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A Study: Network Technologies for Rural Regions

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ABSTRACT
This paper provides a theoretical overview on the various restrictions, constraints, possibilities, and the necessity of digital connectivity in the rural regions of India. Through this paper, an attempt has been made to identify, abstract and generalize the fundamental concepts, terminologies and principles governing the behaviour of, this paper also presents some background information about Network Technologies present for Rural Regions. A comparative analysis of papers published earlier on similar topic and their brief description has been provided in this paper.

Keywords:- Network Topologies, IEEE Standards, ETSI Standards and Proposal.

I. INTRODUCTION

Rural areas are isolated from urban parts of India. The only media is radio and television in these areas. In the age when everything is fast growing and there is so much to learn every day, television and radios do not cover such a wide variety of information, several websites, numerous online education sites, in fact these days people even buy and sell things over Internet. Internet has become such an inseparable and inevitable part of our lives, that it has become essential to make the villagers aware of what Internet is, how to operate it, how to use it in day to day life, how it can be used as a tool for making themselves visible in the Global Market.

The World can be viewed as one big connected network where some parts are yet to be connected and are isolated. This can be termed technically as a Digital Divide. Digital divide refers to the difference between people who have easy access to the Internet and those who do not. Lack of access to the Internet is a disadvantage as people living in these regions will be deprived of a sea of knowledge that can only be found online. The term 'digital divide' appears in a number of different contexts, including:

- Differences between rural and urban Internet access.
- Socioeconomic differences between people of different races, income and education that affects their ability to access the Internet.
- Differences between developed, developing and emerging nations in terms of the availability of Internet.

II. BACKGROUND STUDY

1.1. Different Network Topologies:

Wired technologies such as fibre optics are considered to be costlier than wireless alternative. It is also difficult for wired technology to extend connectivity when it comes to rural and/or hilly areas. Most of the works addressing the digital divide are being done with wireless technologies. Wireless networks are found to be most suitable option as a whole for rural area development.

Wireless technologies can to be looked into from two perspectives: that of access network and the backhaul network. Even the access networks are principally categorized into two groups. There is cellular network group and the popularly known 802.11x family. Cellular networks have enjoyed successful diffusion right across developing nations with their rural areas included. The 802.11x family has seen the proliferation of different standards since its inception. Desired properties include range, bandwidth, costs of deployment and time taken to complete deployment. Range determines the maximum area that can have full coverage. As more and more network applications emerge, bandwidth becomes critical to network efficiency. Different network standards have been developed to provide needed bandwidth. Bandwidth of a network is

responsible for a number of QoS (Quality of Service) attributes that the network exhibits. Deploying a network is associated with a lot of costs. These costs determine the viability of a project and efforts are directed to balance the investment trade-offs. Cost of deploying infrastructure is proportional to the time taken to complete deployment. For that reason, different IEEE, ETSI standards have been developed. These are discussed below-

2.1.1 IEEE Standards:

The IEEE is the world's largest professional association advancing innovation and technological excellence for the benefit of humanity. IEEE and its members inspire a global community to innovate for a better tomorrow through its highly-cited publications, conferences, technology standards, and professional and educational activities. IEEE is the trusted "voice" for engineering, computing and technology information around the globe [1].

2.1.1.1 Wi-Fi: Wi-Fi is the marketing name for IEEE standard 802.11. It is a popular technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network, including high-speed internet connections. A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wired networks (which use IEEE 802.3 or Ethernet). It is an open standard technology that enables wireless connectivity between equipment and LAN.

2.1.1.2 WiMAX: WiMAX is the 802.16 IEEE standard technologies that has the potential to replace all forms of telecommunications. While Wi-Fi is good for campus buildings, WiMAX can provide connection to areas spanning more than 25 km from the base station on line of site. Its ability to offer broadband connection makes it suitable for a wide range of applications. The deployment of WiMAX can be to provide backhaul for another technology e.g. Wi-Fi, and can also be used as a last mile e.g. used as cellular towers. The 802.16 has a lot of applications which makes it a promising technology. But despite of its promising characteristics, WiMAX is cost inefficient and its operating frequency is not licence free.

2.1.1.3 Wireless Regional Area Networks (WRAN): WRAN is the first explicit cognitive radio standard. It is aimed at bringing broadband access in rural and remote areas. Takes advantage of better propagation characteristics at VHF and low-UHF. Takes advantage of unused TV channels that exist in these sparsely populated areas.

2.1.1.4 Bluetooth: Bluetooth is a short range technology that can connect devices like laptops, cell phones and computers within a radius of 10 meters. It is used primarily in personal area networks (PANs). PANs are ad hoc and can be used anywhere within the reach of signals, they don't require any infrastructure. The Bluetooth technology operates on 2.4 GHz frequency spectrum and does not need a license. But it doesn't fulfil the requirements for long distance networks.

