QOS AWARE AODV FOR IMPROVING THE PERFORMANCE OF WMSN

ABSTRACT

Our contribution in this paper is to propose a new solution called EQ-AODV (Energy and QoS supported AODV) for better performance in WMSNs (Wireless Multimedia Sensor Networks). EQ-AODV aims to improve AODV protocol and make it effective for multimedia data in WMSNs. This improvement is based on the adaptation of the routing process of AODV according to two parameters. The first one is the energy of sensors belonging to the routing roads and the second parameter is the nature of the packets received by these sensors. The considered data are text data, audio and video streaming data. After the evaluation of the performance and based on the obtained results, EQ-AODV showed a better performance compared to AODV. EQ-AODV improves important QoS parameters namely the network load and the end to end delay. Important improvement in terms of the life time of sensors and the consumed energy is recorded too.

KEYWORDS: *Wireless Multimedia Sensor Networks; Multimedia, Traffic, Communications, Services, Applications; Energy; Quality of Services; Routing Protocols; AODV; Evaluation Performance; E-health.*

INTRODUCTION

A WSN [l] [2] is a set of sensors, equipped with a Wireless interfaces, deployed over a geographic area known as the sensors field. In some situations, some or all of these sensors are equipped with multimedia devices (such as cameras and microphones) allowing them the production of multimedia data content. In this case, we talk then about a new type of WSN which is wireless multimedia sensor networks (WMSN)

[3]. The main task of such a network is the monitoring of specific characteristics of environment where they are deployed or collecting an important data from that environment. In order to ensure the communication within the WMSN, each sensor must act, at given time, as router and this to retransmit packets received from any neighbor to another sensor or to the process central unit of these packets. This kind of networks offer a great flexibility of use, a good robustness and can be deployed very quickly especially in emergency situations [4].The limited resources of such networks ma.kes complex the support of multimedia applications which require significant resources like high bandwidth, reduced delay, low packets loss, and an efficient consumption of energy. Many factors, at different levels of the OSI communication model (collisions, connectivity break, congestion, energy ...etc.) reduce the performance of these networks. Although many researches in WMSNs are referred to the design of new routing algorithms, most of them still do not consider the new requirements of such networks. Some of the proposed protocols are presented in these references [5] [6] [7], Although they are different from each other, each one leads to improve the network performance. The WMSNs components are generally without any infrastructure, thus they have a limited resource in terms of energy. The design of new routing protocols for such etworks becomes a difficult task since they should take into account the constraints of the limited energy and the reduced computing power [8]. Another constraint which is also very important for the WMSNs is the quality of services (QoS). This latter is a set of services to ensure for the multimedia applications to be properly performed and generate the expected results by the users. Although solving these two constraints together by the routing protocols seems a hard task, it is important to ensure a good compromise between QoS and Energy for a global network performance. In this paper we are interesting to propose a new routing protocol for WMSNs called EQ-AODV (Energy and QoS supported AODV) supporting energy

efficient and QoS assurance. The proposed solution is implemented by exploiting the existing AODV with adding some metrics and treatments. The goal is to improve this protocol by making it more suitable for multimedia applications, This improvement is based on the adaptation of the routing process of the protocol according to the energy of sensors belonging to the routing roads and to the type of the packets received by these sensors. We used the OPNET platform and we simulated several scenarios with generating different multimedia data over the network. Through the simulations, we take into account some performance evaluation metrics namely the end-to-end delay, the network load, the lifetime of the sensors and the consumed energy. Our paper is structured in five sections: the section two presents some proposed solutions in the literature and addressing the same problem studied here. Our EQ-AODV solution is given in the section three. Section four presents theevaluation of performance of the proposed solution with discussing the obtained results. We finish with section five which consists on conclusion and perspectives.

