A Bio Inspired Energy Efficient Routing Approach to Resolve Broken Link Problem in WSN

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ABSTRACT

Energy and efficiency are always the main concern in wireless sensor network. In a sensor network the nodes are present with limited energy and with each transmission they loss some energy. Because of this it is required to minimize the rerouting to save the energy loss. Our work is defined in same area. We proposed an algorithm to get the efficiency as well as the reliability. In this work an energy efficient maximally covered sensor network algorithm is presented such that addresses the requirements of power efficient infrastructure issues for WSN. In this work we proposed a bio inspired dynamic route identification approach in case of any broken link or intrusion in the path. The system will look for the compromising path to optimize the throughput

Keywords

WSN, Energy Optimization Bio Inspired Ant Optimization Approach, Lifetime, Research Methodology.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) are a new technology foreseen to be used increasingly in the future due to their data acquisition and data processing abilities. A sensor network is a collection of communicating sensing devices, or nodes. All of the nodes are not necessarily communicating at any particular time, and nodes can only communicate with a few nearby nodes. The network has a routing protocol to control the routing of data messages between nodes. The routing protocol also attempts to get messages to the base station in an energy-efficient manner. The base station is a master node. Data sensed by the network is routed back to a base station. The base station is a larger computer where data from the sensor network will be compiled and processed. The base station can be thought of as a controller for the sensor network. It is the source of instructions concerning the type of phenomena to be sensed, and it collects all results. Human operators controlling the sensor network send commands and receive responses through the base station.

The concept of wireless sensor networks is based on a simple equation:

Sensing + CPU + Radio = Thousands of potential applications. As soon as people understand the capabilities of a wireless sensor network hundreds of applications spring to mind. It seems like a straightforward combination of modern technology.

Figure 1 : Wireless Sensor Nodes

2. BACKGROUND KNOWLEDGE

2.1 Overview

Wireless sensor networks have attracted much research attention in recent years and can be used in many different applications. The deployment and application of Wireless sensor networks in our surrounding environment is increasing day by day. These various applications include tunnels and bridges monitoring, wildlife surveillance, object detection and tracking for security or military affairs, road traffic coordination and other countless context-aware applications which require surrounding phenomenon and events.

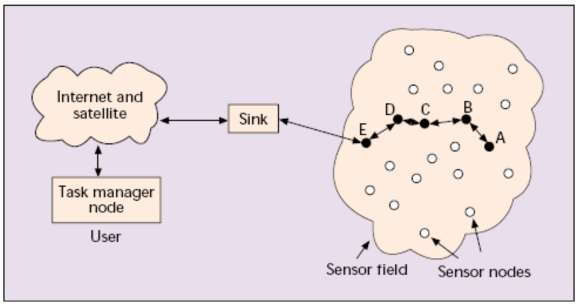

Figure 2: Wireless Sensor Nodes and Networks

For some sensor network applications however energy efficiency and security is crucial as they can be deployed in hostile environments with active intelligent opposition. One obvious example are battlefield applications where there is a pressing need for secrecy of location and resistance to subversion and destruction of the network. Less obvious but just as important security reliant applications include:

• Disasters: In many disaster scenarios, especially those induced by terrorist activities, it may be necessary to protect the location of casualties from unauthorized disclosure.

• Public Safety: In applications where chemical, biological or other environmental

Threats are monitored, it is vital that the availability of the network is never

Threatened. Attacks causing false alarms may lead to panic responses or even

worse total disregard for the signals.

• Security Monitoring: One of the sensor network applications is security monitoring. Security monitoring networks are composed of nodes that are placed at fixed locations throughout an environment that continually monitor one or more sensors to detect an anomaly. A key difference between security monitoring and environmental monitoring is that security networks are not actually collecting any data. This has a significant impact on the optimal network architecture. Each node has to frequently check the status of its sensors but it only has to transmit a data report when there is a security violation. The immediate and reliable communication of alarm messages is the primary system requirement.

