# Development of Long-Range and High-Speed Wireless LAN

**Dr. Shantala C P**

Professor & Head, Dept of CSE, Channabasaveshwara Institute of Technology, Gubbi, Tumkur, Karnataka, India.

**Abstract**
The development of long-range and high-speed wireless LAN (Local Area Network) technologies has become increasingly important in modern networking applications. We have developed 2.4 GHz wireless LAN units with the longest coverage, which comply with the IEEE 802.11g standard and Indian radio regulations, to re-establish communications temporarily between disaster-devastated areas and hospitals, among other locations. The network deployment is carried out in the college campus, involving two types: a) point-to-point (PtP), and b) point-to-multipoint (PtMP). The throughput within ranges of 500m and 6Km is approximately 100 Mbps, while for 15Km, the achieved throughput was 80 Mbps. Real-world applications and use cases of long-range wireless LAN systems are also highlighted to demonstrate their significance in diverse scenarios, ranging from rural connectivity to urban deployments.

**Keywords:** LAN, IEEE 802.11g, High-speed, Wireless

## 1. Introduction

Wireless Local Area Networks (LANs) have become ubiquitous in modern society, enabling users to connect to the internet and share resources without the constraints of physical cables. Traditional wireless LAN technologies, such as Wi-Fi, operate within relatively short ranges and moderate data transfer speeds, making them suitable for indoor environments and small-scale deployments. However, as the demand for wireless connectivity continues to surge, particularly in scenarios requiring extended coverage and high data throughput, the need for long-range and high-speed wireless LAN solutions has become increasingly apparent [1].

The development of long-range wireless LAN technology addresses the challenge of extending network coverage to remote or geographically dispersed areas where deploying traditional wired infrastructure is impractical or cost-prohibitive. By leveraging advanced antenna designs, signal propagation techniques, and frequency bands, long-range wireless LAN systems can transmit data over significantly larger distances, bridging connectivity gaps and expanding access to internet services in underserved regions [2]. Concurrently, the demand for high-speed wireless LAN solutions has grown exponentially with the proliferation of bandwidth-intensive applications, such as video streaming, online gaming, and cloud computing. Traditional Wi-Fi standards, while adequate for basic internet browsing and email communication, may struggle to meet the bandwidth requirements of these demanding applications, especially in densely populated urban environments where network congestion and interference are prevalent.

In response to these challenges, researchers and engineers have been actively exploring new technologies and protocols to enhance the performance and capabilities of wireless LAN systems. This includes the development of innovative modulation schemes, channel access methods, and network architectures optimized for long-range communication and high-speed data transmission. Additionally, advancements in hardware components, such as radio transceivers and signal processing algorithms, have played a crucial role in improving the reliability, efficiency, and scalability of wireless LAN networks.

Overall, the evolution of long-range and high-speed wireless LAN technology represents a significant milestone in the ongoing evolution of wireless communications, offering new possibilities for connectivity, innovation, and socioeconomic development. In the following sections, we will delve deeper into the key principles, technologies, and challenges associated with the development of long-range and high-speed wireless LAN, as well as the potential applications and implications of these advancements in real-world scenarios.

## 2. Background

Long-range wireless LAN (WLAN) systems have gained significant attention due to their ability to provide connectivity over extended distances, bridging coverage gaps and expanding network access. These systems play a crucial role in various applications, including rural connectivity, disaster recovery, and industrial automation. The development of long-range WLAN technologies has been driven by the need for reliable and high-performance wireless communication solutions in challenging environments [1-3].

Understanding the propagation characteristics of wireless signals is essential for designing long-range WLAN systems. Various propagation models, including free space path loss, log-distance path loss, and Rayleigh fading, influence signal strength and coverage. Directional antennas and beamforming techniques play a crucial role in extending the range and coverage of long-range WLAN systems. Smart antenna arrays and beamforming algorithms optimize signal transmission and reception. Advanced modulation schemes, such as OFDM and QAM, along with error-correction coding techniques, enhance the reliability and throughput of long-range WLAN links, mitigating the effects of noise and interference [4-6].

