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Energy Efficient Enhancement of TDEEC Wireless Sensors Network Protocol Based on Passive RFID Implementation

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Abstract: Radio frequency identification (RFID) and wireless sensor networks are two important wireless technologies which have a wide variety of applications in current and in future systems. By integration of these technologies, it is feasible to improve the operating functionalities. In the heterogeneous network, the need to apply the balancing of energy consumption across all nodes is very important to prevent the death of those nodes and thereafter increase the lifetime of the network .The most part of the network energy is consumed in the localization and in the communication stages, when nodes are sending HELLO packet, this energy can be recovered by implementing a passive RFID circuit in each node. This approach extends the network lifetime and increase the number of packet messages sent to the base station. Computer simulation in MATLAB with different scenarios comparison shows that the proposed method presents an efficient solution to enhance the energy network performance.

Keywords: Wireless sensor network, TDEEC, Passive RFID, Energy, routing, clustering.

I. INTRODUCTION

Wireless sensor networks are an emerging technology that has a wide range of potential applications including environment monitoring, smart spaces, medical systems and robotic exploration... Such a network normally consists of a large number of distributed nodes that organize themselves into a multi-hop wireless network [1]. However, the sensor nodes are usually powered by batteries and thus have very limited lifetime if no power management is performed. The sensor node contains four basic building blocks of components, those are sensing unit, processing unit, radio unit, and power unit [2]. These sensors are able to communicate with each other to collaboratively detect objects, collect information and transmit messages. However, as sensors are usually small in size, they have many physical limitations such as battery, computational power and memory. The important part of energy is consumed in the communication circuit which must be minimized. Because of those limitations, energy-efficient techniques are main research challenges in wireless sensor networks. A number of techniques have been proposed to solve these problems. The major challenge is the energy consumption, In order to support data aggregation through efficient network organization; nodes can be partitioned into a number of small groups called clusters. Each cluster has a cluster head, and a number of member nodes [2].In clustering WSNs, the imbalanced power consumption among nodes is the main factor modifying the WSN lifetime. Wireless sensor nodes can be divided into various types based on the various capabilities in sensing, energy and communication. The heterogeneity is not unusual in the WSNs [3]. DEEC (Design of a distributed energy-efficient clustering algorithm) [4], is used in heterogeneous wireless sensor networks. This protocol is based on the election of cluster head by the balance of the probabilities of the remaining energy for each node, it use the average energy of the network as the reference energy, the cluster-heads are elected by a probability based on the ratio between the residual energy of each node and the average energy of the network. Threshold Distributed Energy Efficient Clustering protocol [18] propose an energy efficient cluster head scheme, for heterogeneous wireless sensor networks, by modifying the threshold value of a node based on which it decides to be a cluster head or note. Locating the heterogeneous nodes in WSN and clarifying cluster members by HELLO packet are unfavorable ways to affect network energy consumption and stability of WSN. RFID (radio frequency identification) [20] is a means of storing and retrieving data through electromagnetic transmission using a radio frequency (RF)-compatible integrated circuit An RFID system usually consists of two main components: tags and readers. A tag has a unique identification number (ID) and memory that stores additional data such as manufacturer name, product type, and environmental factors including temperature, humidity, and so on. The reader can read and/or write data to tags through wireless transmissions. By integrating RFID technology with WSN [21], we can route RFID data from readers to base stations by using existing WSN clustering protocols. The integration of RFID and sensor networks can increase their utilities to other scientific and engineering fields by exploiting the advantages of both technologies. There are several ways of integrating RFID with WSN [20,21]. In an RFID enhanced WSN, it is acceptable that we consider the energy of all nodes are not equal and these networks are heterogeneous [5]. In our proposed method, for increasing the lifetime period and enhance the network performance , we present a cluster-based protocol for heterogeneous RFID enhanced based on exploiting the advantages offered by the RFID technology to recover the energy lost during the localization HELLO packet transmission. The remains of this paper are organized as follows. In section 2 we defined Integration of RFID and Wireless Sensor Networks. In Section 3, we described the related work. In Section 4, we defined the heterogeneous model and performance measures for WSN. In section 5 we show the performance of our approach by simulations and compare it with DEEC. Section 6 contains our concluding remarks.

