ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 5, May 2014

Fault Node Identification and Route Recovery in Distributed Sensor Networks

Pavithra B Raj[1], R Srinivasan[2]

PG Student, Department of Computer Science & Engineering, M.S.Ramaiah Institute of Technology, Bangalore, India [1]

Professor, Department of Computer Science & Engineering, M.S.Ramaiah Institute of Technology, Bangalore, India [2]

Abstract: In this paper we propose a fault node recovery algorithm in order to enhance the lifetime of a wireless sensor network when some of the sensor nodes shut down. A wireless sensor network (WSN) often contains hundreds or thousands of sensor nodes equipped with sensing, computing, and communication devices such as short-range communication devices over wireless channels. These nodes may be distributed over a large area. The sensor nodes in WSNs equipped with batteries for their energy source, but it is inconvenient to recharge or replace batteries because of the sudden giving off energy. Hence, maximizing the lifetime of the network through minimizing the energy is an important challenge in WSN. The algorithm is based on the combination of grade diffusion algorithm and the genetic algorithm. In the current approach, a route discovery approach is proposed which reduces amount of power consumption and number of nodes becoming obsolete (dead) will be less as compared to Grade Diffusion algorithm. The proposed algorithm will also determine set of nodes known as "grades" which has two values namely 0 or 1. Each node will become 1 if battery is greater than threshold otherwise it will be 0. This process of finding the set of nodes whose battery power is less than threshold is called Fault Node Determination. The nodes will be replaced with new nodes of same node id this process is called Fault Node Recovery. The FNR algorithm replaces the deactivated sensor nodes and uses more reused routing paths. In the simulation the FNR algorithm reduces the packet loss rate by approximately 97% and reduces the rate of energy consumption by 70-80%.

Keywords: Fault Node Recovery (FNR) algorithm, Genetic algorithm, Grade diffusion algorithm, Wireless Sensor Networks (WSN)

I. INTRODUCTION

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions.

Recent advances in micro processing, wireless and battery technology, and smart sensors have enhanced data processing [3], [11], [13], wireless communication, and detection capability. A wireless sensor network (WSN) often contains hundreds or thousands of sensor nodes equipped with sensing, computing, and communication devices such as short-range communication devices over wireless channels. These nodes may be distributed over a large area; e.g., WSNs can do area monitoring for some phenomenon of interest. In such an application, the main goal of the WSN is to collect data from the environment and send it to a sink node. Since Wireless WSN Networks are inherently different from the well-known wired networks, it is an absolutely new architecture. Thus some challenges raise from the two key aspects: self-organization and wireless transport of information. First of all, since the nodes in a Wireless WSN Network are free to move arbitrarily at any time. So the networks topology of WSN may change randomly and rapidly at unpredictable times. This makes routing difficult because the topology is constantly changing and nodes cannot be assumed to have persistent data storage. In the worst case, we do not even know whether the node will still remain next minute, because the node will leave the network at any minute. New innovations in micro processing, wireless and battery technology, and smart sensors have improved the quality of data processing, wireless communication and detection capability. Each sensor node in WSN has a limited wireless computing power to process and transmitting live data to the base station in the network. Therefore, WSN contains many sensor nodes to enhance the sensor area and the transmission area. Each sensor node in WSNs is equipped with batteries for their energy source, but it is inconvenient to recharge or replace batteries because of the sudden giving off energy. Hence, maximizing the network lifetime through minimizing the energy consumption is an important challenge in WSN. A wireless sensor network (WSN) often contains hundreds or thousands of sensor nodes equipped with sensing, computing, and communication devices such as short-range communication devices over wireless channels. These nodes may be distributed over a large area; e.g., WSNs can do area monitoring for some phenomenon of interest. In such an application, the main goal of the WSN is to collect data from the environment and send it to a sink node. In the previous approaches two algorithms were considered namely Grade Diffusion algorithm and Direct Diffusion algorithm. The energy efficient coverage problem can be solved by using the ant colony based scheduling algorithm.FNR algorithm is used to replace deactivated sensor nodes in WSN to improve network lifetime. In this algorithm the nodes whose battery power is below threshold are determined and replaced with the new nodes but with same node id. It also results in most reused routing paths.

