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LOCALIZATION DETERMINATION FOR RADIO COMMUNICATION USING TDOA TECHNIQUE

ABDUL HADI RAMLI[1] , NOR FADZILLAH ABDULLAH, MAHAMOD ISMAIL, ROSDIADEE NORDIN,

Dept. of Electrical, Electronic and System Engineering,

Universiti Kebangsaan Malaysia, 43600, UKM Bangi, Selangor, MALAYSIA

E-mail: hadira73@gmail.com,{fadzilah. abdullah, mahamod, adee}@ukm.edu.my

ABSTRACT

Localization for communication radio very important for commercial or military especially for search and rescue response, military intelligence and commercial service during national disaster incident for the past and future years. This paper mainly works on analyzing constrained optimization approach to determine localization hybrid technique bearing approach Frequency Difference of Arrival (FDOA) and Time Difference of Arrival (TDOA) to detect any targeting by sensor in each static surveillance station. Basically, FDOA and TDOA method for detection any signal processing measurement data required solve for the emitter's location and target whether static or movement**.** Localization of an emitter using in civilian applications, government, industrial aerospace or commercial and military missions depends on locating platforms measure the electromagnetic spectrum and extracted signals for processed and analyse to the target's location**.** Emitter Localization using TDOA is a classified into a long-range and short-range distance depends on techniques and location of all the transmitters near the target by radio frequencies. The techniques of localization correspond to the range radio transmitter and receiver whether approach of FODA or TDOA by pair to of a sensors or receivers and the emitter location on the hyperbola corresponding to this range influence by technology and network architecture utilized. Localization in this paper to how measurement within some local coordinate system or by latitude and longitude on the Earth's surface which uses the time of arrival of signals where the radio communication whether transmitter and receiver within distance by kilometres. This localization method for detect any target by radio communication both Malaysian Peninsular and Malaysian East and have been used to simulate model with fixed input parameters. Then we proceed analyse data to gain estimation of target observed depend on distance and hearbility accuracy and CDF plot can shows the performance of localization by TDOA of Matlab simulation results were presented.

Keywords: *TDOA, FDOA, Emitter Location, Location Fix, Deployment Scenario, Correlation, Time Synchronization, DDC.*

1. INTRODUCTION

Presently, there are many different technologies used in position detection. But, as signal receiver operating in different locations is used to detect precise positions of objects located at long distances, it is hard to know when an object's or users terminal devices send a signal. The passive location of both hostile and friendly electromagnetic emitters has been an important capability for the war-fighter, for law enforcement and in search and rescue operations. The characteristics of an emitted signal once received by several sensors in an operating environment can be exploited to passively locate an emitter. According to [1], the active or passive location of both hostile and friendly electromagnetic emitters has been important localization. The characteristics [2] of an emitted signal once received by several sensors in an operating environment or strategic location. Two of the characteristics that can be measured by separate receivers of such signal are: [3] the differences in Doppler shifts (if any) in the signal's frequency and [4] the difference in the time that the signal arrived at the sensors. In this case, the technology using the for measurement is Time of Arrival (TOA) is impossibly unreliable, Frequency Difference of Arrival (FDOA) and the Time Difference of Arrival (TDOA) technology is a more suitable option. The sensors are tuned to the signal of one of these emitters, snap shot of the received signal is captured simultaneously and in time synchronism by all the sensors. Since the arrival time at each sensor is going to be different one can measure this TDOA by suitable digital signal processing. TDOA of a radio signal measured at three or more receiver sites can be used to locate the position of an RF transmitter (emitter). The system comprises of number of sensor receivers geographically separated over a distance whose locations are known and are interconnected through data communication links for transfer of received signal snap shot (SS) data. The snap The snap shot data is collected at each sensor with highly accurate time synchronization. One of these sensors is designated as reference station for obtaining the TDOA with respect to other sensor stations. In the following paragraphs dual band TDOA based emitter location system is described. The design of sensor unit covers for multiple RF bands out of which two signals belonging to two different bands can be simultaneously captured. In the past, the measurement of such quantities in the tactical and strategic environment has been difficult due to their sensitivities to timing errors between any at least two or more sensors. Further, when trying to use this measurement for the geolocation or localization by emitter, errors in sensor's own location and velocity measurements compound with the signal processing errors to provide unreliable emitter fixes. Data from the localization judgments were then compared with the findings from the acoustical measurements of time and intensity. Three sets of measurements were carried out, using the head as an acoustical obstacle, (6) interaural time differences and (7) inter-aural intensity differences were obtained at several frequencies over a wide range of azimuth positions. Several systematic trends were found and compared with results of the study. The remaining section of this paper is structured as follows. In section 2, we review briefly on the relevant localization technology by radio frequency. In section 3, time difference of arrival technology techniques will be discussed. Next the model of the localization approximation will be explained in section 4. The simulation development and concept of methodology analysis that has been done to evaluate the accuracy and error localization will be discussed in section 5. Lastly, in section 6 this paper end with conclusion.

