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Design of Wireless Sensor Network Protocol, Routing Algorithm and Terminal based on Embedded Linux

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***Abstract* — with the integrating of sensor technology, modern network, wireless communication and low power consumption embedded technology, it pushes the modern wireless sensor network production and development. It could collect and process perceived information in the network coverage, then sending to the users timely. Wireless sensor network have so many advantages in low power consumption, low cost and no restriction of space, so it has a very broad application prospect. Sensor network node can collect and transmit perceived information. In the sensor network, because the nodes are distributed intensively and need to deal with the large amounts of data, however the node itself is not suitable for it, so the design of communication terminal between the nodes has the extremely vital significance. The system proposed to design wireless sensor network for multiple sensor nodes and a communication terminal with user interface to manage all the client nodes.**

***IndexTerms*- Wireless sensor network, Sensor node, Communication terminal, Protocol, Routing algorithm**

I. INTRODUCTION

A sensor network is defined as being composed of a large number of nodes which are deployed densely in close proximity to the phenomenon to be monitored. Each of these nodes collects data and its purpose is to route this information back to a sink. The network must possess self-organizing capabilities since the positions of individual nodes are not predetermined. Cooperation among nodes is the dominant feature of this type of network, where groups of nodes cooperate to disseminate the information gathered in their vicinity to the user. Major differences between sensor and Ad Hoc networks[1]:

- Number of nodes can be orders of magnitude higher.
- Sensor nodes are densely deployed.
- Sensor nodes are prone to failure.
- Frequent topology changes.
- Broadcast communication paradigm.
- Limited power, processing and power capabilities

The factors driving the design of sensor networks and proceeds to present its own communication architecture and design factors to be used as a guideline and as a tool to compare various protocols. After surveying the literature, this is our impression as well and we include it in the open research issues that can be explored for future work. The design factors listed are:

1. **Fault Tolerance:** Individual nodes are prone to unexpected failure with a much higher probability than other types of networks. The network should sustain information dissemination in spite of failures.
2. **Scalability:** Number in the order of hundreds or thousands. Protocols should be able to scale to such high degree and take advantage of the high density of such networks.
3. **Production Costs:** The cost of a single node must be low, much less.
4. **Hardware Constraints:** A sensor node is comprised of many subunits (sensing, processing, and communication, and power, location finding system, power scavenging and mobilizer). All these units combined together must consume extremely low power and be contained within an extremely small volume.
5. **Sensor Network Topology:** Must be maintained even with very high node densities.
6. **Environment:** Nodes are operating in inaccessible locations either because of hostile environment or because they are embedded in a structure.
7. **Transmission Media:** RF, Infrared and Optical

II. WIRELESS SENSOR NETWORK

A wireless sensor network (WSN) is a computer network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. The development of wireless sensor networks was originally motivated by military applications such as battlefield surveillance. However, wireless sensor networks are now used in many civilian application areas, including environment and habitat monitoring, healthcare applications, home automation, and traffic control[4][5].

In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery. The size a single sensor node can vary from shoebox-sized nodes down to devices the size of grain of dust. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few cents,

depending on the size of the sensor network and the complexity required of individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, and computational speed and bandwidth.

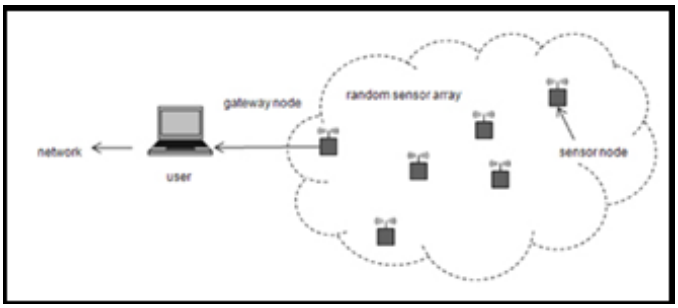

Fig 1. Architecture of Wireless Sensor network

The main characteristics of a WSN include[4][5]:

- Power consumption constraints for nodes
- Ability to cope with node failures
- Mobility of nodes
- Communication failures
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use

The focus is on the design and implementation of the wireless sensor node and the coordinator based on wireless technology. A monitoring system is built by taking advantage of the RF network. To support multi-hop communications, an improved routing algorithm.

