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Research Article

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Posted Date: March 9th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-197461/v1>

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Version of Record: A version of this preprint was published at Wireless Personal Communications on August 20th, 2021. See the published version at <https://doi.org/10.1007/s11277-021-08715-6>.

Intelligent decision making algorithm for balanced cluster formation in Wireless Sensor Networks

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Abstract:

In this paper, we propose an optimal cluster-based multiple sink reconnection technology for wireless sensor networks using a hybrid optimization algorithm. The proposed design used an intermediate sensor / mobile node next to the sink node and a sensor node ready to transmit data. Here, the weighted k-mean algorithm is converted to a cluster node. The optimal cluster head code was chosen using a mass optimization method that targets the available energy and available bandwidth for successfully transferring data without node optimization. So with resource updates, you can find the right location for your sink node for better data transfer.

Keywords: cluster-based multiple sink, hybrid optimization algorithm, intermediate sensor, sink node and a sensor node ,weighted k-mean algorithm.

Introduction:

Wireless Sensor Network (WSN) is compatible with home network environments with features such as home architecture, infrastructure and fault tolerance. WSN has many sensors and actuators that can detect, process, and send home source data to remote source sockets. [1] [2] Typical home applications for WSN include home automation, home activity detection and home hygiene. Network sensor devices are usually small and hard to charge. Therefore, it is very important to design an energy efficient network layer algorithm to increase the home network lifetime. Recently, energy-efficient routing algorithms and protocols have been proposed to enhance WSN's network life. In this routing scenario, zinc nodes are usually fixed inside or

outside the WSN [3] - [5]. Hotspot events inevitably occur when sensors near the sink node have a higher traffic load than the sink node on multi-hop transmissions. It consumes much faster than all available power, reduces network performance, reduces network layer, insulated nodes, and network life.

The quality of service received for these applications begins to diminish with the amount of real-time data, and most packets lose significant time. One of the solutions is to explore the gateway's ability to obtain real-time data to improve time in these situations. In this case, reinstalling the gateway balances the traffic load on multiple nodes and reduces the miss rate of real-time packets [7]. The gateway is a laptop computer or other small device that does not expect a long journey behind the rescue team. Changing the gateway during regular network operation is difficult [8] [9]. Gateway reconfiguration is where gateways go, and how gateway tasks handle data traffic. When adding real-time packets, you must first promote gateway broadcasting for traffic sharing, network performance improvements, inefficient power outages or downtime. Game Theory and Advanced Agent Colony-Based MS. Path selection and data collection (GTAC-DG) technology is used to select the best RP for MS and to evaluate the overall intelligence of advanced agent colony optimization [11]. The main objective of this study is to improve the energy consumption and network life of the sensor nodes in relation to the optimal clustering effect.

Keyword: multi-sink repositioning, queen honey bee optimization, multi-choice chaos optimization, intelligent decision making

The paper is arranged six sections. It starts with introduction in which details of the WSN, sink repositioning its application, major issues in the existing technique. The second part is the related work, in this section different papers are survived to gets idea about different technique that isinvolved. The third section is the problem definition where major problems that are involved in the current technique are mention and its possible solution. The fourth section is gives the details of proposed algorithm. The fifth section is the result and its analysis. The last section is the conclusion.

2. Related work

During the data transmission in the WSN the sensor nodes are closer to the sink nodes and they provide the energy earlier than nodes as they away from the data packets [15]. The advantage of WSN is energy saving and its cost is effective. Karkvandiet al. [16] introduces technique to solve the problem of linear program. AlShawiet al. [17]introduces a combination of Fuzzy approach and A-star algorithm for the improve the network lifetime. Yanget al. [18]introduces technique to reduce the energy in the node. Sensors are used to monitor and control the environment. Singhet al. [19] proposes PSO for cluster head and the data in the cluster node. Senturket al.[20]describes several factors such as battery depletion and hardware failures are the effect of wireless sensor networks. According to Thanigaivelu et.al [21] a typical wireless sensor network scenario, all the data are routed back to a static sink. Xiaet al. [22]have proposed traditional underground coalmine monitoring systems are mainly based on the use of wired transmission. Premanand and Rajaram proposed a routing scheme based on the backbone routing for the mobile ad-hoc network [27]. Rajaram and Palaniswamy proposed a trust based routing scheme in the wireless sensor network [28].

3. Problem methodology and system model

3.1 Problem methodology

In a WSN various numbers of sinks are there with large number of resources and sensors. Source is field where the data are generated. From the study it is clear that the data can be send to different multiple sinks[23]. Depending upon the real-time trafficsink relocationis used for different cases. This will reduce the life time of the node. Also due to the frequent movement of nodes the traffic of thenetwork will increase. Thus the reliability of the data transmission reduces. An optimal multi-sink repositioning (OMSR) technique is proposed using hybrid optimization algorithm. The main contributions of proposed technique are summarized as follows:

In OMSR technique, a queen honey bee optimization (QHBO) algorithm used for balanced cluster formation. It is inspired from the honey bee optimization algorithm.

Then, compute cluster head (CH) for each cluster using a multi-choice chaos optimization (MCO) algorithm. CH gathers data transmitted by its corresponding cluster member nodes and send it to base station via other CHs.

The sink repositioning is enhanced by an intelligent decision making (IDM) algorithm under consideration of performance metrics namely distance, received signal strength, available bandwidth and cooperation rate.

3.2 System Model

The figure 1 shows the system model. The system consist clusters, sink and nodes. The nodes are connected to transfer data. In a cluster the cluster head is calculated. Then the data transmission is performed with respect to the cluster head. The network is divided into different cluster. For the cluster formation the used technique is the queen honey bee optimization. In the cluster different nodes are present. For each node the trust degrees are calculated. The trust degree values are calculated by taking the parameters like receiver signal strength(RSS), bandwidth (BW) and distance (d).By comparing the highest trust degree node is identified and that node is taken as the cluster head. For the cluster head multi choice chaos optimization algorithm is used. The data transmitted using the cluster head. Then this node is link to the sink. The sink repositioning is enhanced using the intelligent decision making algorithm.

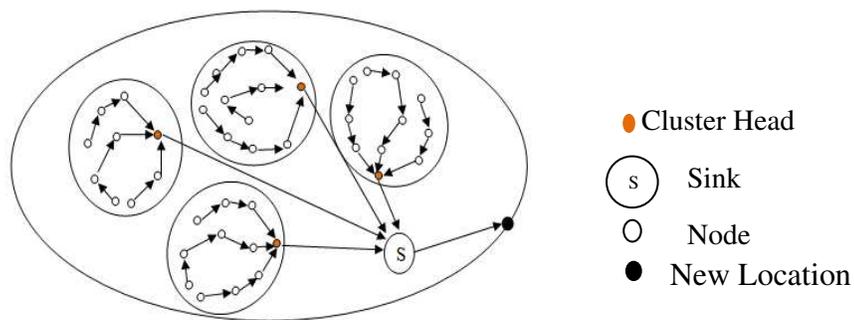


Figure 1 System Model of proposed OMSR technique

4. Proposed Optimal Multi-Sink Repositioning (OMSR) Technique

4.1 Cluster Formation using Queen Honey Bee Optimization Algorithm

In this work, the foraging behavior of honey bees (HBAC) is used to select the CHs. Clusters are formed based on the selected CHs. The role of CH is assigned to other nodes which have more nectar than old one. The CH nodes are re-elected after all members in a cluster sent their data via a time division multiple access (TDMA) schedule. The proposed HBAC algorithm works in two phases. The first one is the cluster setup, and the second is cluster maintenance and communication phase. Node which is having different mobility and different direction is the one which is not recommended for the CH. Thus the total energy of the node is calculated as y_i :

$$Y_i = E_n + Q_n + D_n + M_n \quad (7)$$

For the optimization process CH is calculated by using the distance of each CH. It is considered that the distance between the two CH is same. The distance between the food sources are approximately same. This technique will help to solve the problem of grouping that existing in the cluster. It will also reduce the overlapping of clusters. Also the position of the node is given by $y_i \in I_n$ and the average fitness value is given by $c_j \in I_n$. the weight of the node is given by z_{ij} .

$$\text{Minimize } F(w, c) = \sum_{i=1}^n \sum_{j=1}^k z_{ij} (x_i - c_j)^2 \quad (8)$$

$$\text{When } \sum_{j=1}^k z_{ij} = 1 \quad (9)$$

$$c_j = \frac{2}{n_j} \sum_{i=1}^k z_{ij} y_i \quad (10)$$

where n_j is the total number of node in the j^{th} cluster. It is assumed that if node i is assigned to a cluster j , the value of z_{ij} will be 1 or 0. This is the initialization process. The next step is the new population or new connecting clusters that are coming to the existing cluster. The clusters will accept the cluster head in the new cluster by checking the value of the CH. The process of checking the property of the new cluster is given by the equation below. The actual quantity of nectar at node i is given by $Q(N_i)$.

$$Q_i = \frac{1}{1 + cf_i} \quad (11)$$

Where cf_i is the cost function of the node and the equation of the cost function is given by:

$$cf_i = \frac{1}{k} \sum_{i=1}^k d(x, N_i) \quad (12)$$

The probability of the working bee at the node y_i is given by P_i :

$$P_i = \frac{Q_i}{\sum_{k=1}^{f_s} F(N_j)} \quad (13)$$

The cluster formation of the using QHB algorithm is explained in the Algorithm 1.

