# THEME 5 : Short range positioning

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# Why TOF methods are not suitable in short range positioning?

Short range positing systems are used relatively on shorter distances typically less than 100 meters. They are best suited and used indoors positioning.

Time of flight and time of arrival method are used basically indoors and here wireless signals are subjected to non-line of sight and severe multipath conditions due to which they are not quite accurate.

Multi path conditions arise when signals bounce back from the intermediate objects both stationary and non-stationary ones.

# How is multipath propagation affecting on the accuracy of RSS method indoor?

Multipath problem can be defined as receiver getting multiple copies of signal from the transmitter each of which taking different paths due to the reflections because of the intermediate objects like furniture , movement of people , machinery and equipment that exist in the signal path.

These received signal copies are characteristically phase shifted and time delayed.

Deviation of accuracy for distance calculation is proportional to length of non direct path travelled by the signal. Calculating the distance as a function of signal strength can lead to considerable inaccurate results when the non direct /multipath differs from the shortest or direct path even by one half of wavelengths. So this means tiny variation of phase shifts caused as result of refractions and reflections in the signal would result in inaccurate distance calculations. Given this case , both the reflected signals arrive out of phase and composite signal can be even 20 dB below the actual RSS value if direct path exists.

# Explain how two-way TOA method is used in WLAN positioning

Two way TOA is the time difference between the period between sending the message and receiving the reply at the initiator and the period between receiving the message and sending the reply at the transponder.

In two way TOA method. distance measurement in WLAN(IEEE 802.11) networks and ad-hoc measurement is that a message response is generated after a fixed time interval from message reception. This message response is triggered and generated by the hardware layers of the access protocol. Time of arrival distance measurement depends on precise determination of the time of received packet. Once the message is received by the responder , it replies back to the sender with an acknowledgement . The purpose of sending acknowledgement (ACK) is to inform the sender that his message is received correctly. If sender has not detected the ACK , it will try to resend the message thinking that message did not get received to the intended receiver. This message-ACK feature greatly reduces the chance of data drop even in dense traffic conditions. ACK transmission is done in a time period called **S**hort **I**nterframe **S**pace between end of the received message and beginning for ACK transmission.

Value of SIFS is set less than the minimum channel clear period so that other terminals waiting to access channels will hear the ACK and back off.

In a TOA principle , A frame is sent from the initiator WiFi terminal to a responder, If the frame reaches the responder it sends back the ACK to the initiator

The time difference between the end of the received message and beginning of the acknowledgement must be less than SIFS which in 802.11 has value of 10 micro seconds.

This time include changeover time plus hardware and packet processing delays counted for. Logic for this embedded in the chip firmware which is possibly the best place to send back the ACKs. The initiator then receives the ACK from responder through which total propagation time and time of flight is calculated.

2 = ( - )

where Propagation delay

Time of initiator message sending

Time of receiving acknowledgment.

# Why is fingerprinting the most popular method used in WLAN positioning?

Fingerprinting can achieve higher accuracy than direct calculation of distances from RSS.

This is also one of the most widely used indoor positioning systems because of the following advantages.

* Location system based on fingerprinting does not need time synchronization like TDOA based systems.
* As RSS calculations are done at the protocol level (IEEE 802.11) and hence does not demand any special hardware. As a result all the devices based on this protocol can be tracked with no additional hardware support.
* Multi path problem can be eliminated by accounted this while creating reference databases.
* It is possible to achieve greater accuracy by effectively making reference databases by effectively planning grid points.

# Explain the use of sniffer network technique in WLAN positioning.

In the sniffer based technique, a dedicates sniffer hardware infrastructure is present whose job is to perform the location function independently of the network. These dedicated sniffers scan for WLAN radio frequency channels and station their station identity information time stamped for correlation and processing at location server. There are several advantages and few disadvantages of sniffer based systems.

* Theses sniffers hardware can be deployed at best possible geometry and can be independent of access points locations to help in best possible coverage across the area.
* Signal emitters can be added to the existing location infrastructure to facilitate regular database updating particularly applicable in dynamic environments.
* Also independent sniffers can be deployed for minimum database profiling which will enable lesser density and low number of database points for a specific area and location performance.

Disadvantage of using sniffers is it needs an independent sniffer infrastructure which can be eliminated by other methods like client based systems where there is no need for special hardware.

# How is client-based method differing from sniffer-based technique?

Client based system works on the principle that target picks up RSS readings from the access points in the specific area and compares them to a preexisting database created from client RSS readings. Target uses protocols Probe Request responses for calculating the signal strengths from different access points. Sniffer based technique purely works on the principle that, it comes with independent sniffer hardware deployed that would scan for WLAN channels and send the information to location servers for further processing.

Both sniffer based and client based systems fare equally good in terms of accuracy , one advantage of Client based systems compared to sniffer based ones is that, client based systems does not needs any additional hardware and uses existing WiFi network. One clear disadvantage of client based system is that system cannot filter location of unwanted/rogue terminals in the network.

# What are the difficulties in Bluetooth positioning, when a moving object is the target?

In the Bluetooth positioning systems , moving object shall need to make an attempt to connect to multiple host Bluetooth devices. Once connections are made target object tries to fetch the reference location coordinates of the stationary BT devices. It is often proved that the total time to attain location coordinates (establishing connection plus getting host locations) by a moving target is quite more when compared to a stationary target.

Following are the certain problems faced by target in motion for calculating location coordinates by

* Accuracy of calculating location positions by Bluetooth may be impaired when position measurements are calculated by a target in motion.
* Radiated power and antenna patterns and directions of the hand held mobile devices can have impact on the accuracy of location information. This is because the way these moving hand held devices are held and their distance from the body and indoor transmission path obstructions limit the accuracy and rage.

