Research Article

A Survey of Different IoMT Protocols for Healthcare Applications

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Abstract

The increasing use of wireless technologies in healthcare has provided new opportunities for remote patient monitoring, medical device communication, and electronic health record management. However, choosing the appropriate wireless technology for healthcare applications can be challenging due to their unique advantages and limitations. In this context, the following study explores the applications and limitations of various wireless technologies used in healthcare, including BLE, Zigbee, Wi-Fi, Cellular, LoRaWAN, NB-IoT, and Thread. BLE is commonly used for wireless data transfer from medical devices, remote patient monitoring, and location tracking. Zigbee is used for remote patient monitoring, medical device communication, and home health monitoring. Wi-Fi is used for remote patient monitoring, telemedicine, and electronic health record management. Cellular technology is used for remote patient monitoring, telemedicine, and emergency response. LoRaWAN is used for remote patient monitoring, asset tracking, and environmental monitoring. NB-IoT is used for remote patient monitoring and medical device communication. Thread is used for remote patient monitoring, asset tracking, and environmental monitoring. The study reveals that each wireless technology has its own unique advantages and limitations. For example, BLE has a limited range of up to 10 meters and limited bandwidth, while Zigbee has a range of up to 100 meters and limited bandwidth. Wi-Fi has high power consumption, which may not be suitable for battery-operated medical devices, while Cellular technology also has high power consumption and limited coverage in certain areas. LoRaWAN has limited bandwidth, and NB-IoT coverage may be limited in certain areas. Thread has a limited range and limited bandwidth. Our study recommend that healthcare providers should consider the range, bandwidth, power consumption, and reliability of communication to ensure that the chosen wireless technology meets the requirements of their application.

Keywords: Healthcare, BLE, Zigbee, Wi-Fi, Cellular, LoRaWAN, NB-IoT, Thread

Introduction

Healthcare modernization is of paramount importance in today's rapidly evolving world. The continuous advancement of technology and the increasing demands and complexities of the healthcare industry necessitate the need for modernizing healthcare systems. This process involves the integration of innovative technologies, improved infrastructure, streamlined workflows, and enhanced patient-centered care. Healthcare modernization enhances operational efficiency and cost-effectiveness [1]–[4]. Outdated systems and manual processes can lead to inefficiencies, increased administrative burdens, and rising healthcare costs. By implementing modern technologies, such as artificial intelligence (AI), machine learning (ML), and data analytics, healthcare organizations can automate routine tasks, streamline workflows, and optimize resource allocation. Predictive analytics can help identify high-risk patients and proactively intervene to prevent hospitalizations [5]–[7]. Supply chain management systems can minimize waste, control inventory, and improve cost control. Modernizing healthcare systems also allows for improved communication and collaboration among healthcare providers, leading to more efficient care coordination and reduced medical errors.

The Internet of Medical Things (IoMT) describes the use of interconnected medical devices, sensors, and software applications in the healthcare industry. It involves the integration of advanced technology with healthcare to improve patient outcomes, reduce healthcare costs, and enhance the overall quality of care [8]. IoMT is gaining popularity in the healthcare industry, and its adoption is expected to increase significantly in the coming years.

The IoMT ecosystem comprises a wide range of devices and technologies such as wearables, remote patient monitoring systems, telemedicine, and smart implants. These devices can collect patient data and transmit it to healthcare providers in real-time, enabling them to make more informed decisions and provide better care. IoMT devices can also alert healthcare providers if a patient's condition worsens, which can result in early intervention and improved outcomes [9].

The capacity to remotely monitor patients is one of IoMT's most important capabilities. This is particularly useful for patients with chronic conditions, such as diabetes or heart disease, who need ongoing monitoring and management. Remote monitoring devices can provide healthcare providers with a wealth of data, including vital signs, medication adherence, and activity levels. This data can be used to adjust treatment plans, detect potential complications early, and prevent hospitalizations. By enabling remote monitoring and early intervention, IoMT can

prevent costly hospitalizations and emergency department visits. It can also reduce the number of clinic visits required for routine care, freeing up healthcare resources for patients who need more intensive care [10], [11].

