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A SURVEY ON WIRELESS SENSOR NETWORK ARCHITECTURE, PROTOCOLS AND APPLICATIONS

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Abstract: In this paper, we survey the current state of the art in wireless sensor network which has been gaining interest platform that changes how we interact with the physical world. Today, researchers and practitioners utilize low power nodes composed of wireless radios, sensors and computing elements for a variety of applications in medicine military, biology, manufacturing, etc. Most of wireless sensor networks use off-the-shelf commodity based microcontrollers, through the energy consumption of these systems can limit the effective lifetimes of the wireless sensor network nodes. We provide a discussion on the definition of wireless sensor network, design architecture, issues in various protocols and various applications of wireless sensor network.

Keywords: Wireless Sensor Networks, local storage, alternative routing

WIRELESS SENSOR NETWORKS (WSN) INTRODUCTION

A sensor network is a group of specialized transducers with a communications infrastructure intended to monitor and record conditions at diverse locations. Commonly monitored parameters are temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollutant levels and vital body functions. A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable. Every sensor node is equipped with a transducer, microcomputer, transceiver and power source. The transducer generates electrical signals based on sensed physical effects and phenomena. The microcomputer processes and stores the sensor output. The transceiver, which can be hard-wired or wireless, receives commands from a central computer and transmits data to that computer.

The power for each sensor node is derived from the electric utility or from a battery. Recent technological improvements have made the deployment of small, inexpensive, low-power, distributed devices, which are capable of local processing and wireless communication, a reality. Such nodes are called as sensor nodes. Each sensor node is capable of only a limited amount of processing. But when coordinated with the information from a large number of other nodes, they have the ability to measure a given physical environment in great detail. Thus, a sensor network can be described as a collection of sensor nodes which co-ordinate to perform some specific action. Unlike traditional networks, sensor networks depend on dense deployment and co-ordination to carry out their tasks.

Previously, sensor networks consisted of small number of sensor nodes that were wired to a central processing station. However, nowadays, the focus is more on wireless, distributed, sensing nodes. But, why distributed, wireless sensing? When the exact location of a particular phenomenon is unknown, distributed sensing allows for closer placement to the phenomenon than a single sensor would permit. Also, in many cases, multiple sensor nodes are required to overcome environmental obstacles like obstructions, line of sight constraints etc. In most cases, the environment to be monitored does not have an existing infrastructure for either energy or communication. It becomes imperative for sensor nodes to survive on small, finite sources of energy and communicate through a wireless communication channel. Another requirement for sensor networks would be distributed processing capability. This is necessary since communication is a major consumer of energy. A centralized system would mean that some of the sensors would need to communicate over long distances that lead to even more energy depletion. Hence, it would be a good idea to process locally as much information as possible in order to minimize the total number of bits transmitted.

GENERAL DESIGN ARCHITECTURE OF WSN

The Framework of Wireless Sensor Network consists of collection of sensor nodes. Each node can sense, compute and communicate each other. They can either receive message or transmits message, and can transmit messages to a gateway via self-configuration and multi-hop routing. The gateway can use many ways to communicate with remote network, such as Internet, satellite and mobile communication network (in this system we use Ethernet). More than one gateway may be used for large-scale application. Because of its limited communication areas the node must use multi-hop routing to access the nodes out of communication areas.

A functional block diagram of a versatile wireless sensing node is provided in Fig 1. A modular design approach provides a flexible and versatile platform to address the needs of a wide variety of applications. For example, depending on the sensors to be deployed, the signal conditioning block can be re-programmed or replaced. This allows for a wide variety of different sensors to be used with the wireless sensing node. Similarly, the radio link may be swapped out as required for a given applications' wireless range requirement and the need for bidirectional communications. The use of flash memory allows the remote nodes to acquire data on command from a base station, or by an event sensed by one or more inputs to the node. Furthermore, the embedded firmware can be upgraded through the wireless network in the field.

The microprocessor has a number of functions including:

- managing data collection from the sensors
- performing power management functions
- interfacing the sensor data to the physical radio layer
- managing the radio network protocol

A key feature of any wireless sensing node is to minimize the power consumed by the system. Generally, the radio subsystem requires the largest amount of power. Therefore, it is advantageous to send data over the radio network only when required. This sensor event-driven data collection model requires an algorithm to be loaded into the node to determine when to send data based on the sensed event. Additionally, it is important to minimize the power consumed by the sensor itself. Therefore, the hardware should be designed to allow the microprocessor to judiciously control power to the radio, sensor, and sensor signal conditioner.