Algorithm 1 Queen Honey Bee Algorithm for Cluster Formation

Input	E_n, Q_n, D_n, M_n
Output	Cluster Formation
1	Initialize the values of E_n, Q_n, D_n, M_n .
2	Find the value of total energy of the node x_i
3	Calculate the value of CH
4	Find the fitness value ζ_i
5	Calculate the value of Q_i, ζ_i, P_i .
6	while ($P_{i,new} < \zeta_{i,new} > \zeta_i, P_i$)
7	Create new cluster.
8	Calculate the cluster value CH using MCO algorithm
8	Replace the old cluster with the new cluster
9	end
Return	Cluster formation

4.2 Cluster head formation using Multi Choice Chaos Algorithm

The CH is selected according to the trusted degree value. The node which is having the highest trusted value is selected as cluster head. The CH of one cluster can communicate with the cluster head of other cluster. Received signal strength (RSS) is measured by taking the distance and transmission energy. The equation of RSS is given by:

$$RSS = \frac{FFE(n, d)}{4\pi D_i^2} + T_{a, a_1/a_2} \quad (1)$$

The life time is the maximum time duration of network and the perfect network maintains congestion should be less and high life time.

The distances (d) between the clusters are calculated using Euclidian distance and this distance is same for the entire cluster head.

$$d = \sqrt{(x_A - x_B)^2 + (y_A - y_B)^2} \quad (2)$$

where (x_A, y_B) is the position of node A in the network and (x_B, y_B) is the position of node B in the network. Consequently, Euclid distance between two nodes has a square relation with the sent energy.

The equation for calculating the BW is given by:

$$BW = \frac{Ns (CH(n) + 1)}{l} \quad (3)$$

Where Ns all sensing child nodes, l is the length of the length of the link. If the BW is high then the QoS will high it will improve the performance of the network.

Depending on all the above mention condition the trust values are calculated for every node. Then, the depending on those values the CHs are assigned for each cluster. The trust values for neighbor nodes are given by T_n :

$$T_n = \text{Avg} (RSS, BW, d) \quad (4)$$

4.1.1 Multi-Choice Chaos Optimization (MCO) Algorithm

The ‘chaos’ means something that cannot be predicted. Chaotic phenomena are involved when chaos is combined with the deterministic. Chaotic phenomena involve specific laws, mathematical apparatus and a physical origin. There are no random or any stochastic effects in the deterministic chaos. A discrete chaotic map is a type of deterministic chaos. It uses iterated functions to determine the function. For the CH formation the used map is the Lozi map, the common equation is given by:

$$X_{n+1} = 1 - a |X_n| + bY_n \quad (5)$$

$$Y_{n+1} = X_n \quad (6)$$

This is used because it is simple type map that are used for repeated comparison of the values in the group of areas. The cluster head formation of the using MCO algorithm is explained in the Algorithm 2.

Sink Repositioning using Intelligent Decision Making

From biological species like shoals of fish, flocks of birds, and colonies of ants IDM is originated. It is commonly used for analyzing the unsophisticated agent interaction locally with their environment. This interaction will make coherent functional global patterns. It consists of s particles and it is operating in n -dimensional space. The number of nodes to be optimized is given by n . The position of the node is given by x_i and the velocity of the node is given by c_i . The value of i is given by $1 \leq i \leq s$. Initially the position of the node is given by $x_{\min} < x_i < x_{\max}$ and $c_{\min} < c_i < c_{\max}$.

Algorithm

Input: RSS, BW, d , T_n
Output: CH

- 1 Initialize network
- 2 For each node the trust value (T_n) is calculated.
- 3 Send the node value to the neighbor node
- 4 while (T_n of clusters are compare)
- 5 Cluster having highest T_n is calculated as CH.
- 6 For all cluster the CH value is calculated
- 7 end

Return CH value

$$c_i(k+1) = w \cdot c_i(k) + c_1 \cdot rand_1 \cdot (p_{best} - x_i) + c_2 \cdot rand_2 \cdot (g_{best} - x_i) \quad (14)$$

$$x_i(k+1) = x_i(k) + c_i \cdot (k+1) \quad (15)$$

where $rand_1$ and $rand_2$ are random numbers having uniform distribution in the range (0, 1), w is the inertia coefficient and its value varies from $0.2 < w < 1.2$, the velocity is given to each node and it is given by x_{\min} and x_{\max} . Magnitude and direction of movement of a particle is influenced by its previous velocity, its experience and the knowledge it acquires from the swarm through social interaction. The working function of sink repositioning using the IDM algorithm is given in Algorithm 3.

5. Result and Discussion

The simulations are performed using NS2 simulation environment. The simulations are carried out with metrics for both proposed systems and existing. From the comparison it is clear that existing LTRC-ORC technique [25] has low performance as compared to the proposed system OMSR. For the simulation process the total number nodes varied from 10000 to 90000. The operating bandwidth is 2.4GHz. The initial energy of the node is given by 18520J. The network area is considered as 500×500 m. It is taken that the topology is a uniform type. The table 1 shows the parameter values that are used for the simulation.

Algorithm 3 IDM for Sink Repositioning

Input	c_i, x_i
Output	Sink Repositioning
1	Initialize the node values x_i .
2	Find the initial velocity c_i .
3	Find the value of x_i and c_i .
4	Find the k^{th} value of x_i and c_i i.e. $x_i(k + 1)$ and $c_i(k + 1)$.
5	The velocities are assigned to each node again
6	Calculate threshold value t .
7	While (c_i is less than t)
8	Update the each node and compare.
Return Performance Enhancement	

Table 1: Performance Parameters

Parameter	Value
No: of node	10000 - 90000
Velocity of node	1 m/s
Simulation area	100m
Initial energy	18,520 J
Topology	Uniform
Area	500×500 m
Threshold voltage	100mv
Data rate	250 kbps
BW	2.4 GHz
Packet size	97 bytes

5.1 Varying number of nodes

This section simulation is carried out with the number of node as the common parameter. The simulation graph of the security level is shown in the figure 2. It is clear that the proposed OMSR technique is having high security as compared to the existing system. From the graph there is 10% improvement in the security level when OMSR is used. The next parameter is the energy consumption. The simulation graph of energy consumption is shown in the figure 3. It is clear that the OMRS technique will reduce the energy by 27% as compared to the existing LTRC-ORC technique. The figure 4 shows the simulation analysis of the false. There false positive rate for the 45% less than the existing LTRC-ORC technique. The figure 5 shows simulation result of the packet delivery ratio. From the analysis it is clear that the delivery ratio of the proposed OMSR technique has an improvement of 20%. The figure 6 shows the simulation result of the network life time. It is clear that by using the proposed technique the lifetime of the network increases by 27.5%. The figure 7 shows the simulation graph of the packet loss. The graph shows that packet loss is low for the proposed technique.

