Conférence Internationale en Automatique & Traitement de Signal (ATS-2018)
Proceedings of Engineering and Technology – PET
Vol.35pp.32-39

MULTI-LEVEL DEPLOYMENT IN EXTENDED THREE-DIMENSIONAL SPACES FOR WSN

Abderrahmane EL AALAOUI[1], Abderrahmane HAJRAOUI[2]
Department of Physics,Communication and detection systems laboratory
Faculty of Sciences, University of Abdelmalek Essaadi Tetouan, Morocco
[1]elaalaoui.abderrahmane@gmail.com
[2]hajraouiabder@gmail.com

Abstract*— The challenge of modern researches is how to organize the energy consumption in wireless sensor networks, which been more used in the communications. LEACH is one of the protocols that make such an organization of energy consumption. The estimation of this consumption is further from reality. This due to the deployment of nodes in a distorted space; where the nodes are not at the same height. In a two-dimensional WSN, the energy will be consumed more in large spaces. Therefore, this consumption will be more seriously increased in large three-dimensional spaces. In this paper, we compare the energy efficiency of a three-dimensional network in different extended spaces, then we organize the nodes deployment in these spaces so that the energy consumed is the minimum, in order to increase the WSN lifetime over than 18% and LEACH performance, two times more.

Keywords—WSN, LEACH, Multi-level deployment, Three dimensions, Two dimensions, Energy efficiency.

I. Introduction

In the reality, the nodes deployment of WSN is done in a random manner and on a three-dimensional space (see figure 1), against a two-dimensional plane model (see figure 2) [1]. Node clustering is an effective technique, for improving the energy efficiency and prolonging the network lifetime of a WSN [3].LEACH [3,4] is one of the first protocols, which use this technique and has been applied into the underwater environment [5,6,7,8].

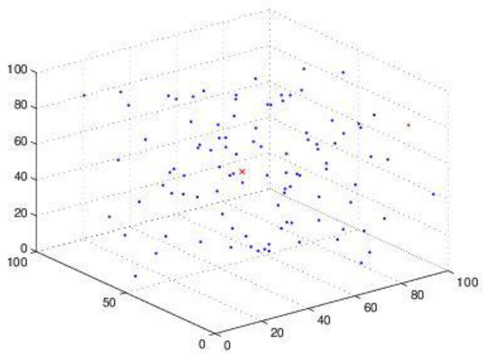


Fig. 1 : 3D deployment

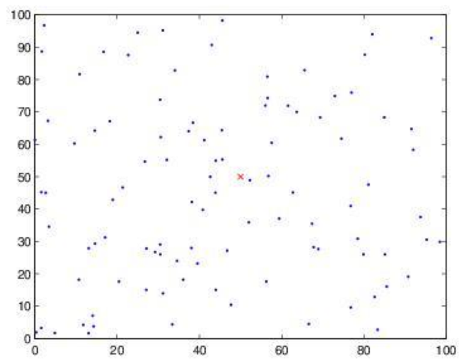


Fig. 2 : 2D deployment

The works in [2] show that a real network consumes more energy than a network in two-dimensional plan. However, in large spaces, the energy consumption increases even the network communicates with a technique like LEACH, only a good management of the nodes deployment can solve this problematic. We propose in our work a controlled deployment of sensors, in order to control the intensive energy leakage in extended spaces.

II. Overview

Generally, in a WSN, the transmission energy of a segment of size L is expressed as follows:

$$\begin{cases} E_{TX} = LE_{elec} + L\varepsilon_{fs}d^2 & if\ d \leq d_0 \\ E_{TX} = LE_{elec} + L\varepsilon_{mp}d^4 & if\ d > d_0 \end{cases} \quad (1)$$

With: $d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$

When the distance between the node and the base station increases, the transmission energy also increases. In Figure 3, we illustrate the difference between the energy consumption, in the two spaces: 2D and 3D.

ISSN 2356-5608

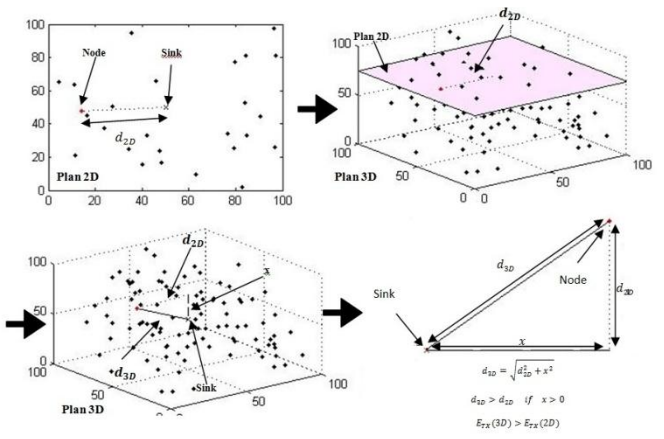


Fig. 3 : the difference between the energy dissipated in 3D and 2D

The distortion of the space results a change of the vertical location of the nodes, therefore, an extended distance from the base station. This distance can be more extended also in a large space.

