

A Wireless Sensor Network for Weather and Disaster Alarm Systems

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Abstract. In the last few years, the occurrences of natural disasters have been continuing changing our lives, damaging property and life styles in many different ways. In this paper, we present a system that can be used to prevent enormous damage from natural disasters. In this system, a wireless sensor network based on Zigbee/IEEE802.15.4 standard is utilized as a weather station network sending weather information and disasters' alerts. The weather information is analyzed by using decision tree techniques to announce the disasters' alerts. This proposed system takes advantage of wireless sensor networks which can send signals over far distances by using a mesh topology, this transfers the data and also consumes low power. Therefore, this system can be installed in locations that are difficult to hardwire or have no access to electricity.

Keywords: Disaster Alarm system, Wireless Sensor Network, Weather Station, Zigbee/IEEE802.15.4

1. Introduction

Natural disasters are becoming more severe. One important reason is the results of global warming around the world causing many of the disasters. To carefully protect people in these areas, we need a monitoring and alarm system. In many events such as landslides and water flooding, they can be warned by a raised alarm within in a specified period. The surveillance system's equipment is a tool used to measure parameters such as sample temperature, air pressure, moisture, vibration etc. These parameters will vary depending on the requirement of the surveillance system.

Monitoring system, the equipment used for detection is the heart of the work. The monitor system devices are installed in different places. Sometimes it is not easy to install equipment in some areas for many reasons such as lack of access to power or unable to connect to signal wiring. In addition, tools used for measurements are very expensive. To resolve this problem, a wireless sensor network can be implemented to help in data communications. The advantages of using a wireless network are: using less energy, no need for hardwiring, and high transmission distance.

In this research, the advantages of a wireless sensor network are taken to benefit weather monitoring stations. Many sensor stations measure and send parameters through a wireless network server. Or if the station is outside the server's radius, it can send data to the nearest wireless weather station forwarding the data to the server. In addition, the wireless sensor network is easy to maintain, devices are cheaper and uses less energy.

Today, the wireless sensor network is cheaper and more efficient than other systems, the high flexibility can be used in various ways depending on the need to measure different values in the environment, it can be used to measure the amount of carbon dioxide using gas sensors. In structure measurement, it can measure the motion of buildings. Or in the military, it can be very important as it uses a large number of sensor nodes to scatter in battlefield to measure temperature, vibration and movement of enemy spies and so on.

In other research, the application of a wireless sensor network system are employed in fields such as medical, [1] proposed an application as Personal area network system for monitoring of a patient's heart, In agricultural, [2] used the wireless sensor network to check and control the greenhouse effect from

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temperature, humidity, light parameter and record weather statistics for planning, and [3] presented the development of a wireless sensor for use in various applications.

This research uses arduino microcontroller board [4] and Xbee module to create a wireless sensor network using decision tree to analyze the weather data and to alert when it matches with pre-conditions.

2. Related Works

2.1. Decision Tree

A decision tree, [5] is a diagram that a decision maker can create to help select the best of several alternative courses of action. The primary advantage of a decision tree is that it assigns exact values to the outcomes of different actions, thus minimizing the ambiguity of complicated decisions. Because they map out an applied, real-world logical process, decision trees are particularly important to build "smart" computer applications like expert systems. They are also used to help illustrate and assign monetary values to alternative courses of action that management may take.

In this research, the use of a decision tree will process input parameter to alarm when an inputted parameter matches predefined conditions.

2.2. Zigbee Standard

ZigBee/IEEE 802.15.4 [6][7] is the only standards-based wireless technology designed to address the unique needs of low-cost, low-power wireless sensor and control networks in just about any market. Since ZigBee can be used almost anywhere, is easy to implement and needs little power to operate, the opportunity for growth into new markets, as well as innovation in existing markets, is limitless.

2.3. XBee

XBee [7] is a device used to send and receive data wirelessly and can build up a ZigBee/IEEE 802.15.4 network reference standard. XBee functions can be divided by network topology in different ways including the Coordinator, Router and End Device.

