EFFECTS OF MOBILITY MODELS AND NODES DISTRIBUTION ON WIRELESS SENSORS NETWORKS

Ali A.J.Al-Sabbagh[1,3], Ruaa A.S.Alsabah[1,2] and Ahmed.Y.Mjhool[1,4]

[1]Electrical and Computer Engineering, Florida Institute of Technology, Florida, USA
[2]Department of Computer Science, University of Karbala, Iraq
[3]Department of Babylon, SCIS, Ministry of Communication, Iraq
[4]University of Kufa, Najaf, Iraq

ABSTRACT

Wireless sensor networks (WSN) is an important future technology, in several applications in military, health, environment and industries. Currently the integration of social and sensor is very important by considering the characteristics of social networks in designing wireless sensor networks WSN for improvement such as (number of messages from source to destination, radius of coverage, connectivity, and spreading). This area has not received much attention and few researches focus on the performance evaluation. In this paper we have studied the impact of different mobility and distribution models which is a variable one should define which model is best for the infrastructure given their differences, also study include the exact effect of nodes distribution and analyzed by calculation the number of messages of 12 cases to get a real performance evaluation under different conditions and same routing techniques. This work provides us a greater understanding and clear an idea of the effect of mobility plus distribution.

KEYWORDS

Wireless Sensor Networks, Social networks, Mobility Models, Node Distribution, Performance Analysis.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) have become demand research area because significantly in touch with several fields in life, WSN are self-configuring, networks containing of dynamic / static sensor nodes in wireless connection to form an random topology. A typical WSN consists of many small devices deployed over a geographical area, where each device is called a Sensor, that can measure or sense an environmental or physical conditions (e.g., Pressure, recognition and humidity) in a particular area. [1] Data forwarding (routing) in WSNs is the process of choosing the best strategies for sending data the source to the final destination. WSN are not currently deployed on a large scale, this research area is mostly simulation founded. Specifically mobile nodes: Mobile wireless sensor networks owe its name as a mobile sink. An advantage of dynamic WSN with respect to static WSN are well energy efficiency that's make forwarding a sense data from source to destination in first priority , improved coverage and improve target tracking and larger channel capacity.[2,3] A social network is a description of the relations between a set of actors. The integration of social networks can help to get better performance and understand the relations among people and the behavior of actors in a network. Integration WSN with (Social Network of Sensors) where this aspect comes from the movement of nodes with sensing

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capability such as phones, navigation systems, and other smart objects brought around by humans, vehicles, or even animals. A mobility model in a dynamic network describes the movement of mobile nodes and how their positions, directions, and velocity variation by time [4]. In the context of social movement of humans, we need models that have the ability to describe most of human mobility characteristics or any other models because most of the future sensors will been carried by cars, human, animal and vehicle. In 2010 proposed a model for human mobility to better describe by Song et al [5]. Integration with WSN makes them different from traditional sensor network because some of these sensors can be mobile without needing energy to achieve mobility. In this paper we have studied the performance of the networks under different nodes distribution and mobility models as shown in figure (1):