II. INTEGRATION OF RFID AND WIRELESS SENSOR NETWORKS

Radio frequency identification and wireless sensor networks are two important wireless technologies that have a wide variety of applications in current and future systems. RFID facilitates detection and identification of objects that are not easily detectable or distinguishable by using conventional sensor technologies. However, it does not provide information about the condition of the objects it detects. WSN, on the other hand, not only provides information about the condition of the objects and environment but also enables multi-hop wireless communications. Hence, the integration of these technologies expands their overall functionality and capacity [6]. By joining RFID tags to WSN nodes, it is possible to remotely 'wake up' the processor and other parts on demand. The RFID prods technique can use either a passive or an active RFID tag [7]. In integrating RFID readers with a WSN node scenario, integrated RFID readers-sensor nodes are assumed [8]. Zhang et al. [5] present possible architectures for integrating RFID and WSN, and provide a detailed list of real world applications.

To ensure the heterogeneity of our network by considering three types of integrations : integrating tags with sensors, integrating tags with wireless sensor nodes, integrating readers with wireless sensor nodes. Hence, we can distinguish among the following node types:

- ✓ nodes integrated with a passive RFID Tag(too weak).
- ✓ nodes integrated with semi passive RFID Tag(weak nodes).
- ✓ nodes integrated with active RFID Tag(strong nodes).
- ✓ RFID reader enhanced WSN node for interrogation and reading tags data (very strong node).

Because an RFID radio uses much less energy than an RF sensor radio for simplicity, we do not consider RFID tags and readers specifications in our network, and specific to the needs of our model we considered a WSN with energy heterogeneity.

III. RELATED WORK

There exist two types of distributed clustering techniques used to reduce energy consumption: the homogeneous and heterogeneous clustering algorithms. It is very difficult to design heterogeneous clustering schemes due to their complexity on the contrary of homogeneous protocols. Currently, WSN are more possibly heterogeneous networks than homogeneous ones. Actually, clustered routing protocol has gained increasing attention from researchers because of its potential of extending WSN lifetime. Heizelman [10]designed and implemented the first distributed and clustered routing protocol with low energy consumption [9]. LEACH [11], performs well, but its performance become badly in the heterogeneous network as shown by [9], [14]. PEGASIS [12] it is an improved version of LEACH as nodes will be organized to form a chain, which can be computed by each node or by the base station. However, excessive delay is introduced for distant nodes, especially for large networks. SEP performs poorly in multi-level heterogeneous networks and when heterogeneity is a result of operation of the sensor network [9], [4]. In HEED [13] a stochastic algorithm used to define the cluster-heads based on probability election of each node which is correlative to the residual energy. Q. Li, Z. Qingxin and W. Mingwen are proposed Distributed Energy Efficient Clustering Protocol (DEEC) [4]. This clustering protocol is based on multi level and two level energy heterogeneous schemes. The cluster heads are selected using the probability utilizing the ratio between residual energy of each node and the average energy of the network. The epochs of being cluster-heads for nodes are different according to their initial and residual energy. A particular algorithm is used to estimate the network lifetime, thus avoiding the need of assistance by routing protocol [4]. Parul Saini, Ajay K Sharma have proposed an energy efficient cluster head scheme, for heterogeneous wireless sensor networks, by modifying the threshold value of a node based on which it decides to be a cluster head or not, called TDEEC (Threshold Distributed Energy Efficient Clustering) protocol [18]. Since the network nodes are deployed randomly in a monitoring zone, the aim problem of clustering algorithms that it aren't takes into account the localization energy consumption to calculate the total network energy consumption. When multiple cluster heads are randomly selected within a large number of nodes into expanded area, a wide additional loss of energy occurs because the localization energy is approximately proportional to the number of HELLO packet message size and the distance between these nodes. In the face of this scenario, it is necessary to recover the lost energy ratio by using the RFID technology.

IV. HETEROGENEOUS MODEL AND PERFORMANCE MEASURES FOR WSN

A. Performance measures

We describe the indicators that apply here to assess the performance of protocols that are defined in Smaragdakis et al.[15] and used in our paper. Network stability: first dead , all-dead ,number of packets messages in each round finally number of alive nodes received per round.

B. Radio Energy Dissipation Model

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Radio Energy Model used is based on [10, 19]. Energy model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics is shown in Figure 1 [10,19].

