Use of E and V Spectrum Bands for providing IoT in Rural Areas through Optical Fiber Communication

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ABSTRACT
As cities' communication networks develop continuously with new technologies like 4G, the rural areas still remain void of such services. The use of optical fibers for providing broadband network is already being implemented. However, there are some problems faced by the optical fiber communications. This paper will discuss a few advantages of the optical networks and introduce the use of E and V bands for providing point to point wireless backhaul in place of fiber connections. It will also be discussed as to how IoT can use these bands to provide improved services to rural areas thereby bridging the gap between urban and rural parts and fulfilling the concept of Digital India.

Keywords
IoT, Optical fibers, E and V bands, rural areas

1. INTRODUCTION
In the past few years, the telecommunication network connectivity has been increasing tremendously. From 2G to 3G and now an extensive network of 4G systems exists in the cities and metropolitan areas of the country. In spite of having such dense networks with more than 600 million subscribers to wireless connections, the idea of Internet access to everyone is yet to be fulfilled.

It is seen that the number of broadband subscribers is around 86 million, where it is 46 for the rural tele-density (compared to 148 for the urban tele-density). However, it can be stated emphatically that affordable wireless broadband access for the rural populace is an unsolved problem in India. However, rural India has sufficient purchasing capacity, and it contributes almost 50% to the GDP of India, even though it has only 1.5% registered broadband connections. So, it appears that the rural broadband area is an untapped market with immense potential [1].

However, many challenges are faced in providing broadband access in the rural areas, namely: (i) minor average revenue per user as a fraction of total revenue [1]; (ii) lofty capital and operation disbursement (iii) affordable backhaul which is aggravated due to massive population, (iv) energy cost which is worsened due to the paucity of reliable power supply; and, (v) geographic accessibility issues. The Government of India has been working with the initiative BharatNet (formerly National Optical Fiber Plan or NOFN) to mitigate the lack of broadband in rural regions. With BharatNet (which is being implemented in two phases), the point of presence (PoP) with optical connectivity at all Gram Panchayat, or village offices will be provided [1].

2. USE OF OPTICAL FIBERS
Optical fibers are designed using extremely thin strands of ultra-pure glass for transmitting light from a transmitter to a receiver. These light signals represent electrical signals like video, audio, or just data information in any combination. The inner fiber called core is used to transmit light, while the glass coating also called as cladding, prevents the light from leaking out of the core by reflecting the light present within the boundaries of the core. The cladding is fashioned in such a manner that it causes the light to be angled back into the core, resulting in being carried along the length of the fiber. Fiber is used because it provides a single pipeline that can carry huge amounts of data.

To provide reliable transmission of large quantities of information, fiber optical communication techniques are highly coveted facilitate the access and transmission of large-scale information ranging up to terabits per second (Tbit/s). Keeping in mind of the intelligent processing of mass information, the optical switching- and interconnection-based fiber optical networks will play a major role in accessing and transmitting such high-capacity sensing information.

3. E AND V BANDS
Generally, as the airwaves go higher and higher in frequency, the distance covered by the bands reduces. E and V bands do not go long distances, but can be used in a radius for faster speeds. Normally, microwaves are used which handle voice but are unable to handle data beyond a certain can limit hence; these bands are required. E&V bands act as a "fiber extension" to extend broadband connectivity from existing points of presence (POPs) to nearby locations for applications in semi-urban and rural areas.

V-Band ranges from 57 and 66 GHz, Due to the oxygen absorption, there is immunity to interference for communications in this spectrum. Also, there is a better possibility of reuse in this band. Although considered as a good spectrum for communications, this is licensed in many countries.

E-Band is the higher frequency bands at 71-76 GHz and 81-86 GHz. E-Band has the ability to enable gigabit-per-second data rates given the huge amount of available spectrum (10 GHz). It can achieve longer distance transmission than V-band since it has no oxygen absorption [2]

The de-licensing of V bands in India will increase the use of the band for making broadband available everywhere.

