BII - Broadband for Industrial Internet

Technology Overview

Overview

BII® (/Bee/, Broadband for Industrial Internet) is an innovative long range wireless broadband networking technology developed by Doodle Labs. Standing on the shoulders of the underlying state-of-the-art MIMO technology used by the ubiquitous IEEE 802.11 (Wi-Fi), BII further extends the technology to facilitate deployment of high performance mobile networks. BII focuses on high reliability data communication over long distances and frequency flexibility for licensed and license free bands. BII is carrier grade and field proven in numerous demanding applications. The mix of feature rich networking, long range, choice of frequency bands, and native IP architecture makes BII an attractive wireless communication technology.

Key Features

PERFORMANCE RF

- Interference resistant COFDM for improved link quality in busy RF environments

- Adaptive radio modulations from DSSS up to 256 QAM and continuous per packet optimization to maximize link performance in dynamic environments

- Software defined channel size for efficient re-use of spectrum

- Software defined operating frequency band for global applications

- Exceptional Multipath and NLOS performance

- Convolutional Coding, Forward error correction (FEC), Ack-retransmits for robust data transmission over noisy spectrum

- Maximal Ratio Combining and beam forming for diversity antenna gain

- Spatial Multiplexing for enhanced throughput

- Space Time Block Coding for increased robustness

- Time Division Duplexing (TDD) for bi-directional traffic

- Distributed control with CSMA/CA to auto balance the network for asymmetric up/down traffic and throughput requirements of each node

- Long range with auto adjusting RF power to reduce interference

- Fast handoff for mobile applications

PERFORMANCE NETWORKING

- High data throughput

- Self-healing/self-forming mobile mesh for highly reliable network with redundancy

- Advanced QOS and multimedia traffic prioritizations for low latency Command and Control as well as HD video streaming on the same link

- Multiple network access and authentication methods

- AES256, 128-bit WPA2-PSK encryption for over the air data

- Firewall - MAC/IP/protocol/port filtering for restricted access control

- Supported Protocols - DNS, HTTP, HTTPS, IP, ICMP, NTP, TCP, UDP,

RADIUS, DHCP, VLAN, STP/RSTP, VPN, IPSec, L2TP, GRE

- Self-healing Mesh for easy to deploy and low maintenance networks

- Support for all network topologies, including infrastructure, Adhoc, PtP, PtmP, and Repeater modes

IIoT Connectivity Landscape

There is a diverse set of needs for the optimum wireless connectivity. Many technologies have been developed to optimize a different set of criteria (e.g. range, power, speed). Fig 1 shows the application space for each of the major wireless technologies. It is easy to understand that each connected object will have its own requirements in terms of data throughput, latency, range, mobility, power etc. No single technology can satisfy all different use cases.
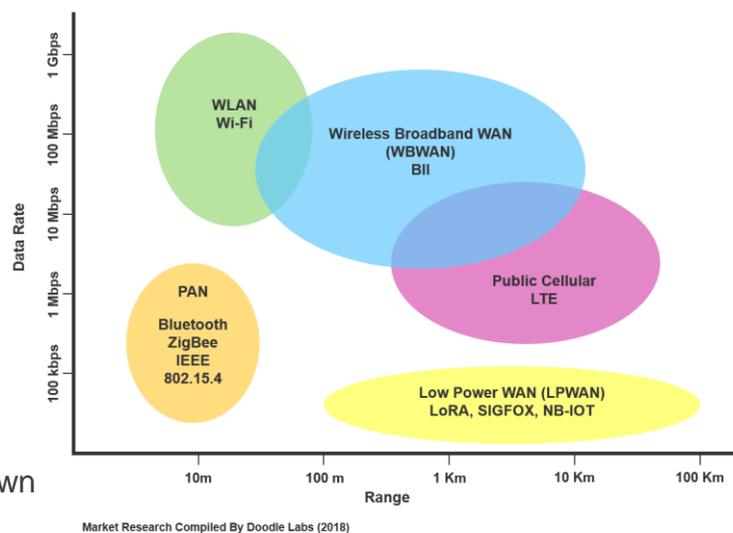

Fig 1 – Overview of Wireless Technologies

At present, the industry is abuzz with discussions on various wireless connectivity options for IIoT. As it can be seen, ubiquitous Wi-Fi is the uncontested choice for license free, high speed WLAN category. Bluetooth and few variants of IEEE 802.15.4 are being considered for the very short-range applications. On the other end, LoRA, SIGFOX and NB-IOT are discussed for the extremely long-range, low power, low throughput sensor connectivity.