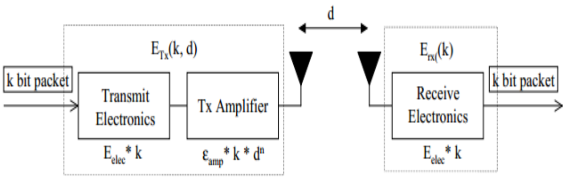

Figure 1: Radio Energy Dissipation Model

In this model, both the free space (d^2 power loss) and the multipath fading (d^4 power loss) channel models were used, depending on the distance between the transmitter and receiver [10,19].Power control can be used to invert this loss by appropriately setting the power amplifier if the distance is less than a threshold do, the free space model is used otherwise, the multipath model is used. Thus, to transmit an L-bit message a

$$E_{TX}(L,d)=\begin{cases} LE_{elec}+L\varepsilon_{fs}d^2 & d<d_0 \\ LE_{elec}+L\varepsilon_{amp}d^4 & d\geq d_0 \end{cases} \qquad (1)$$

distance, the radio expands.

The electronics energy, E_{elec} , depends on factors such as the digital coding, modulation, filtering, and spreading of the signal defined at [9] ,whereas the amplifier energy, $E_{fs}.d^2$ or $E_{amp}.d^4$, depends on the distance to the receiver and the acceptable bit-error rate.

C. Contribution and Proposed Method:

In our proposition, we note that energy dissipated for localization can be covered by integration of RFID passive tags model datasheet microID® 125 kHz [21].so as we know the hello packet size is L=512 bytes the localization energy becomes:

$$E_{TX}(512,d)=\begin{cases} (2*8*512)E_{elec}+(2*8*512)\varepsilon_{fs}d^2 & d<d_0 \\ (2*8*512)E_{elec}+(2*8*512)\varepsilon_{amp}d^4 & d\geq d_0 \end{cases} \qquad (2)$$

We based our work on [16] using the energy model consumption sending and receiving one byte of data from node i to node j over a distance d meters, and we consider that the energy consumption costs:

$$\begin{cases} e_{ij}^{s}=c_1+c_2d_{ij}^2 \\ e_{ji}^{r}=c_1 \end{cases} \qquad (3)$$

$$d_{ij}=\sqrt{\left|\frac{e_{ij}^{s}-c_1}{c_2}\right|} \qquad (4)$$

by calculating the distance d we place the node destination j on the circle where the node i represent his centre. The angle of arrival serves for locating the node j on the segment S and reducing the probability of positioning the node on all area of the circle. Considering the segment S proximately similar to line, and using the Euclidian distance d between node I and j at the instant t we denote [17]:

$$d_{ij}=\sqrt{(x_i-x_j)^2+(y_i-y_j)^2} \qquad (5)$$

$$S\cong 2.d_{ij}(t).\sin(\frac{\alpha}{2})$$

$$S\cong 2.\sqrt{(x_i-x_j)^2+(y_i-y_j)^2}.\sin(\frac{\alpha}{2}) \qquad (6)$$

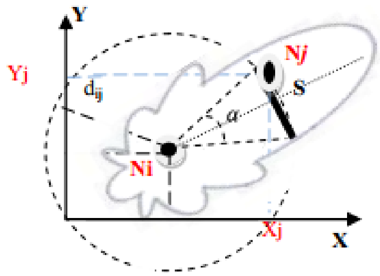

Figure 2: Representation of the localization method

The techniques (angle of directional antenna and the energy of transmission), can sufficiently locate node with reduced probability.

D. Network model

In our model, we assume that there are N sensor nodes, which are evenly scattered within a M×M square region and organized into clusters hierarchy for aggregate data by cluster heads to base station which is located at the center of this region. Nodes have low mobility or stationary as assumed at [4], [10].In fact we will use the same conception as mentioned at [4],noted by m fraction of stronger nodes with a times more energy than the others which have an initial energyE_0. In two and multi-level heterogeneous networks, the clustering algorithm should consider the discrepancy of initial energy, E_{total} is expressed by:

$$E_{total}=\sum_{i=1}^{N}E_0\left(1+a_i\right)=E_0\left(N+\sum_{i=1}^{N}a_i\right) \qquad (7)$$

TDEEC Cluster-head selection algorithm

TDEEC protocol, we choose different parameters based the residual energy of $E_i(r)$ node s at round r. If nodes e different amounts of energy, pi of the nodes with more energy should be larger than p_{opt} Let $\bar{E}(r)$ denotes the