IoMT devices can also improve the patient experience by enabling more personalized care. For example, wearables can track a patient's activity levels, sleep patterns, and stress levels, allowing healthcare providers to make recommendations for lifestyle changes that can improve overall health. Telemedicine can also improve the patient experience by providing convenient access to healthcare providers from the comfort of their own homes.

However, IoMT also presents several challenges. One of the most significant challenges is data security and privacy. With the increasing amount of patient data being transmitted, stored, and analyzed by IoMT devices, there is a risk of data breaches and unauthorized access. It is essential to ensure that IoMT devices comply with relevant data security and privacy regulations to protect patient data.

Another challenge is interoperability. IoMT devices are often produced by different manufacturers and may use different standards and protocols. This can make it difficult to integrate different devices and platforms, hindering the ability of healthcare providers to access and analyze patient data. Standardization and interoperability are essential to ensure that IoMT devices can communicate and share data effectively.

There is also a need for healthcare providers to have the skills and expertise to interpret and act on the data collected by IoMT devices. Healthcare providers must be able to analyze the data and make informed decisions based on the information collected. This requires training and education to ensure that healthcare providers are comfortable with using IoMT devices and interpreting the data they generate. The potential benefits of IoMT, including improved patient outcomes, reduced healthcare costs, and enhanced quality of care, are too significant to ignore. As technology continues to evolve, IoMT is likely to become an increasingly essential tool in the healthcare provider's toolbox.

The emergence of wireless technology has brought about a significant revolution in healthcare services, particularly in the field of the Internet of Medical Things (IoMT). The use of wireless sensors and wearable devices has made it possible to monitor patients remotely and in real-time, which is a critical aspect of patient care. The benefits of this technology are numerous, with one of the most important being the ability to provide continuous monitoring and early intervention when necessary. For patients with chronic conditions, this can be particularly useful as they require ongoing monitoring and management to keep their condition in check.

Wireless sensors and wearable devices have enabled healthcare providers to remotely monitor patients without the need for them to be physically present. This is particularly beneficial in situations where patients are unable to travel to healthcare facilities for regular check-ups, such as those living in rural areas. With wireless technology, healthcare providers can receive real-time data on a patient's vital signs, medication intake, and other health-related information, allowing them to make informed decisions and intervene promptly if necessary. Additionally, patients can have more control over their health by being able to access their own data, which can help them better manage their conditions.

Furthermore, wireless technology in IoMT can also help healthcare providers to reduce healthcare costs by preventing hospitalizations and emergency visits. By continuously monitoring patients with chronic conditions, healthcare providers can identify and address potential health issues before they escalate, leading to better health outcomes and cost savings. Additionally, patients may experience a better quality of life by being able to stay at home and receive care remotely, rather than having to visit hospitals or clinics for regular check-ups. The use of wireless technology in IoMT is rapidly expanding, and its benefits are expected to continue to grow as more advanced sensors and devices are developed.

The role of Artificial Intelligence (AI), Machine Learning (ML), Natural Language Processing (NLP), and HealthTech in the realm of the Internet of Medical Things (IoMT) is paramount, particularly when it comes to wireless technology [12], [13]. The IoMT leverages interconnected medical devices and systems to collect, analyze, and transmit health-related data. AI and ML play a significant role in this ecosystem by enabling the extraction of valuable insights from vast amounts of data generated by these devices [14]. Through sophisticated algorithms, AI and ML can identify patterns, predict outcomes, and detect anomalies, thereby aiding in diagnosis, treatment planning, and proactive healthcare interventions [15].