2. LOCALIZATION TECHNIQUES

Basically, Radio Direction Finder (RDF) system can be used in search and rescue operations. However, the existing RDF system is complex, expensive and not suitable for mobile operation such as search and rescue operations [8]. This system usually used to locate source of interference, locate non-authorized transmission or locate any known transmission in search and rescue operations. Knowing the direction to, or even better, the position of an adversary in a tactical situation is advantageous. In our line of work this means localizing a transmitter. HF direction finders are either costly, semi-permanent installations or simple, manually operated devices, whereas a front-line tactical system needs to be easy-to-deployed, low-cost and non-manual operation-wise. HF direction finders are either costly, semi-permanent installations or simple, manually operated devices, whereas a front-line tactical system needs to be easy-to-deployed, low-cost and non-manual operation-wise. The herein presented direction finder has the potential of complying with those requirements. One way to find the direction to a transmitter is to use an antenna with a distinctive directivity pattern. A small loop antenna, for example, is turned until the incoming signal disappears, whereby the antenna's lobe minimum will point in the direction of the signal source. Another method is to use several antenna elements with lobe maxima in a circular pattern, and conclude that the signal source comes within the angular sector covered by the antenna element with the strongest signal level. It is possible to approximate the direction of arrival of an incoming signal by using two antennas with a distinctive and known directivity pointing in different directions.

2.1 Purpose Of Localization Techniques

Localization application purpose for TDOA is a method does not require the time that the signal was sent from the target, only the time signal was received and the speed the signal travels. The traditional TDOA localisation techniques allowing merging TDOA measurement from synchronous and non-synchronous receivers [13]. Emitter localization using TDOA is a system that enables one to find the location of all the transmitters in the surroundings communicating with the frequencies of HF Band. Localization of mobile users is very important feature that has been used to determine the range between the two radio receivers' direction finding and using as follows:

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- Surveillance and Monitoring Radio Network
- Search Jammer Source
- Location Finder.
- Radio Astronomi.
- Military Intelligence.
- Search and Rescue.

2.2 Ranging Techniques

Ranging Techniques is an important technique used in range-based localization are received signal based on method as Received Signal Strength Indication (RSSI), Angle of Arrival (AOA), Frequency Difference of Arrival (FDOA), Time of Arrival (TOA) and Time Difference of Arrival (TDOA).

2.3. Received Signal Strength Indication (RSSI)

RSSI can measured signal strength with many devices depends power level being received by the receiving radio after the antenna and possible cable loss and another factor as below:

- Signal Decay with Distances.
- Many devices measure signal strength with received signal strength indicator (RSSI).
- In free space, RSS degrades with square of distance.
- Expressed by Friis transmission equation
  $Pr/Pt = Gt/Gr\ (\lambda\ 2/\ (4\pi)\ 2\ R2)$
- Actual attenuation depends on multipath propagation effects, reflections, noise, etc.

