

The Ubiquitous Influence of WiMAX for Next Generation Applications

D. Barhani,¹ P. Kharabi,² El Fanaa Jarhoumi³

¹⁻³College of Applied Science, University of Technology and Applied Sciences, Ibri, Sultanate of Oman

KEYWORDS:

Cross-layer optimization,
Radio frequency identification (RFID),
Beam scanning,
Environmental sensing,
Underwater antennas

ARTICLE HISTORY:

Received 03.03.2022
Revised 11.04.2022
Accepted 02.05.2022

DOI:

<https://doi.org/10.31838/NJAP/04.01.04>

ABSTRACT

With the relentless march of technological progress, the world has witnessed a transformative shift in how we communicate and connect. Among the multitude of innovations, WiMAX (Worldwide Interoperability for Microwave Access) stands as a beacon of wireless broadband technology, offering high-speed internet access over large geographical areas. In this comprehensive exploration, we delve into the multifaceted applications of WiMAX technology, its impact on various industries, and its potential to shape the future of connectivity.

Author's e-mail: barhani.d@gmail.com, kharabi.p@gmail.com, el.fanaa.jar@gmail.com

How to cite this article: Barhani D, Kharabi P, Jarhoumi EF. The Ubiquitous Influence of WiMAX for Next Generation Applications. National Journal of Antennas and Propagation, Vol. 4, No. 1, 2022 (pp. 21-26).

UNDERSTANDING WiMAX

WiMAX, a standard based on the IEEE 802.16 family, represents a significant advancement in wireless communication technology. Unlike traditional Wi-Fi networks, which are limited in range and coverage, WiMAX offers broadband connectivity over extended distances, making it ideal for providing internet access in underserved and remote areas. Operating in licensed and unlicensed frequency bands, WiMAX supports data rates ranging from tens of Mbps to several Gbps, catering to a wide range of applications and user requirements.^{[1][18]} WiMAX, which stands for Worldwide Interoperability for Microwave Access, is a wireless communication technology that provides high-speed broadband access over long distances. It operates on the IEEE 802.16 standard and is designed to offer wireless connectivity similar to Wi-Fi but with extended range and higher data rates, making it suitable for both fixed and mobile applications.

One of the key features of WiMAX is its ability to deliver broadband access over large geographic areas using point-to-multipoint and non-line-of-sight (NLOS) transmission techniques.^[19-27] This allows WiMAX networks to cover urban, suburban, and rural areas efficiently, bridging the digital divide by providing internet access to underserved communities as given in Fig. 1.

WiMAX supports multiple frequency bands, including licensed and unlicensed spectrum, offering flexibility in

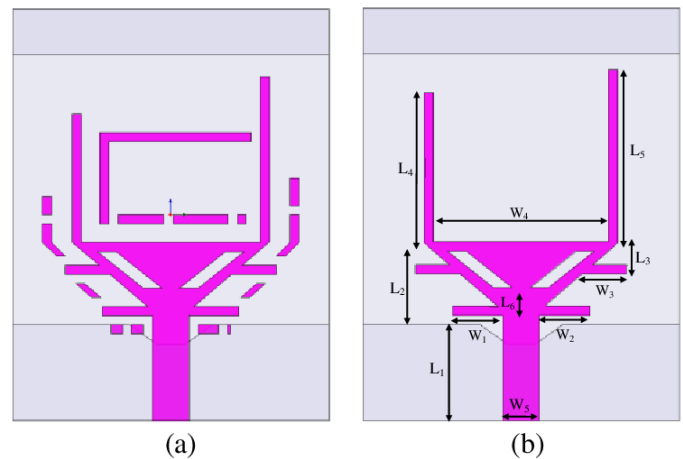


Fig.1: Antenna structure for use in WiMAX systems

network deployment and optimization. It operates in both licensed and unlicensed spectrum bands, providing operators with options to deploy networks in accordance with local regulations and spectrum availability.^[28-37] Furthermore, WiMAX offers scalability and quality of service (QoS) capabilities, allowing operators to prioritize traffic and allocate resources dynamically based on application requirements and user demand. This ensures optimal performance for real-time applications such as voice and video streaming, as well as high-speed data transfer.

