

An Optimal Path Determination of Moving Beacons Using Localized Directional Routing Protocol in Mobile Adhoc Network

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Abstract: *The prior communication between the mobile nodes (beacons) in the network is not possible in some situations. As the network topologies and the network traffic conditions vary, the optimum position of the neighbor node should be determined. Localization is one of the fundamental problems in wireless adhoc networks, since locations of the mobile nodes are critical to both network operations and most application level tasks. Localization accuracy and reduction in the number of position information messages can be achieved, in real-time, by determining the optimal position from where the beacon should transmit its next position information. The RREQ sent by the sender is broadcasted leading to the flooding of the information messages. Directional Routing Protocol floods the RREQ packet in the network. We, first outline localized directional routing protocol to unicast the RREQ messages. For this an advisory can keep track of nodes using three hop concepts to find the shortest hop. We further present the pseudo formation control problem as an unconstrained optimization problem under free space propagation model.*

Keywords: Localization; Three hop; Trajectory; DRT; DNT

1. Introduction

Mobile Ad-Hoc Networks (MANETs) by definition are a kind of nodes capable of moving in a bounded or unbounded area [1]. These nodes can form ad hoc or decentralized networks without the support of any infrastructure. With the aid of this network (MANET) formation, the nodes of the network can communicate with the other nodes in the network. The possibility of existence of a prior communication network in a battlefield is very low, it necessitates deployment of an ad hoc network comprised of a number of small robots known as nodes with limited mobility to act as communication relays [2].

Localization [3] based routing protocols require the addition of new hardware. This hardware, attached to each node, provides each node with its own point of reference. In general, the addition of new hardware to sensor nodes decreases their lifespan by increasing their operating cost (power consumption). Also important, when GPS devices are used, each node does not need to be configured to have a unique identifier, because their position can be used as a unique identifier (beacons).

Flooding is a technique that relays message from the source node to all other nodes in the network. The main drawback of flooding is redundancy of messages, complexity and it is not energy aware. Duplicate packets may circulate forever, unless certain precautions are taken.

Range-free localization depending only on connectivity may underutilize the proximity information embedded in neighborhood sensing. DRP is an on-demand directional routing protocol [4]. DRP closely couples the routing layer with the MAC layer and assumes a cross-layer interaction between some of the modules. In DRP the Directional Routing Table (DRT) is local to routing layer and maintains

the routing information to different destination. The Directional Neighbor Table (DNT) on the other hand is shared with MAC. Reactive protocols [5] employ a lazy approach whereby nodes only discover routes to destinations on demand.

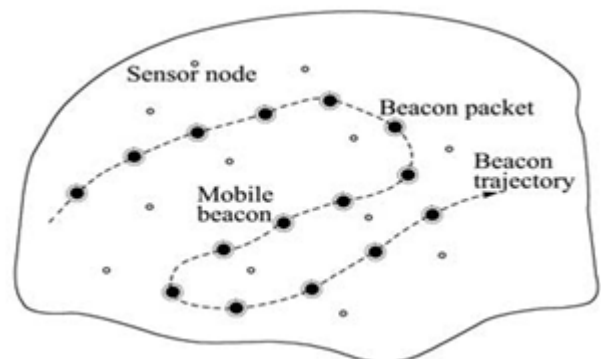


Figure 1: Beacon path determination

An omnidirectional DSR protocol running over a single switched beam directional antenna system is considered which lead to the foundation of Directional Routing Protocol (DRP). In a single switched beam directional antenna systems, sweeping is needed across all antenna beams in order to cover a node's one hop neighbor. But this adds to both packet redundancy and delay. Hence a specific direction is set by determining the optimal route to the destination.

2. Literature Review

Tian He, Chengdu Huang et.al proposed the APIT algorithm based on the triangles formed by reached anchors. When a normal node is reached by a set of anchor nodes, it randomly chooses three of them and tests whether it is inside the triangle region formed by those three anchors. In [6], the authors use neighborhood information to help the test. The