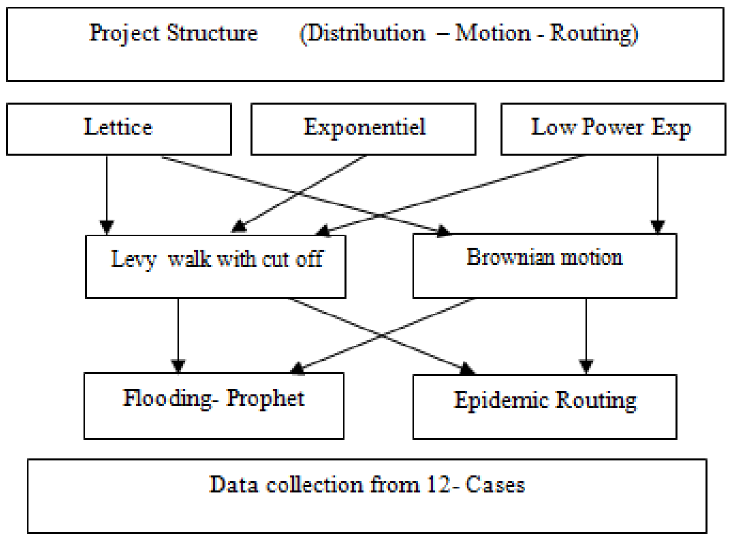


Figure (1) Implementation diagram for multi scenarios

2. RELATED WORK

The most recent studies that related to sensor networks, focus on coverage, algorithms, and protocols to reposition sensors in the environment. Typically, dynamic networks are the hottest topic between wireless sensor networks and social networks. Since dynamic networks depends on mobility models, there are many works discuss nodes mobility from difference perspective. Nowadays, the general understanding of human mobility patterns are non-random; indeed that sound completely true because usually the human move or travel with purpose [6] Moreover, people have a plans before travel to anywhere. For example, going to school or work, the one normally route specific ways with less distance and time to get our final destination frequently. So it is clear that our mobility are random. Continuous-time random walk CTRW, in 2006, is a random walk has been used by Brokmann et al. to explain the scaling laws for the flow of bank notes and then to infer the dynamics of human travels. Mtibaa et al. in 2010 offered PeopleRank as a new forwarding method. This method is based on the PageRank algorithm and the centrality of nodes. Ranking nodes are considered to their social information, a node is given higher weight if it is socially connected to the significant network nodes [7] . The results exposed that the PeopleRank method outperforms the Epidemic approach. Song et al. in 2010, has suggest a pattern model for human mobility according to their preferred locations. This model is based on two mechanisms which are: exploration and preferential return. Li et al. in 2011, proposed that mobility of sensors can be used to efficiently decrease the detection time of a stationary intruder. Tomasini et al. in 2013 proposed that wireless sensor networks with social mobility patterns can enhance the performance in terms of nodes' coverage in addition to data delivery. The same authors, but in another study, evaluated which mobility models are more convenient among different mobility models in social networks of sensor for data delivery. The study results are like that (1) not big changes in the performance when using different mobility models in dense networks; (2) communication range plays important role in performance in terms of data delivery; (c) delivery rate is a big issue when using individual mobility model in wireless sensor network. De Melo et al. in 2013, suggest a new technique called RECAST to analyze individuals' interactions in a dynamic network. This technique group individuals' interactions to four groups: Random, Bridges, Acquaintance and Friends. The results of the research showed friends group was the highest used to deliver data message and random group was the lowest used. Li et al. in 2014, proposed a social group-based forwarding approach. The initial proposal is depends on the history of encounters of individuals to choose the right relays to data delivery according to diverse social relationships between network characters. [7, 8] In this paper have studied the performance of WSN in both different mobility and different distribution.

3. MOBILITY MODELS

The node mobility to achieve big effect on the performance of mobile ad hoc networks and wireless sensor networks (WSN). Because mobility is to help security, increase capacity and more reliable of detection in mobile ad hoc networks and WSN. In contrast mobility can also lead to reduce the unpredictable random topology and the change of links [2,12]. In this project, we use two common mobility, which are Brownian motion, and Levy walk.

3.1. Brownian Motion

This type of mobility model is describe the motion of the atoms, which move randomly. Where the time is divided with an interval of constant slot T. At every slot I .where the destination (Xi+1, Yi+1) is selected depending on the current location, (Xi, Yi), i.e., [5].

$$X_{i+1} = X_i + \eta W_1$$
$$\mathrm{Y_{i+1}} = \mathrm{Y_{i+1}} + \eta W_2, \qquad (1)$$

Where W1 and W2 follows normal distribution.