By collecting this data, IoMT allows for early detection of deviations from baseline and abnormalities that could indicate compromised immune function. Real-time monitoring empowers individuals and healthcare professionals to identify potential health risks promptly, enabling timely interventions and proactive management of immune-related conditions [16], [17].

Wireless technology acts as the backbone of the IoMT, facilitating seamless connectivity and real-time data transmission between various medical devices and healthcare systems. AI and ML algorithms can process this data to recognize patterns and identify potential health risks, enabling personalized and proactive care. NLP, on the other hand, empowers the IoMT by allowing devices and systems to understand and interpret human language.

This capability facilitates efficient communication between patients, healthcare professionals, and machines. By analyzing and understanding textual data, NLP enables voice commands, chatbots, and virtual assistants to provide accurate information, answer queries, and even assist in clinical decision-making [18], [19].

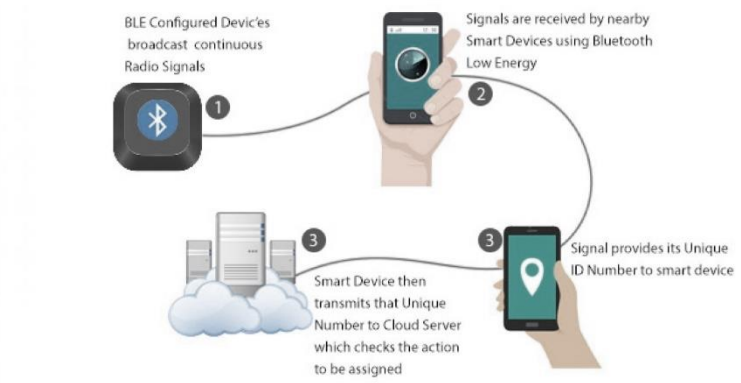
In the domain of HealthTech, AI, ML, and NLP contribute to advancements in remote patient monitoring, telehealth, and predictive analytics. Wireless sensors and wearable devices equipped with AI algorithms continuously collect vital signs, activity levels, and other health-related data, allowing for real-time monitoring of patients outside traditional healthcare settings [20]. AI-driven predictive analytics can identify trends and predict potential health issues, enabling early intervention and preventive measures [21], [22]. Telehealth platforms, supported by AI, ML, and NLP technologies, enhance remote consultations, enabling healthcare professionals to provide virtual diagnoses, monitor patients, and deliver personalized care plans.

IoMT protocols

Bluetooth Low Energy (BLE):

Bluetooth Low Energy (BLE) is a type of wireless technology that has gained widespread use in healthcare applications. This technology is designed to transfer data wirelessly between devices, such as medical equipment and wearable devices, with low power consumption. It is highly beneficial for patients, physicians, and healthcare providers, as it enables continuous data monitoring and real-time tracking, leading to better diagnosis, treatment, and outcomes [23].

Figure 1. Bluetooth Low Energy (BLE)



The low power consumption of BLE technology is one of its main advantages in healthcare applications. It requires minimal energy to operate, making it an excellent choice for medical devices that require long battery life. This makes it ideal for wearable health monitoring devices that are worn for extended periods, such as smartwatches, fitness trackers, and medical sensors. This technology is also used in remote patient monitoring devices that require continuous data transfer, such as blood glucose meters, blood pressure monitors, and heart rate monitors [24].

However, one of the main limitations of BLE technology is its limited range, which is typically up to 10 meters. This means that devices need to be within close proximity to one another for data transfer to take place. As a result, it may not be suitable for healthcare applications that require devices to communicate over longer distances, such as between different rooms or floors in a hospital or healthcare facility. This limitation may require additional infrastructure, such as repeaters or routers, to extend the range of the BLE signal [25].

While BLE is designed to transmit small packets of data, it may not be suitable for real-time applications that require high-bandwidth data transfer. This can cause delays in data transmission, which can be problematic for applications that require immediate data feedback, such as remote patient monitoring. In some cases, other wireless technologies may be more appropriate, such as Wi-Fi or cellular networks, which have higher bandwidth capabilities [26].