III. ARCHITECTURE OF WIRELESS SENSOR NETWORK

To design the wireless sensor network system architecture from the high level application requirements, the system architecture can be classified as below components

a) Wireless sensor Nodes

b) Wireless network

c) Remote monitoring station

A. Wireless Sensor Node

A sensor node, also known as a mote, is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.A mote is a node but a node is not always a mote.The main components of a sensor node are a microcontroller, transceiver, external memory, power source and one or more sensors

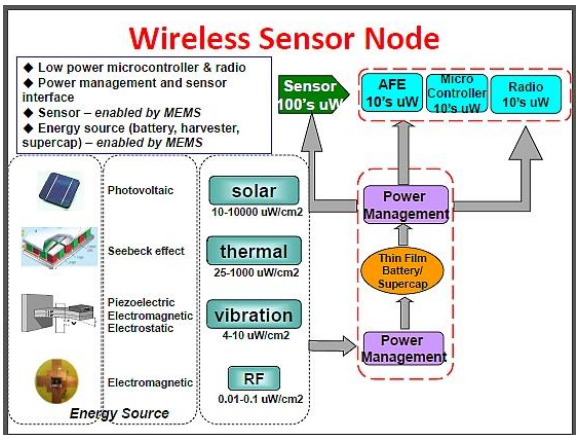

Fig 1. Sensor Node

General Requirements of Wireless Sensor Node:

1) **Low Power Consumption** -Since the deployment of a wireless sensor network tends to be large, replacement of batteries would be a difficult, if not impossible, task. Therefore, any processing the node performs has to be low power and energy efficient.
2) **Self-healing Structures** -A fault in one nodes should not overtly impact the operation of the network. Communication failures should be minimal and in the event of such occurrences, back up control should take over in order to avoid losing data.
3) **Robust** -Since these nodes are deployed under different harsh physical conditions, they need to be able to operate accurately for long periods of time without any problems.

B. Wireless Network

The design of routing protocols for WSNs is challenging because of several network constraints. WSNs suffer from the limitations of several network resources, for example, energy, bandwidth, central processing unit, and storage.As compared to the traditional wireless communication networks such as mobile ad hoc network and cellular systems, wireless sensor networks have the following unique characteristics as mentioned below

1) **Protocol Stack of WSN** -The protocol stack used by the sink, cluster head and sensor nodes. The sensor network protocol stack is much like the traditional protocol stack, with the following layers: application, transport, network, data link, and physical. The physical layer is responsible for frequency selection, carrier frequency generation, signal detection, modulation and data encryption
2) **Media, Coverage and Connectivity** –The media is responsiblefor frequency selection, carrier frequency generation and data rate. Network coverage measures the degree of coverage of the area of interest by sensor nodes.The communication ranges and physical locations of individual sensor nodes define the connectivity of a network. If there is always a network

connection (possibly over multiple hops) between any two nodes, the network is said to be connected.

3) **Network Size -**The number of nodes participating in a sensor network is mainly determined by requirements relating to network connectivity and coverage, and by the size of the area of interest. The network size may vary from a few nodes to thousands of sensor nodes or even more. The network size determines the scalability requirements with regard to protocols and algorithms.

C. Remote monitoring station

A remote monitoring station is the Central Monitoring Station. It contains setup software to connect data input streams to data output streams, define communication protocols, and troubleshoot installation problems.The base stations are one or more components of the WSN with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user as they typically forward data from the WSN on to a server. Other special components in routing based networks are routers, designed to compute, calculate and distribute the routing tables.The Basic function of a remote monitoring terminal are

- Real time monitoring of different nodes.
- Analyse the performance of the captured data.
- Store the captured data and results.
- Control the nodes remotely.
- Decision maker.

IV. IMPLEMENTATION DETAILS

Efficient design and implementation of wireless sensor networks has become a hot area of research in recent years, due to the vast potential of sensor networks to enable applications that connect the physical world to the virtual world. This section gives implementation details of design and development description ofhardware and software of each components.

A. Sensor Node

Design a sensor node the first an important work is hardware selection, the hardware components should be chosen carefully to obtain high efficiency with minimum hardware and cost.

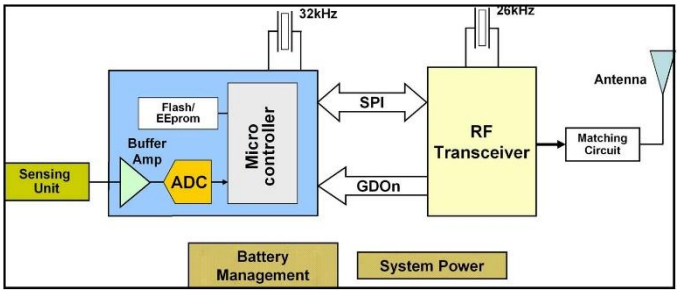

Fig 2. Sensor Node block diagram

The Three main functions of sensor node are:

1) **Sensor Interface** - Sensor interface will have the data acquisition circuit. A Signal conditioning means manipulating an analog signal in such a way that it meets the requirements of the next stage for further processing. Most common use is in analog-to-digital converters**.**

2) **Data Processing and management** -A microcontroller based to collect sensor data, perform calculation and to communicate the data over the network

3) **Physical Communication Network** - A 2.4Ghz based network. Using Chipcon 2500 transceivers manufactured by Texas Instruments. This transceiver is interfaced with the controller with SPI bus, Operating in the 2.4 GHz (CC2500) frequency band, the devices include several useful digital features like full packet handling, FIFO buffers, clear channel assessment, wake-on-radio and more.

