A Novel Energy-efficient Cooperative Transmission Scheme Based on V-BLAST Processing and ICA clustering for WSNs Lifetime Maximization

Mohammad Sadeghian Kerdabadi[*], Reza Ghazizadeh

Department of electrical and computer engineering, Birjand University, Birjand, Iran
*Corresponding author: mohammad.sadeghian@birjand.ac.ir

Abstract In wireless sensor network, one of the main objectives is how to improve its lifetime because the sensor nodes are generally energy-limited. Thus, providing ways to optimize energy Consumption, which ultimately increases the network lifetime, is of great importance. In this paper, we propose and evaluate an energy-efficient cooperative MIMO transmission scheme based on V-BLAST technique. In proposed scheme the clustering is done based on Imperialist Competitive Algorithm (ICA) then V-BLAST technique based virtual MIMO transmission are used. This proposed protocol performance is analytically and experimentally is compared with previous presented works. From the analysis and the simulation results, it is seen that the proposed method can reduce the energy consumption of the network and prolong the sensor networks lifetime compared with existing techniques.

Cite This Article: Mohammad Sadeghian Kerdabadi, and Reza Ghazizadeh, "A Novel Energy-efficient Cooperative Transmission Scheme Based on V-BLAST Processing and ICA clustering for WSNs Lifetime Maximization." *American Journal of Sensor Technology*, vol. 3, no. 1 (2015): 5-12. doi: 10.12691/ajst-3-1-2.

1. Introduction

Unlike wired designs, wireless sensor network have limited energy storage and the efficient use of this energy will be vital in determining the range of suitable applications for these networks, thus a main design requirement of the wireless sensor networks is to reduce the total energy consumption of the sensor nodes. Cooperative transmissions or cooperative diversity is a relatively new physical layer approach which helps to achieve performance gains similar to multiple input Multiple output (MIMO) enabled transmissions in wireless networks. The use of cooperative communications in WSNs allows for energy saving or reduce the transmission energy consumption through diversity gains or range improvement using space-time coding. Cooperative transmissions exploit a fundamental feature of the wireless medium: the ability to achieve diversity through independent channels created between the multiple transmitters and the receiver, because these channels are likely to fade independently [1]. In cooperative MIMO, nodes can be partitioned into a number of small groups called clusters. Each cluster has a leader, referred to as a cluster head, and a number of member nodes, thus a method to improve the lifetime is to reduce the number of transmissions by clustering the nodes [2].In this approach cluster heads collects and aggregates data received from its cluster members and thus decrease the number of relayed packets. Low Energy Adaptive Clustering Hierarchy (LEACH) is one of the first major improvements on conventional clustering approaches in wireless sensor networks that forms clusters based on the received signal strength and uses these local cluster heads as routers to the BS [2]. LEACH provides a balancing of energy usage by random rotation of cluster heads, but because of the election of cluster head is randomized, it may cause some problems such as uneven distribution of the cluster head, uneven energy loading and so on. So, LEACH does not guarantee that the positions evenly placed across the network and can't effectively prolong the lifetime of the network. Its proposer later improved it, proposing the LEACH-C [3]. In LEACH-C, the cluster formation is done at the beginning of each round using a centralized algorithm by the base station. The optimum selection of the cluster heads with high energy, their number and cluster members are NP-hard problem. Hence evolutionary algorithms are generally more suitable to solve these problems because they are population based stochastic approaches that can avoid being trapped in a local optimum and can often find global optimum solution [4]. Introduction of artificial intelligence in CH selection shows an improvement of network lifetime compared to classical random selection method. Sajid Hussain and et al [5] successfully utilized a genetic algorithm approach to clustering the nodes. In [6] the authors used PSO to equalize the number of nodes and candidate cluster heads in each cluster in order to minimize the energy expended by the nodes while maximizing the data transmission. In [7], Abdul latiff and

et al proposed a centralized cluster based protocol to expend the sensor network lifetime by using PSO and GA algorithms that can minimize the maximum intra cluster distance between cluster head and the cluster members and the optimization of energy management of the network so, they proved that both PSO and GA can be give optimal clustering compared with LEACH and LEACH-C algorithm. Furthermore, PSO algorithm gives a higher network lifetime compared with GA. In [4] author utilized a clustering algorithm based on Honey Bee Mating optimization (HBMO) algorithm to optimize clustering process by considering the energy and consumption costs and other factors. Cupta's literature shows an improvement of network lifetime over LEACH protocol but it only selects one cluster head (CH) in each round. In this method, during each period, the sensor that has the most chance is selected as cluster head [8]. Three fuzzy variables are used to calculate the chance including: the number of neighbors of the nodes, residual energy of the nodes and centrally [8]. Siew and et al described the use of fuzzy logic to select suitable CH among sensor nodes [9]. Reference [10] proposed a clustering algorithm based on Imperialist competitive algorithm (ICA). The other ways to improve wireless sensor networks based on cooperative MIMO is data transmission structure kinds. Many of these structures are based on V-BLAST technique. In [11] authors propose a receiver side vertical Bell Laboratories layered Space time (V-BLAST) MIMO processing communication architecture where the transmitter side jointly encoding is indispensable. Using VBLAST for spatial multiplexing, the authors in [12] optimized MIMO's operation under power and delay constraints. Authors in [13], propose a delay and channel estimation scheme without transmission synchronization for decoding in such cooperative MIMO scheme. In [3], an energy efficient cooperative MMO transmission scheme based on V-BLAST technique is proposed which not require transmitter side cooperation. In [14] kumar sachon and et al propose a novel energy-efficient virtual MIMO communication architecture based on V-BLAST receiver processing. In this architecture, cooperation protocol with low overhead is proposed and synchronization requirements among cooperating sensors are discussed. Ding Jie and et al instead of using cluster members as cooperative nodes, multiple cluster nodes cooperative to form virtual array so that MIMO transmission can be implemented. According to the MIMO techniques used in this architecture. V-BLAST based cluster head cluster heads cooperative transmission (VCHCT) are developed [15].

