IJETST- Volume||01||Issue||04||Pages 533-537||June||ISSN 2348-9480 2014

Open access Journal International journal of Emerging Trends in Science and Technology

A Novel Concept On Efficient Routing Mechanism On Wireless Sensor Networks

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Abstract

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental condition such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. How nodes communicate with each other effectively and intelligently is a key issue in these types of networks. This work presents a simple but yet efficient network discovery and an intelligent metric for route selection in smart environments that combines several parameters through the use of fuzzy logic, shortest hop method and through virtual backbone scheduling (VBS).

INTRODUCTION

One of the major challenges in this century is the management of the growth of cities. Better environment monitoring, better logistics, better healthcare, energy saving, smart grids and smart homes should also be monitored. IoT based platforms will support this. Internet of Things(IoT) is driven primarily by the wireless sensor networks. It requires human intervention, because it is focused on hardware rather than software. Many companies all over the world are completing interesting platforms for controlling smart cities.For the creation of smart cities, wireless sensor networks are used. It may consist of some distributed network of sensor nodes to measure various parameters for efficient city management like temperature, noise, ambient light levels, location and availability of parking space, carbon monoxide concentration etc. An example for a smart city application is the Smart Santander project[[1]. It is a collaboration between institutions designed as a laboratory for technology and companies to benefit the level of all citizens and city dwellers.

SmartSantander project is designed for future Smart City Implementation which supports typical applications. SmartSatander project is used to measure different parameters like temperature, carbon monoxide concentration, ambient light, free parking space and noise. For this organization, they deployed 20000 sensors in European cities of Belgrade, Lubeck, Guliford and Santander which incorporates a wide range of technologies.

In this project 1,125 Waspmotes are deployed in different locations within Santander city, to measure the above mentioned parameters. Different types of sensors are used to take measurements, which are connected to the Waspmote. The sensors used are Parking Sensor Board(for parking spaces), Gases Sensor Board(for carbonmonoxide concentration), the Smart Cities Sensor Board(noise) or directly to Waspmote (ambient light and temperature sensors).

The GhostCity[2] project presents an emerging idea: In the State of New Mexico, USA, a "ghost town" will be build. This is used as a testbed for further smart city technologies. Pegasus Holdings and its New Mexico subsidiary, CITE Development will construct this smart city. CITE (The Centre for Innovation, Technology and Testing) is billed as a first-of-its kind smart city. This experimental smart city will be developed next to Hobbs, Lea County, near the Texas-New Mexico border.

The initial construction cost is estimated at $400 million, although the total investment in this smart city project is estimated to exceed $1 billion. The ghost town will be modeled on the real city of Rock Hill, South Carolina, complete with roads, houses and commercial buildings, old and new. No one will live there, although it would be possible, as houses will include all the necessities, like appliances and plumbing.

Smart city developers will use this scientific "ghost town" to look at everything from efficient traffic systems and next-generation wireless sensor networks to automated washing machines and self-flushing toilets. The point of this smart city to enable developers to test new technologies on predefined infrastructure without interfering in everyday life.

The WISEBED[3] project aims to provide a multi-level infrastructure of interconnected testbeds of large scale wireless sensor networks for research purposes. This project organizes an interdisciplinary approach that integrates software, hardware, data and algorithms. This project is completed by the joint effort of nine academic and research institutes across Europe.

Libelium[4] is a typical example for Smart City applications, in which it measures dust quantities, noise pollution, garbage levels and structural health. We can implement this board in a preconfigured sensor boards – for radiation detection, gas monitoring and Smart Parking of vehicles, thus giving a sophisticated range of sensors for city use.

NetEye[5] is a wireless sensor network infrastructure which enables high fidelity experimentation. This can be used in both multi-hop and single-hop platforms. Researchers from Asia and USA are widely using NetEye for experimentation and monitoring. NetEye provides a web portal for users in which it streamlines user's experience in the total life cycle of scientific experiments. Another variation of NetEye is the NetEye Doctor which monitors health status of users by robust experimentation and analysis. NetEye adopts a Time Division Multiple Access(TDMA) mechanism to assure integrity in infiltrating user's data. This is running successfully for few years. 10 or more experiments are executed per day on average using NetEye.

As we study protocols we find following problems in solution explored in literature.

- Current solutions for smart city involve manual organization of the network
- Current solutions suffers from scalability problems
- The routing mechanism are not intelligent enough to adapt to dynamic network conditions.