In addition to fixed broadband access, WiMAX also supports mobile applications through the IEEE 802.16e amendment, which enables seamless handovers and

mobility management for users on the move. This makes WiMAX suitable for applications such as mobile broadband, public safety communications, and machine-to-machine (M2M) connectivity.^[38-43] Overall, WiMAX offers a cost-effective and versatile solution for delivering high-speed broadband access over wide areas, making it an attractive option for operators, governments, and enterprises looking to deploy wireless networks in underserved or remote regions. Despite the emergence of newer technologies like LTE and 5G, WiMAX continues to play a significant role in bridging the digital divide and expanding internet access to communities worldwide.

APPLICATIONS OF WiMAX TECHNOLOGY:

1. Telecommunications and Internet Service Providers (ISPs)

One of the primary applications of WiMAX technology is in telecommunications and ISP networks. WiMAX enables ISPs to offer high-speed internet access to residential and business customers in areas where traditional wired infrastructure is impractical or unavailable [44]-[56]. By deploying WiMAX base stations and subscriber units, ISPs can extend their coverage footprint, bridge the digital divide, and deliver broadband connectivity to underserved communities. WiMAX technology has gained traction among Telecommunications and Internet Service Providers (ISPs) due to its ability to provide high-speed broadband access over wide geographic areas. ISPs leverage WiMAX to expand their network coverage and reach underserved or remote regions where deploying wired infrastructure is economically unfeasible as given in Fig. 2.

WiMAX allows ISPs to offer a range of services, including internet access, voice over IP (VoIP), video streaming, and other multimedia applications. Its flexibility in supporting both fixed and mobile applications makes it a versatile solution for addressing diverse connectivity needs [52]-[61]. Moreover, WiMAX enables ISPs to deliver broadband access to customers in urban, suburban, and rural areas, bridging the digital divide and enhancing connectivity in underserved communities. Its non-line-

of-sight (NLOS) capabilities make it particularly suitable for reaching customers in challenging environments where traditional wired infrastructure is impractical or costly.

Overall, WiMAX technology empowers Telecommunications and ISPs to expand their service offerings, improve network coverage, and provide reliable broadband access to a broader customer base. As technology continues to evolve, WiMAX remains a viable option for ISPs looking to enhance their network infrastructure and meet the growing demand for high-speed internet connectivity.

2. Mobile Broadband and Wireless Access

WiMAX technology serves as a key enabler for mobile broadband services, providing high-speed internet access to users on the go. Mobile WiMAX networks, also known as 4G WiMAX, deliver broadband connectivity to smartphones, tablets, and other mobile devices, allowing users to access the internet, stream multimedia content, and engage in online activities with ease. With its robust performance and wide coverage area, WiMAX complements existing cellular networks and enhances the overall mobile broadband experience. WiMAX technology has revolutionized mobile broadband and wireless access by offering high-speed connectivity on the go. With its ability to support mobility and seamless handovers, WiMAX enables users to stay connected while moving between different locations, making it an ideal solution for mobile broadband applications as given in Fig. 3.

WiMAX provides users with access to a wide range of services, including internet browsing, video streaming, online gaming, and VoIP calls, all at broadband speeds. Its robust performance and reliability make it suitable for delivering a consistent user experience, even in densely populated urban areas or areas with limited wired infrastructure.

Furthermore, WiMAX offers flexibility in network deployment, allowing operators to build networks that cater to both fixed and mobile applications. This versatility

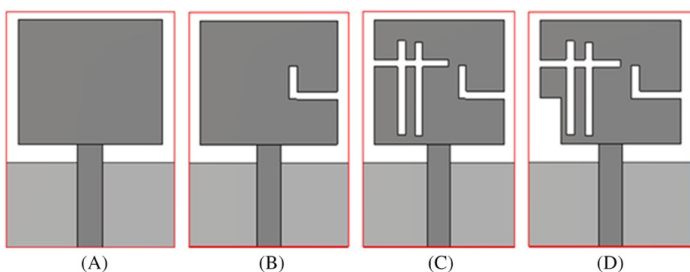
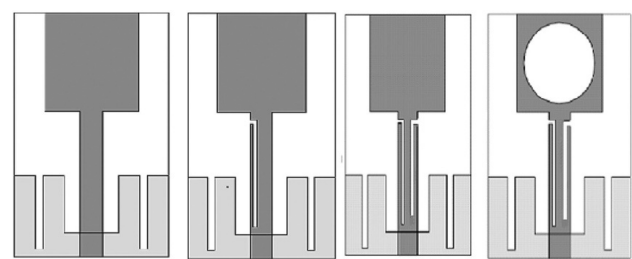


