Short Survey of Wireless Indoor Positioning Techniques and Systems

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Abstract— Smart city offers different services to different people depending on a wish list. It fulfills people's aspiration level, wherever there is willingness to change and to reform. Due to the complexity people movement within and between cities, localization techniques became popular with the global positioning system for outdoor applications, followed by Personal Networks (PNs) localization for indoor applications. PN are designed to provide a flexible and fast wireless communication between user's devices and other devices, in various indoor environment places. PN mainly uses indoor positioning systems (IPSs) for improving numerous factors such as Self-organizing sensor networks, location sensitive billing, ubiquitous computing, context- dependent information services, tracking, and guiding. This paper gives a short survey of some kinds of IPSs, and focuses on triangulation to predict the target location, where for example it calculates the distance by measuring time difference of signals arrival (TDOA) over Orthogonal Frequency Division Multiplexing (OFDM), as one of several techniques identify the distance between the transmitters and receivers.

Index Terms— Personal Networks, Indoor Positioning Systems, Location Techniques, orthogonal frequency division multiplexing (OFDM), time difference of arrival (TDOA).

I. INTRODUCTION

Personal Networks (PNs) are designed to meet the demands of users to interconnect their various personal devices at different places into a single network, as shown in Figure 1. So a good PNs should include user's needs of an accurate, reliable, and real-time indoor positioning protocols and services [3], [4], [5], especially for the future generation of communications networks in smart cities, where there is rapid development of integrated networks and services in PNs [6]. Besides that, location information helps to get better network planning [7], network adaptation [8], and load balancing [9], etc. Nowadays, indoor positioning systems (IPSs) enables valuable position-based applications and services for users in PNs such as homes, offices, sports centers, etc. For example inside complex hospitals environments, provide guidance to the patients for efficient use of the limited medical resources. Another example is: inside museums where it guides tourists in some large museums to see the artifacts in different places in sequence. IT can also help in specifying a location of products stored in a warehouse, detecting firemen location in a building on fire, following up police dogs trained to find explosives in a building; and finding out tagged maintenance tools and equipment scattered all over a plant.
Global positioning system (GPS) [10] offers an accurate enough positioning system in outdoor environment. Unfortunately GPS cannot be deployed for indoor use, because there is no line-of-sight transmission between receivers and satellites in indoor environment. This leads us to indoor environments which are more complex due to multipath generated by various obstacles, interference and noise sources from other wired and wireless networks. So more attention has been spend to position information in indoor environments to improve intelligent services for personal use, and reduce the uncertainty in dynamic and changing indoor environments. With all these issues, IPSs for indoor applications raise new challenges for the future communications systems. Using wireless technologies in PN to determine a location positioning means location sensing, geolocation, position location, or radiolocation.
Depending on Different applications there are different types of location information mainly classified as physical location, symbolic location, absolute location, and relative location [11]. Physical location is expressed in the form of coordinates; Symbolic location expresses a location in a natural-language way; Absolute location uses a shared reference grid for all located objects; finally Relative location depends on its own frame of reference.
Various wireless technologies are used in PNs such as infrared (IR), ultrasound, radio-frequency identification (RFID), wireless local area network (WLAN), Bluetooth, sensor networks, ultra-wideband (UWB), magnetic signals, vision analysis, and audible sound. Categorizing IPSs can be based on the technology options as well as on the positioning algorithms used for. From positioning algorithms point of view there are three types: traditional triangulation, scene analysis, and proximity positioning algorithms [2].
Based on these fundamental technologies and algorithms, research centers and universities try to find out new IPSs. They do it by taking into account the advantage of a particular positioning technology or combining some of these technologies and also some kind of tradeoff between the overall performances of the IPSs have been taken, where