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 5, May 2014

II. RELATED WORK

A set of routing algorithms and energy efficient algorithms for WSNs have been proposed in recent years. This paper has been carried out after the study of existing methodologies involved in providing energy efficient and effective communication in wireless sensor networks. A wireless sensor network (WSN) often contains hundreds or thousands of sensor nodes equipped with sensing, computing, and communication devices such as short-range communication devices over wireless channels. These nodes may be distributed over a large area; e.g., WSNs can do area monitoring for some phenomenon of interest. In such an application, the main goal of the WSN is to collect data from the environment and send it to a sink node.

In the previous approaches two algorithms were considered namely Grade Diffusion algorithm and Direct Diffusion algorithm [9].The algorithm proposed in this paper is based on the GD algorithm, with the goal of replacing fewer sensor nodes that are inoperative or have depleted batteries, and of reusing the maximum number of routing paths. These optimizations will ultimately enhance the WSN lifetime and reduce sensor node replacement cost.

A. *Directed Diffusion Algorithm*

In the Directed Diffusion algorithm the source node will broadcast the RREQ packets to all its neighbours and then the neighbours will broadcast it its neighbours and the process repeats until the RREQ packet is received by the destination node.

Therefore such a huge transmission of data will consume lot of power and decrease the battery life by which the nodes in the network will become no longer functional. The DD algorithm is also called as query-driven transmission protocol. The data will be transmitted only if it fits the query from sink node.

B. *Grade Diffusion Algorithm*

In the Grade Diffusion algorithm the source node will broadcast the RREQ packets to all its neighbours and then the neighbours will broadcast it its neighbours and the process repeats until the RREQ packet is received by the destination node. Therefore such a huge transmission of data will consume lot of power and decrease the battery life by which the nodes in the network will become no longer functional.

This algorithm was proposed by H C Shih et al in 2012. The main aim of this grade diffusion algorithm is to improve the ladder diffusion algorithm with ant colony optimization (LD-ACO). The GD algorithm is used to reduce the transmission loading. The GD algorithm also identifies a nearest neighbouring nodes and creates the routing path for each sensor node. Regarding the data transmission the GD algorithm once identifying the neighbours then it generate the path based on set of rules. This algorithm has less data transmission loss and less hop count compare to DD algorithm.

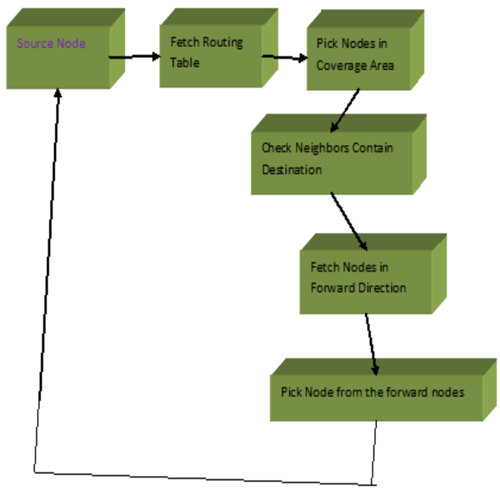

Fig 1 Grade diffusion flowchart

C. *Genetic Algorithm*

The Genetic algorithm is one of the best energy efficient algorithm in wireless sensor networks. It optimizes the signal strength of sensor nodes. This algorithm also helps in reducing the energy consumption and thus increases the life time of wireless sensor networks. This algorithm consists of five steps i.e., i) Initialization ii) Evaluation iii) Selection iv) Crossover v) Mutation

i. Initialization

Initially many individual solutions are (usually) randomly generated to form an initial population. The population size depends on the nature of the problem. The chromosomes will be created during the initialization step. The number of chromosomes depends on the population size which is specified by the user. The total number of chromosomes will be the number of non-functioning nodes or dead nodes. The genes values will be 0 or 1.

ii. Evaluation

The second step in Genetic algorithm is Evaluation. Here in this stage fitness function is evaluated by providing fitness values. The fitness function is defined over the genetic representation and measures the *quality* of the represented solution. The fitness function is always problem dependent. The input parameters will be chromosomes itself. However genes cannot be put into the fitness function.

