Wireless Netw (2016) 22:453–465
DOI 10.1007/s11276-015-0979-z

Adaptation of a routing algorithm in wireless video sensor network for disaster scenarios using JPEG 2000

Mounir Tahar Abbes[1] · Belhirech Mohamed[1] · Senouci Mohamed[2]

Published online: 31 May 2015

Abstract In this work we will develop an extension of one of existing routing algorithm in wireless sensor network. This new adaptation will permit the sensor node to save more energy and transmit images in wireless mode. This situation will be strategic and helpful especially in disaster scenario, where groups of rescuers must be on site to accomplish emergency tasks; therefore it's very important and necessary to establish a wireless communication in real time between individuals or groups. The nature of wireless video sensor network makes it suitable to be used in the context of emergencies because introducing a video give more information in precise time and this is very advantageous when the existing infrastructure is down or severely overloaded. In emergencies the network topology may change rapidly and randomly. The increasing mobility of terminals makes them progressively dependent on their autonomy from the power source. This is illustrated by introducing many mobility models and using many scenarios of mobility in emergency situation, where image transmission via sensor node is used. Low complexity algorithm in image processing in order to reduce time transfer of selected data by this way allows saving energy. Efficiency in emergency scenario is the main objective of this work, achieved by the combination of three strategies: low-power mode algorithm, a power-aware routing strategy and compression technique in image processing used in sensor node. A selected set of simulations studies and real test bed on sensor node platform (Telos-B) indicate a reduction in energy consumption and a significant increase in node lifetime whereas network performance is not affected significantly. This is the big interest of our work in emergency situation, by increasing life time of node, individual can communicate longer and give more chance to rescuers to find them.

Keywords WSN · AODV · GloMoSim · Disaster management

✉ Mounir Tahar Abbes
mtaharabbes@yahoo.fr

1 University Hassiba Ben Bouali de Chlef, Chelf, Algeria

2 University of Oran, Oran, Algeria

1 Introduction

Since the emergence, wireless networks have become very popular in the society and computing industry. Typically applications covered by WSN are [1]: (1) search-and-rescue in disaster situations, (2) defense (army, navy, and air force), (3) health care, (4) academic environment, (5) industrial or corporate environment, and (6) home network. Advances in electronics and computer industry bring us more and more powerful wireless terminals. Consequently, many applications of video communications via wireless terminals and wireless networks have emerged in recent years, such as wireless video calls and video surveillance [2].

Almost every year, the world is hit by many major natural disasters, in a flood or a chemical accident, it is important that information will be quickly in hand and available as soon as possible, between the organs of action, intervention forces and the affected population. The new communication technologies offer many possibilities. We often forget that the telecommunication networks can be vulnerable to disasters. So what good if everyone has a cell phone, if you cannot use them after a disaster? The case study, introduced in this paper, focuses on disastrous events, such as earthquakes and flood. In order to limit the loss of life, it is importance that the rescue teams have reliable information about the state of the ruins and the places where people have been trapped. The main objective is to install special sensor node equipped with energy control routing algorithm and camera module, in order to increase life time of battery and connectivity of nodes. This operation is called management of the network.

The basic functionality of any WSN routing protocol should include a route discovery mechanism, whereby routes are established between source and potential destinations or actual destinations, as well as a route maintenance mechanism which involves maintaining the validity of a route during data transmission. Currently, the Ad Hoc network routing protocols are grouped together as proactive, reactive and as a hierarchical router. The proactive routing protocols keep information about all of the routes in the network, thus they are not required. The Destination Sequence Distance Vector routing (DSDV) protocol is an example of this type of protocol. The reactive routing protocols generate routes on demand when one node wants to communicate with another. There are, in general, two components: discovering the route used when a source does not know how to get to a destination and the route maintenance to deal with failure in the routes brought about by mobility in the nodes. The Ad Hoc Demand Distance Vector (AODV) protocol proposed by Perkins and Royer [3] is an example of a reactive protocol. The hierarchical routing protocols divide the network into subsets of nodes called clusters, in which a cluster head is used to concentrate and distribute the information generated within the cluster [4]. An example of this type of protocol is the Cluster Based Routing Protocol (CBRP) [5].

This research focuses on improving AODV protocol in emergency situation, in this environment, users terminals must provide sufficient time to keep the communication between them and to avoid disruptions caused by the depletion of batteries and therefore partitions and congestion. The idea is based on an adaptation of AODV protocol with one of the approaches to improve the Sleep/wake mechanism and also integration of compression technique in the sensor that allows limitation of time transfer. The solution is involved on three layers in OSI model: Mac Layer, Network layer and application layer.

The rest of this paper is organized as follows: Sect. 2 reviews the related work. Sect. 3 studies the mobility model in disaster scenario; Sect. 4 provides the formulation problem and the proposed solution; Sects. 5 and 6 provide performances, simulations and results analysis for WSN in emergency situation using video transmission; finally,we conclude this paper in Sect. 7.

2 Related work

In this section we classify and discuss related studies into three parts (Routing in WSN, Emergency situation, Image transmission over WSN).

For each type of routing protocol, there can be several performance objectives, such as energy efficiency, latency, lifetime, capacity, and delivery ratio. Each proposal in the literature can often optimize one or two such objectives [6]. in our case we will focus on energy and lifetime. In research literature and industrial specifications have jointly shown that radio dominates the energy consumption compared with all other hardware components in sensor nodes(motes) [7]. Xiang et al. [8] promoted a new data aggregation technique derived from compressed sensing, and minimizing the total energy consumption of a WSN in collecting sensory data from the whole network. Chilamkurti et al. [9] proposed a cross-layer architecture using MAC and Routing layer The cross layer architecture implemented is defined by the interaction of 802.11 MAC protocol and the Dynamic Source Routing protocol. Cheng et al. [10] have addressed the problem of channel assignment and aimed at minimizing the overall network interference while preserving the original topology. they have formulated an algorithm named as DPSO-CA which is based on the discrete particle swarm optimization and can be used to find the approximate optimized solution. Zeng et al. [11] present a novel DRSS to provide energy efficient and delay-bounded data delivery by combining forwarding and replication method, they make simulations on vehicular DTN networks and make performance evaluations.

Routing in Emergency situation WSN is crucial because of the absence of a central routing in WSN. Each intermediate node is part of the path between a source and a destination, is like a router. In [12] the performance evaluation of several routing protocols, namely AODV, BATMAN, DYMO and OLSR in a specific emergency response scenario, which is a disaster response operation after an explosion in a chemical plant, shows that the packet loss rate can go up 70 % caused by high mobility. Ramrekha and Politis [13] presents the performance of AODV, OLSR in emergency situation inside a building, show that OLSR proactive behavior is better than AODV reactive behavior for networks with low density. However, the performance of AODV is much better, if the delay and jitter, in dense networks. In [14–16], the hybrid protocol Chameleon (CML) uses two protocols AODV and OLSR, which aims to adapt to the change in the topology according to the behavior of nodes in disaster.Another protocol is designed specifically for emergency situations is the Random Walk Gossip protocol (RWG) [17, 18]. It is a multi-cast protocol. RWG mechanism is based on a “storecarry-forward", that is to say, each node stores messages to be transmitted in a local buffer until they are delivered. This mechanism prevents the loss of messages due to network partition. The protocol is designed to address the challenges faced by networks in the area of disaster such as intermittent connectivity and topology unknown and unpredictable network partitions. These solutions have not used a mechanism for energy conservation. The energy problem is a classic problem in Ad-Hoc networks, and these consequences are serious on the general network communication in emergency because firstly in a disaster, the chances of recharge devices are low. Secondly, the need for communication requires that nodes will be available as long as possible, and third the greedy environment because of the great services (video, photo, message...) requested may also consumes much energy appliances.