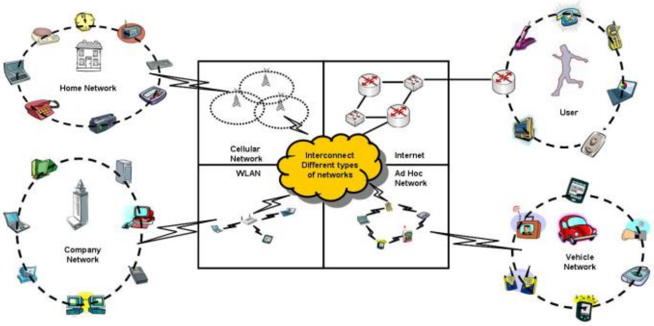

Figure 1 Personal Network

performance metrics include accuracy, precision, complexity, scalability, robustness, cost, security and privacy..

In somehow the capability of positioning a device can be done through several steps first by taking into account the signals come from fixed access points within particular vicinity, second calculate the propagation times of them, third depending on previous step the estimation of device position is calculated with respect to these access points. Further the indoor infrastructure is used to create indoor positioning systems. Several IPSs technique and mechanism have been proposed by many researches.

Positioning systems can classified to four different topologies, first remote positioning system by fixing several measuring units receive that the transmitter's signal, or collecting the results from all measuring units and the location of the transmitter is computed in a master station, second one by self-positioning where the measuring unit is mobile itself, If a wireless data link is provided in a positioning system, it is possible to send the measurement result between a self-positioning measuring unit to the remote side and vice versa, and this is called indirect remote positioning and indirect self-positioning.

As mentioned before, multipath is considered as the most important problem faced by the IPSs; on the other hand multi carrier systems are designed to be robust against multi-path channels. Recently, OFDM led to its worldwide adoption in numerous emerging communication standards like DVB-T, IEEE 802.11a/g, 802.11n, WiMAX, UWB, LTE/4G, and etc. [12]. Therefore, this has triggered extensive research where OFDM signals could be adopted as positioning signals for IPS. Several papers that have addressed the positioning with OFDM signals could be divided into two categories; timing synchronization algorithms and super resolution algorithms. Each one has its week and good points.

Besides that, this short survey introduces and explains to the reader a review of the wireless positioning systems for indoor applications, discusses the advantages and disadvantages of these IPSs in terms of performance metrics, and tries to determine the positioning techniques' drawbacks in view of indoor wireless positioning.

The remainder of this paper is organized as follows. Section II explains performance metrics for indoor positioning techniques. In Section III current wireless indoor positioning systems and solutions, and their performance comparison are presented. Section IV shows the measuring principles for location sensing and the positioning algorithms corresponding to different measuring principles. In Section V some positioning techniques' drawbacks are mentioned. Finally, we conclude this paper in Section VI

II. Performance Metrics

It is not fair to depend only on accuracy to compare between positioning systems and measure the performance of a positioning techniques. Referring to [13], we introduce the following performance criterias for indoor wireless location system: accuracy, precision, complexity, scalability, robustness, and cost. So we can use these criterias to do some performance measuring of systems and solutions in Section III.

a. Accuracy

The main aspect to decide if the positioning system is efficient is Accuracy (or location error); simply it can be represented by average Euclidean distance between the estimated location and the true location. The system is better if it has higher accuracy. However some tradeoff between accuracy and other characteristics has to be taken into account.

b. Precision

Precision is the variation in its performance over many trials. The best way to do so is by using the cumulative probability functions (CDF) of the distance error between the estimated location and the true location.

c. Complexity

Hardware, software, and operation factors are the areas where the complexity of the positioning system is presented. Here we focus on computing complexity of the positioning algorithm. The lowest rate complexity is found where the computation of the positioning algorithm is performed on a centralized server side, because the mobile units lack strong processing power and long battery life. The important indicator for complexity is Location rate; it is the delay of reporting the new location of that target by the system.

d. Robustness

The system is robust if its positioning technique could function almost normally even if there is incomplete information due to blocking of the signal from a transmitter unit, or some measuring units could be out of function.