iii. Selection

The third step is Selection. The main aim of this step is to select the chromosomes having the highest fitness value. First it selects the pair of chromosomes from the node. Then it eliminates the chromosomes which is having lowest fitness value and holds the chromosomes having high fitness value. The selected chromosomes which is having highest fitness value will be send to the mating pool to produce new set of chromosomes which will happen in the crossover step.

iv. Crossover

The Crossover step in Genetic algorithm is to vary the programming of chromosomes from one generation to next. One-Point crossover strategy has been used here in

IJARCCE

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 5, May 2014

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

this algorithm. The two individual chromosomes will be selected from the mating pool to generate a new set of offspring. A one-point crossover is selected between the two parents and then the fraction of each of the individual according to the crossover will be swapped.

v. Mutation

The purpose of mutation in GAs is preserving and introducing diversity. This flips the gene in the chromosomes. The sensor nodes will be replaced in the chromosomes with gene of 1 in order to get better network life time. The massive and random placement of sensor nodes on a monitored field renders node communication a difficult task to be achieved. Interference, congestion, and routing problems are possible to arise at any point in such networks. Routing challenges in WSNs stem from the unique characteristics of these networks, such as limited energy supply, limited computing power, and limited bandwidth on the wireless links, which impose severe restrictions on the design of efficient routing protocols. According to this paper, a number of routing challenges and design issues, node placement and energy consumption, can affect routing process in WSNs. Thus, topology control, in conjunction with routing challenges, becomes an important issue that has to be carefully considered in order to achieve proper network operation.

III. FAULT NODE RECOVERY ALGORITHM

In the current approach, a route discovery approach is proposed which reduces amount of power consumption and number of nodes becoming obsolete (dead) will be less as compared to Grade Diffusion algorithm. The proposed algorithm will also determine set of nodes known as “grades” which has two values namely 0 or 1. Each node will become 1 if battery is greater than threshold otherwise it will be 0. This process of finding the set of nodes whose battery power is less than threshold is called Fault Node Determination. The nodes will be replaced with new nodes of same node id this process is called Fault Node Recovery.

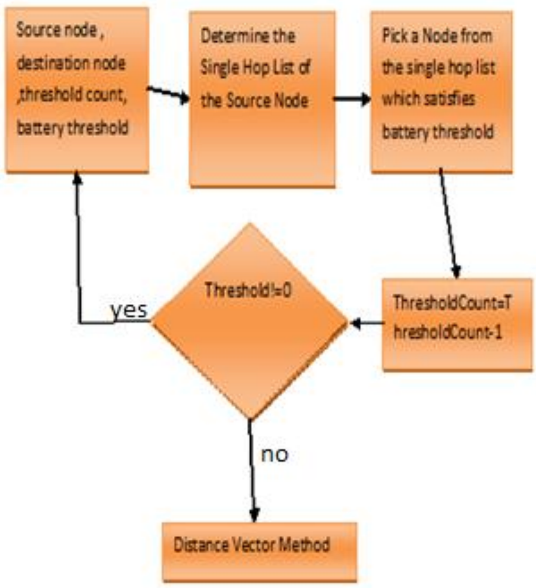

Fig 2 Fault node route discovery process

This module is responsible to route a single packet from source node to destination node and it is integral part of Fault Node Detection and Recovery Algorithm to send packets from source node to destination node. The algorithm has following steps

1) The sensor node maintains a single hop list, which contains the ids of all nodes within its transmission range.
2) When a source node wants to send control packet to the sink, it includes a packet threshold with initial value N in each control packet
3) The RREQ packet is flooded to the single hop list .
4) Each neighbor will then send the RREQ packet by picking the nodes which has highest battery power. This process is repeated until the link is established till the destination.
5) If packet threshold is zero then a process is followed by picking a node which helps us to reach the destination faster.