η is the variance of Brownian motion. So, the jump distance during a slot can be obtained from the distribution

$$F^{bm}(d) = 1 - e^{-\frac{d^2}{2\eta^2}} \qquad (2)$$

3.2. Levy walk with cut off model

The levy model describe the most of human mobility characteristics for this reason it is used in order to achieve the social movement of humans. This model is first described by Song et al. [9] proposed a model for individual mobility (IM) to better describe human movements which is Levy walk. It is a different type of random walk in which the jump distance is distributed depending on a heavy-tailed distribution for every movement. It follows a power law form.

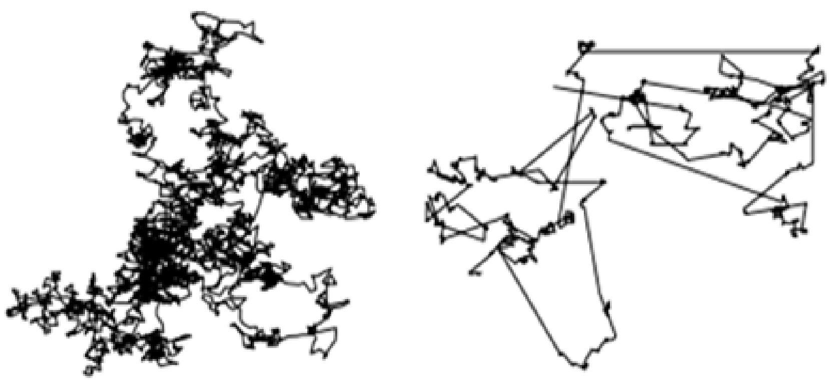
$$F(d) = 1 - (\tfrac{a}{d})^{\alpha}. \qquad (3)$$

In this model, the upper limit of the jump distance can be set as infinite. To overcome this limitation, the model has been studied Levy extended so that the probability density cutoffs should be applied on both small and large distances. So the CDF of the jump distance in the Levy is expressed by:

$$F^{lw}(d) = 1 - \frac{\gamma^{\alpha}(d^{-\alpha} - v^{-\alpha})}{1 - (\gamma/v)^{\alpha}} \quad (4)$$

Where γ and v are the minimum and maximum distances, respectively. This model is based on two mechanisms which describe the human mobility [10, 12]:

Exploration: The tendency to explore new locations decreases with time. Where the next step is completely independent of the previously visited locations. Preferential Return: the human's behavior shows an important property, which is the tendency to return to the most visited locations (e.g., home, work). Different scenarios can be achieve by the mobility models described above. For example, in the Brownian motion by changing one parameter η, different levels of randomness can be offered. On the other hand, the Levy walk can describe the motion characteristics of human agents in various environments such as campus and downtown, by altering the parameters α, γ, and v [11]. Figure (2) shoes the difference between the Brownian motion and Levy Walk.



(a) (b)

Figure (2) mobility model (a) Brownian motion and (b) Levy Walk.

4. EPIDEMIC ROUTING (ER)

The ER is a flooding-based routing protocol mainly used in delay tolerant networks (DTNs). In DTNs, the assumption of traditional routing of the end to end path from the source to the destination always exists for successful transmission, is not always valid. Thus, ER rely on transit transmission in its operation. In ER, if a source node generates a packet and needs to send it to a destination node, it floods this packet. The source node and all neighboring nodes received this packet will re-flood this packet whenever they meet a new neighboring node, results in multiple replica of this packet throughout the network and consequently maximize the probability of one node encounters the destination node. However, ER causes a massive energy consumption and therefore, more dead nodes which inversely decrease the probability of packet delivery. [13,14]

If energy consumed by nodes is not an issue, the ER is considered a very efficient in packet delivery perspective. In wireless sensor networks (WSNs), where the majority of nodes are battery-powered and battery recharging or replacements is not applicable, renders the energy consumption is of our highest priority. Each node has to have a buffer to store a created or received messages destined to other nodes. Message indexing is performed as a way to efficiently manage the messages. Also, summery vector is an array of bits maintained at each node indicates the entries stored in hash table.