We consider a base station located in the center of a space designated by a cube, the farthest point (node) of the center (BS), is the corner of the cube, by distance of :

$$d = \frac{\sqrt{3}}{2}x \qquad (2)$$

where x is the dimension of cube

Graph 1 (see Figure 5) shows the position of the farthest node from the base station, respecting to the space volume.

The change of d in equation (1) by that in (2), gives the equation (3):

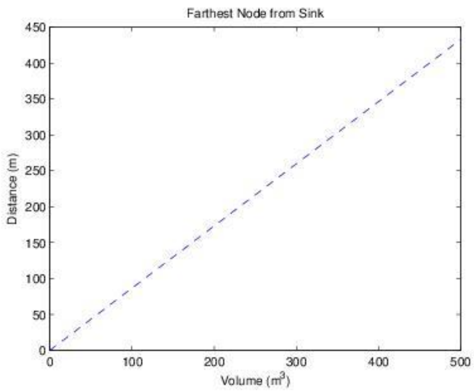
$$\begin{cases} E_{TX} = LE_{elec} + L\varepsilon_{fs}\frac{3}{4}x^2 & if\ d < d_0 \\ E_{TX} = LE_{elec} + L\varepsilon_{mp}\frac{9}{16}x^4 & if\ d \geq d_0 \end{cases} \qquad (3)$$

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$$

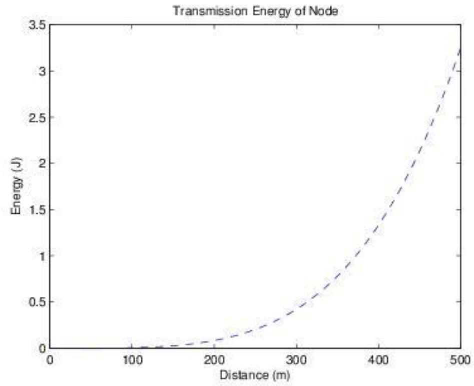
In our research, we are interested only by the extended spaces ($d > d_0$).. Equation (3) therefore can be written as follows:

$$E_{TX} = LE_{elec} + L\varepsilon_{mp}\frac{9}{16}x^4 \qquad (4)$$

We can conclude that, the more the studied spaces are extended enough; the more the energy consumption increases during transmission of the bits. The graph 2 (see figure 4) shows this relationship. For energy consumption, the space remains equitable, if it does not exceed the dimension limit: 100m, beyond, it is infected by intense energy leaks.



1



2

Fig. 4 **:** The influence of the space dimension on the distance of the farthest node from the base station and the energy consumed by this node

III. The controlled deployment model of three-dimensional WSN

This study, measures in the extended spaces, the effect of the node deployment on energy consumption. Therefore, a controlled deployment will be chosen to develop our conception. Such dynamism minimizes the energy dissipation consequence of the wide distance of the base station (d^4 power loss), and on the contrary, to maximize the dissipation of short distance (d^2 power loss).

M.baghouri et al [2], studied the WSN in a volume space of $100m^3$ with centered base station, and according to equation (2), the distance d of the farthest node cannot be greater than 86.6 m.

$$d = \frac{\sqrt{3}}{2} \text{ x } 100 = 86.6 \text{ m}$$

And since

Conférence Internationale en Automatique & Traitement de Signal (ATS-2018)
Proceedings of Engineering and Technology – PET
Vol.35pp.32-39

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \approx 87.7\ m$$

Then, the equation (1) of the energy according to the simulation [2] is written as follows:

$$E_{TX} = LE_{elec} + L\varepsilon_{fs}d^2$$

Our proposition is to segment the deployment of the nodes in levels, when the dimension of the space exceeds the limit 100 m, according to the critical distance d_0; the number of levels is calculated in the following way:

$$n = real(\frac{D}{d_0}) \qquad (5)$$

D : the space dimension

Each level contains a nodes rate different to next level, as well as the dense levels are closer to the base station and vice versa.

A. *Energy Model*

This study assumes a simple model for the radio hardware where the transmitter dissipates energy for running the radio electronics to transmit and amplify the signals, and the receiver runs the radio electronics for reception of signals [7]. Multipath fading model (d^4 power loss) for large distance transmissions and the free space model (d^2 power loss) for proximal transmissions are considered. Thus to transmit a bits message over a distance d, the radio expends:

$$E_{TX}(l,d) = E_{TX-elec}(l) + E_{TX-amp}(l,d)$$

$$E_{TX-elec}(l) = lE_{elec}$$

$$E_{TX-amp}(l,d) = \begin{cases} l\varepsilon_{fs}d^2 \ when\ d < d_0 \\ l\varepsilon_{mp}d^4 \ when\ d \geq d_0 \end{cases}$$

Where d is the distance threshold for swapping amplification models, which can be calculated as :

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$$

To receive a *l* bits message the receiver expends:

$$E_{RX}(l) = lE_{elec}$$

To aggregate n data signals of length l bits, the energy consumption was calculated as:

$$E_{DA-expend}(l) = lnE_{DA}$$

B. *Network Model*

1. N sensors are uniformly distributed in n levels within a square 3D rectangular field of area A=D x D x D. The base station is positioned in the center of the square region.