2.4 Angle Of Arrival (Aoa)

The angle of arrival (AOA) positioning method has not been applied to short-range location to the extent of RSS and TOF. A method has been developed to determine the angle of arrival (AoA) of incident radiation using precomputed lookup tables [14]. The phase difference between two receiving antennas can be used to infer AoA as measured from the pair baseline, but there will be more than one possible solution for antenna spacings greater than or equal to half a wavelength. Larger spacings are preferable to minimize mutual coupling of elements in the receive array and to decrease the relative uncertainty in measured phase difference [15].

Angle of arrival is equal to: $\theta_{arrive} = 180°$ - sum (angle to zeros) + sum (angle to poles).

2.5 Frequency Difference Of Arrival (FDOA)

Frequency difference of arrival (FDOA) or differential Doppler (DD), is a technique analogous to TDOA for estimating the location of a radio emitter based on observations from other points. This relative motion results in different doppler shifts observations of the emitter at each location in general. Estimates for the time difference and frequency difference of signal arrivals are used. Frequency difference of arrival (FDOA) is estimated through the use of a mixing product. Standard regression analysis procedures are then applied to estimate the slope of the unwrapped phase angle. The problem of moving source localization by introducing an additional Doppler frequency shift (DFS) measurement into the previous location system using time differences of arrival (TDOAs) and frequency differences of arrival (FDOAs) [16]. Because of the separation of associated data channels and the difference in the estimation techniques, the DFS is independent of TDOA and FDOA measurements.

The Cramer-Rao lower bound (CRLB) analysis shows that introducing DFS can improve source localization accuracy comparing with that of the TDOA and FDOA localization system, especially for the velocity location accuracy. An improved two-step weighted least-squares (I-TSWLS) source localization method utilizing DFS as well as TDOA and FDOA is developed. Based on the time differences of arrival (TDOA) and frequency differences of arrival (FDOA) measurements of the given planar stationary radiation source, the joint TDOA/FDOA location algorithm which solves the location of the target directly is proposed. Compared with weighted least squares (WLS) methods, the proposed algorithm is also suitable for well-posed conditions, and gets rid of the dependence on the constraints of Earth's surface [17].

In recent years, TDOA and FDOA have received much attention due to the possibility of better estimation performance. TDOA/FDOA localization generally consists of two parts. First, we need to estimate the TDOA and FDOA of the intercepted signals. Then this information is used via solving the appropriate set of nonlinear equations. Let r1(t) and r2(t) be intercepted signals at two moving sensors located far apart from each other. The signals are time-shifted and frequency-shifted from a radiated signal of an unknown emitter s(t) and given by [18]. Formula as follows:

$$r1(t) = s(t - \tau 1)ej2\pi v1t + n1(t),\ 0 \le t \quad [1]$$
$$r2(t) = s(t - \tau 2)ej2\pi v2t + n2(t),\ 0 \le t \quad [2]$$

2.6 Time Difference Of Arrival (TDOA)

Time-difference-of-arrival (TDOA) estimation of signal impinging on two spatially separated sensors is an important method for passive location [19]. To improve algorithm performance, the cyclostationarity of the man-made signals e.g., amplitude modulation, frequency modulation, and phase modulation signals is exploited to reduce the effect of interference and noise signals, which are either not cyclostationary, or do not share the same cycle frequency of signal-of-interest. Target localization based on a group of sensor nodes whose positions are known has been extensively studied in research on signal processing [20].