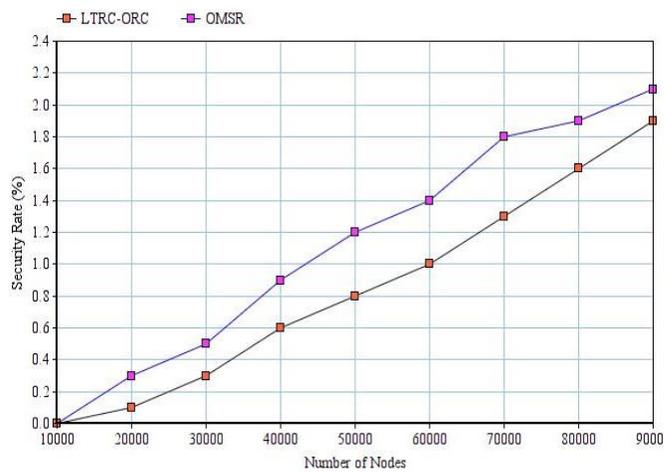


Figure 2 Security Level with Number of Node

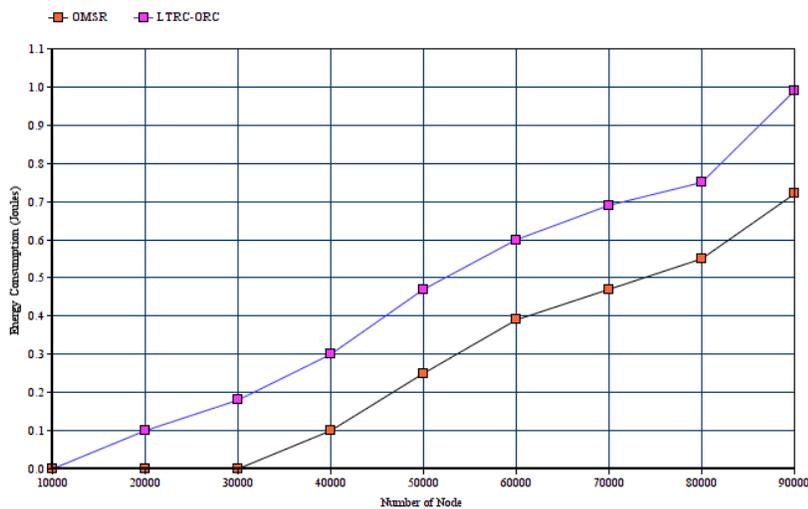


Figure 3 Energy Consumption with Number of Node

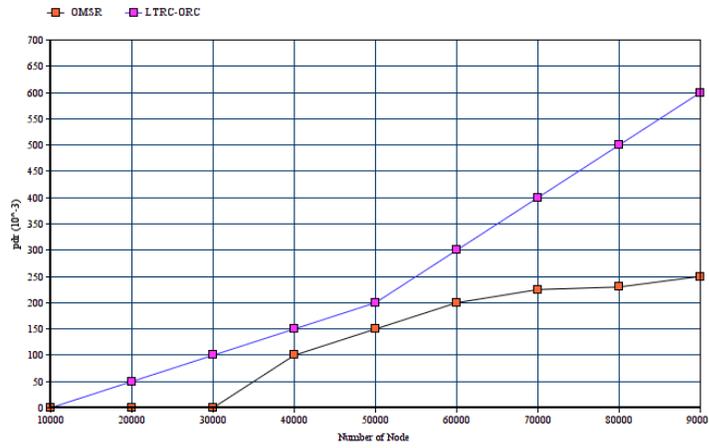


Figure 4 False Position Rate with Number of Node

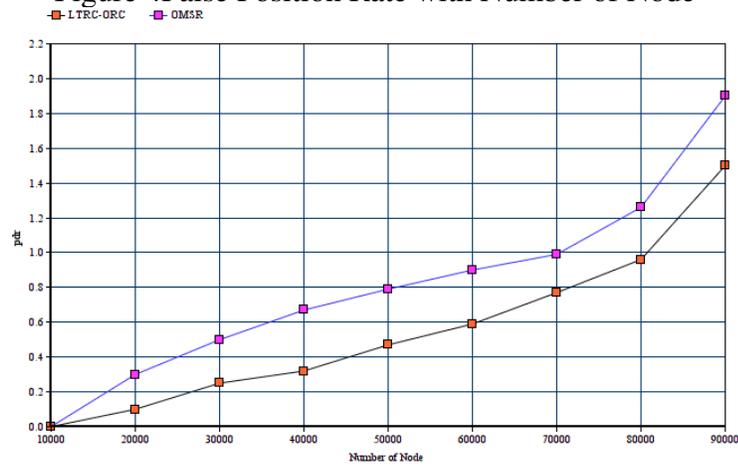


Figure 5 Packet Delivery Rate with Number of Node

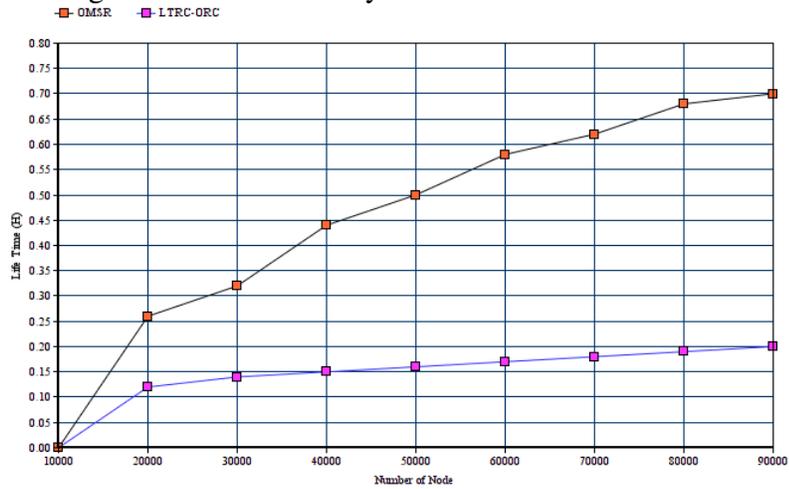


Figure 6 Network Lifetime with Number of Node

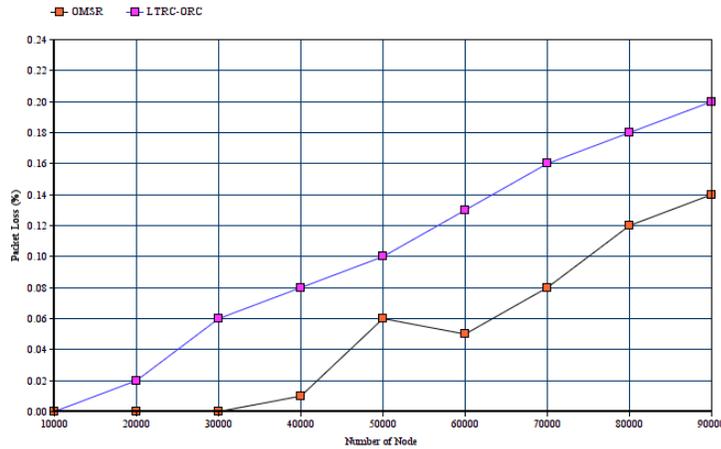


Figure 7 Packet Loss with Number of Node

5.2 Varying the Mobility

As similar to that of 5.1 all the parameters are simulated with the constant parameter mobility. The variation of the analysis is shown in the below. The figure 8 shows the simulation analysis of the security level. From the analysis it is clear that there is a 30% of improvement of security level in the proposed OMSR technique. The figure 9 shows the simulation analysis of the energy consumption. From the analysis it clear that the proposed technique OMSR reduces the energy consumption by 54%. The simulation analysis of the false positive rate is given in the figure 10. The graph shows that the using OMSR technique it is possible to identify false 54% as compared to the LTRC-ORC. Figure 11 shows the simulation of the packet delivery ratio. OMSR has an improvement of 46%. Network lifetime simulation analysis is given in the figure 12. The network lifetime increased by 55% when OMSR technique is used. Simulation of the packet loss is given in the figure 13. The packet loss is reduced by a percentage of 50%.

