ARPN Journal of Engineering and Applied Sciences

COOPERATIVE NODE SELECTION IN VIRTUAL MIMO BASED WIRELESS SENSOR NETWORK USING MAXIMUM A POSTERIORI ESTIMATION

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ABSTRACT

A wireless sensor network is a low-cost, low-power network. Because of its multi functionality, it is suitable for wide range of applications. In recent years, the research has focussed interest in to reducing energy consumption in Wireless Sensor Networks. As sensor nodes are battery powered which is very limited resource. Because of the limited energy resource, the life time of network has reduced. In this paper, we proposed a node selection algorithm which prolongs the network lifetime by effectively using advanced physical layer technique such as Virtual MIMO. The cooperative sensor nodes are selected on the basis of prior conditions like residual energy and distance between neighbouring nodes and sink node. Along with the prior conditions, the post conditions such as channel condition, overload and delay for transmission are considered. Based on these conditions, the co operative nodes are randomly selected. After selecting the cooperative nodes, the maximum a posteriori estimate is applied to select the appropriate nodes before transmission. The simulation results are taken for network lifetime, end to end delay and residual energy. The results show the significant improvement of the proposed algorithm than already existing V-BLAST transmission scheme.

Keywords: sensor network, cooperative nodes, residual energy, MAP estimate, network lifetime.

INTRODUCTION

A wireless sensor network consists of large number of densely deployed array of sensor nodes. Each sensor node contains microcontroller, data processing unit, low power radio transceivers and battery. Sensor nodes are randomly deployed to monitor environmental conditions. These networks possess self organizing capability [1] [2]. One of the major issues of sensor network is the energy consumption. Due to the lack of energy consumption, the network life time is reduced. Since the sensor nodes are densely deployed and the nodes are very close to each other. Hence, multihop communication is used. It will consume less energy than single hop communication [3] [4] [5]. In order to reduce total energy consumption of the sensor nodes, highest diversity gain is needed. This can be possible only due to cooperative MIMO communication. The cooperative MIMO communication leads to higher link reliability and lower retransmission rates. Due to dense nature of sensor network, the cooperative MIMO concept has introduced. Instead of using multiple antennas in one device or node, multiple sensor nodes are physically grouped to form the cooperative MIMO network [6].

In WSN, the advanced physical layer technique called MIMO technology has been used to improve the data rates, transmission quality and also to consume less energy. However, each device is equipped with multiple antennas while using MIMO technique. But it is not realistic in many situations when considering size and cost of the device and also power consumption has to be taken in to consideration. Therefore, a novel technique like Virtual MIMO has been used. The VMIMO has assumed multiple sensor nodes as a single node. Therefore, as a conventional MIMO, a node will have multiple antennas. It saves energy and also improves the transmission quality by mitigating multipath fading [7] [8].

LITERATURE REVIEW

A conventional MIMO based WSN architecture and node selection algorithm has been proposed. The scalability of this algorithm has been analyzed under different channel conditions and network density [8]. A trust based cooperative node selection has been done. Here trust model is proposed which involves both direct trust and indirect trust of node. The cluster head will select a high trust nodes based on this model. This high trust node will assist the CHN to transmit data to the destination node in presence of malicious nodes [9]. This method considered residual energy and link quality between cluster head node and data fusion centre. Initially the intra cluster nodes will compare its residual energy with predetermined energy threshold. If the condition satisfied, then it will take part in the transmission as a cooperative node [10]. The cluster head and cooperative nodes are selected hierarchically based on their residual energy. Communication between intra cluster nodes are done via SISO and communication between cluster heads are done via MIMO [11]. The algorithm for selecting sensor nodes has been studied under rich scattering transmission environment. This algorithm is based on signal to noise ratio maximizing [12].By using the feedback channel, channel state information the better node is selected for

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cooperative transmission [13].To maximize the life time of the WSN, the virtual MIMO based cluster- based V-BLAST technique has been proposed. This technique does not require transmission side cooperation and it needs only receiver side cooperation. Therefore V-BLAST transmission scheme is used. And also cooperative node selection is done based on SNR [14]. The energy efficiency of WSN is improved by cluster-based virtual V-BLAST transmission scheme. Instead of single cluster transmission, multiple cluster heads are transmitting simultaneously [15]. The previous work is proposed to select cooperative nodes by probabilistic approach. Only residual energy and channel conditions are considered for cooperative node selection. In our proposed work, at every single hop the cooperative nodes are selected before transmission. Along with the residual energy and channel conditions, posterior conditions like transmission delay and overheads at intermediate nodes are considered [16].

