# Innovation Researches of the Reader and the Tag Asymmetric Connection Strategy in RFID Systems

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**Abstract** In this paper, by analyzing the current situation of reader and tag connection technology, between the reader and the tag is structural asymmetry and asymmetric characteristics of the amount of data transmission in passive RFID (Radio frequency identification) system. The nature of communication technology of UWB (Ultra-wide band) high-speed short-range ultra-wideband and TH-PPM (Time Hopping Pulse Position Modulation) are researched. It is propounded that in passive RFID system, asymmetric connection between the reader and the tag, the forward connection use to UHF (Ultra high frequency) technology and reverse connection use to TH-PPM.

**Keywords** RFID • Reader • Tag • TH-PPM • UWB

## 1 Introduction

The Internet of Things is a combination of network technology, sensor technology, database technology, middleware and other technology. It is a much larger network than the Internet, based on RFID systems, composed of a large number of readers and mobile label networking (Xu Yan 2011). In the Internet of Things, System can automatically and in real-time to identify, locate, track, monitor objects and trigger the corresponding event. Currently, the design of the internet of things still faces important challenges in three areas: (1) How to make low-cost, low-complexity small smart devices implanted commodity; (2) From the physical world, how to use the powerful sensing capabilities and high-speed transmission function to generation and access data automatically and quickly; (3) How to use the network

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services and data mining techniques to transform into the underlying raw data into a content-rich high-level information. In the face of these three challenges, the most critical question is that how to make a good, fast and complete communication between the reader and the tag at first.

## 2 Current Situation of Reader and Tag Connection Technology

### *2.1 Tag Technology*

In RFID systems, there are three types of tag application. Active tags: big volume, expensive, because the use of battery so lifespan is relatively short. Because they send signal, so identify the long distance, more accurate identification; Passive tags: small size, cheap and long life (Shen Jinpeng et al. 2012). But passive tags access the antenna emitted electromagnetic waves signal and then transmission signal within the tags. So identification distance is shorter than the active tags; Semi-active tags: semi-active tags lies dormant until enter the working state, tags internal battery power consumes low, so the battery can be maintained for several years, even a decade-long. When the semi-active tag reader enters into reading and writing area, the reader emits the RF signal to incentive tags into the working state. The reader supplied RF energy is the main energy of the information exchanged between the reader and the tag, frequently used in reflection modulation. Tags internal battery power is not converted to RF energy; its main role is to cover the tags of the circuit power consumption when tags of the location of the RF field strength insufficient (Occhiuzzi et al. 2010; Nakamoto et al. 2007).

By comparison, passive tags are low cost, small size, no batteries, easy maintenance features. So, it widely used to build the Internet of Things in passive RFID system. However, it was found that the existing passive RFID system data rate is only a few hundred Kbps. And between the tags, there are serious conflicts problems of transmission (Wang Yao et al. 2011).

### *2.2 Reader and Tag's Connection Technology*

The reader and the tag's connection technology include forward connection and reverse connection. Forward connection is that reader connected to tag, the highest transmission data rate is 160 Kbps; Reverse connection is that reader connected to tag, the highest transmission data rate is 640 Kbps. Currently, in a passive RFID system, the ultra-high frequency technology are commonly used in the forward and reverse connections (Yang Hai et al. 2012; Wang Yao et al. 2009; Hong and Ji-wen 2012), the data rate is little difference. In the Internet of Things, analysis of the

reader and the tag's connection technology can be found in the structure of the reader and the tag is extremely asymmetrical. A reader might have to face multiple tags, and passive RFID system is very sensitive to the distance between the reader and the tag, vulnerable to the impact of multipath effects and multi-user interference (Zhong-xiang et al. 2009). For the Internet of Things, based on the asymmetric structure of the reader and the tag, high-performance sensing function of the passive RFID system building is very important.

