Dynamic Position Location and Tracking (D-PL&T) using Location based Hash Scheme for Malicious Detection under Doppler Spread Rayleigh Channel

NIRAJ SHAKHAKARMI[1], D.R.VAMAN[2]
Department of Electrical and Computer Engineering
Prairie View A & M University (Member of Texas A & M University System)
Prairie View, Houston, Texas-77446, USA
{e-mail: nshakhakarmi@navajotech.edu, drvaman@pvamu.edu}

Abstract: - A novel approach of the integrated security and dynamic Position Location and Tracking (PL&T) for malicious node maintaining two friendly nodes is proposed. Location based hash security scheme is deployed for detection of friendly and malicious nodes by encrypting hash functions using private location assets to increase the security level. In addition, PL&T is deployed forming the robust tracking zone and triangulation using two friendly nodes equipped with steered Directional antenna in Mobile Ad hoc Networks. The integrated "zone finding" and "triangulation" with adaptive beam forming allow the system to use only two references by switching nodes in and out of range. Pre-zone finding of a node permits proper geometry to be established for triangulation. This provides significantly improved tracking accuracy as compared to the triangulation only using three references. Also, narrow zone reduces beam width, thus significantly decreasing the tracking error but increases the zonal overhead. The PL&T performance analysis shows that by deploying interleaving Koay-Vaman (KV) transform coding technique for forward error correction and sample interleaving will achieves greater tracking accuracy using lower E_b/N_o in fast Doppler spread Rayleigh channel. The average estimated location tacking errorand average zonal overhead are significantly decreased under fast Doppler spread fading channel than slow Doppler spread fading channel.

Key-Words:Dynamic Position Location Tracking, Location based Hash Scheme, Malicious Detection, Doppler Spread, Rayleigh Channel

1. Introduction

The next generation mobile ad hoc networks and sensor networks provide extensive ability to be highly mobile and support multi-service network centric applications that requires transmission of video, voice and data in any form. However, it creates two operational difficulties of protecting the friendly nodes and their locations from the intruder or malicious; and preventing the malicious nodes from entering the end-to-end paths. Maintaining multi-hop secure connectivity with friendly nodes requires the use of dynamic PL&T algorithm and encryption to co-exist for secured communication and location tracking in ad hoc networks and battlefield theatres.

In this paper, we focus only on designing the real time PL&T algorithm to support maintaining strict friendly radios (or nodes) on single hop and multi hop connected paths. We assume that the USA.architecturaldesign of radios do not violate the Systems layered approach of the Open Interconnections (OSI) methodology.

The use of Omni-directional antennas pose significant challenge in handling channel impairments such as multi-path fading both indoors and outdoors in MANET as the need to maintain power efficiency becomes critical. Therefore, we attempt to use Directional Antennas on radios to concentrate the beam power in a focused direction for communications between a reference node and a target node. This significantly increases the directional gain and received power at the receiving end which contributes to increase the accuracy during ranging. In addition, the use of two friendly reference nodes with known PL&T allows significant tracking accuracy of malicious target nodes when the two beams converge over the tracking zone.

The Average Time Difference of Arrival and Departure of IP based packets is deployed for ranging and localization using directional antenna in this paper. This method has outstanding ranging and

N. Shakhakarmiis Assistant professor, ECE Department in Navajo Technical College, USA and he worked withD.R.Vaman in ARO funded CEBCOM, ECE Department, Prairie View A&M University (Texas A & M system), Prairie View, Houston, Texas-77446,

location tracking performance over traditional ToA, TDoA and received signal strength based localization. This method is performed deploying IP layer request packets between transmitter and receiver. First the transmitter sends n number of request packets to receiver marked with ToD time stamps. As soon as receiver gets those transmitted packets then it set up ToA time stamps to corresponding request packets. The receiver also sends response packets with ToA time stamps corresponding to request packets to the transmitter. When the transmitter receives the corresponding response packets then it computes the average of the time difference of all ToA and ToD time stamps of 'n' number of IP packets. The Euclidean distance between transmitter and receiver is computed by the product of velocity of light 'c' and average time difference of ToA and ToD as shown in equation(1).

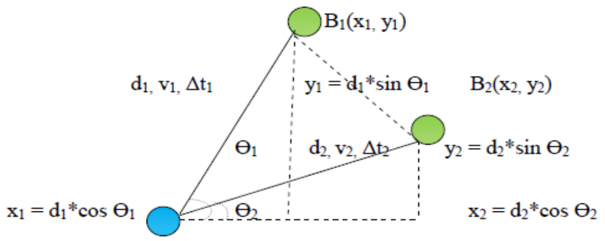

Fig.1 Position & Location Computation

$$D_{Euclidean}(d) = c * \sum_{i=1}^{n} (ToA_i - ToD_i) / n \qquad (1)$$

$$AoA(\theta) = \sum_{i=1}^{n} (AoA_i) / n \qquad (2)$$

In addition, the direction of receiver with respect to transmitter is decided using the average Angle of Arrival (AoA) of ToA or ToD packets from transmitter to receiver with a predefined direction (for instance the north) as shown in equation (2). This AoA is direction of arrival of packets which can be deployed perfectly using dynamic ranging where the beam width is reduced to increase the range as well as localization and tracking accuracy. AoA approach improves over received signal strength ranging scheme because it does not need any assumptions on the propagation model that relates the RSS to the distance. It needs only knowledge of the radiation pattern to estimate the AoA of the incoming messages. In addition, AoA-based localization needs a lower number of anchor nodes than localization based on distance estimates.

TABLE I
Comparison of Different Localization methods

Prediction Methods	Features	Drawbacks	Proposed Research Solutions
Forward Movement based Prediction	Considers zone prediction within a constrained forward movement of a target node.	Uses single reference node, limited random movement and does not consider sharp turns or obstacles.	Proposed optimal zone forming considers any random movement of a target node.
Received Signal Strength based Prediction	Better tracking accuracy over the triangulation method as long as multi-path fading is small and longer averaging availability.	Without zone finding, the signal is spread and errors are accumulated in the computation of both the distance and the angle for limited non-random trajectory.	Zone finding and adaptive beam forming significantly enhances the received signal strength and tracking accuracy for a random trajectory.
Multi hop based Prediction	All the position locations of nodes are estimated using multiple levels of reference nodes.	Increases cumulative errors in multi hop measurements and has no beam adaptation used. Thus, significantly reduces accuracy of tracking.	Zone forming with Dynamic switching of reference nodes and dynamic ranging provides improved accuracy of the localization and tracking.
Directional Lines Intersection based Prediction	Localization of nodes using point of intersection of highly directional beams has better accuracy for low speed mobile anchor nodes.	Higher overhead in scanning and does not address random trajectory.	Zone forming and adaptive beam forming reduces the scanning overhead in the random trajectory.