It is to be noted that currently, for applications requiring Broadband performance in medium to long range (about 10 miles), the only possibility is to use public cellular networks with its associated high monthly recurring costs and low QoS.
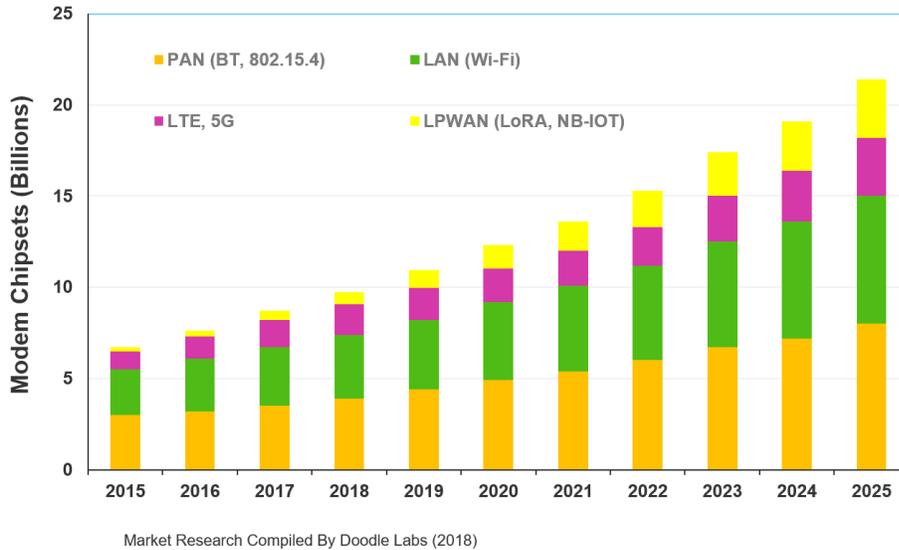
Fig 2 – Market Forecast of Wireless Technologies

Doodle Labs conducted the market survey of the expected market demand for various wireless technologies. As can be seen from Fig 2, high speed data throughput technologies for PAN, WAN and WBWAN make up the bulk of the demand. This observation is consistent with the industry trends of streaming more video and collecting more data for AI. BII focuses on this bulk of the demand requiring higher data throughput.

The LTE and 5G public networks are increasingly considered for IIoT applications due to their easy access. However, as shown in Fig 3, the public cellular networks offer the worst price-performance ratios. The public networks are shared with a large number of users and hence they are lower speed, low QoS, high latency, and available at high monthly recurring charges. Traditionally, the large cellular networks have been built for connecting very large number of people and carry voice/data traffic. These networks are struggling to keep up with the explosion of the data requirements from the smartphone users. Sharing these networks for the IIoT traffic is not the most ideal situation.
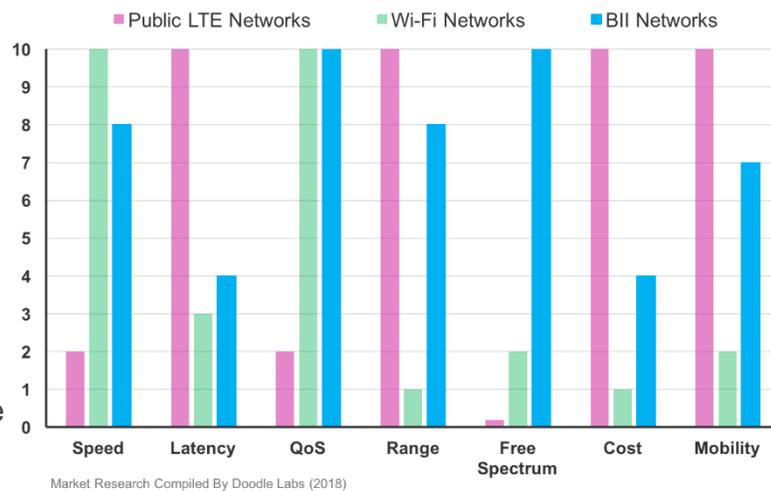

Fig 3 – Comparison of WBWAN Performance

BII Wireless Technology

Doodle Labs' BII wireless technology is focusing on the requirements for robust communication, advanced QoS and data security over long distances. BII embraces and extends the state-of-the-art MIMO technology. At its core, BII uses the same MIMO technology used in the Wi-Fi. BII's CSMA/CA PHY is based on IEEE 802.11 standard. However, as shown in Fig 4, various physical and MAC layer parameters in the BII waveform are fine tuned to achieve interference resistant and robust wireless communication. Additionally, BII incorporates extensions for software defined frequency band, channel size and center frequency. The BII waveform can operate in any frequency band between 100 MHz ~ 6 GHz. This frequency flexibility allows operations in various countries and in Industry specific frequency bands. The