Fig. 2: Compact triband slotted printed monopole antenna for WLAN and WiMAX



(A) Antenna (1) (B) Antenna (2) (C) Antenna (3) (D) Antenna (4)

Fig. 3: Design of a compact T-shaped slot antenna

makes WiMAX a valuable technology for delivering wireless access to homes, businesses, public spaces, and vehicles, meeting the diverse connectivity needs of users in various environments.

Overall, WiMAX mobile broadband and wireless access empower users to stay connected wherever they go, enabling them to access the internet, communicate, and collaborate seamlessly while on the move. As technology continues to evolve, WiMAX remains a key player in the mobile broadband landscape, providing reliable connectivity and expanding access to high-speed internet services for users worldwide.

3. Smart Grid and Utilities

WiMAX technology finds applications in smart grid and utility networks, enabling efficient monitoring, control, and management of critical infrastructure assets. WiMAX-based communication systems facilitate real-time data collection from smart meters, substations, and distribution equipment, allowing utilities to optimize energy distribution, detect faults, and improve grid reliability. By leveraging WiMAX connectivity, utilities can enhance operational efficiency, reduce downtime, and support the transition to a smarter, more sustainable energy ecosystem. WiMAX technology has emerged as a crucial enabler for smart grid and utility applications, offering robust wireless connectivity to support advanced metering, monitoring, and control systems. With its high-speed broadband capabilities and long-range coverage, WiMAX facilitates the deployment of smart grid infrastructure, enabling utilities to improve efficiency, reliability, and sustainability in energy management as given in Fig. 4.

WiMAX enables utilities to deploy smart meters and sensors across their distribution networks, allowing for real-time monitoring of energy consumption, grid conditions, and equipment performance. This data

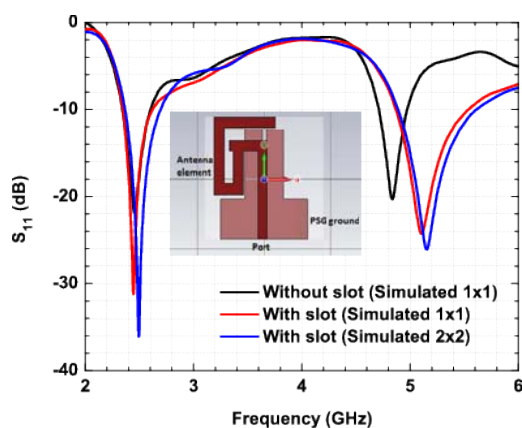


Fig. 4: S_{11} parameter of proposed antenna element

can be used to optimize grid operations, identify potential issues, and implement proactive maintenance strategies, leading to improved grid reliability and reduced downtime.

Moreover, WiMAX supports bidirectional communication between utility devices and control centers, enabling utilities to remotely manage and control grid assets, respond to outages, and implement demand response programs. This enhances grid resilience and flexibility, enabling utilities to better manage peak demand, integrate renewable energy sources, and support emerging grid technologies such as energy storage and electric vehicle charging.

Overall, WiMAX technology plays a critical role in modernizing utility infrastructure and enabling the transition to smart grids. Its ability to provide reliable, high-speed wireless connectivity over wide areas makes it an ideal solution for utilities looking to improve operational efficiency, optimize resource utilization, and enhance customer service in the rapidly evolving energy landscape.

4. Public Safety and Emergency Services:

WiMAX technology plays a vital role in public safety and emergency response systems, providing reliable communication capabilities for first responders, law enforcement agencies, and disaster management organizations. WiMAX networks enable high-speed data transmission, video surveillance, and real-time situational awareness during emergencies, enabling timely coordination and effective response efforts. With its robust and resilient connectivity, WiMAX enhances the effectiveness of public safety operations and contributes to enhanced community safety and security. WiMAX technology serves as a vital communication tool for public safety and emergency services, offering reliable, high-speed wireless connectivity to support critical communication and coordination efforts during emergencies and disaster response scenarios. WiMAX networks provide a resilient communication infrastructure that enables first responders, emergency personnel, and government agencies to effectively communicate, coordinate, and access essential information in real-time, even in challenging environments as given in Fig. 5.

