Overview of Positioning Techniques for LTE Technology

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***Abstract*—This paper explains about the capabilities of location positioning in wireless broadband communications and potential of hybrid positioning which are based on long term evolution (LTE) system. Mobile positioning technology has become a widely used in condition such as emergency and also in commercial services. Nowadays, with the presence of LTE technology there is a new mission on enabling Enhanced 911 (E911) and location-based services (LBS) on these 4G/5G networks. The positioning methods that were supported for LTE technology are Enhanced Cell ID (E-CID) method, Observed Time Difference of Arrival (OTDOA) and Global Navigation Satellite Systems (GNSS). A hybrid positioning system is a combination of such technologies and improves positioning accuracy by implementing the different mechanisms of the different technologies. In particular, this paper describes a concept and principle of each technique and explores important technical details of the location positioning techniques.**

***Index Terms*—Hybrid Positioning, Location Positioning Techniques, LTE.**

I. INTRODUCTION

Requirement in mobile services is increasing and one of the particular things is about Location Based Services (LBS), basically lead by primary necessities such as commercial applications and emergency services. In part of emergency services, the most important things is the implementing of the positioning in FCC's E911 mandate in the US, which requires location of emergency callers to be supported [1]. A lot of varieties for commercial applications need faster and accurate positioning performance such as mobile tracker and location-based advertising. In the generation of networks such as Wideband Code Division Multiple Access (WCDMA) and Global System for Mobile Communications (GSM) have added some improvement for some positioning technologies, which in terms in their accuracy and Time to First Fix (TTFF) performance is slightly different in return to these requirements. It involved and exists from simple network-based systems and also expands into multi-trilateration and satellite-based solutions.

The release of LTE which is more focusing on E911 on these 4G/5G networks will improve from previous generation. Three independent handsets based positioning techniques that support LTE standard is Assisted Global Navigation Satellite Systems (A-GNSS), Observed Time Difference of Arrival (OTDOA), and Enhanced Cell ID (E-CID). LTE Positioning Protocol (LPP) is a new protocol for LTE, although Secure User Plane Location (SUPL) version 2.0, remains as a headstone User Plane protocol which enabling LBS and emergency services on the networks, with some help from positioning techniques such as Wi-Fi positioning. Hence, although the price of the setup and deploy is extremely high, these latest positioning techniques provides effective and convenient positioning performance in form of LTE networks.

Some of methods which are available to locate the user positions is Enhanced Cell ID (E-CID), Assisted-Global Navigation Satellite System (A-GNSS) and Observed Time Difference on Arrival (OTDOA). By comparing their advantages and disadvantages for different kinds of services, it is suitable to choose one selection over another. All of these positioning methods depend on various aspects including required accuracy indicator such as locality (urban, rural and suburban) which will be discussed in this paper.

II. POSITIONING ARCHITECTURE FOR LTE

A. Positioning Architecture in LTE Networks

There are three main network elements in LTE positioning architecture which are location service (LCS) client, location service (LCS) server and location service (LCS) target. LCS server acts as an entity that handles positioning for a LCS target device which it also gather and collect some of the data of location information, helping the UE in determining the data when required and measure the LCS target location. LCS client involves software and hardware element that interacts with LCS server to get location data for LCS targets. LCS client performs an action which sending a request to the LCS server to achieve location data, the LCS server processes the request and transmit the positioning results, which the LCS client is estimate back by a velocity [2,3,4]. The two positioning protocol that operates using the radio network for LTE are LTE positioning protocol (LPP) and LPP Annex (LPPa).

LPP allows the positioning data exchange between the LTE network and UE. LPP is used to position the device and also point-to-point protocol for communication between an LCS server and an LCS target device. Both user plane and control plane can be used for LPP and multiple LPP procedures are allowed for reducing latency whether in series or in parallel. Communication protocol between an eNodeB and an LCS server for control-plane positioning is called LPPa which it can help user-plane positioning by querying eNodeBs for data and measurements. Transport for LPP is used by SUPL protocol in the user plane. Some protocols are already deployed in 2G and 3G networks such as radio resource control (RRC), radio resource location services protocol (RRLP) and IS-801 protocol which are similar function to LPP [3,4].