RELATED WORK

Since the emergence of WMSNs, many routing protocols designed for them, have emerged. In the literature, various surveys went around these protocols, examples of work presented in [5] [6] [7] [8]. In general, the proposed protocols can be classified in two big approaches, data centric approach and reactive approach. Some characteristics of sensor networks encourage favoring some routing protocols on other. The reactive approach, called On-Demand routing [8], has largely gained the upper hand because of the benefits to deal with the ad hoe nature of WMSNs. In fact, this approach doesn't require knowledge about the global network topology. The most popular protocol belonging to this family is AODV [9]. In addition to what is mentioned previously, AODV has an efficient routing method that reduces the WMSN load using broadcasting route discovery mechanism and by updating dynamically the routing information at eachintennediate sensor. For these reasons, We have chosen AODV in the designing of our proposed solution EQ-AODV. For better situate our work among those proposed and conducted in the same context, We devote the rest of this section to present some of them. Despite the difficulties to which the WMSNs are faced while trying to support efficient energy and QoS, several works have been conducted in the literature, some deal to offer new approaches supporting these two parameters. However other works are limited to study the behavior of these networks using standard protocols. We are going to list some of these works in what follows. In [10], a new protocol called SPEED is developed which can support soft real-time communication based on feedback control and stateless algorithms for large-scale sensor networks. The objective of this protocol is to propose a cross layer approach by the combination of a non-deterministic QoS-aware geographic forwarding and feedback control. This is to maintain a desired delivery speed across the network through. The authors, after the evaluation of SPEED, improved the end-to-end delay and provided a good response when detecting congestion in the network. These results were have been eonfinned when SPEED is compared to DSR, AODV, GF, SPEED-S and SPEED-T. In order to addresses the issue of QoS routing in wireless sensor networks, a QGRP protocol (QoS and energy aware geographic routing protocol for MWSN) is proposed in [1 l]. This protocol takes into account two parameters that are the bandwidth and delay. An analytical model of IEEE 802.11 DCF is adopted by QGRP and this to make more accurate the estimation of the available bandwidth. The authors used, in order to guarantee loop-free routing paths, a destination sequence numbers. After performance evaluation, QGRP recorded better performance compared to AODV in terms of residual energy, energy efficiency and standard energy deviation. To take into account the end to end delay, reliability, energy consumption , lifetime and fairness, a new protocol, which is called MREEP (Multimedia Reliable Energy Efficient routing Protocol) is proposed in [12]. This protocol, based on different priorities and QoS requirements based, provides sending traffics for WMSNs. Using different scenarios to evaluate the performance of MREEP, the simulations results show the proposed solution has a total control over the parameters studied by the authors in this work. In [13], the authors propose a routing protocol offering some QoS by reflecting the changes in network status regarding reliability and delay, even in circumstances with a deficiency in sensor node resources. The idea exploited by the authors is the minimizing of the routing control messages in order to guarantee an energy efficient result. Through simulation, they observed that the sensor node establishes a routing table based on three information namely the shortest route towards a sink, the energy efficiency of the foothold, and the least amount of congestion.

In order to takes into account the medical communication environment to manage efficiency the energy of the sensors, M-EE (Medical Energy Efficient) is proposed in [14]. The idea is to exploit the routing protocols with adding a new algorithm for energy fairness. With M-EE, the sensors which are using image and video medical data are allowed more energy than other sensor nodes. The simulation results showed that the proposed approach recorded significant energy consumption of the network, a reduction of the data loss and an increase in average working time of the sensors. In [I5], we continued our previous work by proposing a new solution called ES-WSN: Energy Efficient by Switching between roles of nodes in WSNs. The principle used is the exploitation of the distance between sensors and also their remaining energy. ES-WSN makes a change of the roles between the relays and sensors in order to maintain overall connectivity of the global network. After evaluation, ES-WSN showed better performance compared to two other solutions proposed in the literature which are OLSR and EENPA. To understand how to select the routing with high energy efficiency and quality of service, a serial of studies have been conducted in [16]. Based on the obtained results, the authors proposed an energy efficient QoS assurance routing based on cluster hierarchy for WMSN, called EEQAR. The EEQAR routing can efficiently balance the energy consumption and meet the requirement of QoS between the source and destination. To validate the proposed solution, some simulation experiments have been conducted by several performance indexes. The results show that EEQAR improves the WMSN in terms of performs network lifetime and QoS. The present work is within the same context of those presented in this section. It constitutes a continuation of what has been done in [I4] and [I5] by addressing a new problem which is the design of routing protocol for WMSNs supporting an efficient energy and an assurance of QoS. The idea exploited to propose our solution is the improvement of an existing routing protocol which is AODV. The choice of this protocol is motivated by the fact that it contains some characteristics allowing it to be more interesting for a nature dynamic of WMSNs. In fact, AODV don't overload the network by avoiding generating traffic every time when there is change topologies.