2.1.1.5 ZigBee: ZigBee was designed to provide high data throughput in applications where the duty cycle is low and low power consumption is an important consideration. Many devices that use ZigBee are powered by battery. Because ZigBee is often used in industrial automation and physical plant operation, it is often associated with machine-to-machine (M2M) communication and the Internet of Things (IoT). ZigBee is based on the Institute of Electrical and Electronics Engineers Standards Association's 802.15 specification. It operates on the IEEE 802.15.4 physical radio specification and in unlicensed radio frequency bands, including 2.4 GHz, 900 MHz and 868 MHz. The specifications are maintained and updated by the ZigBee Alliance. There are three ZigBee specifications: ZigBee, ZigBee IP and ZigBee RF4CE. ZigBee IP optimizes the standard forIPv6 full mesh networks and ZigBee RF4CE optimizes the standard for partial mesh networks [5]

2.1.2 ETSI Standards:

ETSI, the European Telecommunications Standards Institute, produces globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and Internet technologies. ETSI produces a variety of standards, specifications and reports to suit different purposes, in response to market demand. All Specifications developed by the Third Generation Partnership Project (3GPP) are also published by ETSI as Technical specifications [6].

2.1.2.1 **Code-Division Multiple Access (CDMA):** CDMA refers to any of several protocols used in second-generation (2G) and third-generation (3G) wireless communications. As the term implies, CDMA is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth. The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800-MHz and 1.9-GHz bands. CDMA employs analog-to-digital conversion (ADC) in combination with spread spectrum technology. Audio input is first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined pattern (code), so it can be intercepted only by a receiver whose frequency response is programmed with the same code, so it follows exactly along with the transmitter frequency. There are trillions of possible frequency-sequencing codes, which enhances privacy and makes cloning difficult. The CDMA channel is nominally 1.23 MHz wide. CDMA networks use a scheme called soft handoff, which minimizes signal breakup as a handset passes from one cell to another. The combination of digital and spread-spectrum modes supports several times as many signals per unit bandwidth as analog modes. CDMA is compatible with other cellular technologies; this allows for nationwide roaming. The original CDMA standard, also known as CDMA One, offers a transmission speed of only up to 14.4 Kbps in its single channel form and up to 115 Kbps in an eight-channel form. [8]

2.1.2.2 **Global System for Mobile Telecommunication (GSM):** GSM is a digital mobile telephony system that is widely used in Europe and other parts of the world. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

2.1.2.3 **Enhanced Data GSM Environment (EDGE):** EDGE is a faster version of GSM wireless service designed to deliver data at rates up to 384 Kbps and enable the delivery of multimedia and other broadband applications to mobile phone and computer users. The EDGE standard is built on the existing GSM standard, using the same time-division multiple access frame structure and existing cell arrangements. EDGE became commercially available in 2001. It is regarded as an evolutionary standard on the way to UMTS.

2.1.2.4 **CDMA2000:** CDMA2000, also known as IMT-CDMA Multi-Carrier or 1xRTT, is a code-division multiple access (CDMA) version of the IMT-2000 standard developed by the International Telecommunication Union (ITU). The CDMA2000 standard is third-generation (3G) mobile wireless technology. The world's first 3G commercial system was launched by SK Telecom (South Korea) in October 2000, using CDMA2000 1X. CDMA2000 can support mobile data communications at speeds ranging from 144Kbps to 2 Mbps. Versions have been developed by Ericsson and Qualcomm. [9]

2.1.2.5 **Universal Mobile Telecommunications Service (UMTS):** UMTS is a third-generation (3G) broadband, packet-based transmission of text, digitized voice, video,

and multimedia at data rates up to 2 megabits per second (Mbps). UMTS offers a consistent set of services to mobile computer and phone users, no matter where they are located in the world. UMTS is based on the Global System for Mobile (GSM) communication standard. It is also endorsed by major standards bodies and manufacturers as the planned standard for mobile users around the world. Once UMTS is fully available, computer and phone users can be constantly attached to the Internet wherever they travel and, as they roam, will have the same set of capabilities. Users will have access through a combination of terrestrial wireless and satellite transmission s [10].

