

Comparative Study of Bluetooth, ZigBee and Bus Communication under Different Usage Scenarios

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Abstract. In the modern communication markets, thousands of communication methods are available for different situations, among these different means of communication, the ZigBee protocol, IEEE 802.15, and the derivative protocols provided possible solutions of cheap and energy-saving wireless communication methods, which were considered major members of modern communication. However, these technologies carried the drawbacks like low data rate and difficulties to build a complicated system. On one other hand, wired communications like Bus communications have features like high data rate and high data quality, on the other hand, the volume of hardware and the cost were the two biggest disadvantages of this technology. As communication measures are getting more and more important, discussion in this field is becoming more and more necessary. In this paper, multiple technologies would be discussed from the angles of principle, current situation, and advantages and flaws. Next, these technologies would be discussed under different scenarios that could be faced in the daily life of common people, industrial fields and other uses, then compared from several perspectives to select the one that fits the situation best.

Keywords: Bluetooth; ZigBee; Bus communication.

1. Introduction

Communication systems have long been an essential part of multiple fields like industrial productivity, environmental monitoring, and housing systems. Among thousands of communication hardware and protocols, choosing the one that best fits the demands in a short time could be challenging for persons who aren't experienced enough, therefore, such work as discussion and the preparation of guidelines is particularly important to save resources and time. Although such topics have been discussed, the differences between methods, advantages and applicable scenes remained unclear to some extent.

The focus of this essay is technical facts and comparison, which provides some information that may be useful in solving the problems mentioned above. In Section 2, three techniques would be discussed from different angles. And the comparison would take place in Section 3. In Section 4, there would be some conclusions drawn from the information listed above.

2. Communication technologies

2.1 Bluetooth

2.1.1 Principle

Though followed up by IEEE802.15.4, an alternative short-range communication protocol, Bluetooth still stood an important place in the wireless communication market thanks to the mature product and complete tutorial. The protocol can adapt to changing radio conditions, but the standard does not specify any algorithm for switching the signal and coding rates [1].

2.1.2 Current situation

Being an early developed and widely applied technology, Bluetooth was applied to every corner of human lives. Over the past decade, it experienced breakthroughs in communication speed, security, and power consumption, which brought a lot of advantages to not only individual consumers but also industrial companies. For consumers, not only Internet access could be established through this

technology, wireless devices like headsets and even two terminals could be linked up in this way [2]. For industrial uses, Bluetooth could perform as a monitoring element in industrial IoT plants [3]. Another innovative usage of Bluetooth recently brought up was performing as a controller or position detection measure in an automated guided vehicle field [4].

2.2 ZigBee

2.2.1 Principle

Owing to the characteristic of short distance, low power dissipation, and relatively low data transfer speed, this unique technique stands in the place between Smart label and Bluetooth., now playing important roles in the industrial field, remote sensor, monitoring and automation. Operating on the ISM band, ZigBee operates in the ISM radio bands and provides data rate up to 250kbit/s, 40 kbit/s for the 915MHz and 20kbit/s for 868MHz [5]. This brings the technique extra convenience of not having to request communication frequencies.

2.2.2 Current situation

As a widely applied tech, ZigBee undertook a wide variety of tasks from industrial productivity to environmental monitoring to smart housing. For instance, an intelligent low voltage distribution system [6]. It also demonstrated potential in smart housing because of its small element and low power consumption characteristics [7].

2.3 Bus communication

2.3.1 Principle

Known for its reliability, high signal quality, and ability of interference resistance, Bus communication participated widely in the industrial field and personal computer. They differ from many traditional LANs (such as Ethernet) in that they are optimized for the exchange of short point-to-point status and command messages [8]. Consequently, there are variations in the protocols, and the cables used were different, here Fig. 1 showed the pin-out chart of cable used by some terminal-to-terminal Bus communication protocols, the GPIB, which is also a representative of the cables used [9].