There are existing studies on improving video transmission performance over wireless networks. On one hand, a lot of papers proposed enhanced scheduling mechanisms to reduce video frame dropping probability. On the other hand, researchers explored adaptive algorithms to improve system throughput and/or reduce video transmission distortion. Some work have demonstrated that the complexity of certain compression algorithms leads to greater power consumptions than the simple transmission of the uncompressed image. For instance, in [19] present a platform to evaluate the performance of different traditional algorithms for image compression in a single sensor node. In [20] has introduced a power aware technique that incorporates the local compression JPEG2000 standard. [21] Proposed a distributed source coding scheme for images captured by sensor nodes having overlapping fields of view. In [22] a global survey regarding image transmission over WSN, More information's and details are given by Pinal [23] and [24]. Based on the problem formulation of video transmission over IEEE 802.11e networks, Wan et al. [25] propose an adaptive unequal protection scheme for video communications.

Others methods using compression and data collection via WSN exist, we can find: The prediction-based approach saves energy by reducing redundant data communications. Since the prediction-based approach is structure-free, it can be used to couple with other route or topology-based data aggregation approaches.By analyzing energy efficiency and data accuracy, a novel prediction-based data collection protocol is proposed by [26] to specify the cooperation between the sensor node and the sink node. Liu et al. [27] presents a novel compressive data collection scheme for wireless sensor networks, this scheme compresses sensory readings on the fly under an opportunistic routing. Li et al. [28, 29] propose Code Pipe, a novel reliable multicast protocol, in lossy wireless networks. By employing four key techniques, namely, LP-based opportunistic routing structure, opportunistic feeding, fast batch moving and inter-batch coding, it offers significant improvement in throughput, energy-efficiency and fairness. Yen et al. [30] present a Flooding Limited and Multi-Constrained QoS multicast routing method using the GA and the available resources and also minimum computation time in a dynamic environment. By selecting the appropriate values for parameters such as crossover, mutation, and population size, the GA improves and optimizes the routes. In addition, Yao et al. [31, 32] describe the Energy efficient Delay-Aware Life (EDAL) time-balancing protocol for data collection in wire less sensor networks, which is inspired by recent techniques developed for open vehicle routing problems with time dead-lines (OVRP-TD) in operational research. The goal of EDAL is to generate routes that connect all source nodes with minimal total path cost, under the constraints of packet delay requirements and load balancing needs. Meng et al. [33] demonstrate that they can signi cantly improve the end-to-end throughput in multihop wireless networks, by carefully considering spatial reusability of the wireless communication media, they have presented two protocols, SASR and SAAR, for spatial reusability aware single path routing and any path routing, respectively.

In recent years methods inspired from biology to advance computational or networking systems has received increasing attention. Liu et al. [34] proposes a new biology-inspired heuristic algorithm based on a cellular computing model in the physarum organism. this proposed physarum optimization can be applied to designing new algorithms for the Steiner tree problem in large-scale graphs. In addition, Song et al. [35] Exploits a biological model of physarum to design a novel biology-inspired optimization algorithm for MEP. After that formulate MEP and the related models, and then convert MEP into the Steiner problem by discretizing the monitoring field to a large scale weighted grid.

Note that in this paper, we will develop a solution that take in consideration three aspects: Routing, Emergency and image transmission and compression over WSN. In order to maintain connectivity between nodes, we offer the sleep-AODV protocol based on AODV, we have choose AODV protocol to maintain low complexity parameters in the sensor node by this way we save energy (by reducing the processing time). The protocol takes into account the behavior of nodes and the using of camera module in the sensor node.

It does seem necessary at the end of this section to review and compare different vision sensors motes used in wireless network (Table 1).

The following figure present the global architecture of a sensor node (Fig. 1):

Table 1 Comparison of sensor nodes [36]

MOTES	CPU	OS
Cyc lops	A Tmega l 28L (6 MHz)	TinyOS
CMUcam	MSP430	
Imote2	PXA270	Linux
XYZ	ML67Q5002 (60 MHz)	
Panoptes	StrongRM (206 MHz)	Linux
Telos	MSP430	TinyOS
MeshEye	AT91SAM7S	
Stargate	PXA255 (400 MHz)	Linux
uAMPS-2	TMS320c55xx	

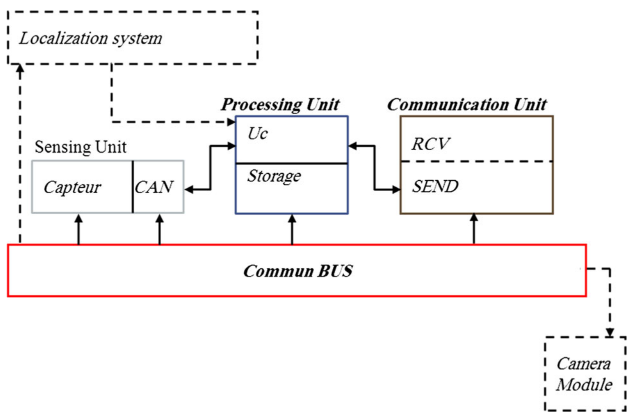


Fig. 1 Structure of sensor node [36]

3 Mobility model in disaster scenario

The mobility models determine how the nodes move on the target scenarios. Aschenbruck et al. [37] propose a mobility model for disaster scenarios. In this mobility model, the movements of the whole rescue team are modeled. The disaster scenarios are divided into different action areas, and the nodes emulate both mobile and static components of the rescue team, such as ambulances or firefighters. It was included in the mobility generator BonnMotion developed at the University of Bonn (Germany) [38]. It provides an output file which can be integrated in GloMoSim in order to run the simulations. Consequently, the performance of ad hoc network under disaster area scenarios can be analyzed.

The disaster area mobility model is based on a method called separation of the room [39]. Using this method, the disaster scenario is divided into different areas. These areas are: (1) incident site, (2) casualties treatment area, (3) transport zone, and (4) hospital zone.

1. Incident site: is the place where the disaster happened. In this place, people normally injured wait for being transported to the casualties treatment areas.
2. Casualties treatment area: consists of two places, (a) patient waiting for treatment and (b) the casualties clearing station. In the first zone, people wait for a first inspection and classification; after that they can be transported to the casualties clearing stations in which patients will be waiting for being transported to a hospital.
3. Transport zone: is an area where transport units wait in stand-by areas to transport people to hospitals. The transport units can be either ambulances or rescue helicopters.

Finally, the technical operational command: is the zone where the rescue operations are commanded and it is usually located in the casualties treatment area.

Every person participating in the rescue operation belongs to any of the above areas and they are represented by nodes. For example, firefighters take part in the incident site whereas paramedics belong to the casualties treatment areas in order to first evaluate incoming patients.

Note that, this mobility model does not take into consideration mobility of patients, so it only models the mobility of the rescue teams. Within the rescue team, two types of nodes can be distinguished, static and mobile nodes. The mobile nodes are normally either people carrying patients or vehicles transporting patients to other locations. The maximum speeds of the mentioned types of nodes are clearly different. Mobility of people is significantly slower than mobility of vehicles. The vehicles transport people to hospitals and then go back to the disaster area.

4 Proposed solution

In order to maintain connectivity, we offer the sleep-AODV protocol [3]. The protocol takes into account the behavior of nodes and the using of camera module in the sensor node.

We can say mostly that every disaster scenario is composed with three periods in terms of nodes behavior (1) random node, this model of mobility will cause many changes in neighbors, (2) high mobility, this level will cause many broken links, and the last period is (3) stability of network.