In this paper after forming clusters by ICA algorithm in each rounds, the number of nodes in each clusters are selected as cooperative nodes. These is nodes are called VBN (V-BLAST nodes). Now, after a cluster head receives data packets from its cluster members, it will perform data aggregation and then distribute the fused data to preselected VBN nodes. In the next step, VBN nodes simultaneously transmit the data packets to the BS.

The rest of this paper is organized in the following manner: Section 2 present the system model and the proposed scheme. In section 3 the energy consumption model for collaborative communication is presented. In section 4 simulation results in Matlab software are given and finally in section 5 is the conclusion.

1.1. Imperialist Competitive Algorithm (ICA)

Imperialist Competitive Algorithm (ICA) is a novel evolutionary algorithm that is inspired by the socio-political competition. This algorithm was suggested by Atashpaz and Lucas [16] evolution. ICA simulates the socio-political process of imperialism and imperialistic competition like the same evolutionary algorithms, ICA commences with an initial population of P countries which are generated randomly within the feasible space. Countries in this algorithm are the Transcript of chromosomes in Genetic Algorithm (GA) and particle swarm optimization (PSO) and it is an array of values of a candidate solution of optimization problem. In an N dimensional optimization problem, a country is a $1 \times N$ array as: country = [p_1, p_2,..., p_N], where p_i $(1 \le i \le N)$ represents ith trait of the country. Each variable of a country represents the socio-political characteristics. Two main operators of this algorithm are Assimilation and Revolution. Assimilation makes the colonies of each empire get closer to the Imperialist state in the space of socio-political characteristics (optimization search space). Revolution brings about sudden random changes in the position of some of the countries in the search space. During assimilation and revolution a colony might reach a better position and has the chance to take the control of the entire empire and replace the current imperialist state of the empire [17]. Imperialist Competition is another part of this algorithm. All empires try to take ownership of colonies of other empires. In each step of the algorithm based on their power, all the empires have a chance to take control of one or more the colonies of the weakest empire [16]. The cost function, cost t=f (country) =f (p_1, p_2,..., p_N),is used to evaluate the cost of countries in every decade. The best countries in the initial population, considering the cost function of them are selected as imperialists and remaining countries known as the colonies of these imperialists. One colony at least is assigned to every empire and 50% of the countries can be selected as empires in the population. To distribute the colonies among imperialists proportionally, normalized cost of an imperialist is expressed as: $C_n = c_n - \max(c_i)$ [18] where c_n is the cost of the nth empire and C_n is its normalized cost. An empire with higher cost will have lower normalized value. The total power of every empire is calculated by: $P_n = \left| \dfrac{C_n}{\sum_{i=1}^{N_{imp}} C_i} \right|$ where C_n is the cost of an empire, C_i and N_{imp} are the cost of colony i and the total number of empires, respectively. The initial colonies are divided among empires based on their power. The initial number of colonies of the an empire will be be $N \times C_n = \left| \underline{P_n} \times \underline{N_{col}} \right|$, where $N \times C_n$ is the initial number of colonies of the nth empire and N_{col} is the number of all colonies are randomly chosen and given to the nth empire. The imperialist countries absorb the colonies towards themselves using the absorption policy shown in Fig.1, makes the main core of this algorithm and causes of the countries move towards to their minimum optimal where parameter d represents the distance of a colony from its empire and d' is a random variable (representing

the distance between old and new positions of a colony) with uniform (or any proper) distribution, $d' \sim U(0, \beta \times d)$, the parameter β should be greater than one, α is a parameter (representing the angle of direct and indirect) with uniform(or any proper) distribution, $\alpha \sim U(-\delta, \delta)$, δ is an adjustment parameter of deviation from the main direction. However, the values of β and δ are arbitrary.

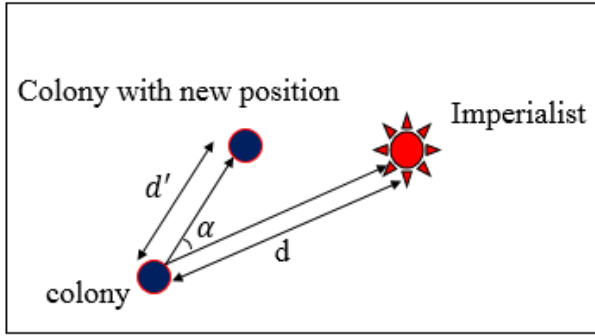An appropriate choice can be $\beta = 2, \delta = \frac{\pi}{4}$ (rad) respectively [16].