Its low power consumption and ability to operate wirelessly make it an excellent choice for wearable health monitoring devices and remote patient monitoring equipment. It also enables healthcare providers to collect valuable data continuously and in real-time, which can help them make informed decisions about patient care and treatment. The benefits of using BLE technology in healthcare applications outweigh its limitations. However, it is essential to understand its capabilities and limitations before deploying it in a healthcare environment [27]. Healthcare providers and device manufacturers need to consider the range, bandwidth, and power requirements of BLE devices before implementing them, to ensure that they are effective and efficient in meeting the needs of patients and healthcare providers alike.

Zigbee:

Zigbee is a wireless technology that operates on a low-power, low-data rate platform, making it an excellent choice for healthcare applications. It is particularly well-suited for remote patient monitoring, where it is used to connect various medical devices to a central monitoring system [28]. Zigbee-enabled medical devices such as blood glucose monitors, blood pressure monitors, and pulse

oximeters can provide healthcare providers with real-time data about a patient's health status, allowing for prompt intervention in case of emergency.

Remote patient monitoring using Zigbee technology offers several benefits, including reduced hospitalization rates, decreased healthcare costs, and improved patient outcomes. Patients can receive care from the comfort of their homes, eliminating the need for frequent hospital visits. Healthcare providers can monitor their patients' vital signs and medical conditions remotely, making it easier to detect and treat potential health problems before they become serious.

However, one of the limitations of Zigbee technology is its limited range. Zigbee devices typically have a range of up to 100 meters, which can limit their usefulness in certain healthcare settings. For example, in a large hospital or healthcare facility, a Zigbee-enabled device may not be able to communicate with a central monitoring system if it is too far away. In such cases, other wireless technologies with a larger range, such as Wi-Fi or cellular, may be more suitable [29].

Zigbee's data rate is significantly lower than that of other wireless technologies, which can make it unsuitable for real-time applications that require high-speed data transfer. For example, streaming live video or transmitting large amounts of medical data in real-time may not be possible with Zigbee technology. In such cases, other wireless technologies with higher bandwidth, such as Wi-Fi or Bluetooth, may be more appropriate [30].

Zigbee technology continues to be a popular option for healthcare applications despite its drawbacks, especially in the field of remote patient monitoring. Its low-power, low-data rate platform makes it an excellent choice for medical devices that need to operate on a battery for extended periods. Zigbee's mesh networking capabilities also make it possible to create large-scale healthcare monitoring systems that can be easily scaled up or down as needed [31].

In addition to remote patient monitoring, Zigbee technology is also used in home health monitoring systems. These systems use Zigbee-enabled devices to track patients' vital signs and activities of daily living, such as sleeping patterns, physical activity, and medication adherence [32]. The data collected by these devices can be used to develop personalized care plans for patients and to identify potential health problems before they become serious.

Wi-Fi:

Wi-Fi enables remote patient monitoring, which allows healthcare professionals to track patient vital signs, medications, and other health indicators remotely. This capability has been particularly useful for patients with chronic conditions, such as diabetes or heart disease, as it allows healthcare professionals to monitor their

condition and intervene when necessary. Wi-Fi also facilitates telemedicine, which enables healthcare professionals to conduct virtual consultations with patients, saving time and improving access to care.

Another significant advantage of Wi-Fi in healthcare is its ability to connect medical devices to a central monitoring system. Medical devices can be connected wirelessly to a network, enabling real-time data collection and analysis. This capability has been critical in enhancing patient safety and improving the quality of care. For example, Wi-Fi-connected infusion pumps can be programmed to alert healthcare professionals when medication doses are incorrect or if the pump is not functioning correctly [33].

