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Clustering Based and Centralized Routing Table Topology of Control Protocol in Mobile Wireless Sensor Networks

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Abstrat: A strong challenge in the wsn is to save the energy and have a long life time in the network without having a high rate of loss information. However, Topology Control (TC) protocols are designed in a way that the network are devieded and having a standar system of exchange packets between nodes. In this study, we will propose a clustering based and centralized Routing table protocol of TC (CBCRT) which delegates a leader node that will encapsulate a single routing table in every cluster nodes. Hence, if a node wants to send pakets to the sink, it requests the informations routing table of the curent cluster from the node leader in order to root the packet.

Key words: Topology, control, WSN, cluster, mobile , protocol

INTRODUCTION

Each Wireless Sensor Network (WSN) contains devices transmitter/receiver radio to communicate with each other and form a network connected with sensor nodes. The latter can be static or mobile which is the case in this study. Each network is characterized by infrastructure, algorithms, computing unit and limited energy storage. This scalability makes a great importance for different field. The WSN are also characterized by their density of nodes with dynamic topology and a connectivity degree which lies between nodes. However, to maintain an appropriate and entirely connected topology, it is neccessary to apply the Topology of Control (TC).

In several topologies of control which have been realized the primary purpose is energy saving. Many researchers have proposed some protocols which are based on minimization of cost link between nodes and save the transmission/reception power (our curent case in this study) with different geometry optimization of the network topology. In fact, coverage and connectivity are two performance metrics that are studied in the literature.

Literature review: In the literature Intanagonwiwat *et al.* (2003) has designed a data aggregation paradigm for wsn called directed diffusion as a Data Centric (DC) and application aware paradigm. However, each data is identified by pairs value. The DC paradigm functioning is a fusion between different nodes of the given source and route the data to a single destination by removing redandant nodes and the minimizing the number of transmissions in order to save energy and extend the lifetime of MWSN and also to eliminate redandant data. The process of use DD protocol is as follows (Fig. 1): interest propagation phase in the cluster node, a variable gradient that encapsulates the couple (identification, direction to the sink) is configured in each node so as to reply to the request from the seeker node after reception of interest. Phase of elected root and send data to the requesting node.

Another functionality included in the DD is the local repair for failed path. As above quoted, DD ensures better communication between nodes which involves repair

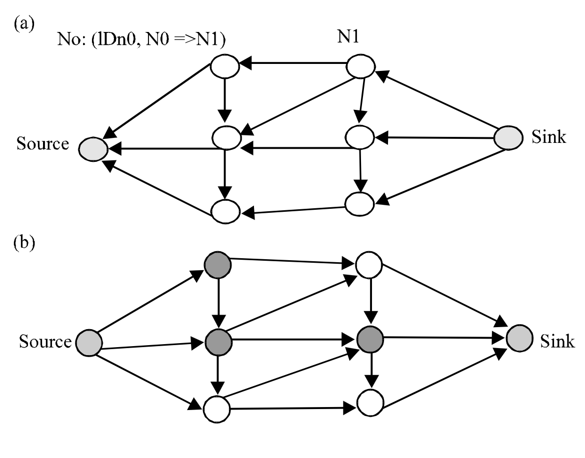

Fig. 1: DD Functioning in cluster: a) Brodcasting interest and confiuration gradients and b) Elected root aand sending data

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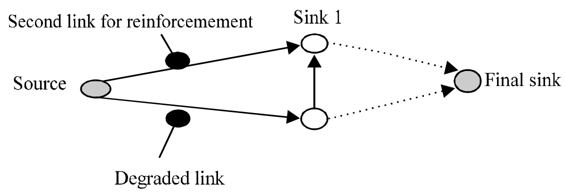

Fig. 2: DD reinforcement Mechanism in MWSN

connections in the event of degradation which are caused for exemple by environmental effects. The sink sends a reporting rate to the neighboring node (connected directly) that wants to reinforce the connection (case degraded link) in order to find a second root that will balance the degradation of quality link (Fig. 2).

MATERIALS AND METHODS

In this study, the CEC (Cluster Based Energy Conservation Protocol) is used as clustering mode of WSN which focuses on connectivity between nodes and select nodes that can be into the off state (Li and Liu, 2016). The cluster formation contains a cluster head node and gateway node that is puted in to subsets. This organisaation of clusters aims to have coordination only between nodes of the same cluster in order to reduce the costs of communication, the following Fig. summarizes the steps for clustering formation of CEC (After a interval of time the process is reiterated (Fig. 3).