PROPOSED SYSTEM

The main aim of the proposed system is to design an architectural framework for modeling an intelligent and efficient routing mechanism in wireless sensor networks which ensures very low overhead. In this area, we propose to conduct an experimental evaluation of a novel intelligent metric for routing protocols. The work consists of the experimentation of this new metric in three steps:

1) Evaluation through simulation.
2) Evaluation over laboratory test bed.
3) Evaluation over a real Smart City test bed.

The protocol proposed above can deal with several metrics, allowing the selection of the most convenient depending on the particular application and current network requirements. In this work, we compare the network performance when using various well-known metrics such as number of hops, signal strength (RSSI), and fuzzy logic (FL), a promising technique that is able to combine different metrics, and that has already obtained good results in simulated experiments.

In this project work, the routing is efficiently done by 3 ways. They are

- Shortest Hop Method(SH)
- Fuzzy Logic Method(FL)[6]
- Virtual Backbone Scheduling Method(VBS)[7]

These may include calculations, data manipulation and processing and other specific functionality. In this system following are the functional requirements:-

- Sensor network must be created with configurable number of nodes and a sink
- Sensor nodes must be placed randomly in the network
- From any sensor node events can be triggered
- From sensor node to sink packet must be routed using Shortest Hop routing
- From sensor node to sink packet must be routed using Fuzzy Logic routing
- From sensor node to sink packet must be routed using VBS routing
- Measure QOS parameters - Packet delivery ratio, delay ,energy consumed across all routing methods.

This method supposes that each node in the wireless sensor network possess a unique identifier. The data transmission is done through this nodes till it reaches the destination nodes. The proposed system architecture of the project work is shown in the Figure 1.

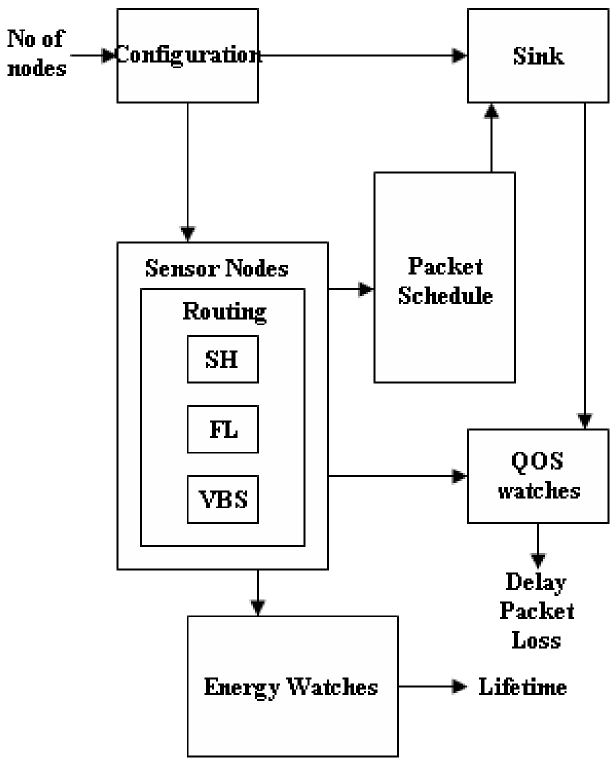

Figure 1 Proposed Architecture

In the configuration module, we will give the input such as number of nodes should be placed in the network. After that a wireless sensor network is simulated with the particular number of nodes. The user have the ability to select which routing technique (SH, FL or VBS) should have to do in the network. The packet is scheduled according to the routing technique and it reaches the destination node. The parameters such as energy, RSSI and lifetime of each node are monitored.

Module Description

The proposed system consists of following 3 modules:

1) Shortest Hop Method: in a tree-based WSN, the Shortest path tree represents a tree in which all nodes have the lowest number of hops to the sink node. After this construction, packets are sent to the neighbouring node which has the shortest distance to the destination. The process is repeated until the packet reaches the destination. The distance is measured using the Euclidean Distance formula.

- **Received Signal Strength Indicator**: for this metric, the power of the received signal is considered. Nodes will select as parent that node having the highest RSSI value.For better or correct communications between nodes in the wireless sensor network, we use high RSSI links which ensures packet delivery in single hop communication. We can ensure the packet is delivered in the destination node properly by selecting the best RSSI link at each hop.