algorithm assumes if two nodes receive signals from the same transmitter, the node that gets stronger signal (with higher energy) is closer to that transmitter Niculescu et al [7] found that locally positioning only the nodes involved in communication, instead of trying to construct a relative relationship for the whole network, is good enough. The authors of [8], considered the limits and communication constraints of wireless ad hoc networks, and extend the classical multidimensional scaling algorithm with more advanced features. Specifically [9] provides iterative multidimensional scaling (IT-MDS) and simulated annealing multidimensional scaling (SA-MDS). The ITMDS algorithm considers the constraints from communicating neighbors, and embeds these constraints into the MDS algorithms in order to minimize the estimate errors iteratively. Huan-Qing CUI et.al considered the network based technologies [10] for obstacle in trajectory determination using combinational techniques 1) Time of Arrival (TOA), worked by measuring the arrival time of a known signal sent from a (mobile) node received at three or more measurement units It was reported that the accuracy of TOA was about 100-200m. 2) Time Difference of Arrival (TDOA): It worked similar as TOA in that both technologies utilize signal propagation time The known accuracy was about 100-200m. V.Bhanumathi et.al [11] proposed RSS based energy efficient scheme ,for reducing the amount of overhearing the rebroadcast in MANET. Dinesh Ratan Gautam, Sanjeev Sharma and Santosh Sahu in their paper [12] have discussed the issues of power consumption in MANETS. They also proposed a technique to conserve the power of nodes by varying the input power to the transmitting antenna which will vary the range of the node according to the distance of communication. Farah Mourad, Hichem Snoussi et.al [13] proposed an original algorithm for self-localization in mobile ad-hoc networks. The proposed technique, based on interval analysis, was suited to the limited computational and memory resources of mobile nodes. Ravishankar, Rakesh V, Praveen Kumar K [14] proposed a new localized routing protocol, called localized energy-aware restricted neighborhood routing (LEARN). In LEARN, whenever possible, the node selects the neighbour inside a restricted neighborhood that has the largest energy mileage (i.e., the distance travelled per unit energy consumed) as the next hop node. Fabio Pozzo, Lucio Marcenaro, Carlo Regazzoni et.al [15] implemented Location Aware Optimized Link State Routing Protocol (OLSR) protocol, based on the introduction of the Perceived Coverage Radius and the Perceived Coverage Area concepts. Our proposed method differs significantly from the previous work by determining a path for the moving beacons using the estimated positions of the ULN. This will improve localization efficiency and reduce flooding in comparison with the pure flooding.

3. Proposed Work

3.1 Determination of unlocalized nodes (beacon position and states)

Consider the beacons moving in a straight line with a velocity v in the adhoc network area. The initial direction of beacon motion is chosen randomly using the random waypoint model. The node receiving the data packet contains the position messages and the transmission range of the

beacon. Unlocalized node can only receive the message if its distance is less than or equal the transmission range R .

- i) The beacon receiving the first message enters into init state .The message contains the position, node id and flag value as 0.
- ii) Estimate: After entering the in it states, the node receives the second message and it is capable of determining the confining area. The flag value as 1. Then it can enter into intermediate or localized state.
- iii) Intermediate: If the node is not successful in determining the confining area, then it enters into the intermediate state and broadcasts the ack with flag as 2. iv) Localized: If the node has received all the messages and is successful in determining the confining area and its distance of the ULN is within the transmission range then it enters into localized state and flag value as 3.

The flow is considered as follows:

Step1: Variable for storing the value of status of node ($i=0, \dots, 49$). Step2: Four states: in it, estimate, intermediate, localized are considered. Step3: If the status is in it, then it enters into intermediate for finding the confining area and flag =2. Step4: If the node is localized, then it is capable of transmission ie continue. Step5: Obtaining the node id and its position at an interval. Step6: If not successful in determining confining area, then node is transferred to estimate (1) and consider following cases

- i) if (distance < minimum distance) then minimum distance = distance, and consider that minimum distance.
- ii) if (distance > maximum distance) then maximum distance = distance, consider that maximum distance;