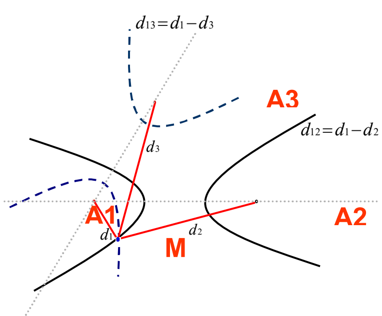

Figure 2: Tdoa Localization Method

It has been applied widely in military and civil fields, including sensor networks, wireless communication, radar, navigation, and so forth. Commonly adopted positioning methods include the signal's time of arrival (ToA), time difference of arrival (TDoA), frequency difference of arrival (FDoA) or doppler shift. Compared with FDoA, the TDoA and ToA methods can achieve higher positioning accuracy and require only one channel for each sensor node to perform the measurement, which can minimize the load requirement for a single-sensor node. Once these are known, the distance from the reference point can be calculated using the simple equation:

$$d = c * ({}^{t}\text{arrival} - {}^{t}\text{sent}) \quad [3]$$

where c is the speed of light. Using this distance, the set of possible locations of the target can be determined. In two dimensions, this yields a circle with the equation:

[4]

Time Difference of Arrival is the second-most popular ranging technique, and it is somewhat more versatile than ToA. This method does not require the time that the signal was sent from the target, only the time the signal was received and the speed that the signal travels. Once the signal is received at two reference points, the difference in arrival time can be used to calculate the difference in distances between the target and the two reference points. This difference can be calculated using the equation:

$$\Delta d = c * (\Delta t) \quad [5]$$

where c is the speed of light and Δt is the difference in arrival times at each reference point. In two dimensions, this leads to the following equation:

$$\Delta d = \sqrt{(x_2 - x)^2 - (y_2 - y)^2} - \sqrt{(x_1 - x)^2 - (y_1 - y)^2} \quad [6]$$

3. TIME DIFFERENCE OF ARRIVAL (TDOA)

Location sensing provides endless opportunities for a wide range of applications in GPS-obstructed environments, where, typically, there is a need for a higher degree of accuracy. Ranging Techniques using as follows:

- Time-of-Arrival (TOA)
- TOA/TWR
- DTOA
- TOA/OWR
- TDOA
- Received signal strength (RSS)
- Angle-of-Arrival (AOA)

3.1 Localization Application Technique Comparison

There is some undesirable issued faced in GPS systems such as information not being robust or not available for some applications. There are different localization methods are proposed by the researchers such as dead reckoning, cellular localization and image/video localization, to overcome issues of GPS systems [21]. Localization Techniques comparison in Table 1 as follows:

Table 1: Localization Techniques Comparison

	Localization Features			
	Infrastructure	Accuracy	Availibity	Synchronize
Map Matching	No	No	Yes	No
Cellular Loc	Yes	No	No	No
Loc. Services	Yes	Yes	No	Yes
Dead Reckoning	No	No	Yes	No
Img/Video Loc.	Yes	Yes	No	Yes
Rel. Ad Hoc Loc	No	Yes	Yes	Yes
GPS	Yes	No	No	No

4. SIMULATION AND ANALYSIS

The overall studies comprise the detection, interception and analysis of intelligence information and activities derived from communication and non-communication electronics emission in the HF/VHF/UHF bands before an electronic countermeasure is accomplished. Among others, these involve frequency detection, target source identity and location. Once the signal information been gathered, their position or location can be estimated using various ranging and localization determination techniques.

In this study, signal emitter from 10 static or monitoring stations statics with their location pinpointed as shown in Table 2 within the selected region.

Table 2: Sensor Location Information

No	Longitude	Latitude	Remarks
1.	116.894531	7.100893	KKU
2.	113.994860	4.333131	MRI
3.	115.092773	5.790897	LBG
4.	113.466797	4.346411	SDK
5.	112.324219	3.162456	TWU
6.	110.258789	2.284551	KCG
7.	108.632813	2.416276	KGR
8.	106.083984	2.504085	KBH
9.	105.292969	1.537901	SGB
10.	104.809571	0.527336	JBU

The moving target pathway are pre-defined to follow four different paths as shown in Figure 4, taking into consideration the sea-floor morphology [24] and its impact on the signal reception. To ease simulator visualization, a two-dimensional target position been mapped into *x-y* coordinates from 3D spectral coordinates.