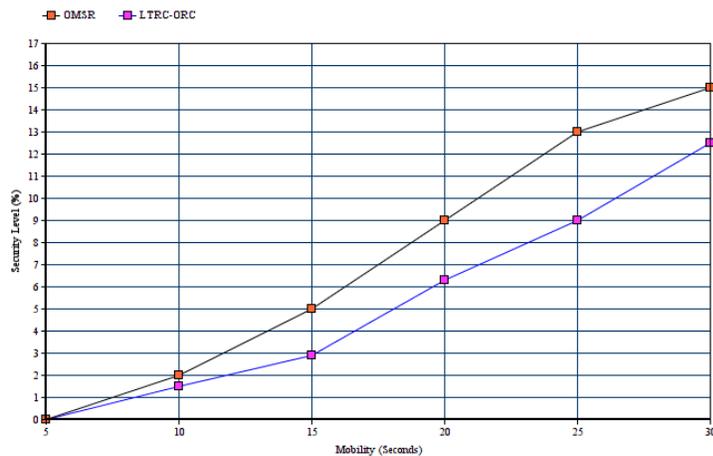


Figure 8 Security level with Mobility

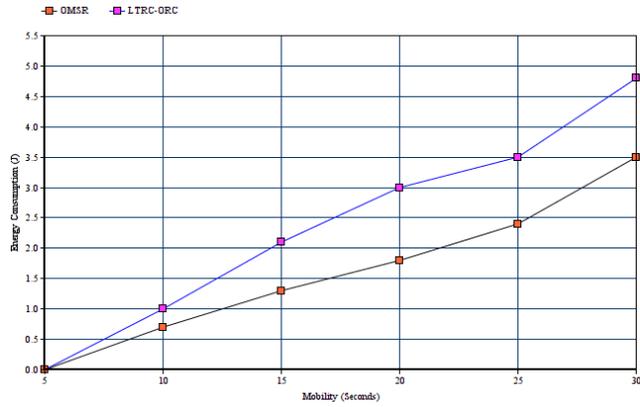


Figure 9 Energy Consumption with Mobility

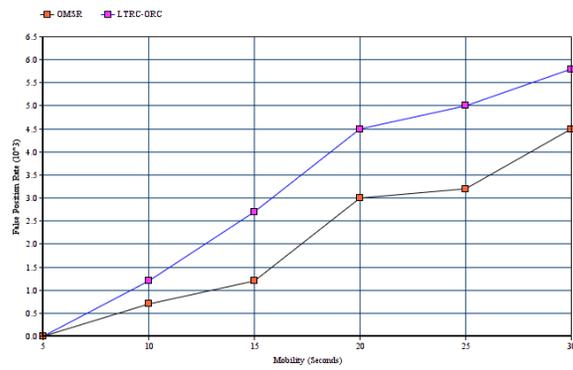


Figure 10 False Positum Rate with Mobility

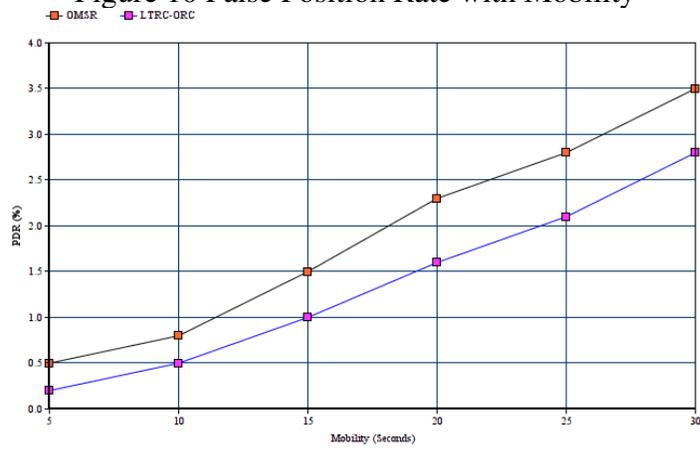


Figure 11 Packet Delivery Ration with Mobility

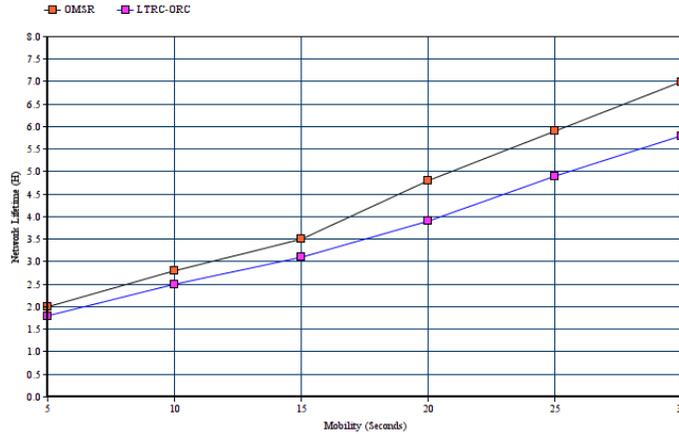


Figure 12 Network Lifetime with Mobility

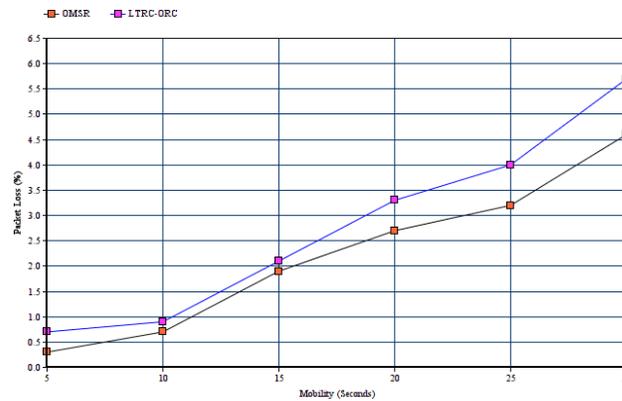


Figure 13 Packet Loss with Mobility

Conclusion

In a WSN there are sets of resource constrained sensor nodes. These nodes are normally used for monitoring and transmitting the data of the particular region. Thus the two main parameters that are to be considered are the network life time and reliable transmission of the data. Thus the sink relocation is the best method for optimizing these issues in the WSN. By comparing different technique a new algorithm is proposed and is named as OMSR. In the proposed algorithm first the clusters are formed using the algorithm QHBO. After that the cluster head values are calculated using the algorithm MCO. Finally for the enhanced of the sink repositioning IDM is used. The simulation is carried out in NS2. Security level, energy consumption, packet delivery ration, false positive rate, network lifetime, packet are the parameters that are simulated in the NS2. From the analysis it is clear that the proposed algorithm is having high performances as compared to the existing algorithm.

Declarations

Funding

No Funding involved.

Conflict of Interest

There is no conflict of interest

Availability of data and Material

Not available in websites.

Author's contributions

The first author formatted the paper and implementation under the guidance of the second author.