Node Failure Detection

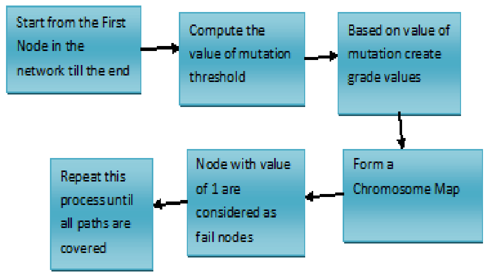

Fig 3 Node failure detection

The above flowchart shows the Node Failure detection process

1) The Nodes are scanned from the first node onwards and link is established to collect data from each single hop list
2) The mutation is computed by comparing the battery power with the threshold
3) Each node is assigned a grade value of 0 or 1. A 1 is assigned if the battery power of node is less than threshold otherwise it will be assigned a value of 1
4) A chromosome Map is created which will contain key as Node ID and value as the grade value
5) Set of nodes are determined from the map which have a value as 1
6) The process is repeated until all nodes have been scanned

Node Recovery

The node recovery takes the set of nodes from the chromosome map which has failed and replaces them with new one with the same node id.

The FNR algorithm is calculated based on bandwidth.

$$Bth = \sum_{i=1}^{max\{grade\}} Ti$$

Where,

Grade – sensor node grade value

Fitness function can be calculated using the below equation

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 5, May 2014

$$fn = \sum_{i=1}^{max\,\{grade\}} (Pi \times TP^{-1})/(Ni \times TN^{-1}) \times i^{-1}$$

Where,
Ni – no of sensor nodes that are replaced with respect to grade value
Pi – no of reusable routing paths wrt grade value i
TP – total no of routing path in wireless sensor networks
TN – total no of sensor nodes in wireless sensor networks

Power consumption can be calculated using below equation

$$Tpc = \sum_{i=1}^{l} Pci$$

Where,
Pc = $\frac{Pt}{1+d^{\gamma}}$

IV. SIMULATION

The simulation of fault node recovery algorithm described in the above section has been performed to verify the methods and results. The grid based topology is used to place the nodes. It will work for any topology. All the nodes are placed in the form of 8 x 8 matrixes. The distance between each node is calculated using Euclidian distance. All the nodes will be given with same battery energy at the initial state. The graph for this is also shown. After some iterations there will be a loss of energy when packets has been sent from source node to sink node. The fault node recovery algorithm is more useful as and when more number of iterations is considered. After some iteration there will be energy loss, then FNR algorithm will check for the threshold count. The proposed algorithm will also determine set of nodes known as "grades" which has two values namely 0 or 1. Each node will become 1 if battery is greater than threshold otherwise it will be 0. This process of finding the set of nodes whose battery power is less than threshold is called Fault Node Determination. Once the fault node has determined then it will be replaced with the other node by using genetic algorithm. This is done using five steps described above in the previous section.

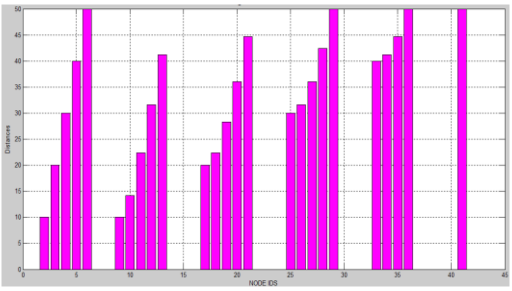

Fig 4 coverage area nodes considered for source node

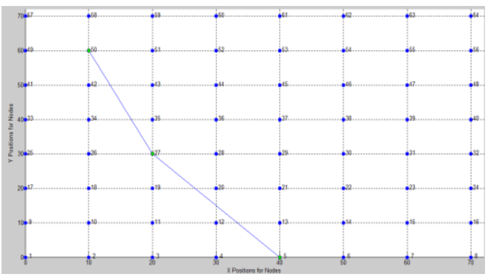

Fig 5 route discovery using FNR algorithm

The comparison is also done with respect to grade diffusion algorithm. Here in FNR algorithm the active nodes are those whose battery is more than or equal to the threshold value. The dead nodes are those whose battery is less than the threshold value such that it won't be having enough energy to send packets to the sink node.