Evolved Serving Mobile Location Center (E-SMLC) is the key entity in the core network that handles positioning. The E-SMLC is in charge for providing of precise assistance information and calculation of location. 2G, 3G and 4G networks can be deployed by SUPL 2.0 to support one universal user plane protocol. It is possible to implement SUPL 2.0 with RRLP over LTE during initial LTE deployments, which helps in allowing user plane positioning before applying LPP. Call flows of LPP are procedure based, where each process has a specific objective. The main functions of LPP are to supplying the E-SMLC with the positioning capabilities of the UE in order to transport assistance data from the E-SMLC to the UE. It is also providing the E-SMLC with co-ordinate position information or UE measured signals and to report errors during the positioning session. Hybrid positioning such as OTDOA + A-GNSS can also be supported by LPP. E-SMLC may require data from the eNodeB (such as receive-transmit time difference measurements for assisting ECID) in case of network-based positioning techniques. LPPa is used to transport this information. There are two different possibilities for how the device (client) can communicate with the location server. There is the option to do this over the user plane (U-Plane), using a standard data connection, or over the control plane (C-Plane) [4,5]. Gateway Mobile Location Center (GMLC) is the connection for client LBS service application to the mobile network. GMLC sends requests for mobile location data to a Mobile Switching Center (MSC) and accepts the feedback of such requests.

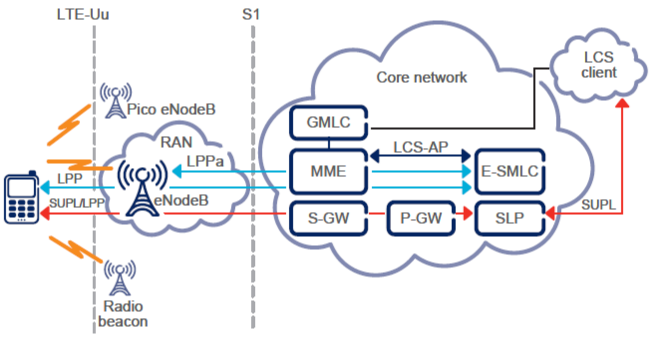

Figure 1: Positioning architecture in LTE release 9/10 [5].

B. *Control Plane Positioning*

Most commonly used in emergency services, positioning messages are exchanged between the network and the UE over the signaling connection with control plane implementations. Mobility Management Entity (MME) enabled the control plane positioning in LTE, which directs LPP messages from the E-SMLC to the UE using NAS Downlink Transfer Messages.

Control Plane positioning is quick, reliable and secure to overcome possible network congestion in an emergency scenario. C-Plane LBS sessions are the protocol used for LBS is established and assistance data message exchange is executed over the 'control' channels (LPP). The call flows of control plane can be characterized by three components which is Network Initiated Location Request (NILR), Mobile Terminated Location Request (MTLR), Mobile Originated Location Request (MOLR). NILR basically used for emergency positioning which the network orders the UE to provide a location, and may send unsolicited Assistance Data. MTLR start up by the network, which vary from NILR with some addition of privacy element where the user can deny the location request. MOLR is about the positioning session is triggered by the UE, which contacts the MME with the request. The rest of the call flow is identical with NILR. [2,3,4,5].

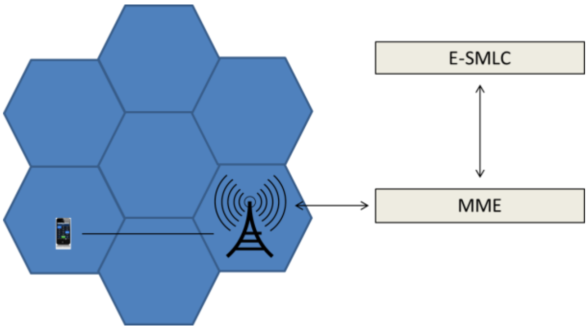

Figure 2: Control Plane Positioning

C. *User Plane Positioning*

User Plane Positioning of LTE uses the data link to send positioning information which is enabled by the Secure User Plane (SUPL) protocol. SUPL was developed to support LBS for wireless communications which is an encrypted IP technology. SUPL can be implemented to multiple wireless standards including LTE where SUPL 2.0 is commonly used for U-Plane LBS sessions [2]. For a newer version of SUPL, SUPL 2.0 provides a basic user plane medium for all air interfaces and supports positioning over LTE as well as 2G and 3G networks. SUPL use existing protocols such as RRLP, IS-801 and LPP, which does not introduce a new technique to package and transport Assistance Data. SUPL Location Platform (SLP) enabled the data link to transmit positioning information. SUPL is basically able to interface with the E-SMLC for obtaining Assistance Data and also operates SUPL messaging. LTE P-GW and the S-GW elements routed SUPL messages over the data link. A complex feature set that is compatible to mobile applications enables by SUPL 2.0 which is including area based triggering, periodic reporting and batch reporting. SUPL 2.0 also support for major positioning technologies (including multi-location technologies such as Wi-Fi positioning) and also for emergency positioning over the data link [3,4].