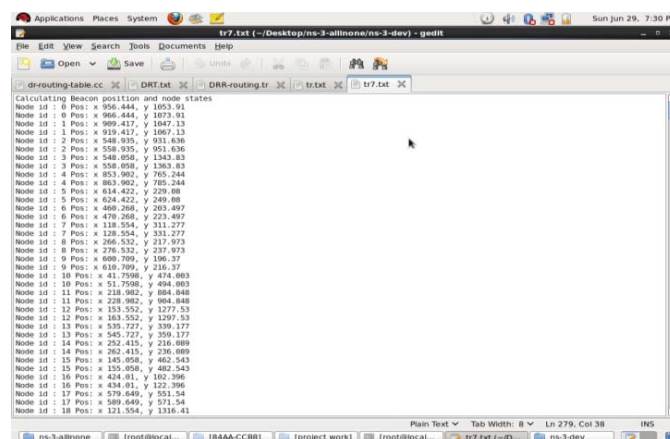


Figure 3.1: Positions of moving beacons

The maximum vertical and horizontal errors are given by the following equations: $EV = \sqrt{4R^2 - D^2}$, $EH = \sqrt{2R^2 - D^2}$ where D is the distance between two nodes. The number of information position messages will be reduced by selecting only those neighbor nodes which are lying in the confining area of the source and destination and it should be nearer to the circumference of the confining area. Beacon entering into different states before locating the exact position and no requirement for formation of particular shape.

3.1.1 Determining beacon trajectory

For a single beacon to determine its confining area the estimated new position of the beacon is considered [16]. When the beacon is inside the limiting contour (K), the

range circle of additional position message is generated to intersect with the lens shaped contour.

Step1: For the ULN to receive message distance $\leq (2 \times \text{transmission range})$.

Step2: If the condition satisfies then beacon traversing is done.

Step3: New node to be considered must intersect the confining area.

Cases: i) if (minimum distance > 0 & minimum distance $\leq (2 \times \text{transmission range})$)

ii) Positions of two nodes ($n1$ & $n2$).

iii) midx and midy to be calculated.

iv) calculating K, deltheta, newx, newy

$K = 2R/D$,

$\text{deltheta} = D/2(K-1)\sqrt{K+1}/\sqrt{K+\cos 2\theta}$

As K comes closer to unity, deltheta decreases, reducing the confining area.

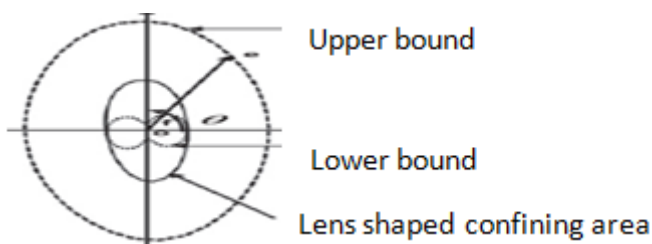


Figure 3.2: Limiting contour for K=2.0287

3.2 Designing the Directional Routing Protocol

Directional Routing protocol is an on-demand routing protocol. To find the information of the neighbor node directional routing table (DRT) and directional neighbor table (DNT) are constructed. It is a cross interaction between MAC layer and routing layer. DRT provides the respective destination to which message is forwarded and the route (route indicates the respective neighbor node and the beam id) and the DNT indicates the neighbor information. Range free propagation with nodes divided into different lobes (four quadrant) [17]. To overcome the flooding of route request in DRP, for a given source X (considered as beacon) and the destination Y (beacon), if Y is not in the DNT of X, X floods a RREQ packet in the network. To reduce the broadcasting of the packets the localization technique is applied on the source node. The beacon X will construct the three hop table formation. In the first hop the nodes which are closest two to the X are determined. Then in the second hop the nodes which are slight faraway are determined. Then in the third hop all the other nodes can be determined. But in the scenario if still Y is not in the three hop table, then only X will broadcast the RREQ. In the method if a node receives multiple packets from the same node, it maintains and rebroadcasts the one with the least hop counts while ignoring all the rest. This optimization will eventually lead to a shortest path to the beacons. Thus reducing the flooding.

3.2.1 Directional Neighbor Table

Providing the information of neighbor beacons. It consists of node id and quadrant. The distance from same source to destination is considered to be 0. But if the distance between the nodes is within transmission range then shortest path is considered to be 1. Sectorization of the node is to be done, dividing the nodes into four quadrant. For the source beacon

selecting the optimal route to identify unlocalized nodes a specific angle is to be determined by the source node. The nodes which are confining with the area set by the direction angle (θ) are considered for the table construction. The angle can be determined by the respective (X,Y) co-ordinates of the source node (beacon)