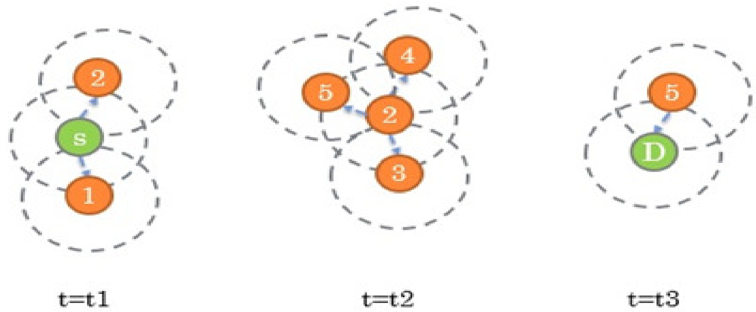


Figure (3) Epidemic Routing

The process of anti-entropy session initiated by the node with lowest id with the highest id, through which the message are forwarded. Each node must have a list of nodes with which the node has encountered recently to avoid multiple anti-entropy sessions with the same nodes during a preconfigured period of time. To calculate the delivery ration DR(t), let N be the total number of nodes moving within a square area L2, and the transmission range r, where r << L. The pair wise meeting time between nodes is a random variable and it is exponentially distributed. Thus the probability that two nodes can meet is defined as pairwise meeting rate and can be calculated by equation (5).

$$\rho \approx 2\omega r E[v^*]/L2 \quad (5)$$

Where, ω, is a constant depends on the mobility model. E[v*], is the average relative speed between two nodes. The number of nodes that received a packet after time t, denoted as I(t) can be calculated by equation (6).

$$I(t) = N/[1+(N-1)e\text{-}\rho Nt] \quad (6)$$

It is intuitive that the more nodes have received the packet, the large probability the message will be delivered to the destination. The delivery ratio of a packet increases with time, so it is a function of time DR(t) and equals to:

$$DR(t) = I(t)/N = 1/[1+(N-1)e\text{-}\rho Nt] \quad (7)$$

5. PROBABILISTIC ROUTING (FLOODING)

The mobility of nodes in social networks is not completely random. Thus, the movement patterns of nodes are most likely to be predictable. For example, if a location has been frequently visited, it is probably to be visited again. Delivery predictability is the metric calculated based on node's movement pattern and used in probabilistic routing to improve performance. This metric is calculated at each node for each known destination node mapping the probability of that node delivering a message to each known destination node. To mitigate resources waste incurred in ER, nodes exchange only information about delivery predictabilities and each node decide whether to forward messages or not based on these probabilities. This Probability P ϵ [0, 1] indicates the probability of encountering a certain node. Whenever a node is encountered, corresponding P must be updated according eq. (8)

$$P(a, b) = P(a, b)_{old} + (1-P(a, b)_{old})*P_{init} \quad (8)$$

Where, P(a, b) , delivery predictability nod (a) has for node (b) Pinit ϵ [0, 1], an initialization constant If a node doesn't encounter the destination node for a while, it is less likely to be a good forwarder to that destination, thus the delivery predictability must be aged. Equation (9) is the aging equation.

$$P(a, b) = P(a, b)\ old * \gamma k \qquad (9)$$

Where, $\gamma \in [0, 1)$, is the aging constant k, is the number of time units have elapsed since the last time the metric was aged

6. SIMULATION RESULTS

In this section, we verify our findings by the implantation all cases mentioned in figure (1) to find number of messages in each cases (source to distention i.e LBF case mean: Lattice, Brownian, Flooding and ECE: Exponential, Levy with cut off, Epidemic) and the representation for each block as shown in table (1):

Node Distribution	Mobility	Routing
L: Lattice Uniform	B: Brownian motion	E: Epidemic
E: Exponential		
P: Power low	C: Levy walk with cut off	F: Flooding Prophet