Underlying control plane protocol (such as RRLP or LPP) is the primary positioning enabler in SUPL 2.0. This states that SUPL 2.0 can be used over any network, as long as the SLP and SMLC are agree upon a common positioning protocol and also able to interface. During initial LTE rollouts this flexibility is very useful, as it allows operators to enable SUPL 2.0 positioning over an existing control plane protocol such as RRLP [4,5,7] .

III. TYPES OF POSITIONING TECHNIQUES FOR LTE

A. *Enhanced Cell ID (E-CID)*

In this method, the serving cell identifier (Cell-ID) is implemented to track down the mobile (user) location. Many LBS applications provide the location of the user by simply determining which base station (or sector) the user is currently connected to. All GSM handsets supported basic form of location tracking that involves cell identifier [8]. In every site's geographic position has its own ID/Mac address which based on data to be used for cell id. The handset's exact geographic area is known when someone obtains the location of this specific id or address the handset is connected to. GSM network cells sometimes have wide coverage and the location is uncertain due to that factor [9].

This method accuracy is basically compatible with cell size or more specifically sector size, though the use of directional antennas can improve location accuracy. The cell size has difference in terms of population density which being very small for location of dense urban areas and much larger for location of remote rural areas. The smallest size may be between 200 meters and 1 kilometer whilst in the remote rural areas a cell may be 35-100 km [8]. The accuracy for this particular method relies upon the radius of the cell [8,10].

A network-based location technology which is an improvement of Cell-ID is called Enhanced Cell ID (E-CID). This technique calculates the distance between a mobile device and an evolved NodeB (eNB) by measuring the Round Trip Time (RTT) of a signal. This method was introduced by the 3GPP as an Evolved Universal Terrestrial Radio Access (E-UTRA) Release 9 feature [2]. Some information and data based on the serving cell and the power level is collected by mobile terminal. Improvement to the E-CID technique which further enhances accuracy is Calibrated E-CID and RF Pattern Matching (RFPM) [11]. E-CID is now compatible with LTE where purposely for devices that have no GNSS receiver has been combined. By using data of the geographical coordinates from serving base station, the location of the device more accurate by undergo measurements involves radio signals.

ECID is based on the acquisition of (RxTx) measurements. This measurement is defined in 3GPP specification TS 36.214 [12]. The process can be defined in three steps. The eNB measures the RTT of a message transmitted by itself as in (1).

$$eNBRx - Tx = T_{eNBRx} - T_{eNBTx} \tag{1}$$

The eNB sends a Timing Advance (TA) command to the mobile device to correct its uplink timing. The User Equipment (UE) measures and reports its RTT as in (2).

$$UERx - Tx = T_{UERx} - T_{UETx} \tag{2}$$

Some advantages of baseline E-CID is low price, accurate for locating and easy to develop. Furthermore, no improvement to devices and it is also easily working with all types of phones. E-CID is restricted and also limited in terms of precision and not have a constant performance. E-CID can be caused by various external effects due to the attribute of power propagation, which involve surroundings such as foliage or precipitation, altitude above ground level or motion. E-CID also needs a complete and accurate database of antenna locations and characteristics for the cell site which make the mobile operators to provide a precise and timely data [11].

B. Assisted Global Navigation Satellite Systems (A-GNSS)

GNSS involves with many types of satellite systems such as United States Global Positioning System (GPS), Russian GLONASS, European Union (Galileo) and China (BeiDou). GNSS receiver in user mobile devices is functions to obtain satellite signals and figuring out its position with only standalone GNSS. The process of receiving the data can be difficult due to capacity of battery and processing performance, and the TTFF can take longer to respond. Assisted GNSS can enhance the performance of standalone GNSS with some improvement in certain features. When A-GNSS constructed and deployed, data provided by the network was developed by the standalone GNSS equipment of the phone, called as "Assistance Data", which allow information of the user GNSS receiver can use to speed up the process of satellite signal transmit and receive. Network or User Equipment (UE) can be distributed and shared among third parties (such as emergency PSAPs) to measure the final position of user.