Reference

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Figures

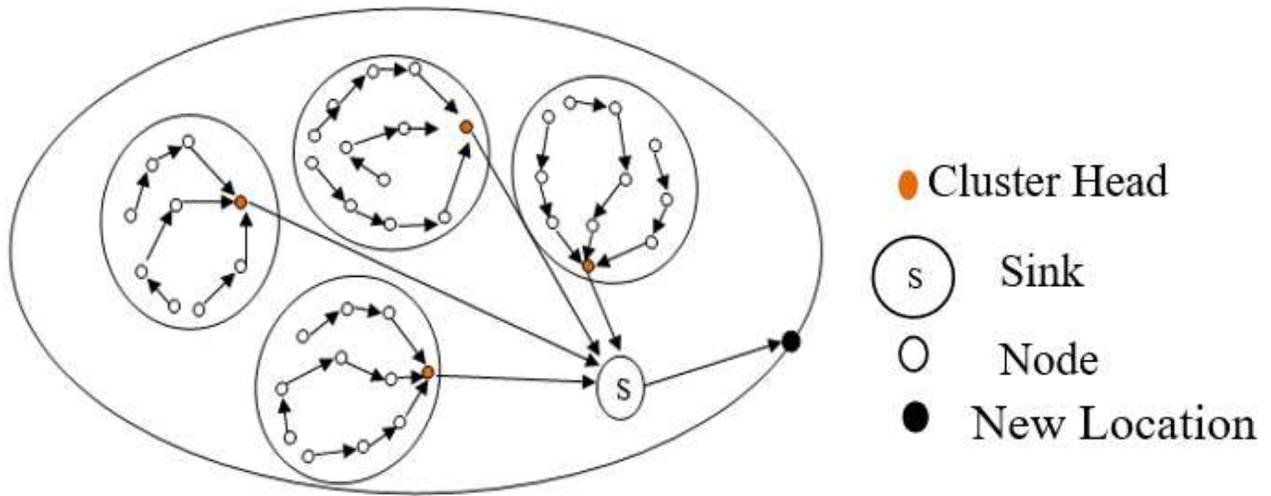


Figure 1

System Model of proposed OMSR technique

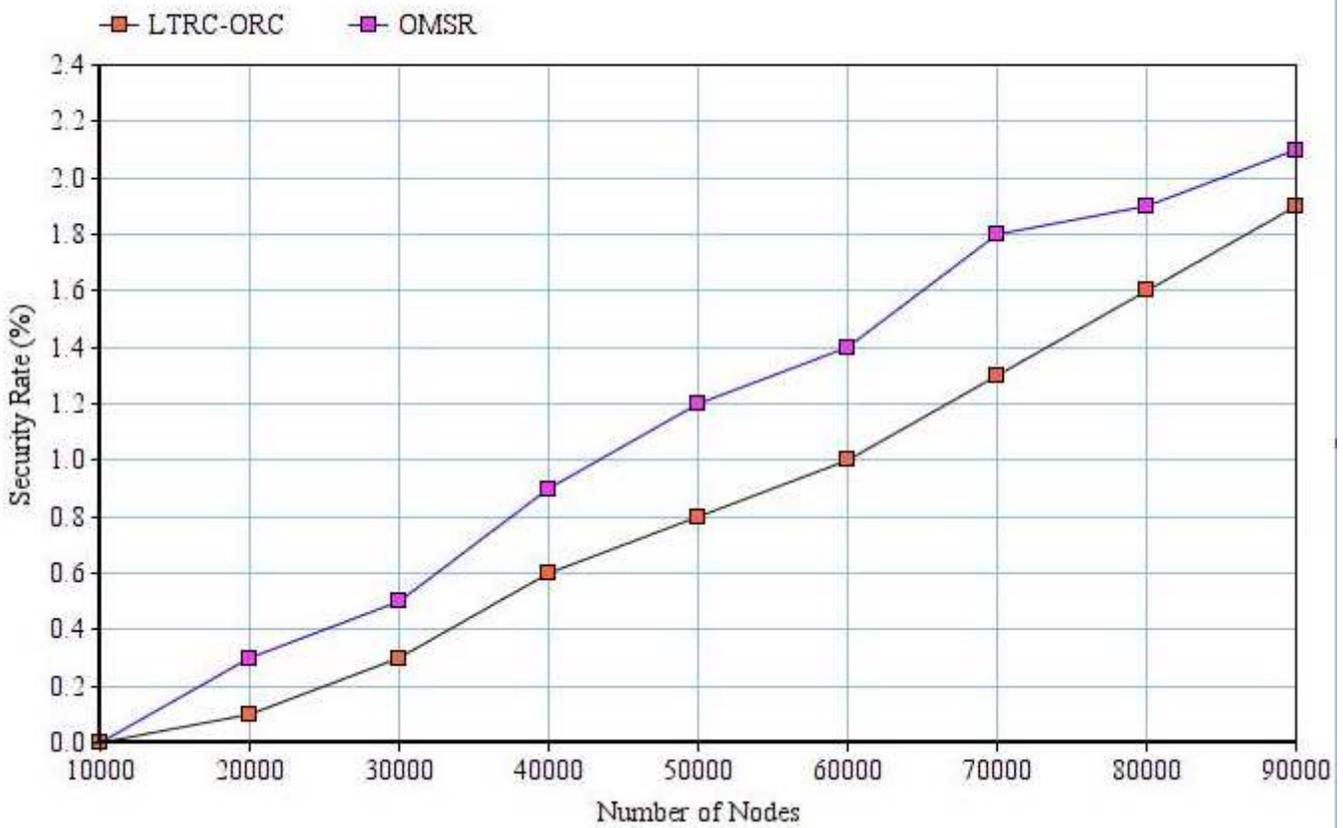


Figure 2

Security Level with Number of Node

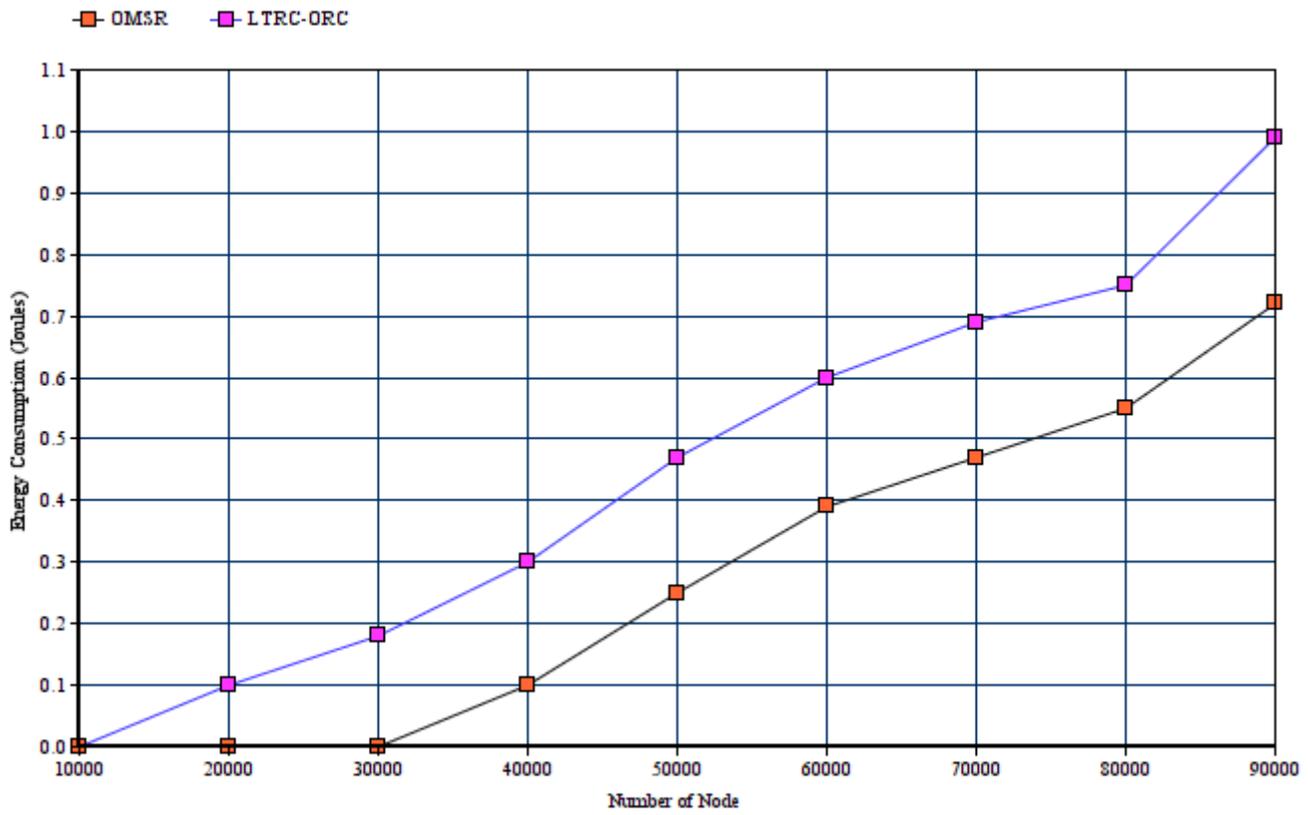


Figure 3