e. Scalability

Scalable system means that positioning function works in normal way when the targeting area gets large. The system has to be scalable when main parameter geography and density are presented. Geography means increasing in the distance between the transmitter and receiver influences the positioning system performance. Density is the number of units located per unit geographic area/space per time period. In another point of view, scalability is increasing the dimensional space of the system.

f. Cost

The cost of a positioning system may be affected by many factor including money, time, space, weight, and energy. The hardware of the systems may cost a lot if it has to build up from the beginning. Time of system installation and maintenance is cost function. System weight and space are cost constraints. Space cost depends on unit density. The infrastructure used to construct the positioning systems may be considered to have no added hardware cost if all the necessary units are available. Finally, the energy plays an important subject in cost parameter due to consumption of devices.

III. INDOOR POSITIONING SYSTEMS

In this section we introduce a short review about variety of IPSs that perform indoor location estimations as in figure 2. These IPSs will be explained according to the criteria and requirements specified in the previous section which focus on the needs of user in PNs. Thus we can know the advantages and limitations of these IPSs from the view of users in PNs.

A. Infrared (IR) Positioning Systems

Infrared (IR) positioning systems [14]-[25] use IR technology to perform localization as shown in figure 2. Three main systems which are: Active Badge, Firefly, and OPTOTRAK PRO series. All of these systems are limited within a room and need line-of-sight communication between transmitters and receivers without interference from strong light sources. Simplicity of the systems architecture, positioning estimation in an accurate way and easy to be carried by a person, is the common advantages between these systems. On the other hand the disadvantages of these systems include security, privacy, cost, some limitations for sensing location, and finally the IR wave cannot penetrate opaque materials.

B. Ultra-sound Positioning Systems

Another way to perform positioning is by using ultrasound signal [26]-[32]. With this kind of inexpensive positioning solutions, ultrasonic technology and triangulation location technique are used to estimate the location of a tag carried by a person, combined between RF signals to perform synchronization and coordination in the system. This increases the system coverage area. There are three Ultrasound positioning systems: Active Bat, Cricke, and Sonitor. All of them suffer from reflected ultrasound signals and other noise. In addition, they have lower measurement accuracy (few centimeters) than IR-based systems (few millimeters).

C. Radio Frequency (RF) Positioning Systems

Radio frequency (RF) technologies [33], [34] are used in IPSs to provide larger coverage area, in addition they need

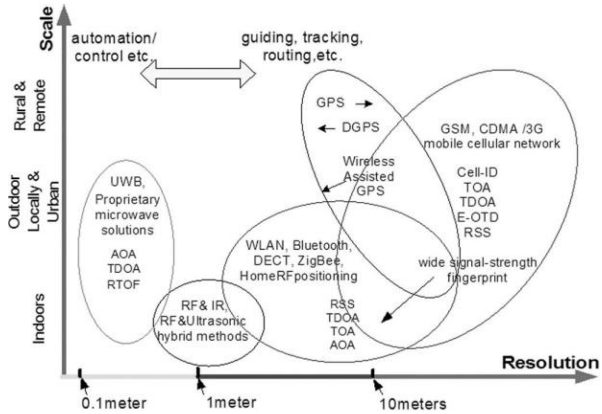

Figure 2 Outline of current wireless-based positioning systems.

less hardware comparing to other systems because of their capability of easy travel through walls and human bodies. The main techniques used by RF-based positioning systems are Triangulation and fingerprinting techniques. Fingerprinting gives a good estimation performance in complicated indoor environments, where it depends on location related characteristics to calculate the location of a user or a device. Here are some introductions of different types of this system.