2.2 Lifetime

Critical to any wireless sensor network deployment is the expected lifetime. The goal of both the environmental monitoring and security application scenarios is to have nodes placed out in the field, unattended, for months or years. The primary limiting factor for the lifetime of a sensor network is the energy supply. Each node must be designed to manage its local supply of energy in order to maximize total network lifetime. In many deployments it is not the average node lifetime that is important, but rather the minimum node lifetime. In the case of wireless security systems, every node must last for multiple years. A single node failure would create vulnerability in the security systems. In most application scenarios, a majority of the nodes will have to be self powered. They will either have to contain enough stored energy to last for years, or they will have to be able to scavenge energy from the environment through devices, such as solar cells or piezoelectric generators. Both of these options demand that that the average energy consumption of the nodes be as low as possible.

2.3 Energy Optimization

To save energy in WSNs, many techniques and protocols have been investigated using different approaches, such as reducing transmit power, condensing the data for transmission, or the combination of the two approaches.

Energy constraints are the driving factors in the design of wireless sensor networks, which require low power consumption and energy efficient communication protocols.
.The radio interface of a sensor node consumes a significant amount of energy in sensing the medium and transmitting the data. Thus, energy consumption can be minimized by reducing the communications overhead of a sensor node. In general, energy efficiency of a system can be defined as the ratio between the amount of data transmitted and the energy consumed for that operation

2.4 Bio Inspired Ant Optimization Approach

Ants have the ability to select the shortest path among all possible paths from their nest to a food. The pheromone, a volatile chemical substance laid on the ground by the ants while walking and affecting in turn their moving decisions according to its intensity, is used as the mediator of this behavior.

The shorter branch has pheromone at a higher intensity than the longer one. As ants can smell pheromone, and their decisions are based in favor of paths marked with higher amount of pheromone. The ACO follows the way real ants find the shortest route. The ants communicate with one another by means of pheromone trails and exchange information about which path should be followed. The more the number of ants traces a given path, the more attractive this path (trail) becomes and is followed by other ants by depositing their own pheromone. This auto catalytic and collective behavior results in the establishment of the shortest route.

3. LITRATURE SURVAY

In Year 2010, Maumita Bandyopadhyay performed a work*," Zone Based Ant Colony Routing In Mobile Ad-hoc Network".* Here In this paper Author have used Zone based ANT colony using Clustering which assures to find shortest route using the DIR principle (In this principle, the source or intermediate node transmits message to several neighbors and the node whose direction is closest to the direction of destination gets selected as the next hop forwarding node.) together with minimum overhead for route discovery and mobility management. Unlike other Zone based approach, in clustering it is not required to consider zone related information of each node while finding shortest path. Here, it is being proposed a new routing algorithm for mobile ad hoc network by combining the concept of Ant Colony approach and Zone based routing approach using clustering to get shortest path with small number of control messages to minimize the overhead.

Ahmed A. A. Zakzouk performed a work," *An Ant Colony Optimization Approach for Solving Shortest Path Problem with Fuzzy Constraints*". This paper presents an Ant Colony Optimization Approach (ACO) to solve the shortest path problem, especially with fuzzy constraints. The proposed algorithm consists of five sequential steps. The first step is to determine the number of possible paths from the source to the target. The second step calculates the probability of each path of possible paths. The third step calculates the expected number of ants through each path of possible paths then calculates in the fourth step the new trail of each weight component for each path of possible paths, which leads to the final step to calculate the average trail of each path .

In Year 2010, Afshin Ghanizadeh performed a work*," A Fuzzy-Particle Swarm Optimization Based Algorithm for Solving Shortest Path Problem*". In this paper, an efficient particle swarm optimization (PSO) algorithm based on fuzzy logic for solving the single source shortest path problem (SPP) is proposed. A particle encoding/decoding scheme has been devised for particle-representation of the SPP parameters, which is free of the previously randomized path construction methods in computational problems like the SPP .The search capability of PSO is diversified by hybridizing the PSO with fuzzy logic.