Energy Consumption with Number of Node

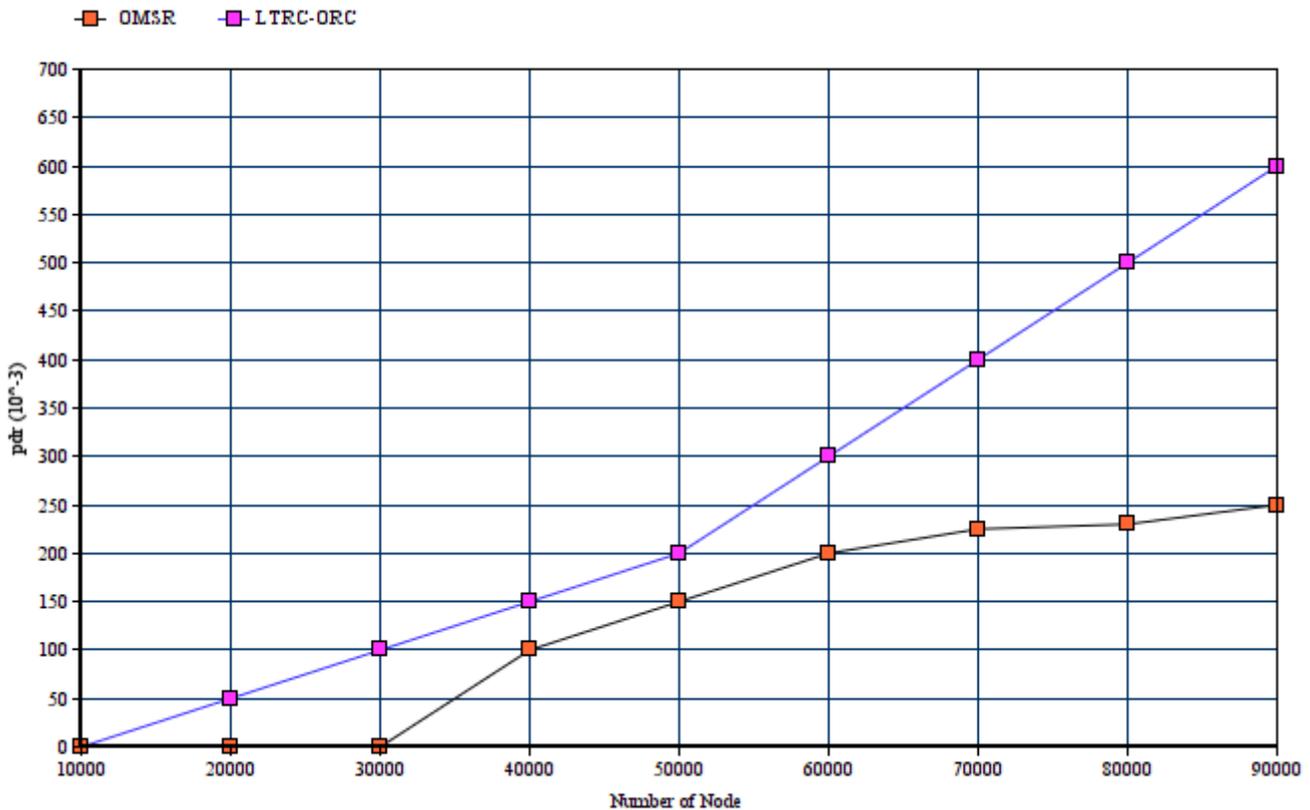


Figure 4

False Position Rate with Number of Node

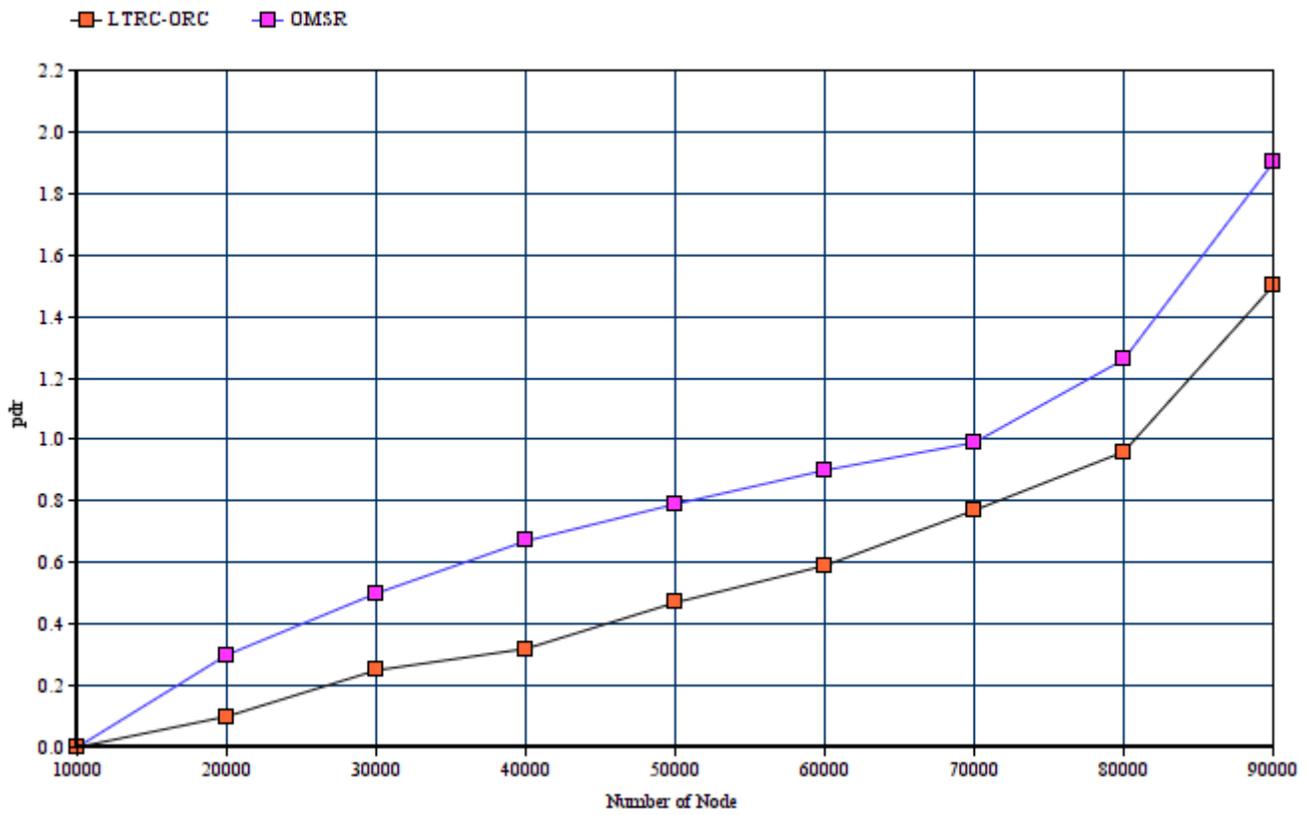


Figure 5

Packet Delivery Rate with Number of Node

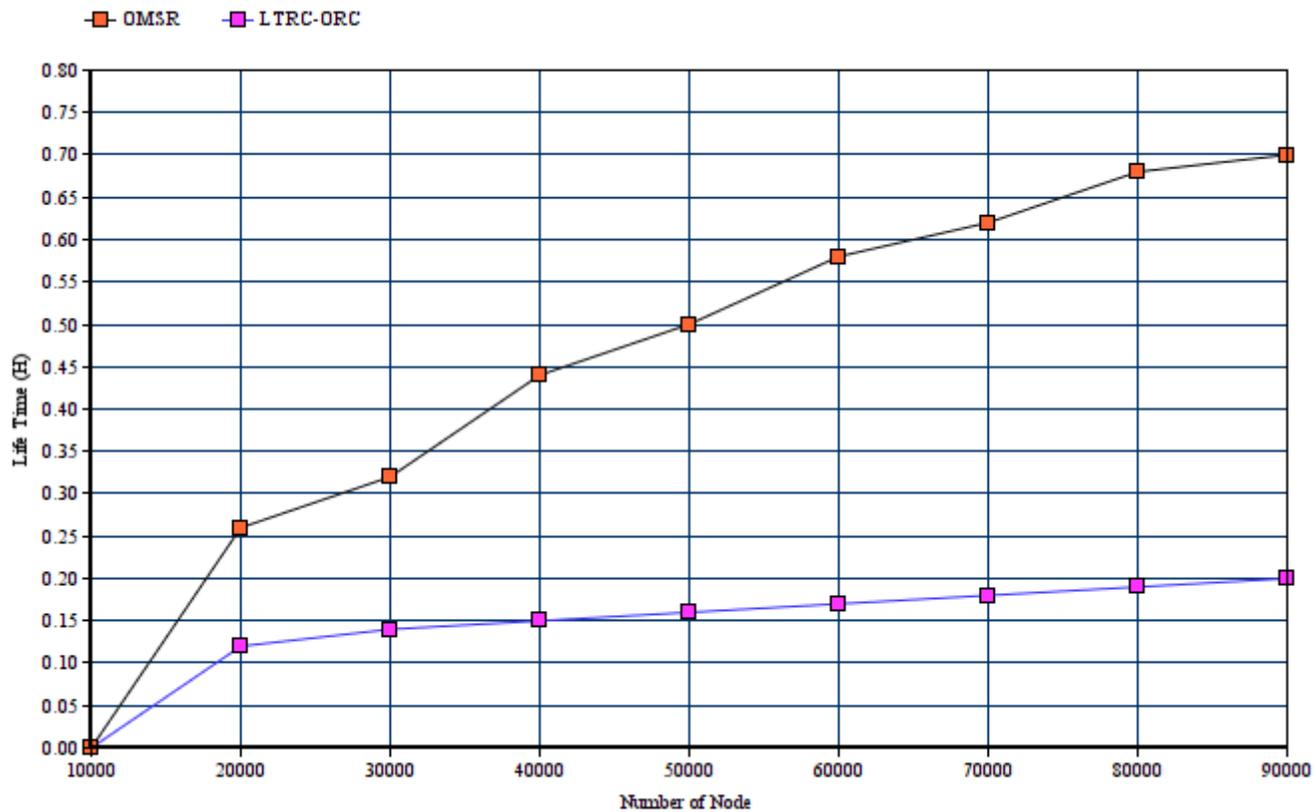


Figure 6

Network Lifetime with Number of Node