- **Topology**

To create a wireless network of ZigBee, it will consist of at least two nodes including coordinator node and sensor node types (Router/End device) to be able to communicate and work in PAN (Personal. area network). Wireless sensor network topology can be divided into 3 topologies: Star Topology (Fig. 1-a), Cluster Tree Topology (Fig. 1-b) and MESH Topology (Fig. 1-c).

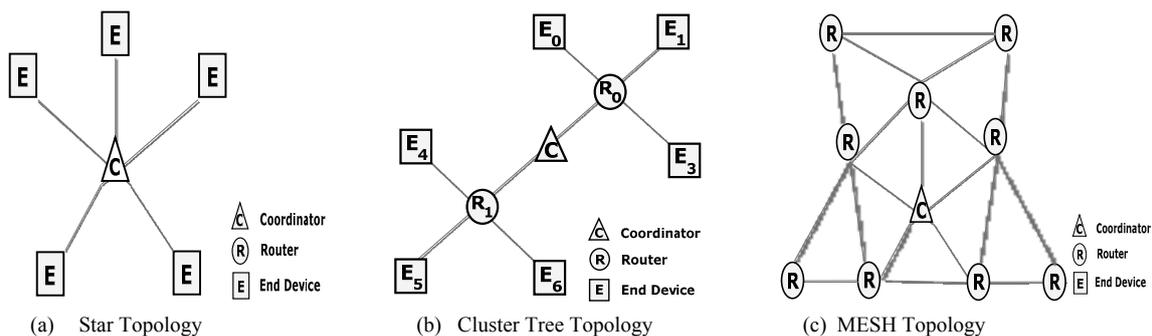


Fig. 4: Wireless Network Topology

Star topology or a Broadcast is non-specific transmission. All destinations or on the same network can Get all the information any time (Fig. 1-a).

The transmission of data transmission, such as E_0 need contact to C_0 , but C_0 is far from E_0 and E_0 can connect to R_0 , and R_0 is between E_0 and C_0 , so Cluster Tree will use R_0 as an intermediary (Repeater) connecting the 2 nodes C_0 and E_0 (Fig. 1-b).

Mesh topology is the most effective since data can be sent to the target in more ways; it can transfer data to a destination even if parts of the system are lost (depending on system design) (Fig. 1-c).

Mesh networks [3] are regularly distributed networks that generally allow transmission only to a node's nearest neighbours. The nodes in these networks are generally identical, so that mesh nets are also referred to

as peer-to-peer (see below) nets. Mesh nets can be good models for large-scale networks of wireless sensors that are distributed over a geographic region, e.g. personnel or vehicle security surveillance systems.

- **Serial Interface Protocols**

Xbee module supports both transparent and API (Application Programming Interface) serial interfaces.

- **Transparent Operation:** when operating in transparent mode, the modules act as a serial line replacement. All UART data received through the DIN pin is queued up for RF transmission. When RF data is received, the data is sent out through the DOUT pin.

- **API Operation:** API operation [8] is an alternative to transparent operation. The frame-based API extends the level to which a host application can interact with the networking capabilities of the module. When in API mode, all data entering and leaving the module is contained in frames that define operations or events within the module.

3. System Design and Implementation

Our wireless sensor network for weather and disaster alert system uses mesh network topology. The system design is divided into two main sections consisting sensor node (Router/End Device Node) and coordinator node (Fig. 2).

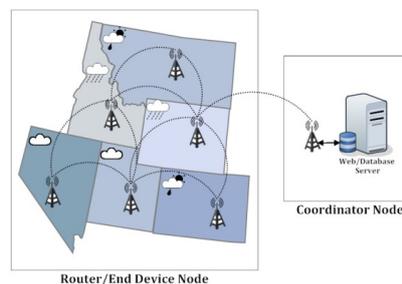


Fig. 2: System overview consists of Router/End Device Node and Coordinator Node.