Figure 1. Motion of colonies toward their relevant imperialist

In ICA algorithm to search different points around the imperialist, a random amount of deviation is added to the direction of colony movement towards the imperialist while moving toward the imperialist countries, a colony may reach to a better position, so the colony position changes according to position of the imperialist [19]. The total power of an empire can be determined by the power of imperialist country plus a percentage of power of its colonies is given by:

$$T.C_n = \cos(\text{imperialists}) + \\ \vartheta \times \text{mean}\{\text{cost(colonies of empires)}\} \quad (1)$$

Where $T.C_n$ is the total cost of the nth empire and the parameter ϑ a positive number less than one. The continuation of the mentioned steps will hopefully cause the countries to converge to the global minimum of the cost function. Various criteria can be used to stop the algorithm. One idea is to use maximum number of iterations, called maximum decades or the end of imperialistic competition when there is only one empire can be considered as the stopping criterion of ICA. On the other hand, the algorithm can be stopped when its best solution in different decades cannot be improved for some consecutive decades [20]. In summary, this algorithm is expressed as [21]:

1) Select some random points on the function and initialize the empires.

2) Move the colonies toward their relevant imperialist (Assimilating).

3) If there is a colony in an empire which has lower cost than that of imperialist, exchange the positions of that imperialist and the colony.

4) Compute the total cost of an empire (Related to the power of both imperialist and its colonies).

5) Pick the weakest colony from the weakest empire and give it to the empire that has the most likelihood to possess it (Imperialistic competition).

6) Eliminate the powerless empires.

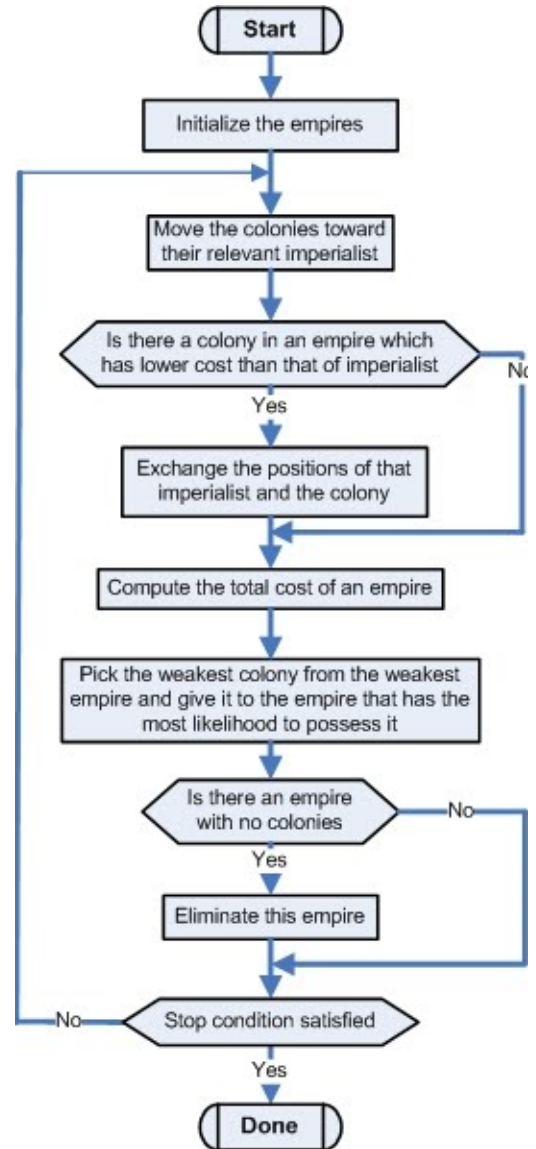7) If there is just one empire, stop if not go to 2.The flowchart of the ICA is shown in Figure 2.

Figure 2. Flowchart of the Imperialistic competitive algorithm

We use the clustering method and parameters presented in [10] for sensor network clustering with ICA. We consider the number of cluster heads as a main parameter for selecting the cluster heads. Other mains parameters are residual energy of the all nodes and distance between cluster members and their cluster head. The lower the communication distance the less energy will be consume during transmission. As cluster heads receive more data and transmit them to sink, so nodes with a more residual energy are better choices to become cluster heads. Therefore we use the same fitness function described in [7] as cost function. Eq.1 shows cost function.

Cost funtion

$$= (1 - \alpha) \times [\text{SUM}(E(n_1)) / \text{SUM}(E(CH_k))] \quad (2) \\ + \alpha \times [\max\{\text{SUM}(d(n_i, CH_k)) / |C_k|\}]$$

Where first term represent the ratio of initial energy of all nodes $n_i, i = 1, 2, \ldots, N$ in the network with the total current energy of the cluster head candidates in the current round and second term represents maximum average Euclidean distances from all cluster nodes toward their

cluster head and $|C_k|$ is the number of nodes that belong to cluster C_k, $k = 1, 2, \ldots, K$. The α used to weigh the portion of each of the sub-objectives. The BS uses the optimization algorithm to specify the best K cluster heads that can minimize the cost function defined above.

2. System Model and Structure

We assume a sensor network with the following properties. As shown in Figure 3:
- The sensor network consist of N sensor nodes distributed over on area M×M.
- The BS is fixed and are placed Away from the sensors area.
- Location and ID for all nodes is known for base station.
- The nodes power control capabilities to vary their transmission power.
- Data fusion is used to reduce the total data message sent.
- Fixed rate BPSK is used in analysis.
- A node is dead if its energy level reaches 0.