In the first period of disaster and in the place of the incident, there are nodes everywhere, some of them are isolated, so the network is not enough loaded. The number of people began to increase over time as functions of the gravity of the situation, the purpose of sleep-AODV protocol is to limit excessive routing messages (overhead) caused by the large number of neighbors because a routing table with many entrances involve a large number of control packets (hello, maintenance), which consumes more energy spent in the transmission, reception and overhearing mechanism.

In the second period when the topology is highly dynamic, node mobility causes unstable nodes, we called unstable node; every node that the links are broken after a time t(in our study $t = 3$ s, this value is taken after many simulations) unstable nodes participate in a significant way to generate Broken links, at the same time the generation of control packets has an immediate consequence, energy is consumed unnecessarily (wasting). Our sleep-AODV protocol takes into account the unstable nodes, nodes don't need to have active paths, isolated nodes and nodes that are in areas where there is no communication. In the third and last period there is stability of the network because every node takes its proper place.

As we have discussed it before, our proposed solution impacts three layers in OSI model; Mac, network and application layers. In the next section we try to present these two points.

4.1 The solution in Mac layer

A wireless network interface can be in one of the following states, where each state represents a different level of energy consumption (power values of each state used in this study are Silver-Lucent interface [40]):

$$Energie_{state} = Power_{state} * Time_{state} \quad (1)$$

The total energy is the sum of energy of the four states:

$$E_{total} = E_{rx} + E_{tx} + E_{idle} + E_{sleep} \quad (2)$$

Where the different power energy components are:

- Transmission (E_{tx}): The station transmits a data frame with a transmission power $P_{transmission}$ (1.3 W).
- Reception (E_{rx}): the station receives a data frame with a reception power $P_{reception}$ (0.90 W).
- Listen to "Idle" (E_{idle}): the station is ready to send or receive, so the nodes remain inactive and listen to the medium with a power P_{idle} (0.74 W).
- Sleep "Sleep,, (E_{sleep}): is when the station is off and the node is not able to detect radio signals, i.e. no communication is possible. Power is the smallest in general P_{sleep} (0.048 w).

We found that passive listening is the main cause of energy loss. We propose to minimize this result in passive listening nodes by using a periodic sleep state based on a fixed "duty cycle" Indeed, each node goes to sleep for a time and then wakes up and listens to see if another node wishing to initiate a communication with itself or, if the node initiates communication. During the sleeping state, the node off the "radio" and starts a timer for waking later. According to the state transition in WSN applications, there are different phases of network tasks: data collection, coordination and task execution. There are different demands and constraints for these task phases that lead to different sub-deadline [41]. In order to understand the general operation of a node with four states (idle(initial stat), Sleep, receive or transmit, we present the following state diagram that illustrates the transitions between modes (Fig. 2).

If several neighboring nodes want to communicate with the same node at the same time, they will try to send their data when this node will begin his period "listen". This will lead to a collision of their requests. The collision avoidance principle is the same as that used in DCF (Distributed Coordinated Function) in the case of IEEE 802.11 [42] which proposes the use of a prelude to exchange short frames before sending a frame of information to decrease the probability of collisions due to hidden terminals. This mechanism using control frames called RTS (Request To Send) and CTS (Clear To Send). Exchanges RTS/CTS standard combines a reservation mechanism are called Vector Allowance or NAV (Network Allocation Vector), which improves access to the medium. At each station, the NAV indicates how long the channel is used by someone. NAV mechanism plays the role of virtual carrier sensing. The physical carrier sensing mechanism cannot be launched if the virtual mechanism says that the link is free (NAV equal to zero), then if a value other than zero is given to the NAV station can transmit or receive, thus adding the time value of the NAV counter sleeping, and the NAV will be decremented until it reaches zero.

4.2 The solution in network layer

The principle of Sleep-AODV protocol is to switch a node in standby mode for some time; its operating according to the network status. Ideally, the radio must be turned off in the following cases:

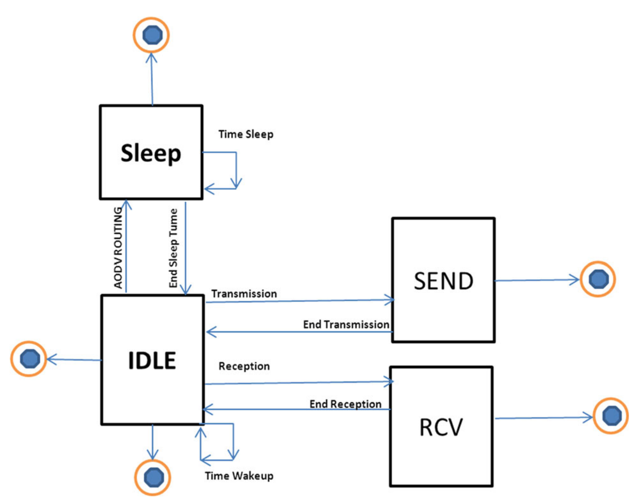


Fig. 2 State diagram of AODV-SLEEP

- Number of neighbors: If the number of neighbors exceeds the number of hops (from the destination).
- Low traffic: If the node has not received a message for a specific time t = 2

$$(t = 2) \tag{3}$$

- Inactive paths: If there are no active paths in the routing,

$$\sum (actifpath)_t = 0 \tag{4}$$

- Isolated node: If the size of the neighbors table is empty,

$$\sum (N_{neighbors})_t = 0 \tag{5}$$

  Unstable Node: a node is called node unstable when there is changing of its neighbors in a period of time t, or $t > 3$.
- The unstable nodes are detected by the following algorithm:

```
Input: Routing and neighbor table
Output: Detecting unstable node
U = {Node_i..i ∈ {1..N}} , N:maximum number of node.
if (Buffer_time ≠ 0) then
    t = Current_time − buffer_time(OldTime);
    if (t > α) then
        current = Neighbor_Table− > head ;
        while (current ≤ size(neighbor_table)) do
            if (current ∉ buffer_node) then
                Ajoute_node = Ajoute_node + 1
            end
        end
        while (current ≤ size(buffer_node)) do
            if (current ∉ neighbor_node) then
                Del_node = Del_node − 1
            end
        end
        Neighbor_changing = Del_node + Ajoute_node;
        if(neighbor_changing ≥ Count_neighbor * 2/3)
        then
            unstable = True
        end
        free(buffer_time);
        free(buffer_node);
        insert(current_t ime, buffer_t ime);
        insert(Neighbor_list, buffer_node);


    end
end
Return(unstable).
```

Algorithm 1: Unstable node detector.

4.3 The solution in application layer

The transmission of image via WSN network will consume more CPU time and more energy; it will be benefit to integrate some compression technique in the process of communication between nodes. In this paper, the implementation of JPEG compression is proposed for the development of an image-based wireless sensor node. It will be experimentally shown that such implementation will reduce the execution time for the image compression, while simultaneously reducing the total energy consumption in the network by using also the solutions A and B.

The implementation of JPEG Compression for images is typically carried out on raw binary files where each byte represents the intensity of a pixel. The image is split into blocks of 8 × 8 pixels, and each block of pixels is serially fed into the image compression device in a raster order. The first step in JPEG Compression is the de-correlation of adjacent pixels by converting their intensities to functions frequency through the use of functions. The de-correlated values are represented as coefficients of the same functions and are obtained using the Discrete Cosine Transform (DCT). After the application of the DCT, the image is represented by parameters that relate to all the frequency components of the original image. The first step in JPEG compression is the removal of high frequency effects through Quantization. Since the quantization process is irreversible, JPEG is a loss compression technique in the sense that some informations content in the original image are lost in the compression process. The second step in JPEG compression is the ordering of the quantized data and its encoding to reduce the size of the image. The zigzag process is an approximate ordering of the basis functions from low to high spatial frequencies. This process will improve the compression that is achieved by imposing order and therefore reducing entropy, the forty steps in coding is Run length coding. This is accomplished by assigning a code, run length and size, to every non-zero value in the quantized data stream. Huffman Coding is the last step in the encoding process.