However, despite its numerous benefits, Wi-Fi has some limitations when it comes to healthcare applications. One of the limitations of Wi-Fi is its high power consumption. This high power consumption can be problematic for battery-operated medical devices, which may require frequent battery replacement. The battery life of a medical device connected to Wi-Fi is dependent on the strength of the Wi-Fi signal and the frequency of data transmission. As a result, healthcare organizations must balance the benefits of Wi-Fi connectivity with the increased power consumption of their devices [34].

The bandwidth of a Wi-Fi network refers to the maximum data transfer rate that can be achieved by the network. This limited bandwidth can be problematic for real-time applications, such as video conferencing between healthcare professionals and patients. The quality of video and audio in a video conference can be affected by limited bandwidth, resulting in a poor patient experience and potentially compromising patient care.

Wi-Fi is still a popular option for healthcare businesses despite these drawbacks. Wi-Fi networks are easy to set up, configure, and maintain. They are also cost-effective compared to other wireless technologies. Wi-Fi networks are also compatible with a wide range of medical devices, making it easy to integrate new devices into an existing network.

Cellular:

Patients can wear medical devices that collect data, such as heart rate, blood pressure, and oxygen levels, which are transmitted through cellular networks to a central monitoring system. This allows healthcare professionals to monitor patients in real-time and make timely interventions, which can help prevent complications and reduce hospital readmissions. Remote patient monitoring has been particularly useful for patients with chronic conditions, such as diabetes and heart disease, who require frequent monitoring and care [35].

Telemedicine is another application of cellular technology in healthcare. Telemedicine refers to the use of video and audio communication to provide medical consultations and treatment remotely. This is particularly useful for patients who live in remote areas or have mobility issues. Telemedicine can also reduce the burden on hospitals and clinics by enabling healthcare professionals to provide consultations from their offices or homes. Cellular technology has played a crucial role in enabling telemedicine by providing reliable voice and video communication.

Emergency response is another area where cellular technology has been invaluable. During emergencies, such as natural disasters or accidents, cellular networks can be used to coordinate emergency response efforts and provide assistance to victims. Emergency responders can use cellular networks to communicate with each other and access critical information, such as maps and weather reports. Cellular technology has also enabled the development of mobile health apps that can be used to request emergency services, such as ambulances and police [36].

One of the main limitations is its high power consumption, which may not be suitable for battery-operated medical devices. Medical devices that rely on cellular technology may require frequent charging, which can be inconvenient for patients and may limit their mobility. Additionally, the use of cellular technology for remote patient monitoring and telemedicine may be limited in areas with poor cellular coverage [37]. This can affect the reliability of communication and may lead to missed or delayed interventions.

Patient data transmitted through cellular networks may be vulnerable to hacking and other cyber threats. Healthcare organizations must take steps to ensure that patient data is protected by using encryption and other security measures. Additionally, healthcare professionals must be trained on how to use cellular technology safely and securely to prevent data breaches [38].

Finally, the cost of cellular technology can be a barrier to its adoption in healthcare. Medical devices that rely on cellular technology can be expensive, which may limit their availability to patients. Additionally, the cost of cellular data plans and network infrastructure can be prohibitively expensive for healthcare organizations, particularly in low-resource settings. Healthcare organizations must carefully consider the cost-benefit ratio of cellular technology before investing in it [39].

LoRaWAN:

LoRaWAN is a low-power wireless technology that has revolutionized healthcare through remote patient monitoring, asset tracking, and environmental monitoring.

It has enabled the connection of medical devices and sensors to a central monitoring system, enhancing the efficiency of healthcare delivery. The technology has facilitated the location tracking of patients and medical equipment, allowing healthcare providers to keep track of their assets and patients' movements. With its long-range capabilities, LoRaWAN has eliminated the need for manual data collection, improving the accuracy of medical data collection [40].