Fig. 3: CEC functioning protocol; ID: Initialization and Discovery; ECHN: Election of Cluster Head Node with highest energy; EGN: Election of Gatway Node with second highest energy; PON: Power off all other Nodes in the cluster

Theorical view of CBCRT protocol

CBCRT functioning: Following the loss of energy in each node during the creation and exchanges of classical information routing tables, the CBCRT protocol extends network life time by centralizing a single table in the NL. In the case of an Ordinary Node (ON) which wants to send data, it request information relating to routing from the NL and this one will replay this request (NB: the mechanism will be explained here).

Cluster CBCRT formation

Node leader election: First, each node sends a discovery message that contains its node ID and its cluster ID and also its energy stored estimated. The chosen Node Leader (NL) of each cluster is the one with the higher energy and the one which has less energy than the first one will be a Secondary Node Leader (SNL) in case of damage of the First Node Leader (FNL). Thus, it sends a message to all nodes in the cluster in order to inform (Fig. 4).

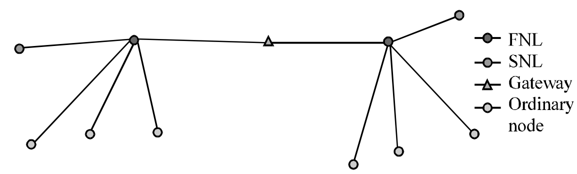

Fig. 4: Exemple of CBCRT clustring formation

Gateway election: The node reachable from the maximum leader of the nodes will be called gateway. Therefore, the cluster renews its formation with Reclustring Interval (Yang and Lee, 2012) (RI) which will be determined as follows:

$$RI = \alpha \text{life time of (FNL+SNL)}/0<\alpha<1$$

To avoid the presence of one or more nodes in n clusters (2<n<number of nodes cluster), each NL calculates its Redandant Degree (RD) as: RD = number shared neighbours list {Nli, Nli+1}/Number union list {j ,k} where number union list {j, k} = number list {j}-{NLi} U number list{k}-{NLi+1}. In the case, where RD>50%, the network is set in re-clustering mode with the re-calculation of RI value per cluster (Algorithm 1).

Algorithm 1 (Cases of re-clustering):

```
Input:
Network: Net
RD: Redandant degree
RI: Re clustering Interval
Clusters: Cn
Nodes per cluster: N
Output: Re Clustering (Cn,Cn+1)
for each Ci ε Net do
RI (Ci) = α Life Time of (FNL+SNL);
Re Clustering (Cn);
for each Ci εNet do
for each nj ε Ci && for each nL ε Ci+1 do
RD = Number shared List {NLi,NLi+1}/Number Union List {i,i+1} ;
If RD>50%
Re Clustering (Ci,Ci+1);
End;
End;
```

Phase of request replay CBCRT routing information: Initially, every NL per cluster collects routing information of all other ordinary nodes and stores them in the routing table leader. Moreover, if an ON wants to send data, it sends a request to LN and will answer the request by a data frame that encapsulates the routing information related to the current cluster (Fig. 5). The sender node route its data according to the routing information in the proper next hops outside the curent cluster, this technique aims to reduce energy consumption by fusing

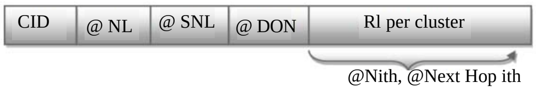

Fig. 5: Data frame encapsulation routing information; CID: Cluster Identifier, DON: Destination Ordinary Node; RI: Routing information

of all routing information in a single table leader. In case PNL reached a critical energy level, SNL takes over the cluster if this one also has an empty power the CBCRT protocol is again applied (Algorithm 2).

