In Doors Location Technology Research Based on WLAN

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Abstract: - Introduced location technology based on wireless LAN (Local Area Network). Analyzed three kinds of commonly used localization methods at present, and pointed out their advantages and disadvantages. Combining triangle position with RSSI (Received Signal Strength Indication), developed the study of location technology base on WiFi (Wireless Fidelity) technology in this paper, and prototype experiment network was set up for location simulation. The experimental result showed that the experiment network has higher precision on localization, and can change its configuration in order to meet the localization demand of different occasions, which indicates this network has good performance and extensive adaptability.

Keyword: - WLAN, Location Technology, WiFi, GPS, Triangle localization, TDOA, RSSI,

1. WLAN

WLAN (wireless Local Area Network) is the combination of the computer network and wireless communication technology. It can send and receive data by wireless medium instead of traditional cable. Compared with the wired network, WLAN has a lot of advantages such as easy to assemble and extend, cheap and little irradiation.

The first WLAN standard in the world-IEEE 802.11-was put forward in June of 1997, its logic structure is shown in Fig.1. This standard defined the protocol criterion of physics layer and Media Access Controller Layer (MAC). When any kind of network application, operating system or protocol runs on WLAN which comply with IEEE 802.11 standard, it very simple just as it is operated on Ethernet. For even higher datum transmission speed and quality, IEEE has made such new standards as 802.11b, 802.11a, 802.11g, etc. in succession. Their technical characteristics are shown in tab.1.

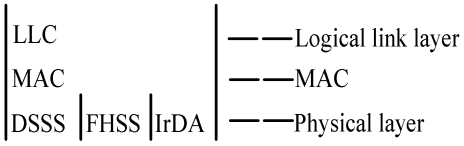

Fig.1 logic structure of IEEE 802.11

Tab.1 technical characteristics of WLAN standard

standard	modulate tech.	trans. speed	trans. distance	work frequency range
802.11	FHSS/DSSS/IR	2Mbps	1000m	2.4GHz
802.11b	DSSS	11Mbps	1000m	2.4GHz
802.11g	OFDM/PBCC	36Mbps	1000m	2.4GHz
802.11a	OFDM	54Mbps	30m	5.0GHz

From now on, IEEE 802.11 is the most popular WLAN standard. IEEE 802.11 exists in several flavors, just like WiFi (Wireless Fidelity), achieving different performances. As a general rule, 802.11 Access Points range is around several tens of meters in indoor environment. The theoretical data rate goes from 11 to 54 Mbps. The data transmission speed of WLAN can reach to 11Mbps(802.11b standard), the covering range can reach to several hundred meters as the radius, even more, the covering range can reach to several kilometers as the radius by the subnet roaming.

Because of the rapid development of the

WLAN, users can access to internet by portable terminal (such as notebook computer, palmtop computer and personal digital assistant) whenever and wherever. With the utilization expanding of the mobile access technique, the demand for wireless location technology in the commercial even military is increasing day by day, so wireless location technology become the research focus on the field of WLAN.

Location technology has a bright future in the fields of finance, tourism, healthcare and exhibition, especially in personal navigation and security. Furthermore, location technology can greatly help in public security, urban search and rescue missions. Recently, a lot of projects are interests in application of location technology within WLAN. In this paper we focus on the methods which can improve the location accuracy on different location technology.

The determination of physical location is sometimes referred to as location estimation, location identification, localization, and positioning or geo-location identification.

The WLAN location technology is to calculate out the position where the mobile terminal locate by analyzing some parameters that are received in the WLAN according to the specific algorithm, so its orientation step can roughly be divided into two steps: First, measurement, second, calculate. There are 3 orientation schemes according to different measurement and calculate entity. The first type of localization is based on mobile terminal, such as the global positioning system (GPS) which is suitable for the orientation service in the spacious outdoor environment; the second is on the basis of the network, such as the Angle of Arriving (AOA) and the Time of Arriving (TOA) that the Cellular Mobile Communication System (CMCS) use the base station to carry on, which is suitable for the lower precision requirements position service; the third is mixed position method, such as gpsOne put out by QUALCOMM Company of U.S.A., which is the representative mixing scheme by combination mobile communication network with GPS satellite information, which is suitable for the position service with higher demand in real time.

