Wireless Sensor Network for Smart Home Services using Efficient Techniques

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Abstract **- A Smart Home is understood as an integration system which uses number of techniques such as computers, synthesized wiring as well as network communication to connect all indoor subsystems which are attached to home appliances and all electrical devices as whole. Wireless sensor networks (WSNs) have become needful and important for smart homes. The objective of this paper is to develop a WSN that can be used to construct smart home systems. The focus is on design of wireless sensor nodes using efficient technique like using ZigBee to effectively give the solutions for variety of areas including consume electronic device control, energy management and home automation. Smart home services using proposed efficient techniques minimize energy consumption. To support multi-hop communication improved routing algorithm based on Dijkstra algorithm is presented.**

Keywords: WSN, ZigBEE, GPRS, Dijkstra Algo.

1. INTRODUCTION

WSNs are wireless networks composed of numerous spatially distributed sensors with limited data gathering and processing capability to monitor the environmental processes. WSNs have become increasingly important because of their ability to monitor and manage situational information for various intelligent services. In many systems, communication technologies, such as Bluetooth, IrDA and ZigBee, GPRS (General Packet Radio Service), etc., have been used. Nowadays, in many real time systems multiple sensors are connected to one gateway unit as it is necessary, and they are transformed into wireless sensor networks (WSNs). Now a days, WSNs are being used in the home for energy management services. Still, there are still some challenges in designing and operations of wireless sensor network systems and applications. First, limited power resource is used for operation of sensors, such as a battery. Thus, the network lifetime is greatly affected by the Battery lifetime. Second, sensors have limited hardware resource Capabilities (e.g. limited storage, communication range, and processing capabilities). Thus, each sensor is not having whole software/middleware component and is not able to provide complex services. Third, the wireless link bandwidth is scarce and very important in WSN, and needs to be managed carefully. Fourth, to reduce cost of system and to increase capability of sensor nodes. In this paper we introduce ZigBee based self adjusting sensor along with dijikstra algorithm for shortest route path for home energy management service considering limited features of sensors. Smart energy networks could include ZigBee 2006 and IEEE 802.15.4. Han suggested that most of the nodes in the network should be based on one stack profile to get reliable performance [2].

Many wireless sensor projects use complex sensors like microphone, camera which need higher level computation for feature extraction. We preferred to use simple sensors like switches or light sensor, which are cheap as well as easy to implement, available off-the-shelf, resistant to hostile environmental conditions and can be used in many different situations [3]. In this paper, we present an improved routing algorithm based on the Dijkstra algorithm. The traditional Dijkstra algorithm [4] generates the shortest path according to the order of increasing path length, and greedily searches path based on the edges connected with nodes. Using this algorithm we can obtain shortest path in the network.

ZigBee network include the following device types – coordinator, router, end devices. In practice, nodes can be deployed to establish different types of topological structures. Using efficient components we can implement wireless sensor network for smart home services giving reduced cost of design implementation and increased capability of sensors. It also provides with home energy management services.WSN gives different standards so as to cater to the requirements of different applications.

This paper covers following points:

- Basics of smart home designs.
- Paper present wireless sensor network using ZigBee based self adjusting sensors. This structure reduces cost of design as well as improves the capability of sensors.
- Dijkstra shortest path routing algorithm which will give energy consumption of nodes in the network.

2. RELATED WORK AND MOTIVATION

Concerning the communication protocols like Bluetooth, IrDA, GPRS and ZgBEE, several possibilities are available. Each of them has some advantages and disadvantages. To choose good one from them, their pros and cons have to be weighted. The different protocols are compared considering the application requirements including data transmission rate, range, battery life and cost [3]. According to their conclusion it is beneficiary that

ZigBEE communication protocol is appropriate one which gives advantages like high range, very low power consumption and low cost.

Liang *et al* [6] developed a system of wireless smart home sensor network based on ZigBee and PSTN (Public Switched Telephone Network) technologies.To overcome the problems in traditional designs we presented GPRS instead of PSTN technology for better system performance.

3. SELF ADJUSTING SENSOR ARCHITECTURE BASED ON ZIGBEE TECHNOLOGY

In this section, we present intelligent self adjusting sensor (ZiSAS) architecture based on ZigBee technology for smart home services. Fig. 1 shows a view of the ZiSAS and Fig. 2 shows prototype of ZiSAS. The ZiSAS divides into two components: a self-adjusting sensor (SAS) and a sensor management agent (SMA). SAS controls the home environment and provide smart services. It autonomously modifies topology as well as adjusts sensing rate, sensor density routing protocols, and the frequency of data gathering and transmission according to the situations. The SMA plays a major role in sensor management, context analysis, reasoning, pattern generation, and service creation. It has the capability to control an appliance via interaction with a sensor node. The ZiSAS was designed into three layered architecture to provide

