RFID Based Indoor Localization in Library Book Search System

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1 Introduction

1.1 Architechture

The architecture of our system is shown in Fig.1.

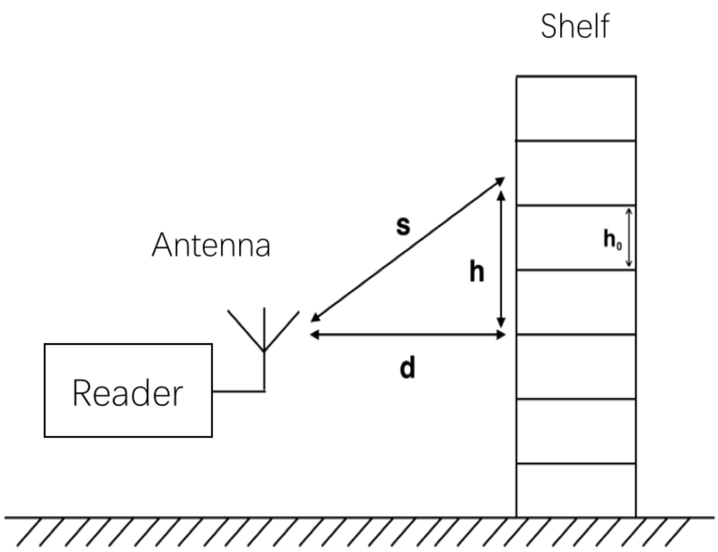

Fig. 1 Architecture of library book search system

The aim of our project is to locate which shelf the book is on. Thus the key point is to find the distance s, then we can find the height h by $h^2 = s^2 - d^2$.

1.2 RFID

As shown in Fig.2, when the communication starts, the reader begins to send signals. Tags receive the signal, use signal to provide it with power, and then modulate the signal. Finally it backscatter the signal into the air and wait for the reader to detect and receive it. The process is half-duplex, which means the reader and tag cannot send and receive at the same time.

1.3 Related work

WLAN and BLE In previous works, there are WIFI based and Bluetooth Low Energy based indoor localization. However it's not suitable for our situation. The cost of deployment and the power assumption are really high for so many books. Besides,

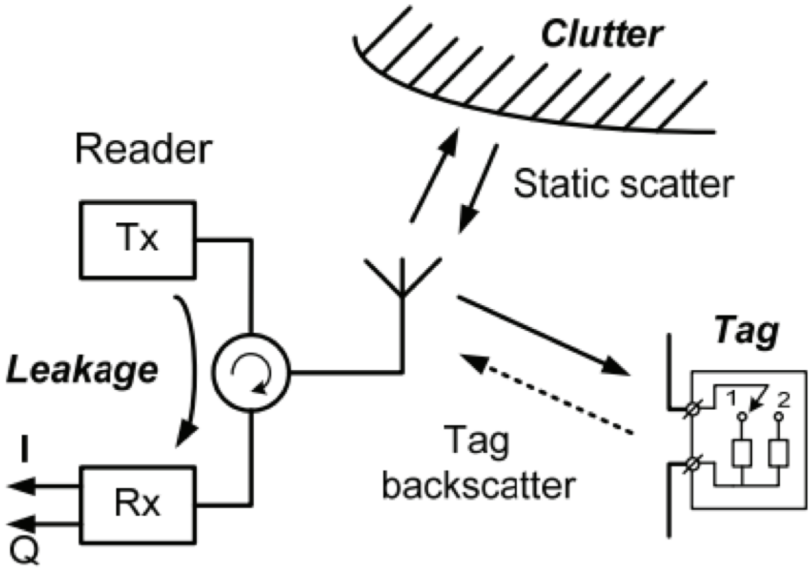

Fig. 2　**RFID schematic diagram**

most WLAN indoor localization are based on RSSI which is sensitive to many kinds of distortions, such as multi path effect.

RFID Some mature techniques are already used in RFID localization systems. For example, RSS(Received Signal Strength),TOA(Time of Arrival),TDOA(Time Difference of Arrival),PDOA(Phase Difference of Arrival). But previous works all use large antenna arrays to reach a high accuracy. In our work, we only focus on the shelf of the book so the accuracy can be not so much high but we can make it a tidy system, with only one antenna in one area.

2　System

2.1　Basic idea

The main technique we used to judge distance is Phase Distance of Arrival(PDOA), illustrated in Fig.3.