A-GNSS increases positioning operation, enhances sensitivity of receiver and assist to sustain the usage of battery power. A-GNSS functions perfectly in condition such as outdoors which have a clear view of the sky is available. The disadvantages are it works badly in conditions with high obstacle and multipath which is indoors and in dense urban conditions [5]. Some of the main commercial satellite navigation systems are United States GPS, Russian GLONASS and European Union GALILEO. Some new programs of navigation system have been introduced into the market, like Chinese BeiDou and Japanese QZSS [15]. It is possible to utilize both satellite systems simultaneously to locate a position even though mobile receivers have basically supported positioning by deploying A-GPS alone. A-GNSS advantages are to enhance the number of satellites available for signal measurement, and enhance performance in high-obstacle conditions like metropolitan area. LTE network can support assistance data for both type of GNSS such as GPS and GLONASS satellites and also Galileo and QZSS [5].

Assisted-GPS (A-GPS) can become a solution to solve the choices of user requirement and achieve some expectation which demanded by certain organizations. Nowadays, new mobile devices are provided with GPS receivers, different devices that lacks of the receivers continue in use and providing GPS-capable handsets for free to subscribers which does not figure out the problem either, as there is no single positioning method including GPS works greatly in all types of environments. GPS is unable to provide a reasonable degree of positioning accuracy in condition of indoor and urban canyon surroundings. Nowadays, the usage of mobile phone calls are made from indoor is more than 50%, there is a huge demand for positioning methods that can support the accuracy in all conditions [4].

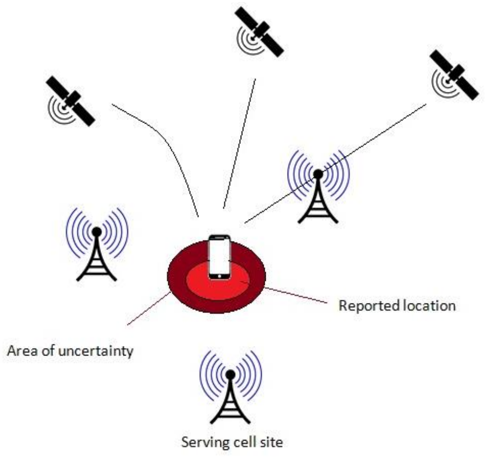

Figure 3: Example of Assisted-GPS illustration

Pseudo-range is a measurement of the range between the satellite and receiver when multiplying by the speed of propagation of the signal in order to evaluate the time between the transmission of a signal by the satellite and its reception [16, 17]. The distance between the transmitter and the receiver using Earth-centered Earth-fixed (ECEF) coordinates can be written as:

$$\rho_{true} = \overline{TxRx} = \sqrt{(x_{tx}-x_{rx})^2+(y_{tx}-y_{rx})^2+(z_{tx}-z_{rx})^2} \tag{3}$$

Measurement of the true range contaminated by the clock biases from transmitter and receiver [18]:

$$\rho = \rho_{true} + c \cdot \tau_{rx} - c \cdot \tau_{tx} + v \tag{4}$$

Where τ_{rx} and τ_{tx} are the clock biases from transmitter and receiver, and v stands for other errors associated with the measurement.

C. Observed Time Difference of Arrival (OTDOA)

The Time Difference of Arrival (TDOA) method considers that a transmitted signal from the mobile devices at the three BSs can determine a location of points on a hyperbola and mobile devices situated at the overlap point which has three hyperbolas or more [14]. In this technique, mobile device measures the Reference Signal Time Difference (RSTD) between several eNBs and reports these time differences to a specific device in the network called ESMLC. ESMLC based on these time differences and the location of eNodeBs calculates the mobile’s location [3]. Although a mobile phone is associated with one base station at certain period of time, it is constantly trading data with another nearby base stations. This permits it to be distributed over efficiently if and when it withdraws from the current cell broadcasting location. Device relative distance from each cell can be measured when measuring in terms of time different in the reception of a transmitted signal at three various cell. A pair of downlink transmissions draw a line of uniform difference (a hyperbola) along which the UE position located for each OTDOA calculation. The crossover of these lines which requires at least two pairs of Node-base station which specified the UE's position. The accuracy of the timing calculation relies upon the accuracy of the position approximates with this technique; the involvement of relative position of the Node-Base station and is also an element to the results of multipath radio propagation [10, 11].