In the first step all the sensor nodes will organized themselves into K clusters based on the ICA. After selecting the cluster heads and formation of the clusters, number of nodes in each cluster are chosen as V-BLAST nodes (VBN) for cooperative MIMO transmission, the VBN nodes are chosen by a threshold γ where

$$\gamma = \frac{E_{remain}}{d_{htovn} + d_{vntos}}$$, E_{remain} is the remaining energy of

each node. d_{htovn} and d_{vntos} are distance between the cluster head and VBN nodes and distance between VBN nodes and the sink respectively. Assume N_t, VBN nodes should be selected in one clusters and all the nodes except the header node are possible candidates for VBN nodes. We choose the N_t nodes with the maximum value of γ as the VBN nodes in the each cluster. In the next step cluster members transmit L bits data to the cluster heads according to TDMA schedule. After the cluster head receives data packets from its cluster members will first aggregates the received data, then split the fused data into N_t parts and distribute the split data to the N_t, VBN nodes simultaneously. Finally the sink will receive all data with N_r antennas and the decorrelating decision feedback detector (D-DFD) [22,23] are used as the V-BLAST detector at the sink.
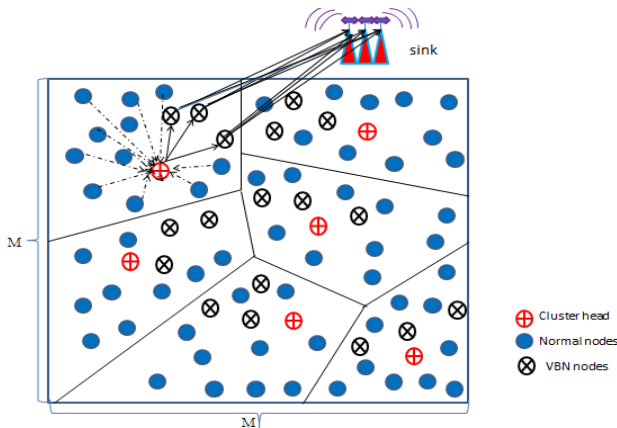

Figure 3. System Model

3. Energy Consumption Model

Energy consumption of proposed scheme can be divided into three main parts: energy consumed by cooperative MIMO transmission and by the normal and VBN nodes in the cluster. To compute the energy of the whole network, first, the energy consumption of transmitting or receiving one bit is calculated. As described in [24] the total power along a signal path can be divided into two major components: the power consumption of all the power amplifiers (P_{PA}) and power consumption of all circuit blocks (P_c). Therefore, the transmitting energy consumption of one bit is defined as:

$$E_{bt} = \frac{P_{PA} + P_C}{R_b} \tag{3}$$

The total power consumption of the power amplifiers can be obtained as: $P_{PA} = (1 + \alpha)P_{out}$ where P_{out} is the transmit power, $\alpha = \frac{\xi}{\eta} - 1$ with η denotes the peak to average ratio that depends on the modulation scheme and the constellation size and ξ denotes drain efficiency of the RF power amplifier. For P_{out} two models are defined based on the transmission distance. If the transmission distance is above a threshold free space model is considered otherwise two-ray ground reflection model is assumed. Thus we have:

$$P_{out} = \begin{cases} E_b R_b \dfrac{(4\pi)^2 M_l N_f}{G_t G_r \lambda^2} d^2 & d \leq d_0 \\[2mm] E_b R_b \dfrac{M_l N_f}{G_t G_r h_t^2 h_r^2} d^4 & d > d_0 \end{cases} \tag{4}$$

where d is the transmission distance. M_l is the link margin compensating the hardware process variations and other additive background noise or interference, G_t and G_r are the transmitter and receiver antenna gains, respectively, N_f is the receiver noise figure defined as $N_f = \frac{N_r}{N_0}$ where N_0 is the single-sided thermal noise power spectral density at room temperature and N_r is the PSD of the total effective noise at the receiver input. λ is the carrier wavelength. h_t and h_r are the heights of transmitter and receiver antenna, R_b is the system bit rate [15]. E_b is the required average energy per bit at the receiver for a given BER requirement P_b, To estimate the values of the circuit power consumption at transmitter side, P_{ct} and at the receiver side, P_{cr}, therefore

$$P_{ct} = P_{DAC} + P_{mix} + P_{filt} + P_{syn} \tag{5}$$

$$P_{cr} = P_{LNA} + P_{ADC} + P_{mix} + P_{filr} + P_{syn} + P_{IFA} \tag{6}$$

$P_{DAC}, P_{mix}, P_{filt}, P_{syn}, P_{LNA}, P_{ADC}, P_{filr}, P_{syn}$ and P_{IFA} are the power consumption values for the D/A convertor, the mixer, the active filters at the transmitter side, The frequency synthesizer, the low noise amplifier, A/D

convertor, the active filters at the receiver side and the intermediate frequency amplifier, respectively. We assume an AWGN channel and free space model for intra cluster communications and a Rayleigh fading channel and a two-ray ground reflection model for cooperative communications.