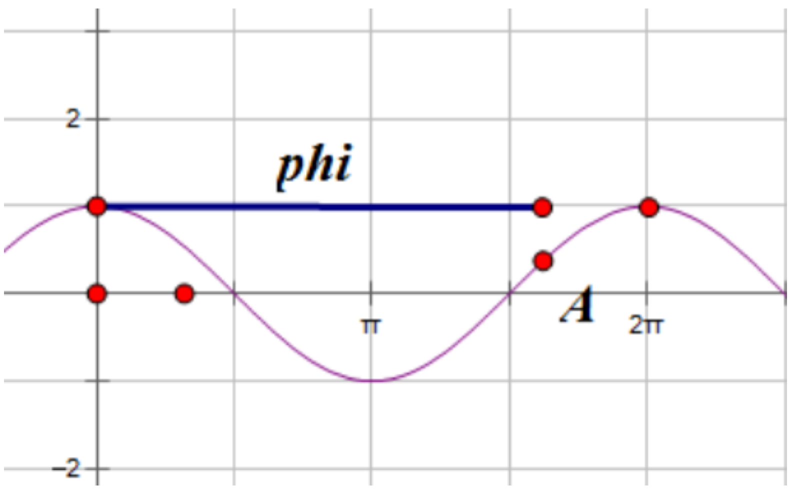

Fig. 3　**PDOA location method**

Reader send a signal with 0 phase angle at first and received a signal with phase angle ϕ. When the phase angle goes for 2π, the distance goes λ. Note that in each send-receive process the electromagnetic wave goes to the tag and go back to the reader, so the real distance is $\lambda/2$. Thus the formula goes

$$d = \frac{\lambda}{2} \times \frac{\phi}{2\pi} = \frac{c}{4\pi} \times \frac{\phi}{f}$$

.

2.2 Without half wavelength

When the distance is within half wavelength, there is no ambiguity. But when it goes beyond half wavelength, there is an error called phase ambiguity, since phase is periodic from 0 to 2π and it can not know which period it is in.

Our solution is RSSI indicator. RSSI-distance figure approximately follows an Log attenuation model, shown in Fig. 4.

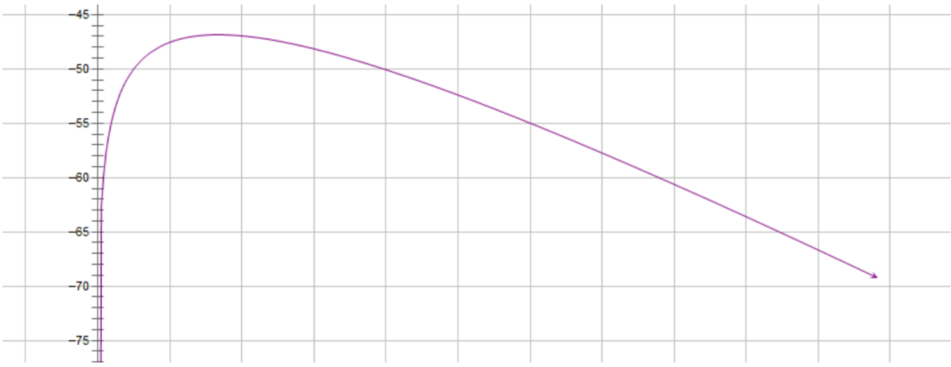

Fig. 4 Log attenuation model of RSSI

Hence we can detect the points where the phase hops from 0 to 2π and record the RSSI number at the points. Then it becomes the threshold of half wavelength hops.

3 Experiment and Result

PDOA are tested over several frequencies. The result is shown in Fig. 5.

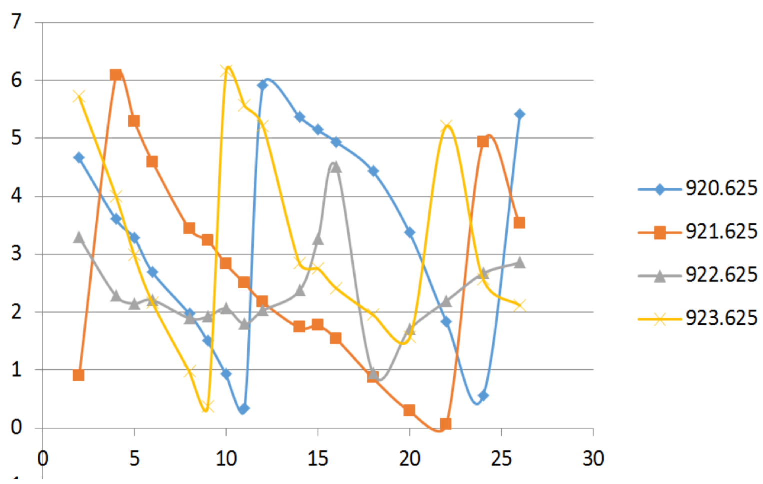

Fig. 5 PDOA-distance figure at different frequencies

In these frequencies, the wavelengths are all around 32cm, but we can see that only 921.625MHz have the best result. Other frequencies suffer from huge errors that we can't use at all. This is another reason why we do not use phase singly to detect distance because it's not correct.