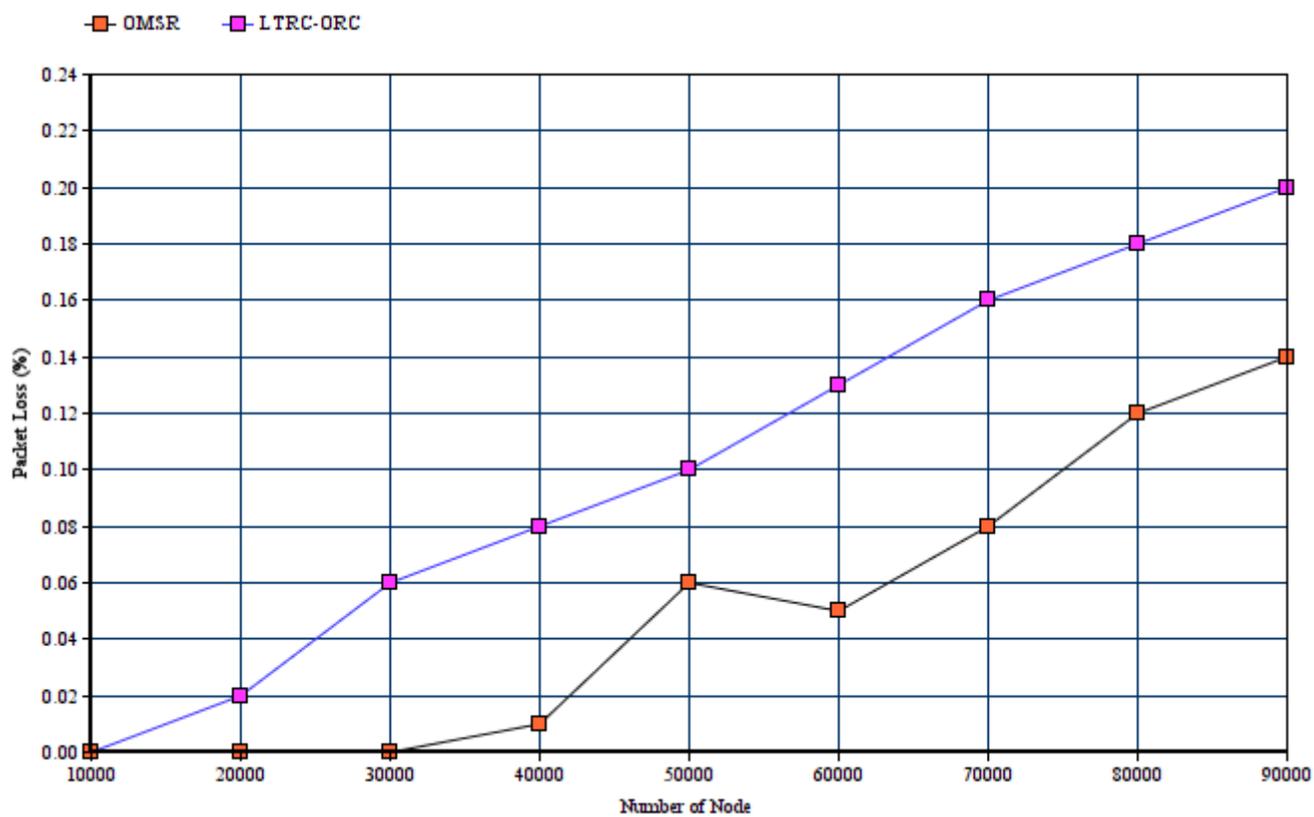


Figure 7

Packet Loss with Number of Node

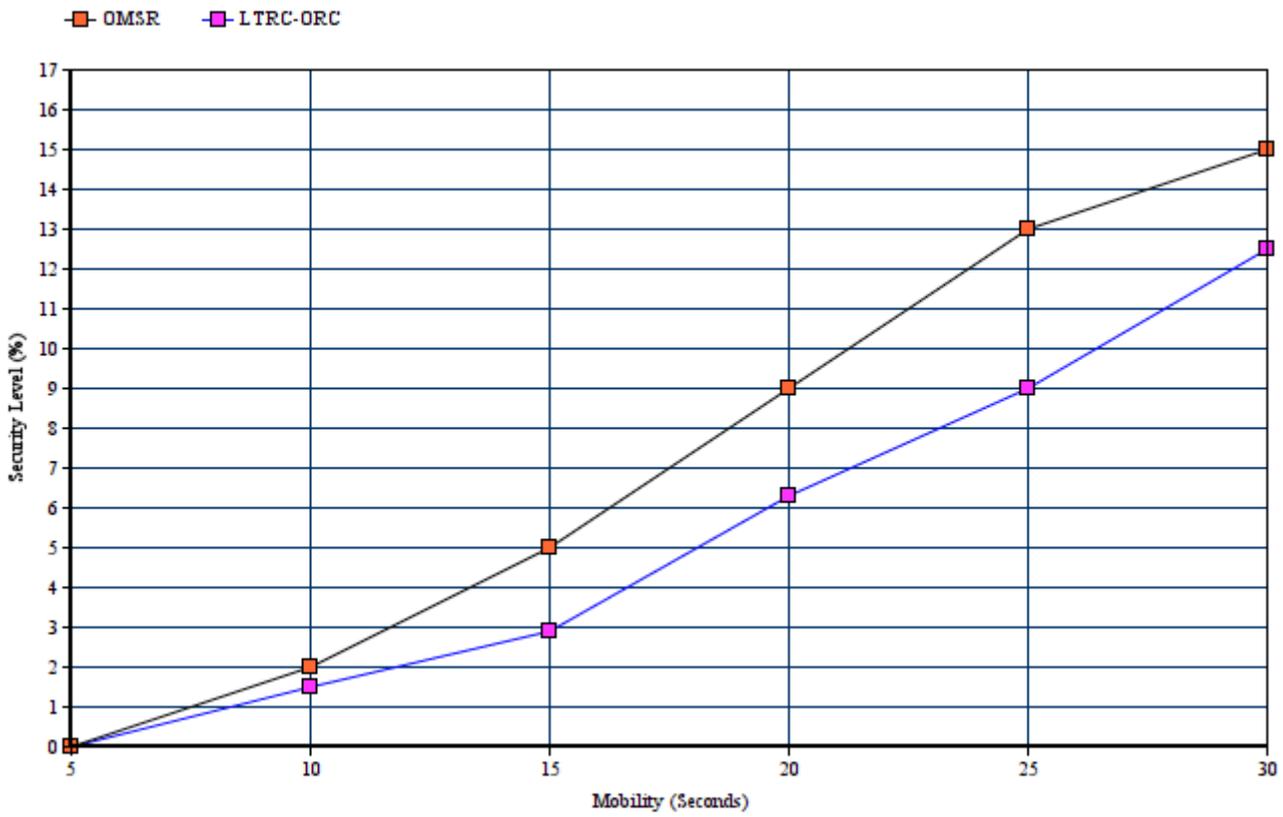


Figure 8

Security level with Mobility

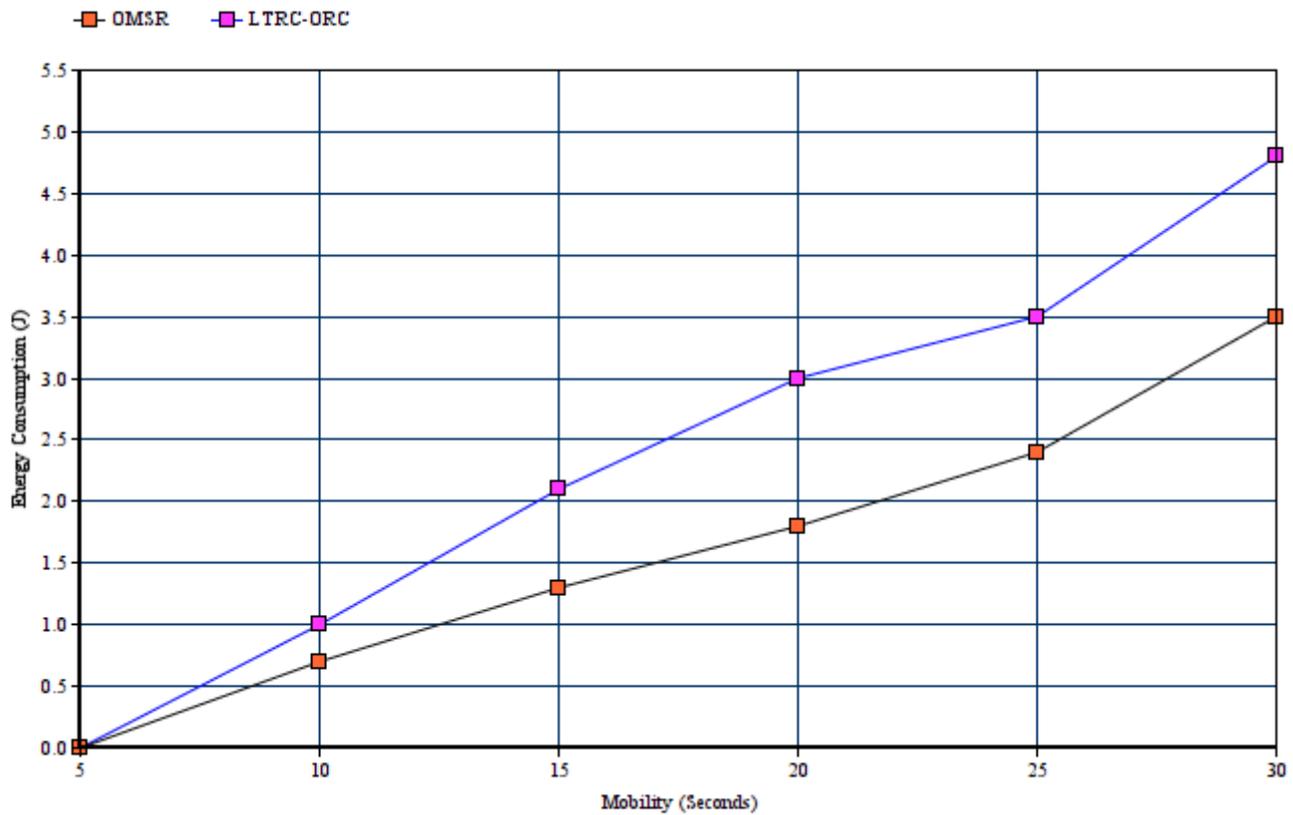


Figure 9

Energy Consumption with Mobility

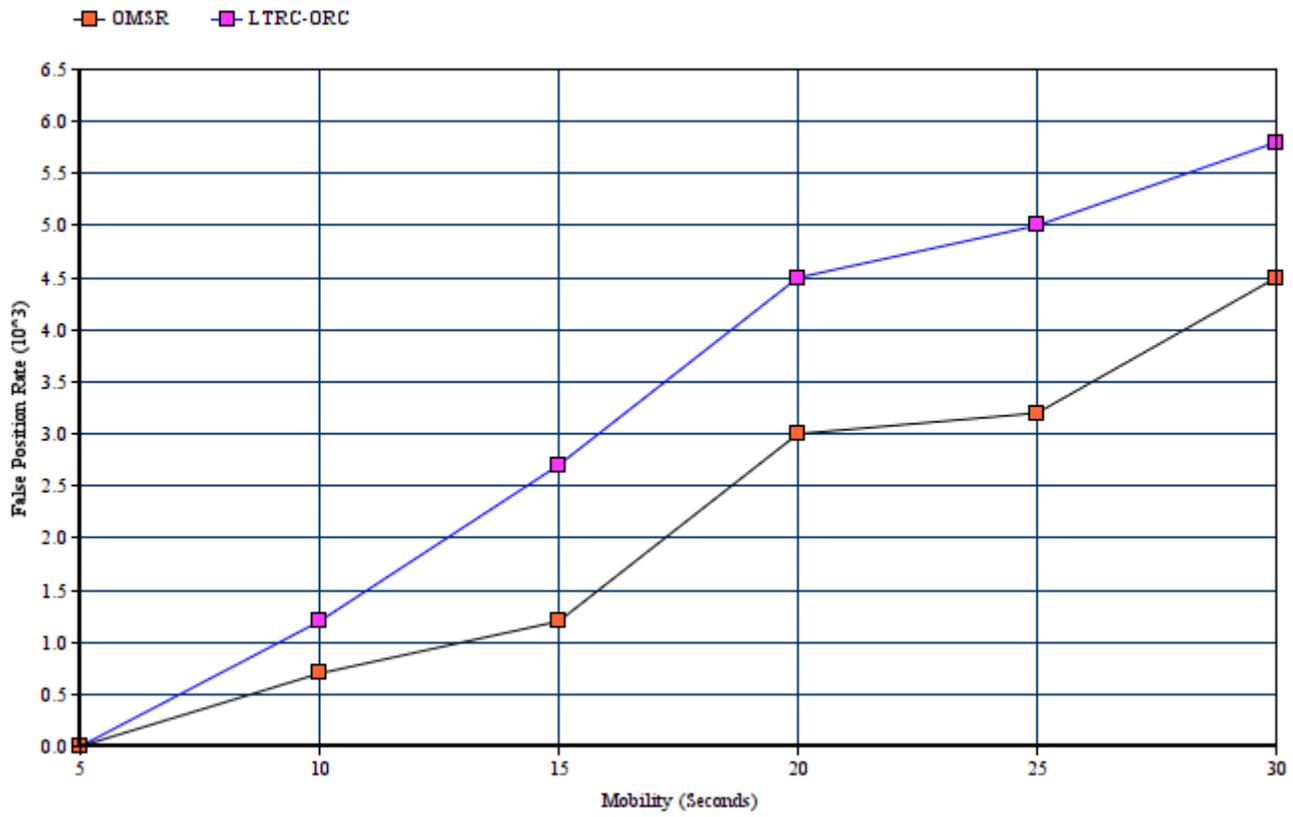