### *2.3 Passive RFID System of Multi-level Network Structure*

At present, passive RFID system network structure is mainly composed of a three-tier network of servers, readers, sensing tag. Top-level network is about communication between the server and the reader; Mid-level network is about communication between the reader and the reader; underlying network is about communication between reader and tag. In the top-level network, the server is the control center; wired connection by USB, RS-232, Ethernet, etc. We can also through ZigBee, Wi-Fi, WiMAX, GSM/GPRS wireless connection (Min et al. 2011), scheduling one or more of the reader cluster. The server storage and process the data that sent by the reader, and server is the gateway of the external network, network services can be provided. The mid-level network solves the conflict between the readers and to complete an effective collaboration mechanism. Underlying network solve or reduce the conflict between the labels in accordance with the passive RFID standards, as the same time, it collects and pretreatment of tags sensing information.

## 3 Innovation Researches of the Reader and the Tag Asymmetric Connection Strategy

### *3.1 There Is Very Asymmetric Transfer Data Between Readers and Tags*

In a passive RFID system, the number of readers is much less than the number of tags. Therefore, either forward connection or reverse connection has very asymmetric transfer data between readers and tags (Rui 2012). Reverse connection requirements for higher data rates, the existing passive RFID system, the forward and reverse connections are used the UHF (Barnett et al. 2009; Liang Xiao-bing et al. 2012; Marrocco et al. 2010) and the data rate is less. This situation does not satisfy the data rate requirement of the asymmetric structure. At some time, it makes very difficult to identify on the tag. At the same time, in the RFID system, also there is a huge difference in features, price, and complexity and in the required number

readers and tags. In order to adapt the characteristics that is the asymmetry of the amount of transmission data, researching asymmetric connection between tags and readers with a certain sense and innovative.

## *3.2 UWB (Ultra-Wideband Technology)*

UWB, high-speed short-range ultra-wideband communication technology, data transmission used to narrow pulses of nanoseconds (ns) to picosecond (ps), transmission speed is greatly improved. UWB signal is not a continuous waveform, but the use of the relative bandwidth greater than 0.2, using narrow pulse of width is generally less than 1 ns to transfer data. Therefore, the bandwidth of the signal is great. In the noise environment, the channel capacity of the communication system with the Shannon formula is expressed as: C = Blog2 (1 + S/N) (C is the channel capacity; B is the signal bandwidth; S/N signal to noise ratio). According to Shannon formula can be seen when the same channel capacity, signal-to-noise ratio and signal bandwidth can be interchangeable. Then in the signal-to-noise ratio is constant, channel capacity and the bandwidth is proportional to, to increase the bandwidth that is to increase the channel capacity, while reducing the requirements of signal-to-noise ratio.

Narrow pulse is usually Gaussian multi-stage differential pulse, multi-cycle pulse, raised cosine pulse, pulse train, etc. Gaussian multi-stage differential pulse are more likely to produce, and by selecting the appropriate order so that the signal does not produce a DC component and better radiation energy to the air, so it is the more commonly used. Gaussian multi-order differential mathematical expression as:

$$f^{(n)}(t) = \left\{ \frac{-1}{\sqrt{2\pi\sigma}} \bullet \exp\left[ \frac{-1}{2} \bullet \left( \frac{t-\mu}{\sigma} \right)^2 \right] \right\}^{(n)} \tag{1}$$

Narrow pulse can occupy several GHz bandwidths; Data transmission rate can reach several hundred Mbps. Because only a very short duration pulse, therefore, the UWB device can transmit low power when implemented in high-speed communication. It is only a few hundredths of the system of continuous carrier. UWB transmission distance is usually within 10 m; its transmission rate can reach 480 Mbps. In the same transmission distance, its transfer rate is nine times the Bluetooth standard and 18.5 time the Wi-Fi standard, which is more suitable for the transmission of large amounts of multimedia information. It can be concluded that: UWB has a high transmission rate, low cost, anti-interference ability and other characteristics; Because the use of non-continuous narrow pulse, UWB devices is characterized by Small transmission power, low power consumption, precise positioning; because of the very short pulse, difficult to detect, therefore, having a high safety characteristic. Through analysis of these characteristic, passive RFID system using UWB technology is an ideal fit.