The OTDOA geolocation technique was first officially defined in the 3GPP TS 36.355 Release 9 which contains one of LPP techniques [19]. The mobile phone does not require specific hardware assistance in terms of hardware or software. In order to implement OTDOA in a GSM network, a huge hardware investment by the network operator is needed. This is due to GSM BS are not synchronized with one another and it is cannot be completed without extra hardware, to measure the relative times at which signals are obtained at the base stations. Additional network features that simply transmit a beacon signal from immobile known locations are needed to figure this problem. Location Measurement Units (LMUs) is the beacon transmitters and effectively permit base stations to synchronize with each other. OTDOA isn't a particularly a choice technology for GSM networks due to the requirement of LMUs and mobile devices is not located in between the range of three base stations. It is capable to detect the location in an accuracy of between 50 and 200 meters in theory. With OTDOA, the devices calculate its location by implementation of TOA downlink signals obtained from many base stations. Positioning Reference Signals (PRS) in LTE network are transmitted to improve the number of base stations eNB from which downlink signals can be obtained by the devices. This improves precision of the location. A central server functions to support assistance data which acquire PRS for the handset and pass on additional data to help the handset examine the transmitting antenna [7, 11].

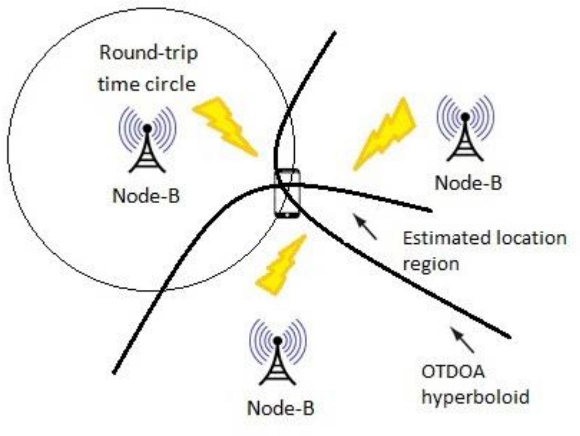

Figure 4: Example of OTDOA illustration

OTDOA is a hyperbolic system based on the difference in time arrival of two signals. The time difference allows locate the receiver on a curve call hyperbola, which follows the equation[20]:

$$\overline{WBS_2} - \overline{WBS_1} = K \tag{5}$$

where K represents a constant value and $\overline{WBS_i}$ is the distance between the receivers located in W and the Base Station i. To simplify the notation, this will be denoted as d_i:

$$d_2 - d_1 = K \tag{6}$$

which $d_i = \sqrt{(x-x_i)^2 + (y-y_i)^2 + (z-z_i)^2}$. The constant value *K* is multiple of the time delay (TD) which is the value of the receiver should measure and report. If υ_p stands for propagation speed, then *K* can be defined as:

$$K = TD \cdot \upsilon_p + e_{TD}, \tag{7}$$

Where e_{TD} represents the error associated to the time delay measurement.

From this, OTDOA measurement can be used to form equations as (5), which *W* is the position of mobile devices, BS_2 is the neighbor cell, BS_1 is the reference cell and *K* is related to the RSTD measurement. By taking consideration of adding time errors at the transmitter and the receiver, τ_{tx} and τ_{rx}:

$$\begin{aligned} RSTD_n[s] = (t_{Rx,PRSn}[s] - \tau_{Rx} - \tau_{Tx,n} - \\ (t_{Rx,PRSref}[s] - \tau_{Rx} - \tau_{Tx,ref})), \end{aligned} \tag{8}$$

Where $t_{Rx,PRSn}$ is the reception time for PRS signal of the neighbor *n*. The equation of the time error of the receiver of the mobile devices will cancels out and the equation will be written as:

$$RSTD_n[s] = RSTD_{n,true} - \tau_{Tx,n} + \tau_{Tx,ref}, \tag{9}$$

Where Eq. (8) plug into Eq. (6) become:

$$K = (RSTD_{n,true} - \tau_{Tx,n} + \tau_{Tx,ref}) \cdot \upsilon_p + e_{RSTD} \tag{10}$$