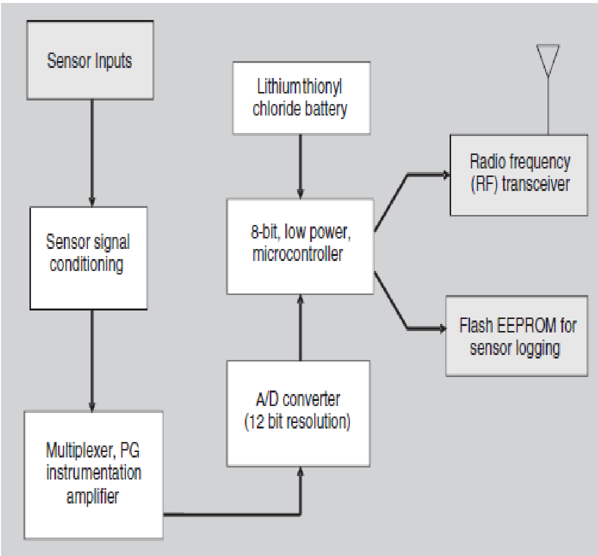

Figure. 1 Wireless Sensor node functional block diagram

Hardware of Wireless Node

The wireless sensor network nodes use battery power and their power capabilities are limited due to its small size of node. The transmission rate of the network is low and it needs enough power to work steadily for a long time. Therefore low-power design is significant. The system adopts MICAz mote module produced by Crossbow Technology and its sketch of hardware is shown in Fig 2. MICAZ is embedded with a ZigBee compliant RF transceiver and it works between 2.4 and 2.4835 GHz, a globally compatible ISM band. Its DDSS radio offers both high speed (250 kbps) and hardware security (AES-128). The MICAz 51-pin expansion connector supports Analog Inputs, Digital I/O, I2C, SPI and UART interfaces. These interfaces make it easy to connect to a wide variety of external peripherals, including a variety of sensor, data acquisition boards and gateway.

Microcontroller

We have considered Atmega128L, a High-performance, and Low-power AVR 8-bit Microcontroller as our processor. The ATmega128 provides the following features: 32 general purpose working registers connected to ALU directly, On-chip 2-cycle Multiplier, 128K bytes of In-System Programmable Flash 1196 with Read-While-Write capabilities, 4K bytes EEPROM, 4K bytes SRAM, 2 USARTs, an SPI serial port linked to CC2420, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain, and it design six sleep modes, especially for the restriction of power.

RF Transceiver

The CC2420 is the industry's first single-chip 2.4 GHz RF transceiver compliant with the IEEE 802.15.4 standard and already to be used in ZigBee products. In a typical application, CC2420 will be used together with a microcontroller and a few external passive components. CC2420 set its work modes by SPI(SI□SO□SCLK□CSn) and achieve its read-while-write operation. The sketch of link between CC2420 and microcontroller is shown in Fig 3.

Gateway

MIB600CA which is one of MICAz mote developer's kits is adopted as a gateway for TCP/IP-based Ethernet. MIB600CA is used as a bridge to link the wired and wireless network. It connects the MICAz to Ethernet and permit server access data from wireless sensor network by TCP/IP-based Ethernet.

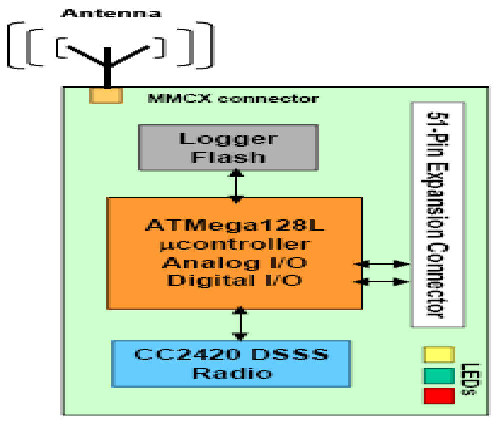

Figure. 2. Hardware Framework of MICAz

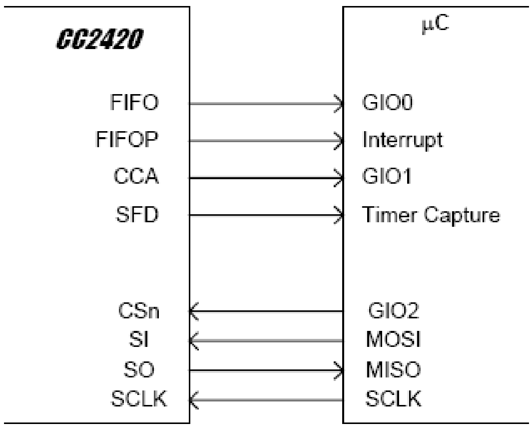

Figure 3. Link between CC2420 and Micro controller.

PROTOCOL ARCHITECTURE SCHEME FOR WSN

One reason that makes the implementation of wireless networks in general and wireless sensor networks in particular so challenging is the need to exchange information between functionalities that belonged, in the traditional ISO/OSI model, to different protocol layers. A simple example is link-layer triggering for handover in cellular networks, transmission power- aware routing protocols in ad hoc networks, and the multitude of mutual influences of protocol functionalities in wireless sensor networks. In such a situation, the reuse of communication protocols, especially from a third party, is challenging.