THE EQ-AODV PROPOSED SOLUTION

The goal of our proposed solution is to integrate anassurance in terms of QoS and an efficiency energy for the multimedia applications executed within a WMSNs. This can be done in two ways: 1- Avoid data retransmissions due to the different types ofinterferences (collisions, channel errors, congestion ...etc.); 2- Avoid the connectivity break in the WMSN due to the energy depletion of one or some sensors. As part of our work, we are interesting to the case 2). The proposed solution is called (EQ-AODV: Energy and QoS supported AODV), it is implemented on the AODV routing protocol by adding some metrics and treatments. The goal is toimprove the AODV protocol by making it more suitable for multimedia applications. This improvement is based on the adaptation of the AODV protocol according to the energy of sensors belonging to the routing roads. The choice of AODV as protocol of routing is motivated by the fact that it doesn't require knowledge of the global network topology. AODV has an efficient method of routingthat reduces the load in WMSNs by broadcasting route discovery mechanism and by dynamically updating routing information at each intennediate sensor. EQ-AODV distinguishes four classes of data manipulated by all applications. These classes are defined as follows: C, for video, C; for Audio, C3 for Image and C4 for Text. The sensors used are able of both sensing, processing and to transfer a data. Hence the importance of distinguishing different data classes since their capture and processing is done by consuming different amounts of energy. A priority Pk is assigned for each data class Ct, as follows:

Pk = (1 for text, 2 for image, 3 for audio, 4 for video} (1)

In addition to the priority of the data, the energy consumption is a parameter which is also taken into account. This parameter is shown on the graph of Figure 1 and its value, represented by the HE,-,,-+1, is calculated as follows:

$$HE_{j,j+1} = \int_{J}^{J+1} f(t)\, d(t) \quad (2)$$

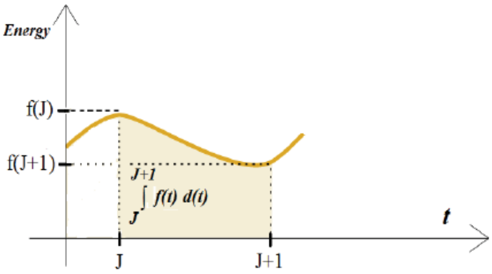

Figure 1: The graphic representation of the function ***HE***

The function (2) represents the history of the energy consumed by every sensor i from the network between two times j and j + I. These moments represents two successive times where the data type changes the class. In other terms, the difference between the j+I and j gives the time during which a sensor from the network processes the data packets ofthe same class Ck. In this case, the total energy consumed between these times corresponds to the colored surface below the curve of Figure 2. We define also two new variables, N and PT. N is thenumber of times that a given sensor from the network changes a data class Ck. P1 is the sum of the priorities of all the data classes Ck processed by the sensor. These two variables change with time for every sensor from the network as follow:

Note by:

CH : the class of the previous data packet processed by the node;

Ct : the class of the current data packet processed by the node;

Begin
| $N := 0;$
| $P_T := 0;$
| **If** $C_k =! C_{k-1}$ **then**
| | $N := N+1;$
| **End If**
| $P_T := P_T + P_k;$
End

In WMSN, they are not only the parameters of energy and type of data that can influence the quality of communication. For this reason, EQ-AODV provides a variable PR that combines these parameters as follows:

$$PR = PR_0 + \sum PR_k \,/\, _{k=1 \text{ to } M} \quad (3)$$

With :

$$PR_k = \begin{cases} +1 & \text{if P participates in the rapid dissipation of the energy} \\ 0 & \text{Else} \end{cases} \quad (4)$$