Node Id	Quadrant1	Quadrant2	Quadrant3	Quadrant4
0	43	49	48	44
1	43	49	48	42
2	46	49	47	42
3	45	49	47	19
4	43	49	47	42
5	31	45	49	47
6	43	45	49	42
7	45	49	48	14
8	45	49	48	19
9	0	43	49	47
10	49	43	48	0
11	43	49	48	46
12	43	49	48	26
13	0	45	49	47
14	45	49	48	7
15	45	49	48	28
16	43	45	49	44
17	0	45	48	49
18	43	49	48	44
19	45	49	47	0
20	45	49	48	15
21	43	49	48	42
22	0	43	49	47
23	43	49	48	44
24	49	43	48	47
25	31	49	48	38
26	45	49	47	0
27	45	43	49	47
28	0	45	49	47
29	43	49	48	44
30	43	45	49	46
31	0	43	49	47
32	43	45	49	48

Figure 3.2.1: Directional Neighbor Table for all nodes

3.2.2 Directional Routing Table

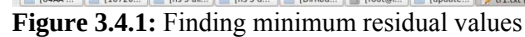
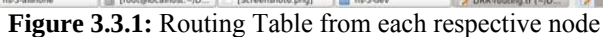
Directional Routing Table consist of route and destination. DRP uses the beam ID kept in the DRT to do an efficiency route discovery.

At Time 1 sec	Dest	Route
Route1	>43 (1)	
49 (2)	45 (2) 43 (2)	
48 (3)	47 (3) 42 (3) 41 (3)	
44 (4)		
Route2	>43 (1)	
49 (2)	45 (2) 43 (2)	
48 (3)	47 (3) 42 (3) 41 (3)	
44 (4)		
Route3	>44 (1) 43 (1)	
49 (2)	45 (2) 43 (2)	
47 (3)	42 (3) 41 (3)	
42 (4)		
Route4	>45 (1)	
49 (2)	45 (2) 43 (2)	
47 (3)	42 (3) 41 (3)	
19 (4)	3 (4)	
Route5	>43 (1)	
49 (2)	45 (2) 43 (2)	
47 (3)	42 (3) 41 (3)	
42 (4)		
Route6	>51 (1)	
45 (2)	43 (2)	
49 (3)	48 (3) 47 (3) 42 (3) 41 (3)	
47 (4)		
Route7	>39 (1) 31 (1)	
49 (2)	45 (2) 43 (2)	
48 (3)	47 (3) 42 (3) 41 (3)	
42 (4)		
Route8	>45 (1)	
49 (2)	45 (2) 43 (2)	
48 (3)	47 (3) 42 (3) 41 (3)	
38 (4)		
Route9	>45 (1)	
49 (2)	45 (2) 43 (2)	
48 (3)	47 (3) 42 (3) 41 (3)	
38 (4)		
Route10	>-	
42 (2)		
49 (3)	48 (3) 47 (3) 42 (3) 41 (3)	
47 (4)		
Route11	>49 (1)	
43 (2)		
48 (3)	47 (3) 42 (3) 41 (3)	
Route12	>43 (1)	
49 (2)	45 (2) 43 (2)	

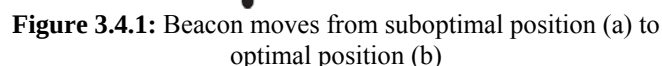
Figure 3.2.2: Directional Routing Table for all nodes

3.3 Three hop method

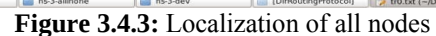
The routing table is constructed by considering the route from among all the individual nodes. The source address, destination address of each node is determined through relay address. The flag value is considered as 0 (valid route) and 1 (invalid route). The hops are considered as 0 (one-hop neighbor), 1 (two hop neighbor), 2 (three hop neighbor). If a beacon receives messages from more than two nodes at same instance, so instead of dropping the three hop method helps to determine the nearest neighbor to forward message on.



In the case of a single ULN, by confining the trajectory of the beacon to the limiting contour, localization can be achieved accurately with a small number of beacon position messages. However, this approach would not work for more than one node.



- ii) if (distance $\leq$ (2 * transmission range)) Obtaining the position of that node by moving it with some coordinate.



Due to localization technique the optimal position of the neighbor node from which the moving beacon should send the further request can be determined. At each and every instance as the nodes get localized their position becomes fixed.

4.1 Stimulation Parameters

Simulations are performed with Network Simulator 3(NS3.25) to examine the localization accuracy of the proposed scheme. The simulation environment is described as follows. The deployment area of 1000m x 1500m, and 50 randomly moving distributed ULNs and transmission radius of 200m. The duration of simulation corresponded to the beacon transmitting 4600 beacon position messages. Since, the LAndroids program required the nodes to operate with approximate location information.