Errors in reconstructed images are mainly artifacts due to quantization. Quantization eliminates information on high frequency components that are less important to the Human Visual System (HVS) [23].

```
Input: Original Image.
Output: Compressed Image
Select the Image Source;
Extract and Read Value of different pixel;
Compression Processing Start;
for (i ← 0 to 7) do
    for (j ← 0 to 7) do
        Wavelet Transformation for This Data Block ;
    end
end
Quantification;
Coding;
Verified Error;
Send Packets;
```

Algorithm 2: Compression Images.

5 Implementatio and simulation

First we present the implementation of the solution C presented in section three and after that we show the simulation part representing solution A and B.

5.1 Implementation of JPEG in sensor node

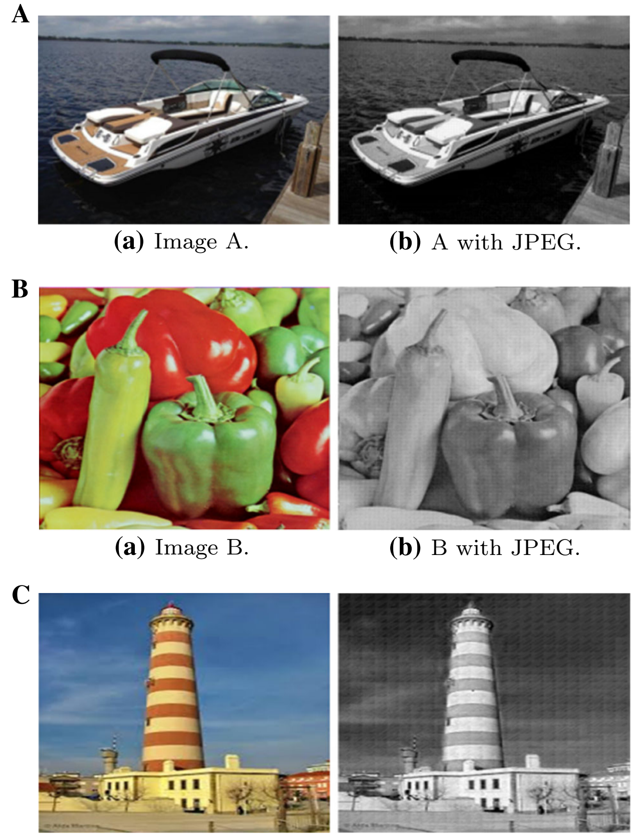
We have developed a test bed including all hardware and software components for our proposed WVSN architecture. This system consists of a flexible hardware architecture designed to adapt to users needs for deploying in emergencies. The software components are suited for a distributed application composing a real time operating systems device drivers and wireless stack supporting IEEE 802.15.4 specifications. The sensor node (Telosb) is equipped with SE TinyOS 2.2.1, and we have used the NesC and MSP430 micro-controller to implement the solution C (Compression technique). The following picture shows the overall hardware design for telosb sensor node and the camera module attached with the sensor node.

The flexible design of Telosb allows us to add components based on his choice. This setup consists of camera attached on UART. This camera is OmniVision1/4, Color CMOS image sensor OV9712 can support UV/M-JPEG/H.264.

The raw test bed images are well recognized in the field of processing images. In our experimentation we have as input some images after that the sensor node makes the JPEG compression according to the algorithm presented in section 03, as illustrated in Fig. 3a is the image source and Fig. 3b is the compressed image by bloc and this is very clear in the output. We have put the image in gray scale to reduce the file and by this way we are also saving energy and reduce time processing (Fig. 4).

The graph in Fig. 5 illustrate the three first blocks of data transmitted by the sensor node for every image by using JPEG algorithm, and the Column 04 in Fig. 5 represents the data sent if there is no compression, its clear that this algorithm is very helpful and advantageous in such situation.

The Fig. 6 presents two windows illustrating the sending and receiving data in the sensor node in real time mode.



(a) Image A. (b) A with JPEG.

(a) Image B. (b) B with JPEG.

(a) Image C. (b) C with JPEG.

Fig. 4 Application of JPEG algorithm

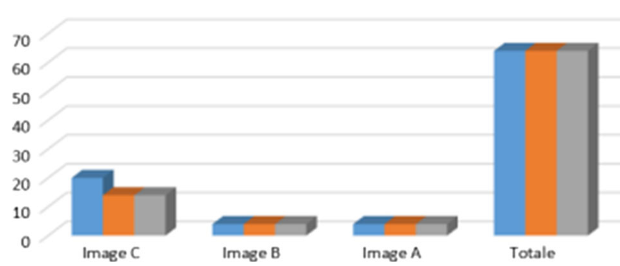
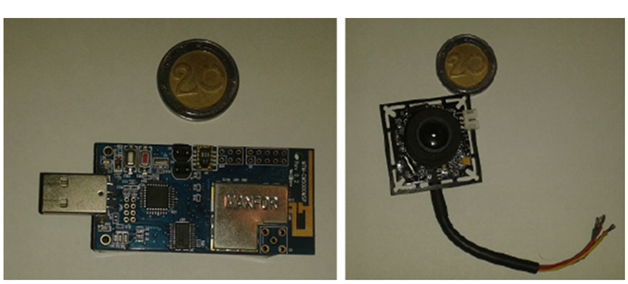


Fig. 5 Number of pixel on the three first block



(a) (b)

Fig. 3 Material used in experimentation. **a** Telosb sensor node. **b** Camera module

5.2 Simulation

In order to highlight the performance of AODV-Sleep protocol, first we implemented and integrated source code in the Simulator. The simulation consists of reproducing an abstract representation of the system studied using the GloMoSim simulator [43]. It is a simulator developed at

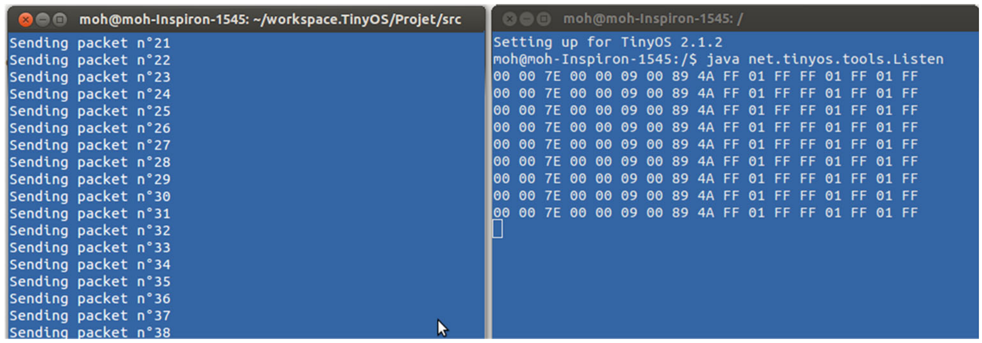


Fig. 6 Real time communication between sensors

Table 2 Simulation parameters

Parameters	Value
MAC layer	IEEE 802.11
Topology	300 m ×300 m
Propagation model	Two-ray
Bandwidth	2 MHZ
Transmission rang	100 m
Simulation time	300 s
Traffic	CBR
Connections numbers	15
Power transmission	1400 mW
Power reception	900 mW
Power IDLE	900 mW
Power sleep	0.050 W
Mobility model	Disaster area

the University of California (UCLA) in Los Angeles. It is written in Parsec [41, 44], specific language based on C developed at UCLA. GloMoSim respects the OSI model and associates an object to each layer. We set their parameters as follows (Table 2).