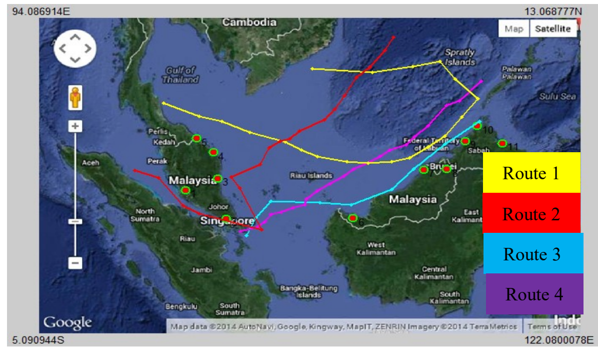

Figure 4: Pathway For Moving Target

The moving target is monitored by at least 3 neighboring static stations within the station range that met minimum signal reception threshold along the selected route as shown in Figure 5, otherwise the moving target failed to be detected or the localization less accurate.

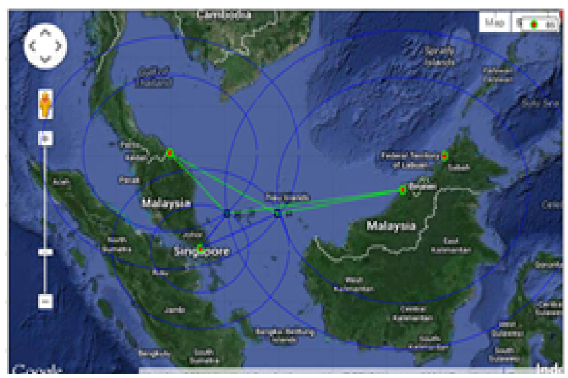

Figure 5: Coverage of Monitoring Station

TDOA technique was used to estimate the position of tracking signal of moving target the receive signal is suggested to signal propagation impairment depend on obstacles, fading, fleet of movement, coastal or sea back reflection (check paper 24), power receive, signal blockage to fleet movement. Coastal terrain. morphography. TDOA performance depends signal strengths active it is most suitable techniques for location and hearbility detection. For the performance of the positioning method that has been chosen, it is important to know how to analyze the accuracy of the technique. The third activity in this study is to design software that can be used to simulate some data e.g., frequency, distance, percentage and Lat long to estimate location by sensors static. The radius of the identified sensor will be plotted from the software based on received signal strength. Then, this work will be proceed with the analyzing and

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approximating the accuracy of positioning technique by using simulation model that has been developed. In this research, localization technique by TDOA can detect any object or target through the any route and distance can by mapping. The 11 sensor statics by simulation in mapping can trigger any movement from 0, 50, 100, 150 & 200 km above for ensure that trilateration method can be done.

This research started with analyzing error detection and hearbility by sensor based on Localization Techniques that suitable used for Radio Frequency either High Frequency (HF), Very High Frequency (VHF) & Ultra High Frequency (UHF). For this research, time-based method such as FDOA or the simultaneous Localization and Mapping allows estimating the position of the transmitting target through its previous and the estimated cinematic features. The possibility, as well as the application of a tracking algorithm to a series of positions estimated with the TDOA approach, goes behind the scope of the paper and it is no further explored in the following. In the proposed approach, the positions of the randomly-dislocated by pathway additional routes are a prior known. This is commonly true for static sensors, but it can be extended also to target route, given that they provide their location together with the measured TOA. Obviously, the target positioning error should be accounted for by the proposed localization determination. The following part of the paper is structured as follows, multi task techniques for determine localization by sensors as Table 2:

4.1 Flow Chart Diagram

The process of research design is start simulated, select target and position, insert any frequency by target detection and simulate by at least three (3) sensors for determine localization by TDOA method and result can be show by triangulation in map for target location together by latitude and longitude. For simulation techniques by MATLAB application can show result by location, graph, error detection and hearbility percentage. Figure 3 shows the flowchart of general positioning activities of the target, pathway, sensor, frequency and pathway for determination localization by error detection and hearbility percentage as simulate result.