	Item included	Item description parameter
1	Simulation Area	1000mx1500m
2	No of nodes(beacons)	50
3	Radio propagation model	Wifi-model
4	Channel Type	IPV4 wireless channel
5	Antenna Model	Omni Mobility model
6	Routing Protocol	Localized Directional routing Protocol
7	Hop count	3
8	Sequence no	10

For trajectory based on random waypoint model, the beacon transmitted a new position message for every distance travelled.

1. PFCA based localization performance

The number of nodes localized in the deployment area of 1000m x1500m for the pattern based on PFCA with transmission radius of 200m, considering the variation in the simulation time. The scenario is deployed on 50 nodes. The improvement in performance ranges from 19 nodes to localization of all nodes. The poor performance of the localization with random waypoint trajectory can be attributed to the beacon not having any knowledge of the estimated position of the ULNs and a majority of the position messages received not contributing to the localization process.

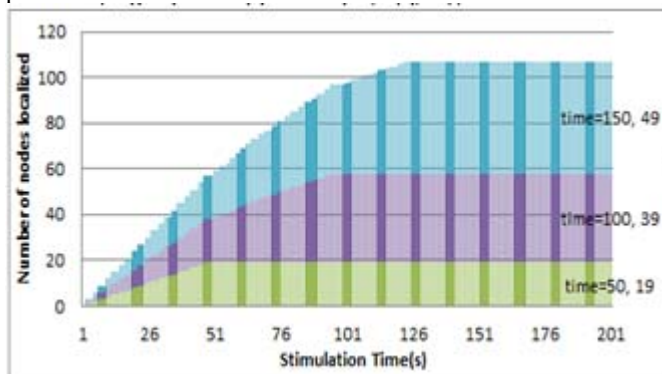


Figure 4.1: Number of nodes localized using PFCA based trajectory

In fig 4.1, the number of nodes are localized using different time interval, at the time interval of 50s, 19 ULNs are localized. As the time increases, considering 100s, 39 ULNs are localized and in case of 150 s, the maximum number of ULNs are localized. The power consumed by the beacon for transmitting position messages is reduced significantly with the PFCA based trajectory. As the distance is less, according to variation in transmission radii, then more number of nodes get localized within area.

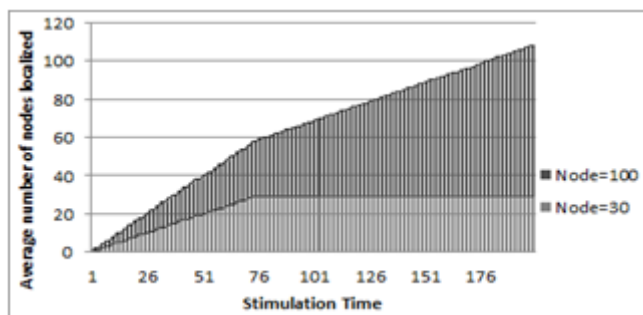


Figure 4.2: Number of nodes localized with 30 and 100 ULNs

To analyze the effect of varying nodes and the simulation time, more time is required for localization of nodes. The transmission relay between the nodes also increases. In fig 4.2, localization of 30 nodes required the time interval as 100s. But as the nodes increased as 100, the time required for localization can be considered as 200s. The sectorizations of the nodes are done in order to determine the nearest neighbor

along with the shortest hop. In fig 4.3, at each and every time instance, distribution of the nodes, in various quadrants can be seen. Also from the simulation, while localizing a node at different time interval 5sec, it is found that at first instance, 440 in quadrant1, 752 in quadrant2, 752 in quadrant3 and 489 in quadrant4. Now, as time interval increases to 15s, 541 in quadrant1, 657 in quadrant2, 657 in quadrant3 and 595 in quadrant4. Now, at time interval of 20s, 583 in quadrant1, 619 in quadrant2, 619 in quadrant3 and 629 in quadrant4. The difference between the nodes lying in the respective quadrant decreases as the time interval increases. That is, the increase in time is directly proportional to the localization of the nodes in the transmission area. More and more nodes get localized as the time increases respectively.