2) Fuzzy Logic Method: Fuzzy logic can be used as a single metric by combining different parameters efficiently. Fuzzy logic can be considered as a decision approach. In fuzzy logic, the parameters and their internal relationships are defined using human language. A Fuzzy Logic System (FLS) can be considered as a non linear mapping of an input data vector into a scalar output. A fuzzy logic system is composed of fuzzifier, fuzzy rules, fuzzy inference engine and defuzzifier. Raw data is converted into fuzzy values. These values are evaluated by fuzzy inference engine. The evaluation is based on a set of rules that relates input and output variables. The value obtained as output in the previous stage is the defuzzified. This provides a numerical value which is used as a metric. Table 1 shows the rules for creating the fuzzy logic method.

- **Number of hops**: represents the number of necessary message forwardings for a packet to reach the sink node.
- **Residual energy**: this parameter must be considered in order to preserve available energy and extend as much as possible node lifetime.
- **RSSI**: the quality of the received signal is significant to assure correct data reception, so nodes with higher RSSI will be selected.

NUMBER OF HOPS	RESIDUAL ENERGY			RSSI
	low	medium	high	
few	bad	bad	medium	poor
few	bad	medium	good	average
few	medium	good	good	excellent
medium	bad	bad	bad	poor
medium	bad	medium	medium	average
medium	medium	medium	good	excellent
many	bad	bad	bad	poor
many	bad	bad	medium	average
many	medium	medium	medium	excellent

TABLE I
FUZZY RULE SET

3)Virtual Backbone Scheduling(VBS): VBS employs heterogeneous scheduling, where backbone nodes work with duty-cycling to preserve network connectivity, and non-backbone nodes turn off radios to save energy. Only these backbone nodes should take participate in data transmission from source to sink node.

IMPLEMENTATION & ANALYSIS

The proposed system is implemented in 32 bit Windows OS with 1.84 GHz Processor. The design environment is selected in Java. In this section how these routing techniques are implemented are described below.

Like in all proposed routing methods, First they will create a random network of nodes according to the configuration given by the user. The user have the ability to specify from which node to start the routing of packets. In Shortest Hop Method, It will calculate the shortest path from that node to the sink node. If it reached the sink node, routing is terminated, else it will calculate the shortest path from the particular node until it reaches the destination. The pseudo code for the shortest hop method is given below.

```
.// SH Routing
// compute next shortest hop count to sink for all nodes
Start = 0; // 0 is the sink node
Q<-Null;
Node(start).hopcounttosink=0;
Q.add(Start);
While (Q.isempty ==false)
{
NinQ = Q.poll();
Visit(NinQ) = 1;
For all  neighbours NX for NinQ
If  Visit(NinQ) == 0
Node(NX).nexthoptosink = NinQ;
Node(NX).hopcounttosink = Node(NinQ).hopcounttosink+1;
Else
If
Node(NX).hopcounttosink< Node(NinQ).hopcounttosink
Node(NX).hopcounttosink = Node(NinQ).hopcounttosink +
1;
Node(NX).nexthoptosink = NinQ;
end
end

// when any event is triggered at node packet is forwarded to
next hop
Start = fromnode
While (Start != 0)
{
Nexthop = Node(Start).nexthoptosink;
forwardPacket(packet,Nexthop);
Start = Nexthop;
}
```

In Fuzzy Logic Method, Based on the fuzzy rule set, the system will calculate the outscore. The node having the greatest outscore will collect the packet from the source node. This outscore is calculated based on the number of hops, RSSI and the energy of the node. This process is repeated until it reaches the destination node. The pseudo code for Fuzzy Logic routing is given below.

```
// FL Routing
//For   all node NX
```

For each neighbor Ny of node NX
NX(NY).score = Fuzzy(Current energy, RSSI, congestion);
end
Node(NX).nexthoptosink = Neighbour with higgest score NX(neighbours) score.
End
// when any event is triggered at node packet is forwarded to next hop
Start = fromnode
While (Start != 0)
{
 Nexthop = Node(Start).nexthoptosink;
 forwardPacket(packet,Nexthop);
 Start = Nexthop;
}

In Virtual Backbone Scheduling Method(VBS), it will determine whichever nodes need to participate in data transmission. Rest of the nodes will be inactive. This nodes which are participating in transmission are referred as dominant set of nodes. The dominant set is calculated based on the number of hops, energy and RSSI value of the node. After creating these dominant set of nodes, the packet is routed through these nodes. The pseudo code for VBS Routing is given below.