2. Each level contains a rate R of N like table 1 shows:

TABLE I
NODES RATE

Rate (%)	90	70	40	35	30	25	20	15	10	5
Two Level	√	-	-	-	-	-	-	-	√	-
Three Level	-	√	-	-	-	-	√	-	√	-
Four Level	-	-	√	-	√	-	√	-	√	-
Five Level	-	-	-	√	-	√	√	√	-	√

According to the following equation:

$$N = \sum_{i=1}^{n} R_i \times N$$

3. All nodes are deployed randomly.
4. Each sensor can sense the environment in the 3D sphere of radius r.
5. All sensors are homogeneous, i.e., they have the same capacities.
6. All the sensor nodes have a particular identifier (ID) allocated to them. Each cluster head coordinates the MAC and routing of packets within their clusters.

C. *Optimal number of cluster*

We assume there are N_1 and N_2 nodes distributed uniformly in $d_0 \times d_0 \times d_0$ and $(D - d_0) \times (D - d_0) \times (D - d_0)$ respectively, 3D region. If there are c_1 and c_2 clusters, there are on average $\frac{N_1}{c_1}$ and $\frac{N_2}{c_2}$ respectively, nodes per cluster. Each cluster-head dissipates energy receiving signals from the nodes and transmitting the aggregate signal to the base station. Therefore, the energy dissipated in the cluster-head node during a single frame is:

$$\begin{cases} \boldsymbol{E_{CH1}} = \boldsymbol{l}\frac{N_1}{c_1}E_{elec} + l\frac{N_1}{c_1}E_{DA} + l\varepsilon_{fs}d_{toBS}^2 \\ \boldsymbol{E_{CH2}} = \boldsymbol{l}\frac{N_2}{c_2}E_{elec} + l\frac{N_2}{c_2}E_{DA} + l\varepsilon_{mp}d_{toBS}^4 \end{cases}$$

Where *l* is the number of bits in each data message, d_{toBS} is the distance from the cluster head node to the BS, and we have assumed perfect data aggregation E_{DA}.

The expression for the energy spends by a non-cluster head is given by:

$$\boldsymbol{E_{nonCH}} = \boldsymbol{l}E_{elec} + l\varepsilon_{fs}d_{toCH}^2$$

ISSN 2356-5608

Conférence Internationale en Automatique & Traitement de Signal (ATS-2018)
Proceedings of Engineering and Technology – PET
Vol.35pp.32-39

Where d_{toCH} is the distance from the node to the cluster head.

Let $E[d_{toBS}^2]_1$ and $E[d_{toBS}^2]_2$ be the Expected distance of cluster head c_1 and c_2 respectively, from the base station. Assuming that the nodes are uniformly distributed in each level, so it is calculated as follows:

$$\begin{cases} E[d_{toBS}^2]_1 = \int_0^{x_{max}}\int_0^{y_{max}}\int_0^{z_{max}} (x^2+y^2+z^2)\, f_1(x,y,z)dxdydz \\ E[d_{toBS}^4]_2 = \int_0^{x_{max}}\int_0^{y_{max}}\int_0^{z_{max}} (x^4+y^4+z^4) f_2(x,y,z)dxdydz \end{cases}$$

Where $f_1(x,y,z)$ and $f_2(x,y,z)$ is the probability density functions of three dimensions random variable $X(x,y,z)$ which is uniform for each level and given by:

$$\begin{cases} f_1 = \frac{1}{V_1} = \frac{1}{(2d_0)^3} \\ f_2 = \frac{1}{V_2} = \frac{1}{D^3-(2d_0)^3} \end{cases}$$

If we assume that base station is the center of the network we can passing in the spherical coordinates:

$$\begin{cases} E[d_{toBS}^2]_1 = \int_0^{r_{max\,1}}\int_0^{\pi}\int_0^{2\pi} r^2 f_1(r,\theta,\varphi) r^2 \sin\theta\, dr d\theta d\varphi \\ E[d_{toBS}^4]_2 = \int_{r_{max\,1}}^{r_{max\,2}}\int_0^{\pi}\int_0^{2\pi} r^4 f_2(r,\theta,\varphi) r^2 \sin\theta\, dr d\theta d\varphi \end{cases}$$

The area of network is aspheric with radius $r_{max\,1} = 2d_0\sqrt[3]{3/4\pi}$ and $r_{max\,2} = D\sqrt[3]{3/4\pi}$.