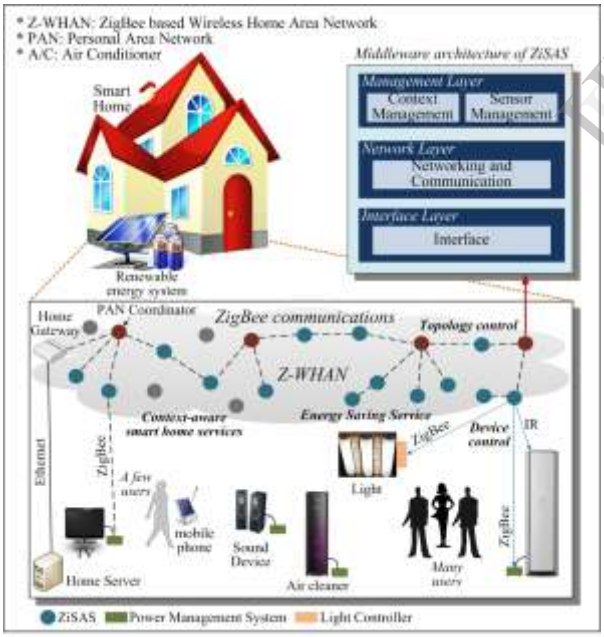

Fig. 1. Overview of the ZigBee based self-adjusting sensor (ZiSAS).

modularity: a network layer, a management layer.

The ZiSAS can autonomously reconfigure middleware, network topology, sensor density, and sensing rate based on the environmental situation. The ZiSAS predicts the required service and provides the appropriate action in the given situation by using generated patterns.

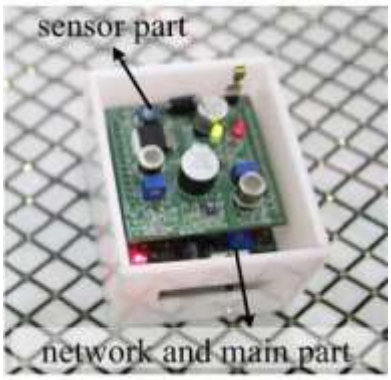

Fig. 2. Prototype of the ZiSAS.

To generate the user and surrounding patterns, the ZiSAS applies the learning mechanism, such as a hidden markov model (HMM) that considers the user and surrounding events. If an event occurs (i.e. the ZiSAS gathers event data and transmits the data to a pattern generator at SMA), the pattern generator generates patterns, rules, and services according to the location, user, and environmental states.

4. MONITORING SYSTEM USING GPRS TECHNOLOGY

The network node and the coordinator are key components of the system. Assumption is that the coordinator will always be connected to the monitoring center/server via a computer that can access the Internet or the GPRS network. When the server sends out a command, the CPU of the network coordinator will read the content of the command and get the details by analyzing it, such as turning on the air conditioner or microwave oven.

Through serial ports, the main control program within the network coordinator writes the details to the ZigBee module. Then using ZigBee module, messages will be sent to the family network. Design of Coordinator node can be given by using peripheral circuits according to the functional requirements, and can develop a network coordinator by integrating the ZigBee coordinator node and the GPRS module together on a PCB board [4]. Fig. 3 shows the hardware board of the coordinator node [4]. In this way, a monitoring system can be built using GPRS network.

Fig. 3. Coordinator node developed

5. ROUTING ALGORITHM

The smart home system using the WSN developed can be modeled as a (wireless) network, and the routing point is the node in the network. The traditional Dijkstra algorithm [7] generates the shortest path according to the order of increasing path length, and greedily searches path based on the edges connected with nodes. However, there is no edge in the wireless network. Therefore in this paper, we propose an improved Dijkstra algorithm for the WSN, which obtains the shortest path in the network.

Assume that there are *n* nodes in a wireless network, and the location of each node is available. Then we can get table of distances between nodes by using the following algorithm [8]:

(1) A node is arbitrarily selected as the root node. After initialized, it will send messages to surrounded nodes asking for their IDs and location information.

(2) In response to Step (1), the remaining *n*-1 nodes send their IDs and location information to the root node.

(3) The distance table is created after the root node has received all the information of remaining *n*-1 nodes.

As an example, Table 1 distance table taken using a simple wireless network example of 10 nodes from figure 4.

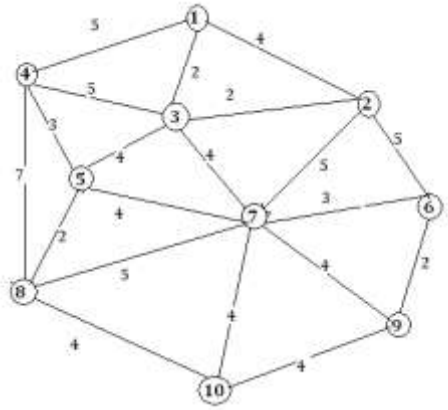

Fig. 4. An Example Network of 10 Nodes

The corresponding distance table is shown in Table I.