Algorithm 2 (CBCRT protocol functioning):

```
Input:
Network: Net
Clusters: Cn
Nodes per cluster: N
Next hops in the curent Cluster: NHCC
Cluster Formation (Cn): CF(Cn)
Sending Routing Information(@ NL, @ DON): SRI (@NL, @ DON)
Output:
DD (ID Souce, ID Destination, Direction to thesink)
for each Ci ε Net do
CF(Ci);
for each Ci ε Net do
for each nj ε Ci  && nk ε Ci+1 do
if (nj want to send to nk)
SRI (@ Nlj, @ nj);
DD(ID nj, ID nk, @ {nj = >nj+1 = >....=>nk} );
End;
End;
```

RESULTS AND DISCUSSION

Performance evaluation: The first objective of CBCRT protocol is to reduce the energy consumption by centralizing a single routing table in an NL in order not to repeat the collecting RI at each node per cluster and then also reduce the collision rate during this phase. In the practical part, the NS2 simulator is used to experiment the energetics state of NL and ON senarios (Fig. 6): the first will be on the filling phase of the NL's routing table and make the comparative study in NL and ON Throughput's and the second part will be on the sending Routing Information (RI) in the requesting node (our experience is focused on a single cluster with N0 as NLP, N2 as SNL and N1 as ON, N6 is the router connected directly to PNL and N4 will be the requesting node of routing information from the PNL). Interestingly, the consumed energy are compared of the second senario with the amount of energy of all the nodes in a simple routing FSR (Fisheye State Routing protocol Exchanging RI containing the same number of nodes in Grid WSN. NSG2.1 presents the structure of the General CBCRT Network (Fig. 7), The simulation CBCRT parameter's is indicated in Table 1.

Table 1: Parameter's of simulation

Parameter's	Values
Time of simulation	40000 msec
Chanel-type	Channel/wireless channel
Propagation model	Propagation/two ray ground
Mac protocol type	MAC/802_11
Max packet in queue	50
Routing protocol	AODV
Agent type	TCP
Packet size	1500 bytes
Freq	2,7932 Hz
Antenna type	Omni type
N1 waypoint setup	Start time 20, destination (744, 307), speed (20)
N2 waypoint setup	Start time 30, destination (760, 240), speed (30)
Distancce inter-nodes per cluster	100 m

Gathering routing information in NL: In this part, every NL collects the RI from every node per cluster in order to create the routing table leader (Fig. 8 and 9). This sub part presents the behavior throughput of PLN (N0) and ON (N1) for sending/reception of local RI (Fig. 10).

According to Fig. 11, the throughput at PNL in reception mode takes a higher values than the ON in sending mode, the explanation is that PNL receives all RI from the four nodes in gathering phase and put it in routing table leader, hence this one must increase its maximum throughput. Therfore, the ON is limited to send its local information that clarify the use of a lower throughput.

Request/replay of RI from PNL: In case , a node wants to send data outside its cluster, ON requests to send RI from RTL of all nodes in the curent cluster and PNL reply that information to the requesting node (Fig. 12).

Evaluation: After the complete storage of all the routing information in NLP, it switches to listening mode and waits for local demand per cluster. In this case, the NLP make the suitable route for these data to request ON with an appropriate transmission energy. Consequently, ON consumes a reception energy of all RI (same for the case of a simple routing):

$$Etx\,(s,d) = (Eelect\times S)+(\varepsilon amp\times s\times D2)/S\text{: bits to send, d:distance between the PNL(N0) and ON(N1)} \quad (1)$$

$$Erx = STP\times Eelect/STP\text{: Size of Transfered Packet} \quad (2)$$

Indications: Eelec is taken as 50 nJ/bit to run the transmitter and receiver circuitry. Eamp is taken as 100 pJ/bit/m^2, the energy dissipation of the transmission amplifier. This two formulas will be implemented in our case for CBCRT protocol and compared with the total consumption of Energy in a simple exchanging RI for all ON per cluster in time of simulation in transmission (Fig.) 12 and reception mode (Fig. 13) as indicates in the following Eq. 3 (Fig. 13 and 14):

