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Wireless Sensor Network with DCDD

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Abstract. A sensor network is collection of sensing, computing, and communication elements that give an ability to observe and react to events in different environment. The environment can be the small office area or a huge industrial plant. Wireless sensor network overcome limitations of traditional wired network i.e. flexibility, can be deployed in dense area. Nodes of wireless sensor network are battery powered and frequent change of batteries is not feasible solution. Instead of frequent change of batteries it is better to go for deployment of new plant. So energy usage of sensor nodes should equivalent. In WSN sensor nodes which are closer to SINK node consumes more energy than sensor nodes far away from SINK node. This incorporates the idea of having protocol which balances the load among sensor nodes. Diversity coded directed diffusion (DCDD) is the transport layer protocol which balances the load among all sensor nodes so energy consumption of each sensor node is equivalent. In DCDD secondary receiver i.e. Prongs are used. Long observation is divided in small fragments and these fragments sent to SINK via multiple paths and prongs which distribute the load. Reliability is achieved by using TWOFISH algorithm for encoding and decoding.

Keywords: DCDD, energy efficiency, diffusion, wireless sensor networks.

1. Introduction

Now days wireless sensor network is deployed in large number due to its several benefits i.e. flexibility and deployment of network. But Sensor nodes are limited in processing power, size, and energy source. Frequent changes of batteries are not good solution for WSN. So WSN requires energy efficient protocol in every layer. In WSN specifically transport layer consumes large amount of energy due to its functionality like flow control and congestion control. For reliable communication WSN uses the ACK/NACK packets due to this congestion occurs and to overcome this situation lots of energy is wasted. Energy management of each node is very crucial in WSN. In this paper we reviewed Diversity coded directed diffusion protocol with extension in encoding and decoding using TWOFISH algorithm which gives reliable and energy efficient communication. In DCDD for path setup exploratory packets are used but this packet format is little bit large and requires extra data bytes. We reworked on formats of different packet and made it compact in size. Key idea behind smaller packet format is that for transmission it will require less amount of energy. Key idea of diversity coded directed diffusion is to fragment the large observation and forward it to Sink (base station) by multiple paths. This strategy distributes the load as well as energy consumption. Due to balanced load frequent change of batteries are not required and increases the life of wireless sensor network.

2. Existing Work

At transport layer many protocols are available which gives reliable communication but at cost of energy some protocols are discussed in this section.

2.1. Congestion detection and avoidance (CODA)

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CODA detect congestion by sensing the sensor buffer and channel load if channel load exceed the predefined threshold value then it notify to its neighbor nodes to decrease their sending rate. Whenever any node need to send packet it will first sense the channel if the channel busy more than predefined number then it enable the congestion bit in outgoing packet. When base station receives packet with congestion bit set in its header then it sends the ACK to source nodes to decrease their sending rate. Such way congestion is detected. CODA gives the congestion support and reliable communication but on cost of energy which is not applicable to the wireless sensor network [5].

2.2. Pump slowly fetch quickly (PSFQ)

Pump slowly and fetch quickly gives reliable communication by broadcasting packets with sequence number slowly in network if next node observe the gap in sequence number then it issue fetch operation which halt regular communication and it gives NACK to its immediate neighbor if it is having missing packet then it will retransmit it otherwise forward NACK to its upstream immediate neighbor. This way reliable communication takes place in pump slowly fetch quickly protocol but on cost of energy consumption [5].

CODA and PSFQ protocols give the reliable communication for WSN but on cost of energy. For reliability these protocols uses ACK, NACK and retransmission of packets which increase the energy utilization. These protocols are not advisable solution for WSN.

3. Diversity Coded Directed Diffusion Protocol

Diversity coded directed diffusion is the transport layer protocol uses directed diffusion at network layer for routing the packet. The long observation is fragmented in small packets. These packets forwarded to SINK i.e. base station via multiple paths through different secondary receivers called prongs. Diversity coded directed diffusion uses the directed diffusion at network layer to route packets to multiple prongs. DCDD uses the different elements such as named data, path setup and observation propagation.

- Named Data :

In DCDD observation is identified using attribute and value pair. SINK transmits the interest packet in attribute-value pair format. e.g.

Table. 1: Named Data Format

Attribute	Value
Type	ImageID23
Location Range	[100,100 300,300]
Time	<= 15:30:30
ProngId	1

In observation packet exact location and timings are specified instead of range.

Table. 2: Observation Packet Format

Attribute	Value
Type	ImageID23
Location Range	[200,200]
Time	= 12:30:30
ProngId	1

Sensor node sense the observation which match to SINK request i.e. observation ImageID23 then it checks the timing and then fragment the observation if it is bigger in size then transmit it to SINK via prong 1.