Despite its great advantages, LoRaWAN has several drawbacks. One of its major drawbacks is its restricted bandwidth. The technology's bandwidth may not be sufficient for applications that require high data transfer rates. This limitation may hinder the technology's effectiveness in delivering real-time data, which is critical in healthcare. In medical emergencies, the speed of data transfer can make a difference between life and death. Therefore, healthcare providers may have to supplement LoRaWAN with other technologies that can meet their high data transfer needs.

Real-time applications require low-latency communication channels, which LoRaWAN may not provide. Due to the technology's limited bandwidth, data may experience delays, which may lead to inaccurate readings. Healthcare providers may not be able to make timely decisions based on delayed data, which can be detrimental to patient health [41]. Therefore, healthcare providers may have to use other technologies that can meet their real-time communication needs.

LoRaWAN has been instrumental in improving healthcare outcomes. For instance, the technology has enabled remote patient monitoring, allowing healthcare providers to monitor patients' health in real-time. Patients can receive timely interventions in case of emergencies, reducing the need for hospitalization. LoRaWAN has also enabled asset tracking, ensuring that healthcare facilities can keep track of their equipment, reducing the risk of loss or theft. Additionally, LoRaWAN has facilitated environmental monitoring, ensuring that healthcare facilities provide a conducive environment for patients and medical personnel [42].

NB-IoT:

NB-IoT, or Narrowband Internet of Things, is a wireless communication technology designed to enable IoT devices to communicate wirelessly with each other and with a central server. It is a low-power, low-cost solution that provides extended coverage, making it an ideal choice for healthcare applications, including remote patient monitoring and medical device communication. NB-IoT is one of the most popular wireless technologies used in healthcare, mainly due to its reliability, affordability, and energy efficiency.

NB-IoT is designed to work in the licensed spectrum and is optimized for IoT devices that require low data rates, long battery life, and extensive coverage. In healthcare, it can be used for various applications, including remote patient monitoring, medical equipment tracking, and preventive maintenance. NB-IoT's low power consumption enables devices to operate for extended periods without requiring frequent battery replacement, making it a cost-effective solution for healthcare providers [43].

NB-IoT has some limitations that can affect its suitability for certain healthcare applications. One of the most significant limitations of NB-IoT is its limited bandwidth. NB-IoT devices can transfer only a small amount of data, limiting its usefulness in applications that require high data transfer rates, such as video streaming or high-resolution image transmission. In such cases, other wireless technologies, such as Wi-Fi or Bluetooth, may be more appropriate.

While it can provide extended coverage, its coverage area may be limited in certain areas, such as in buildings or areas with high interference levels. This can affect the reliability of communication between devices, leading to data loss or delays. To address this limitation, healthcare providers may need to deploy additional NB-IoT base stations or use other wireless technologies that can provide more extensive coverage [44].

NB-IoT remains a popular choice for healthcare applications due to its reliability, energy efficiency, and low cost. In particular, it is an ideal choice for applications that require low data rates, long battery life, and extended coverage. Its ability to provide secure and reliable communication makes it a valuable tool for remote patient monitoring and medical device communication, enabling healthcare providers to monitor patients' health status and medical equipment from a central location.

Thread:

Thread is a low-power wireless technology that has become increasingly popular in healthcare for its ability to connect medical devices and sensors to a central monitoring system. The technology has revolutionized remote patient monitoring, asset tracking, and environmental monitoring, enhancing the efficiency of healthcare delivery. Thread has facilitated the location tracking of patients and medical equipment, allowing healthcare providers to keep track of their assets and patients' movements. With its low-power requirements, Thread has reduced energy consumption, prolonging the life of medical devices and sensors.

One of its significant limitations is its limited range, which is typically up to 100 meters. This limitation may hinder the technology's effectiveness in large

healthcare facilities that require longer ranges. Patients or medical equipment may move beyond the technology's range, leading to data loss or inaccurate readings. Therefore, healthcare providers may have to use other technologies that can cover a larger range to ensure reliable connectivity [45].

