



SHORT-RANGE WIRELESS TECHNOLOGY

A COMPARISON OF BLUETOOTH™ & NEARLINK™



Bluetooth™ and NearLink™ are two prominent wireless communication technologies designed for short-distance data transmission, each with unique capabilities and applications. Bluetooth, established in the late 1990s, operates within the 2.4 GHz ISM¹ frequency band and is widely adopted across billions of devices, facilitating seamless connections for

¹ ISM bands (industrial, scientific, and medical) are parts of the RF (radiofrequency) spectrum reserved for general use by, as the name suggests, scientific, medical, and industrial devices.



consumer electronics like smartphones, audio devices, and wearables^{[1][2]}. In contrast, NearLink, launched commercially in 2023 and developed by the NearLink Alliance, aims to enhance performance and power efficiency while reducing reliance on existing Western technologies, particularly within the context of geopolitical tensions^{[3][4][5]}.

Bluetooth's advantages include broad compatibility and low power consumption, while its limitations encompass a restricted range and various security vulnerabilities, making it less suitable for certain high-performance applications^{[6][7]}. NearLink, designed with a three-layer architecture, boasts microsecond latency and high concurrency capabilities, positioning it as an ideal solution for real-time applications like online gaming and industrial IoT environments^{[8][5]}. Moreover, its focus on efficient power management allows for prolonged device longevity, addressing the increasing demand for sustainable solutions in wireless communication^[8].

The comparison between these two technologies also highlights significant differences in their application areas. While Bluetooth dominates personal area networks and consumer devices, NearLink is gaining traction in industrial settings, smart homes, and enterprise environments, where its robust performance metrics can provide a competitive edge^{[7][9]}. However, NearLink's rapid rise raises questions about its long-term implications for the wireless landscape, particularly regarding market competition and security standards, as it challenges the established dominance of Bluetooth and Wi-Fi^{[5][10]}.

Overall, the evolution of both Bluetooth and NearLink is indicative of a shifting technological landscape, with each technology catering to distinct user needs and preferences. The ongoing advancements in both fields will shape the future of wireless communication, impacting a wide range of applications from personal devices to interconnected smart systems in various sectors^{[11][12]}.



Overview of Bluetooth



Bluetooth is a wireless communication technology that facilitates the exchange of data over a short-range radio band. It enables various devices, including smartphones, tablets, headphones, and home automation systems, to connect and communicate without physical cables^{[1][2]}. Bluetooth technology is widely recognised and utilised, with over 4.7 billion devices shipped globally in 2021, making it one of the most prevalent technologies in the world^[1].

Applications

Bluetooth technology is embedded in a multitude of devices across various domains. In home automation, it allows for the control of smart lights, thermostats, and locks, while in the fitness industry, it enables wearables to communicate health data with mobile applications^[1]. Additionally, advancements like LE Audio enhance the audio experience by providing better quality and lower power consumption, catering to devices such as hearing aids and Bluetooth headphones^[1].

Advantages and Disadvantages

The advantages of Bluetooth include its wireless connectivity, broad compatibility across devices, and power efficiency, which have contributed to its widespread adoption^[6]. However, it does come with limitations, notably a restricted range compared to other wireless technologies like Wi-Fi. Physical barriers can further diminish its effective operational range, which may affect usability in certain environments^{[6][2]}.

Key Features

Bluetooth technology supports the formation of a network called a piconet, which can accommodate multiple devices, typically more than five^[13]. Its transmission capacity is 720 kbps, and it is designed to operate over short distances, generally up to 30 feet (10 meters) under ideal conditions^[6]. The effective range can be influenced by factors such as physical obstructions and interference from other electronic devices^[14].



Bluetooth operates primarily through two standards:

1. **Bluetooth Classic**, which includes Basic Rate (BR) and Enhanced Data Rate (EDR) for higher data throughput.
2. **Bluetooth Low Energy (LE)**, optimised for low power consumption, making it ideal for battery-operated devices like fitness trackers and smart home gadgets^[2].

Below is a table comparing the two standards:

Feature	Bluetooth BR/EDR	Bluetooth LE
Frequency band	Operates on a 2.4 GHz Industrial, Scientific, and Medical (ISM) band, with the values in the range from 2.4000 GHz to 2.4835 GHz	
Channels	79 channels	40 channels (37 data channels and 3 advertising channels)
Channel bandwidth	1 MHz	2 MHz
Spread spectrum technique	1600 hops/sec frequency-hopping spread spectrum (FHSS)	
Modulation scheme	- Gaussian frequency shift keying (GFSK) $\pi/4$ differential quadrature phase shift keying (DQPSK) 8 differential phase shift keying (DPSK)	Gaussian frequency shift keying (GFSK)
Power usage	1 W (reference value)	$\sim 0.01 \times W$ to $0.5 \times W$ of reference (depending on the use case scenario)
Maximum transmission power	- Class 1: 100 mW (20 dBm) - Class 2: 2.5 mW (4 dBm) - Class 3: 1 mW (0 dBm)	- Class 1: 100 mW (20 dBm) - Class 1.5: 10 mW (10 dBm) - Class 2: 2.5 mW (4 dBm) - Class 3: 1 mW (0 dBm)
Data rate	- BR PHY (GFSK): 1 Mb/s - EDR PHY ($\pi/4$ DQPSK): 2 Mb/s - EDR PHY (8 DPSK): 3 Mb/s	- LE Coded PHY (S = 8): 125 Kb/s - LE Coded PHY (S = 2): 500 Kb/s - LE 1M PHY: 1 Mb/s - LE 2M PHY: 2 Mb/s
Device discovery	Inquiry or paging	Advertising
Device address privacy	None	Private device addressing supported
Encryption algorithm	E0/SAFER+	AES-CCM
Audio capable	Yes	Yes (Bluetooth LE audio is introduced in Bluetooth Core Specification 5.2)
Network topology	Point-to-point (including piconet)	- Point-to-point (including piconet) - Broadcast - Mesh