5.0 RESULT AND DISCUSSION

5.1 Performance Route Detecting By Sensors

Several data frequency have been observed from the pathway and route taken from location 1 until location 11. After any object by simulation started from point 1 to 2, each sensor near target can detect automatically by Time Difference of Arrival (TDOA) approach. The location method works by multipath network and coverage depend on sensors near a target. A simulation model of the TDOA technique with Fixed Algorithm to determine the location of this target has been successfully developed. Its accuracy has been measured taking into account the various features of the target area with high network density. For lane 1 in red, lane 2 is dark blue, lane 3 is green and lane 4 is light blue. Based on Table 3, which sets the target range of 100 kilometers, route 4 is most effective for the Locator function as the position accuracy is at 0.5 at 95% level. For the most ineffective route 3 up to a new distance of 63 meters reached 95%. The results as a sample simulation as a Table 3.

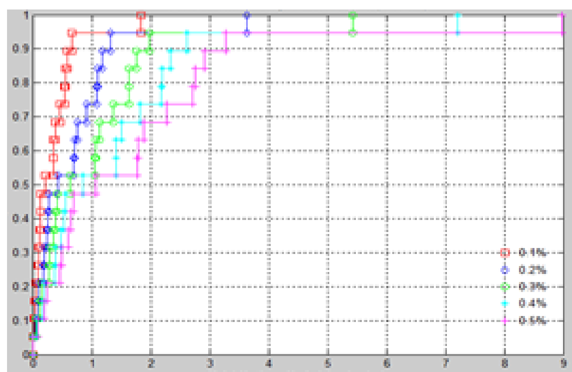

Table 3: Performance Detecting Localization Results

Table 4: Empirical CDF

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5.2 Hearbility Vs Localization

The signal strength received by the surveillance station depends on the distance specified in the simulation of 50, 100, 150, 200 and 250 meters. Table 5 shows the listening with the target position. At locations 1 to 12 the listening level is zero while at the 12 to 14 listening level at 3 and down to 1 at the target location 15 and up again at the target location 16. For a distance of 100 km the listening level at the maximum target location 13. Distance 150 hearing kilometers start a target location 8 and are maximal at target location 11 and above. For 200 kilometers the listening level starts at target location 1 and the maximum target location is 6. The overall assessment made through the 4 stage clearly states that the target listening level to surveillance stations depends on the target distance set in MATLAB 7.0 simulations.

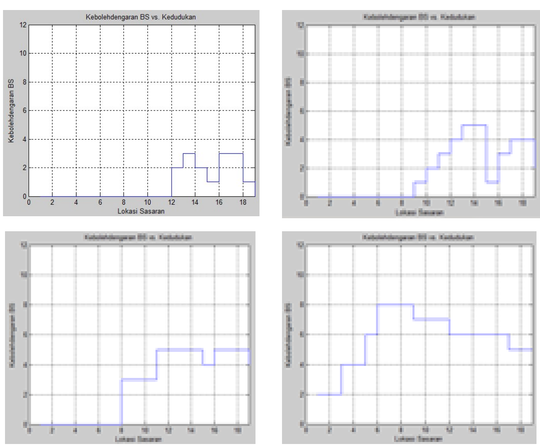

Table 5: Signal Strength Vs Localization

5.3 Permissibility Vs Pattern Percentage

Table 6 shows the comparison between lanes 1, 2, 3 and 4 according to the positioning error of 50, 100, 150 and 250. From the analysis it is found that the greater the distance entered in the simulation then the accepted form of radiation is high up to 100%. The route set varies by geolocation factor and each time the target through the monitoring station will determine the effectiveness of the actual localization factor. Table 6 shows each percentage difference between route and target distance.