If the density of sensor nodes is uniform throughout the area then becomes independent of r, θ and φ then:

$$\begin{cases} E[d_{toBS}^2]_1 = \int_0^{2d_0\sqrt[3]{3/4\pi}}\int_0^{\pi}\int_0^{2\pi} r^2 f_1(r,\theta,\varphi) r^2 \sin\theta\, dr d\theta d\varphi \\ E[d_{toBS}^4]_2 = \int_{2d_0\sqrt[3]{3/4\pi}}^{D\sqrt[3]{3/4\pi}}\int_0^{\pi}\int_0^{2\pi} r^4 f_2(r,\theta,\varphi) r^2 \sin\theta\, dr d\theta d\varphi \end{cases}$$

$$\begin{cases} E[d_{toBS}^2]_1 = \frac{6}{5}\left(\frac{3}{4\pi}\right)^{\frac{2}{3}} {d_0}^2 = 0.4664\, {d_0}^2 \\ E[d_{toBS}^2]_2 = \frac{3}{14}\left(\frac{3}{4\pi}\right)^{\frac{4}{3}} \frac{(D^7-(2d_0)^7)}{(D^3-(2d_0)^3)} = 0.0319\, \frac{(D^7-(2d_0)^7)}{(D^3-(2d_0)^3)} \end{cases}$$

The expected squared distance from the nodes to the cluster head (assumed to be at the center of mass of the cluster) is given by:

$$\begin{cases} E[d_{toCH}^2]_1 = \int_0^{2d_0\sqrt[3]{3/4\pi}}\int_0^{\pi}\int_0^{2\pi} r^2 f_1(r,\theta,\varphi) r^2 \sin\theta\, dr d\theta d\varphi \\ E[d_{toCH}^2]_2 = \int_{2d_0\sqrt[3]{3/4\pi}}^{D\sqrt[3]{3/4\pi}}\int_0^{\pi}\int_0^{2\pi} r^2 f_2(r,\theta,\varphi) r^2 \sin\theta\, dr d\theta d\varphi \end{cases}$$

If we assume this area is a sphere with radius $r_{max\,1} = 2d_0\sqrt[3]{3/4\pi}$ and $r_{max\,2} = D\sqrt[3]{3/4\pi}$ is constant for r, θ and , (10) simplifies to:

$$\begin{cases} E[d_{toCH}^2]_1 = f_1 \int_0^{2d_0\sqrt[3]{3/4\pi c_1}}\int_0^{\pi}\int_0^{2\pi} r^4 \sin\theta\, dr d\theta d\varphi \\ E[d_{toCH}^2]_2 = f_2 \int_{2d_0\sqrt[3]{3/4\pi c_1}}^{D\sqrt[3]{3/4\pi c_2}}\int_0^{\pi}\int_0^{2\pi} r^4 \sin\theta\, dr d\theta d\varphi \end{cases}$$

If the density of nodes is uniform throughout the cluster area of the two levels, then $f_1 = \frac{c_1}{(2d_0)^3}$ and $f_2 = \frac{c_2}{D^3-(2d_0)^3}$

$$\begin{cases} E[d_{toCH}^2]_1 = \frac{6}{5}\left(\frac{3}{4\pi c_1}\right)^{\frac{2}{3}} {d_0}^2 \\ E[d_{toCH}^2]_2 = \frac{3}{10}\left(\frac{3}{4\pi c_2}\right)^{\frac{2}{3}} \frac{(D^5-(2d_0)^5)}{(D^3-(2d_0)^3)} \end{cases}$$

Therefore, the total energy dissipated in the network per round, is expressed by:

$$\begin{cases} E_{Total\,1} = c_1 E_{cluster\,1} \\ E_{Total\,2} = c_2 E_{cluster\,2} \end{cases}$$

Where $E_{cluster\,1}$ and $E_{cluster\,2}$ are the energy dissipated in cluster of each level which giving by:

$$\begin{cases} E_{cluster\,1} = E_{CH} + (\frac{N_1}{c_1} - 1)E_{nonCH} \approx E_{CH} + \frac{N_1}{c_1} E_{nonCH} \\ E_{cluster\,2} = E_{CH} + (\frac{N_2}{c_2} - 1)E_{nonCH} \approx E_{CH} + \frac{N_2}{c_2} E_{nonCH} \end{cases}$$

This can be calculated by:

$$\begin{cases} E_{cluster\,1} = l\left(\frac{N_1}{c_1}E_{elec} + \frac{N_1}{c_1}E_{DA} + \epsilon_{fs} d_{toBS}^2\right) + l\left(\frac{N_1}{c_1}E_{elec} + \epsilon_{fs} d_{toCH}^2\right) \\ E_{cluster\,2} = l\left(\frac{N_2}{c_2}E_{elec} + \frac{N_2}{c_2}E_{DA} + \epsilon_{mp} d_{toBS}^4\right) + l\left(\frac{N_2}{c_2}E_{elec} + \epsilon_{fs} d_{toCH}^2\right) \end{cases}$$

Therefore, the total energy dissipated in the network is simplified by:

ISSN 2356-5608

$$\begin{cases} E_{Total\,1} = l\left(2N_1E_{elec} + N_1E_{DA} + c_1\epsilon_{fs}d_0^2 + N_1\varepsilon_{fs}\frac{6}{5}\left(\frac{3}{4\pi c_1}\right)^{\frac{2}{3}}{d_0}^2\right) \\ E_{Total\,2} = l\left(2N_2E_{elec} + N_2E_{DA} + c_2\epsilon_{mp}\,d_{toBS}^4 + N_2\varepsilon_{fs}\frac{3}{10}\left(\frac{3}{4\pi c_2}\right)^{\frac{2}{3}}\frac{(D^5-(2d_0)^5)}{(D^3-(2d_0)^3)}\right) \end{cases}$$

The total energy consumption of our study is :

$$E_{TotalTwoLevel} = E_{Total\,1} + E_{Total\,2}$$

$$E_{TotalTwoLevel} = l\Bigg(2NE_{elec} + NE_{DA} + c_1\epsilon_{fs}d_0^2 + c_2\epsilon_{mp}\,d_{toBS}^4 + \varepsilon_{fs}\frac{3}{10}\bigg(4N_1{d_0}^2\left(\frac{3}{4\pi c_1}\right)^{\frac{2}{3}} + N_2\frac{(D^5-(2d_0)^5)}{(D^3-(2d_0)^3)}\left(\frac{3}{4\pi c_2}\right)^{\frac{2}{3}}\bigg)\Bigg)$$

M.Baghouri et al [2], gives the energy consumption of three dimensional WSN as :

$$E_{Total} = l\left(2NE_{elec} + NE_{DA} + c\epsilon_{mp}\,d_{toBS}^4 + N\varepsilon_{fs}\frac{3}{10}\left(\frac{3}{4\pi c}\right)^{\frac{2}{3}}D^2\right)$$

$$E_{TotalTwoLevel} < E_{Total} \quad implies\ that\ \ c_1\epsilon_{fs}d_0^2 + c_2\epsilon_{mp}\,d_{toBS}^4 < c\epsilon_{mp}\,d_{toBS}^4$$

$$c_2 < c - c_1\left(\frac{d_0^2}{d_{toBS}^4}\right)$$

Noting that: $d_0 \approx 87.7\ m$ and $d_{toBS} = 200\ m$
Thus:

$$\frac{d_0^2}{d_{toBS}^4} \approx 0$$

Then:

$$c_2 < c$$

Similarly, we conclude the other conditions of the other studies: three levels, four levels and five levels as follows:

Three levels

$$c_3 < c - c_1\left(\frac{d_0^2}{d_{toBS\,2}^4}\right) - c_2\left(\frac{d_{toBS\,1}^4}{d_{toBS\,2}^4}\right)$$

Four levels

$$c_4 < c - c_1\left(\frac{d_0^2}{d_{toBS\,2}^4}\right) - c_2\left(\frac{d_{toBS\,1}^4}{d_{toBS\,2}^4}\right) - c_3\left(\frac{d_{toBS\,2}^4}{d_{toBS\,3}^4}\right)$$

Five levels

$$c_5 < c - c_1\left(\frac{d_0^2}{d_{toBS\,2}^4}\right) - c_2\left(\frac{d_{toBS\,1}^4}{d_{toBS\,2}^4}\right) - c_3\left(\frac{d_{toBS\,2}^4}{d_{toBS\,3}^4}\right) - c_4\left(\frac{d_{toBS\,3}^4}{d_{toBS\,4}^4}\right)$$

IV. Simulation Results

A. *Parameter settings*

TABLE II
SIMULATION PARAMETERS

Parameter	**Value**
Initial Node Energy	0.5 J
N	100
E_{elec}	50 nJ/bit
E_{DA}	5 pJ/bit
ϵ_{fs}	10 pJ/bit/m^2
ϵ_{mp}	0.0013 pJ/bit/m^2
l	4000 bits
P	0.05
Rounds	4000

In this section, we study the performance of LEACH 3D protocol under different scenarios using MATLAB. We consider a model illustrate in the figure 1 with N=100 nodes randomly and uniformly distributed in a different space dimensions and divided in a levels. To compare the performance of LEACH 3D with LEACH 3D-MultiLevel protocol, we use the parameters shown in Table 2 and for each level, we apply the probabilities shown in Table 3.

TABLE III
PROBABILITIES

Dimension(m)	**P_1=P**	**P_2**	**P_3**	**P_4**	**P_5**
100	0.05	N/A	N/A	N/A	N/A
200	0.05	0.01	N/A	N/A	N/A
300	0.05	0.01	0.005	N/A	N/A
400	0.05	0.01	0.005	0.001	N/A
500	0.05	0.01	0.005	0.001	0.0005

B. *Simulation metrics*

We define two performance metrics to evaluate both protocols as: First Node Dies (FND), or stability period and Last Node Dies (LND), or instability period. Moreover, the performance metrics used in the simulation study can be as follow:

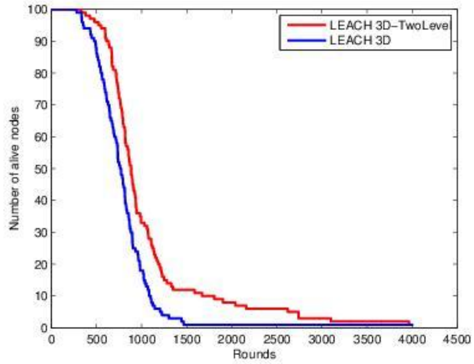
- Lifetime
- Throughput
- Increase

C. *Simulation results*

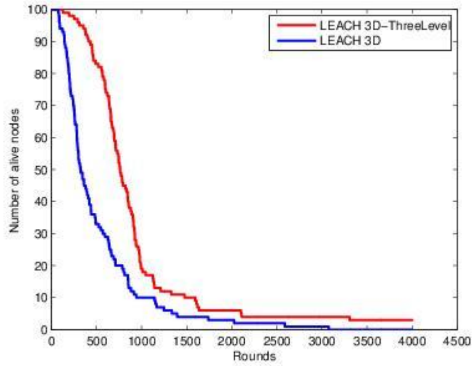
1) ***Network lifetime*** *:*The number of nodes dead for each round of data transmission is observed for the LEACH 3D and 3D-MultiLevel protocols to evaluate the lifetime of the network. Figure 5 (graphs 1, 2, 3 and 4) and table 4 show the performance of LEACH 3D compared to LEACH 3D-MultiLevel. It is observed that the LEACH 3D is less perform than LEACH 3D-MultiLevel due to energy dissipation of individual node throughout the network which depend essentially on the distance between nodes and sink.

ISSN 2356-5608

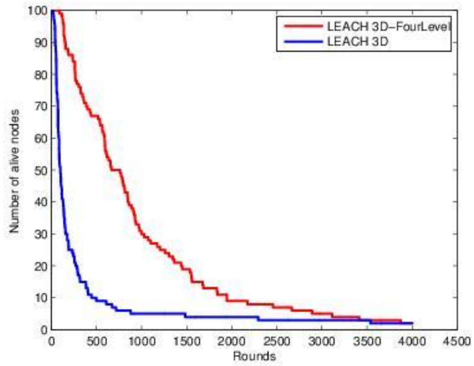
Conférence Internationale en Automatique & Traitement de Signal (ATS-2018)
Proceedings of Engineering and Technology – PET
Vol.35pp.32-39



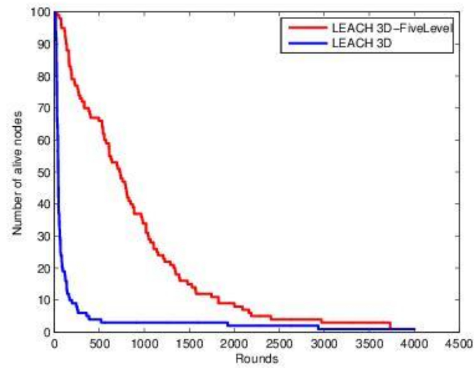
a)



b)



c)



d)

Fig. 5 : Number of alive nodes per round comparison of LEACH 3D and LEACH 3D-MultiLevel : a) Two levels, b) Three levels, c) Four levels, d) Five levels

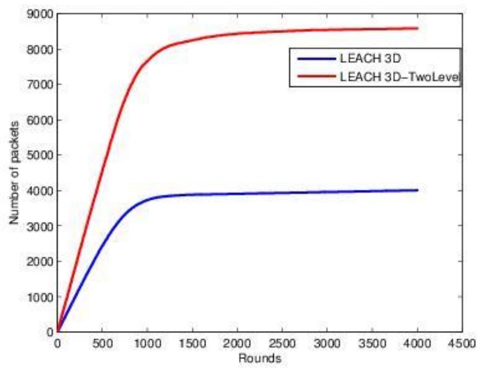
TABLE IV
ROUND of FIRST DEAD NODE

Dimension (m)	200		300		400		500	
Protocol	LEACH 3D	LEACH 3D-TwoLevel	LEACH 3D	LEACH 3D-ThreeLevel	LEACH 3D	LEACH 3D-FourLevel	LEACH 3D	LEACH 3D-FiveLevel
Round	278	328	74	125	17	89	16	62

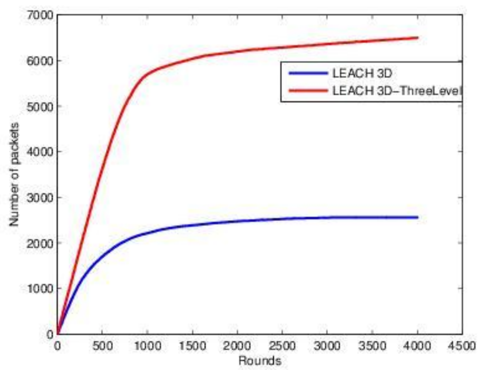
TABLE V
NUMBER of LAST REMAINING NODES at ROUND 4000