Where $RSTD_{n,true}$ represents the real RSTD value without timing errors and υ_p equals the speed of light. Replacing the extent of the hyperbola equation and the PBSI range between the receiver, *P*, and the base station *i*, the range can been defined OTDOA as:

$$\begin{aligned} P_{otdoa} &= RSTD_{n,true} \cdot c - \tau_{TX,n} \cdot c + \tau_{TX,ref} \cdot c + e_{RSTD} \\ &= RSTD_{n,true} \cdot c + \upsilon_{RSTD} \\ &= \sqrt{(x-x_n)^2 + (y-y_n)^2 + (z-z_n)^2} - \sqrt{(x-x_{ref})^2 + (y-y_{ref})^2 + (z-z_{ref})^2} \end{aligned} \tag{11}$$

Where υ_{RSTD} represents all the errors associated with the RSTD measurement that includes clock errors form base station and is modelled as Gaussian random process.

D. RF Fingerprinting

Fingerprinting is a type of positioning technique that implemented specifically geographical maps of radio properties for purpose of positioning. E-SMLC receives the radio properties measured by UE. The E - SMLC then examined for a best combination of the measured radio properties sent by the UE and between its stored geographical maps of radio properties. The UE position determines by the best match. Fingerprinting positioning is prepared for the LTE positioning standard and enables for signaling of CIDs, signal strengths, time arrival, and angle of arrival along with OTDOA and A-GPS/A-GNSS measurements between eNodeB, UE and the E - SMLC. LPP and LPPa protocols can carry over the information. RF fingerprinting or RF pattern matching is denoted the most common technique for fingerprinting. The UE measurements of received signal strength would exploit from a number of eNodeBs in LTE. Advanced radio signal strength prediction software can created the geographical RF maps, using very specified information of the 3-D geographical topology together with precise data of the cell plan, tower locations, tower heights, antenna directions, antenna tilting, antenna patterns, and transmission power. Prediction software may need to be complemented with surveying in order to achieve a good accuracy. Another method would be to depend fully on surveying, which, however, would be very expensive even for normally sized cellular networks since the positioning accuracy will always be limited by the density of the geographical grid of the RF map [21].

IV. PERFORMANCE PARAMETERS FOR POSITIONING

From the perspective of positioning, the determination of user's location can be determined as a simple mechanism consisting in measuring the geographic positions of the user. However, in order to obtain the exact location of a user is extremely difficult which in most of the cases regarding the position of the user and their environments. The performance parameters need to be suitable with the user requirements in order to find a match positioning technology for a certain application [22-28].

A. Accuracy

The accuracy of a system is a major component for user requirement which should be mentioned in any details of an application. The term of accuracy has been explained as the closeness of agreement between a measured quantity value and true quantity value of a measured. Basically, performance metric is implementing mean distance error which is average Euclidean distance between true and estimated location. Positioning system by considering the accuracy can indicates for a better the system. Some drawbacks from this parameter which will compromise between other characteristic that relates to obtain the suitable accuracy.

B. Coverage

Coverage is about the spatial extension where system performance must be achieved by a positioning system. Some of the categories which include local coverage which is small and limited area, scalable coverage which is a systems that can improve the area by inserting hardware (through deployment of sensors) and global coverage which contains worldwide or specified area of system performance (GNSS). Coverage area for positioning method must be correlates to the area in which the location service is potentially exist.

C. Integrity

Integrity corresponds to the output of a system. Probability that is not responding in the system result in to an estimated position that contradict from the desired position by more than sufficient amount and the user is not knowledgeable within the required period of time is called integrity risk. Integrity performance parameters have been studied by regulatory bodies in some division such as civil aviation, however, in other category, including those related to indoor navigation it is more challenging to obtain quantified integrity parameters. The integrity parameter is usually not specified in academic research papers which involve indoor/outdoor positioning approaches.

D. Availability

Availability is about percentage of time during which the positioning service is available in the coverage area and provides with the required accuracy and integrity performance. Availability parameter may be limited by random causes such as failures or communications congestion as well as by scheduled factors which is routine maintenance. Basically the following three levels could be distinguished, although it will rely upon certain applications, for low availability the condition is below 95%, for regular availability is more than 99% and high availability is higher than 99.9%.