2.1.2.6 High-Speed Downlink Packet Access (HSDPA): HSDPA is a packet-based mobile telephony protocol used in 3G UMTS radio networks to increase data capacity and speed up transfer rates. HSDPA, which evolved from the WCDMA standard, provides download speeds at least five times faster than earlier versions of UMTS, allowing users of HSDPA networks a broader selection of video and music downloads. HSPDA specifies data transfer speeds of up to 14.4 Mbps per cell for downloads and 2 Mbps per cell for uploads. In practice, users are more likely to experience throughput speeds of 400-700Kbps, with bursts of up to 1 Mbps. [11]

2.1.2.7 Very Small Aperture Terminal (VSAT): This technology uses a very small satellite transmitting and receiving station that transfers Internet applications via satellite. Its advantage in remote areas is that it can provide backhaul connection to access networks where other technologies are not viable. Its bandwidth capability ensures that it can provide service for all Internet applications. It is a satellite communications systemthat serves home and business users. A VSAT end user needs a box that interfaces between the user's computer and an outside antenna with a transceiver. The transceiver receives or sends a signal to a satellite transponder in the sky. The satellite sends and receives signals from an earth station computer that acts as a hub for the system. Each end user is interconnected with the hub station via the satellite in a star topology. For one end user to communicate with another, each transmission has to first go to the hub station which retransmits it via the satellite to the other end user's VSAT.

2.2 Typical Network Structure:

A typical wireless network have the following six basic components:

2.2.1 Wireless nodes. Low-power single board computers support multiple wireless cards for different network links. To create a mobile node capable of wireless communication, one changes default configuration parameters. The node configuration interface consists of two parts. The first part deals with node configuration, while the second part actually creates nodes of the specified type. Node configuration essentially consists of defining the different node characteristics before creating them. All nodes contain at least the following components:

- An address or id
- A list of neighbours
- A list of agents
- A node type identifier
- A routing module

2.2.2. Point-to-point links. These links make use of high directional antennas and provide network connectivity over long distances for example to the range of 50-100 km. It is basically a communication connection between two nodes i.e. 1-hop. Directional antennas are the ones that radiate and receive on a narrower portion of the field as compared to Omni directional antennas. For a given amount of input power, a directional antenna can reach out to more distance with a clearer signal. They have much higher sensitivity to radio signals in the dominant direction. In order to set up a stable high speed wireless network, setting up of high gain directional antennas is preferable. This antenna is used to create a point to point Wi-Fi network by connecting a wireless router to a high speed DSL or cable modem. Line

of site (LOS) works best for sending and receiving 802.11, so the antenna should be mounted in areas that are free of trees and buildings, if possible. We recommend using two directional antennas if user really wants a strong signal. Even if one mounts a one directional antenna outdoors and it connects with the wireless router, the other computer (or wireless access point, wireless bridge, etc.) may not get a strong signal if it is indoors in the other building. So basically, two external directional antennas will allow the user to share a high speed wireless network.

2.2.3. Point-to-multipoint links. These links make use of sector antenna that distributes connectivity to multiple end points within relatively short distances that last few kms. Here, many nodes can receive information transmitted by one node. Sector antenna is suitable for use in Computer Radio LANs conforming to the IEEE 802.11b/g standard. This antenna can be used on an Access Point (or wireless Router) or Wi-Fi client with equal benefits. Sector antennas are designed to provide segmented microwave coverage over a selected (sector) area; they deliver a wider beam width than point-to-point parabolic antennas. Wi-Fi Sector antennas are typically used for wireless connections between LAN base stations, wireless Internet, subscriber networks, PCs and other point-to-multi point communications. This type of setup is usually found in outdoor areas, where the main antenna is broadcasting a signal from a building that is located at one end of the park. A sector antenna should be used to force the signal in a desired direction. It avoids sending the Wi-Fi signal to unwanted areas. For the best results, Sector Antenna should be used in situations where client locations are in LOS of each other.

2.2.4. Multi-radio mesh links. These links use Omni-directional links and extend wireless coverage within small local regions. Omni directional antenna is a class of antenna which radiates radio wave power uniformly in all directions in one plane, with the radiated power decreasing with elevation angle above or below the plane, dropping to zero on the antenna's axis. This radiation pattern is often described as "doughnut shaped". Omni directional antennas oriented vertically are widely used for non-directional antennas on the surface of the Earth because they radiate equally in all horizontal directions, while the power radiated drops off with elevation angle so little radio energy is aimed into the sky or down toward the earth and wasted. These antennas are widely used for radio broadcasting antennas, and in mobile devices that use radio such as cell phones, FM radios, walkie-talkies, wireless computer networks, cordless phones, GPS as well as for base stations that communicate with mobile radios, such as police and aircraft communications.

2.2.5. Cell phones/low cost computing devices. With Wi-Fi-enabled interfaces that can act as end-devices. A mobile phone, also known as a cellular phone, cell phone or a hand phone is a device that can make and receive telephone calls over a radio link while moving around a wide geographic area. It does so by connecting to a cellular network provided by a mobile phone operator, allowing access to the public telephone network. By contrast, a cordless telephone is used only within the short range of a single, private base station.