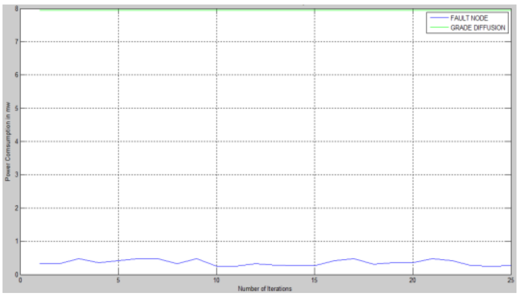

Fig 6 no of iterations v/s power consumption in mw

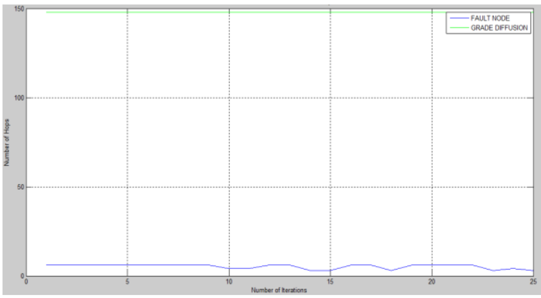

Fig 7 no of iterations v/s no of hops

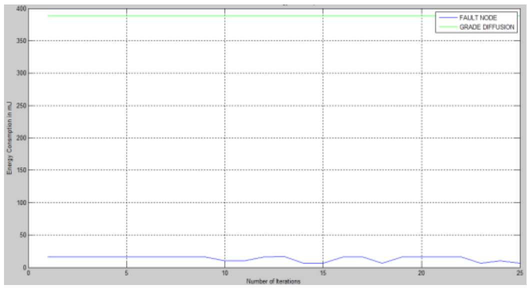

Fig 8 no of iterations v/s energy consumption in mj

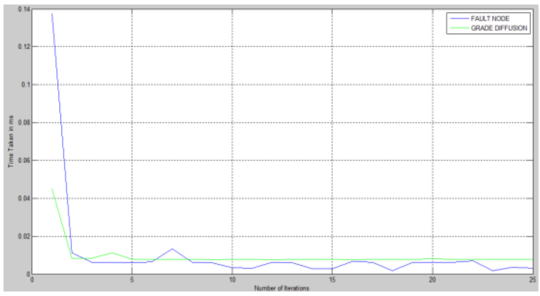

Fig 9 no of iterations v/s time takes in mv

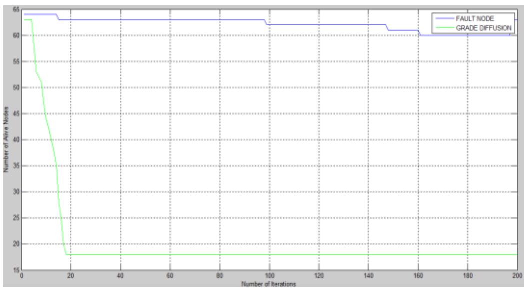

Fig 10 no of iterations v/s no of alive nodes

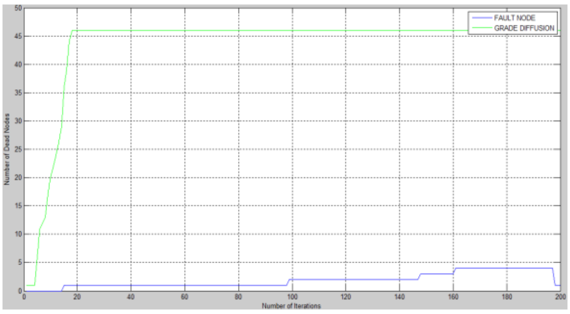

Fig 11 no of iterations v/s no of dead nodes

The Fault node recovery algorithm has almost active sensor nodes. This is due to the algorithm replaces the non-functioning nodes whose threshold value exceeds. In the comparison of FNR algorithm with grade diffusion algorithm the results shows the above figures. Here the green colour represents Grade diffusion algorithm and blue colour represents Fault node recovery algorithm. Figure 4 shows the coverage area nodes with respect to the source node is shown. Figure 5 shows the optimal route discovery of fault node recovery algorithm. Figure 6 shows the total power consumption when the packet sent from source node to sink node. Figure 7 shows the number of hops. Figure 8 shows the energy consumed when packet sent in mile joules. Figure 9 shows the time taken to sent the packets. Figure 10 shows the no of alive nodes after transmission whose battery energy is more than the threshold value. Figure 11 shows the number of dead nodes.