To simulate, we need to express the behavior of nodes in the emergency which is made from a model of mobility's role is to move the nodes during the execution of the simulation, in our simulator there is no one model of mobility for emergency situations, so we will use the BoonMotion application mobility model "disaster area".

In this case study, a rescue environment is modeled and analyzed. Relief operations are conducted in a place of incident (incident location: IL) surrounded by barriers, and to enter this area we added two points to reach everyone inside, which implies two areas of treatment of patients (Patient Waiting for treatment areas: PWTA) are required. A casualty clearing station (Casualty Clearing Station CCS) is placed in proximity to each of WPTA and also another is in an intermediate position as a backup. A parking spot in the ambulance (Ambulance Parking Point: APP) is located east using clear transportation routes for each hospitals. Everything is coordinated by a technical control operation (technical operation command: TOC)

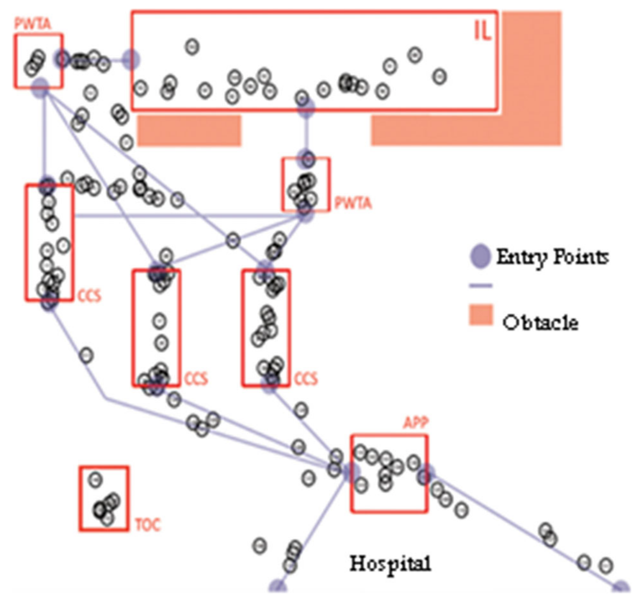


Fig. 7 Real time communication between sensors in disaster area

The disaster area and the area used for all relief operations, medical assistance and transportation is 300 × 300 sqm. Each area points of entry and exit are defined on the middle of the border areas. The entrance and exit scenario for transport units (vehicles, ambulances) are attached to the bottom right border of the scenario. In addition, some obstacles are added to the scenario to represent buildings. A sketch of how the scenario looks is plotted in the following Fig. 7.

The following table shows the distribution of node in every area and the number of nodes moving on these areas (Table 3).

6 Results

Performance metrics that have been used to analyze the proposed protocol are as follows:

Rate of delivered packets (PDR):	This is the ratio between the number of data packets received by destinations and the number of data emitted by the sources.
Average time from start to finish (EED):	The average time taken for a packet to move from a source node to a destination node.
Routing packet number (OH):	The amount of control packets generated by the protocol in question for research, creation and maintenance of roads.

Each point in the following graphs has been obtained by averaging out the result of five different simulations. Confidence intervals of 95 % have been added to the bar graphs. With regard to the obtained simulations results.

Table 3 Area distribution

Area	Size	Nodes	Transport
1 IL	30 m × 150 m	8	5
2 WPTA	16 m × 36 m	6 × 2	3
3 CCS	26 m × 50 m	6 × 3	0
4 APP	40 m × 40 m	10	5
5 TOC	20 m × 25 m	2	0
All	300 m× 300 m	50	13

Figures 8 and 9 shows the level of energy consumed by 35 nodes on the same set of simulation parameters, we can see that the average energy consumed by the Sleep-AODV protocol is less than AODV, because the protocol Sleep-AODV conserves energy as the node cannot be used under the conditions that we have added.

6.1 Traffic impact on the network in disaster

In Fig. 10 Sleep-AODV protocol loses a quantity of data packets from a low load (5.15) compared with AODV protocol. But these performances are predictable high network load more at low load because the packets sent with its stable paths in AODV against by increasing traffic causes interference and congestion, which causes more loss packets over node mobility and worm sending invalid paths, that explains this loss compared Sleep-AODV with increasing number of communication sessions.

Figure 11 shows an idea of high undelivered packets because the sources did not find their destinations. Note that all nodes using the AODV protocol are available and the number of undelivered packets is zero in all the used number of connections. As against in the AODV-Sleep protocol the number of undelivered packets are increasing with the increasing number of connections because the nodes are inaccessible in the time to sleep. But despite, this