1. Radio Frequency Identification (RFID)

The radio frequency identification (RFID) is commonly used in complex indoor environments such as office, hospital, etc. It can be used to stores and retrieves data through electromagnetic transmission, also it enables flexible and cheap identification of individual person or device. There are two kinds of RFID technologies, passive RFID and active RFID [35]-[37]. The tags with passive RFID are small and inexpensive. But the coverage range of tags is short, per contra in Active RFID the cost of tags is higher, and the coverage area of active tags is larger.

2. Wireless local area network (WLAN)

Many of the public areas such as hospitals, train stations, universities have used WLAN technology to implement their networks. So the existing WLAN infrastructures in indoor environments have been reused by WLAN-based positioning systems which lower the cost of indoor positioning, this make it as an example of low cost positioning technology in IPSs. The WLAN-based positioning systems can also reuse PDAs, laptops, mobile phones as tracked targets to locate persons, since that WLAN technology is already integrated in those wireless devices. There are many problems effect the accuracy of location estimations based on the signal strength of WLAN such as movement and orientation of human body, the overlapping of Access points APs, the nearby tracked mobile devices, walls, doors, etc.

3. Bluetooth, the IEEE 802.15.1 standard

Bluetooth replaces the IR ports mounted on mobile devices, because it enables a range of 100 m (Bluetooth 2.0 Standards) communication. Various types of devices such as mobile phone, laptop, desktop, PDA, etc integrates Bluetooth technology. Bluetooth chipsets are low cost, which results in low price tracked tags used in the positioning systems. In general, the infrastructures of Bluetooth-based positioning systems [38] - [49] consists of various Bluetooth nodes, the effort of other mobile terminals in the same node locates the position of the target Bluetooth mobile device. However, accuracy from 2 m to 3 m and delay of about 20 s is only what can Bluetooth-based positioning system provides since it suffers from the drawbacks of RF positioning technique in the complex and changing indoor situations [38].

4. The ultra-wide band UWB

Short duration of the ultra-wideband (UWB) [53] pulses helps to filter the multipath of original signal, this offer higher accuracy. So UWB technology in positioning systems has been a popular way of improving the accuracy [54]. In addition UWB technology offers various advantages over other positioning technologies used in the IPSs, such as need for line-of-sight, affective behavior in multipath environments, less interference, high penetration ability, etc. Furthermore, the positioning system is a cost-effective solution, because the UWB sensors are cheap.

D. Magnetic Positioning System

One of the oldest and classical position estimation ways is to use magnetic signals [55]. It gives a high accuracy and does not suffer from non-line of sight. In addition the magnetic sensors are small in size, robust and cheap; these add more benefits to positioning estimations in indoor environments. However, the performance of the magnetic IPSs is affected by the limited coverage range with about 3 m. Thus more needs further study, design and development need to increase the coverage range or use various magnetic infrastructures to cover enough area for indoor use.

E. Vision-based Positioning System

Vision-based positioning can easily provide some location-based information, just by low price camera to cover a large specified area. So it could track the locations and identifying persons or devices in a complex indoor environment [56]-[58]. Also it does not need the tracked person to carrying or wearing any device. But it has some drawbacks. Firstly, there is no privacy. Reliability of the system bases on the saved vision information in a database, so the system suffers from a dynamic changing environment and needs to update due to the changing in the environment. Third is influenced by many interference sources such as weather, light, motion, etc. finally tracking the moving objects around at the same time challenge for the vision-based positioning, which needs higher computational ability of the positioning system.

F. Audible Sound Positioning System

Audible sound is a possible technology for indoor positioning [59]. Since everyone has his own mobile device such as mobile phone, PDA, etc., and each various mobile devices has audible sound service. Then these devices owned by the users can be reused by the audible sound-based positioning system for indoor positioning, and the users can use their personal devices in an audible sound positioning system to get their positions. Using audible sound for indoor positioning has some limitation, because of its properties, like the interference with sound noises, and low penetration ability. The scope of this approach is therefore within a single room.