PR0: a value initialized by the multimedia application executed in the network; M: the number of parameter considered in the network; According to the parameters presented previously, we define the energy threshold used by EQ-AODV as follows:

$$S_i = [P_T * (e^N / HE_{j,j+1})] + 1/PR \quad (5)$$

N: The number of times a node i changes the data class Ck of the data packet; For every sensor i from the network, the threshold S,- is calculated ifa change in the packet class is detected. This S,- is compared to energy ratio, RE,, calculated by this sensor i. by dividing the energy of the sensor i at THE instant J (see Figure 1) on its current energy (at the instant J+I). According to the result, actions will be taken by the EQ-AODV as follows:

```
Begin
|       If RE_i < S_i then
|       |     < initiate the procedure for calculate a new
|       |  routing road without node i>;
|       End If
End.
```

More details about this pseudo code, in the case where the CE,~ of the sensor i is lower than the calculated S,-, the sensor I will be forced to leave the routing road. Then, the sensor I send to the sensor source, which initiated the routing road, its identity and its intention to not participating in the routing (leave from the routing road). These two information may be included in the control packet transferred between the sensors (piggyback). At the reception, the source sensor (the sensor which created the current road) initiates a new procedure of AODV route discovery, with avoiding including the sensor I that just left the road. It should be noted that this sensor i may again participate in the routing process when the energy level of all the sensors in WMSN becomes the same.

The diagram of the Figure 2 gives the main steps of the EQ-AODV solution.

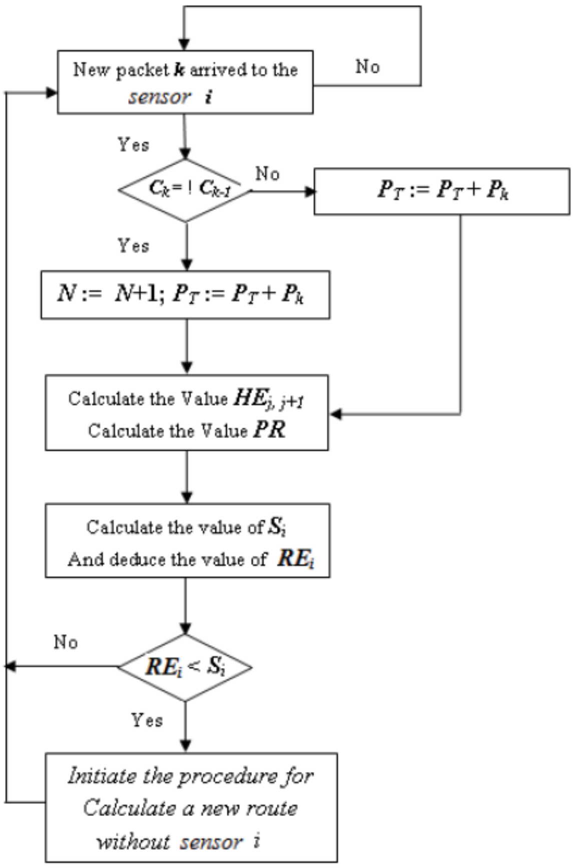

Figure 2: The functioning of the EQ -AODV solution

PERFORMANCE EVALUATION OF EQ-AODV

A. Simulation and evaluation parameters

In this section, we are interesting to evaluate the performance of EQ-AODV. To do it, some evaluation parameters are considered: The network load, the end-to-end delay, the energy consumption and the lifetime of sensors in the network. For the simulation environment, we use OPNET and we decided to keep almost the same parameters than those of our previous works [l4] [15]. The default simulation parameters used are listed in the following Table 1.

Parameters	values
Position of sensors	random
Number of sensors	70
Size of the network	1200mX1200m
Time of the simulation	1000s

Table.1: The default simulation parameters used in the simulations

The protocols and the applications settings used for the simulation are given in the following Table 2.