SYSTEM MODEL

In Wireless sensor network, the data has to be transmitted from source node to destination node. The virtual MIMO structure has been used; therefore the intermediate nodes are used as a M_t number of transmitting nodes and M_r number receiving nodes. Among these nodes, appropriate nodes have to be selected. Then only the energy consumption will be minimized and network life time will be maximized.

The main objective of the work is to select cooperative nodes. The data from source node will take multiple hops to reach destination node. At each hop, the appropriate nodes have to be selected. Then only the network life time will be prolonged. To select the better cooperative nodes, the following parameters are needed. The initial parameters are residual energy (E_{res}) and distance between source node and intermediate nodes (D_i). The posterior conditions like Transmission delay (τ_d), channel conditions (C_H) and over heads (O_H). The maximum a Posterior decision is made to select the cooperative nodes with the help of initial and post conditions. The MAP estimate is calculated and the data is transmitted to next of tier intermediate nodes by V-BLAST transmission technique. The pseudo code for cooperative node selection based is depicted in Figure-1.

At Source node:

1. Get prior conditions E_{res} and D_i
2. Get post conditions τ_d, C_H and O_H
3. If prior and post conditions ≥ critical value
   (a) If Yes then cooperative nodes are selected.
   (b) Data is transmitted through MISO transmission and using MAP estimate next hop cooperative nodes are to be found.
   Else again search for cooperative nodes.

At intermediate nodes:

1. Get prior conditions E_{res} and D_i
2. Get post conditions τ_d, C_H and O_H
3. If prior and post conditions ≥ critical value
   (a) If Yes then cooperative nodes are selected.
   (b) Data is transmitted through V-BLAST transmission and using MAP estimate next hop cooperative nodes are to be found.
   Else again search for cooperative nodes.

Process is continued till sink node.

Figure-1. Pseudo code for cooperative node selection.

PROBABILISTIC MODELLING

Consider a network which contains N number of nodes. Among these nodes at each hop M_t and M_r intermediate nodes are acting as a transmitter and receiver nodes. The probability model of selection function which is used to select cooperative nodes should have minimum value. Then only probability of selecting the particular node will be maximum.

The selection function is $$P(S) = \frac{f(B)}{f(A)} \quad (1)$$

here, f(A) involves initial parameters such as residual energy (E_{res}) and distance between source node and intermediate nodes (D_i). The f (B) involves posterior conditions such as Transmission delay (τ_d), channel conditions (C_H) and over heads (O_H). The flow chart for selection of cooperative nodes with MAP estimate is depicted in Figure-2.