//VBS Routing
VBS = ComputeVBS();
// when any event is triggered at node packet is forwarded to best node in VBS
Start = fromnode
NextHop = Node in VBS with shortest hop & congestion
forwardPacket(Nexthop);
Start = NextHop;
While (Start != 0)
{
 Nexthop = NextNode_in_VBS();
 forwardPacket(NextHop);
 Start = Nexthop;
}

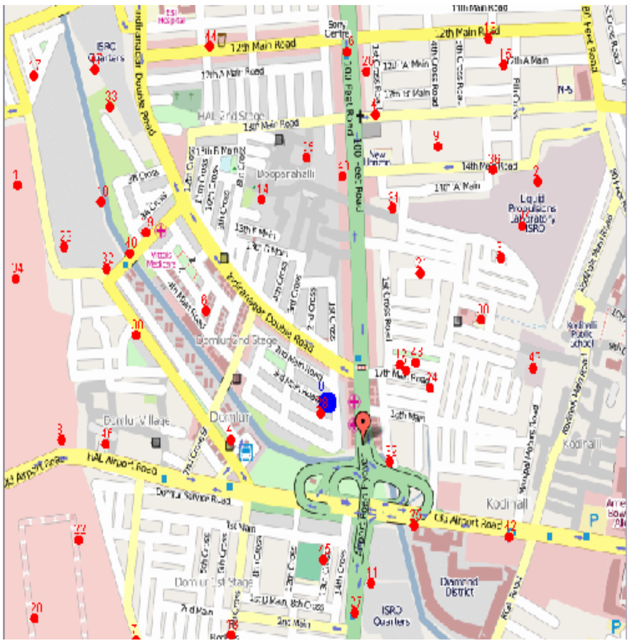

Figure 2: A WSN with 50 nodes

The figure 2 shows the simulation of a sample network with 50 nodes. The user can determine the number of sensor nodes that should be placed in the network. Figure 3 shows the performance in the basis of energy consumption, delay and success ratio of packets is noted. These parameters are measured with respect to the number of nodes in the wireless sensor network.

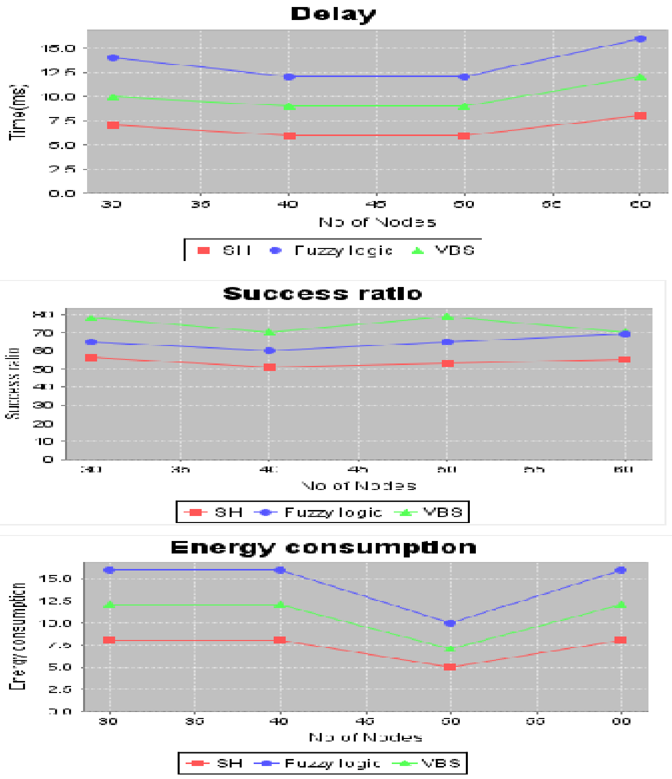

Figure 3: Performance with respect to number of nodes.

Conclusion

This paper details with the aim of implanting a useful wirelesss sensor network for the citizens in the context of smart cities. The applications in this context require the synchronization of communication tasks. The paper presented explains a simple but efficient tree construction protocol and network discovery that can be executed using different metrics depending on the application and network requirements. A metric based on fuzzy logic has been also proposed. This metric combines several node and network parameters with the aim of constructing an efficient communication tree. Testbeds are useful tools for protocol testing prior to the implementation in a real deployment. These experiments have been focused on the execution of the network discovery and tree construction protocol proposed when using three different metrics for parent selection: Shortest Path Tree, Received Signal Strength Indicator and Fuzzy Logic and VBS Method.

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