During emergencies, such as natural disasters, accidents, or public safety incidents, WiMAX networks facilitate the rapid deployment of temporary communication solutions, enabling emergency responders to establish command centers, set up temporary shelters, and coordinate rescue and relief efforts more efficiently. WiMAX technology supports a wide range of communication devices,

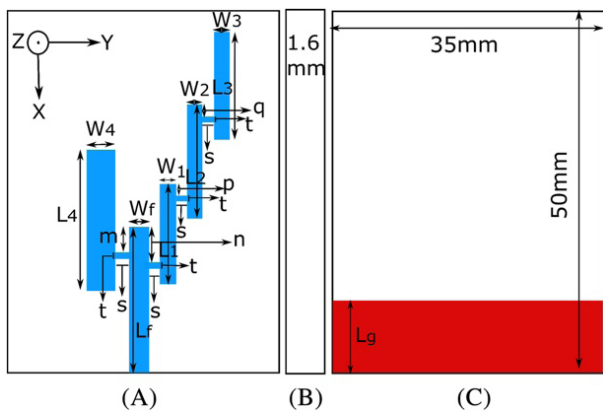


Fig. 5: Circularly polarized quad-band monopole antenna

including smartphones, tablets, laptops, and specialized communication equipment used by first responders, ensuring interoperability and seamless communication across different agencies and jurisdictions.^[62]

Moreover, WiMAX networks offer robust coverage and capacity, allowing emergency services to maintain communication continuity and provide timely assistance to affected communities, even in areas with damaged or overloaded infrastructure. By providing reliable wireless connectivity and supporting mission-critical applications, WiMAX technology enhances the effectiveness and efficiency of public safety and emergency response operations, ultimately helping to save lives and protect property during times of crisis.

5. Transportation and Intelligent Mobility

WiMAX technology supports various transportation applications, including intelligent transportation systems (ITS), fleet management, and connected vehicle initiatives. WiMAX-enabled communication networks facilitate real-time traffic monitoring, congestion management, and traveler information services, improving traffic flow, reducing travel times, and enhancing overall transportation efficiency. By enabling seamless connectivity between vehicles, infrastructure, and passengers, WiMAX contributes to the development of smarter, safer, and more sustainable transportation systems. WiMAX technology plays a crucial role in transportation and intelligent mobility applications, enabling the development of connected and smart transportation systems that improve efficiency, safety, and sustainability. WiMAX networks provide high-speed wireless connectivity to support a wide range of transportation applications, including traffic management, vehicle-to-infrastructure (V2I) communication, and intelligent transportation systems (ITS) as given in Fig. 6.

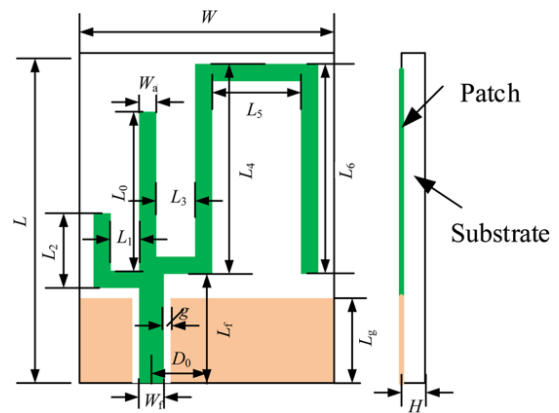


Fig. 5: A compact CPW-fed monopole antenna

With WiMAX, transportation authorities can deploy real-time traffic monitoring and management systems to collect data on traffic flow, congestion, and road conditions. This data can be used to optimize traffic signals, reroute traffic, and improve overall traffic flow, reducing congestion and travel times for commuters.

WiMAX also facilitates communication between vehicles and roadside infrastructure, enabling vehicles to exchange information with traffic signals, road signs, and other vehicles in real-time. This enables advanced safety features such as collision avoidance, lane departure warnings, and adaptive cruise control, enhancing driver safety and reducing the risk of accidents on the road.