Figure 10

False Position Rate with Mobility

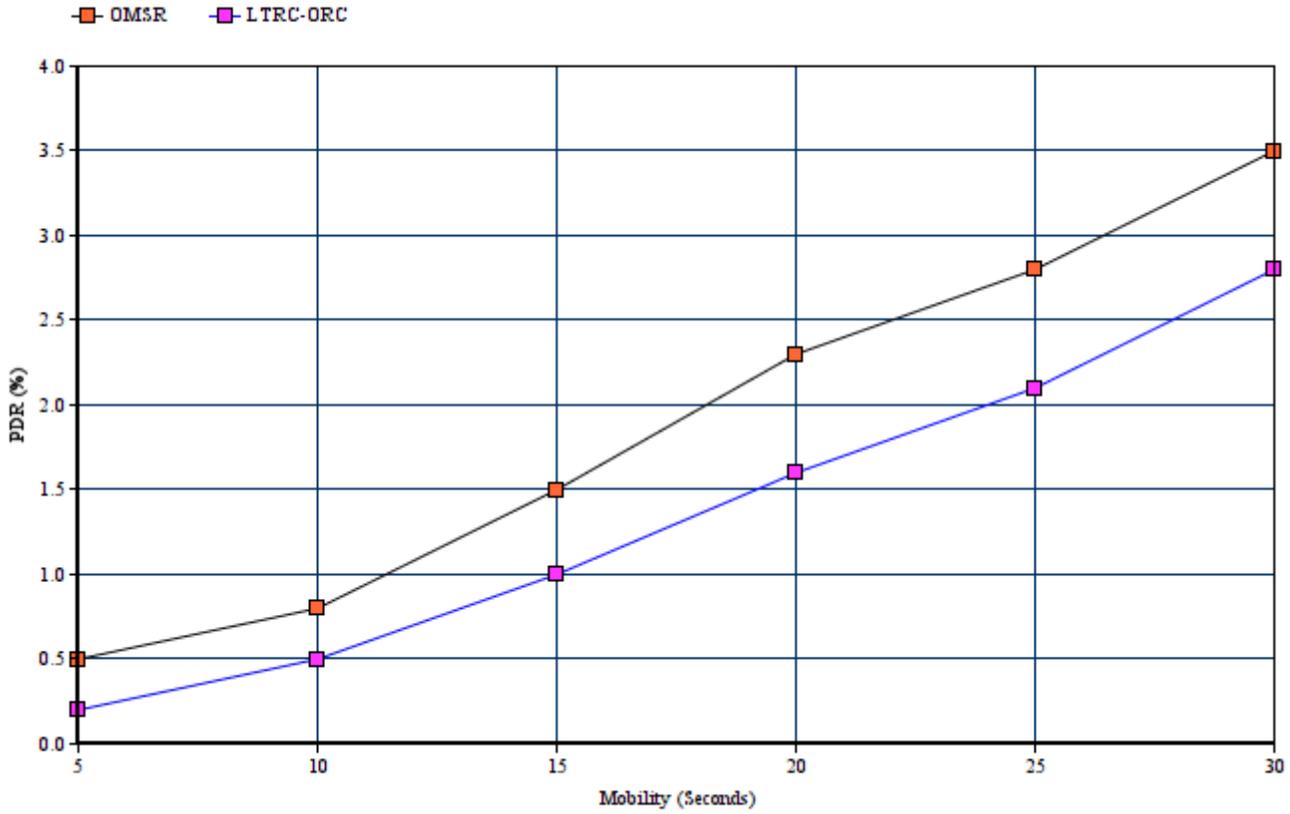


Figure 11

Packet Delivery Ratio with Mobility

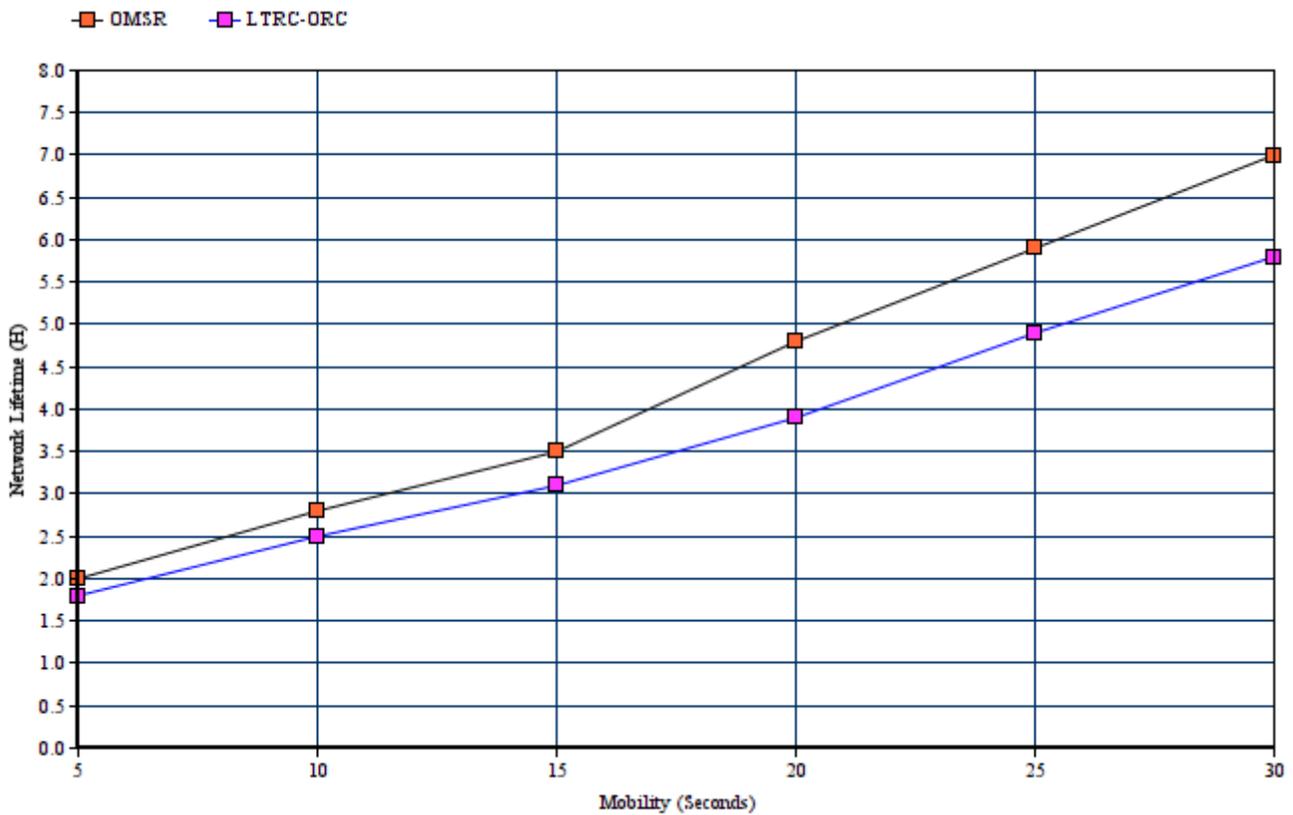


Figure 12

Network Lifetime with Mobility

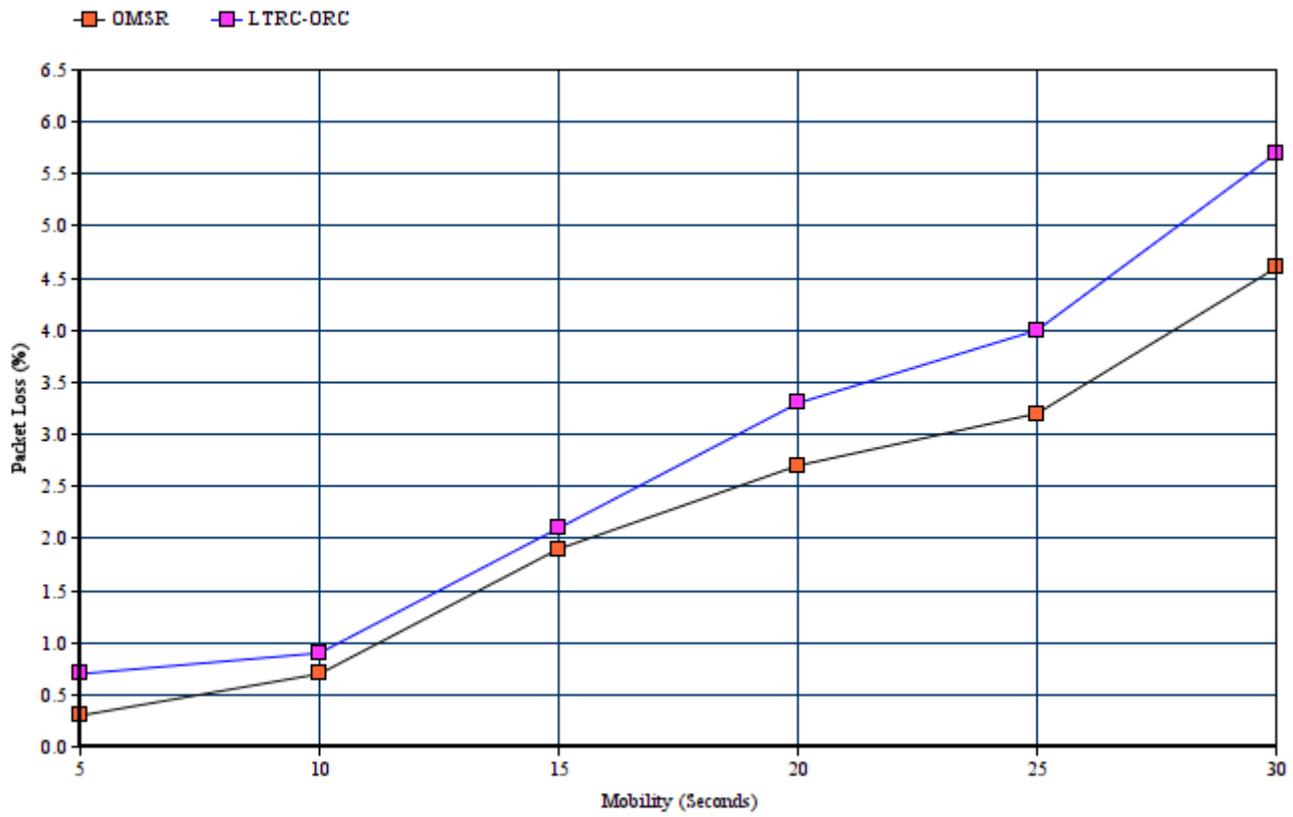


Figure 13

Packet Loss with Mobility