3.1. Energy Consumption for Intra Cluster Communication

The energy consumption for transmitting one bit from normal node to the cluster head can be written as:

$$E_{bt}^{ntoCH} = (n_c - 1)(1+\alpha)E_b^{ntoCH} \frac{(4\pi)^2 M_l N_f}{G_t G_r \lambda^2} d_{ntoCH}^2 \quad (7)$$

where E_{bt}^{ntoCH} is energy consumption for transmitting one in the cluster, d_{ntoCH} is the average distance from cluster member to the cluster head which can be approximated as $[d_{ntoCH}^2] = \frac{M^2}{2\pi K_c}$ where K_c is number of clusters [25]. n_c is the number of the nodes in each cluster, E_b^{ntoCH} is the required energy per bit for a given BER requirement which can be expressed by $N_0(Q^{-1}(R_0))^2/2$ where Q^{-1} is inverse Q-function. We then have E_{bt}^{ntoCH} as:

$$E_{bt}^{ntoCH} = (n_c - 1)(1+\alpha)E_b^{ntoCH} \frac{(4\pi)^2 M_l N_f}{G_t G_r \lambda^2} \frac{M^2}{2\pi K_c} \quad (8)$$

The circuit blocks energy consumption of intra cluster communication can be written as:

$$E_c^{ntoCH} = \frac{(n_c - 1)P_{ct}}{R_b} + \frac{P_{cr}}{R_b} \quad (9)$$

Assume E_{DA} is the energy consumption for data fusion per bit in the cluster by the cluster head in each round [25]. Then the energy consumption of data fusion is given by:

$$E_{fus} = E_{DA} L(n_c - 1) \quad (10)$$

and data length after data fusion by cluster head is expressed as:

$$L_{agg} = \frac{L(n_c - 1)}{f_{agg}(n_c - 1) - f_{agg} + 1} \quad (11)$$

The energy consumption for transmission aggregated data from cluster head to VBN nodes can be calculate the same as above thus we assume $E_b^{ntoCH} = E_b^{CHtovn}$

$$E_{bt}^{CHtovn} = (1+\alpha)E_b^{CHtovn} \frac{(4\pi)^2 M_l N_f}{G_t G_r \lambda^2} (d_{CHtovn})^2 \quad (12)$$

and circuit blocks energy consumption is:

$$E_c^{CHtovn} = \frac{P_{ct}}{bB} + \frac{N_r P_{cr}}{bB} \quad (13)$$

3.2. Cooperative MIMO Transmission Energy Consumption Model

As in [27], the average probability of joint symbol errors of the V-BLAST receiver can be defined as:

$$P_s \approx 1 - \prod_{k=1}^{N_t}(1 - P_k) \quad (14)$$

$$P_k = 4(\frac{\sqrt{2}-1}{\sqrt{2}})(\frac{1-\tau}{2})k \sum_{i=0}^{k-1}(^{k-1+i}_{i})(\frac{1+\tau}{2})^i \quad (15)$$

Where $k = 1,\dots,N_t$, $\tau = \frac{\gamma}{\gamma+1}, \gamma = \frac{E_b^{mimo}}{N_o}, E_b^{mimo}$ is required average energy per bit for a given BER, $\bar{P_b}$, As in [3]. The given average BER of the V-BLAST receiver can be estimated as:

$$\bar{P_b} \approx P_s(\frac{N_t b + 8}{8 N_t b}) \quad (16)$$

Thus the energy consumption of transmitting one bit for V-BLAST based MIMO technique is:

$$E_{bt}^{mimo} = \frac{P_{PA} + N_t P_{ct} + N_r P_{cr}}{R_b} =$$
$$(1+\alpha)E_b^{mimo} \frac{M_l N_f}{G_t G_r h_r^2 h_t^2} d_{vntos}^4 + \frac{N_t P_{ct} + N_r P_{cr}}{R_b} \quad (17)$$

Where d_{vntos} is the distance from the VBN nodes to the sink Therefore, the total energy consumption for the whole network can be obtain as:

$$E_{total} = \sum_{i=1}^{k_c} (L_{agg}E_{bt}^{mimo} + LE_{bt}^{ntoCH} +$$
$$LE_c^{ntoCH} + L_{agg}E_{bt}^{CHtovn} + L_{agg}E_c^{CHtovn} + E_{fus}) \quad (18)$$

4. Performance Evaluation and Simulation Experiments

In this section, simulations are carried out on the basis of the proposed protocol. The energy consumption model used in [2,10] is considered for LEACH algorithm. We present simulation to evaluate the performance of the optimal scheme. We compare the proposed scheme with LEACH, Previous proposed architecture in [15] which we have named LEACH-VBLAST and finally, GA-VBLAST scheme. The difference between the proposed protocol and LEACH-VBLAST can be described as follows. In LEACH-VBLAST approach. First, LEACH is used to select suitable cluster head among sensor nodes in the network, then the V-BLAST technique based cooperative MIMO transmission are used, but in proposed scheme the clustering is done based on ICA. In GA-VBLAST method, the clusters are formed by using genetic algorithm, then the V-BLAST technique are used. The selection criterion for VBN nodes in three methods is same. The list of the used simulation parameters are shown in Table 1, Table 2, Table 3 and Table 4.