Long-range wireless LAN standards are IEEE 802.11 and non-IEEE standards. The IEEE 802.11 family of standards including 802.11n, 802.11ac, and 802.11ax, incorporate features to enhance the range and performance of WLAN systems. MIMO, beamforming, and higher transmit power levels are key advancements Proprietary protocols and standards developed by industry vendors, such as WiMAX and LTE, offer long-range wireless connectivity solutions for specific applications and deployment scenarios [7-8].

Mesh networking architectures enable the creation of self-configuring WLAN networks with extended coverage and range. Mesh nodes collaborate to relay data, providing redundancy and resilience in challenging environments [9-10].

The main aim of this project is to connect experts from different domain around the world with our rural community using Last-Mile Internet connectivity. It aims to experiment on different domains like transmission of telemedicine, distance learning etc with longest cover of around 25+km using wireless LAN units [11-15].

### 3. Methods & Materials

Figure 1 shows the proposed system. CIT in figure 1 stands for our college, Channabasaveshwara Institute of technology where the network deployment is done. The role of CIT is to bring domain experts from different domain and connect them to our rural community. It uses airFiber X antenna with airFiber X Radio for point-to-point (PtP) and point-to-multipoint (PtMP) communications. PtP has a receiver and a transmitter to offer communication between two nodes or endpoints. It is deployed between two locations that are in Line of Sight (LOS). The communication range is over more than 20 miles and operates on both unlicensed and licensed frequencies with speed ranging from 100Mbps to 10Gbps. The distance is usually affected by the height of each device. PtMP has single transmitter and multiple receivers referring to a communication system which distributes a radio signal from one location to several others. Receivers do not communicate with each other but instead all have a single connection with main base. PtMP operates in both licensed and unlicensed frequencies with speed of up to 1Gbps. Backhaul link in PtP refers to side of network connected to global internet.