In all the comparison of simulation results shows that Fault node recovery algorithm consumes less power and energy. The numbers of alive nodes are more and the numbers of dead nodes are less compare to grade diffusion algorithm. Once it find the dead node during transmission it calls genetic algorithm. There it performs all the five steps and replace the new node on the path which is in the coverage area or which is nearer to the sink node and also has high battery power. Here the most routing paths are reused the replacement cost is also less. The FNR algorithm reduces the energy consumption to 70% – 80%

V. CONCLUSION

In real wireless sensor networks, the sensor nodes use battery power supplies and thus have limited energy resources. In addition to the routing, it is important to research the optimization of sensor node replacement, reducing the replacement cost, and reusing the most routing paths when some sensor nodes are nonfunctional.
The various simulations demonstrate that the round trip time, Number of Hops. Power Consumption in mw, Energy Consumption in MJ, Number of Alive Nodes, and Number of Dead Nodes the proposed approach performs better than the Grade diffusion algorithm. In this paper the Fault node recovery algorithm we promoted takes less time to deliver the packets hence the energy consumption is less and power consumption is also less and the dead nodes are less and alive nodes are more.

The rate of packet loss is reduced to 97% and the energy consumption is reduced to 70% - 80%. Thus it enhances the life time of the network. As it reuses the routing paths the replacement cost is also reduced. In future more security methods like highly secure encryption scheme and back up node concept is used to increase the life time of the network.

REFERENCES

[1] J. A. Carballido, I. Ponzoni, and N. B. Brignole, "CGD-GA: A graphbased genetic algorithm for sensor network design," Inf. Sci., vol. 177,no. 22, pp. 5091–5102, 2007.

[2]] F. C. Chang and H. C. Huang, "A refactoring method for cache-efficient swarm intelligence algorithms," Inf. Sci., vol. 192, no. 1, pp. 39–49,Jun. 2012..

[3] S. Corson and J. Macker, Mobile Ad Hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations. New York, NY, USA: ACM, 1999.

[4] M. Gen and R. Cheng, Genetic Algorithms and Engineering Design. New York, NY, USA: Wiley, 1997.

[5] Z. He, B. S. Lee, and X. S. Wang, "Aggregation in sensor networks with a user-provided quality of service goal," Inf. Sci., vol. 178, no. 9,pp. 2128–2149, 2008.

[6] J. H. Ho, H. C. Shih, B. Y. Liao, and S. C. Chu, "A ladder diffusion algorithm using ant colony optimization for wireless sensor networks,"Inf. Sci., vol. 192, pp. 204–212, Jun. 2012.

[7] J. H. Ho, H. C. Shih, B. Y. Liao, and J. S. Pan, "Grade diffusion algorithm," in Proc. 2nd Int. Conf. Eng. Technol. Innov., 2012,pp. 2064–2068.

[8] T. P. Hong and C. H. Wu, "An improved weighted clustering algorithm for determination of application nodes in heterogeneous sensor networks," J. Inf. Hiding Multimedia Signal Process., vol. 2, no. 2, pp. 173–184, 2011.

[9]] C. Intanagonwiwat, R. Govindan, D. Estrin, J. Heidemann, and F. Silva, "Directed diffusion for wireless sensor networking," IEEE/ACM Trans.Netw., vol. 11, no. 1, pp. 2–16, Feb. 2003.

[10] Navdeep Kaur "Genetic algorithm for optimizing the routing in the wireless sensor networks",International journal of computer applications(0975-8887) volume 70-No 28,May 2013

[11] Jehn-Long Liu "Leach GA: Genetic algorithm based Energy Efficient Adaptive Clustring Protocol in Wireless Sensor Networks", International Journal of Machine learning and Computing, Vol 1, No 1, April 2011.

[12] K. Montuno and Y. Zhacfi, "Fairness of Resource Allocation in Cellular Networks: A Survey," Resource allocation in next generation wireless networks, pp. 249–266, 2006.

[13] E. M. Royer and C. K. Toh, "A review of current routing protocols for ad-hoc mobile networks," IEEE Personal Commun., vol. 6, no. 2,pp. 46–55, Apr. 1999.