3.1. Sensor Node

The sensor node consists of the microcontroller, temperature and humidity sensor, light sensor, pressure sensor and XBee module (Fig. 3-a shows sensor node block diagram). The wireless sensor nodes are programmed with C language (for Arduino [4]). It stays on standby for requests of data transmitted from the server (coordinator with server). Upon receiving the request for weather data, the microcontroller will read the data from different sensors and send the data back to the server (Fig 4-a. shows the flowchart of sensor node process).

This experiment is set up with XBee module working in mesh topology. For data transmission, it has only one sensor node which is the coordinator with server for data recording and processing. For the transmission to coordinator, sensor nodes cannot directly contact the coordinator, it needs to transmit data to sensor nodes near the coordinator.

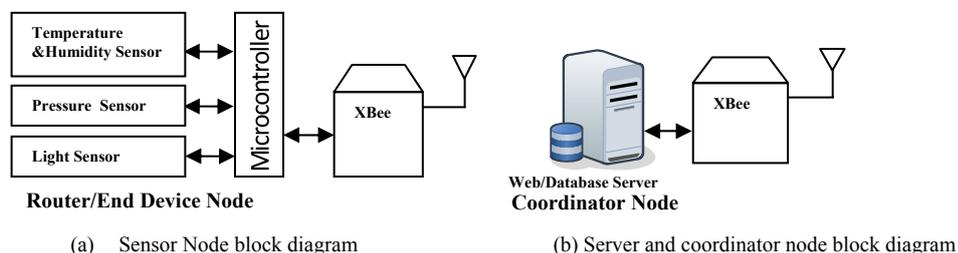


Fig. 3: System block diagram.

In the API Frame type, it can check whether the data has been sent to the server or not. When the sensor sends data out, the server will receive it and send API Frame back to show completed state. Otherwise, it will retransmit such as the destination offline.

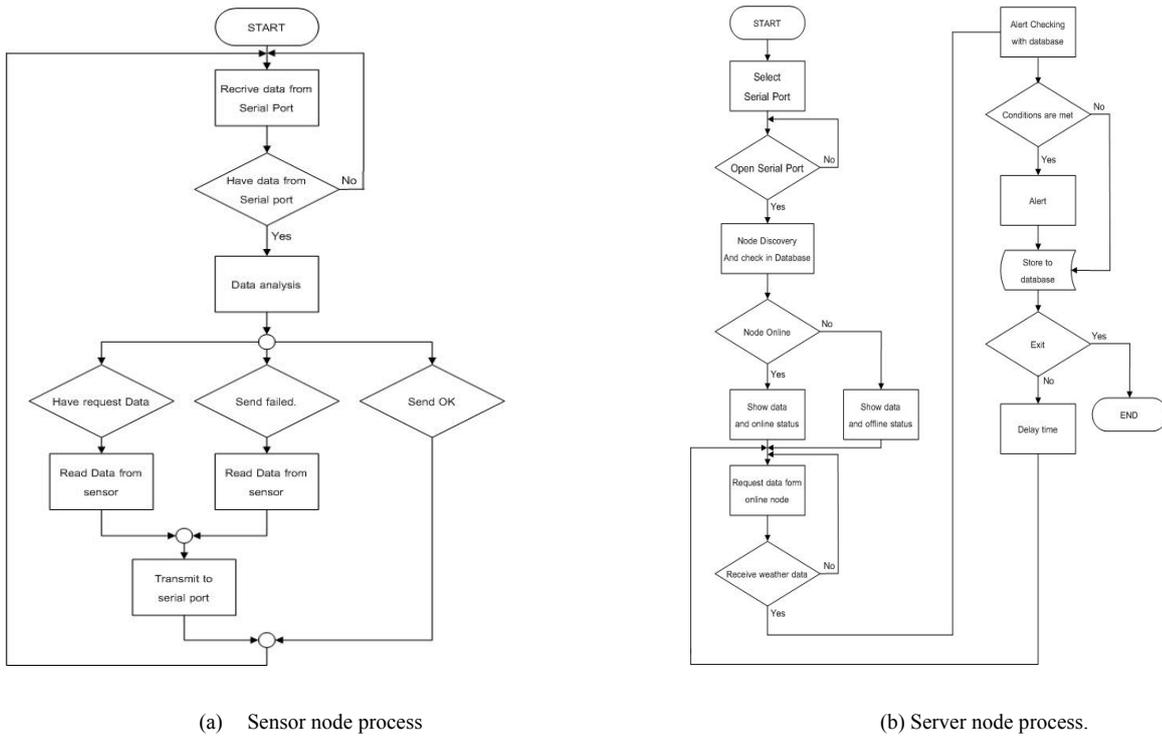


Fig. 4: Flow chart of Sensor node and Server node processes.