UWB systems commonly use pulse-modulation that is BPSK (Binary-Phase-Shift-Keying), OOK (On-Off-Keying), PPM (Pulse-Position-Modulation), etc. Compare these types of modulation: The BPSK modulation advantage is adding Gaussian white noise and the lowest error rate after fading channel. The disadvantage is that BPSK modulation has the highest circuit complexity; however, OOK and PPM modulation scheme circuit structure is relatively simple, it is more suitable for passive tags (Dori 2009). But OOK modulation scheme is susceptible to multi-user interference, asymmetric connection of the reader and the tag cannot be achieved, but also because it does not have the potential of multiple accesses. PPM modulation scheme make use of pulse position relative to the standard position offset to represent a specific symbol. In order to support multi-user access, Generally, PPM and TH (Time Hopping) combine to form TH-PPM jump pulse phase modulation; it can greatly reduce the conflict between the Tags.

### *3.3 TH-PPM (Time Hopping Pulse Position Modulation)*

TH-PPM (Time Hopping Pulse Position Modulation) is a combination of the modulation scheme of time hopping and pulse modulation. TH-PPM makes use of PN code to select the time slot of the transmission symbol.

TH-PPM signal as:

$$S(t) = \sum_{i=-\infty}^{+\infty} f^{(n)}(t - iT_s - c_i T_c - a_i \Delta) \tag{2}$$

If a binary source carries on time hopping in the period of 2N-1 PN code, first of all, according to the state of the PN code generating $c_i$, select the slot space offset $c_i T_c$ of the transmission PN code ; When the symbol is "0", pulse position is not offset in a time slot; When the symbol is "1", pulse position is offset ai$\triangle$ in a time slot; Then the requirements of ai$\triangle <$ ciTc(ci $\neq 0$),the total offset of the pulse reign space for ciTc + ai$\triangle$. Each label in the TH-PPM modulation and demodulation system have adopted their own specific time-hopping code, the reader demodulate signal unless know the tag's time-hopping code. Tag may clash only when the new tag's time-hopping code is the same as the old tag's time-hopping code. While the probability of this happening is almost zero. While the probability of this happening is nearly impossible. It can be concluded that: TH-PPM can significantly reduce the probability of tag conflict, and TH-PPM modulation mode is simple circuit, low cost, low power consumption, it is very suitable for passive RFID system (Zhang et al. 2012).

Through the above analysis to verify, in a passive RFID system, forward connection is still using existing UHF technology, but reverse connection use TH-PPM technology. This asymmetric connection has several advantages: data transmission rate of ultra wideband TH-PPM technical is 10 Mbps. Solve the

problem that the reverse connected transport the large amount of data; since the connecting structure is asymmetrical, forward connections and reverse connection is no longer a question of frequency interference, and they partially overlap in time, but also to avoid reader to reader interference, accelerate the identification process of the tag; The ultra-wideband TH-PPM technology is not easy to be listening, the confidentiality of information and security can be improved; Ultra-wideband TH-PPM technology also has millimeter positioning accuracy.

## 4 Conclusion

In order to solve the good, fast and complete communication problems between the reader and the tag, the nature of the UWB technology and TH-PPM modulation mode are analyzed, an asymmetric connection technology to adapt to characteristics of asymmetric structure and asymmetric data traffic are proposed. The forward connection is still using existing UHF technology, and reverse connection use TH-PPM technology. Thereby the problem is solved that asymmetric structure leads to the problem of asymmetric amount of transmission data, and effectively prevent the interference between the inter-tag and the inter-reader, and accelerate the tag identification process, to improve the positioning accuracy. This connection technology between the reader and the tag is very important to build and develop the Internet of Things.

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