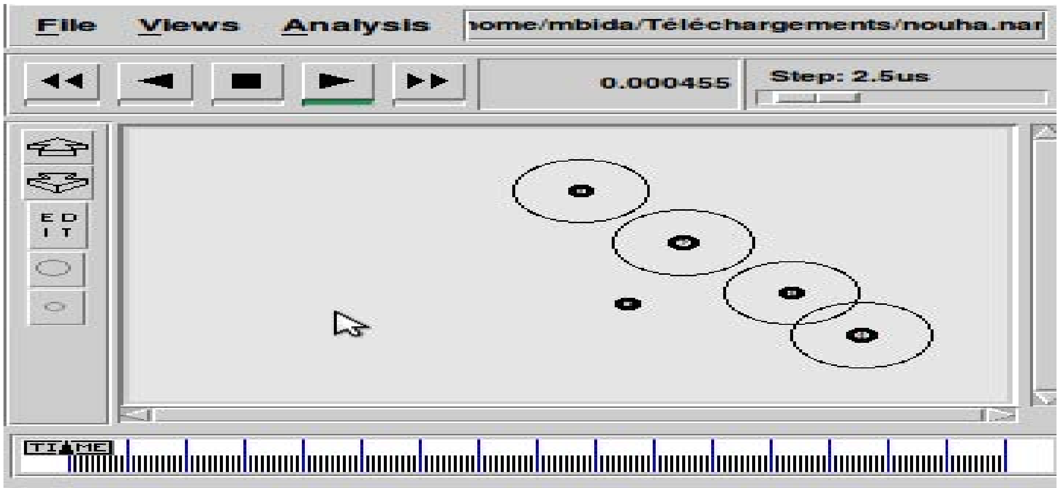

Fig. 6: General CBCRT simulation view in NS2 Simulator

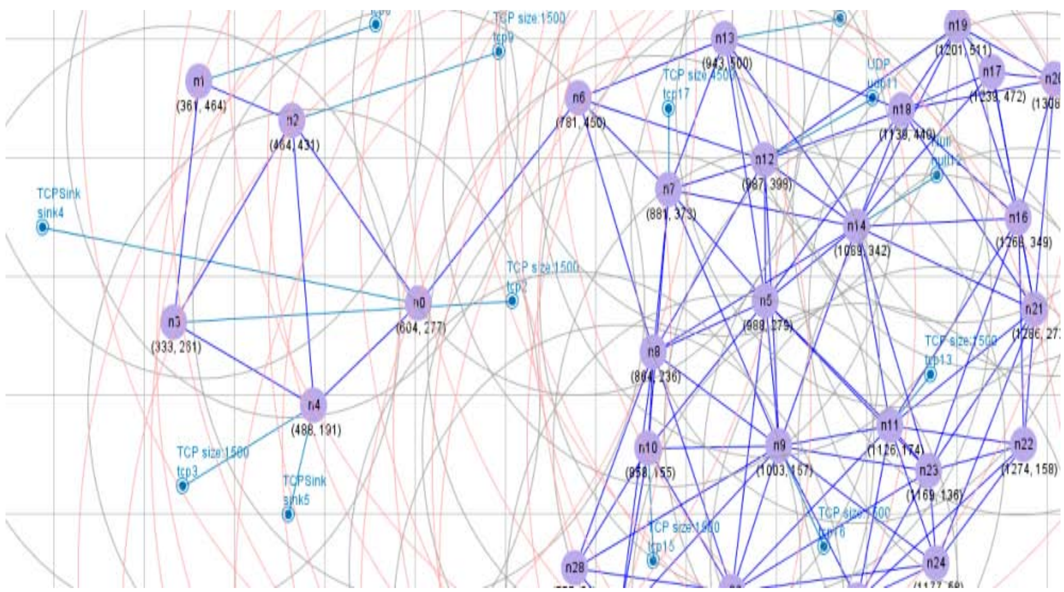

Fig. 7: General senraio of CBCRT protocol

$$\text{Et (CBCRT)} = \text{Erx CBCRT (RICP)} + \text{Etx (TER)} \tag{3}$$

$$\text{Et (SR)} = \text{Erx SR (RICPAN)} + \text{Etx (SET)} \tag{4}$$

Where:

RICP = RI Collecting Phase
TER = Transmission Energy of Replay all RI from NL to the ON requester
RICPAN = Collecting RI for all nodes in the same times for a classical routing
SET = Sum of Energies of Transmission at every node

Analyse and deduction: Figure 11 presents the Energy Consumed (EC) in transmision mode for the reply of RI at PNL and economise the consumption when it is compared with the total energy consumed in a simple exchanging RI for all nodes that transmit their local information to the others (Xiaohong *et al*., 2013) which implies an approximate representation of the values of energy as follows:

$$\text{Etx PNL (CBCRT)} \cong \text{Etx (TESR)} \times N \tag{5}$$

N: number of ON per cluster, TESR: Total Energy of Simple Routing

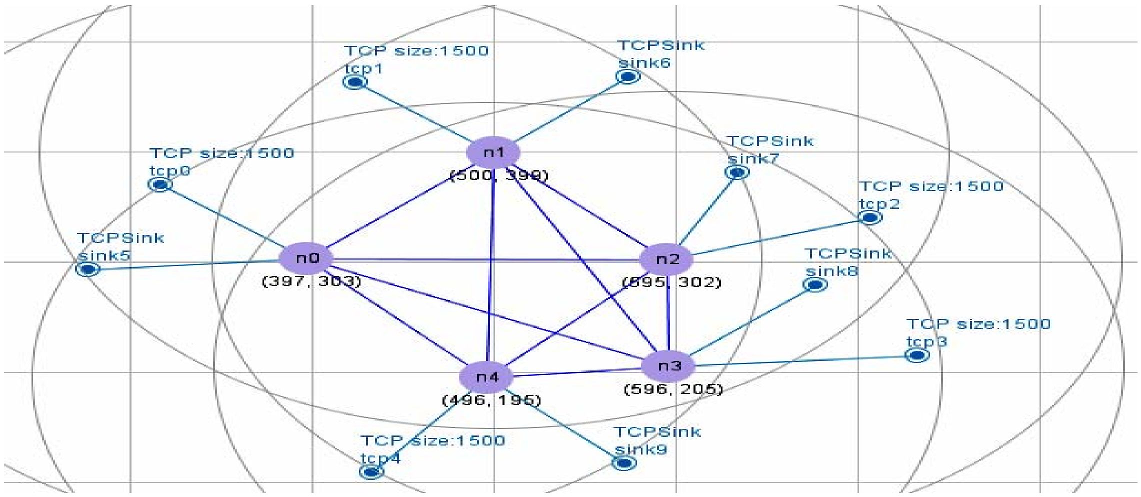

Fig. 8: General senario of SR

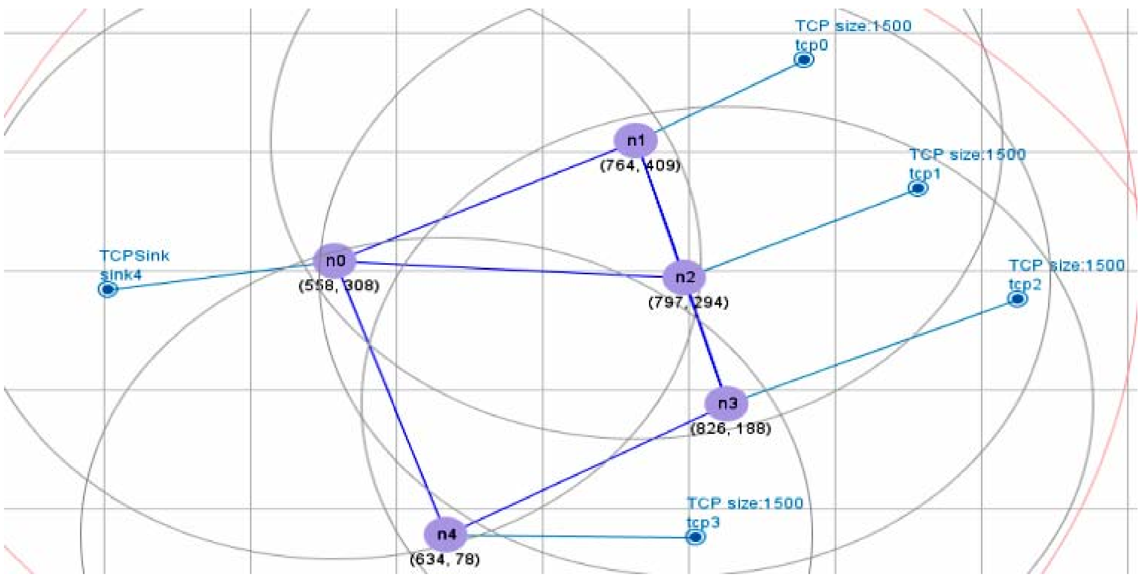

Fig. 9: Senario of collect the routing information

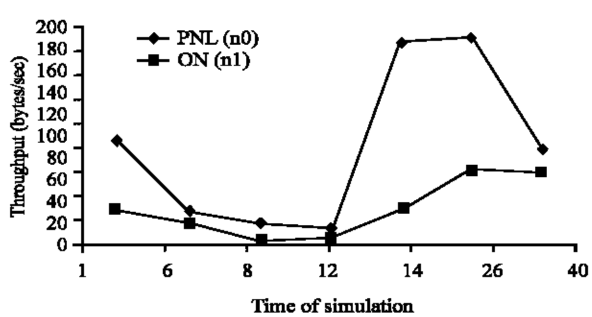

Fig. 10: Comparative performance in CBCRT sending/receving mode

However, the PNL in reception mode using CBCRT consumes less energy than in SR (Karaki and Kamal, 2014):

$$\text{Erx PNL(CBCRT)} \cong \text{Erx(SR)} \times \text{N/N:number of ON per cluster} \tag{6}$$