Table 1. The LEACH Algorithm Parameters

parameters	Value
BS location	x=100m, y=150 m
Number of nodes(n)	100
Network Size	100 m x 100m
Packet size(k)	5j
E_{elec}	50 nj
E_{DA}	50 nj
Amplifier energy free space (ε_{fs})	10 Pj/bit/m^2
Amplifier energy multipath (ε_{mp})	0.013 Pj/bit/m^4

Table 2. The Used Parameters in GA Algorithm

| parameters	Value
N	100
Initial energy of each node	5j
Packet Size	4000 bit
Population Size	100
Crossover rate	0.9
Cross over Type	Single point
Mutation rate	0.1
Number generation	500
Selection type	Roulette Wheel Selection

Table 3. The Used Parameters in ICA

parameters	Value
Initial countries	100
Initial imperialistic	20
Network Size	100 m x 100m
Nodes initial energy	5j
β	2
Number of iteration	500
δ	45°
Packet size	4000 bit

Table 4. The System Communication Parameters

Nodes number=100	Sensor area=100 m x 100 m	Nodes initial energy=5j
α=0.47	P_{filt}= P_{filr}=2.5 mw	f_c=2.5 KHZ
λ=0.12 m	P_{LNA} =20 mw	P_b=0.003 mw
G_tG_r=5dBi	P_{syn} =50 mw	M_l=40dB
N_f=10dB	$N_0/2$=-135 m/HZ	P_{IFA}=20mw
P_{mix}=30.3m	B=10 KHz	f_{agg}=0.7
R=0.75	L=4000 bit	b=1
h_t=h_r=1m	P_{ADC}=20mw	E_{DA}=50 nj

Figure 4 indicate the results of sensor network clustering by the Genetic Algorithm during the twentieth round and Figure 5 is the use of ICA algorithm to optimize cluster. We can see that the cluster head distribution is uniform in both algorithm.
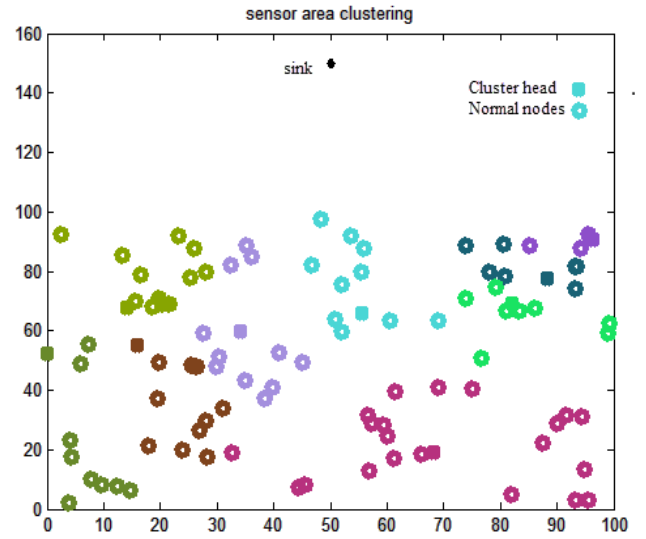
Figure 4. Sensor network clustering by Genetic Algorithm
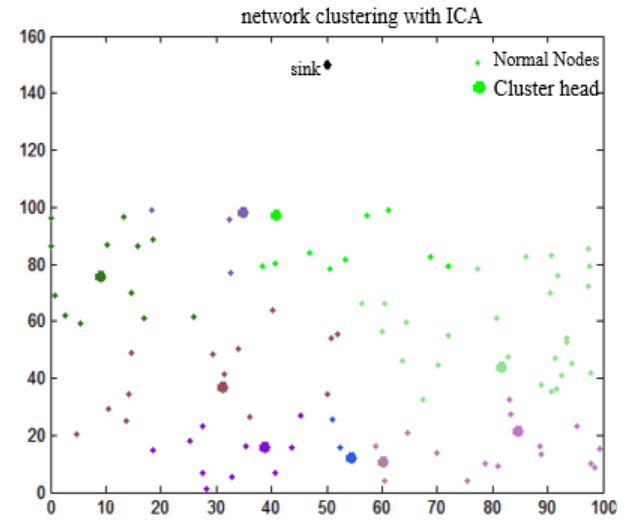
Figure 5. Sensor network clustering by Imperialist Competitive Algorithm (ICA)

In the second experiment, we compared the number of dead nodes in the proposed protocol and LEACH, LEACH-VBLAST and GA-VBLAST schemes. It can be said from Figure 7, clearly, ICA-VBAST achieve comparatively better extension to network lifetime. The reason behind the significant attainment is the optimized localization of the cluster head by ICA optimization.