In above Figure 1, transmitter A computes the first location and position of a desired receiving target B_1 (x_1,y_1) moving with velocity v_1 at time Δt_1, along the direction of motion $\check{\theta}_1$ until the node changes the direction in terms of x co-ordinate and y co-ordinate as shown in equations (3)- (6).

$$x_1 = d_1 * \cos\theta_1 \qquad (3)$$

$$y_1 = d_1 * \sin\theta_1 \qquad (4)$$

$$\check{\theta}_1 = (\cos(\theta_1)\check{x} + \sin(\theta_1)\check{y}) \qquad (5)$$

$$P_1 = v_1 * \check{\theta}(1) * \Delta t_1 = v_1 * (\cos(\theta_1)\check{x} + \sin(\theta_1)\check{y}) * \Delta t_1 \qquad (6)$$

Similarly, transmitter A computes the second location and position of a receiver target B_2 (x_2,y_2) moving with velocity v_2 at time Δt_2 , along the direction of motion $\check{\theta}_2$ in terms of x co-ordinate and y co-ordinate as shown in equations (1) to (6).

Furthermore, different two dimensional Localization and PL&T schemes based on forward movement, received signal strength, multi hop connected reference nodes and greatest gain direction of directional intersection are analysed, compared and their drawbacks are addressed in the proposed Dynamic PL&T as presented in the Table-1 [5]-[8].

This paper includes the novel approach of the location based hash security scheme, Dynamic PL&T, modelling of target's movement, Dynamic PL&T with interleaving KV coding under Fast Doppler spread Rayleigh channel and the performance analysis indicating the significant improvement in malicious detection, bit error rate and tracking accuracy.

2. Problem & Proposed Solution

Position, Location and Tracking (PL&T) of malicious node is deployed with Dynamic Demilitarized zone and public cryptography in MANET which consists of complex structure is difficult to achieve in ad hoc networks [1]. In addition, single node tracking a target node is not realistically exact to locate position in ad hoc environment until some reference with robust zone forming is made. This is address in this paper. On the other hand, the integrated key based strict friendly verification has higher computational overhead as it generates different keys for encryption of different packets [3]. These are resolved by location based hash security with cascaded hash functions and encryptions for malicious node detection.

PL&T is determined by means of different ranging methods using angle of arrival, received signal strength, time of arrival, time difference of arrival [4-7]. However, these techniques have the draw-back of lack of proper zone finding which increase accumulated errors in the computation of distance and the angle as explained in the state of art. In addition, the ranging tends to be inaccurate in multipath faded channel due to burst error, which is severe for indoor tracking. These issues are addressed in this paper by the integrated approach of zone forming and triangulation, and interleaving KV transform for error detection and correction to increase the tracking accuracy under Doppler spread multi-path fading. The proposed approach has the advantage of only using two friendly references instead of three references for 2D PL&T used in IP based triangulation. However, the reference nodes have to continuously be switched to locate new zones for the target tracking.

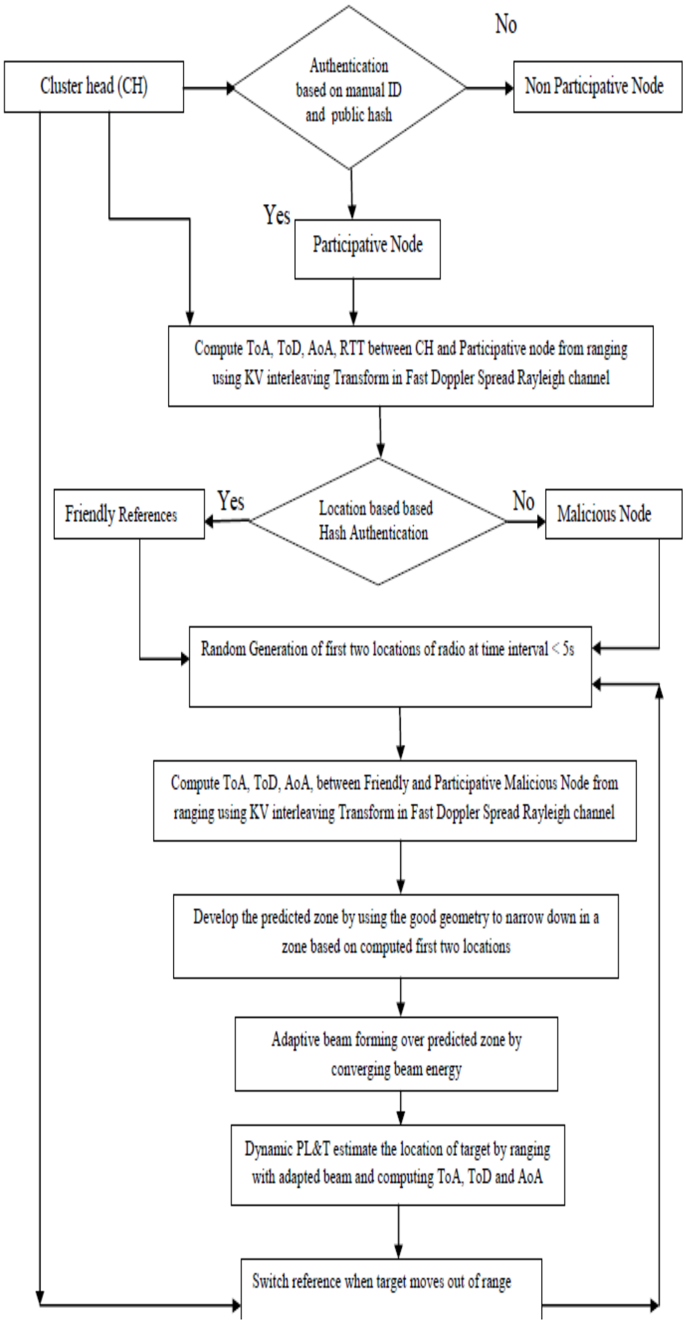

Fig. 2 Proposed Dynamic PL&T using Location based Hash Security under Doppler spread Channel

The proposed solution includes the following methodologyas illustrated in Figure 2:

- Specifying and executing Location based Hash scheme
- Specifying and executing Dynamic PL&T using zone finding and triangulation
- Modeling the movement of malicious target node during PL&T

- Performance analysis of secured Dynamic PL&T scheme
- Dynamic PL&T using interleaving KV transform under Doppler Spread multipath fadingchannel