In Year 2010, Michael Rinehart performed a work*," A Graph Reduction for Bounding the Value of Side Information in Shortest Path Optimization".* Author consider a generalization of this framework whereby the agent has access to a limited amount of side information about the edge weights ahead of choosing a path. Specifically, Author define a notion of information and information capacity, provide bounds on the agent's performance relative to the amount of side information it receives, and offer algorithms for optimizing information within a capacity constraint.

In Year 2010, Michael Rinehart performed a work*," The Value of Sequential Information in Shortest Path Optimization"*. Author consider a generalization of this framework whereby the agent has access to a limited amount of side information about the edge weights as it traverses the graph. Specifically, Author define a notion of side information and capacity, and Author provide bounds on the agent's performance relative to the total amount of side information it receives.

In Year 2010, Yanfang Deng performed a work*," Dynamic Shortest Path in Stochastic Traffic Networks Based on Fluid Neural Network and Particle Swarm Optimization*". The shortest path algorithm is critical for dynamic traffic assignment and for the realization of route guidance in intelligent transportation systems (ITS). In this paper, a hybrid Particle Swarm Optimization (PSO) algorithm combined fluid neural network (FNN) to search for the shortest path in stochastic traffic networks is introduced. The algorithm overcomes the weight coefficient symmetry restrictions of the traditional FNN and disadvantage of easily getting into a local optimum for PSO algorithm.

In Year 2011, Michael Rinehart performed a work**,"** *The Value of Side Information in Shortest Path Optimization*". Author consider a generalization of this framework whereby the agent has access to a limited amount of side information about the edge weights ahead of choosing a path. Author define a measure for information quantity, provide bounds on the agent's performance relative to the amount of side information it receives, and present algorithms for optimizing side information. The results are based on a new graph characterization tied to shortest path optimization.

In Year 2010, Marina Yusoff performed a work*," A Discrete Particle Swarm Optimization with Random Selection Solution for the Shortest Path Problem***"**. This article proposes a discrete particle swarm optimization (DPSO) for solution of the shortest path problem (SPP). The proposed DPSO adopts a new solution mapping which incorporates a graph decomposition and random selection of priority value. The purpose of this mapping is to reduce the searching space of the particles, leading to a better solution. Detailed descriptions of the new solution and the DPSO algorithm are elaborated. Computational experiments involve an SPP dataset from previous research and road network from Malaysia.

In Year 2010, Zhang Huidang performed a work**,"** *The Particle Swarm Optimization with decaying ICMIC for Shortest Path Computation in Computer Network**s***". This paper proposes an improved particle swarm optimization utilizing Iterative Chaotic Map with Infinite Collapses (ICMIC) perturbations (ICMICPSO) for shortest path computation in computer networks. The chaotic perturbation generated by the ICMIC is incorporated into the particle's velocity updating rule to make the particles have a larger potential space to fly. With the coefficient of chaotic perturbation decaying, the dynamics of ICMICPSO algorithm is a chaotic dynamics first and then a steepest descent dynamics.

In Year 2011, Je´ roˆme Berclaz performed a work," *Multiple Object Tracking Using K-Shortest Paths Optimization".* In this paper, Author show that reformulating that step as a constrained flow optimization results in a convex problem. Author take advantage of its particular structure to solve it using the k-shortest paths algorithm, which is very fast. This new approach is far simpler formally and algorithmically than existing techniques and lets us demonstrate excellent performance in two very different contexts.

In Year 2011, Kavitha Bhaskaran performed a work," *Dynamic Anycast Routing and Wavelength Assignment in WDM Networks Using Ant Colony Optimization (ACO)".* In this paper, Author propose an ACO-based algorithm to solve the dynamic anycast routing and wavelength assignment (RWA) problem in wavelength-routed optical networks. Using extensive simulations, Author show that ACO-based anycast RWA significantly reduces blocking probability compared to the fixed shortest-path first

(SPF) and other load-balancing and dynamic algorithms.