Overview of NearLink



NearLink (formerly known as StarSpark) is an innovative wireless communication technology designed for short-distance data transmission, aimed at overcoming the limitations of established standards like Bluetooth and Wi-Fi. Launched commercially in 2023, NearLink has garnered significant support from the NearLink Alliance, which includes over 430 members from various sectors, notably driven by Huawei and numerous Chinese companies^{[3][4]}.

Technical Architecture

The NearLink framework is structured into three distinct layers:

- **Basic Application Layer**

This layer implements multifunctional applications tailored for various scenarios, such as automotive, home automation, and audiovisual needs. It provides extensive functionalities that enable the widespread application of NearLink technology across different industries^{[15][3]}.

- **Basic Service Layer**

Comprising several functional units, this layer supports upper-layer applications and system management. It serves as a robust foundation to ensure stability and reliability within the NearLink system^{[15][3]}.

- **NearLink Access Layer**

This layer includes two communication interfaces: SLB (SparkLink Basic) and SLE (SparkLink Low Energy). These interfaces cater to different operational scenarios, allowing for high-bandwidth, high-capacity communication in the 5GHz unlicensed frequency band^{[15][3][8]}. The SLB interface focuses on high bandwidth and precision, while SLE optimises for low power consumption, extending device longevity during standby or low-load conditions^[8].



Performance Advantages

NearLink boasts several technical advancements over traditional standards. It features microsecond latency, high concurrency capabilities, and enhanced interference resistance, making it particularly suitable for applications that require real-time performance, such as online gaming and real-time audio and video communication^{[5][8]}. Additionally, the architecture's efficient power management strategies contribute to reduced energy consumption, further enhancing device usability^[8].

Geopolitical Implications

The development of NearLink is positioned within a larger context of reducing dependence on Western technologies, especially considering geopolitical tensions. By establishing its own wireless communication standards, China aims to enhance its technological sovereignty while facilitating innovation across a broad range of applications in consumer and enterprise devices^{[5][4]}. The anticipated rapid growth in NearLink's adoption underscores its potential role as a mainstream communication standard, rivaling established technologies like Bluetooth and Wi-Fi^[5].



Comparison between the 2 Technologies

Range and Connectivity

Bluetooth's range is typically around 10 meters but can be extended using Bluetooth Long Range features, which leverage techniques such as Forward Error Correction (FEC) to enhance device sensitivity and connectivity over longer distances^[16]. In contrast, NearLink is engineered for both short-range and long-range applications, providing flexibility in connectivity depending on user requirements, which may offer advantages in specific use cases where Bluetooth's limitations become apparent^{[16][9]}.

Power Consumption

Power consumption has been a critical issue for Bluetooth, especially in its earlier versions (1.0-3.0), which required significant energy, making them impractical for small IoT devices. This limitation has been largely addressed in Bluetooth Low Energy (BLE), which was introduced in version 4.0 and optimised for low-power consumption, enabling a wider range of applications in the IoT sphere^{[17][18]}. NearLink was specifically designed with power efficiency in mind from the outset, catering to the growing demand for sustainable solutions in IoT connectivity^[17].

Security Vulnerabilities

Bluetooth technology has faced several security challenges over the years. In April 2005, researchers from the University of Cambridge highlighted vulnerabilities in the PIN-based pairing of Bluetooth devices, demonstrating that passive attacks could quickly compromise the symmetric key establishment method used by Bluetooth. They proposed an asymmetric key establishment method as a potential solution for certain devices, such as mobile phones^[7]. More recently, in October 2018, a security researcher identified the Connection Dumping Vulnerability (CDV), which allowed attackers to disrupt Bluetooth connections across various devices from different manufacturers^[7].

In 2019, a serious vulnerability known as KNOB (Key Negotiation of Bluetooth) was discovered, enabling attackers to brute-force encryption keys, which compromised encrypted messages



and allowed for real-time message injection. Google responded with an Android security patch shortly after the discovery^[7]. In contrast, NearLink, which emphasises secure and low-power connectivity for IoT applications, has implemented stricter security measures in its design, reducing the likelihood of such vulnerabilities^[7].