Real-time applications require low-latency communication channels, which Thread may not provide. Due to the technology's limited bandwidth, data may experience delays, which may lead to inaccurate readings [46]. Healthcare providers may not be able to make timely decisions based on delayed data, which can be detrimental to patient health [47]. Therefore, healthcare providers may have to use other technologies that can meet their real-time communication needs [48].

Thread has been instrumental in improving healthcare outcomes. For instance, the technology has enabled remote patient monitoring, allowing healthcare providers to monitor patients' health in real-time. Patients can receive timely interventions in case of emergencies [49], reducing the need for hospitalization. Thread has also enabled asset tracking, ensuring that healthcare facilities can keep track of their equipment, reducing the risk of loss or theft [50]. Additionally, Thread has facilitated environmental monitoring, ensuring that healthcare facilities provide a conducive environment for patients and medical personnel [51].

Conclusion

Wireless technology has become an integral part of the Internet of Medical Things (IoMT) ecosystem. It enables the transfer of data wirelessly between medical devices, sensors, and software applications, providing healthcare providers with real-time access to patient information. Wireless technology has transformed the healthcare industry by providing mobility, flexibility, and convenience, allowing healthcare providers to offer more personalized and efficient care to patients. IoMT is a rapidly growing field that has the potential to transform the healthcare industry. The integration of advanced technology with healthcare can improve patient outcomes, reduce healthcare costs, and enhance the overall quality of care.

Bluetooth Low Energy (BLE) technology has considered to be a valuable asset in the healthcare industry. Its low power consumption, ability to operate wirelessly, and real-time monitoring capabilities make it ideal for wearable health monitoring devices and remote patient monitoring equipment. However, it is essential to recognize its limitations, such as its limited range and bandwidth capabilities, before deploying it in a healthcare environment.

Zigbee technology is an important wireless technology that is widely used in healthcare for remote patient monitoring and medical device communication. Its low-power, low-data rate platform makes it an excellent choice for medical devices

that need to operate on a battery for extended periods. While Zigbee's limited range and bandwidth can be a limitation in certain healthcare settings, its benefits, including reduced hospitalization rates and improved patient outcomes, make it a popular choice for healthcare providers.

Wi-Fi is a wireless technology that has transformed healthcare in many ways, enabling remote patient monitoring, telemedicine, and real-time data collection. While Wi-Fi has some limitations, its benefits have made it a popular choice for healthcare organizations. As the healthcare industry continues to evolve, new wireless technologies are emerging that may be more appropriate for specific healthcare applications.

Cellular technology has transformed healthcare by enabling remote patient monitoring, telemedicine, and emergency response. It has provided healthcare professionals with real-time data and communication tools that have improved patient outcomes and reduced healthcare costs. However, cellular technology has some limitations, such as high power consumption, limited coverage, security concerns, and cost.

LoRaWAN has transformed healthcare through remote patient monitoring, asset tracking, and environmental monitoring. The technology has enabled healthcare providers to improve healthcare delivery and outcomes, making it a valuable addition to the healthcare sector. However, the technology's limitations, such as limited bandwidth and lack of support for real-time applications, may hinder its effectiveness in delivering critical healthcare services. Healthcare providers may have to supplement LoRaWAN with other technologies to meet their high data transfer and real-time communication needs.

NB-IoT is a low-power wireless technology that has become increasingly popular in healthcare applications, including remote patient monitoring and medical device communication. Its reliability, energy efficiency, and low cost make it an ideal choice for healthcare providers. However, its limited bandwidth and coverage area may limit its suitability for certain healthcare applications.

Thread has transformed healthcare through remote patient monitoring, asset tracking, and environmental monitoring. The technology has enabled healthcare providers to improve healthcare delivery and outcomes, making it a valuable addition to the healthcare sector. However, the technology's limitations, such as limited range and lack of support for real-time applications, may hinder its effectiveness in delivering critical healthcare services.

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