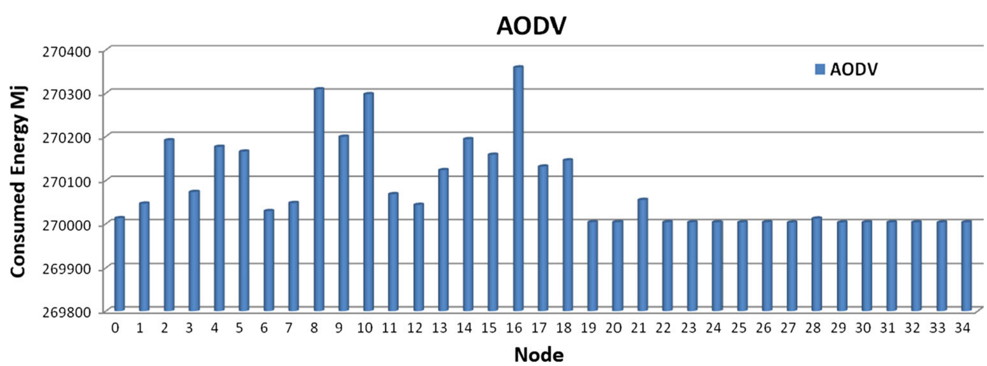


Fig. 8 Real time communication between sensors in disaster area

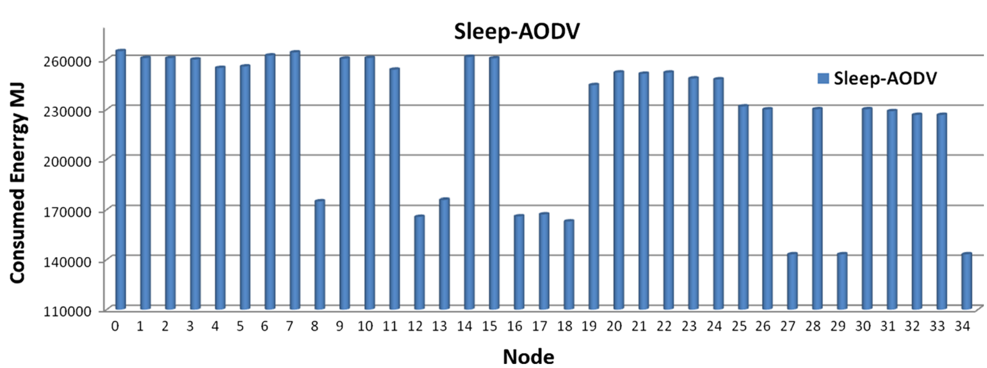


Fig. 9 Real time communication between Sensors in disaster area using Sleep-AODV

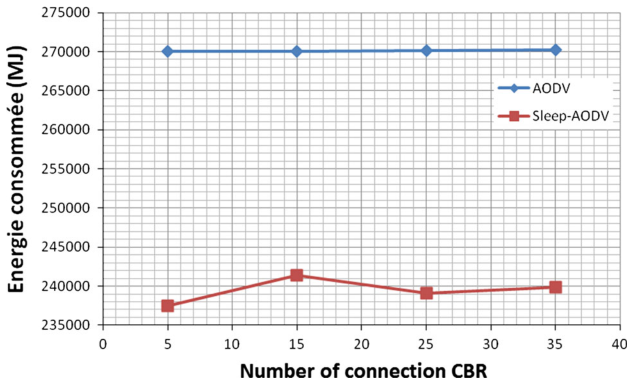


Fig. 10 Consumed energy versus traffic

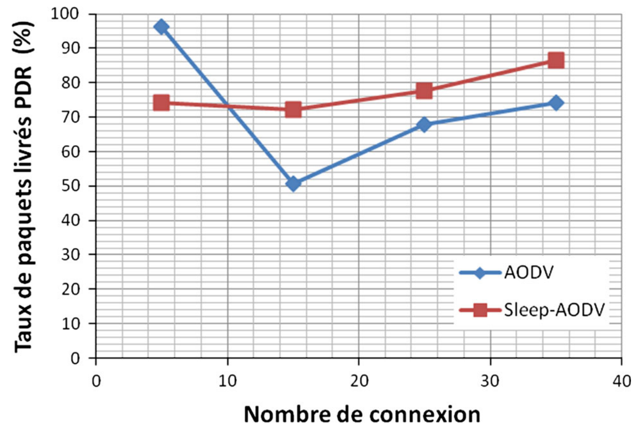


Fig. 11 Packets delivered

loss AODV-Sleep protocol is better than AODV in the network at high load as we have already shown in Fig. 10.

In Fig. 13 for the two protocols we see that they have a long time packet transfer and they are influenced by the increase of traffic leads to the occurrence of more collisions and congestion. Consequently, data packets spend more time in queues communication interfaces due to frequent retransmissions. This explains the increase in the period of both protocols by increasing the number of communication sessions. In all cases, the period of Sleep-AODV is the worst that can be trivially explained by the fact that the data packets spend more time in queues source nodes pending establishment paths because they are inaccessible, this illustrate the packets loss in Fig. 12.

The Fig. 14 reflects the evolution of the traffic overhead in terms of network load, we see that the control traffic increases dramatically with the number of connections. We also observe that the difference of control traffic generated by the protocol is very low when the number of connections is 5, but the difference increases when the network loads increase more than 25 and 35 connections.

The overhead traffic generated by AODV represents 20 % of that generated by AODV-Sleep heavy load, this is justified by the use of a larger number of control packets for the calculation and maintenance of roads because there are inaccessible nodes in the case of sleep-AODV protocol because the state still sleeping. The results shown in Fig. 15 reports the measurements to calculate the average energy as a function of the number of nodes. That despite, the remarkable difference in the average number of packets successfully delivered (Fig. 10), the average residual energy measured for our mechanism is much better than that of AODV protocol.

In Fig. 16 packets delivered in Sleep-AODV protocol is better than AODV regardless of the number of nodes because the nodes always use stable paths. Increasing the reception in a highly dense network (110 nodes) is reflected in the large number of paths between sources and destinations.

Figure 17 shows an idea of undelivered packets because the sources did not find their destinations. Note that all

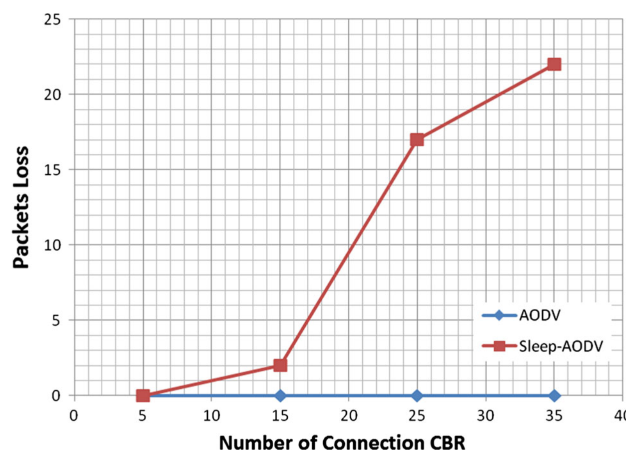


Fig. 12 Packets loss

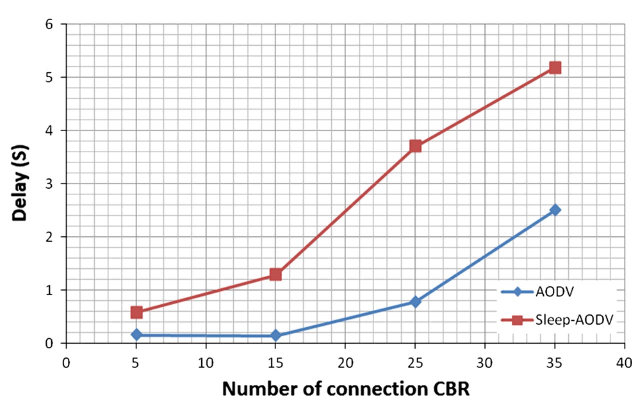


Fig. 13 End to end delay

nodes using the AODV protocol are available and the number of undelivered packets is zero some of the number of nodes and even Sleep-AODV protocol the number of undelivered packets is not large enough and it takes the value zero in a highly dense network, and still the Sleep-AODV protocol is better than AODV in packet receptions.