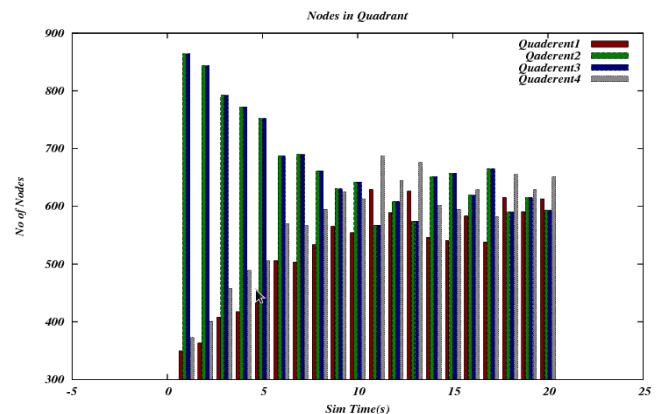


Figure 4.3: Sectorization of nodes

Fig 4.4 indicated that LDRP with its antenna handoff module is able to maintain a fairly constant throughput with increasing time interval. For example with the simulation time of 25s, 100 kbps throughput is achieved. The RREQ message is unicasted for localizing a node. In contrast, frequent flooding of messages, due to broadcasting in DRP leads to a decreasing throughput. It goes on decreasing rapidly to 20kbps.

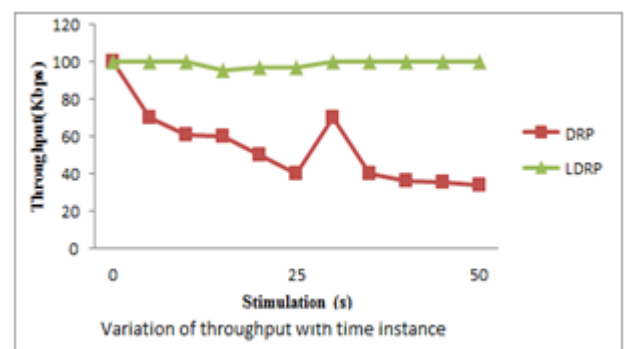


Figure 4.4: Variation of throughput with time instance

B) Simulation Result

Simulation mainly investigated location accuracy of the proposed LDRP. The simulation result for localization of nodes using PFCA based trajectory is shown in fig 4.5. At the time interval of 5 sec, 7 nodes are localized, as time increases to 15 sec, 16 nodes are localized and as the time increases to 45 sec, 18 nodes are localized and finally at 50 sec all the nodes get localized and we obtain a constant value and straight line. A staircase scenario is generated for localizing nodes at different time instance. The proposed PFCA increases maximal localization using LDRP.

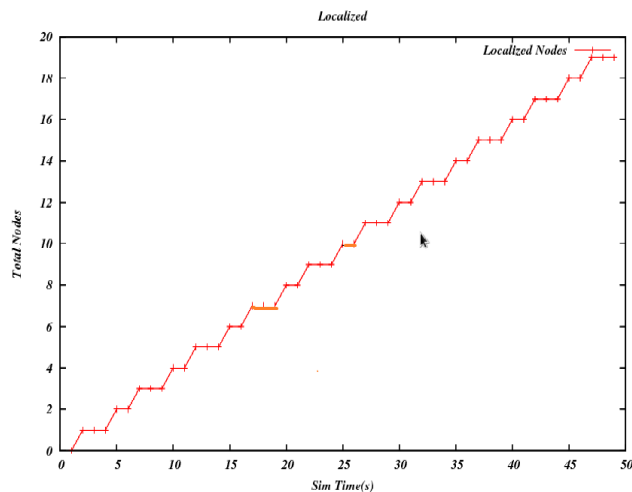


Figure 4. 5: Localization using PFCA based trajectory

LDRP localized the nodes before transmitting the message to the intermediate neighbor to avoid flooding. In fig4.6 the comparison is determined with DSR protocol and our proposed LDRP protocol. In DSR, with the time interval of 25 s, 225 packets are flooded, and with increasing in simulation time for 45 s, 550 packets are flooded. As the result performance for localization accuracy decreases. But in our proposed protocol, there is decrease in flooding of the packets as message is transmitted only after finding the optimal position of the neighbor node. For example with the time interval of 50s only 150 packets are flooded. Thus increasing the performance for location accuracy and the power consumed by the beacon to localize. Location accuracy and reduction in the number of position information messages can be achieved.