This leads us to deduce that CBCRT as the topology of control decreases the consumed energy in transmission and reception mode per cluster for the case of request/reply of RI. The aim is to centralize the RI per cluster in one NL and extend the ON lifetime per cluster in order to avoid repeating the same mechanisms of NL

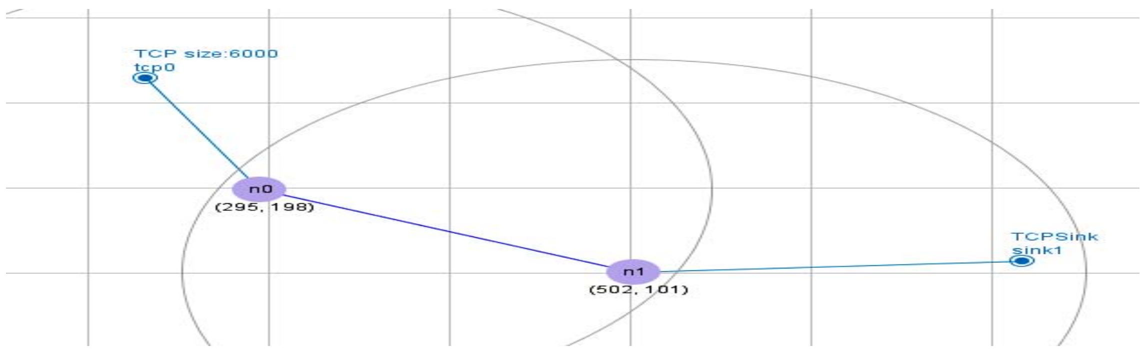

Fig. 11: Senario of request replay of all RI from PNL in CBCRT protocol

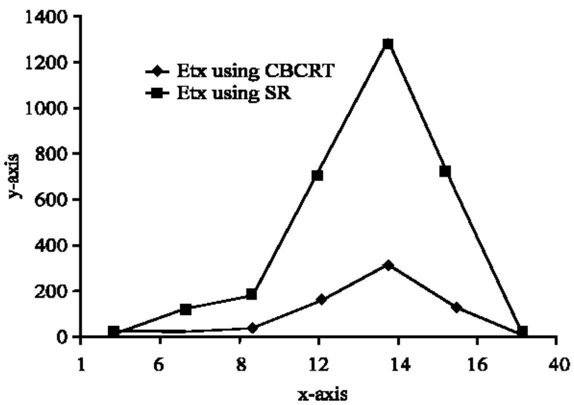

Fig. 12: Comparative performance Etx using CBCRT protocol and SR

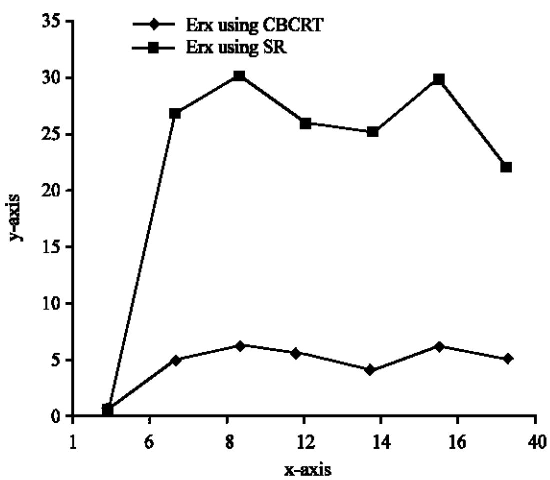

Fig. 13: Comparative performance Erx using CBCRT and SR protocol; Indication: Etx: Energy consumed (*10exp 5 pJ/sec); Indication: Erx (*10exp-19 pJ/sec)

which is the case in a SR with grid topology, following this the CBCRT Protocol saves the RI energy in each ON.

CONCLUSION

CBCRT protocol has managed to expand the lifetime of MWSN by the gain of part of energy in RI exchange phase which is characterized by a single centralized RTL per cluster in transmission/reception mode. One can conclude that this protocol as TC reduced total energy consumption compared to a network topology with a classic standard RI. The future work include a study of redandants ON between clusters in CBCRT and compares it with the existing TC protocols.

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