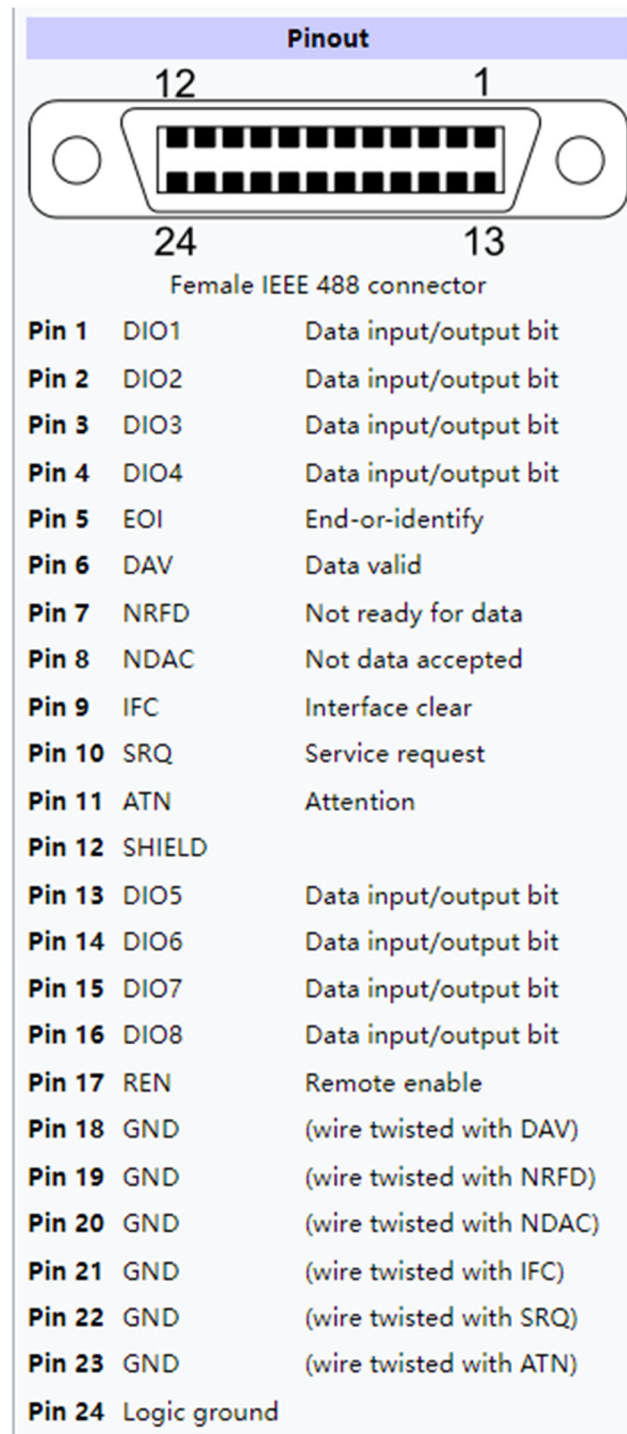


Fig. 1 Pin out chart of GPIB

2.3.2 Current situation

As a well-developed measure, there are multiple possibilities for applying this technique. From Integrated measurement system [10] to Element control [11]. And the topology of systems varies from one to another due to the situation faced, for instance, a star topology like the one shown in Fig. 2.