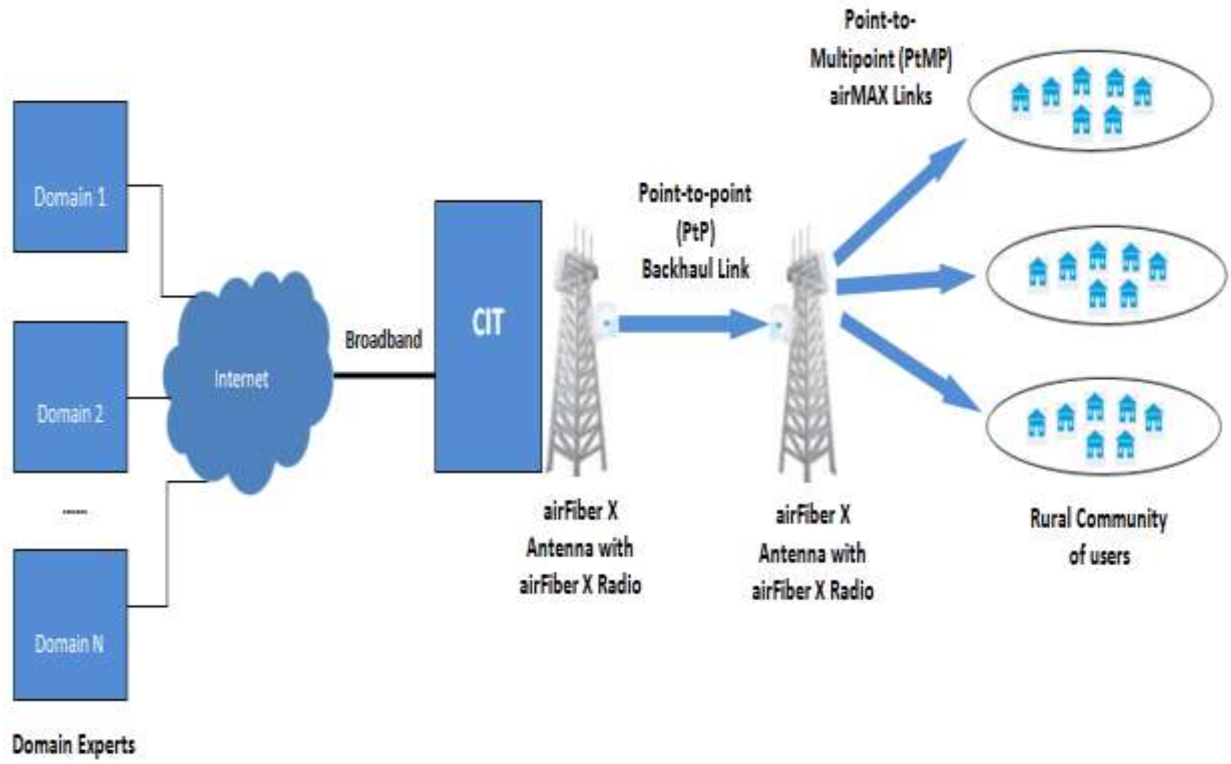


**Figure 1: Proposed workflow**

Figure 2 shows Air Fiber-5XHD device used for Point to Point link. It is 5 GHz Carrier Radio with LTU Technology. It draws up to 1+ Gbps. The real throughput is 100+ km Range. It has Configurable GPS Synchronization and Bluetooth Wireless Configuration. It has wide Voltage Range and Enhanced Surge Protection. It has ultra-Low Latency with HDD Technology. Figure 3 shows Rocket Dish-5G30 antenna. It is airMAX® 2x2 PtP with bridge Dish Antenna. It has Powerful Performance for Long-Range Links with robust design and construction for outdoor use. It supports plug and play integration. This device can create the endpoint of a high-performance, Point-to-Point (PtP) bridge or network backhaul.
Figure 4 shows Rocket Prism 5AC-Gen2 Radio. It is airMAX ac Radio Base Station with airPrism Active RF Filtering Technology. It is designed to deliver maximum spectral efficiency and up to 500+ Mbps with

real TCP/IP throughput. It has 5 GHz Wide Band Operating Frequency with dedicated Wi-Fi Radio for Management and GPS for Superior Co-Location Performance. It supports PtP & PtMP networks.

Figure 5 shows AirMax-5G19-120 Sector Antenna. It's a 2x2 MIMO BaseStation Sector Antenna that was designed to seamlessly integrate with Rocket radios. It can be deployed in a PtMP network with 19 dBi. It provides superior gain and beam performance for high-capacity, multipoint networks. It has highly resistant to noise interference and Plug and Play Integration.

Figure 6 shows PowerBeam-5AC-500. It has high-performance airMAX® Bridge with 29dBi gain. It's a customer premises equipment installed at customer premises. It has uniform beam width and maximizes noise immunity. It provides up to 450+ Mbps throughput & range up to 25+ Km. It has long Range PtP link Mode and also supports PtMP link mode. It supports selectable channel width for PtP and PtMP link mode.

Figure 7 shows PtP and PtMP server side connection deployed in the college campus. Figure 8 and figure 9 shows client 1 and client 2 respectively for PtMP connection deployed in different locations in college. Figure 10 shows PtP client.

**Figure 2: Air Fiber-5XHD Device**

**Figure 3: Rocket Dish-5G30 Antenna**


**Figure 4: Rocket Prism 5AC-Gen2 Radio**

**Figure 5: AirMax-5G19-120 Sector Antenna**

**Figure 6: PowerBeam-5AC-500**

**Figure 7: PtP and PtMP Server side connection**

**Figure 8: PtP Client 1**

**Figure 9: PtMP Client 2**

**Figure 10: PtP client**

## 4. Results

This section describes the results of both PtP and PtMP network deployment in college campus.