Physical layer	OFDM (802.11a)	
MAC layer	IEEE 802.11a with a transmission rate of 54Mbit/sec for the applications used.	
Transport	TCP/UDP	
Network layer	AODV, EQ-AODV	
Application type	**Video stream**	
	Low resolution video	
	Frame interarival time information	10 frames/sec
	Frame size information (byte)	128*120 pixels
	Type of service	Streaming multimedia
	Audio stream	
	PCM quality speech	
	Encoder scheme	G.711
	Voice frames/packet	1
	Type of service	Streaming multimedia
	Print (Text File)	
	File size (bytes)	Normal (3000,90000)
	Print inter arrival time (second)	Exponential (90)
	Type of service	standard

Table 2. The protocols and the application settings used for the simulation

B. Results and Interpretations

We propose in this section to evaluate our solution under the conditions described in the previous section. We use an application that uses different types of data streams and at equal time intervals. To concentrate our evaluation on multimedia setting, we decided to set the parameter PR at ∞ (infinity), then the ratio l/PR in the equation (5) becomes zero. The results obtained through OPNET simulations are given in this section.

The evolution of the network load

The network load represents the amount of information circulating in the network, more it's important more there is degradation of the network performance. This is due to many problems such as collisions, congestion and energy depletion.

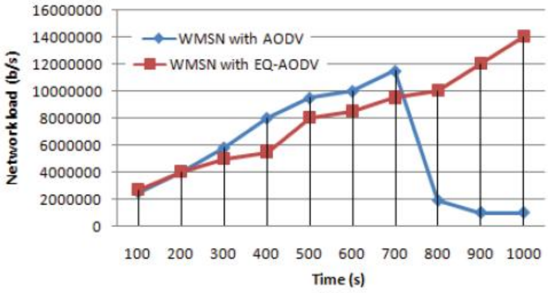

Figure 3: The averages network load for AODV and EQ-AODV

In term of the network load, AODV and EQ-AODV generate almost the same network load in the beginning of the simulation and this until the second 200. From this second, AODV recorded an important network load compared to EQ-AODV. This is due to multiple data retransmission in the network after detection of their losses. An essential source of these losses is the break of the routing paths due to sudden abandonments of some sensors after depletion of their total energy. This increasing of the load continues until time 700 sec, from where there is important decrease of this load to get values approaching to zero. This is due to the almost total cessation of the network activity. At this level, AODV has difficulties in building of new routing roads because there are not enough actives sensors. However, we see the continuity of network activity using EQ-AODV solution. Network load continues to increase through time and this means that the network has not encountered the connectivity problem due to the depletion of energy of some sensors, This difference in results, even with same environment, EQ-AODV reduces and prevents the break of the connectivity due to the sudden disappearance of some sensors nodes from the network. In fact, fair energy consumption is assured by EQ-AODV since it takes into consideration the energy parameter and the type of the processed data in the building of routing roads. From these results we can say that our solution improve the performance of the network in terms of the reliability by reducing data loss due to improper energy consumption. Note that the network reliability is an important element for measuring QOS supported by this network.

The evolution of the end to end delay

This parameter represents the time consumed between the instant of sending of a package to and from the moment of its acknowledgment of receipt. More the end to end delay is small more the performance of the network is good.

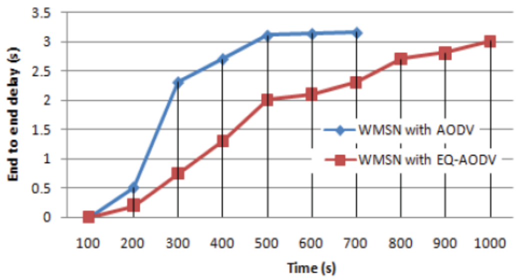

Figure 4: The evolution of the end to end delay with AODV and EQ-AODV

We see in Figure 4. that the network using EQ-AODV as protocol recorded better end to end delay than the network using AODV protocol. In fact, our solution takes into account some parameters to use fairly the energy in the network (fair evolution). This improvement avoids the packets loss due the break of the connectivity between sensors nodes after their energy depletion. During the interval of time [I00, 600], we can see that both of networks have recorded an increasing of the delay and the values of this delay are more important with AODV than with EQ-AODV. The activity of the network continues after the time t = 600 second with our solution but stopped with AODV (time tends to infinity, no network response), In fact, the absence of activity with AODV is due to the unfair consumption of energy between sensors in the network. This disadvantages some sensors over others, especially if they are participating in the routing road. However, EQ-AODV allows a fair energy consumption since it takes into consideration the remaining energy and the type of the processed data in the routing process. With this new mechanism offered by our solution, sensors are able to prolong the functioning of the network. This explains the evolution of the end to end delay over time. This result is added to that of the previous scenario, and both constitute already a crucial proof that EQ-AODV provides an improvement of QoS in the WMSNs.