Path for observation transmission is setup on demand. Exploratory packets are used for path setup. Exploratory packets are small in size for efficient utilization of energy. SINK transmit exploratory packet to its neighbor sensor nodes. After receiving exploratory packet sensor node process the packet depends on its energy level. If energy level of sensor node is greater than energy threshold specified in exploratory packet then sensor node takes following action

- Increment the hop count

- Forward exploratory packet to its neighbor sensor nodes.
- Generate the reply packet and transmit to SINK via sensor node from which it receives the exploratory packet.
- Otherwise drops the packet.

Working of DCDD is shown in fig. 1. The long observation is divided in 32bytes of fragments. For reliability TWOFISH algorithm is used. These fragments pass through encoder of TWOFISH algorithm. Encoder increases the number of packets. First 32 packets are transmitted to SINK node via prong1 i.e. secondary receiver number 1.next 32 packets are transmitted to SINK via prong 2 and so on. At receiver fragments of observation are collected and reassembled. TWOFISH decoder is used at the time of reassembly of observation [7].

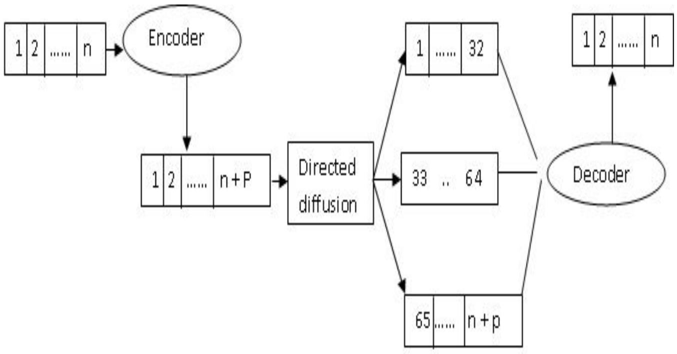

Fig. 1: Working of DCDD

4. Simulation Details

Diversity coded directed diffusion is implemented in NS 2 simulator. At Mac layer we have used 802.11. In network simulation scenario 50 nodes are arranged flat grid topology. Three cases are implemented and compared with respective to energy consumption. DCDD with 4 prongs i.e. secondary receiver, in second case DCDD with 8 prongs is implemented and in third scenario with 16 prongs. Energy consumption in first scenario i.e. with 4 prongs is larger than energy consumption in DCDD with 8 prongs and with 16 prongs.

Gradient setup is done by using exploratory and reply packet by sink. Sink forwards the exploratory packets to its neighbors. Depending upon energy level of sensor, it processes or drops the packet. Processing of packet includes maintaining neighbor table, reply back the Reply packet to sensor from which exploratory packet is received and forward exploratory packet to its neighbors. Sink has different multiple paths for specific sensor then out off that effective path is reinforced by sink node. Data transmission is done only through this path.

Table. 3: Exploratory Packet Fields

E	S_ ID	P_ ID	ET	HC	D_ ID

E: Identification of Exploratory Packet
S_ID: Sink Identification
P_ID: Secondary receiver i.e. Prong Identification
HC: Hop Count
ET: Energy Threshold
D_ID: Destination Sink Identification

The reply packet is generated and transmitted by the sensor node which is eligible for transmission. Reply packet format is as follows:

Table. 4: Reply Packet Fields

R	S_ID	P_ID	ET	HC	SS_ID	IS_ID

Reply: Identification of reply packet
S_ID: Sink Identification
P_ID: Secondary receiver i.e. Prong Identification
HC: Hop Count
ET: Energy Threshold
SS_ID: Source Sensor Identification
IS_ID: Intermediate sensor Identification

In energy threshold field sensor specifies its residual energy, in source sensor ID field it specifies its own identification and an intermediate sensor Id field consists of neighbor sensor id to which reply packet is to be sent. When sensor receives the reply packet then it is forwarded to its upstream neighbor by specifying its ID in intermediate sensor ID. When intermediate sensor node receives the reply packet then this packet is forwarded to its upstream neighbor by replacing IS_IS field of reply packet by neighbor identification number. The HC filed of reply packet is not altered by any intermediate sensor nodes. Such a way gradients are setup. Sink has multiple paths, among that the optimal path is reinforced for observation propagation.

When SINK node i.e. base station requires the observation then transmit interest packet via reinforced path. SINK specifies the prong identification in interest packet. Sensor node maintains the interest cache if the sensed observation matches the interest entry in cache then sensor transmits observation to the SINK. If the observation is long then it is fragmented and then transmitted to SINK via prong mentioned in interest packet for this P_ID field is added in interest and observation packet format.