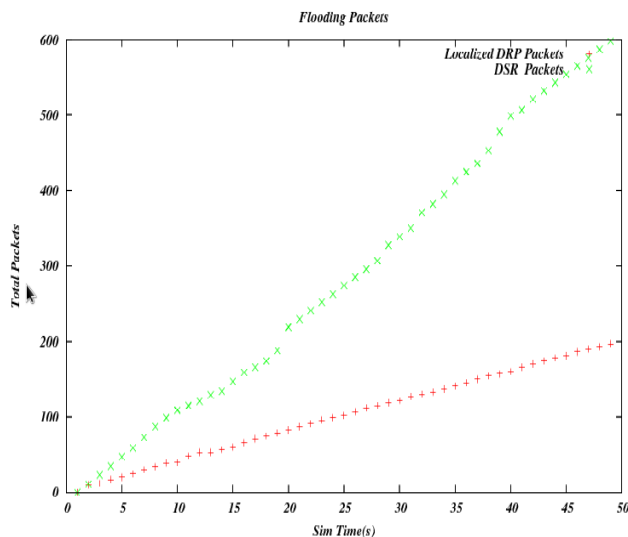


Figure 4. 6: Flooding of packets for LDRP and DSR protocol

2. Effect of OPT, transmission range and number of ULNs on PFCA based localization

To analyze the effect of optimal threshold position (OPT) and transmission range on localization performance with the PFCA based trajectory, simulations were performed with different OPT and transmission range of 200m. The number of nodes localized with increasing values of OPT for transmission range of 200m. In fig 4.7, with increasing value of OPT for the transmission radius of 200m, the number of

nodes localized decreases. As the OPT value increases with fixed a fixed transmission radius, the probability of the beacon having the number of ULNs equal to OPT within its transmission radius decreases further. For example with the OPT value 5, 90% nodes are localized, whereas with OPT value 20, only 40% nodes are localized. This lead to better localization performance as compared to fig 4.7.

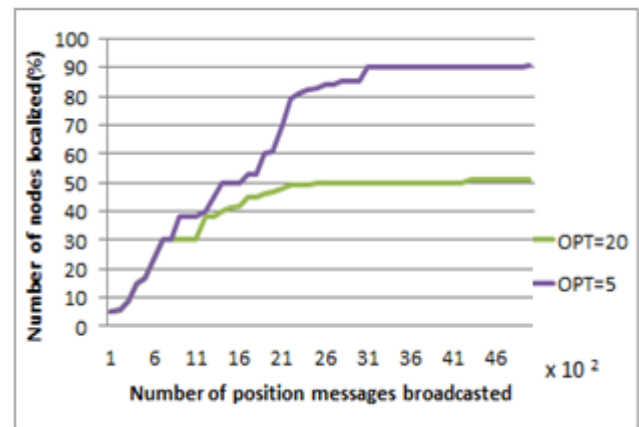


Figure 4.7: Number of nodes localized with transmission radius 200 for our proposed work

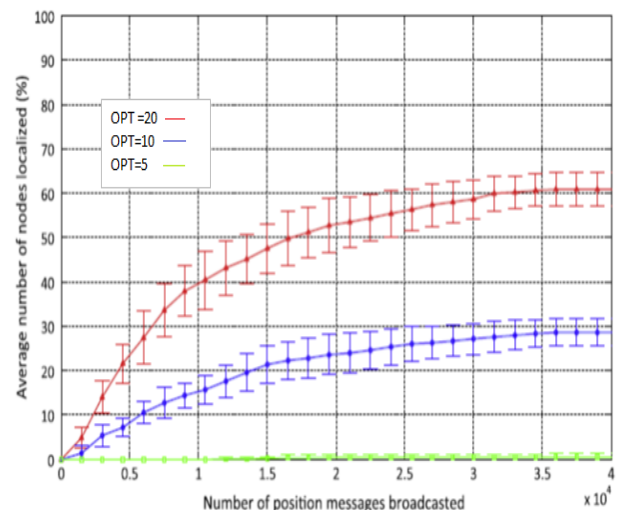


Figure 4.8: Number of nodes localized with transmission radius 200m for previous work

5. Conclusion

In this paper, we proposed a three hop concept for creation of routing table to determine an optimal trajectory for the moving beacons to improve the localization accuracy. The basic idea is to determine a beacon position such that the ULNs are located close to the circumference of the circular transmission. The pseudo control flow algorithm under free-space propagation model was considered for finding the localized node. The pure flooding leads to broadcasting of messages; this has been reduced by applying localization. We have also shown that with an increase in the deployment area, the location accuracy remains the same as compared to random waypoint model.

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