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average energy at round r of the network, which can be obtained by:

$$\overline{E}(r)=\frac{1}{N}E_{total}\left(1-\frac{r}{R}\right) \quad (8)$$

where R denotes the total rounds of the network lifetime, R can be calculated as:

$$R = \frac{E_{total}}{E_{round}} \quad (9)$$

The total energy dissipated in the network during a round E_{round} is equal to:

$$E_{round} = L(2NE_{elec} + NE_{DA} + k\varepsilon_{mp} d_{toBS}^{4} + N\varepsilon_{fs} d_{toCH}^{2}) \quad (10)$$

$$d_{toBS} = \frac{M}{\sqrt{2\pi k}}, \quad d_{toCH} = 0.765\frac{M}{2} \quad (11)$$

Where k is the number of clusters, E_{DA} is the data aggregation cost expended in the cluster-heads. When the networks are heterogeneous, the reference value of each node should be different according to the initial energy. In the model of multi-level heterogeneous networks, the weighted probability shown as:

$$p(s_i) = \frac{p_{opt} N (1 + a_i) E_i(r)}{\left(N + \sum_{i=1}^{N} a_i\right)\overline{E}(r)} \quad \text{if } s_i \in G \quad (12)$$

Threshold for cluster head selection is calculated based on ratio of residual energy and average energy of that round in respect to the optimum number of cluster heads by:

$$T(s) = \begin{cases} \dfrac{p(s_i)E_i(r)}{1 - p(s_i)\left(r \bmod \dfrac{1}{p(s_i)}\right)\overline{E}(r)} * k_{opt} & \text{if } s_i \in G \\ 0 & \end{cases} \quad (13)$$

where $p(s_i)$, r, and G represent, respectively, the desired percentage of cluster-heads, the current round number, and the set of nodes that have not been cluster-heads in the last $1/p(s_i)$ rounds. Using this threshold, each node will be a cluster head, just once at some point within $1/p(s_i)$ rounds.

$$k_{opt} = \frac{M}{d_{toBS}^{2}} \sqrt{\frac{N}{2\pi} * \frac{\varepsilon_{fs}}{\varepsilon_{amp}}} \quad (14)$$

V. SIMULATION RESULTS

The proposed approach has been implemented in MATLAB and the performance has been evaluated by simulation, the lifetime of the network is measured in terms of rounds when the first sensor node dies. The base station is assumed in the center of the sensing region. All the parameters values including the first order radio model characteristic are mentioned in the table1 below. To compare the performance of the proposed approach with TDEEC protocol, the effect caused by signal collision and interference in the wireless channel is ignored, a multi-level heterogeneous network is considered.

Parameter	Value
Network area	100 m×100 m
Number of nodes	100
E_0	0.5 J
E_{elec}	1.3nJ/bit
ε_{fs}	10 pJ/bits/m2
ε_{emp}	0.0013 pJ/bit/m4
E_{Tx}=E_{Rx}	50 nJ/bit
E_{DA}	50 nJ/bit/message
$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$	70 m
Packet Size	4096 bits
P_{opt}	0.05

Table 1 : Simulation Parameters

The effect of varying α on the lifetime of the network and on the number of packet messages received in the base station is studied in different scenarios as shown in table2,where m and m_0 are the fraction of the advanced and super nodes, which own a and b times more energy than the normal ones [9]:

Parameters	***m***	***m0***	***α***	***b***
Scenario1	0.6	0.4	2	3
Scenario2	0.6	0.4	4	3

Table 2 : Simulation scenarios

Thus, each node in the sensor network is randomly assigned different energy levels between a closed set $[E_0, E_0(1+a_{max})]$. In the simulation results figures 3and 5 the lifetime evolution of the network for each scenario, whereas figures 4and 6 shows the number of packet messages received in the base station per round for each scenario. The tables 3and 4 provides statistics on the number of dead nodes per rounds as well as the percentage increase in the lifetime of the network for the proposed approach compared to TDEEC protocol. It is very clear that the proposed approach gives a lifetime network greater than TDEEC protocol whether for the first dead node rounds or for all dead nodes rounds due to their remaining energy. In TDEEC protocol all nodes die early on the contrary of the proposed approach in which all nodes die tardily for all studied scenarios. On the other hand, the energy efficiency of the proposed approach improves significantly the number of packets message

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received which increases with a remarkable manner increasing α.