It is assumed that continuity, accuracy and integrity requirements are fulfilled in order to achieve availability. Specification of availability usually contains in application descriptions, whereas availability figure does not specify by system developers. Availability usually affects the characteristics of accuracy which relies upon

E. Continuity

The continuity is the feature of constant operation of the system over a connected period of time to undergo a particular function. The frequencies of acceptable outages should be given. The continuity requirement is usually quite alike with availability [18].

F. Update Rate

The frequency which the positions are measured on the device or at an external processing facility are called update rate. Some of the types of measurements rates that exist are periodic, on request and on event. For periodic, it has regular update and also specified in an interval. While on request, it is controlled by a remote device or triggered by the user. In condition of on event, the local device initiated measurement update when a particular event happens.

G. System Latency

It is about the delay which contains the requested data that is available to the user. Latency stands for the duration of time between the position request and the provision of the location estimate and basically it is expressed in seconds. The latency contains the following types which are real time and post processing. Real time system is important in navigation and almost all indoor positioning application. It is also become most demanding latency requirement. For post processing, there is no specific time of delivery.

H. Data Output

Others than times and positions, a set of spatio-temporal data measurement may be requested, many of these can be completed without slightly enhancing the data capture or storage requisite. The following types of data are required in some of the applications such as velocity/speed acceleration, bearing/heading and also estimated position. The requirements parameters should slightly mention if the direction of a mobile object is required. There are some applications that need the full spatial orientation, for example in form of values for 6 Degrees of Freedom.

I. Precision

Accuracy only considers the value of mean distance errors. However, location precision considers how consistently the system works, as it is a measure of the robustness of the positioning technique as it reveals the variation in its performance over many trials. Standard deviation in the location error or the geometric dilution of precision (GDOP) is define as the location precision by some literatures, but it is consider as the distribution of distance error between the estimated location and the true location.

When comparing the two positioning techniques, if both accuracies are the same, it is prefer to look for the system with the CDF graph, which reaches high probability values faster, because its distance error is concentrated in small values. In practice, percentile format is being used for CDF. For example, if a system has a location precision of 90% within 2.3 m (the CDF of distance error of 2.3 m is 0.9), and 95% within 3.5 m; another one has a precision of 50% within 2.3 m and 95% within 3.5 m. Based on that, the former system is chosen because of its higher precision.

J. Complexity

Complexity of positioning system depends on several factors such as hardware, operation factors and software. Considering the software complexity, the computing becomes more complex for the positioning algorithm. If the computation of the positioning algorithm is undergo on a server side, the positioning could be measured quickly due to the powerful processing capabilities and the conditions of power supply. If it is performed on the mobile unit, the effects of complexity could be less performed. Most of the mobile units contain low processing power and long battery life; hence it is prefer positioning algorithms with low complexity. Usually to derive the analytic complexity formula of different positioning techniques is difficult, thus, the computing time need to be considered. Location rate is one of important indicator for complexity. The dual of location rate is location lag, which is a delay between a mobile target moving to a new position and reporting the new position of that target by the system.

K. Robustness

Positioning technique with higher robustness could function normally even when some signals are distorted, or when some of the RSS value are not the same like before. Sometimes, the signal cannot be obtained from some measuring units due to the signal from a transmitter unit is totally blocked. The signal from other measuring units is the only information to estimate the position. Sometimes, some measuring units could be out of function or damaged in a harsh environment hence, the incomplete information need to be used to compute the location.

L. Scalability

The scalability character of a system ensures the normal positioning function when the positioning scope gets large. Usually, the positioning performance degrades when the distance between the transmitter and receiver increases. A location system may need to scale on two axes which is geography and density. The area or volume is covered is called geographic scale. The number of units located per unit geographic area/space per time period defined for density scale. Wireless signal channels may become congested, more calculation may be needed to undergo location positioning, or more communication infrastructure may be required as more area/space is covered or units are crowded in an area/space. Dimensional space of the system is another measure of scalability. The current system can detect the objects in 2-D or 3-D space while some systems can support both spaces.

M. Cost

The cost of a positioning system relies on many factors such as money, time, space, weight, and energy. Time factor is related to installation and maintenance. Mobile units may have limited space and weight constraints. Measuring unit density is considered to be a space cost. Sometimes, sunk costs also need to be considered. For example, if all the necessary units of that network have already been purchased for other purposes hence the positioning system layered over a wireless network may be considered to have no hardware cost. The important cost factor of a system is cost. Some mobile units which contains electronic article surveillance (EAS) tags and passive RFID tags are completely energy passive. These units only react to external fields and could have an unlimited lifetime. Other mobile units which are devices with rechargeable battery have a lifetime of several hours without recharging.