Pairing Mechanisms

Bluetooth employs several pairing methods to establish secure connections between devices. Techniques such as Numeric Comparison and Passkey Entry provide mechanisms for users to validate the pairing process, ensuring protection against Man-in-the-Middle (MiTM) attacks^[18]. NearLink also supports secure pairing methods, but often focuses on simplicity and user experience, enabling faster and more seamless connections while maintaining security standards^{[7][18]}.

Applications

Both Bluetooth and NearLink serve distinct but overlapping applications. Bluetooth is widely used in audio devices, wearables, and personal area networks (PANs), enabling easy connectivity for consumer electronics^[19]. NearLink, however, is gaining traction in industrial IoT applications, smart homes, and enterprise environments, where its low-power and secure design can provide significant advantages over traditional Bluetooth technologies^{[7][9]}. But with the rise of HarmonyOS for consumer devices, we expect to see a sharp increase in NearLink adoption for PAN devices.



Use Cases

Bluetooth Use Cases

Bluetooth technology has found applications in a variety of domains, revolutionising the way devices connect and communicate.

- [Home Automation](#)

Bluetooth Low Energy (BLE) plays a significant role in home automation, allowing for seamless connectivity between devices such as smart lights, thermostats, and security systems^[1]. This enables users to control their home environment through their smartphones, enhancing convenience and energy efficiency.

- [Fitness Tracking](#)

Wearable devices like smartwatches and fitness bands leverage Bluetooth to transmit health data, such as heart rate and step count, to associated mobile applications^[1]. This real-time data exchange facilitates users in monitoring their fitness progress and health metrics effectively.

- [Audio Devices](#)

The introduction of LE Audio is a significant advancement in Bluetooth technology, providing enhanced audio quality and reduced power consumption compared to traditional Bluetooth^[1]. This advancement supports a variety of audio applications, including headphones and hearing aids, broadening accessibility options for users.

- [Contact Tracing](#)

Bluetooth-enabled contact tracing systems have emerged as crucial tools in public health, allowing for anonymous tracking of individuals who may have come into contact with an infected person. This is achieved through continuous scanning of BLE signals from smartphones^[1].



- [Item Finding Tags](#)

BLE technology is utilised in precision tracking devices like AirTags and Tiles, which help users locate lost items. These devices can be easily attached to belongings and tracked via smartphone applications, providing peace of mind in a fast-paced world^[1].

NearLink Use Cases

As NearLink technology begins to commercialise, its potential applications are being explored across various sectors, promising improvements in connectivity and user experience.

- [Enhanced Device Communication](#)

NearLink aims to provide superior wireless communication between devices, overcoming limitations seen in existing technologies like Bluetooth and Wi-Fi. This could lead to new possibilities in creating interconnected smart devices that communicate more efficiently and with lower latency^{[15][5]}.

- [Retail Innovations](#)

NearLink's ability to connect multiple devices simultaneously may transform retail environments, facilitating the use of Electronic Shelf Labels (ESL) that offer real-time product information and pricing^[20]. This could enhance customer engagement and improve inventory management practices.

- [IoT Integration](#)

NearLink is expected to play a vital role in the Internet of Things (IoT) ecosystem, allowing for more devices to connect with improved performance metrics. This could result in smarter homes, cities, and industries, where devices interact seamlessly and autonomously^[5].



Future Trends

Advancements in Bluetooth Technology

As the demand for wireless connectivity continues to rise, Bluetooth technology is expected to evolve significantly. Future developments will likely focus on enhancing range, performance, and reliability, which are crucial for the growing number of interconnected devices in both private and commercial settings^{[2][21]}. Innovations in Bluetooth Low Energy (LE) are particularly noteworthy, as they enable new Internet of Things (IoT) applications, contributing to sustainable growth across various industries^{[21][11]}. The latest Bluetooth versions, such as 5.2 and 5.3, are set to provide improved data transfer rates and extended ranges, making them more suitable for real-time applications^{[11][6]}.

The Rise of NearLink Technology

Simultaneously, Huawei's NearLink technology is positioning itself as a game-changer for wireless communication, especially for AI applications. With throughput up to 3000 Mbps (with plans for even higher speed) and ultra-low latency of sub-1 millisecond, NearLink is tailored to meet the rigorous demands of real-time device coordination^{[10][22]}. This technology combines the strengths of existing wireless standards like Wi-Fi and Bluetooth while addressing their limitations, thereby unlocking new possibilities for AI-enabled devices to interact intelligently and collaboratively^{[10][22]}. As NearLink matures, its widespread commercial implementation is anticipated within the next couple of years, potentially reshaping the landscape of intelligent connectivity^[22]. All this coupled with NearLink being a core part of HarmonyOS would also push faster adoption on the technology.

Societal Implications

The integration of both Bluetooth and NearLink technologies into everyday life will have profound societal implications. For Bluetooth, the emphasis on energy efficiency and multi-device connectivity will enhance user convenience and experience^{[11][6]}. On the other hand, NearLink's high-speed, low-latency capabilities are expected to revolutionise sectors like healthcare, education, and entertainment, fostering a more interconnected lifestyle^{[12][10]}. However, the societal shift brought on by these advancements will also necessitate ongoing discussions around ethics, security, and the economic impact of such technologies^[12].



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