2.1 Location based Hash Security Scheme

Malicious node is detected at first deploying the manual ID and location based hash scheme [2], [7] and then later tracked by two friendly nodes using PL&T strategy [1]. For malicious node detection, all member node IDs are registered and different Hash functions H_1, H_2, H_3, Encryptions E_1, E_2 and Decryptions D_1, D_2 are provided to them during the clustering shown in Figure 3. In addition, the location based hash keys are also provided by the cluster head. These hash keys depend upon the threshold range of the Euclidean distances between nodes. When two nodes A and B need to do mutual authentication based on location then the Euclidean distance based hash key, RTT (Round Trip Time) and Euclidean distance are deployed to determine whether nodes are malicious or friendly nodes. First, node A conducts the ranging to node B based on the average time difference of ToA(Time of arrival) and ToD (Time of Departure) time stamps of the IP (Internet Protocol) based management packets to compute the Euclidean distance (D_{AB}). Then, its corresponding hash key K_A is determined based upon the threshold range of the Euclidean distance. In addition, the round trip time RTT_{AB} between the sending node A and receiving node B is also computed in the threshold time period. Then, node A sends request consisting the hash value $\ddot{H}_A$ as shown in equation (7) achieved from triple hash functions and double encryption over location based hash key for authentication to node B with the nonce N_a as shown in Fig. 3.

$$\ddot{H}_A = H_3\left(E_2\left(D_{AB}, E_1\left(H_2\left(R_{TT\_AB}\right), H_1\left(K_A\right)\right)\right) \parallel N_A\right) \quad (7)$$

On the other hand, node B also execute ranging to node A deploying the average time difference of ToA and ToD of the IP based management packets to compute the Euclidean distance (DBA) and its corresponding hash key K_B. The round trip time ($RTT_{\_BA}$) between the node B and node A is also computed in the threshold range. Then, node B computes the hash value $\ddot{H}_B$ by using hash key K_B, round trip time ($RTT_{\_BA}$) and Euclidean distance (D_{BA}) in hash functions and encryptions to generate hash value $\ddot{H}_B$ as shown in equation (8). Then, node B verify the hash value received from node A to generated hash value by itself, whether same or different from the current Euclidean distance range as shown in equation 3.3.

$$\ddot{H}_A = \ddot{H}_B,\ iff\ D_{AB} = D_{BA},\ R_{TT\_AB} = R_{TT\_BA}\ and\ K_A = K_B \quad (8)$$

$$\ddot{H}_B = H_3\left(D_2\left(D_{BA}, D_1\left(H_2\left(R_{TT\_BA}\right), H_1\left(K_B\right)\right)\right) \parallel N_B\right) \quad (9)$$

When both the hash value are same then receiving node B decide that requesting node A is friendly node , otherwise malicious target node which is to be tracked using dynamic PL&T in co-operation with another friendly node. The condition of friendly node holds true if and only if the same RTT and the same hash key for the same Euclidean distance as shown in equation (9). Then, node B reply $\ddot{H}_B$ to node A with the flag set either 1or 0 indicating the neighbour node is friendly or malicious as shown in equation (10). The nonce N_a and N_b avoid the replay and location forgery by verifying that the particular confidential entity is send by particular node at certain time instant.

$$\ddot{H}_B = H_3\left(E_2\left(D_{BA}, E_1\left(H_2\left(R_{TT\_BA}\right), H_1\left(K_B\right)\right)\right) \parallel N_A \parallel N_B \parallel 1\right) \quad (10)$$

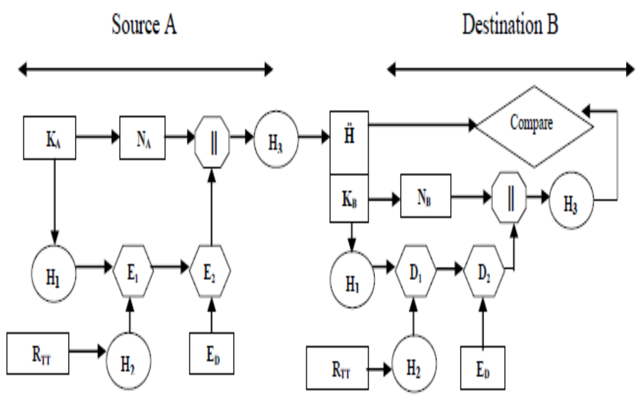

Fig. 3Location based Hash Security

This location based hash scheme can counteract against sybil attack, location replication attack, and worm hole attack. The probability of malicious node detection by a friendly node is computed as:

$$P_{Detection} = P_k * P_{RTT} * P_{ED} \quad (11)$$

where, P_k is the probability of replayed hash key,

P_{RTT} is the probability of replayed RTT,

P_{ED} is the probability of replayed Euclidean distance

The probability of malicious node mis-detection by a friendly node is computed as:

$$P_{Mis-detection} = \left(1 - P_{Detection}\right) = \left(1 - P_k * P_{RTT} * P_{ED}\right) \quad (12)$$

2.2Dynamic Position Location &Tracking

Dynamic Position Location and Tracking of a malicious node is the robust and scalable localization of radio nodes or sensors as per demand in the highly mobile environment. The future locations of a target node are computed deploying the integration of the zone forming and triangulation based on the current location of two reference nodes and a malicious target node. The target node is detected by location based hash functions and later tracked by two nearest friendly neighbours by focusing their steered directional beams over the target node. This is typically the proactive location based dynamic tracking tactic deploying the optimal energy resources. The dynamic tracking zone is formed using the previous two locations of the target with two friendly nodes and mapping time difference of ToA and ToD packet estimation into corresponding location information. Later directional beams of two friendly neighbors are converged over the tracking zone and dynamically updated till the target is inside the dynamic range of tracking nodes [8-11]. These friendly neighbors can be dynamically changed as per requirement, in out of range scenario, while tracking the target node. The proposed dynamic PL&T algorithm operates as follows as shown in Figure 4:

- Each node in a MANET cluster scans neighboring nodes using location based hash scheme as explained in section 3 by steering directional beam. Those nodes which could not authenticate are malicious target nodes to be tracked using two authenticated friendly neighbor nodes. When a target node is detected in the neighborhood range of a node then each target node is tracked by two nearest friendly neighbor nodes $A_j$and C_k by concentrating their steerable directional beam spreads over the target B_i. The fresh initial position of the target node B_i is localized by mapping the time difference between Time of Arrival (ToA) packets and Time of Departure (ToD) packets into radial distances $d_{Aj,}$ d_{Ck}, and Angle of Arrival (AoA) into the direction. This is simultaneously done by both tracking nodes $A_j$and C_k using over target node for its initial position localization**.**
- After localizing initial position of the target node B_i by tracking nodes A_j and C_k, a tracking zone is developed depending upon the latest two position information of the target. The following procedure is strictly deployed to develop the robust tracking zone.Using directional beams, distances $d_{Aj}$and d_{Ck}, are achieved from the time difference of ToA and ToD packets, which are lengthened longer as two sides of a triangle. Then, the average distance $d_{Average} = \left(d_{Aj} + d_{Ck}\right)/2$ is marked on the line joining the latest two position of the target B_i and B_{i+1}. The base of the triangle is drawn through the marked point along the line parallel to the line joining two tracking nodes $A_j$and C_k. This triangulation represents both the position of target node B_i and tracking nodes $A_j$and C_k, to predict the future position of the target.