Interest packet includes the Sink Id, PID, sensor ID, type of observation, co-ordinate of area from which observation needed and time (observation between specific timing ranges is required)

Table. 5: Interest Packet Fields

S_ID	D_ID	Type	Location	Time

S_Id: Source Sink node Identification
D_ID: Destination sensor node Identification
Type: Type of observation
Location: Location range
Time: Observation required before timing specified by this field

Observation packet includes the observation identification count. Observation is fragmented so fragment number is also specified in observation packet header i.e. FSN. For reassembly of observation at destination the total number of fragments is required so the count of maximum fragment is specified in packet format i.e. M_cnt. P_ID filed is added in the observation field as fragments are transmitted through different path via different prongs.

Table. 6: Observation Packet Fields

S_ID	D_ID	Type	Location	Time	P_ID	O_ID	FSN	M_CNT	SS_ID	IS_ID

S_Id: Source Sink node Identification
D_ID: Destination sensor node Identification
Type: Type of observation
Location: Exact Location of observation.
Time: Time at which observation sensed.
P_ID: Prong i.e. Secondary receiver Identification.
O_ID: Observation Identification
FSN: Fragment sequence number
M_CNT: Total fragment Count
SS_ID: Source sensor node Identification
IS_ID: Intermediate sensor node identification

When sink observers sequence gap, then lost packet is taken from respective prong for this prong maintains the observation cache.

➢ Simulation Results :

Simulation results are shown in graph. . Graphs are plotted time verses energy consumption. Graph shows the energy consumption of sensor nodes in three scenarios :

- With 4 prongs in network.
- With 8 prongs in network
- And with 16 prongs in network.

24 Joules energy consumed using 4 prongs which much larger than energy consumed in wireless sensor scenario with 8 prongs and with 16 prongs. 18 Joules energy consumed with 8 prongs scenario and 15 joules of energy is consumed with 16 prongs scenario. With these findings it is revealed that DCDD improves the energy utilization and life of WSN.

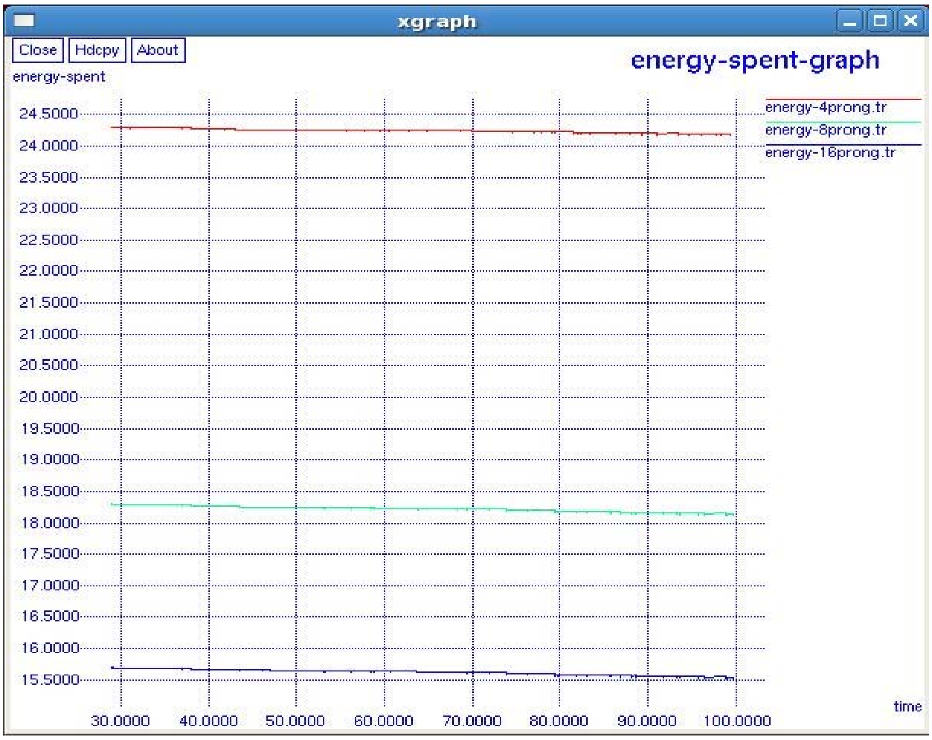

Fig. 3: Energy Consumption with 4 prongs, 8 prongs and 16prongs.

5. Conclusion

Diversity coded directed diffusion is the transport layer protocol which balance the load of wireless sensor network which improves the energy utilization. Instead of taking single long path for transmission DCDD takes multiple different paths for transmission of long observation via multiple secondary receivers i.e. prongs. DCDD is the best solution for wireless sensor network where the observation required on query basis.

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