Under the environment of WLAN, two basic factors need to be considered in the portable terminal orientation: First, in doors orientation; second, higher orientation precision. Considering the tow factors, both the GPS and network orientation have certain limitation: GPS has localization blind areas, and the network's precision is too low. So, the space position technology suitable for WLAN environment must be developed.

2. Commonly used localization technology

(1) Triangle localization[1,2]

Triangle localization is the most commonly used algorithms, it realize the relative localization of the nodes by the coordination calculating among triangle and nodes. But a triangle localization algorithm is relying on the distance measurement and information exchange among the nodes. The distance measurement is easy to be affected by environment, so big errors might occur. It is unable to get high accuracy.

(2) TDOA(Time difference of arrival) [3,4]

The terminal position is calculated out by the position coordinate and arrival time difference of lots of Access Points (at least 3). This technology is based on the time difference of arrival waves, which can reduce the influence of the environment. But this kind of method needs to solve a lot of problems in the course of practical applications, such as signal disturbance, having multi-foot-path effect, and orientate result uncertainty.

(3) RSSI (Received Signal Strength Indication)

Because WLAN is actually one kind of radio, studies shows that the wireless signal spreads follows certain laws. The strong the signal intensity received by receiver, the less distance of the sender. Its distance of the mobile platform to the base station can be calculated by signal intensity. RSSI based location systems [5- 7] are becoming more-and-more precise and sophisticated. Although its technique is relatively complicated, it can reduce the interference of

signal, and get higher precision and reliability.

In IEEE 802.11 standard, WLAN or AP (Access Point) circuit can measure RSSI. IEEE 802.11 based WLAN have two methods to measure the signal channel, that is initiative way and passive way.

AP broadcast beacon frame in passive way, while in initiative way, wireless network adapter send probe request frame in different usable signal channel by broadcasting way, and AP response to the adapter, and then the adapter find out and connect to the AP whose signal strength is the strongest. The connection will not be switched unless even stronger a signal strength is found. If the signal strength of the AP becomes weak, a connection switch is needed. In this occasion, adapter will send probe request frame in different usable signal channel by broadcasting way again to find out the AP who has the strongest signal.

There have two methods to get RSSI in IEEE 802.11 standard, one is to measure probe response frame by mobile device, and another is measured by AP. Compared with mobile device, the transmitting power of AP is higher, and signal attenuation is more stable, so the AP measurement is recommended.

Theoretically, wireless signal loss is proportional to the logarithm of the corresponding T-R distance in transmission; however, all kinds of obstacle will weaken the strength of the signal. The environment factor has less impact on the signal strength near the AP, while it will bring bigger errors when the AP is far away.

How to reduce the error is the most concerned problem to the researchers.

The direct way to get accurate position is to set up an experiment database by abundant signal data collection under the indoor environment,.

The collection data format is as follow:

$$(x, y, d, r_i) \quad i=1...n$$

In witch: x and y are coordinate of location, d is direction of user, r_i is RSSI value of the i^{th} AP, n is the number of AP.

After data collection, the data was pretreated as follow:

$$(x, y, d, a_i, v_i) \; i=1...n$$

In which: a_i is the average RSSI value of i^{th} AP, v_i is RSSI standard deviation of i^{th} AP.

In the location process, average RSSI value is calculated for m times measurement values,

$$r_i->a_i->sa_i \quad i=1...n$$

In which: sa_i is sorted a_i..

It can be found that the RSSI value for a certain position is subject to gauss distribution.