Table (1) Description for each simulation case

In this work we proposed to change some factor by keeping the other the general case generates by 300 nodes as a mobile and 50 static for a specific location for both source and sink, then we have repeated the simulation procedure under different distribution by keeping the mobility and changing the routing tech. Obviously this work proposed 2 type of routing techniques, Two type of mobility models and 3 kind of distributions (each option represented by a letter as shown in figure above). The simulation result of the number of messages and spreading percentage for each case as follow for example (LBF: Lattice-Brownian-Flooding Prophet) table (2):

No	Case	No'- Messages	Spreading
1	LBF	160	52.77 %
2	LCF	200	65.75 %
3	LBE	274	88.38 %
4	LCE	237	76.69 %
5	EBF	243	73.07 %
6	ECF	270	87.62 %
7	EBE	288	93.00 %
8	ECE	269	90.13 %
9	PBF	381	95.11 %
10	PCF	294	97.36 %
11	PBE	326	93.57 %
12	PCE	293	94.67 %

Table (2) Simulation results for each case under different distribution, Mobility and Routing

Obviously simulation results shows that Epidemic Routing will arrive the distention (sink) by number of message more than Flooding Prophet. Also the levy walk with cut off mobility motion gives a better results compare with the Brownian motion because higher number of messages mean higher radiated power. Integration in this paper clearly make the effect of mobility. In other side node distribution play a main role as well for selection an appropriate routing in designing WSN and compression of results for each same group case constant like changing only distribution. For example at lattice distribution and Brownian motion we can implement the WSN under Epidemic then under Flooding Prophet to get different results as shown in figure (4):

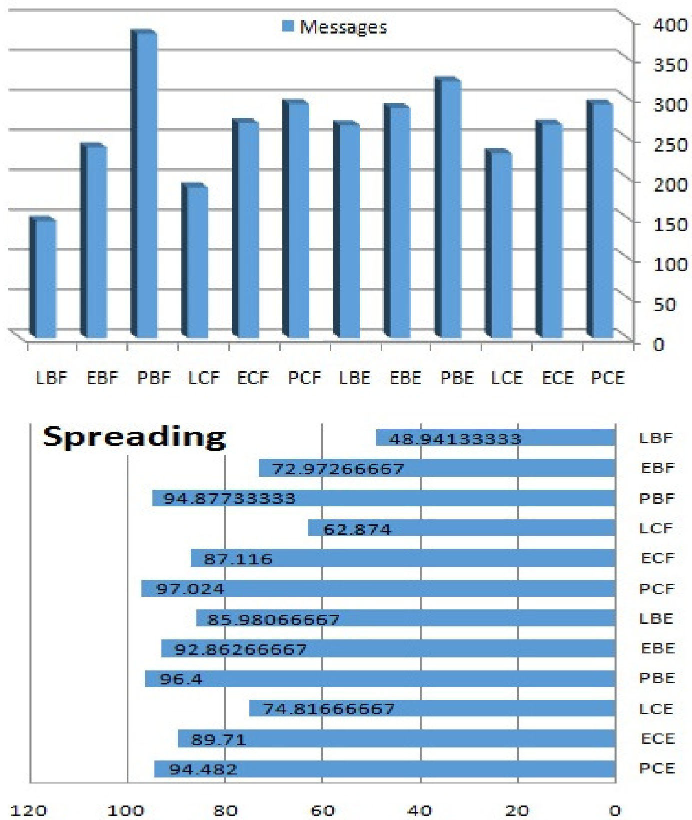


Figure (4) Result compression for each case – A) Messages number from source to destination, B) Spreading percentage (i.e LBF: Lattice, Brownian, Flooding and ECE: Exponential, Leavy with cut off, Epidemic)

7. CONCLUSIONS

WSN have greatly extended playing an important role for the data efficient delivery source to destination and It is an important emerging communication system which takes the advantages of any possible contact opportunities to deliver data among mobile devices. Integration WSN with any other connection details like social network will lead to improve the network performance and provide deep understanding. Routing and forwarding data to the sink are main challenges. In this paper, we propose a good evaluation procedure to compare different cases in mobility and distribution to get a full view of each factor how effect on WSN performance. In the previous section, we analyzed our results for the scenario mentioned in figure (1) by calculation the number of messages for each case. Now, we can conclude the following:

1) Mobility motion has a main effect on WSN for any individual application like power consumption, spreading messages and directions.