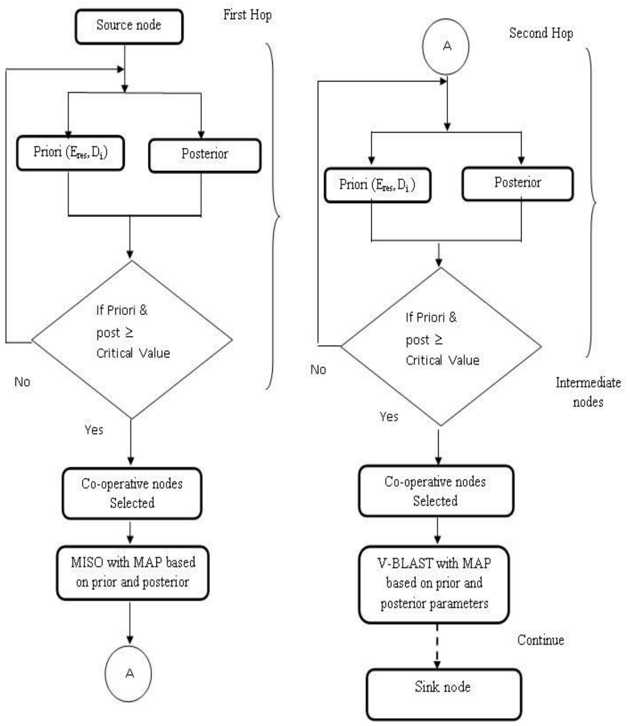

Figure-2. Flow chart for cooperative node selection based on MAP.

For cooperative communication, with the help of prior probabilities, the posterior condition estimates are obtained by using maximum a posterior estimation,

$$\widehat{B}(x) = \underset{B}{\operatorname{argmax}} \frac{f(A/_B)f(B)}{f(A)} \tag{2}$$

Here, f (A) is initial or prior conditions and f(B) is posterior conditions. If these conditions are satisfied, then the selection function will have minimum value. The nodes which have minimum valued section function is selected as a cooperative nodes.

After selecting the cooperative nodes, the data is transmitted by V-BLAST transmission. In V-BLAST transmission, the transmission path has to be detected.

$$P_{error} = P\{\ddot{s} \neq s\} \tag{3}$$

Where $\ddot{s} = (\ddot{s}_1, \ddot{s}_2, \dots, \ddot{s}_T)$ and T is the size of matrix.

For every path input vector x is estimated with assumption that the receiver has perfect knowledge of existing path. Then the decision is made on path by path basis by neglecting statistical dependencies. The sequence of vectors $\ddot{s}$ for all paths is measured which is nothing but statistical parameters. Then the probability of decision error is calculated. To reduce the interference between paths on V-BLAST transmission, the probability of decision error should be minimized.

RESIDUAL ENERGY

The residual energy for cooperative nodes is remaining energy after transmission. The residual energy is given by,

$$E_{res} = E_{res0} + b_t E_{TXl} - M_r b_t E_{RXl} - b_t M_t E_{TXL} \tag{4}$$

Where E_{res0} is remaining energy in previous round for cooperative node, b_t is the bit size, M_t is the number of transmitting nodes, E_{TXl} and E_{TXL} are the required energy per bit for intermediate communication and long haul communication respectively at transmitter side. E_{RXl} is the energy required per bit at receiver side.

EXPECTED ROUND TRIP TIME (EXPECTED RTT)

The Expected RTT is the time taken by the sensor node to send the request signal and receive the acknowledgement signal from neighbour nodes.

$$E[RTT] = E[X_{REQ}] + E[X_{REP}] \tag{5}$$

here X_{REQ} is request signal send by source node and X_{REP} is the acknowledgement signal send by other nodes to source node.

$$\text{Where,} E[X_{REQ}] = N_h(T_{SIFS} + T_{TX}) \tag{6(a)}$$

$$E[X_{REP}] = N_h(T_{sl} + T_{SIFS} + T_{TX}) \tag{6(b)}$$

where $T_{sl,}$ is duration of Idle time slot, T_{SIFS} is duration of SIFS and T_{TX} is duration of transmission.

LINK DELAY

The link delay means time taken by the packets to reach destination node from source node over a number of hops. The link delay depends on number of hops and channel condition.

$$D_L = {}^{(T_E - T_s)}\big/_{\sum N_h} \tag{7}$$

where T_S is the sending time of packet and T_E is the receiving time of packet.

RESULTS AND DISCUSSIONS

The simulation has done in MATLAB. The simulation area has been chosen as 100x100 and 100 sensor nodes are randomly deployed. Initially all nodes have energy of 0.2 to 1.2 mJ. The simulation parameters are given in Table-1,

Table-1. Simulation parameters.