3.2. Server and Coordinator

On the server side, it has a web/database and connects with XBee (Fig. 3-a shows server and coordinator node). The server has an application and web application to control and to manage the system. The server will connect XBee via USB port. When opening the application and selecting serial port to connect to the XBee sensor nodes, the system will search sensor nodes in the network and display the status and data of the sensor node.

Requested data from the sensor node, the server will be sent API Frame via sensor nodes. When the data is sent out, the status of delivery will change if the sensor node successfully receives the data. But if there is no response from the sensor nodes, the system will again send the request data in a specified period. (Fig. 4-b)

When the server receives weather data from sensor nodes, the server will check the weather data with notification value by using decision Tree techniques. If it matches with the pre-conditions, it will notify the system administrator and record of the notification and automatically store weather data to the database.



Fig. 5: Application interface.

3.3. Application

In this section, Visual studio C# is selected to develop an application used to control and display the information (Fig. 12). The application consists of six main parts; 1) **Home**: Main page, 2) **Statistics**: Display node information, weather and operation information 3) **Alert setting**: Configuration and add conditions of the notification 4) **Device**: Management device in network including add, edit and delete 5) **Config**: Setting the display and 6) **About**: About this application.

3.4. Results

The alarm system, we used decision tree to analyze and process the data. Each parameter has 2 boundary values in decision tree process. Testing of the system used black-box testing to test the performance and accuracy of the system. In Table 1-a shows the boundary values and Table 1-b is the expected output with real output. In this testing, rainfall and wind speed are simulated parameters. Testing results confirm that the system perfectly works.

Table 1: Boundary values and Testing Results.

(a) Boundary values used in decision tree process

on	Boundary value											
	T_0	T_1	H_0	H_1	P_0	P_1	L_0	L_1	R_0	R_1	W_0	W_1
1	20	25	30	40	500	600	30	50	0	20	0	30
2	20	25	30	40	500	600	30	50	0	20	0	30
3	20	25	30	40	500	600	30	50	0	20	0	30
4	20	25	30	40	500	600	30	50	0	20	0	30
5	20	25	30	40	500	600	30	50	0	20	0	30

T is temperature, H is humidity,

P is pressure, L is light,

R is rainfall, W is wind.

(b) Comparing expected output with real output

on	Current input						Real Output	Expected output
	Temperature °C	Humidity %	Pressure mmHg	Light	Rain fall mm.	Wind speed Km/s		
1	25	30	510	31	10	20	Alarm	Alarm
2	26	33	520	32	10	20	Alarm	Alarm
3	25	32	520	33	10	20	Alarm	Alarm
4	26	34	530	32	10	20	Alarm	Alarm
5	27	33	525	34	10	20	Alarm	Alarm

4. Conclusion

This research focuses on developing devices and tools to manage, display and alert the weather/disaster warnings using the advantages of a wireless sensor network system in mesh topology. The system can work over far distances. The system uses arduino microcontroller and Xbee Wireless module base on the Zigbee/IEEE 802.15.4 standard. The developed system is very flexible and accurate. The developed system has core competency including 1) display weather information, 2) alert when weather conditions match using decision tree technique and 3) keep weather information statistics.

In the field testing, the specification of the device's communication range is 1 mile at the line of sight. When used in a real environment, the high-rise buildings, it ranges from 300 to 500 meters, the system can work normally. The system can alert when the weather information matches with specified conditions.

5. Acknowledgements

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6. References

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