The evolution of the number of sensors

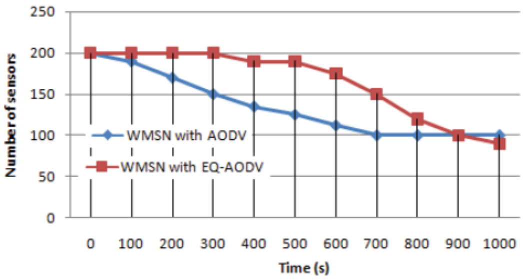

Figure 5: The evolution of the number of sensors with AODV and EQ-AODV

Figure 5 gives the evolution the number of actives sensors with time in the network. At first, with the two networks, we can see that the number of actives sensors decreases and EQ-AODV records better performance since the number of actives sensors decreases slowly compared to AODV. But after the second 700, the number of actives sensors stops decreasing with AODV and continues to decrease normally with our solution. In fact, the activity of the network using AODV as routing protocol stopped after the second 700, as illustrated by the figure. This is due to the no fair in the energy consumption which leads quickly to the disappearance of some sensors from the network. In the case of our solution, the network activity continues to decrease the number of sensors in the network. In fact, EQ-AODV, with its new multimedia energy consumption mechanism allows a fair evolution of the energy between the sensors. Such result is already a strong factor which contributes in the improvement of the energetic performance of the WMSN.

The evolution of the consumed energy

This parameter important for the network performance, its fair consumption between different sensors ensures a better QoS. The good use of the energy avoids many problems, like data loss, and then ensures functioning continuity the network for long time.

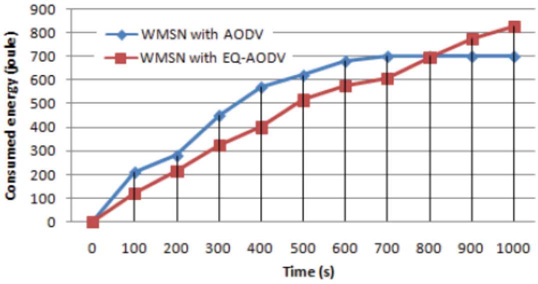

Figure 6: The evolution of the consumed energy with AODV and EQ-AODV

The Figure 6 shows that the energy consumption increases over time and this for both of AODV and EQ-AODV protocols. But we can see that the activity of the network using AODV stop suddenly to increase and stabilized at t=700 sec. Our solution EQ-AODV recorded a lower consumption than AODV. Also, the network activity with our solution does not stop and the evolution of energy continues to grow normally. This difference in performance is due to the good energy consumption provided by our solution. In fact, EQ-AODV takes into some parameters in the network to maintain fair energy consumption. According to these parameters, our solution keeps a fair consumption of energy between sensors. It thus allows increasing the lifetime of the network and avoids excess energy consumption. This explains the continuity of network activity for EQ-AODV compared to AODV protocol. Based on these last two results, we conclude that our solution, in addition to the good QoS which it provides, it also allows energy efficient within the WMSN.

CONCLUSION AND PERSPECTIVES

In this paper we proposed a new protocol called EQ-AODV in order to support an efficient energy and anassurance of QoS in WMSNs. This improvement is based on the adaptation of the routing process of AODV according to the sensors energy and to the type of the packets received by these sensors. After implementation and simulation of EQ- AODV, the obtained results showed a better performance compared to AODV. Our solution improves important QoS parameters namely the network load and the end to end delay. EQ-AODV recorded an important improvement also in terms of energy parameters which are the consumed energy and thelifetime of the sensors.This work can be extended by considering more communication parameters in the modeling of EQ-AODV to be near to a real WMSN. Also, we will conduct a study on the communication environment of the WMSN to better assign meaningful values to the different parameters considered by our solution. In the end, our EQ-AODV approach can be exploited in other areas such as robotic, E-health and VANET.

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