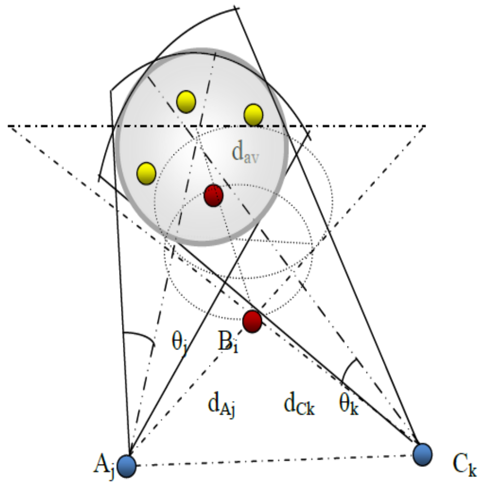

Fig. 4Dynamic PL&T illustration

- An inscribed circle is sketched inside the triangle at the point of intersection of any two angle bisectors and radius 'r_m' as perpendicular distance over all sides of the triangle. The radius can be computed in terms of $s = \left(d_1 + d_2 + d_3\right)/2$ and d_1,d_2,$d_3$are sides of a triangle.

$$r_m = sqrt\left(\left(s - d_1\right)\left(s - d_2\right)\left(s - d_3\right)/s\right) \quad (13)$$

The equation of the inscribed circle is given as:

$$\left(x - x_m\right)^2 + \left(y - y_m\right)^2 = r_m{}^2 \quad (14)$$

- A line is sketched through the latest two posit -ion of the target B_i (x_{i-1},y_{i-1}) and B_{i+1} (x_i,y_i) which is y=kx+ c, where k is the slope andc is the y-intercept which are computed as below:

$$k = \left(y_i - y_{i-1}\right) / \left(x_i - x_{i-1}\right) \quad (15)$$

$$c = \left(x_i y_{i-1} - x_{i-1} y_i\right) / \left(x_i - x_{i-1}\right) \quad (16)$$

Another circle is also drawn such that its radius 'r_n' is the half of the distance between the latest two position of the target B_i and B_{i+1} in the same directional movement of the target as shown in Figure 2. The equation of second circle is given as:

$$\left(x - x_n\right)^2 + \left(y - y_n\right)^2 = r_n{}^2 \quad (17)$$

Then, the point of intersection P (x_p,y_p) of the line joining the target B_i and B_{i+1} and the line joining intersected circles of radii $r_m$and $r_n$is the novel point defined as:

$$x_p = \left\{\left(x_m + x_n\right)\left(x_m - x_n\right) + 2 * \left(r_n{}^2 - r_m{}^2\right)\right\} / 2 * \left(x_m - x_n\right) \quad (18)$$

$$y_p = \left\{\left(r_m{}^2 - r_n{}^2 + x_n{}^2 - x_m{}^2 + y_n{}^2 - y_m{}^2\right) - 2*\left(x_n - x_m\right)x_p\right\} / 2*\left(y_n - y_m\right) \quad (19)$$

The robust tracking zone is developed by drawing a new circle with diameter $d_o = r_m$ over the line joining the target B_i and B_{i+1} at the novel point where the future position of the target $B_{i+n}$is localized and tracked inside the intersection of the two beams from the two reference nodes. Figure 4 illustrates the determination of tracking-zone deploying two friendly nodes as references. Once the tracking zone is determined, the two reference nodes and the target node exchange packets which contain the ToD and ToA of each packet. The average of (ToA – ToD) provides the range between the target and any one reference node.

The beam widths adapted by reference nodes $A_j$and C_k at distance D_j and D_k from the centre of zone having the zone radius r= r_m are Θ_{Aj} and Θ_{Ck} defined by equations (14)- (15).

$$\Theta_{Aj} = 2\arcsin(r / D_j) \quad (20)$$

$$\Theta_{Ck} = 2\arcsin(r / D_k) \quad (21)$$

The Euclidean distances and angle of arrivals of reference nodes about the target node are computed as D_{AB} , D_{CB} and □$_{AB}$,□$_{CB}$ in equations (22)-(25).

$$D_{AB} = c * \sum_{i=1}^{n} (ToA_i^{BA} - ToD_i^{AB}) / n \quad (22)$$

$$D_{CB} = c * \sum_{i=1}^{n} (ToA_i^{BC} - ToD_i^{CB}) / n \quad (23)$$

$$\theta_{AB} = \sum_{i=1}^{n} (\theta_i^{AB}) / n \quad (24) \qquad \theta_{CB} = \sum_{i=1}^{n} (\theta_i^{CB}) / n \quad (25)$$

The location of target node $B(x_{AB}, y_{AB})$ from node A is (x_{AB} =D_{AB} Cos □ $_{AB}$, y_{AB} =D_{AB} Cos □ $_{AB}$) and $B(x_{CB}, y_{CB})$ from node A is (x_{CB} =D_{CB} Cos □ $_{CB}$, y_{CB} =D_{CB} Cos □ $_{CB}$) respectively. The position trajectory of a target node A moving with velocity 'v' at time 'Δt' is estimated by node B and node C are P_{AB} and P_{CB} as in equations (26) and (27).

$$P_{AB} = v_{target}(x_{AB} + y_{AB})\Delta t = v_{target} * D_{AB}(\cos\theta_{AB} + *\sin\theta_{AB}) * \Delta t \quad (26)$$

$$P_{CB} = v_{target}(x_{CB} + y_{CB})\Delta t = v_{target} * D_{CB}(\cos\theta_{CB} + *\sin\theta_{CB}) * \Delta t \quad (27)$$

This can be further deployed in mapping the relative PL&T of the malicious node to GPS information in 2D if any reference node happens to have a known GPS data. Furthermore, the use of dynamic PL&T algorithm is supplemented by the use of Koay-Vaman (KV) transform technique to improve the performance of the algorithm in the presence of multi-path fading [12]. It has been shown that by using sample interleaving and error correction, the data can be recovered at very low Bit Error Rate (BER) at E_b/N_0< 10 db.

Dynamic switching of reference nodes in PL&T is the assignment of new friendly reference nodes as per requirement when the existing friendly node becomes no malicious during the periodic authentication. In addition, when the target node goes out of range from the current reference nodes during PL&T operation then another friendly node is switched after ranging and authentication. Dynamic switching overhead is increased when the velocity of target is comparatively higher than that of reference nodes.