IV. Measuring Principles and Positioning Algorithms

There are three main algorithms used in positioning systems to localize an object: triangulation, scene analysis, and proximity. Due to unstable indoor environment, it is not easy to model radio propagation, where radio propagation is affected by many things like multipath, non-line-of-sight (NLOS) path, and specific site parameters such as floor layout, moving objects, and numerous reflecting surfaces. Scene analysis and proximity are developed mitigate the measurement errors. Each algorithm has its unique advantages and disadvantages. And can be combined for improved performance.

A. Triangulation

To estimate the target location based on the geometric properties of triangles, there are two derivations: lateration and angulation. In general we called them Triangulation. In lateration, multiple reference points are used to estimate the position of an object. Instead of measuring its distances from them directly, lateration measures received signal strengths (RSS), time of arrival (TOA), time difference of arrival (TDOA), Roundtrip time of flight (RTOF) or received signal phase method. Then the distance is derived by computing the attenuation of the emitted signal strength or by multiplying the radio signal velocity and the travel time. Similarly, angulation uses reference points but it computes the angles of the object relative to them.

*1) **Lateration Techniques:***

a) ***TOA****:* The time of signal propagation is directly proportional to the distance between the mobile target and the measuring unit. It is simply velocity law, the time is measured and the speed is already known (3*10e8: speed light) then we could calculate the distance. At least three reference points are used to enable 2-D positioning as shown in Figure 3. In general, there are two problems in using TOA. First, precisely synchronization is necessary between all transmitters and receivers in the system. Second, each transmitter signal labeled to gives the measuring unit ability to distinguish between the distances of each signal. There

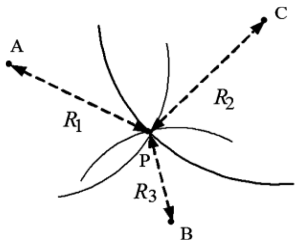

Figure 3 Positioning based on TOA/RTOF measurements.

are many algorithms for measuring TOA-based indoor location system like closest-neighbor (CN), residual weighting (RWGH), and straightforward approach.. In CN algorithm, the location of the user is the location of the base station or reference point closest to it. Where The RWGH algorithm uses a form of weighted least-squares algorithm, it is suitable for LOS, non-LOS (NLOS) and mixed LOS/NLOS channel conditions. The position of the target in straightforward approach uses a geometric method to compute the intersection points of the circles of TOA To locate the target using TOA by minimizing the sum of squares of a nonlinear cost function, i.e., least-squares algorithm [60], [61]. By assuming the location of the mobile terminal at (x_0,y_0), and it transmits a signal at time xt_0, and the N base stations located at (x_1,y_1), (x_2,y_2),. . . , (x_1,y_2) receive the signal at time t_1, t_2, . . . , t_N . The cost function can be formed by

$$\boldsymbol{F}(\boldsymbol{x}) = \sum_{i=1}^{N} \alpha_i^2 \; f_i^2(\boldsymbol{x}) \qquad (1)$$

Where α_i can be chosen to reflect the reliability of the signal received at the measuring unit i, and $f_i(x)$ is given as follows.

$$\boldsymbol{f_i(x) = c(t_i - t) - \sqrt{(x_i - x)^2 + (y_i - y)^2}} \qquad (2)$$

Where c is the speed of light, and $x = (x, y, t)^T$. This function is formed for each measuring unit, $i = 1. . . N$, and $f_i(x)$ could be made zero with the proper choice of $x, y,$ and t. The location estimate is determined by minimizing the function $F(x)$.

b) ***TDOA:*** Unlike the TOA which is the absolute arrival time of each signal at the measuring unit, TDOA is the difference between arrival time of two signals at each pair of measuring units, each TDOA produced has a hyperboloid related to two measuring units where the transmitter must lie on it as in figure (4). The equation of the hyperboloid is given by

$$R_{i,j} = \sqrt{(x_i - x)^2 + (y_i - y)^2 + (z_i - z)^2} - \sqrt{(x_j - x)^2 + (y_j - y)^2 + (z_j - z)^2} \quad (3)$$

Where (x_i, y_i, z_i) and (x_j, y_j, z_j) represent the fixed receivers i and j; and (x, y, z) represent the coordinate of the target [60]. The easier solution for the hyperbolic TDOA equation shown in (3) is to linearize the equations through the use of a Taylor-series expansion and create an iterative algorithm [63]. To estimate a 2-D location of the target P as shown in Fig. 4 two hyperbolas are formed from TDOA measurements at three fixed measuring units (A, B, and C).