3.1 Backhaul

The backhaul in the mm-wave spectrum utilizes a narrow beam width, thus reducing interference between links in close proximity. The high frequencies help in creating smaller, compact antennas and help meet the zero footprint requirements of small cell backhaul. The full duplex bandwidth capacity for 60 GHz bands is between 0.5 Gbps and 1 Gbps. For the E-band range of 70 GHz to 80 GHz, the bandwidth capacity can reach up to 2 Gbps.

Small cell backhaul bandwidth needs 100 Mbps. The backhaul bandwidth may reach peaks of 1Gbps if LTE and LTE-Advanced are used with an additional support for Wi-Fi/3G within the capability of a 60 GHz to 70/80 GHz link with a 7 Gbps channel. As MNOs become denser their RANs, capacity requirements increase and transmission ranges decrease. Thus, the prospective of using millimeter link for small cell backhaul is attractive when reliability issues are to be addressed and range is not an important factor to be considered.

The highly directional beam in a millimeter link transmits data between two transceivers and transports it in a straight line with little or no fading or multipath radio interference. This is a highly efficient use of spectrum because multiple microwave transceivers can function within a few feet of each other and reuse the frequency band for transmitting separate data streams [3].

3.2 Data Throughput

An important consideration for small cells employed in dense population networks is data throughput. The coverage area of small cells is size 0.5 Sq. Km to 4 Sq. Km, and they could be handling high traffic from multiple data users. In this, the data throughputs become a function of the modulation and compression schemes on the backhaul link and channel width. The frequency and throughput are proportional to each other. Higher throughput is achieved when the frequency is higher. The V-band (60 GHz) can handle 7+ Gbps while the E-band can handle 10+ Gbps (see table below) [3].

Table 1. Properties of E and V bands

Characteristics	V-band (60 GHz)	E-band (70/80 GHz)
Carrier Frequency	56 to 64 GHz	70 to 80 GHz
Capacity	7 Gbps+	10 Gbps +
Latency	<200 users max, 40 to 50 µs/hop	65 to 350 µs/hop
Range (km)	<1	~3
Topology	LoS	LoS
Installation	PTP	PTP

3.3 Advantages

3.3.1 Multiple V-band Radio Co-location

The very narrow beams that associated with 60 GHz radios can enable a number of radios to be installed on the same roof. The Co-located radios that operate in the same transmitter and receiver frequency ranges can be isolated from one another by changing angular separations between them and using antennas having cross-polarization.

3.3.2 Easy Installation

The V-band spectrum is wide enough to be aligned accurately by an installer without getting affected by the wind variations or building/tower obstructions or tilts due to other atmospheric disturbances. Hence, easy installations of antennas are achieved in the 60GHz range having narrow beam width and hence, high directivity.

3.3.3 High Signal Security

There is a high degree of physical security associated with E and V-band as they are primarily used for Line of Sight (LoS) data transmissions. For an unknown party to capture a signal traversing in this spectrum band, its receiver will have to be placed in the same line path as that of the desired transmitter. In addition to this, the receiver needs to be tuned to the carrier signal of the transmitting radio in order to receive the signal properly. The existence of the third party will create an interference in the transmit path of the signal and degrade it. Thus, the LoS transmissions prevent the third-party signal interceptors from causing interference in the transmission system.

4. INTERNET OF THINGS

Place The development of most aspects of optical fiber networks for the E and V Bands would be enhanced by applying the technologies of IoT (the Internet of Things). The architecture of IoT can be expressed as three layers: the perception layer, the networks layer, and the application layer. The fiber-optic communications network is very suitable for expanding IoT applications since it is capable of carrying higher bandwidth and it is suitable for long distance transmission. Hence it is applied to the network layer of IoT (the Internet of Things). The initial information is provided to the IoT perception layer (bottom layer). The emergence of the optical fiber sensor resulted in significant achievements in the fields, such as fiber optical communication, lasers, and optical detection. The optical fiber sensor also promotes the development of IoT in many ways.