In Year 2011, H.Kusetogullari performed a work*," K-Shortest Path Network Problem Solution with a Hybrid Genetic Algorithm: Particle Swarm Optimization Algorithm***".** This paper presents a hybrid evolutionary algorithm (HGAPSO) to maximize utilization and improve the Quality of Service (QoS) in expanding networks. Two meta-heuristic optimization algorithms, namely a Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) are combined to find the feasible solution within a search space of telecommunication networks. By employing a local search based priority encoding method, each individual in the GA and each particle in PSO is represented as a potential solution for the routing problem.

In Year 2011, Mingcong Deng performed a work," *Optimal Path Planning for Material and Products Transfer in Steel Works Using ACO*". In this paper, a method to plan schedule for railway train in steel works is proposed. First, a node-arc model of railway systems in steel works is given. Then derived is an optimal path for materials transportation problem. The path goes through specified places in the works in a given order in the shortest steps. In this paper, an algorithm based on Ant Colony Optimization(ACO) is proposed to solve the problem and the ACO method is modified to apply the scheduling problem

4. ENERGY-EFFICIENT ROUTING PROTOCOL

4.1 Path Selection Algorithm

Energy should be under consideration when a routing protocol is designed for wireless sensor networks. The reason is because how much energy the network retains is directly related to how long the network can work. Therefore, minimizing the energy consumption is an important factor for the protocol design. In this paper, we consider not only minimization of the energy required for transmission, but also the available energy in the nodes when deciding a "right path". A "right path" means that among many possible paths, it is a path consisting of the nodes that have enough energy for transmission and it has the highest selectivity, which will be defined below in this section. When a source requires a new path to a destination, there could exist many possible paths to the destination. However, we choose only one right path in terms of energy and selectivity. The source would not pick such paths that have low energy, even though they are the ones with minimum energy consumed for transmission. If these paths are selected, they would die out more quickly than other paths that have enough energy.

It will affect the network lifetime.

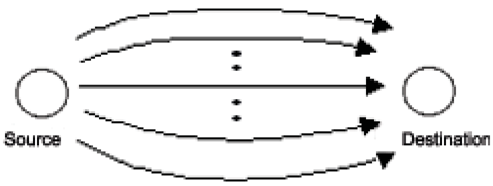

Figure 3 . Many Possible Paths

Fig.3 shows that there exist many possible paths when a source asks for a new path to a destination. For path selection, we take the node energy in the paths into account.

The available energy Ea,pi for a particular path pi is defined as the sum of the available energy of each node on that path. Whenever this particular source sends a packet to the same destination, a path is required from the source to the destination. Therefore, the concept of round can be brought in. When the source requests a path to the destination for the first time, the source will choose a "right path" among many paths found by considering all the factors such as node energy and the number of times this path has been selected. This is a round 1 and it continues to go on whenever the source needs a path to the same destination for transmission. The difference between the traditional routing protocol MTE and our protocol is that the MTE protocol only works in an energy consumption point of view. However, we also consider the available energy in the nodes for each path.

- MTE protocol: min(Ec,p1, ... ,Ec,pn)

Ec,pi denotes the energy consumed for transmission in a certain path pi.

- Available energy: Ea,p1, Ea,p2, Ea,p3, ... Ea,pn.