# Explain the use of RSSI in Bluetooth positioning

As like in any position methods , RSSI can be used in Bluetooth positioning system as well.

As we know that there are difficulties for location calculation with signal strength to distance in an indoor environment due to multipath problems , Bluetooth is no exception for this.

The main purpose behind RSSI reading in Bluetooth is to provide feedback for the power adjustment of the transmitter for which the receiver is linked. Every received signal has an upper threshold termed as strong signal and lower threshold termed as weaker signal

If a received signal is with in 20 db range of upper threshold and lower threshold , signal is stated to be in golden received power range. RSSI value at this state is reported as ZERO.

Negative RSSI values are reported when the signal is below lower thresholds and is a

indication to the transmitter to increase its signal power. Similarly a positive RSSI value is an indication to the transmitter to cut down its signal power. Increasing and decreasing of the signal power is normally achieved by variable attenuators in separate antennas present in BT access points. These attenuators help in measuring the signal strength in wider areas by shifting the linear position of RSSI curve.

Location coordinates of client can be figured out by initially measuring RSSI to obtain the distance to multiple Bluetooth access points at known locations and then using triangulation principle thereafter.

Since RSSI precession is relatively low, a large spread RSSI vs Signal strength would be expected across different BT modules leading to reduced accuracy.

# Explain picture 10.7.

Picture 10.7 in the book is graph that presents the RSSS signal output plotted against signal strength for Bluetooth devices.

As we discussed above, any received signal will have upper and lower thresholds with in range of 20 db and a deviation margin around +/- 6d.b. The signal strength that falls in between these ranges are considered good enough and this range is termed as golden power range. Any signal strength above and below this golden power range would eventually request changes in signal strength to push up and push down signal power by transmitter.

Graph in picture shows signal strengths of four Bluetooth devices. Golden power range for all the four BT devices shown as between -63 dB to -47 dB where the RSSI is reported ZERO.

Here upper threshold can be considered as -47 dB and lower threshold as -63 dB with a margin of +/- 6 dB.

Once the signal strength tops above -48 dB (higher threshold) , positive values of RSSI 12, 10 , 9 and 15 are reported for four devices and hence the transmitters are requested to cut the signal strengths further on.

Similarly when signal strength drops below lower thresholds (-63 dB) , negative RSSI values (-2,-4,-6,-8,-10) are reported and transmitter hence boosts the signal power to have it in the golden power range.

# Which method is the most accurate in BT positioning?

The most suitable method for distance measurement that uses BT technology is Zigbee . Zigbee devices are built on IEEE 802.15.4 standard and does distance measurement based on signal strength indication . These devices are known for low power consumption , low cost with a good accuracy and operate on variety of network topologies.

# Which method is used in Zigbee positioning? Explain the method shortly.

Zigbee uses Bluetooth technology for location positioning systems and is based on IEEE 802.15.4 specification. Zigbee devices are typically are designed for low power consumption and low priced. It is usual that when used in multiple networks certain nodes are stationary with known fixed locations and other are mobile which are location measurement logic in them.

IEEE 802.15.4 support different network topologies peer to peer, star , mesh and tree to name a few.

Zigbee nodes are capable enough to participate in data communication in any of the above mentioned topologies. In a peer to peer topology , Zigbee nodes communicate with each other where as in star , nodes is capable enough to communicate only with coordinator nodes and not with other peer nodes.

Zigbee receiver nodes compute Link Quality Indicator (LQI) parameter based on RSSI which is primarily a range estimation when each message is received. This LQI values is passed over to other top layers like Data link , Network & application layers where it is used by location based programs for distance calculation. Similarly ED (Energy Detection) is also calculated at the receivers physical layer and mapping of ED value to received power is done which must be linear with an accuracy of +/- 6dB. ED values are used for scanning frequency channels to find those that are available for connection before attempting to access the channel.

Node tries to find its position by triangulation method having know the RSSI which is related to received power from multiple terminal with known location coordinates. This node here is refered as blind node.

There are two arrangements to talk about here 1. Unilateral and 2. Multilateral. In Multilateral arrangement, RSSI measurements are taken at reference fixed nodes and this data is passed to sub system that does the real location measurement calculation.

In Unilateral case , Node is capable of measuring RSSI from the reference nodes though which the location measurements are carried by the node itself and does not need any external support.

# In RFID usually the tags are moving and readers are fixed. What kind of applications need fixed tags and moving readers? Give examples.

RFID applications come in two flavors , Most common scenario is RFID readers are in fixed positions and tags are mobile. Another flavor which is uncommon but used for cetain applications is vice versa where reader are moving and tags are stationary.

One of the most common example of second case is , Valuable asset tracking systems.

It is common that certain confidential assets belonging to Office or any premises or any highly secured hardware which can be compromised if hardware is taken out of the building. These kind of confidential assets can be tracked , recorder and alarm can be raised when the asset is crossing the premises boundary.

Building can be designed such that the exit points of the building or premises can be marked with stationary RFID tags. Assets that need monitoring shall be equipped with RFID readers.

These RF readers gather the tag ID from the stationary tags when they come to the proximity and relay the information to back end servers.

The equipment that needs to be tracked are essentially supported by IEEE 802.11b WLAN via which their tagIDs can be transmitted to centralized servers from where the location calculations, validations happen and actions are initiated based on the moving path and location of the asset.

# Explain the functioning principle of RFID radar.

Principle that is used in RFID radar is mostly the same as defense and aerospace radar installations.

Underlying principle is that , RFID card reader does the job of transmitting station and obtains two dimensional coordinates of the target. Location coordinates of the target are calculated by combining Time of Flight and Angle of arrival methods. Directional beam antennas are used in AOA measurements.

It is usual that calculation of initial position takes a bit longer time around 20 seconds and there after target is tracked and reported for every second.