2) Routing by probabilistic (PRophet) less than Epidemic by number of message which give a good indication for power reduction by reduce transmission.

3) Static node has not relevant effect on WSN with compare with mobility nodes. Also taking in consideration the nude distribution during design WSN.

4) Levy walk with cut off human mobility motion is better than Brownian motion for any WSN application related to human activities.

5) If the goal is reducing the number of exchanged Messages within the network, the best option is to select an appropriate routing and mobility techniques for each individual application. Finally, in future we can mitigate the impact of integration using a different technology for wireless communications to get better performance in WSN.

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REFERENCES

[1] N. Pantazis, S. Nikolidakis, and D. Vergados, “Energy-efficient routing protocols in wireless sensor networks: A survey,” Communications Surveys Tutorials, IEEE, vol. 15, no. 2, pp. 551–591,2013.
[2] R.Alagu Pushpa1 A.Vallimayil "Impact of Mobility models on Mobile Sensor Networks" International Journal of Communication Network & Security, Volume-1, Issue-1, 2011
[3] Nikolaos A. Pantazis, Dimitrios D. Vergados, “A Survey on Power Control Issues in Wireless Sensor Networks,” IEEE Communications Surveys, 2007, Vol. 9, Issue 4, pp. 86-107.
[4] Marcello Tomasini, Franco Zambonelli, "Evaluating the Performance of Social Networks of Sensors under Different Mobility Models" biomedcomm,62 IEEE COMPUTER SOCIETY 2013
[5] Wang, Pu, and Ian F. Akyildiz. "Effects of different mobility models on traffic patterns in wireless sensor networks." Global Telecommunications (GLOBECOM 2010), 2010 IEEE. IEEE, 2010..
[6] C. Song, T. Koren, P. Wang, and A.-L. Barab´asi, “Modelling the scaling properties of human mobility,” Nature Physics, vol. 6,no. 10, pp. 818–823, 2010.
[7] G. Lin, G. Noubir, and R. Rajaraman, “Mobility models for ad hoc network simulation,” in INFOCOM 2004. Twenty-third AnnualJoint Conference of the IEEE Computer and Communications Societies, vol. 1. IEEE, 2004.
[8] S. Chellappan, W. Gu, X. Bai, D. Xuan, B. Ma, and K. Zhang, “Deploying wireless sensor networks under limited mobility constraints,” Mobile Computing, IEEE Transaction 1142–1157, 2007.
[9] C. Song, T. Koren, P. Wang, and A.-L. Barab´asi, “Modelling the scaling properties of human mobility,” Nature Physics, vol. 6, no. 10, pp. 818–823, 2010.
[10] R. M. M. Tomasini, F. Zambonelli, “Using patterns of social dynamics in the design of social networks of sensors,” ACM, 2013.
[11] I. Rhee, M. Shin, S. Hong, K. Lee, and S. Chong. "On the levy-walk nature of human mobility". In Proceeding of INFOCOM 2008, pages 924–932, 2008.
[12] Wang, Pu, and Ian F. Akyildiz. "Spatial correlation and mobility-aware traffic modeling for wireless sensor networks." IEEE/ACM Transactions on Networking (TON) 19.6 (2011).
[13] Xiaofeng Lu, Pan Hui. An Energy-Efficient n-Epidemic Routing Protocol for Delay Tolerant Networks, IEEE 2010
[14] Floriano De Rango, Salvatore Amelio, Peppino Fazio. University of Calabria, Italy, IEEE 3013.
[15] Anders Lindgrn, Avri Doria, Olov Schelèn, Lulea University of Technology. Probabilistic Routing in Intermittently Connected Networks. Maryland, USA 2003