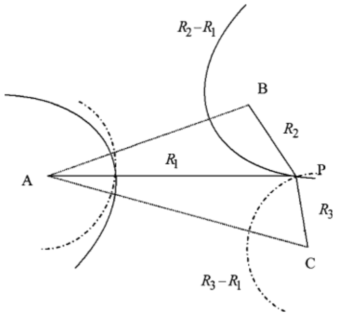

Figure 4 Positioning based on TDOA measurements.

The traditional methods to compute TDOA estimates are to use correlation techniques. The cross correlation between the signals received at a pair of measuring units can provide an estimated TDOA. By taking the first noisy delayed signal as $x_i(t) = s(t - d_i) + n_i(t)$ and similarly for the second one $x_j(t) = s(t - d_j) + n_j(t)$, which arrives at measuring units i,j respectively, the cross-correlation function of these signals is given by integrating the lag product of two received signals over a time period T.

$$\hat{R}_{x_i,x_j}(\tau) = \frac{1}{T}\int_0^T x_i(t)\, x_i(t-\tau)dt. \qquad (4)$$

The TDOA estimate is the value τ that maximizes $\hat{R}_{x_i,x_j}(\tau)$, i.e., the range differences. To do so these measuring units share a precise time reference and reference signals, without imposing any requirement on the mobile target. Calculating τ is usually done by using frequency domain processing techniques.

c) ***RSS-Based*** *(or Signal Attenuation-Based) Method:* The distance of the mobile unit can be estimated, thanks to the relationship between signal attenuation and the signal path loss, due to propagation. Comparing the transmitted signal strength and the received signal strength, results into a range estimates as shown in Figure 5. Multipath fading and shadowing effect on this method, so it can be

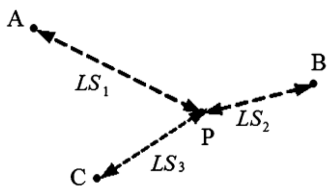

Figure 5 Positioning based on RSS, where LS_1, LS_2, and LS_3 denote the measured path loss.

improved by utilizing the premeasured RSS contours centered at the receiver [64] or multiple measurements at several base stations. Also a fuzzy logic algorithm shown in [65] does so.

*d) **RTOF:*** The main concept in this method is to use common rader in measuring unit, a target transponder responds to the interrogating radar signal, then the measuring units measure the roundtrip propagation time. Notice that its range measurement mechanism is similar TOA, except that TROF replaces the above synchronization requirement in TOA with more moderate relative clock synchronization requirement. The difficulty is to know the exact delay/processing time caused by the responder. It could be ignored in long-range or medium-range systems, where it has to be taken into account for short-range systems. An algorithm to measure RTOF of wireless LAN packets is presented in [66] with the result of measurement error of a few meters.

*e) **Received Signal Phase Method:*** or phase of arrival (POA) depend on the carrier phase (or phase difference). If two sinusoidal signals are emitted at the same frequency f, with zero phase offset, then each needs a finite transit delay to reach the receiver. To explain that let us see Figure 4. As seen, four transmitter stations A to D are placed at particular locations within an imaginary cubic building. The delay is related with the signal's wavelength fraction, which is the symbol $\varphi_i = (2\pi f D_i)/c$ in $S_i(t) = \sin(2\pi f t + \varphi_i)$, where $i \in (A, B, C, D)$, and c is the speed of light. So$D_i = (c\varphi_i)/(2\pi f)$, and by using TOA positioning algorithms we can locate the target, or using TDOA positioning algorithms if measure phase differences between two signals transmitted by pairs of stations. POA needs an LOS signal path.