2.3Modeling the movement of Malicious Targets

We assume that the malicious target node changes its direction randomly. The motion of target node can be represented as follows:

$$x_i(t) = v\, \check{V}(\theta_i) \quad (28)$$

$$\psi_i(t) = F_{\psi}(t) \quad (29)$$

where, x_i (t) represents the B_i^{th}position of the target, ψ_i(t) refers the orientation of target's antenna beam, v is the target's active velocity,and $\check{V}$ (θ_i) represents the direction of motion, specified as $\check{V}$ (θ_i) = cos(θ_i) $\check{x}$+ sin(θ_i) $\check{y}$.

The active direction of motion is determined by the angle θ_i, in which a target changes the direction θ_i at any instant time, with probability P_{turn}. The orientation of the antennas is determined in the functional order of F_{ψ}(t).Deploying Friis transmission, the received power of signals sent by A_j^{th} and C_k^{th} transmitter (neighbors) at B_i^{th} target or receiver node with a power above a certain threshold δ can be expressed in two-dimensions as:

$$\Pr_j(x_i, \psi_i, x_j, \psi_j) = K\, Pt_j G_{Tj}(\check{\psi}_j . x_{ij}) G_{Rj}(\check{\psi}_i . x_{ji}) / x^2_{ij} > \delta \quad (30)$$

$$\Pr_k(x_i, \psi_i, x_k, \psi_k) = K\, Pt_k G_{Tk}(\check{\psi}_k . x_{ik}) G_{Rk}(\check{\psi}_i . x_{ki}) / x^2_{ik} > \delta \quad (31)$$

Regarding A_j^{th} transmitter,$Pt_j$is the transmission power of the transmitter, $G_{Tj}(\psi_j\check{}.x_{ij})$ denotes the gain of the transmitter in the direction to the target or receiver, $G_{Rj}(\psi_i\check{}.x_{ji})$ represents the gain of the target or receiver in direction of the transmitter, K is angular diffusion as K=(η^2/24) P_{turn} where θ_i depends on a step function of width η, and $\check{\psi}$= cos(ψ_j) $\check{x}$+ sin(ψ_j) $\check{y}$, at x_{ij}= $x_i - x_j$ and so on for k^{th} transmitter.

Pr (x_{ij}, ψ_{ij}, x_{ik}, ψ_{ik})is the received power of signals by the target node which is the sum of the received energy power Pr_j(x_i, ψ_i, x_j, ψ_j) and Pr_k(x_i, ψ_i, x_k, ψ_k) from both tracking nodes.

$$\Pr(x_{ij}, \psi_{ij}, x_{ik}, \psi_{ik}) = \Pr_j(x_i, \psi_i, x_j, \psi_j) + \Pr_k(x_i, \psi_i, x_k, \psi_k)$$
$$= K\{ Pt_j G_{Tj}(\check{\psi}_j . x_{ij}) G_{Rj}(\check{\psi}_i . x_{ji}) x^2_{ik}$$
$$+ Pt_k G_{Tk}(\check{\psi}_k . x_{ik}) G_{Rk}(\check{\psi}_i . x_{ki}) x^2_{ij} \} / (x^2_{ij} x^2_{ik}) \quad (32)$$

At every broadcasting time instant Δt,the position of the target is updated by a simple Euler method such that x_i(t+Δt) = x_i(t) + v $\check{V}$ (θ_i(t)) Δt. The direction of motion of node θ_i(t) at each time step with probability P_{turn} is updated by θ_i(t + Δt) which is a random angle between 0 and 2π. Otherwise, θ_i (t + Δt) =θ_i (t). The estimation of antenna's Beam Direction ψ_i(t) is such that the probability of rotation is P_{rot} for ψ_i(t +Δt) as a random angle between 0 and 2π.

$$G_{TR}(\psi_{jk}, x_{jk}, x_i) = G_M(\gamma_{ij}^{TR}) + G_M(\gamma_{ik}^{TR}),$$
$$\text{for } \check{\psi}_j . x_{ij} < Cos(0.5\gamma_j^{TR}) \text{ and } \check{\psi}_k . x_{ik} < Cos(0.5\gamma_k^{TR})$$
$$= 1.4\{(2 - Cos(0.5\gamma_{ij}^{TR}) - Cos(0.5\gamma_{ik}^{TR})) / (1 - Cos(0.5\gamma_{ij}^{TR}))(1 - Cos(0.5\gamma_{ik}^{TR}))\} \quad (33)$$

$$G_{TR}(\psi_{jk}, x_{jk}, x_i) = G_S(\check{\psi}_j . x_{ij}) + G_S(\check{\psi}_k . x_{ik})$$
$$\text{for } \check{\psi}_j . x_{ij} > Cos(0.5\gamma_j^{TR}) \text{ and } \check{\psi}_k . x_{ik} > Cos(0.5\gamma_k^{TR})$$
$$= 1.4\{(2 - \check{}(\psi_k) x_{ij} (-\check{}.\psi_k)) x_{ik}) / (1 (-\check{}.\psi_k)) x_{ij} (-\check{}.\psi_k)) x_{ik} \quad (34)$$

The transmission and receiving gain G_{TR} pair between two tracking nodes and target is computed using γ^{TR} as the angle for maximum gain for the transmitter and receiver as shown in equations (55) and (34).

The states of target and reference nodes can be modeled as time dependent systems. Initially, A_j^{th} and C_k^{th}tracking nodes are in searching 'S' mode for target B_i^{th} in the space. In other words, these two nodes are broadcasting the message, and looking for target in their power range. The 'S' mode is replaced by 'T' asA_j^{th} and C_k^{th}nodes keep tracking target B_i^{th} till it is found inside the range. When the target B_i^{th} is in either 'S' or 'T' mode, the internal clock is coupled with mode by Δt. If the internal clock coupled at mode 'S' marks a time larger than τ, the state of the agent is changed to reset 'R' mode of the clock. If the mode 'R' keeps the clock for a time larger than R_{τ}, the agent moves back to the 'S' mode. The transition from 'S' to 'T', and from 'R' to 'S' are finite processes.

2.4 Simulation and Performance Evaluation

The simulation platform is set up using the simulation parameters as listed in Table-2. Malicious Detection Rate is higher until the network become denser or crowded. The major reason is that member nodes become closer to each other in highly populated cluster and this may create the similar location information and get mis-detected. In addition, when higher number of new nodes entered into the cluster then cluster could not register all of them simultaneously and unregistered nodes become malicious. The malicious detection rate is 100% for 10 member nodes, vary between 92-100% for 11-20 member nodes, 91-98% for 21-45 member nodes and 89-94% for 46-60 member nodes as shown in Figure 5. Themalicious nodes which do not participate are assumed to be non existing nodes. The friendliness maintenance in PL&T is required which is done by eliminating malicious nodes appeared as reference nodes. This is done by dynamic switching of the malicious reference nodes by friendly nodes. The malicious and friendly nodes participation are equivalent at particular number of participated nodes between 10-20, 30-40 and 45-60 in simulation shown in Figure 6. The major reason is that the co-located nodes have equi-probable conditions in maintaining and violating the location information during hash security based friendliness authentication.