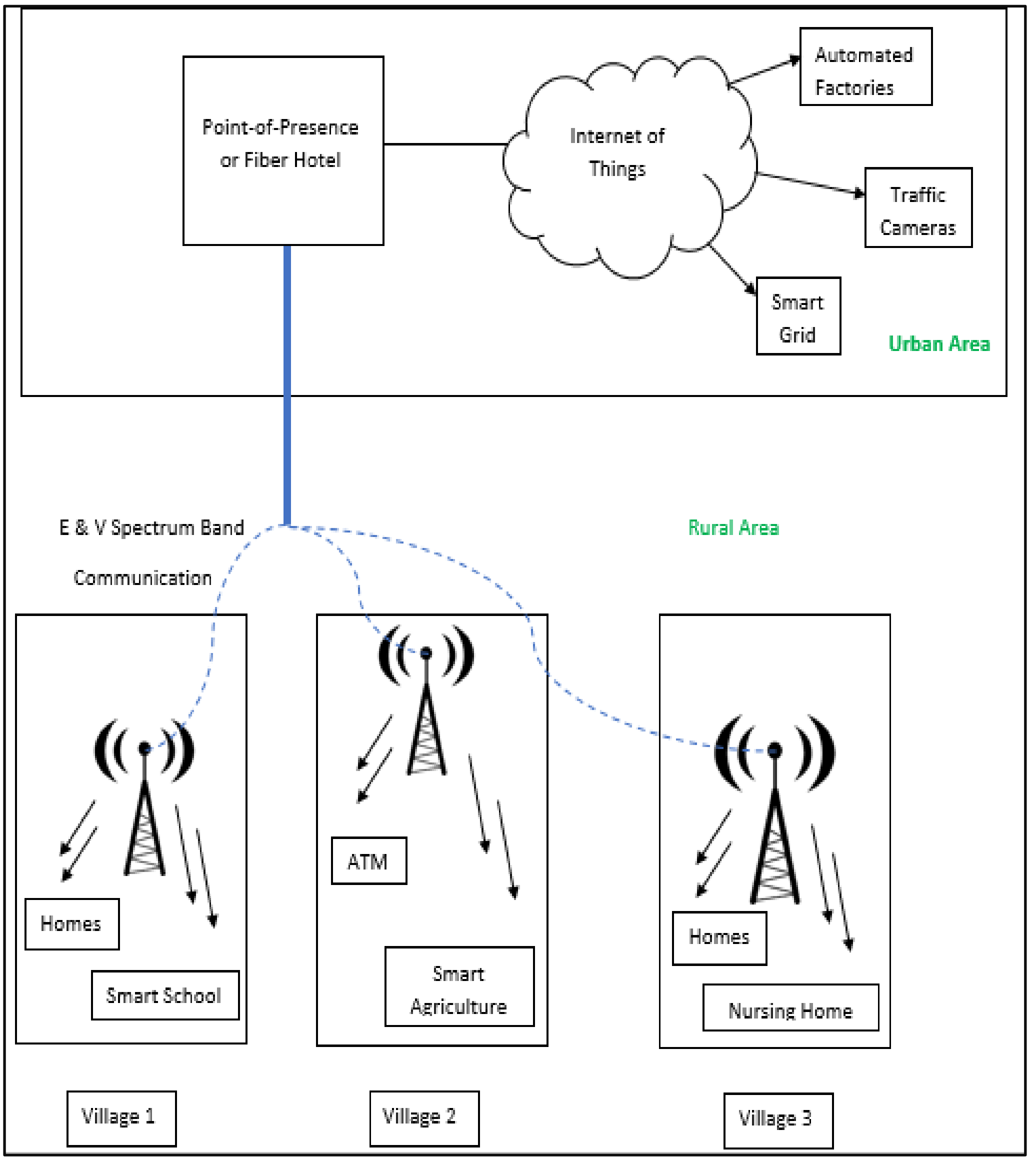

Fig 1: Proposed idea of introducing IoT in rural areas through optical fibers and E & V Bands.