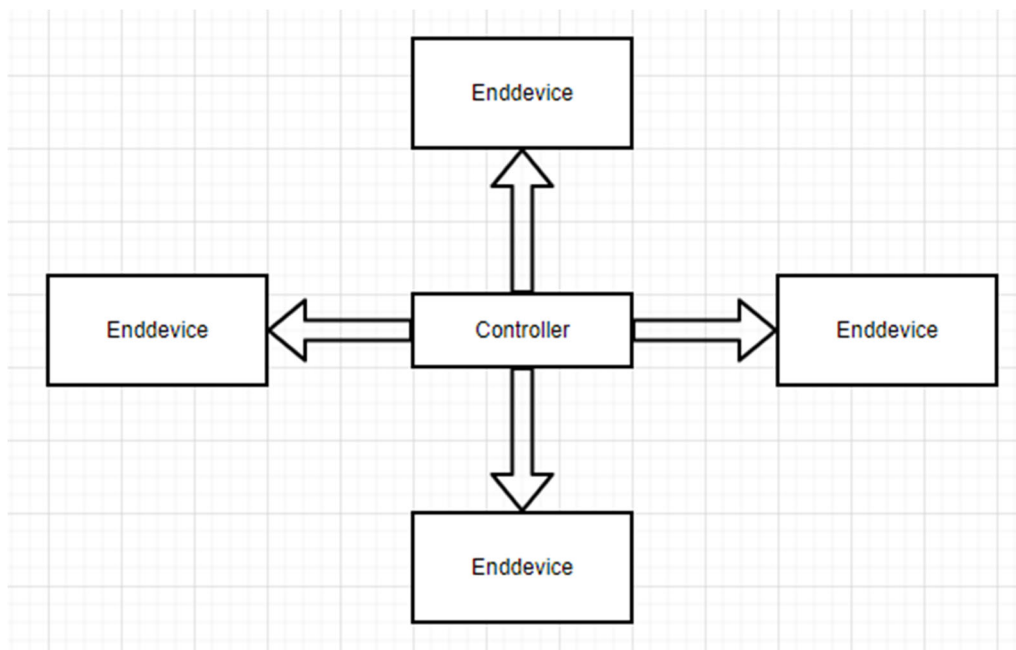


Fig. 2 Star topology of Bus communication

Though the tasks mentioned above could be undertaken by wireless measures and high signal quality wasn't an outstanding advantage when transmitting digital signals, it was essential under some circumstances like transmission of analogue signals.

3. Comparison and Discussion

3.1 Advantages and flaws of Bluetooth

Although the data transmission rate was relatively lower than the wire communication measures, features like small element volume, low product price, and a speed high enough for instant communication and fast image transmission brought this technology a place from the industrial to the smart home field.

Flaws come with advantages. First is the number of devices allowed in the smallest cell, which was limited to seven [12]. Second, a design that stressed on power saving and small volume resulted in a short range, the design commonly applied to civilian usage could only be used within 10 meters for reliability and the data transmission rate would be reduced if the distance goes up. Third, the security of Bluetooth was severely challenged due to the flaw in protocols, there are many ways to launch an attack and most of the measures are hard to detect in time.

3.2 Advantages and flaws of ZigBee

The most outstanding advantage was its flexibility, unlike the Bus system, there are three topology structures available: Star structure, Peer to peer structure, and mesh structure with a routing algorithm [13], the three topology structures were shown in Fig. 3, each has a unique character due to the topology of the router, choosing the topology wisely due to the situation faced would allow the system to operate more effectively.