Parameters	Values
Simulation Area	100X100
Number of Nodes	100
Propagation Channel	Rayleigh channel
E_{TXl} and E_{RXl}	5μJ/bit
E_{TXL}	15μJ/bit
M_t & M_r	**4**
b_t	10Kb

The Residual energy, Expected Round Trip Time and Link delay are the simulated parameters. Figure-3 shows the residual energy is the remaining energy of transmitter and receiver nodes. The results have taken between residual energy and distance.

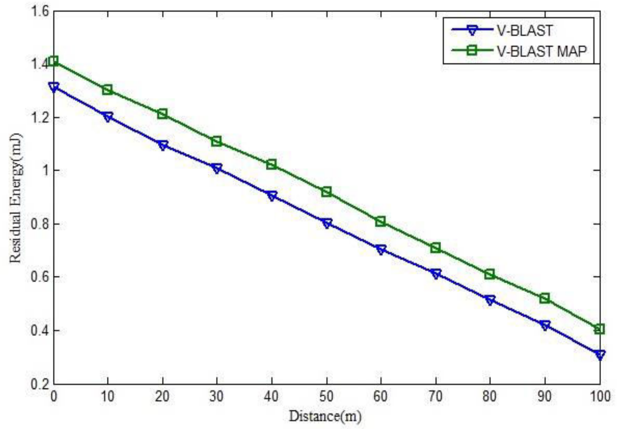

Figure-3. Residual energy.

Figure-4 shows the expected round trip time. The Expected RTT is the time taken by a sensor node to transmit request signal and to receive reply signal. The results have taken between Expected RTT and distance.

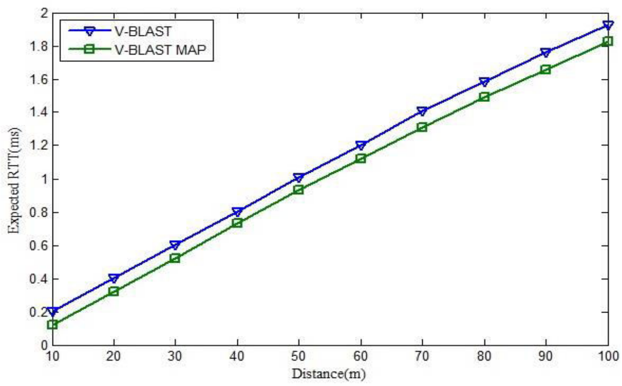

Figure-4. Expected RTT.

Figure-5 shows the link delay. Link delay is time elapsed between the source and sink nodes to transmit and receive the data. The results have taken between link delay and distance.

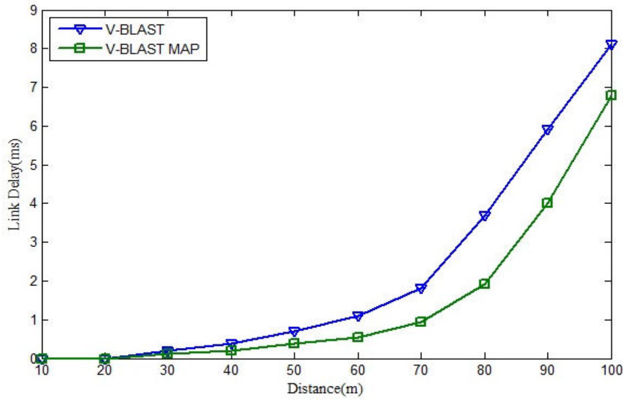

Figure-5. Link delay.

All the results are compared for V-BLAST and V-BLAST MAP. Compare to V-BLAST transmission MAP based V-BLAST transmission performance is better.

CONCLUSIONS

In this paper, we proposed a cooperative node selection algorithm. This algorithm is based on Maximum a posterior estimate. At each hop, before transmission the cooperative nodes are selected based on this algorithm. Then V-BLAST transmission is used for transmitting data from source node to destination node. Before transmission MAP estimate is used to select the appropriate path. This algorithm improves the energy efficiency. By using this algorithm, all the nodes are not actively participate in the transmission. The nodes which are satisfying the condition only selected to participate in transmission. Therefore network life time will be improved.

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