PL&T performance is evaluated in terms of distance over time such that target is moving in random direction at different speed in the range of 10m/s and 40 m/s. The speed is lower only when the target makes the sharp turn along its path and higher along straight path. The tracking zone is developed and ranging is done using adaptive beam forming over the target. When a single location is not pin pointed for a target then the error is equally distributed forboth references to pin point the target, if the error is within the threshold circle of 1 m diameter, otherwise ranging is repeated. The PL&T estimationis performed and the tracking zone is dynamically formed depending upon the target's position. This PL&T error is achieved by the comparison between "true target position" and "PL&T estimatedposition" for a range of distance and time instances. The average PL&T error is 4.16 m for as shown in Figure 7.

TABLE II
SIMULATION PARAMETERS

Element	Value
Cluster Area (sq. m)	500X 500
Density of Nodes	60
Directional Antenna Range (m)	40
Channel Frequency (GHz)	2.54
Radiation Efficiency	0.82
Transmitted Power (dbm)	40
Antenna Size (m)	1
No. of Antenna Elements	5

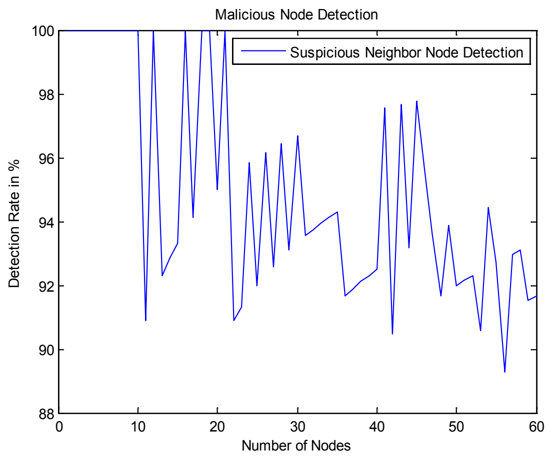

Fig. 5 Malicious Node Detection

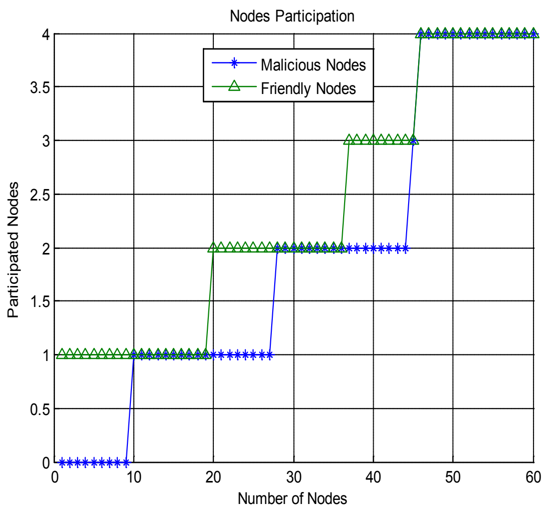

Fig. 6 Friendly & Malicious Nodes participation in PL&T

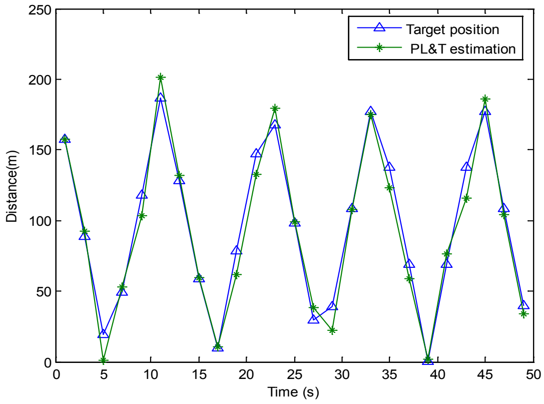

Fig.7 PL&T Estimation

Additionally, the average error of PL&T is demonstrated at different adaptive beam width with random directional movement in Figure 8. The average error goes on increasing with increasing Beam width of tracking nodes over target because higher coverage tracking zone spread the beam energy. The average error percentage is found significantly lower during location tracking in dynamic PL&T with two reference nodes than single reference node even in higher beam width, because of the joint participation of two nodes during narrowed zone finding, adaptive beam forming and average ranging. The minimum average error is 0.04 m at 1 degree beam width and maximum average error is 2.4 m at 60 degree beam width in one reference node using DA. Similarly, the minimum average error is 0.02 m at 1 degree beam width and maximum average error is 1.74 m at 60 degree beam width in the proposed PL&T.

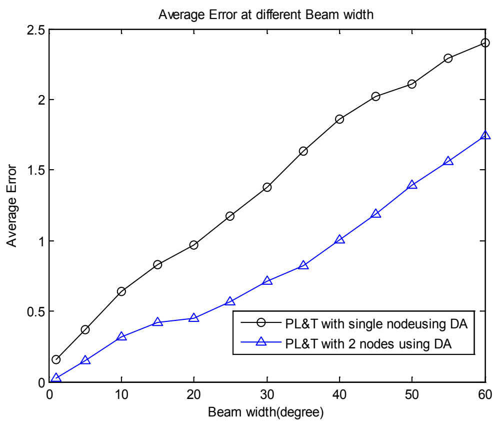

Fig. 8 Average error of PL&T over Beam width

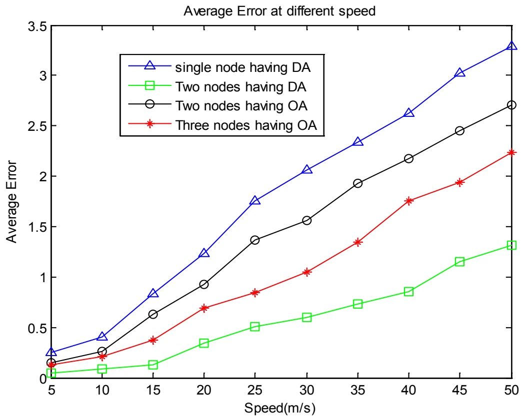

Fig. 9 Comparison of different PL&T schemes

The average error of PL&T is demonstrated at different speed with random directional beam width as well as Omni-directional (OA) beam and found that it goes on increasing with increasing speed of target because of multipath fading and Doppler spread. The average error percentage is found highest in the lack of robust coverage and scalable tracking zone in single node using adaptive beam forming DA, than triangulation based PL&T with two nodes having OA, three nodes having OA and the lowest in two nodes having directional antenna for adaptive beam forming based Dynamic PL&T. The minimum average error is 0.05m at 5m/s and maximum average error is 1.35m at 50 m/s in proposed two nodes based PL&T which proves that the proposed PL&T is very efficient as compared to two OA based PL &T and single directional antenna based PL&T as shown in Figure 9.