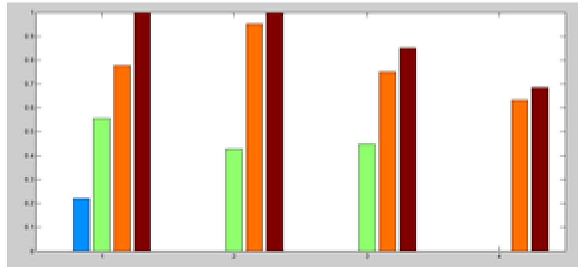

Table 6: Permissibility Vs Pattern Percentage

5.4 Data Analyst

The value of Position error hearing and distance can show TDOA based locating system depends on target and sensor detection. Comparing, locating performance of the TDOA based system with the Matlab Simulation the horizontal range and accuracy is about by locating and distance at 90% probability detection. Based on Table 7, percentage hearing and distance on route 1 until route 4 and distance from range 50 km to 250 km.

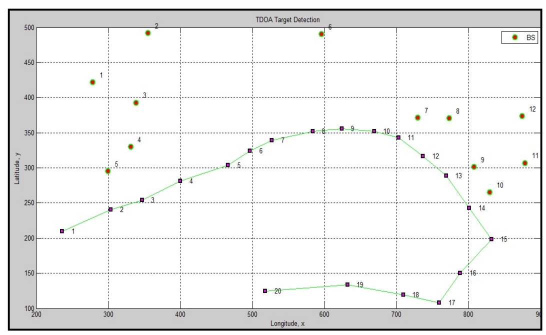

Table 7: Positioning Error Hearing Vs Position Distance

Based on Table 8, shows route 1 to 4 and compare by hearbility and error detection percentage depends on distance from 50 to 250 kilometers. Depends on sensors, if target bit far can accurate for Route 1 and 2, if compare route 3 and 4. There has been massive amount of research have been conducted in the area of indoor positioning systems specifically it's upwards research trending in Localization Based Services (LBS) within a non-open space environment or in the vicinity of high-rise buildings due to the incapability of Global Positioning System (GPS) to do so. Most of the indoor localization techniques proposed by researchers to discover an optimized solution for indoor location tracking that has high precision and accuracy. According to [23] a model for better accuracy on range-based localization algorithm in non-GPS positioning systems. The proposed model adopts the enhanced Kalman Filter (KF) and

Centroid Localization Algorithm that can manipulate noise signal from raw Received Signal Strength Indicator (RSSI).

Path	R=50km	R=100	R=150	R= 200	R=250
1	0	22%	55%	77%	100%
2	0	0	41%	97%	100%
3	0	0	43%	75%	87%
4	0	0	0	63%	65%

Table 8: Path Vs Route

6. CONCLUSION

The most significant contribution of this work is the development of time-base localization determination technique that can be implemented for multipath by frequency or sensor networks. The result of the data analysis is that each transmitted will have error detection of 0.5% and the frequency distribution is below 12. If the transmitter location passes through sensor 1, then the data obtained will be received by the sensor through the TDOA concept. The concept of Triangulation in determining location accuracy is important as long as the receiving antenna is able to process the signal. The simulation model for location determination has been developed with TDOA method. It has been validated with several data of the real location of target during real time approach. The result can be improvement of base on the location and antenna type by any models. The performance evaluation has been simulated and the comparison between the TDOA algorithms with various frequencies and target location has been done. It shows performance at least 65% and up to 100% of the obtained results that fulfil the requirements of analysis. However, the result of this simulation is still not very stable since the location error depends on data value of Radio Frequency received by target device from all pathway and route. For future recommendation, the accuracy of the location determination can be optimized and further analysis need to be done.

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