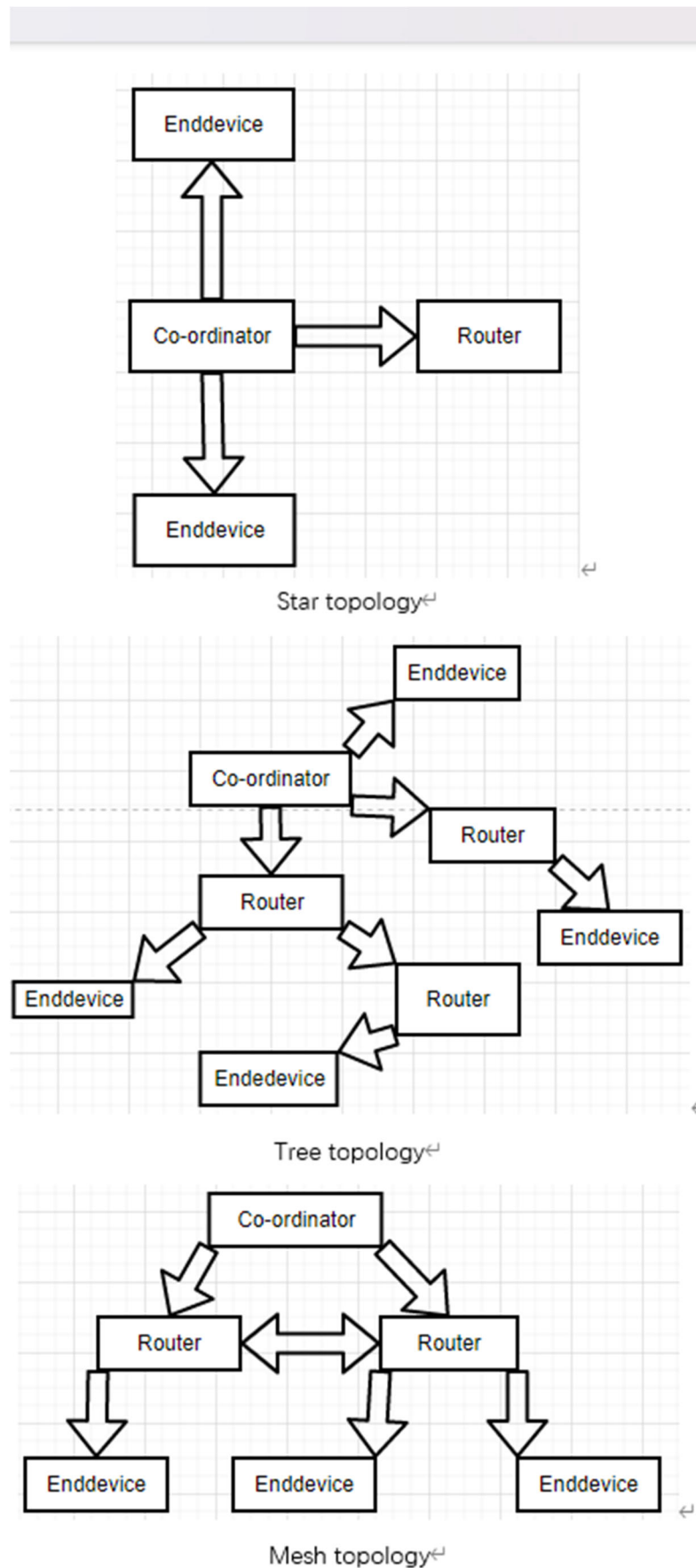


Fig. 3 Three topology structures of ZigBee

Second, the network device has a long battery life [14]. This feature means that a single battery may support an End device working for months, which benefits a lot when it comes to the scenes that

require long hours of operation but frequent maintenance is not possible, like meteorological monitoring.

But there are also obvious drawbacks. The relatively short range of transmission and the signal interruption due to the IEEE 802.15.4 protocol would be the biggest challenges when applied to specific situations. Though applying RFPA could alleviate the problem to a large extent, this would violate one of the biggest advantages of low power consumption. For the same reason, transmitting information in distance through the communication net would require other routers to perform as relays, which would significantly increase the time needed to transmit information and could also cause delays for other communication requests, which could worsen the drawback of low communication speed. Therefore, it has not been able to fully exploit its numerical advantage of maximum nodes. Second, one of the biggest advantages of this technology is the ability to fast self-re-organize, but once this technology was applied to a stationary communication net, like probes in a monitoring net or elements in the factories, this advantage will have no chance to perform anymore.

3.3 Advantages and flaws of bus communication

As a wired communication measure, applying this technology to mobile objects might be challenging, but its outstanding anti-interference ability allowed this technique to operate in an environment which has electromagnetic interference like a power plant, also enables it to transmit messages even if the ISM frequency band was occupied by other devices without the cumbersome paperwork involved in the application process. The second is communication speed. For instance, IEEE 488, which is a relatively outdated technique, could operate at distances up to 20 m at a maximum of 500 000 bytes per second under a specific circumstance [15], which is a speed that much faster than the wireless means of communication at the same period and some protocols nowadays. Though communication at a long distance would cause lower data rates and other problems, Bus communication could establish links at a distance way much farther than the two mentioned above without relay or other components.

As a representative of wired communication, the biggest drawback of Bus communication is the bulky wires, which would take up a lot of space if the communication network was complicated. Second, a communication system that has only one DB-Data Bus, which is a commonly used topology structure to simplify the communication network, like the topology shown in Fig. 4, would cause a delay in communication due to the characteristic that only one link could be established on a single data Bus.