Node ID	1	2	3	4	5	6	7	8	9	10
1	0	4	2	5	5	7	6	8	9	9
2	4	0	2	7	6	5	5	7	7	8
3	2	2	0	5	4	5	4	6	7	8
4	5	7	5	0	3	8	7	7	9	8
5	5	6	4	3	0	6	5	2	7	5
6	7	5	5	8	6	0	3	8	2	5
7	6	5	4	7	4	3	0	5	4	4
8	8	7	6	7	2	8	5	0	6	4
9	9	7	7	9	7	2	4	6	0	4
10	9	8	8	8	5	5	4	4	4	0

Table I. Distances between Nodes

Now, we use an improved Dijkstra algorithm to deduce the optimal path. Some symbols and notations used in the algorithm are listed in Table II.

Symbol	Description
N	Number of network nodes
v	Sending node
w	Receiving node
k	Transmission radius
u	Relay node
s[i]	Visit mark (if not visited, set [*i*]=0;else set *s*[*i*]=1)
cost[i][j]	Distance between node *i* and node *j*
dist to w	Distance corresponding to the optimal path from v

Table II. Symbol Definition

The improved Dijkstra algorithm is described in the following:

(1) Initialization: *num*=0, *dist*=+∞, *s*[*i*] =0, (*i*=0,1,…*n*);

(2) If *cost*[*v*][*i*] ≤*k*, then set *s*[*i*]=1, (*i*=0,1,…*n*);

(3) If *s*[*w*] =1, then *dist*=*cost*[*v*][*w*]; otherwise go to step (4);

(4) ∀ *i* ∈ {*s*[*i*]=1}, *u*[*num*]=1, set *s*[*j*]=1 when *j*∈{*cost*[*u*[*num*]][*j*] ≤*k*}, (*j*=0,1,…*n*);

(5) If *s*[*w*] ≠ 1, then *num*++, repeat step (4); otherwise record the path that fulfills *s*[*w*]=1, and dist[num] = cost [v][u[0]]

$$+\sum_{J=0}^{num-1} \text{cos}\,[\,u[j\,]][u\,[j+1]] + \text{cost}\,[u\,[num]]\,[\,w];$$

(6) For *num*=*num*+1, repeat steps (4) and (5) until all the paths that fulfill *s*[*w*]=1 are obtained;

(7) Set *dist*=min{*dist*[*i*], *i*=0,1,…,*num*}, and output the corresponding path.

We implemented the above algorithm and conducted simulations of a network for the given in table I. Setting *k*=5, the optimal path from sending node 1 to receiving node 10 is to pass a relay node 5, which is better than the path of node 1 → node 3 → node 7 → node 10, and reduces the number of node hops. Therefore, the improved Dijkstra algorithm can solve the problem of optimal path selection in a wireless network, thus providing a feasible routing solution for smart home systems.

To evaluate the performance of routing algorithms, a general concern would be the energy consumption of the network nodes. If a node is put into sleep as long as it has no data to receive or send (and all state switching overheads are negligible), its energy consumption will be

approximately proportional to the number of times it is visited (i.e. the number of packets it has transferred) [4]. In this case, it is possible to examine the relative energy consumption of all nodes by observing the number of times each node is visited.

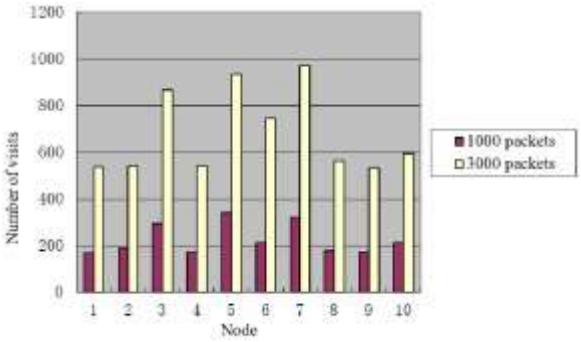

Fig. 4. Number of times each node is visited.

In simulations the sending node and the receiving node are randomly generated. Fig. 4 gives the results with data transformation of 1000 and 3000 times. Noticing that nodes 3, 5 and 7 have more visited times, we can conclude that nodes 3, 5 and 7 consume more energy. This observation could be helpful when placing nodes in a smart home.

6. CONCLUSION

This paper describes the drawback of traditional designs used for smart home services and how wireless sensor network using efficient techniques overcomes it. Paper describes how ZigBee technology is useful with self adjusting sensors. Using GPRS network communication can be done efficiently. Also, this paper presents Dijkstra shortest path routing algorithm along with evaluation of performance which give energy consumption of network nodes. In this way, an efficient business model can be designed with wireless sensor network using various efficient techniques. Furthermore, we can develop smart home design systems by using mobile sensors.

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