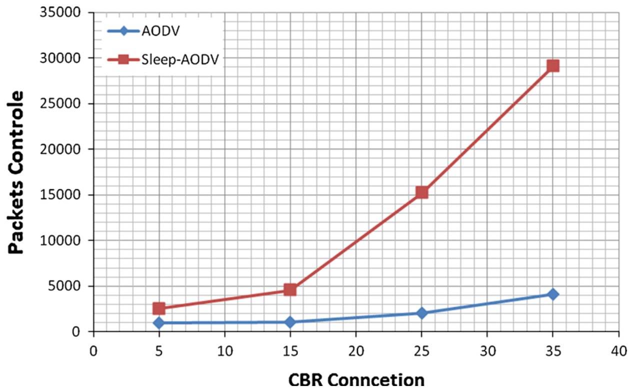


Fig. 14 Packet control

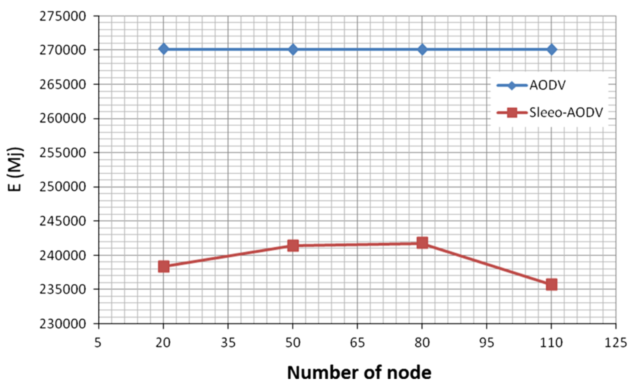


Fig. 15 Consumed energy

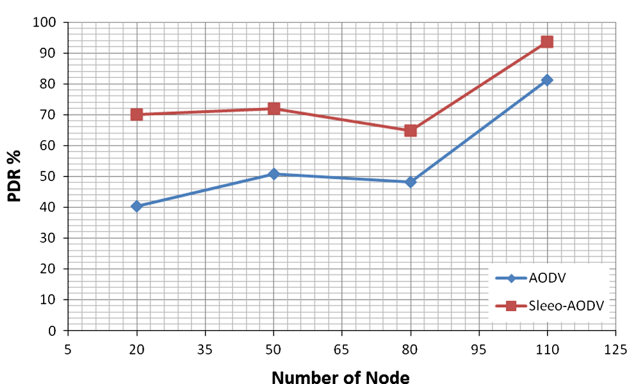


Fig. 16 Delivered packets

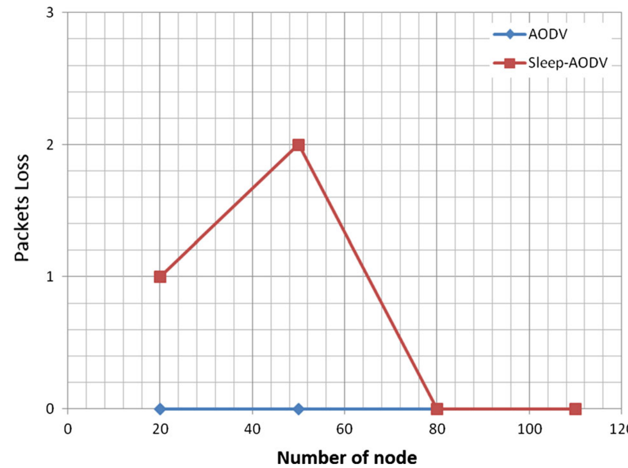


Fig. 17 Packets loss

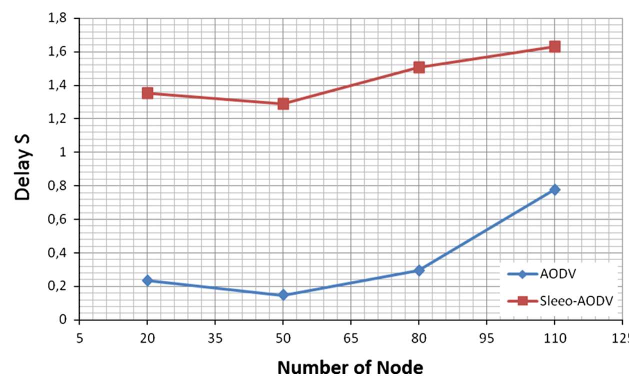


Fig. 18 End to end delay

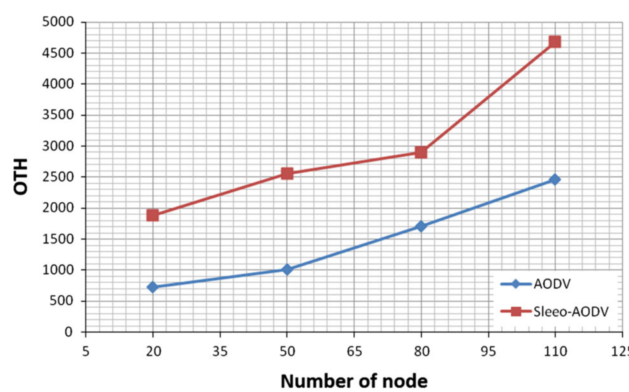


Fig. 19 Packets control

Figure 18 shows a breakdown of time from start to finish depending on the density of nodes in the network. Increasing network density leads to the occurrence of more collisions. Consequently, in both protocols the data packets spend more time in queues communication interfaces due to frequent retransmissions.

In all cases, the period of AODV protocol was less than that of the Sleep-AODV. This can be trivially explained by the fact that the data packets in Sleep-AODV spend more time in queues source node pending establishment of paths.

Figure 19 shows an increase of traffic control based on the density of nodes. We note in this figure that the TOH reaches a maximum value at high density (110 nodes) for all routing protocols because when the node density increases, the number of neighbor nodes increases, thereby increasing the number of packets RREQ broadcast for all protocols.

7 Conclusions

With our adaptation unnecessary communication are avoided in the routing to maintain a good level of energy for all mobile nodes and to route via stable routes. We have demonstrated by various scenarios that the proposed solution is efficient and provides a significant improvement on the level of packet reception and consumed energy. Simulation results show that compared to commonly used protocol, proposed routing scheme provides better performance under various traffic modes.

As perspective of our work, we can improve the functionality of the proposed algorithm to work under high-level traffic, bu using coding method to improve video quality.

References

1. Sakar, S. K., Basavaraju, T. G., & Puttamadappa, C. (2008). *Principles protocols, and applications, ad hoc mobile wireless networks*. London: Taylor & Francis Group.
2. Wan, Z., Xiong, N., & Yang, L. T. (2015). Cross-layer video transmission over IEEE 802.11e multihop networks. *Multimedia Tools and Applications*, *74*(1), 5–23.
3. Perkins, C. E., & Royer, E. M. (1999). Ad-hoc on-demand distance vector routing. *In Proceeding of IEEE Workshop on Mobile Computing Systems and Applications (WMCSA)* (pp.1–11).
4. Ramrekha, A., & Talooki, V. C. (2010). Energy efficient and scalable routing protocol for extreme emergency ad hoc communications. *Mobile Networks and Applications, 17*(2), 312–324. doi:10.1007/s11036-011-0336-0.
5. Jiang, M., Li, J., & Tay, Y. (1999). Cluster based routing protocol (CBRP) functional specication, internet draft. MANET working group.
6. Han, K., et al. (2013). Algorithm design for data communications in duty-cycled wireless sensor networks: A survey. *IEEE Communications Magazine*, *51*(7), 107–113.
7. Li, M., et al. (2013). A survey on topology control in wireless sensor networks: Taxonomy, comparative study, and open issues. *Proceedings of the IEEE*, *101*(12), 2538–2557.
8. Xiang, L., et al. (2011). Compressed data aggregation for energy efficient wireless sensor networks. In *SECON-IEEE communication society* (pp. 46–54).
9. Chilamkurti, N., et al. (2009). Cross-layer support for energy efficient routing in wireless sensor networks. *Journal of Sensors, 2009*, 134165. http://dx.doi.org/10.1155/2009/134165.
10. Cheng, H., et al. (2012). Nodes organization for channel assignment with topology preservation in multi-radio wireless mesh networks. *Ad Hoc Networks*, *10*(5), 760–773.
11. Zeng, Y., et al. (2013). Directional routing and scheduling for green vehicular delay tolerant networks. *Wireless Networks*, *19*(2), 161–173.
12. Awwad, S. A. B., Ng, C. K., Noordin, N. K., & Rasid, M. F. A. (2011). Cluster based routing protocol for mobile nodes wireless sensor network. *Wireless Personal Communications*, *61*, 251–281.
13. Ramrekha, T. A., & Politis, C. (2009). An adaptive QoS routing solution for Manet based multimedia communications in emergency cases. In *First international ICST conference*, MOBILIGHT (pp. 74–84).
14. Panaousis, E. A., Ramrekha, T. A., Millar, G. P., & Politis, C. (2010). Adaptive and secure routing protocol for emergency mobile ad hoc networks. *International Journal of Wireless and Mobile Networks, 2*(2), 62–78.
15. Ramrekha, T. A., Talooki, V. N., Rodriguez, J., & Politis, C. (2011). *Energy efficient and scalable routing protocol for extreme emergency ad hoc communications*. Berlin: Springer Science+Business Media LLC.
16. Ramrekha, T. A., Millar, G. P., Politis, C. (2011). A model for designing scalable and efficient adaptive routing approaches in emergency adhoc communications. In *IEEE Symposium on computers and communications(ISCC)* (pp. 916–923).
17. Cucurull, J., Asplund, M., & Nadjm-Tehrani, S. (2012). Anomaly detection and mitigation for disaster area networks. In *13th International Symposium on recent advances in intrusion detection, MONET* (Vol. 17, No 2, pp. 312–324).
18. Vergara, E. J., Nadjm-Tehrani, S., Asplund et, M., & Zurutuza, U. (2011). Resource footprint of a manycast protocol implementation on multiple mobile platforms. In *The fifth international conference on next generation mobile applications, services and technologies (NGMAST), IEEE* (pp. 154–160). doi:10.1109/NGMAST.2011.36.
19. Ferrigno, L., Marano, S., Paciello, V., & Pietrosanto, A. (2005). Balancing computational and transmission power consumption in wireless image sensor networks. In *IEEE29 international conference on virtual environments, human computer interfaces, and measures systems (VECIMS), VECIMS* (p. 6).
20. Wu, H., & Abouzeid, A. A. (2004). Energy efficient distributed JPEG2000 image compression in multihop wireless networks. In *4th workshop on applications and services in wireless networks* (pp. 152–160).
21. Wagner, R., Nowak, R., & Baraniuk, R. (2003). Distributed image compression for sensor networks using correspondence analysis and super-resolution. *Proceedings of IEEE International Conference on Image Processing (ICIP)*, *1*, 597–600.
22. Misra, S., Reisslein, M., & Xue, G. (2008). A survey of multimedia streaming in wireless sensor networks. *IEEE Communications Surveys and Tutorials*, *10*(4), 18–39.
23. Sarisaray-Boluk, P. (2013). Performance comparisons of the image quality evaluation techniques in Wireless Multimedia Sensor Networks. *Wireless Networks*, *19*, 443–460.
24. Boluk, P. S., & Baydere, S. (2011). Robust image transmission over wireless sensor networks. *Mobile Networks and Applications*, *16*, 149–170.
25. Wan, Z., Xiong, N., Ghani, N., Vasilakos, A. V., & Zhou, L. (2014). Adaptive unequal protection for wireless video transmission over IEEE 802.11e networks. *Multimedia Tools and Applications, 2014*, *72*(1), 541–571.
26. Wei, G., et al. (2011). Prediction-based data aggregation in wireless sensor networks: Combining grey model and Kalman Filter. *Computer Communications*, *34*(6), 793–802.
27. Liu, XY, Zhu, Y, Kong, L, Liu, C, Gu, Y., Vasilakos, A. V., & Wu MY. CDC: Compressive data collection for wireless sensor networks. *IEEE Transactions on Parallel and Distributed Systems*. doi:10.1109/TPDS.2014.2345257.
28. Li, P., et al. (2012). CodePipe: An opportunistic feeding and routing protocol for reliable multicast with pipelined network coding. In *INFOCOM 2012* (pp. 100–108).
29. Li, P., et al. (2014). Reliable multicast with pipelined network coding using opportunistic feeding and routing. *IEEE Transactions on Parallel and Distributed Systems*, *25*(12), 3264–3273.
30. Yen, Y.-S., et al. (2011). Flooding-limited and multi-constrained QoS multicast routing based on the genetic algorithm for MANETs. *Mathematical and Computer Modelling*, *53*(11–12), 2238–2250.