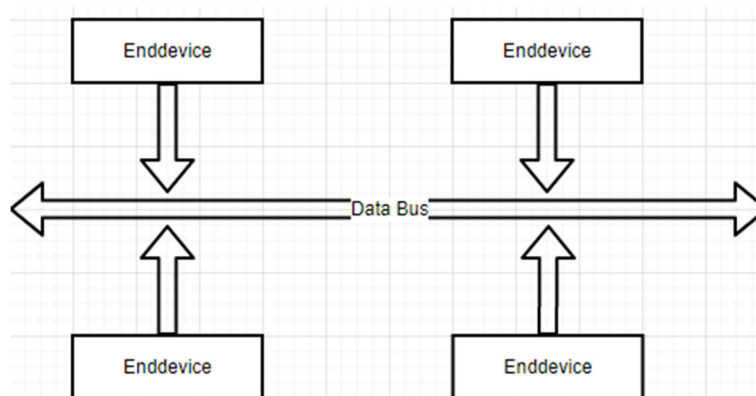


Fig. 4 Bus communication network with one data bus

The effect would be more significant as the number of users goes up. Building more wires to improve the topology structure would solve this problem, but in this method, the whole system would become bulkier as the Data bus must be connected to every device. Another fatal error that this topology may bring is if any point of this loop was cut off, the whole system will not be able to transmit information anymore, and due to this characteristic, the troubleshooting would be complicated because every point of the system must be checked. Third, the same hardware may have multiple protocols available even under the same circumstance, which may cause unnecessary problems.

3.4 Comparison

As mentioned above, on the aspect of communication speed, the other two of the three technologies have dominated advantages over ZigBee, which only has a speed of 250kb per second. As for the other two technologies, they have their merits, most Bus communication protocols used today, for instance, USB3.0, usually have a speed of over 1GB per second. But Bluetooth has the ability to transmit sound signals and image signals at the same time. On the other hand, for the ability to re-self-organizing, the ZigBee has a leading position with a speed of 50ms reconnect time, which would take 5-7 seconds for Bluetooth and is impossible for Bus communication without manual override if a failure occurred in the communication network. For the range of communication, ZigBee could establish a stable connection at the range of 10-100 meters, and for Bluetooth, the class A version has a range of 80-100meter, but due to the high cost and power consumption, it has hardly been used in civilian devices. Class B, which is the most used class in civilian devices, has a range of 8-10meter.

For Bus communication, the communication could be set up over lines tens of kilometers long, but the speed of communication would be severely affected. For the volume of devices, there are hardly any differences between Bluetooth and ZigBee modules, but the Bus communication was much bulkier than the two mentioned above regardless of which communication was chosen, and the volume would go up as the communication network get more complicated and more backup were set up. Therefore, thinking twice would be necessary when applying this to small-volume mobile devices. For the power consumption, Bus communication usually requires a stable voltage, and the current varies due to the task currently undertaken, which were usually much higher than the ZigBee and Bluetooth, compared with Bluetooth's capability to keep working for days relying on a battery, the ZigBee could stay for months, which was considered a major advantage.

4. Conclusion

With the introduction of the three technologies shown above and comparisons made, some conclusions could be drawn. For general industrial productivity scenarios, ZigBee would be a perfect technology for probing due to its outstanding energy-saving ability and advantages in the number of nodes allowed in one network. For the communication between operators on site, Bluetooth would be more suitable due to the higher communication speed and the ability to transmit sound signals and image signals at a relatively high speed that could satisfy the demand of communication and transmit the two signals at the same time on two channels. However, when the communication channel was occupied or interference might take place, the Bus system would be a good choice. For scenes faced in monitoring like flood detection or calculation of parking space in the parking lot, applying Bus communication would be scarcely possible due to the difficulties on the power supply and the cost, moreover, if the distance between probe connected by cables and the controller is very long, it would lose its advantage in terms of communication speed, which is a major advantage over the two techniques mentioned. In the housing field, Bus communication would be a good choice for Ethernet access, which could connect all devices at once with elements invisible. But the drawback is the difficulties of reorganizing wires, which is necessary when adding more components. But the Bluetooth could be considered as a complement to this technique to fix this problem due to its wireless characteristic.

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