2) Angulation Techniques (AOA Estimation):

Also called direction of arrival (DOA), commonly referred to as direction finding (DF). In this method each base station centered in a circular radius from itself to the mobile target, two bases form pairs of angle direction lines, then the location of the desired target can be found in the intersection of these lines. As shown in Fig. 7, AOA methods may use at least two known reference points (A, B), and two measured angles θ_1, θ_2 to derive the 2-D location of the target P. AOA needs as few as two measuring station for 2-D positioning, and so for 3-D. beside that no time synchronization between measuring units is required. But AOA needs relatively large and complex hardware requirement(s). For more detailed discussions on AOA estimation algorithms and their properties, see [67]–[69].

B. Scene Analysis

Scene analysis based on RF signal is done by collecting features (fingerprints) of a scene, then matching them with one taken before. RSS-based location fingerprinting is commonly used in scene analysis. Location fingerprinting consists of two stages: offline stage and online stag. In offline stage collecting signal strengths from nearby base stations/measuring units is done. During the online stage the currently observed signal strengths and previously collected information are used by a location positioning technique. The main challenge to the techniques based on location fingerprinting is that the received signal strength could be affected by diffraction, reflection, and scattering in the

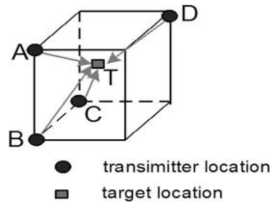

Figure 6 Positioning based on signal phase.

propagation indoor environments. We introduce five location fingerprinting-based positioning algorithms using pattern recognition technique: probabilistic methods, k-nearest-neighbor (kNN), neural networks, support vector machine (SVM), and smallest M-vertex polygon (SMP).

1) kNN: The kNN built up a vector contains all possible Ks those closest to the previous known locations built database according to root mean square errors principle, then taking the averaging uses the online RSS to obtain an estimated location via weighted kNN or unweighted kNN. In this approach, k is the parameter adapted for better performance.

2) Neural Networks: During the offline stage, appropriate weights are obtained through training of neural networks which is done by adopte RSS and the corresponding location coordinates as the inputs and the targets. Then multiply the

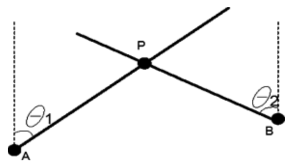

Figure 7 Positioning based on AOA measurement.

input vector of signal strengths by the trained input weight matrix, followed by the transfer function of the hidden layer neuron. The output of the system is a two-element vector or a three-element vector, which means the 2-D or 3-D of the estimated location.

3) SVM: The theory of SVM is found in [70] and [71]. it is a new tool for statistical analysis and machine learning, and promising technique for data classification and regression. A wide range of applications in science, medicine, and engineering are adopted with SVMs results in excellent empirical performance [72], [73], where in location fingerprinting Support vector classification (SVC) and support vector regression (SVR) are used [74], [75].

4) SMP: use each signal transmitter to search for candidate locations in signal space. Then choose at least one candidate from each transmitter to construct M-vertex polygons. Finally it estimates the target location by averaging the coordinates of vertices of the smallest polygon. MP has been used in

MultiLoc [76].

C. Proximity

This technique is one of the simple algorithms to implement and already in use today. Where locate a mobile target is done with respect to a well-known dense grid of antennas. A mobile target is considered to be collocated with the antenna that receives the strongest signal from it. One of the most particular example is the cell identification (Cell-ID) or cell of origin (COO) method where finding out a mobile by which cell site it is using at a given time. Other examples: the systems using infrared radiation (IR) and radio frequency identification (RFID) are often based on this method. In RFID systems, RFID scanners are installed to cover all the area, the presence of the object in a one scanner area is used to determine the location of the object.