There are two requirements on how a particular path pi is selected:

$$E_{a,pi} > E_{c,pi} \quad (1)$$

$$S_{pi} = P(pi)/1 - P(pi) \times (k \bmod 1/P(pi)) * E_{a,pi}/E_{m,pi} \quad (2)$$

In the first requirement, it shows that the available energy in a certain path should be larger than the energy consumed for transmission. This is an obvious condition that must be satisfied, otherwise the transmission would be aborted on the way before the destination. In the second requirement, Spi stands for selectivity of the path pi being selected as a right path. Among all the values of the selectivity, the path that has the largest value will be selected as a right path. The maximum value of the selectivity is 1. P(pi) is the desired probability for the path pi. Normally, it is determined depending on the number of paths n found by the route discovery procedure, as shown in Fig. 1. In this case, the desired probability is set to 1/n for each path, so that all the discovered paths can be used equally, thereby maximizing the network lifetime in terms of energy. On the other hand, it is possible to give priority to some path by increasing the desired probability. For example, if the traffic type is delay-sensitive (e.g., urgent event), priority is given to the path with shortest delay, so that this path can be chosen first. Also, if a certain path retains the available energy close to the consumption energy, the desired probability is lowered enough to prevent this particular path from being selected, because it would cause an energy drain of the path once used. Besides the desired probability, the other factor that affects the path selectivity S is the round k in the first term of the equation above. If a source has discovered n paths to a given destination, one cycle is formed with n rounds between these two nodes, and the desired probability is also determined at this point. Normally, the value of the desired probability is changed on a cycle basis. Each cycle starts from round 0 and ends with round n-1. Whenever one of n paths is used to send a packet to the destination, the round value increases by one until the last round n-1. Once a certain path is chosen, the selectivity of that path is set to 0 so that it cannot be used again during this cycle. For any other path, the selectivity continues to increase according to the increment of the round value, as long as it is not chosen.

Finally, the first term of the selectivity equation approaches to one so that it will be chosen during this cycle. The reason why a certain path even with the higher available energy is used only once at each cycle is because the environment of wireless sensor networks is changing fast in time due to the wireless links, mobility, or node energy consumption for local processing and so on. Therefore, if the source has another data to send to the same destination after one cycle ends, it executes the route discovery procedure again to find new paths and start a new cycle by reflecting the updated network environment.

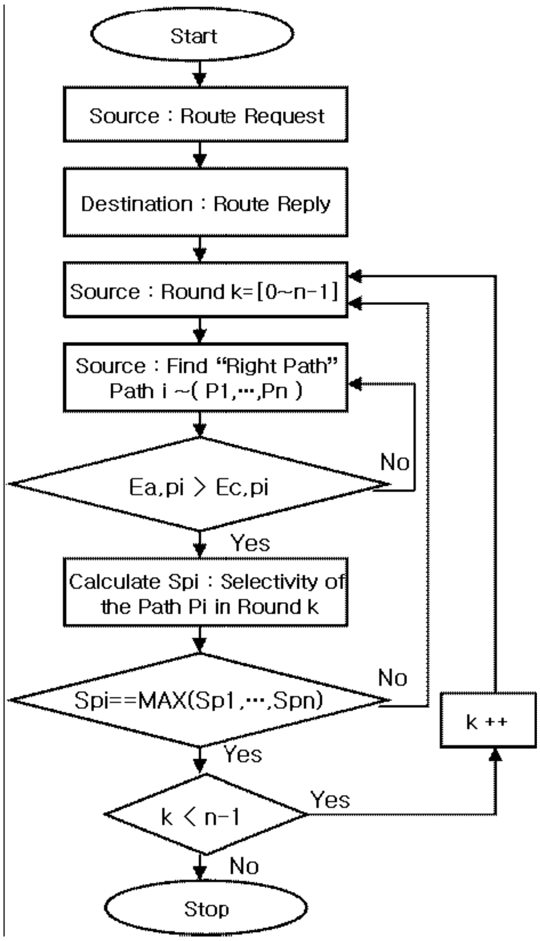

Figure 4. Path Selection Algorithm

In the second term of Eq. (2), Em,pi represents the maximum energy for the path pi. Therefore, if nodes have low available energy, then the value of this fraction will be small (i.e. close to 0), because the value of Ea,pi is small and the value of Em,pi is large. This means if there is not enough available energy, then such a path will not be chosen due to the small value of the selectivity. In contrast, if nodes have full of energy, then the value of this fraction will be very large (i.e. close to 1), because the value of Ea,pi approaches to the maximum energy. As a result, such a path is likely to be chosen as a right path unless there is any larger value than this. Fig. 2 summarizes our path selection algorithm.