V. COMPARISON OF LTE POSITIONING TECHNIQUES

The first step is to examine the important of each method with respect to mobile user requirement for setting a decision rule among the available choices. Even though the demand for location based services will growing, the restricted network and mobile devices resources should be treated among all common services. It is reasonable at some time to spend huge assets to precise positioning, while at same times locating the user in range of an urban cell may enough. The table below symbolizes the differences for various types of methods [5, 9, 11].

Table 1
Comparison Of LTE Positioning Techniques

Technology	***Accuracy***	***Yield***	***Advantages***	***Drawbacks***
Cell-ID	Low	High	Inexpensive, reliable and works with any phone	Very poor accuracy
Enhanced Cell-ID	Medium (Urban and sub-urban) Low (Rural)	High	Relatively inexpensive and works with any phone	Variable accuracy, operator dependency and requires calibration for optimal accuracy
GPS	High	Medium(Rural and Suburban) Low (urban and indoor)	Accurate and widely deployed	Poor yield in urban and indoor environment
A-GNSS	High	Medium(Rural and Suburban)	Very accurate synchronization of the satellites by atomic clocks and 3 dimensional positioning [5]	Line of sight (LOS) access as normal case, not suitable for urban / indoor areas[5]
OTDOA	Medium (Urban and sub-urban) Low (Rural)	Medium	Easy to implement and low cost	Requires synchronized network and operator dependency.
RF Fingerprint	Medium	Medium	Low cost and provides confidentiality of the transmitted messages.	Require high number of signals parameter

The FCC has determined selected targets which telephone companies have to achieve and penalty fee have to pay if do not complete these goals. E-911 have been added with various kinds of accuracy and precision value for instance, the service provider must be able to track a user in a range of an accuracy 100m and a precision of 67% or in a range of 300m and a precision of 90% which means that if a person calls 911 with mobile devices [4], the service provider send the data about the location user to the Public Safety Access Point (PSAP) that differs maximum in 100m from the real position on 67% of the calls [20].

Tables 2, 3 and 4 give some overview regarding the accuracy and precision of some positioning techniques that involves in LTE in conditions of rural, suburban and urban as in [15]. The minuses from the tables mean that it was not possible to find reliable values to fill in. The data must be mentioned that the values from the tables symbolize measurement in selected conditions. It cannot be taken as valid for every status since it relies on the conditions and the conditions are not static but can be used as a benchmark or guideline. The precision functions as the reliability towards the positioning techniques [5, 9, 14].

From all of the types of positioning techniques, the propose solution for enhancing and improving accuracy can be made by A-GNSS, which is able to measure the accurate positions with the presence of four satellites, if less than four satellites are present, A-GNSS can be combined with another positioning techniques which is OTDOA or/and E-CID in order to obtain the targeted accuracy. OTDOA and E-CID without GNSS are suits for measuring two-dimensional positions.

Table 2
Accuracy and Precision for Rural Conditions

Type	**Accuracy**	**Precision**
Cell ID	1746m	95%
Cell ID + Timing Advance	500m-10km	-
Cell ID + Timing Advance + Received Signal Strength	250m-35km	50-550m
OTDOA	27m	95%
A-GNSS	10m-15m	-

Table 3
Accuracy and precision for suburban conditions

Type	**Accuracy**	**Precision**
Cell ID	1870m	95%
Cell ID + Timing Advance	500m-1.5km	-
TDOA	1956m	95%
OTDOA	27m	95%
A-GNSS	10m-15m	-

Table 4
Accuracy and Precision for Urban Areas

Type	**Accuracy**	**Precision**
Cell ID	526m	95%
Cell ID + Timing Advance	80m-800m	-
TDOA	<50m	-
OTDOA	97m	67%
A-GNSS	15m-100m	-

VI. CONCLUSION

This paper describes about various methods for tracking a user mobile which implemented in LTE and also the performance parameter that require for positioning. Each types of positioning have advantages and drawbacks that suits according to the conditions. Exchange happens between performance and other factors. The best solution in most of all cases involves a combination of various location positioning (hybrid positioning) designed to suit the requirement for the LTE system and to achieve a better accuracy for positioning.

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