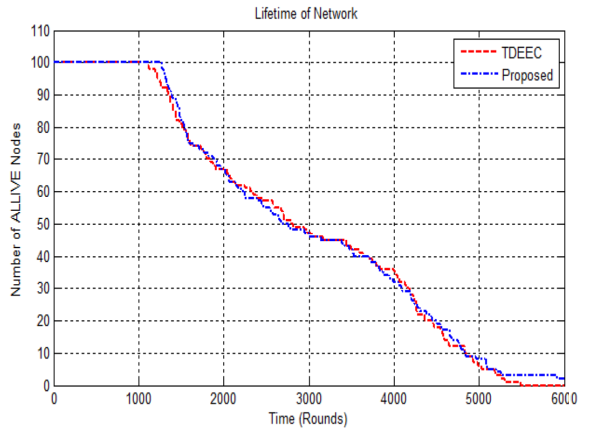


Figure 3: Number of alive nodes over time (Scenario1)

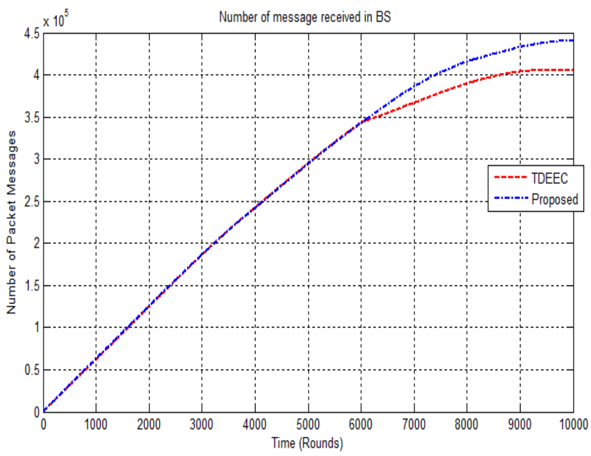


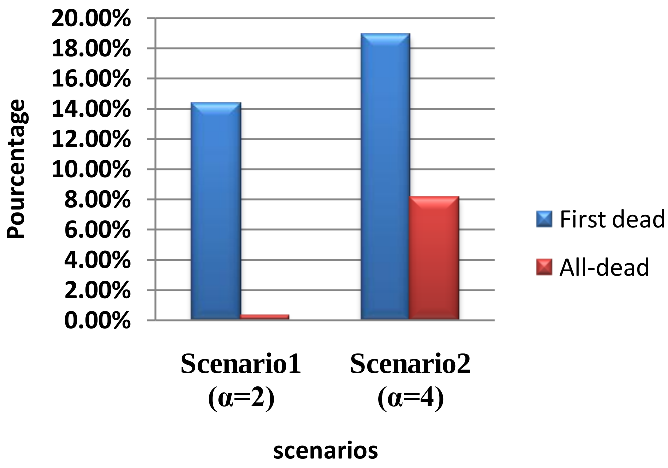
Figure 6: Number of packet messages received per round (Scenario2)

	TDEEC	Proposed	INCREASE
First dead	1114	1274	14,36 %
All-dead	6152	6174	0.3%

Table 3: Number of dead nodes per rounds (Scenario1)

	TDEEC	Proposed	INCREASE
First dead	1020	1213	18,92%
All-dead	9645	10432	8,15%

Table 4: Number of dead nodes per rounds (Scenario2)



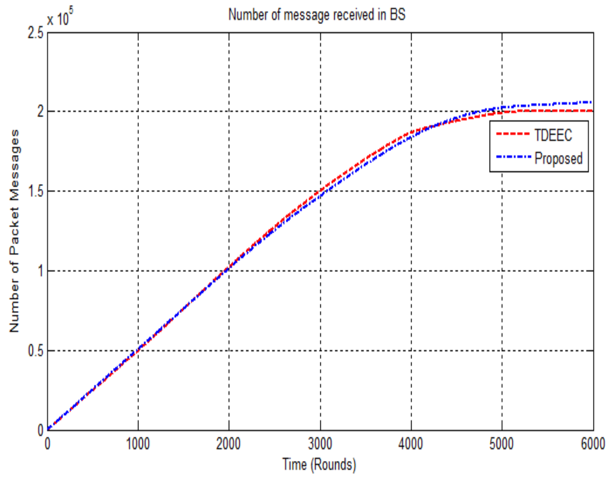


Figure 4: Number of packet messages received per round (Scenario1)