4.2 Performance Evaluation

The objective of our simulation is to demonstrate the increased network lifetime by choosing the right path. The proposed protocol was validated using our own network simulator written in C. Some simulations are conducted with different traffic patterns and the network topology. The network topology is created by randomly placing 100 sensor nodes in the area of 100 by 100 meters, while the traffic pattern is changed using different sizes of an event message. Since the simulation results show similar performance in terms of the increased network lifetime, we provide one example of our simulations, as shown in Fig.5 . It is assumed that there are only ten possible paths for simulation purposes. One path that is shaded represents the one from the MTE routing protocol, which selects the shortest path in this case. However, our protocol finds a path in a different way. The available node energy is also concerned in our protocol.

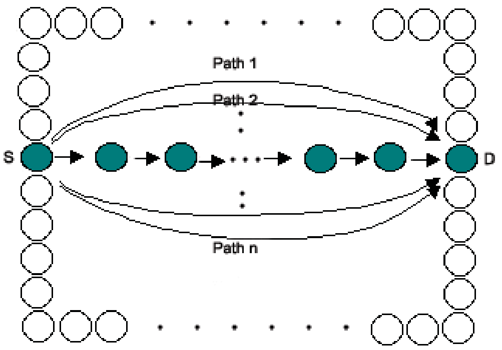

Figure 5 Simulation Model

Our assumptions:
- There are 100 nodes: 10 by 10 nodes
- There are paths p1 through pn (n=10)
- Initial node energy: I (5mJ)
- r: distance between nodes and r is fixed as 10m

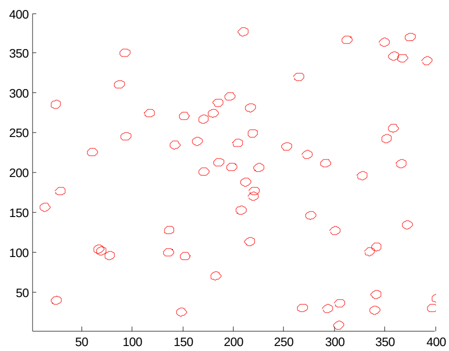

Figure 6 Randomly generated nodes

A right path will be chosen among the discovered paths by taking into account their available energy. Since there are 10 different paths, the average value is calculated over the paths. The path selection algorithm selects every path once for each cycle so that all the discovered paths can be used evenly. In this case, one cycle is assumed to consist of 10 rounds, and one round corresponds to each route request from the source. Therefore, we take the average to figure out the energy that is left and available on the network. In Fig., it is shown that the available energy in our protocol slowly decreases as the number of route request increases, while the MTE routing protocol decreases sharply. In summary, our routing protocol is more efficient than the MTE routing protocol in terms of energy, because the larger the available energy means the longer the network lifetime. Our path selection algorithm enables to use all the discovered paths evenly so that the energy consumption may be distributed.

5. RESEARCH METHODOLOGY

The proposed work is about the improvement of the network reliability with efficiency by resolving the broken link problem in wireless sensor network. In this proposed work we are presented a bio inspired approach to find the compromising path dynamically as the link failure is detected. The proposed energy efficient path selection algorithm will avoid the rerouting and improve the network throughput.

5.1 Hypothesis

The hypothesis defines some research question around which the complete research is performed. In this proposed work we are also finding the answers of some research questions?

5.1.1 Will the proposed routing scheme will increase the throughput?
5.1.2 Will the proposed routing scheme will save the energy transmitted during communication?
5.1.3What parameters will be selected to select the compromising nodes?

5.2 Research Design

The complete search work will be performed in following steps:

The first and foremost work is to establish the network. While constructing the network we have to define some parameters such as:

5.2.1 Network Area
5.2.2 Number of Nodes
5.2.3 Transmission Energy etc

Once the network setup the next work is about to implement the basic routing algorithm on this network.