Moreover, WiMAX technology supports the deployment of intelligent mobility solutions such as autonomous vehicles and connected car services, enabling vehicles to communicate with each other and with the surrounding infrastructure to navigate safely and efficiently. By providing reliable wireless connectivity and supporting advanced transportation applications, WiMAX technology is driving innovation and transforming the future of transportation towards safer, more efficient, and sustainable mobility solutions.

6. Rural Broadband and Community Networks

In rural and remote areas where traditional wired infrastructure is cost-prohibitive, WiMAX technology offers a viable solution for providing broadband connectivity to underserved communities. Community networks and rural broadband initiatives leverage WiMAX technology to establish wireless broadband networks, delivering internet access to homes, schools, and businesses in rural areas. WiMAX enables community-driven initiatives to bridge the digital divide, foster economic development, and empower individuals with access to information and opportunities. WiMAX technology plays a critical role in bridging the digital divide and providing

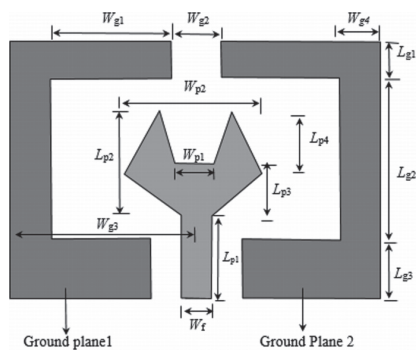


Fig. 5: A Compact CPW-fed Monopole Antenna

broadband access to rural and underserved communities through the deployment of community networks. In rural areas where traditional wired infrastructure is limited or unavailable, WiMAX offers an efficient and cost-effective solution for delivering high-speed internet connectivity to residents, businesses, and community organizations as given in Fig. 7.

WiMAX networks enable rural communities to overcome geographical barriers and access essential online services, such as education, healthcare, and e-commerce, which are essential for socioeconomic development and empowerment. By providing reliable broadband access, WiMAX helps rural communities participate in the digital economy, access online education and training resources, and connect with healthcare providers and government services remotely.

Moreover, WiMAX supports community-led initiatives to build and manage local broadband networks, empowering residents to take control of their connectivity and address their unique communication needs. Community networks powered by WiMAX foster collaboration and cooperation among local stakeholders, including government agencies, businesses, and non-profit organizations, to expand network coverage, improve service quality, and ensure affordable access for all members of the community as given in Fig. 8.

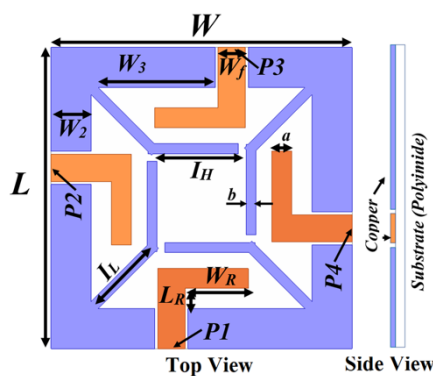


Fig. 8: A Compact CPW-fed Monopole Antenna For Multi-band

Overall, WiMAX rural broadband and community networks play a vital role in fostering digital inclusion, promoting economic development, and enhancing quality of life in rural and underserved areas. By providing reliable, high-speed internet connectivity, WiMAX technology empowers rural communities to thrive in the digital age and unlock new opportunities for growth and prosperity.

Future Directions and Innovations:

As the demand for high-speed broadband connectivity continues to grow, WiMAX technology is poised to evolve and adapt to meet the evolving needs of users and industries. Future advancements in WiMAX technology may include:

- Enhanced Spectrum Efficiency: Ongoing research and development efforts aim to improve spectrum efficiency and spectral utilization in WiMAX networks, enabling higher data rates, increased capacity, and better quality of service.
- 5G Integration: WiMAX technology may integrate with emerging 5G networks, enabling seamless connectivity between WiMAX and 5G-enabled devices and services. This integration could unlock new synergies and opportunities for convergence between WiMAX and next-generation wireless technologies.
- Internet of Things (IoT) Support: WiMAX networks may support IoT applications and devices, providing connectivity for a wide range of IoT sensors, actuators, and smart devices. WiMAX-enabled IoT solutions could enable applications such as smart cities, industrial automation, and environmental monitoring.