Figure 6 shows the relationship between the sum of residual normalized energy of nodes and the network runtime for LEACH, LEACH-VBLAST, GA-VBLAST and ICA-VBLAST schemes. As can be seen in most rounds by using proposed scheme, we can achieve less energy consumption. We may observe that the ICA-VBLAST system is more energy efficient than three other methods. As can be seen from this figure, the proposed scheme offers 3~7 % of energy saving compared to GA-VBLAST architecture and provides 10~15 % of energy saving relative to that of the LEACH-VBLAST and can reduce the network energy consumption about 20% than the LEACH conventional algorithm. One of the reason for this improvement is because the global searching and local refining stage in ICA and GA algorithms can maximizing

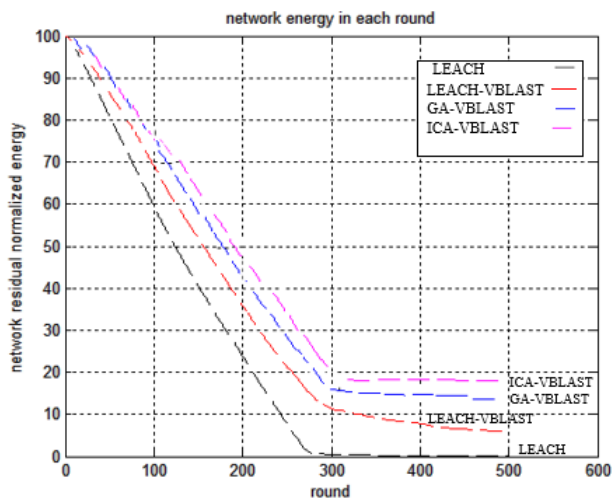in searching for the best solution that can result in the optimal selection of cluster heads for the network.

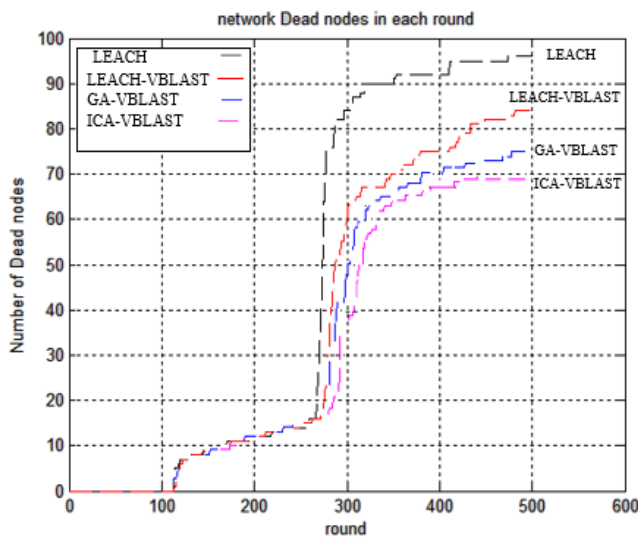

Figure 6. Network Residual Energy vs. simulation round

Figure 7. Number of Dead Nodes vs. simulation round

5. Conclusion and Future Works

In this paper, we presented a cooperative MIMO transmission scheme for WSNs based on V-BLAST receiver processing. In proposed scheme, we replaced the LEACH clustering algorithm with clustering based on Imperialist Competitive Algorithm then V-BLAST technique based virtual MIMO transmission are used.The Simulation results shows that firstly, the proposed cooperative algorithm can reduce the energy consumption of the network and increase the network lifetime .Secondly, the proposed cluster head selection scheme makes better selections of cluster heads to balance the energy consumption among different sensors nodes. Finally, Clustering is a main part in cooperative MIMO communications. Further investigations, for determining clusters, may include the use of other intelligent algorithms instead of ICA. Other extension to proposed work is to study the impact of the different modulations on the network lifetime.

References

[1] Aksu, A., Krishnamurthy, P., Tipper, D.,. Ercetin,, O., "On Security and Reliability Using Cooperative Transmissions in Sensor Networks," *Mobile Netw,* Appl, 17:526-542,2012.

[2] Heinzelman, W. B., Chandrakasan, A. P., Balakrishnan, H., "An Application-Specific Algorithm Architecture for Wireless Microsensor Networks," *IEEE Transactions on Wireless Communications*, vol. 1, no. 4, pp. 660-670, 2002.

[3] Liu, B. L., Wang,Y., " Advances in Differential Evolution," *CHIN. J. Control Decision 22*, 721-729, 2007.

[4] Sadeghian kerdabadi, M., GHazizadeh, R., sadeghian kerdabadi, R., "A novel clustering algorithm for wireless sensor networks based HBMO," *Indian J.Sci.Res.* 7 (1): 662-670, 2014.

[5] Hussain, S., Islam, O., WaseyMatin, A., "Genetic algorithm for energy efficient clusters in wireless sensor networks," *In Proceedings of the 4th International Conference on Information Technology). IEEE Computer Society*, April 2007.

[6] Tillet. J., Rao, R., Sahin, F., "Cluster-head Identification in Ad Hoc Sensor Networks using Particle Swarm Optimization," *IEEE International Conference on Personal Wireless Communications*, pp. 201-205, December 2002.

[7] Latiff, N. C., Tsimenidis, Sharif, B.S,"Performance Comparison of Optimization Algorithm for Clustering in Wireless Sensor Networks," *IEEE International Conference on Mobile Adhoc and Sensor Systems*,pp. 1-4 2007.

[8] Gupta, I., Riordan, D., Sampalli, S., "Cluster-head election using fuzzy logic for wireless sensor networks," *Proceedings of Communication Networks and Services Research Conference (CNSR2), Halifax*, Nova Scotia, Canada, pp. 255-260, 2005.

[9] Siew, Z.W., Kiring, A., Yew, H.T., Neelakantan, P., Teo, K.T.K., "Energy Efficient Clustering Algorithm in Wireless Sensor Networks using Fuzzy Logic Control," *Proc. 2011 IEEE Colloquium on Humanities, Science and Engineering Research (CHUSER 2011)*, pp. 392-397, 2011.