As the network working in flow we have to set some broken link or the dead node over the network.

Now the proposed work is about to detect this link failure by comparing some parameters such as

Forwarding Ratio
Reply time etc

As the broken link detect the next work is about to generate the pheromones to the neighboring nodes. The pheromones are the event information spread to the neighbor nodes to call detect the next energy efficient path.

It will also maintain some piece of information to follower nodes about the new path.
As the work is bio inspired dynamic route generation, it will improve the network reliability.
Finally the analysis will be done in terms of throughput comparison

6. PROBLEM DEFINATION AND MOTIVATION

Energy and efficiency are always the main concern in wireless sensor network. In a sensor network the nodes are present with limited energy and with each transmission they loss some energy. Because of this it is required to minimize the rerouting to save the energy loss. Our work is defined in same area. We proposed an algorithm to get the efficiency as well as the reliability. In this work an energy efficient maximally covered sensor network algorithm is presented such that addresses the requirements of power efficient infrastructure issues for WSN. In this work we proposed a bio inspired dynamic route identification approach in case of any broken link or intrusion in the path. The system will look for the compromising path to optimize the throughput

6.1 Objectives

The proposed research work is about to achieve the following research objectives

6.1.1 Study and analyze existing shortest path techniques in WSN
6.1.2 Define a WSN network along with specific energy based parameters.
6.1.3 Detection of Broken link over the network
6.1.4 Design of new Bio Inspired Path Selection Algorithm
6.1.5 Implementation of proposed algorithm in MATLAB Environment.
6.1.6 Analysis of Results

6.2 Motivation

Wireless Sensor network is an adhoc network of tiny sensors. Each sensor is defined with some energy. As the data is transferred over the network each sensor spend some energy in receiving data, sending data and forwarding data. Because of this network life depends on how much energy spends in each transmission. But in case of any failure in network if complete rerouting is performed, it gives loss of lot of energy. The proposed work is about to optimize the routing process and to avoid rerouting in sensor network. The system will give an improved routing approach.

6.3 Tool Used

MATLAB Editor is used for writing the code to implement our algorithm.
The result will be shown in the command window of MATLAB.

6.4 MATLAB

MATLAB is a high-level language and interactive environment that enables you to perform computationally intensive tasks faster than with traditional programming languages such as C, C++, and FORTRAN. [MATLAB Toolbox]

Introduction and Key Features

6.4.1 Developing Algorithms and Applications
6.4.2 Analyzing and Accessing Data
6.4.3 Visualizing Data
6.4.4 Performing Numeric Computation
6.4.5 Publishing Results and Deploying Applications

MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. Using the MATLAB product, you can solve technical computing problems faster than with traditional programming languages, such as C, C++, and Fortran.

You can use MATLAB in a wide range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis, and computational biology. Add-on toolboxes (collections of special-purpose MATLAB functions, available separately) extend the MATLAB environment to solve particular classes of problems in these application areas.

MATLAB provides a number of features for documenting and sharing your work. You can integrate your MATLAB code with other languages and applications, and distribute your MATLAB algorithms and applications.

KEY FEATURES

6.4.6 High-level language for technical computing
6.4.7 Development environment for managing code, files, and data
6.4.8 Interactive tools for iterative exploration, design, and problem solving
6.4.9 thematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, and numerical integration
6.4.10 2-D and 3-D graphics functions for visualizing data
6.4.11 Tools for building custom graphical user interfaces
6.4.12 Functions for integrating MATLAB based algorithms with external applications and languages, such as C, C++, Fortran, Java, COM, and Microsoft Excel

7. CONCLUSION

In this paper we have define A Bio Inspired Energy Efficient Routing Approach to Resolve Broken Link Problem in WSN with MATLAB. It can automatically integrated with some minor changes in real time application where it communicates with hardware components (mobiles).

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