CONCLUSION

In conclusion, WiMAX technology has emerged as a powerful enabler of high-speed broadband connectivity, offering a wide range of applications across various industries and sectors. From telecommunications and mobile broadband to smart grid and public safety, WiMAX continues to revolutionize the way we connect, communicate, and interact with the world around us. As we look to the future, WiMAX technology is poised to play a pivotal role in shaping the next generation of wireless communication networks, driving innovation, and fostering digital inclusion on a global scale. In conclusion, WiMAX technology has emerged as a versatile and valuable solution for delivering high-speed broadband access to a wide range of applications and environments. Its ability to provide long-range coverage, support mobility, and deliver high data rates

makes it well-suited for addressing diverse connectivity needs in both urban and rural areas. WiMAX has made significant contributions to various industries, including telecommunications, transportation, healthcare, and public safety, enabling the development of innovative solutions that improve efficiency, safety, and quality of life. From providing internet access to underserved communities to supporting smart grid infrastructure and intelligent transportation systems, WiMAX technology continues to drive innovation and transform the way we communicate, work, and live.

As technology continues to evolve, WiMAX is expected to play a significant role in enabling connectivity in emerging markets, supporting the expansion of the Internet of Things (IoT), and addressing the digital divide by providing affordable and accessible broadband access to underserved populations. Overall, WiMAX technology has proven to be a valuable asset in advancing connectivity and driving socio-economic development worldwide.

REFERENCES

1. Meredith, John. "Voice call continuity in 3GPP." Compact-PCI and Advanced TCA Systems (2006).."
2. Behmann, Fawzi. "Impact of wireless (Wi-Fi, WiMAX) on 3G and next generation-An initial assessment." 2005 IEEE International Conference on Electro Information Technology. IEEE, 2005. .
3. Berlemann, Lars, et al. "Coexistence and Interworking of IEEE 802.16 and IEEE 802.11 (e)." 2006 IEEE 63rd Vehicular Technology Conference. Vol. 1. IEEE, 2006..
4. Dhawan, Sanjeev. "Analogy of promising wireless technologies on different frequencies: Bluetooth, wifi, and wimax." The 2nd International Conference on Wireless Broadband and Ultra Wideband Communications (AusWireless 2007). IEEE, 2007..
5. Cacace, Filippo, and Luca Vollero. "Managing mobility and adaptation in upcoming 802.21 enabled devices." Proceedings of the 4th international workshop on Wireless mobile applications and services on WLAN hotspots. 2006..
6. Gaitan, Oscar Salazar, et al. "SIP Embedded Attribute Certificates for Service Mobility in Heterogeneous Multi-Operator Wireless Networks." 2007 IEEE 66th Vehicular Technology Conference. IEEE, 2007..
7. Banerji, Sourangsu, and Rahul Singha Chowdhury. "On IEEE 802.11: wireless LAN technology." arXiv preprint arXiv:1307.2661 (2013).."
8. Saeed, Rashid A., et al. "WiMAX-WiFi Synergy for Next Generation Heterogynous Network." WIMAX New Developments. IntechOpen, 2009..
9. IEEE Std 802.16.4, 2009 "IEEE 802.16 Task Group 4 (WirelessHUMAN TM Task Group)" wirelessman.org/tg4/, accessed on March 2009.
10. Ahmadi, Sassan. Mobile WiMAX: A systems approach to understanding IEEE 802.16 m radio access technology. Academic Press, 2010.."
11. SPOORTHI, AS, TD SUNIL, and MZ KURIAN. "Implementation of Lora based Autonomous Agriculture Robot." International Journal of communication and computer Technologies 9.1 (2021): 34-39.
12. KRISHNA, M. VAMSHI, and K. JANAKI RAM. "Digitization, Preservation and Character Recognition in Ancient Documents Using Image Processing Techniques-A Review." International Journal of communication and computer Technologies 9.1 (2021): 23-26.
13. DANH, NGUYEN TAN. "Analysis of Reliability for Flash Type Analog to Digital Converter." Journal of VLSI circuits and systems 2.2 (2020): 5-8.
14. THOI, NGUYEN THI. "Analysis of Low Power Gdi Based Alu for High-Speed Applications." Journal of VLSI circuits and systems 2.2 (2020): 9-11.