[10] Afrashte Mehr, M., "Cluster Head Election using Imperialist competitive algorithm (CHEI) for wireless sensor networks, "*International Journal of Mobile Network Communications & Telematics (IJMNCT)*, Vol. 4, No.3, June 2014.

[11] Wong, M., Nandi, A., "Automatic digital modulation recognition using artificial neural network and genetic algorithm". *Signal Processing*, 84(2): pp.351-365, 2004.

[12] Qu, Q., Milstein, L.B., Vaman, D.R., "Cooperative and constrained MIMO communications in wireless ad hoc/sensor networks", *IEEE Transactions on Wireless Communications* 9 (10) (2010) 3120-3129.

[13] Xiaohua, L., "Energy efficient wireless sensor networks with transmission diversity," *IEEE Electronics Letters*, vol.39, pp.1753-1755, Nov. 2003.

[14] Kumar Sachan, V., Akhtar Imam, S., Beg, M.T.," Performance Analysis of STBC Encoded Cooperative MIMO System for Wireless Sensor Networks," *IEEE*, 2012.

[15] jie, D. L., Dan-pu, Hua-ri, W.," Energy efficiency of virtual MIMO transmission schemes forcluster-based wireless sensor networks," *The Journal of China Universities of Posts and Telecommunications*, pp. 31-38, August 2011.

[16] Atashpaz-Gargari, E., .Lucas, C, "Imperialist Competitive Algorithm: An algorithm for optimization inspired by imperialistic competition," *IEEE Congress on Evolutionary Computation 7*, pp 4661-4666, 2007.

[17] Nazari-Shirkouhi, S. Eivazy, Ghodsi; H. R. R., Rezaie, Atashpaz-Gargari, E., "Solving the Integrated Product Mix-Outsourcing Problem by a Novel Meta-Heuristic Algorithm: Imperialist Competitive Algorithm," *Expert Systems with Applications* 37 (12): 7615-7626.2010.

[18] Akyildiz, I. F., Sankarasubramaniam, W., Cayirci, E., "Wireless sensor networks: A survey," *Computer Networks*, Vol. 38, No. 4, 2002.

[19] Bahrami, H., Faez, K. Abdechiri, M.., "Imperialist Competitive Algorithm using Chaos Theory for Optimization (CICA),"*12th International Conference on Computer Modelling and Simulation*, 2010.

[20] Hosseinirad, S. M., Basu, S.K., "Imperialist Approach to Cluster Head Selection in WSN," *Special Issue of International Journal of Computer Applications (0975-8887) on Wireless Communication and Mobile Networks*, No.1. Jan.2012.

[21] Biabangard-Oskouyi, A., Atashpaz-Gargari, Soltani, E. N., Lucas, C. "Application of Imperialist Competitive Algorithm for Material Properties Characterization from Sharp Indentation Test," *Int J Eng Simul*, vol.10, no. 1, 2009.

[22] Duel-Hallen, A., "Decorrelating decision feedback multiuser detector for synchronous code-division multiple-access channel," *IEEE Trans. Commun.*, vol. 41, no. 2, pp. 285-290, Feb. 1993.

[23] Varanasi, M. K., "Decision feedback multiuser detection: A systematic approach," *IEEE Trans. Inform. Theory*, vol. 45, no. 1, pp. 219-240, Jan. 1999.

[24] Xu, J., Su, W. Zhou, M., "Likelihood function-based modulation classification in bandwidth-constrained sensor networks," *Proceedings of the 2010 IEEE International Conference on Networking, Sensing and Control (ICNSC'10), Apr 10-13, 2010, Chicago, IL, USA. Piscataway, NJ, USA: IEEE*, 2010.

[25] Ahmadi, N., Berangi, R., "Modulation classification of QAM and PSK fromtheir constellation using genetic algorithm and hierarchical clustering," *Proceedings of the International Conference on Information andCommunication Technologies:*

From Theory to Applications (ICTTA'08), Apr 7-11, 2008, Damascus, Syria. Piscataway, NJ, USA: IEEE, 2008.

[26] Sachan, Syed, V., Imam K. A, Beg, M.T., "Energy-efficiency of Virtual Cooperative MIMO Techniques in Wireless Sensor Networks," *International Conference on Computer Communication and Informatics (ICCCI-2012)*, Jan. 2012.

[27] Xu, K., Yuan, W., Cheng, W., Ding, Y., Yang, Z.," An Energy-efficient V-BLAST Based Cooperative MIMO Transmission Scheme for Wireless Sensor Networks," *IEEE Wireless Communications and Networking Conference,WCNC 2008.*,pp. 688-693, April 2008.

[28] Sachan, V. Syed, K., Imam, A., Beg, M.T., "Energy-efficiency of Virtual Cooperative MIMO Techniques in Wireless Sensor Networks," *2012 International Conference on Computer Communication and Informatics (ICCCI -2012)*, pp. 10-12, Jan, 2012.

[29] Krunz, M., Siam, M. Z., Nguyen, D. N.," Clustering and power management for virtual MIMO communications in wireless sensor networks," *Ad Hoc Networks journal*, Volume 11. Issue 5, pp. 1571-1587, july 2013.