5. FIBER-OPTIC INTERNET OF THINGS

The Fiber-optic Internet of Things focuses on several key techniques like comprehensive perception, reliable transmission, and intelligent processing of mass information [4]. There are many significant basic yet challenging science and technique issues which are considered to construct the fiber Internet of Things. Fiber optical sensors support the comprehensive perception of a significant amount of information. Appropriate fiber communication access techniques enable reliable transmission of information. Intelligent processing of information can be achieved with intelligent optical switching and optical interconnection, including optical link access networks.

Fiber optic cables prove as the best means of data handling and transmission when harsh environmental conditions hinder the operations of wireless networks. So, IoT will lead to an increase in fiber deployments residential areas and industries or commercial buildings. Optic Fiber itself will be able to act as the actual sensor used in Internet of Things applications. As optic fibers possess many advantages like wide bandwidth and good transmission characteristics, their use for a wide range of applications will increase. Also, they can be installed where sensitivity and high performance are required. From [4] it was seen that optical fiber sensors are used in monitoring intelligent electricity substations called Smart Grids [5] in China.

6. APPLICATIONS OF IOT IN RURAL AREAS

6.1 Smart Agriculture

Farmers will be able to take action as per the weather reports obtained from the cloud services on daily basis. The continuous monitoring of the farm and sending data to the server will help the markets to set financial rates using prediction models. Using IoT, the farmers can track the dates of harvesting and reserves of grains obtained in their granaries. This will help in detecting the expiry dates of the food reserves, hence preventing food wastage. In addition, the farmers can also use the data collected from soil monitoring setups in the farms to analyze the soil moisture and soil health.

6.2 Education

Education is of prime concern in rural areas. Lack of adequate facilities or infrastructure for school and skilled teachers hinders the progress of rural population. The use of fiber optic communication and 60 GHz bands to provide Internet connection will help in achieving high quality of education by allowing video conferencing with other teachers and experts, accessing the web for online study material and studying via correspondence courses. This will also encourage research in schools.

6.3 Public Health Services

IoT will transcend barriers of medical intricacies faced in rural areas where expertise is not easily available. Video conferencing with medical experts and doctors residing in the cities will provide better real time medical guidance for difficult cases. Error in diagnosis of diseases and treatment of patients is also minimized. By tracking a person's health history, a large category of diseases can be detected better. Management of drugs is also improved, and the medicines in demand and out of stock can be notified to the cities for restocking.

7. FUTURE SCOPE

Due to the ever-increasing spectrum requirements for catering a large number of users, the efficiency of networks will decrease in terms of data rate. The 5G technology [6] promises to provide high data throughput of about 10Gbps with enhanced features of high security, high scalability, low latency, and low energy consumption.

With current technologies like LTE being used, the spectrum falls short to cater to the needs of every device. The 60 GHz spectrum band can be used to employ 5G networks [7] in an indoor environment or for short range communications. Although this band can support LoS communication, with increased directivity using directional antenna arrays, high gain can be achieved. As [8] suggests, with beam-forming antennas, multiple users can receive signals from one antenna and thus, efficient millimeter-wave band communications can be achieved. This also allows smaller antenna sizes and less interference on the propagation path.

The IoT applications, D2D communication, and V2V communication, can benefit from the use of E and V bands as these bands offer effective communication in the LoS and in a small cell environment.

8. CONCLUSION

The paper discusses the optical communications where the fiber cable provides the 70% of the connectivity to most of the areas. Whereas, the spectrum band of 60 GHz to 86 GHz provides the wireless transmission in places where fibers cannot be installed. The use of this type of system will aid the Internet of Things (IoT) in rural areas. This spectrum band –E and V bands, having high gain and directivity, will enhance the pre-existing networks. With increasing number of devices, the future technologies like 5G can use these band for providing networks for indoor communications, LoS Communications. Furthermore, using directional antennas, spatial multiplexing and beamforming techniques, more efficiency can be obtained using these bands in 5G cellular networks.

This proposed system (refer Fig 1) of using optical fibers to reach out to the rural areas along with the wireless backhaul given by the millimeter-wave spectrum bands thereby introducing IoT services and applications to the villages will help in connecting rural people to the cities, thus fulfilling the vision of Digital India.

9. ACKNOWLEDGEMENTS

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