In order to improve the accuracy of measurement and position algorithm, the research of this paper will combine the triangle localization and RSSI, which can improve the location precision. Its implement step is as follows:

a) Set up WLAN local coordinate system
b) Develop the tool which reads the intensity of WLAN wireless signal
c) Gather the sample data of signal intensity received from the portable terminal (Received Signal Strength Indicator, RSSI) in the area covered in WLAN
d) Set up the fingerprint image of the signal (intensity distribution picture of signal) according to the sample data collection of the intensity of signal
e) Establish database which represents the physics position coordinate of sample point corresponding to the value of intensity of signal.
f) find out the 3 sample point position coordinate according to the coordinate databases set up by step 5, and calculate out the position of the mobile terminal according to triangle localization

By this method, localization precision can reach 1m*1m.

3. The structure of location system

Location System under WLAN environment (WLAN LS) mainly consists of several following parts:

(1) The portable terminal. Such portable terminals as the computer, PDA palm, note-book computer, cell-phone, etc. are the basic hard equipment that users obtained the network service on the environment of WLAN.

(2) Wireless LAN. It includes tow conditions based on. One is individual WLAN

consists of one or more wireless access point (Access Point, AP). Its distance of effective communication is under 100m, commonly in supermarket, service station, museum. The second is several interconnected complex WLAN, its distance of effective communication can be extended to several hundred meters even above 1km, commonly in international Convention and Exhibition Center, large-scale gymnasiums and stadiums, recreation center, hotel, office block, airport, hospital, school, etc.

(3) Plug-in package of WLAN RSSI Sensor. It offers the induction of intensity of wireless signal to user terminal. Only installed this plug-in package, the backstage location server can makes a orientation wirelessly to the portable terminal

(4) WLAN location server. Considering the importance of the orientation function, this system specially established position server to realize the orientation calculation, and also provide data analyze sever for client. According to analyzed result, data claim from client and position coordinate was sent to GIS server and user management server of WLAN.

4. work principle and treatment scheme

The work principle and treatment scheme of location system is shown in Fig.1, Fig.2 and Fig.3:

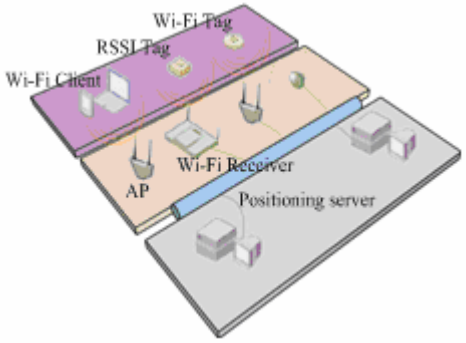

Fig.1 in doors location sketch map

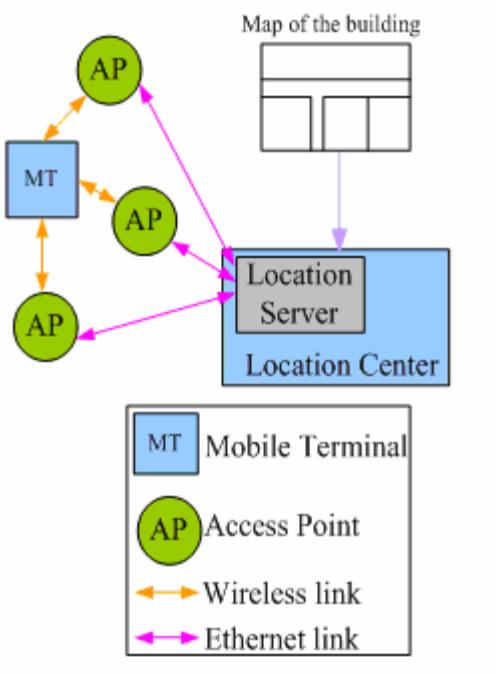

Fig.2 in doors location architecture

Its treatment scheme is as follows:

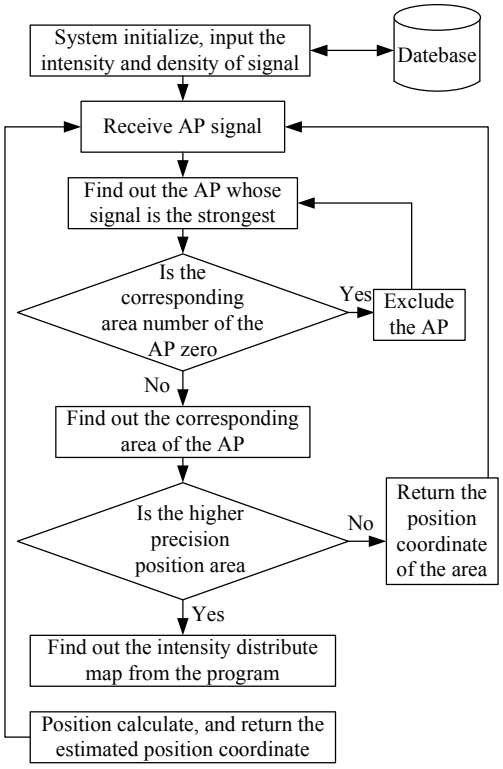

Fig.3 treatment scheme of location technique based on WLAN

5. The prototype testing and conclusion

Based on 802.11b standard, prototype system was developed for testing. The test environment is a server, 2 notebook computers, a palmtop computer, 5 APs and 3 wireless network cards. The system was realized with Java and VC programming. According to the operation conditions of the prototype system, we find that the wireless access point (AP) , wireless network card (Adapter) and signal intensity Fingerprint, etc. are the main factors which affect the location precision and response time of the system. To improve precision of location and accelerate system response can provide better location service to users, so we made further analysis to the prototype system, and drew the following main conclusions:

1) Increasing AP, disposing AP rationally can improve the precision of localization greatly. In the prototype test, when AP rises to 5 from 3, location precision bring up to 3m rapidly from 5m. So, in some application occasions needing to make an accurate location (for example the security control to the special goal), we can increase AP quantity properly, so as to ensure the precision. While erecting AP, should try to choose the high and open place so as to avoid the signal being interfered, such as ceiling, roof, etc.

2) Select sensitive wireless network card which is sensitive to intensity change of signal can improve the precision of localization. This wireless network card used for this test is selected at random, and there are 3 kinds in all. Their sensitiveness to the intensity change of WLAN signal has greater differences (reflecting by the communication state to the same AP), the wireless network card update the intensity of signal received every 150ms with higher sensitive degree, while it will take few second and even more than ten seconds for those lower sensitivity wireless network card. The sensitive degree of the wireless network card makes no difference when the target keep unmoved (static state), while the target keep moving (dynamic state), the impact on precision is very remarkable. The more sensitivity of the wireless network card, the more accurate the localization of the moving goal is.

3) Improving sample density of the fingerprint of signal can improve the precision of localization. In this test, when the sample interval of the fingerprint sample point reduced from 1.8m to 0.9m, average location precision is improve obviously, rising to 4m from 5m. The weak point of reducing the sample interval is that it will increase work load of sampling greatly, and increase cost of the system.

4) While sampling for each sample point, should sample different directions in order to avoid the influence of the directionality of signal intensity. In addition, if use average intensity of signal in 0.5- 2s (select according to the need) for location calculation will increase the location precision remarkably, because it can avoid the influence of some instantaneous unusual intensity value.

However, the higher the location precision, the higher system cost is. So, in different occasion, should compromise between precision and cost. For example, control or scout etc. should try to improve the precision of the localization (under 1m), while in peripheral information inquiry and route analyze, location precision can properly reduced (about 5m).

In this paper we presented an approach for indoor location technology based on combination of RSSI and Triangle localization.

To demonstrate the performance and applicability of the techniques, experiment was performed in a home environment with access points. Then our experiment results indicated the different factors, which can influence the location accuracy.

6 Future work

Even though there have been a number of location technologies and more possible extension, it is the difficult issue that how to choose the method to get RSSI, how to improve the location arithmetic and how to improve the location accuracy. Location technology has just springs up, which has great

future in inter-connect technology and broadband access technology, the location application in real life can make people's daily life more convenient. We expect the new fast development in location technology based on WLAN.

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