B. Wireless communication protocol

The designing of the commutation protocol is key to make sure the reliable transformation. The core of the communication protocol is the designing of frame header. Although it can be simple or complicated, it should match with the system to be designed. The first thing to be considered is to design the exact frame format. Secondly, error correction is used to enhance the reliable communication. And also, a handshake signal is available to make sure the communication between the controller and other sensor nodes. Each of the sensor nodes is able to initiate call to the controller and broadcast the status of the region under monitoring [2].

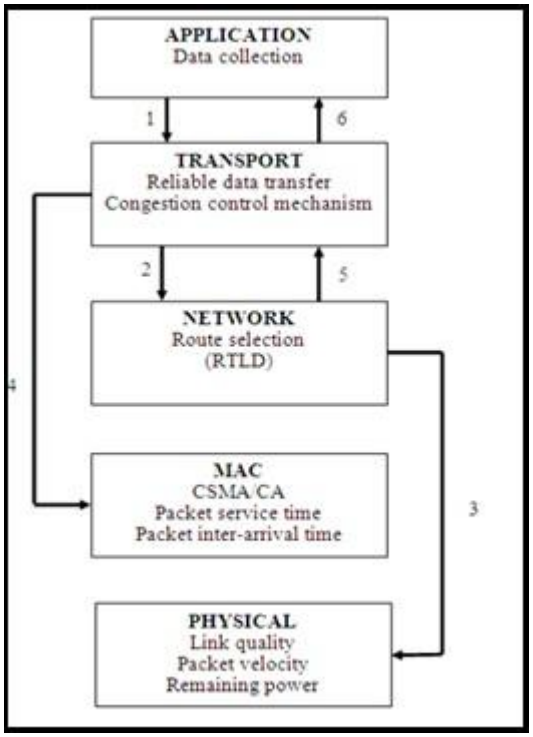

Fig 3. Data Flow Model in communication stack

Based on the data monitored, order from the controller is made to tell the nodes to take further actions.

1) **Physical Layer** -Provide Simple and strong signal modulation and wireless receiving and sending technology
2) **MAC Layer** - Responsible for frame formatting from, Frame correction, error correction.
3) **Network Layer** –Routing Formation and selection of message transmission path.
4) **Application Layer** -Provide application layer software for application layer based on monitoring task

C. GUI based Remote Monitoring station

The remote monitoring station should be a graphical user interface for easy monitoring and controlling purpose. It should provide instant data and access to available data. The available data can be in format of graphs, tables, pie charts etc.

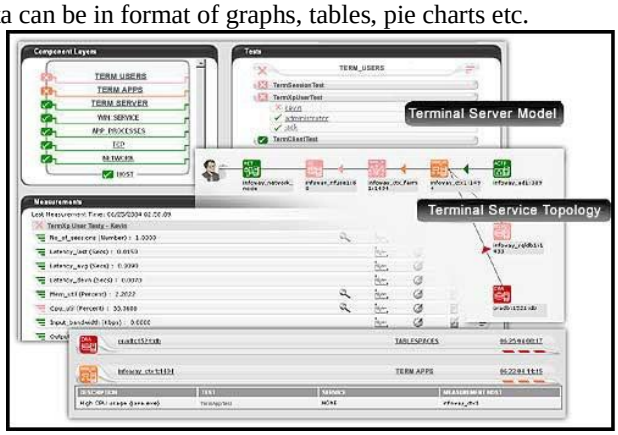

Fig 4. GUI Interface of remote station

The user should have easy access to all the functionality and should receive critical information of node in highlighted form e.g. The Node Status.

The proposed solution for Remote monitoring station is the Raspberry Pi. The Raspberry Pi is a credit-card sized computer.The Raspberry Pi is based on the Broadcom BCM2835 system on a chip (SoC) which includes an ARM1176JZF-S 700 MHz processor, and 256 megabytes of RAM. It has a 100mbps. While operating at 700 MHz by default, the first generation Raspberry Pi provided a real world performance. It can be interfaced with a HDMI monitor for the purpose of display. The Raspberry Pi primarily uses Linux-kernel-based operating systems. This supports different programming language like C, C++, Python and different GUI designing tools like QT framework.

V. CONCLUSION

Wireless Sensor Networks hold a lot of promise in applications where gathering sensing information in remote locations is required. It is an evolving field, which offers scope for a lot of research. Hence, designing efficient routing protocols for sensor networks that suits sensor networks serving various applications is important. In this paper, we identified some of the important design issues of wireless sensor network architecture, routing protocols for sensor networks and also compared a contrasted the existing routing protocols. As our study reveals, it is not possible to design a routing algorithm which will have good performance under all scenarios and for all applications.

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