Fig 4 – IEEE 802.11 Networking Stack

channel size can be software defined between 3~40 MHz as required by the application's throughput requirements. The ability to define the channel size coupled with auto adjusting COFDM bit rates allows BII to be spectrum efficient and operate at the maximum SNR possible. These extensions open many new possibilities, making BII a versatile wireless technology.
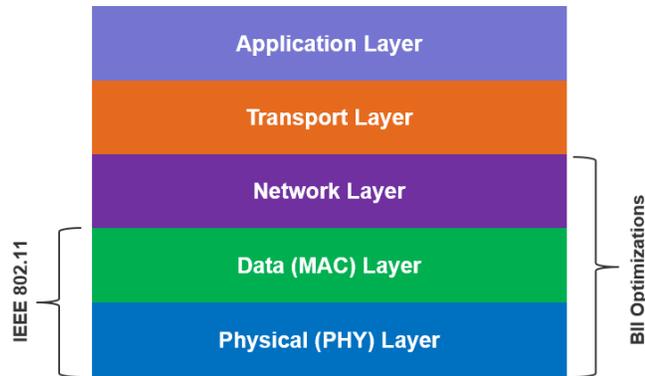
BII's MAC is fully compliant with the feature rich IEEE 802.11 with it's flat IP architecture. The MAC supports numerous advanced networking features - infrastructure, ad-hoc, and mesh modes of operation to implement various wireless network topologies. The MAC supports 256-bit AES encryption to address the concerns of wireless data security. Additionally, the MAC provides queues for multimedia traffic and QoS mechanisms to reduce latency for delay sensitive applications. Thanks to it's fully compliant MAC, BII directly plugs into the thriving IP ecosystem.

Summary

Doodle Labs' BII Wireless Broadband WAN technology leverages the state-of-the-art MIMO performance of the ubiquitous Wi-Fi and extends it's use in any frequency band to provide cost effective solution to implement private wireless networks for applications requiring reliable and high throughput over long distances.

For more information - https://doodlelabs.com/

Appendix: BII in License Free 900 MHz ISM Band

Because of BII's frequency flexibility, it can be adapted to operate in the 900 MHz band. The 900 MHz band is also known as the 33-centimeter band. It ranges from 902 to 928 MHz. The RF signals at 900 MHz have the ability to propagate further distances than the traditional Wi-Fi via two mechanisms: penetration and diffraction. Penetration refers to 900 MHz waves ability to penetrate through building walls, vegetation and other obstacles. 900 MHz waves can go through multiple building walls making it an excellent choice for applications that do not have a direct line of sight between sender and receiver. Diffraction describes the characteristic of a 900 MHz wave that it can go around an object such as a building or vegetation. Because of these transmission characteristics, Broadband communication in 900 MHz band is highly desirable to achieve a good balance of range, penetration and throughput.

The 900 MHz band is license free in large parts of the world - all ITU's region 2 (23 countries in Americas) and few Asian countries like China, Australia, New Zealand and South Korea. In the USA, like WiFi, FCC Part 15 certified radios are permitted for unlicensed operation. A private WBWAN implemented in license free band avoids the recurring monthly cost of public cellular network.

Doodle Labs Smart Radio embedded modules implement the BII technology. The table below provides a quick performance overview of the BII-900 technology.

Table 1 – Salient Characteristics of BII Performance in License Free 900 MHz Band

Peak Data Throughput @ 100 meters range	100 Mbps (TCP/IP) with 26 MHz channel	Targeted at use cases that involve streaming 4K video data links
Range (with 6 dBi antenna and 15 dB fade margin)	10 miles (16 Km)	Sub-GHz frequency provides longer range and higher penetration. Improved connectivity in indoor and outdoor environments.
Channel Sizes	3, 5, 10, 13, 26 MHz	Multiple channel sizes allow optimization for spectrum efficiency.
Wireless Technology	COFDM, MIMO, BPSK-256QAM, auto adapting coding rates with FEC/ARQ error correction	Same as in IEEE 802.11ac
RF Power	Adjustable from 0 to 30 dBm	Meets the requirements of license free operation in target countries.
Latency	Under 20ms	Meets the needs for voice, video and telemetry

Quality of Service	IEEE 802.11e	Multiple traffic prioritization queues for multimedia traffic for lower latency of delay sensitive data.
Wireless Data Security	AES128, 128-bit WPA2-PSK encryption for over the air data	State-of-the-art security measures
Mobility	Fast Handoff	Suitable for most Industrial Internet applications
DC Power	Typically under 5W	Targeted for equipment with adequate power source
Cost of Ownership	Low	Total cost of ownership for private network with total control is significantly lower than using shared public LTE networks with recurring monthly fees.