PL&T simulation shows that the average broadcasting time increases with the increasing probability of changing directions by target because the target always move away in other random direction and it consumes more time to allow the data to be successfully received by the target. Figure 10 shows the average broadcasting time over probability of “changing direction” by the target. This indicates that the beam width of reference nodes plays a vital role specially narrower beam width provides the long range which significantly increases the speed of broadcasting packets and consumes lower broadcasting time. This is sustained as the average broadcasting time is found the most efficient in 15 degree beam width than 30 degree beam width, 45 degree beam width, 60 degree beam width, 90 degree beam width and Omni-directional, even the probability of turning of target is increased.

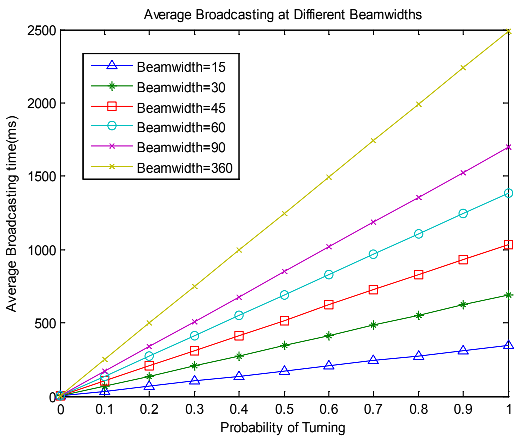

Fig. 10 Average Broadcasting over $P_{turning}$ of target

When the tracking zone is wider, the target can be exactly localized and tracked inside the same zone for higher number of trajectory trials until target does not move away. This increases the tracking efficiency but reduces tracking accuracy as the beam is spread over large coverage. On the contrary, when the zone is smaller, the target falls outside the existing zone and need to update the zone. This reduces the tracking performance as the computational time overhead is accumulated when the zone is frequently updated. In addition, when the zone is narrow the beam width is also narrow and it increases the tracking accuracy as well as data transmission rate. This is the tradeoff between the zone size and tracking accuracy which can be manipulated as the converse relation between the beam width and zone updating time overhead. The increasing zone size yields the increasing beam width which increases the PL&T estimation error but decreases the zonal computational overhead time in time in different experiments and vice-versa.

2.5Dynamic PL&T using interleaving KV transform under Doppler Spread multipath fading

Since multi-path fading forces the tracking operation to be conducted at low E_b/N_o, it is essential to maintain a bounded BER with an average sustained data transmission rate. Using KV transform, it is possible to interleave discrete samples and allow one out of four discrete samples to be corrected exactly, it is expected that both bit error rate and tracking accuracy improves significantly. The bit error rate is improved using sample interleaving KV transform over without interleaving. Figure 11 shows the tracking accuracy improvement when using KV transform that allows sample interleaving over that of without interleaving because of correlated bits recovery.

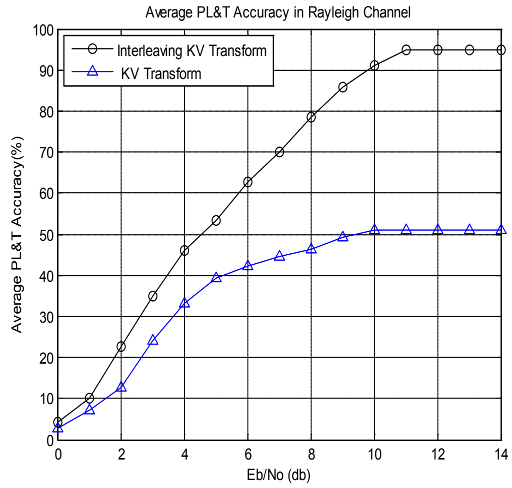

Fig.11 Tracking Accuracy using KV Transform

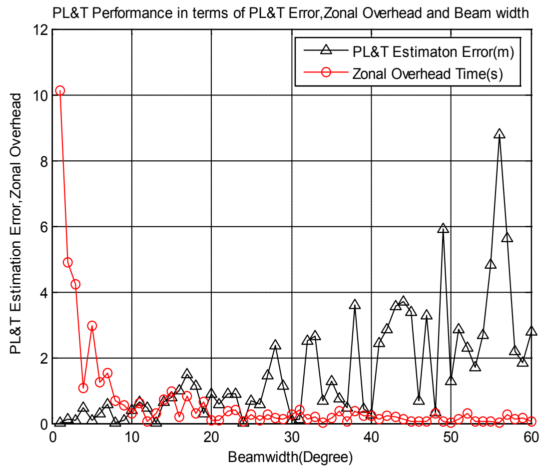

Fig.12 DPL&T in multipath fading(without KV)

Dynamic PL&T has found higher tracking accuracy for bits interleaving KV during data transmission and reception against the multipath interference. For typical wireless channels, the BER is around 10^{-4}. Figure 11 show that using KV transform coding, it is possible to achieve a tracking accuracy of over 90% using 10 db of Eb/No for BER above 10^{-6} and therefore allows the dynamic PL&T algorithm to be very robust under multipath faded channels.

With the increasing beam width, zonal overhead for updating zone decreased but the PL&T estimation error increased as shown in Figure 10 (without KV transform). The zonal overhead is increased for narrow beam width as the zone need to be reconstructed frequently whereas decreased in wide beam width. The estimated PL&T error increased in

