authority, objectivity and relevance of resources has always been, and will always be, a critical part of the information evaluation and utilization process. The challenge is compounded because there is literally no control over Web publishing. Anyone can create and post a Web site. Therefore, educators have a responsibility to vigilantly encourage learners to critically review Internet information. (10).

3. Virtual Data Warehouses

Data warehousing and data mining emerged as new disciplines during the past decade, as large data sets became more and more common and need for new technologies to store and mine them became critical. Advances in sensors, storage systems and computers are producing data of unprecedented quantity and quality. Multi-terabyte and even petabyte (1,000 TB) data sets are emerging. The traditional practice had been to gather data at single location and transform it into a common format prior to exploring it. However, the expense of this approach in terms of network resources has meant that most data is never correlated or compared to other data. Distributed data sources can be diverse in their formats, schema, quality, access mechanisms, ownership, access policies and capabilities. So a new paradigm, based on data integration, is emerging resulting in flexible and managed federation, exploration and processing of data from many sources. Today, data warehouses are centralized repositories of data for reporting and querying. In the emerging scenario, when reports are required, bandwidth can be requested, data merged from multiple sources and reports generated using the most current data. In effect, virtual data warehouses are constructed on the fly. (12).

4. Conclusion

Lot of innovation and developments in the fields of Information and Communication technologies have taken place in the last decade. Its impact on India can be seen by the mushrooming of Internet users and sudden spurt in the cellular/ mobile phone users. The total communication scenario is bound to change in next decade. Optical networks, portable networking , wireless libraries will emerge on the scene. Web based e-education will be used for educating the masses. For exploration and processing of data from distributed databases, a concept of virtual data warehousing is emerging. The trends in the ICT field, expected to emerge in next decade, look very exciting and promising.

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