31. Yao, Y., et al. (2013). EDAL: An energy-efficient, delay-aware, and lifetime-balancing data collection protocol for wireless sensor networks. In *MASS 2013* (pp. 182–190).
32. Yao, Y., et al. (2014). EDAL: An energy-efficient, delay-aware, and lifetime-balancing data collection protocol for heterogeneous wireless sensor networks. In *IEEE/ACM Transactions on Networking*. doi:10.1109/TNET.2014.2306592.
33. Meng, T., et al. (2015). Spatial reusability-aware routing in multi-hop wireless networks. In *IEEE TMC*. doi:10.1109/TC.2015.2417543.
34. Song, Y., et al. (2014). A biology-based algorithm to minimal exposure problem of wireless sensor networks. *IEEE Transactions on Network and Service Management*, *11*(3), 417–430.
35. Liu, L., et al. (2015). Physarum optimization: A biology-inspired algorithm for the Steiner tree problem in networks. *IEEE Transactions on Computers*, *64*(3), 819–832.
36. Zhang, E., & Cai, W. (2010). Vision mesh: A novel video sensor networks platform for water conservancy engineering. In *Proceedings IEEE*
37. Aschenbruck, N., Frank, M., Martini, P., & Tlle, J. (2004) Human mobility in MANET disaster area simulation: A realistic approach. In *29th annual IEEE international conference on local computer network (LCN04)* (pp. 668–675).
38. Aschenbruck, N., Ernst, R., Gerhards-Padilla, E., Schwamborn, M. (2010). Bonnmotion: A mobility scenario generation and analysis tool. In *Simutool* (p. 51).
39. Achenbruck, N., Gerhaps-Padilla, E., Gerharz, M., Frank, M., & Martini, P. (2007). Modeling mobility in disaster area scenarios. In *The 10-th ACM international Symposium on modeling, analysis and simulation of wireless and mobile systems*.
40. Feeney, L. M. (2011). Energy effcient communication in ad hoc wireless networks. In *Computer and network architectures laboratory*, SE 164 29, Sweden.
41. Hong, X., Gerla, M., Pei, G. & Chiang, C. (1999). A group mobility model for ad hoc wireless networks. In *Proceedings of the 2nd ACM international workshop on modeling, analysis and simulation of wireless and mobile systems (MSWiM)* (pp. 53–60). Seattle, WA, USA.
42. Zeng, Y., et al. (2013). Real-time data report and task execution in wireless sensor and actuator networks using self-aware mobile actuators. *Computer Communications*, *36*(9), 988–997.
43. Sanchez, M., & Manzoni, P. (2001). Anejos: A Java based simulator for ad-hoc networks. *Future Generation Computer System*, *17*(5), 573–583.
44. Sum, F. W., Gerla, M. (1999). IPv6 flow handoff in ad-hoc wireless networks using mobility prediction. In *Proceedings of IEEE GLOBECOM* (pp. 271–275)

Mounir Tahar Abbes received the MASTER degree in science computer from University of Poitiers (ENSMA, France) in 2003, and Ph.D. (2012) in computer science from the University of Oran, Algeria. He has participated in TNT European project (The Neanderthalers Transforming Representational Cultural Heritage into Digital Media Popular Scientific Content and Developing a Visual Simulation Engine for Collaborative Real-Time Exploration) from CNRS-France in collaboration with Pr. Roberto Macchiarelli (2004–2006), and from 2006–2008 work as GSM core network consulting in MSI-Consultancy in many GSM projects in different company ZAIN and Orascom. Currently completing many projects in Computer science and telecommunication at UHBC (University Hassiba Ben Bouali) University. He teaches courses on Software engineering and Computer architecture. His current research interests include mobile wireless sensor/actuator networks, Zigbee/IEEE 802.15.4 technologies deployment, hybrid cellular networks, Vehicular ad hoc networks, vehicular sensor networks and heterogeneous wireless networks, with special emphasis on radio resource management techniques, performance modeling, provisioning QoS and industrial applications. He is currently head of a research team on wireless sensor networks and their societal and industrial applications.

Belhirech Mohamed received the MASTER degree in science computer from University of Hassiba Ben Bouali of Chlef (Algeria) in 2014. He is a developer interested by the Information and communications technology especially by wireless sensor networks.

Senouci Mohamed is an Professor of Artificial Intelligence and Pattern Recognition Applications at the Oran University and the LTE Laboratory where he is Member of the TIM3 Laboratory in Grenoble. He holds a Doctor in Computer Engineering and Informatics from the University of Besançon, France and a Ph.D. in Computer Science from the University of Oran, Algeria. He teaches courses on pattern recognition and computer architectural. His research interests are in the areas of pattern recognition and data analysis.