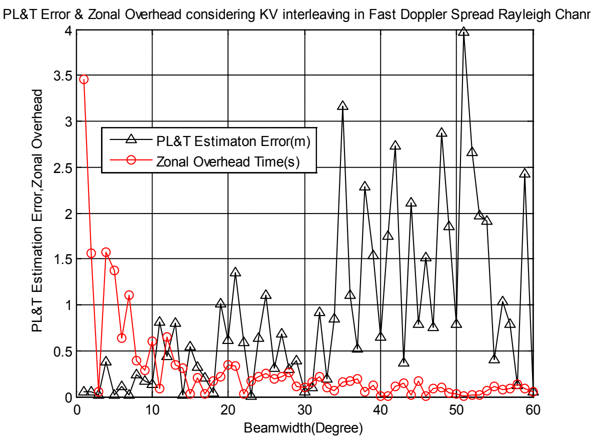

Fig.13 D-PLT in Fast Doppler Rayleigh Channel

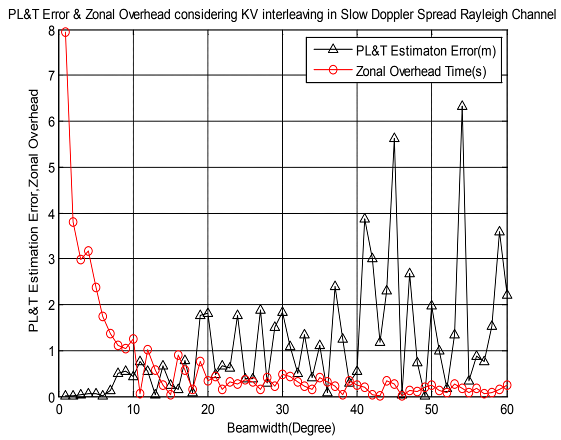

Fig.14 D-PLT in Slow Rayleigh Channel

the severe multipath fading channel with the increasing beam width. The PL&T estimated error has frequent jitters because the multipath faded channel model induced the random number of taps among three to ten. From the simulation results shown in Figure 12-14, the critical beam width for Dynamic PL&T is found 10 degree above which the zonal overhead decreases and estimation error increases significantly. The optimum beam width for Dynamic PL&T deploying narrow zone-forming and triangulation using two reference nodes, is 10 degree to optimize the estimation error and zonal overhead.

The Doppler spread spectrum for mobile speed =35m/s, carrier frequency F_c=2.54 GHz, maximum Doppler frequency shift fmax=45Hz and Doppler spectrum function vary from -4 to 4 at Doppler frequency of -44 Hz to 44 Hz. Doppler spread function increases at the higher range of frequencies observed at the output of the channel. PL&T error and zonal overhead is significantly reduced in fast Doppler spread Rayleigh channel than slow Doppler spread Rayleigh channel because the KV interleavingtransform has significantly better bit recovery performance against the deleterious effect in fast fading channel than slow fading channel under severely varying multiple taps. In other words, transmitted bits can be significantly recovered for symbol time $(T_s) > $ coherent time (T_c) and signal bandwidth $(B_s) < $ channel bandwidth (B_D). From simulation results, the average estimated location tacking errordecreased from 4m to 6m and average zonal overhead also decreased from 4 to 8 in fast Doppler spread fading than slow Doppler spread fading as shown in Figure 11 and Figure12. The major reason is that slow fadingchannel has only single realization and error cannot be detected and corrected whereas fastfading allow detection and error correction which leads to the significant tracking accuracy.

3. Conclusion

This paper described specific dynamic PL&T algorithm using the location based hash scheme to detect the malicious and friendly nodes, and friendly nodes track malicious node by adapting beam width over tracking zone. The average PL&T error is found significantly lower in the proposed PL&T scheme than other PL&T schemes. In addition, the optimum beam width for dynamic PL&T is 10 degree to optimize the estimation error and zonal overhead. On the other hand, the performance in terms of tracking accuracy is significantly improved in faded channels when using interleaving KV transform coding and achieves >90% accuracy using 10 db of E_b/N_o. The average PL&T error and zonal overhead are significantly reduced in fast Doppler spread Rayleigh channel than slow Doppler spread Rayleigh channel.

ACKNOWLEDGMENT

This research work is supported in part by the U.S. ARO under Cooperative Agreement W911NF-04-2-0054 and the National Science Foundation NSF 0931679. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the Army Research Office or the National Science Foundation or the U. S. Government.

4.References

[1]Shakhakarmi N., Vaman R. D.:Distributed Position Localization and Tracking (DPLT) of

Malicious Nodes in Cluster Based Mobile Ad hoc Networks (MANET), WSEAS Transactions in Communications, ISSN: 1109-2742, Issue 11, Volume 9, November 2010.

[2]Shakhakarmi N.,Vaman R. D.: Real Time Position Location & Tracking (PL&T) usingPrediction Filter and Integrated Zone Finding in OFDM Channel, WSEAS 2012 Transactions in Communications, E-ISSN: 2224-2864, Issue 7, Volume 11 , pp-241-250, July 2012.

[3]Shakhakarmi N.,Vaman R. D.: Integrated Key based Strict Friendliness Verification of Neighbor in MANET, IJCST Jan 22, 2011.

[4] Xiaofeng L., Fletcher W., Ian L., Pietro L., Zhang X.: Location Prediction Algorithm for Directional Communication, Computer Laboratory, University of Cambridge, U.K, Beijing University of Aeronautics and Astronautics Beijing, UK, IWCMC, 2008.

[5] Malhotra N., Krasniewski M., Yang C., Bagchi S., Chappell W. :Location Estimation in Ad-Hoc Networks with Directional Antennas, Purdue University, ICSCS, 2005.

[6] Siuli R., Sanjay C., Somprakash B.,Tetsuro U., Hisato I., Sadao O.: Neighborhood Tracking and Location Estimation of Nodes in Ad hoc Networks Using Directional Antenna: A Testbed Implementation, Proceedings of the WCC, Maui, Hawaii, USA, June 13-16, 2005.

[7] Zhang B., Yu F.: Low-complex energy-efficient localization algorithm for wireless sensor Networks using directional antenna, Department of Integrated Electronics, Shenzhen Institutes of Advanced Technology, IET Commun., 2010, Vol. 4, Iss. 13, pp. 1617–1623.

[8] Yanchao Z., Wei L., Wenjing L.,Yuguang F.: Securing Sensor Networks with Location – Based Keys, IEEE Wireless Communications and Networking Conference, 2005, 1909 - 1914 Vol. 4,13- 17 March 2005.

[9] Huang Z., Shen C: Multibeam Antenna- Based Topology Control with Directional Power Intensity for Ad Hoc Networks, IEEE Trans. Mobile Comput., vol. 5, no. 5, May 2006.

[10] Peruani F., Maiti A., Sadhu S., Chat´e H., Choudhury R., Ganguly N.:ModelingBroadcasting Using Omni-directional and Directional Antenna in Delay Tolerant Networks as an Epidemic Dynamics," IEEE J. Sel. Areas Commun., vol . 28, no. 4, May 2010.

[11] Zhang Z., Iskander M., Yun Z., Madsen A.: Hybrid Smart Antenna System UsingDirectional Elements—Performance Analysis in Flat Rayleigh Fading, IEEE Trans. SignalProces., vol. 51, no. 10, October 2003.

[12]Ramanathan R., Redi J., Santivanez C., Wiggins D., Polit S.: Ad HocNetworking with Directional Antennas: A Complete System Solution, IEEE J. Sel. Areas Commun.,vol .23, no.3, March 2005.