III. PROPOSAL FOR LONG DISTANCE NETWORK

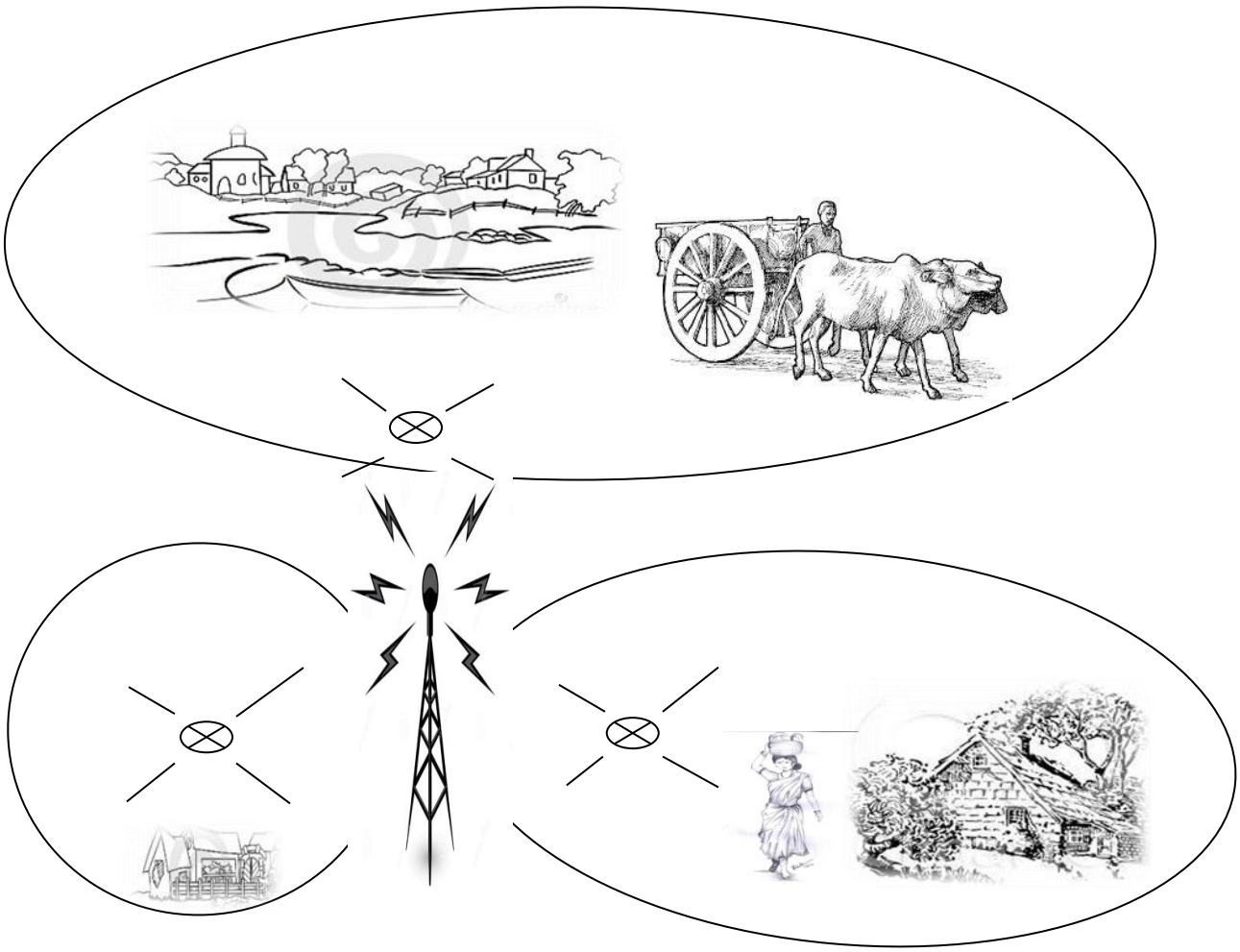

Figure: Proposal for a long distance rural network model.

IV. CONCLUSION

In this paper we have studied about the different networking technologies that can be used for providing Internet connectivity to rural areas. More than half of India's population lives in rural areas. Most of them are remote and too isolated to benefit from the country's economic progress. Yet there is a growing desire among people in rural India to be part of its modernisation process. Increasingly the government is looking at better ways to reach remote, rural India. And it is hoping that technology will provide a solution. With over 68 percent or 833 millions of Indians still living in villages, development of rural areas has become one of the key concern of the government. For this to happen, it is a necessity that the continually upgrading latest news and technologies, particularly the schemes introduced by the government reaches even the farthest and the remotest areas. With more than 638,000 villages, providing technology that is efficient but at a low cost is crucial. Solution is Wi-Fi for long distance.

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