VI. Some positioning techniques' drawbacks

In this section, we try to determine current the positioning techniques' drawbacks in view of indoor wireless positioning.

A. AOA, RSS, *TOA*, and *TDOA*

In triangulation technique, the target position is predicted by using the geometric properties of triangles. As we have seen in previous section triangulation technique is divided into two categories: alteration and angulation. the simplest techniques are AOA and RSS, where simply their measurements are obtained and used, but the main drawback of them is that a dense network of receivers are required to get high accuracy. Thus, while TOA a precise temporal synchronization and training between the transmitter and receiver are needed to get so; TOA tends to perform better compared to attenuation [77]. All the above techniques are quite accurate, but they are not always practical. TDOA measurements are very accurate, but they typically require a bandwidth-intensive cross correlation between receivers. To perform cross-correlation, centralization (retransmitting each received signal to a central location) of multiple copies of a signal are required by TDOA methods, this centralization wastes bandwidth and power. Because of that, TDOA is still too complex for implementation [78]. While the most advantage of TDOA that it does not need synchronization between Transmitter and receivers. In addition, TDOA and TOA schemes suffer from multipath effect, and need LOS channel between the transmitter and the receiver, in presence of these environments properties, the accuracy of location estimation could decreased for calculating distance within a building.

B. Cell-ID

Commonly, sensor based systems use proximity technique, where the place of an object is provided instead of the exact location. As a result, the precision of this technique is fairly low (in the range of 50- 200 m). So it is suitable for certain cases such as a mobile cell acquisition system or any systems alike, and it is not suitable for wireless device positioning in indoor environment, because of several reasons, the major problem is in frequently changing environments or in complex indoor environments, where changing the design of a manufacturing plant or moving walls in an office, need to remounting and rewiring of the RFID readers. Moreover, it does not provide efficient and precise results. Additionally, the cost of the system is very high if we would install sensors to cover all the building. In view of this, it is not useful to implement adaptive technique with proximity technique.

VII. CONCLUSION

In the next generation, smart cities require various types of context information of the environments, persons and devices to offer flexible and adaptive services in PNs. PN provides a private and user-centric solution by combining all user's personal devices at various places in different types of networks into one single network. One of the important context information is location context, which enables to design tracking, navigation; monitoring and other location-aware services for improve the quality of lives. In indoor environments the IPSs produce absolute, relative and proximity location information. In this paper, eight criteria, which include security and privacy, cost, performance, robustness, complexity, user preference, availability and limitations, have been proposed to evaluate and compare these IPSs from the view of users in PNs. the system architecture and working principles of 10 existing IPSs are classified into 6 categories are explained based on the main medium used to sense location, and observe some discussion of different performance measurement criteria with several tradeoffs among them. Then present some of the techniques used by IPSs to find out the position. However, the estimation process should not reliant on additional hardware or equipment. Combining some positioning technologies, Instead of using a single medium to estimate the locations of the targets, can improve the quality of positioning services. To improve the positioning accuracy here are some suggested trends are as follows:

1) Still, most of the systems are based on a single positioning technique, which has particular limitations. So as a research and practical topic, it is worth to find out how to extend the positioning range by internetworking different wireless positioning systems, combining of few positioning techniques, or mixing with other technologies such as optical (e.g., IR), inertial, dc electromagnetic and ultrasonic.

2) Since Sensors are used to detect events or changes in its environment, so deploying them in wireless positioning system is also worth considering.

3) Another promising area of research topic is how to integrate indoor and outdoor positioning system, it could help in developing more efficient and robust detection systems.

4) Mobility is one of challenge in IPSs, it could be future

research issue to be considered, especially the mobility of the located object and the mobility of people and equipment in indoor situations.

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