Dimension (m)	200		300		400		500	
Protocol	LEACH 3D	LEACH 3D-TwoLevel	LEACH 3D	LEACH 3D-ThreeLevel	LEACH 3D	LEACH 3D-FourLevel	LEACH 3D	LEACH 3D-FiveLevel
Number	1	1	0	3	2	2	1	1

2) ***Throughput*** *:* Figure 6 illustrate that the Number of packets sent to base station is greater in our proposition than the LEACH 3D (see graphs 1, 2, 3 and 4), this difference been wide if we pass to the number of levels increases. Referred to figure 7 (graphs 1, 2, 3 and 4), it show clearly that provide LEACH 3D-MultiLevel a good throughput compared to LEACH 3D protocol, this increase is justified by the high lifetime which give the controlled three dimensional deployment of the nodes in the network.

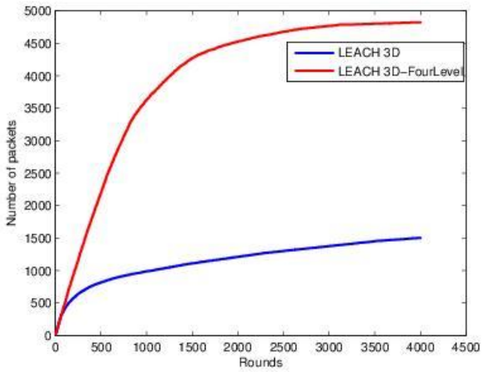


a)

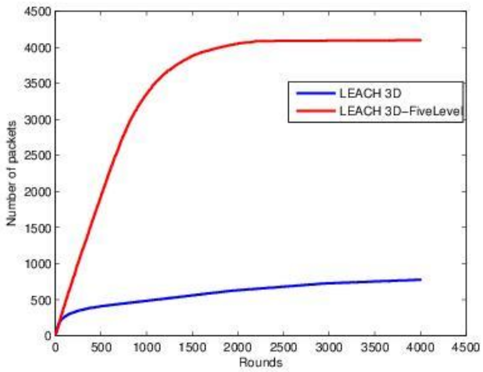


ISSN 2356-5608

b)

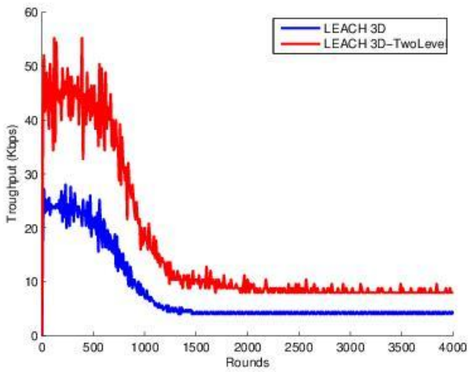


c)

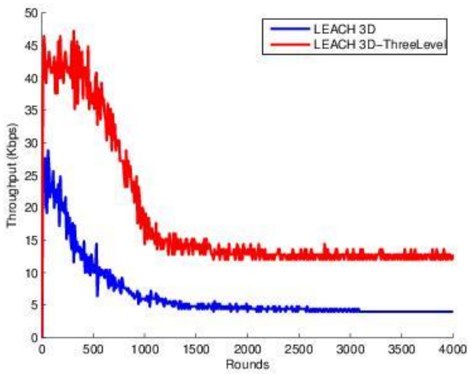


d)

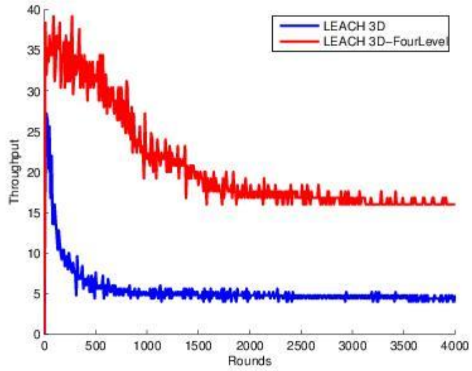
Fig. 6: Performance of the protocols LEACH 3D and LEACH 3D-MultiLevel: a) Two levels, b) Three levels, c) Four levels, d) Five levels



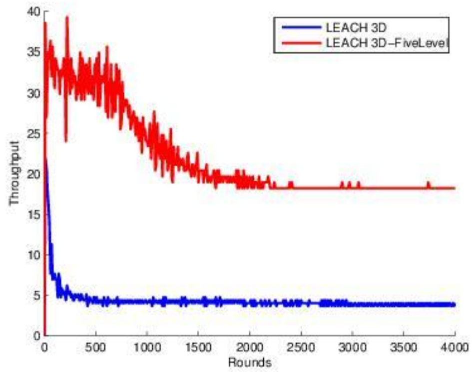
a)



b)



c)



d)

Fig. 7 : Throughput comparison of LEACH 3D and LEACH 3D-MultiLevel : a) Two levels, b) Three levels, c) Four levels, d) Five levels

3) ***Increase*** *:* Generally, we can illustrate the increase of the LEACH 3D-MultiLevel in the table 5. It's noted that the throughput increases more than 100 % due to its high energy. Whereas, LEACH 3D-MultiLevel outperforms the FND by more than 18 %. In the other hand, LEACH 3D-MultiLevel send more than 110 % packets compared to LEACH 3D.