The estimation result in 921.625MHz is shown in Fig.6. Blue line is the real distance for reference and red one is the estimated one by the PDOA algorithm.

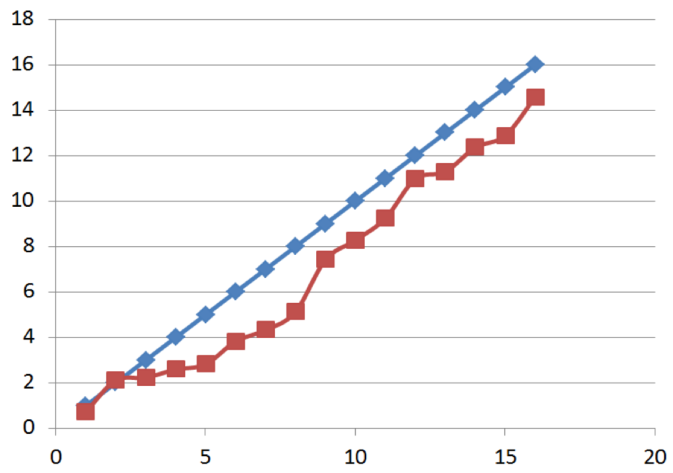

Fig. 6 Distance estimation within half wavelength

The RSSI to distance figure is shown in Fig.7, and the thresholds created according to the function is shown in Table.1.

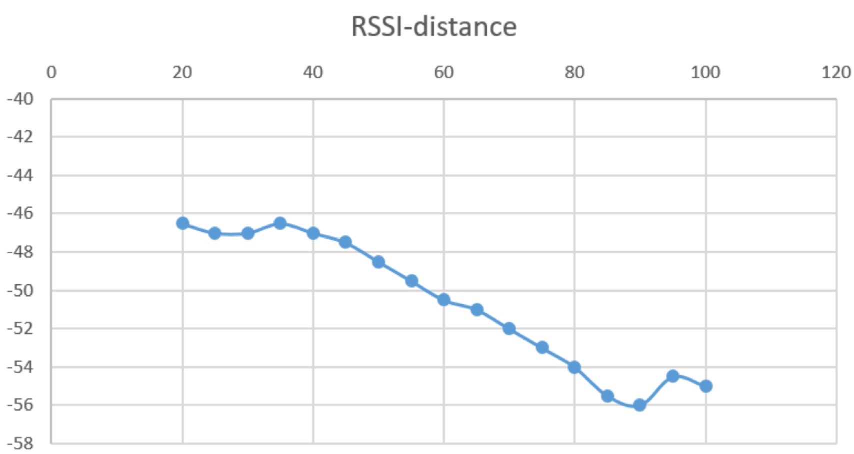

Fig. 7 RSSI-distance figure

Table. 1 **RSSI Threshold**

Half wavelengths	RSSI(dBm)	Half wavelengths	RSSI(dBm)
1	-46.7	5	-54.2
2	-47.0	6	-59.9
3	-49.0	7	-64.0
4	-51.5		

Final result of estimation within 1 meter is shown in Fig.8.

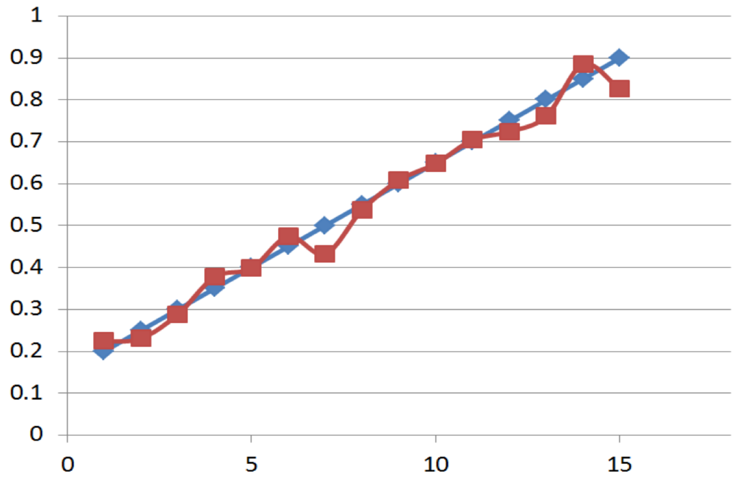

Fig. 8 **Distance estimation without half wavelength**

4 Conclusion

In current stage, we established a system for RFID indoor localization and raise the detect range to up to 3.6 meters. However the system now is basic and we have to make a lot of improvement to our system. For example, find another frequency that has accurate phase detection, or improve the RSSI accuracy. On the other hand, we have to handle with the problem that the interference between many adjacent neighbor tags will occur.