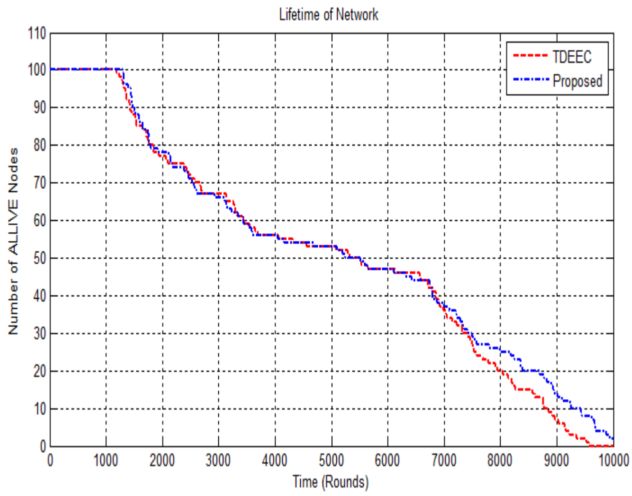


Figure 5: Number of alive nodes over time (Scenario2)

Figure 7: Evolving of lifetime nodes percentage according to different scenarios

Referred to figure 7, the lifetime percentage decreases with increasing α for the first dead node time while this percentage fluctuate between different values and do not keep a monotony for the all dead nodes time when α increase, this is justified by the network instability in this time period

	α=2	α=2.5	α=3	α=4	α=5	α=6
*Packet number *10^5 (TDEEC)*	*2.005*	*2.488*	*2.882*	*4.054*	*4.725*	*4.674*
*Packet Number * 10^5 (Proposed)*	*2.048*	*2.562*	*2.966*	*4.406*	*5.149*	*5.464*
Packet number increasing	*4300*	*7400*	*8400*	*35200*	*42400*	*79000*

Table 5: numerical results for different values of α

It is clear in figures 8 and 9, that the proposed approach preserves the improvement of the network lifetime whether for the first dead node rounds or for all dead nodes rounds compared to TDEEC protocol despite the increase of multi-level heterogeneity value which takes its value from 2 to6. Therefore, the number of packets message received at round=10000 increases also.

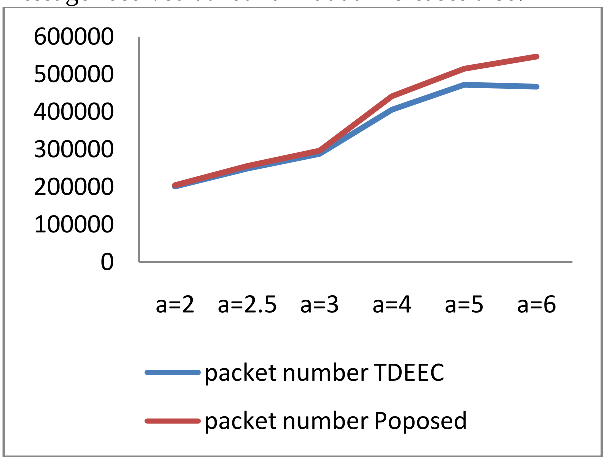


Figure 8: Evolving of lifetime nodes percentage according to different scenarios

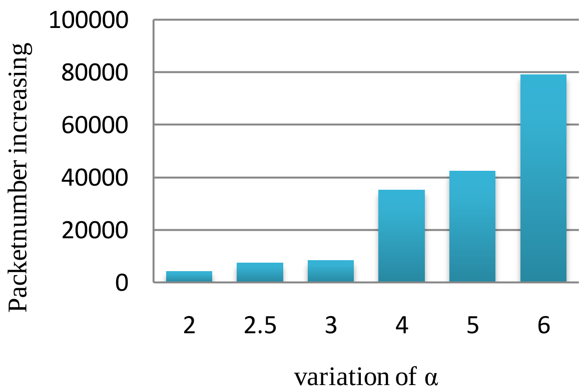


Figure 9: packet message evolution

VI. CONCLUSION

By integrating RFID technology with WSN, it can lead to a heterogeneous network. In such network the major goal of routing clustering protocol is to improve energy consumption and increasing lifetime. In our article we suggest and introduce a cluster-based protocol for heterogeneous RFID enhanced WSNs that can recover the Energy consumed during the localization. The simulation results show that our solution significantly improves the stability period, and consumes energy in a more efficient way in the WSNs in comparison with existing clustering protocol TDEEC at the same time that can increase the packet message number received during the simulation time.

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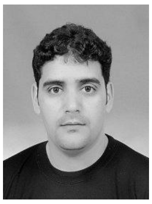
BIOGRAPHIES



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