TABLE VI
INCREASE of LEACH 3D-MULTILEVEL COMPARED to LEACH 3D

Parameter	Two Levels	Three Levels	Four Levels	Five Levels
FND*	18 %	69 %	423 %	287 %
NP**	114 %	154 %	221 %	230 %
Throughput	107 %	182 %	278 %	360 %

*: First dead node
**: Number of packets

4) ***Result analysis*** *:* From our simulations, we observed that LEACH 3D-MultiLevel consumes less energy and delivers more packets to the base station compared to LEACH 3D. These results can be interpreted by the difference of distance between nodes in both situations which causes by the random nodes deployment (LEACH 3D) and controlled nodes deployment in levels (LEACH 3D-MultiLevel).

V. Conclusion

In recently, 3D wireless sensor networks have known a great prevalent due to their large applications in large spaces such as underwater, space communications, atmospheric, forest or building. The analytic of 3D WSN in wide space is more complexity than limited one. Therefore, many researches project the 3D WSN in short projections. In this paper, we demonstrate by simulation, that this approximation is not reasonable if the dimension of network is greater than 100 m. We have proposed a controlled deployment according to solve this problematic.

References:

[1] H.M. Ammari, S.K. Das, *Coverage and connectivity in three dimensional wireless sensor networks using percolation theory*. IEEE Trans. Parallel Distrib. Syst. (IEEE TPDS) 20(6) (2009) Friedemann Mattern. "*The Design Space of Wireless Sensor Networks*". IEEE Wireless Communications, 11(6):54–61, December 2004.

[2] M.Baghouri, A.Hajraoui, S.Chakkor. "*Three Dimensional Low Energy Adaptive Clustering Hierarchy for Wireless Sensor Network*". Recent Advances in Communications, pages 214-218,2015.

[3] Wendi R. Heinzelman, Anantha Chandrakasan, and Hari Balakrishnan, "*Energy efficient communication protocol for wireless microsensor networks*", IEEE International Conference on System Sciences, pp 1-10, 2000.

[4] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "*An application specific protocol architecture for wireless microsensor networks,*" IEEE Transactions on Wireless Communications, vol. 1, No. 4, pp. 660-670, October 2002.

[5] Xia Li, Yongqian Wang, and Jingjin Zhou, "*An energy-efficient clustering algorithm for underwater acoustic sensor networks*," Control Engineering and Communication Technology (ICCECT), 2012 International Conference on, pp. 711 - 714, Dec. 2012.

[6] X.Li, S.-L.Fang, and Y.C. Zhang, "*The study on clustering algorithm of the underwater acoustic sensor networks*," the 14th International Conference on Mechatronics and Machine Vision in Practice (M2VIP 2007), Dec. 2007.

[7] Guangsong Yang, Mingbo Xiao, En Cheng, and Jing Zhang, " *A cluster-head selection scheme for underwater acoustic sensor networks,*" Communications and Mobile Computing (CMC), 2010 International Conference on, vol. 3, pp. 188 - 191, Apr. 2010.

[8] Liu, G., and Wei, C., "*A new multi-path routing protocol based on cluster for underwater acoustic sensor networks*," International Conference on Multimedia Technology (ICMT), pp. 91-94,2011.

ACKNOWLEDGEMENTS

The authors would like to thank, for their technical support, Ph.Ds. Saad Chakkor, El Ahmadi Cheikh, Mostafa Baghouri and Abdelkader Bourzek from abdelmalek Essaadi University Morocco. A great appreciation is also extended to colleagues: Pr Eric Busvelle from Dijon University France and also Pr Jean Louis Lilien from Liege University Belgium, for their continued help. The authors would also like to add a special thanks to Pr A El Khamlichi from Abdelmalek Essaadi University Morocco, for his good assistancy.

BIOGRAPHIE

[1] Abderrahmane El Aalaoui was born in Tantan Morocco. He's a member in the Physics department, Team Communication and Detection Systems, Faculty of Sciences, University of Abdelmalek Essaâdi, Tetouan Morocco, and his research area is wireless intelligent sensors and theirs applications, routing and real time protocols for energy optimization in wireless sensors networks. He obtained a Master's degree in Electrical and Computer Engineering from Faculty of Sciences and Technology of Marrakech Morocco.

[2] Abderrahmane Hajraoui is a professor of the Higher Education at University of Abdelmalek Essaâdi. He's a director thesis in the Physics department, Communication and Detection Systems laboratory, Faculty of sciences, Abdelmalek Essaâdi University, Tetouan, Morocco. His research areas are Signal and Image Processing, Automatics, Automation systems, Simulation systems, Antennas and radiation, Microwave devices and intelligent wireless sensors networks.

ISSN 2356-5608