Ideally, individual "building blocks" for wireless sensor network protocols should be identified and implemented separately, with different ideas for the mechanisms realizing the desired functionalities. These building blocks would pass packets between each other, but also exchange meta-information, e.g., concerning the topology of the network or about the geographic position of individual nodes. In this sense, there will be building blocks that are predominantly engaged in packet exchange (e.g., a link layer building block) while others will be mostly tasked with the collection and computation of Meta information (e.g. building block that provides estimates about a sensor node's position).

When trying to structure a WSN protocol suite along these lines, identifying the most relevant building blocks and their most important packet passing and information exchange relationships, a structure like the one in Fig 1 is a possible outcome (depicting an intermediate state of the EYES project's architecture discussion). This approach results in two challenges: How to organize the passing of a packet to the correct next building block; the second challenge is how to then organize the information exchange between building blocks. The first challenge is akin to the same problem in conventional protocol stacks with well-known solutions like packet filters which should also be applicable here. The second one is more difficult since it is neither clear *when* information is required from another building block nor *to whom* to deliver information. As an example, a building block for location estimates might be used by additional building blocks even after this block has been completed. Hence, a separation of communication in time and space is required—the publish/subscribe model is doing exactly this. Providers of information publish it under a given "name", users of information can subscribe to such names and be informed of any value changes.

One example for such a name would be RSSI: the physical layer could publish this information, and any layer that is interested in it could subscribe to it. One practical implementation concept for such a publish/subscribe structure is a "blackboard", where each building block can "write down" values for a given name and where a building block can post a callback for a given name to be invoked when a value for this name is initialized or changes.

APPLICATIONS OF WSN

Structural Health Monitoring – Smart Structures

Sensors embedded into machines and structures enable condition-based maintenance of these assets. Typically, structures or machines are inspected at regular time intervals, and components may be repaired or replaced based on their hours in service, rather than on their working conditions. This method is expensive if the components are in good working order, and in some cases, scheduled maintenance will not protect the asset if it was damaged in between the inspection intervals. Wireless sensing will allow assets to be inspected when the sensors indicate that there may be a problem, reducing the cost of maintenance and preventing catastrophic failure in the event that damage is detected. Additionally, the use of wireless reduces the initial deployment costs, as the cost of installing long cable runs is often prohibitive. In some cases, wireless sensing applications demand the elimination of not only lead wires, but the elimination of batteries as well, due to the inherent nature of the machine, structure, or materials under test. These applications include sensors mounted on continuously rotating parts, within concrete and composite materials, and within medical implants.

Industrial Automation

In addition to being expensive, lead wires can be constraining, especially when moving parts are involved. The use of wireless sensors allows for rapid installation of sensing equipment and allows access to locations that would not be practical if cables were attached. In this application, typically ten or more sensors are used to measure gaps where rubber seals are to be placed. Previously, the use of wired sensors was too cumbersome to be implemented in a production line environment. The use of wireless sensors in this application is enabling, allowing a measurement to be made that was not previously practical. Other applications include energy control systems, security, wind turbine health monitoring, environmental monitoring, location-based services for logistics, and health care.

Civil Structure Monitoring

One of the most recent applications of today's smarter, energy-aware sensor networks is structural health monitoring of large civil structures, such as the Ben Franklin Bridge, which spans the Delaware River, linking Philadelphia and Camden, N.J. The bridge carries automobile, train and pedestrian traffic. Bridge officials wanted to monitor the strains on the structure as high-speed commuter trains crossed over the bridge.

A star network of ten strain sensors were deployed on the tracks of the commuter rail train. The wireless sensing nodes were packaged in environmentally sealed NEMA rated enclosures. The strain gauges were also suitably sealed from the environment and were spot welded to the surface of the bridge steel support structure. Transmission range of the sensors on this star network was approximately 100 meters.

Wireless Sensor Networks: Principles and Applications

The sensors operate in a low-power sampling mode where they check for presence of a train by sampling the strain sensors at a low sampling rate of approximately 6 Hz. When a train is present the strain increases on the rail, which is detected by the sensors. Once detected, the system starts sampling at a much higher sample rate. The strain waveform is logged into local Flash memory on the wireless sensor nodes. Periodically, the waveforms are downloaded from the wireless sensors to the base station. The base station has a cell phone attached to it which allows for the collected data to be transferred via the cell network to the engineers' office for data analysis. This low-power event-driven data collection method reduces the power required for continuous operation from 30 mA if the sensors were on all the time to less than 1 mA continuous. This enables a lithium battery to provide more than a year of continuous operation. Resolution of the collected strain data was typically less than 1 micro strain.

CONCLUSION

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. In this paper we have made a study on WSN, structure and application of WSN. In future we can develop a sensor network for small application that will enable us to understand more on WSN.

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