**Point to Point link (PtP):**

**Use case 1:** Installed at campus within 500m where throughput was 100 Mbps.

**Use case 2:** Installed client with distance of 15KM where throughput was around 80 Mbps.

**Point to Multipoint (PtMP)**

**Use case 3:** Installed at campus in three different locations at a distance of 300m where throughput was 100 Mbps and input is 100 Mbps.

Main Antenna is installed in fifth floor of the building and the clients are in three different locations with different height.

- 1st client device installed in 4th floor.
- 2nd client device installed in 4th floor.
- 3rd client device installed in Ground floor.

**Use case 4:** Installed at four different locations in and around college campus with a distance of 6 KM and data transfer was at 100Mbps.

Some of the applications used for testing are:

- FTP Protocol to access files.
- Internet and Intranet (same as with cable).
- Database application.
- CCTV Application.

Figure 11 shows screenshot of router login. Figure 12 shows screenshot of different devices connected with the router. Figure 13 shows PtP master and one Receiver details. Figure 14 shows PtMP details with 3 clients connected (Shown as Remote X3)

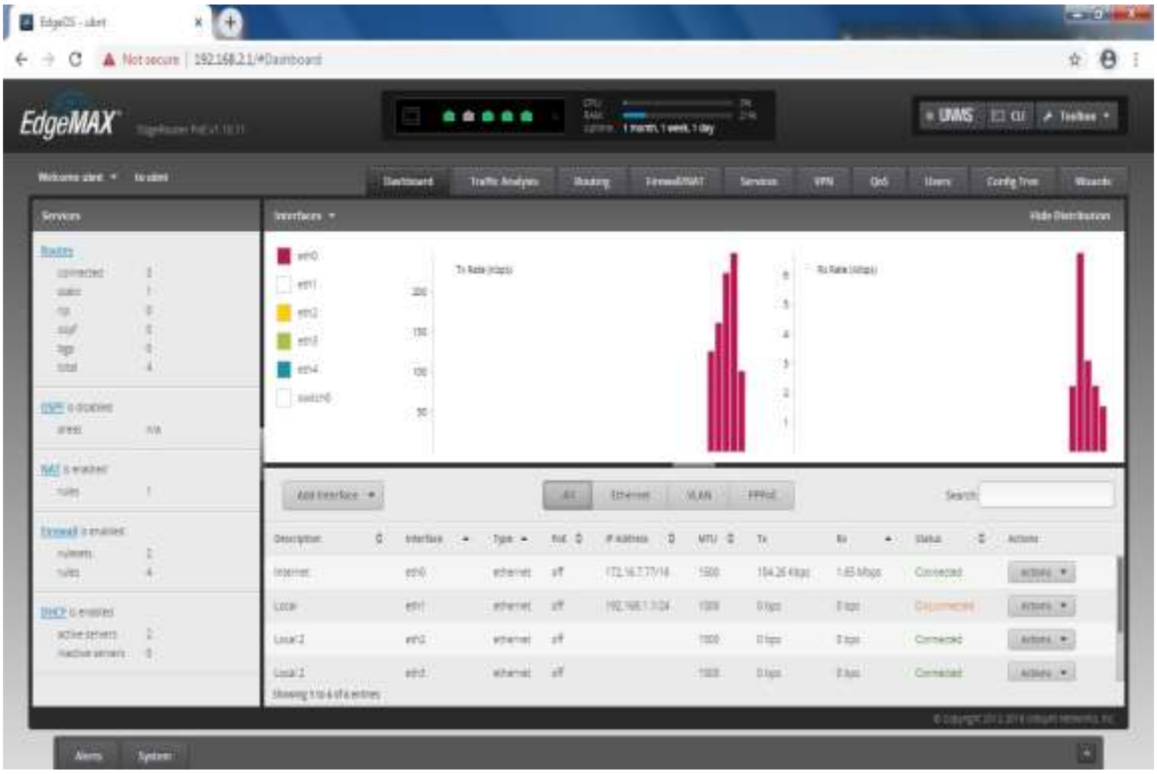


**Figure 11: Router login**

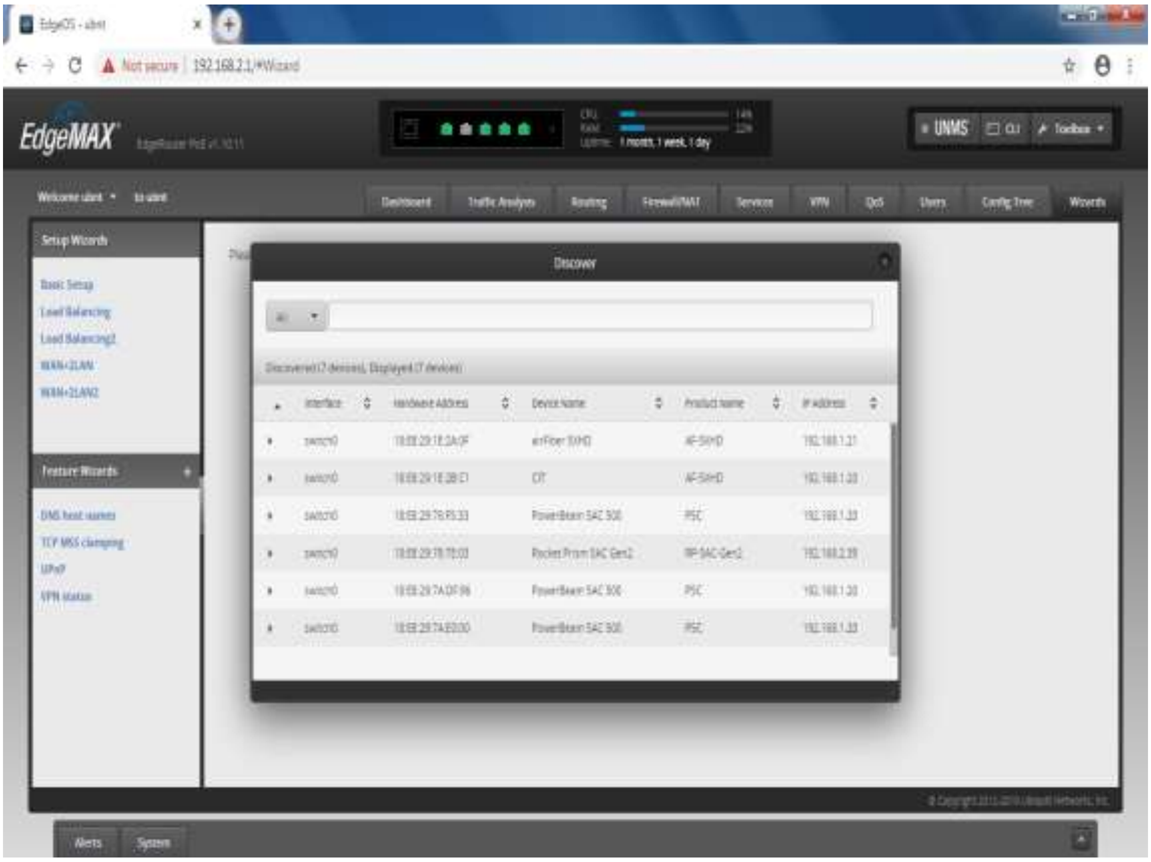


**Figure 12: Devices connected with routers**

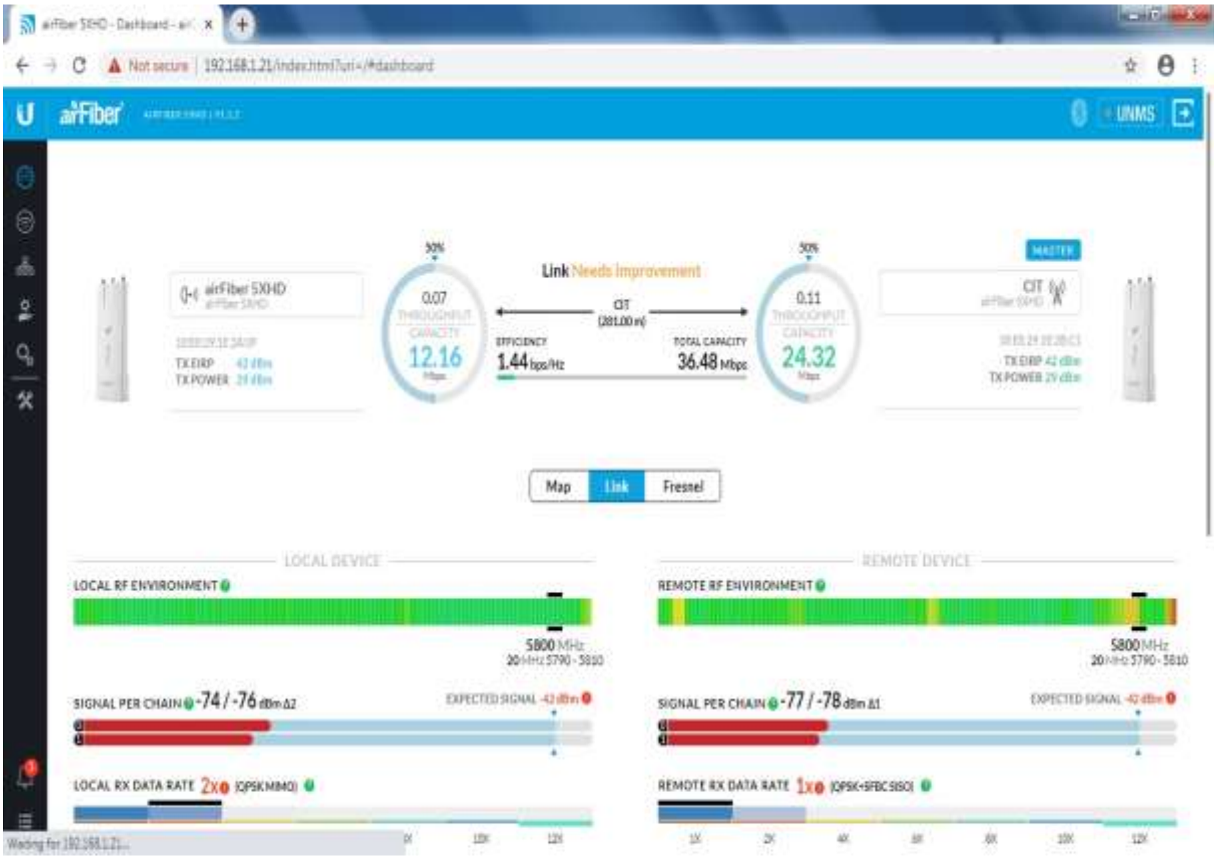


Figure 13: PtP master and one Receiver details


Figure 14: PtMP details with 3 clients connected (Shown as Remote X3)

## 5. Conclusion

The successful deployment of these units within our college campus, utilizing both point-to-point and point-to-multipoint configurations, has demonstrated their versatility and efficacy in facilitating reliable connectivity over varying distances. With impressive throughput rates of approximately 100 Mbps within ranges of 500m and 6Km, and 80 Mbps over 15Km, our wireless LAN units exhibit exceptional performance capabilities. Moreover, the highlighted real-world applications underscore the broad utility of long-range wireless LAN systems, spanning from rural connectivity solutions to complex urban deployments. Moving forward, continued advancements in this technology promise to further revolutionize networking infrastructure, enabling seamless communication across diverse environments and scenarios.

## 6. References

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