Generating testbed for wireless sensor nets

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The development of ICs, microelectromechanical systems (MEMS) and communication theory has paved the way for the emergence of wireless sensor networks with hundreds or thousands of self-sufficient sensor nodes. Each node has the ability to sense elements of its environment, perform simple computations and communicate either among its peers or directly to an external observer. Because of the large number of nodes in such a network, sensors can collaborate to perform high-quality sensing and form fault-tolerant sensing systems. With these advantages, many applications have been proposed for distributed, wireless microsensor networks such as reconnaissance of opposing forces and terrain, intelligent building, biological and chemical attack detection and environmental control in office buildings.

In order to build well-functioning, robust systems, many challenges need to be dealt with. Due to its unique features, wireless sensor networks will have different challenges and design constraints than the existing wireless networks. For example, since the deployment of the sensor nodes is dense, large-scale data management and processing techniques will be needed. Also, a number of inaccessible and unattended sensor nodes, which are prone to frequent failures, make topology maintenance a challenging task.

The energy consumption of the underlying hardware is also important. The wireless sensor node, being a microelectronic device, can only be equipped with a limited power source (<0.5Ah, 1.2V). In some applications, replenishment of power resources might be impossible. Sensor node lifetime, therefore, shows a strong dependence on battery lifetime.

Since reducing energy consumption to prolong system lifetime is a primary consideration in wireless sensor network, many researchers focus on the design of energy-saving protocols and algorithms. A testbed is needed to evaluate these; otherwise, they may run the risk of designing non-effective protocols or algorithms.

In this paper, we introduce a testbed for the protocols and algorithms in the wireless sensor network.

Net testbed

In general, a wireless sensor network consists of sensor nodes and the manager node. The manager node is used to combine the data from the sensor nodes and communicate to the outside. An embedded system operates in the node.

The sensor nodes detect physical parameters of interest, such as acoustics, light, distance etc., process these data and collaborate with other nodes to transport the data to the manager node. There are two operational modes to fit the possible applications arising from the wireless sensor networks: active polling as well as passive detection and notification. For a reading of a sensor, the node acting as sink can actively ask for the information (active polling), or request to be notified when an event is detected by one of the nodes (passive notification). The data obtained by the sensors can also be combined, which can significantly improve network efficiency. This demands the sensor node to have computing abilities.

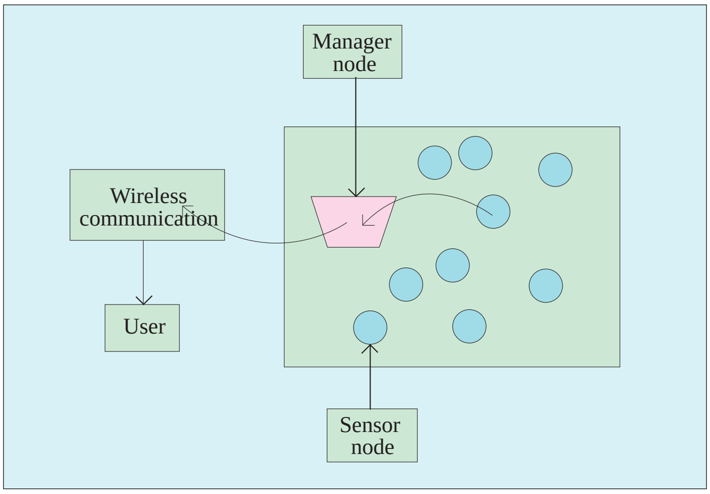

Figure 1: The architecture of the wireless sensor network consists of sensor nodes and the manager node.

A wireless sensor node mainly consists of five parts: power unit, sensor interface, wireless communication unit, computing unit and storage unit. Several factors must be considered in the hardware design of the sensor node in a wireless sensor network testbed. These factors include energy efficiency, size, cost and ease to expand.

Since the wireless sensor network often works in an inaccessible environment, the battery cannot be changed so often. That demands the energy cost of the sensor node to be low. The sensor nodes are often deployed densely, so the cost and size of the sensor node must be low. Since technology is dynamic, the sensor node must be easy to modify to meet the increasing technology demand.

The component used in the computing unit of the sensor node is an MSP-430F149, a microprocessor from Texas Instruments. It is a 16bit processor with 60KB program memory and 2KB data memory. When running at full speed (5MHz), the processor consumes approximately 1.5mW. Besides on-chip memory and various low-power features, the microprocessor also facilitates A/D and I/O lines that can be easily controlled by software. These lines will be used as interface to the sensors.

The communication function between nodes is realized by an nRF903 single-chip RF transceiver. It has low power consumption and is small sized, suitable for wireless sensor network applications. The nRF903 is a multichannel UHF transceiver designed to operate in the unlicensed 433MHz, 868MHz and 915MHz low power radio device bands. It features both Gaussian minimum shift keying and Gaussian frequency shift keying modulation and demodulation

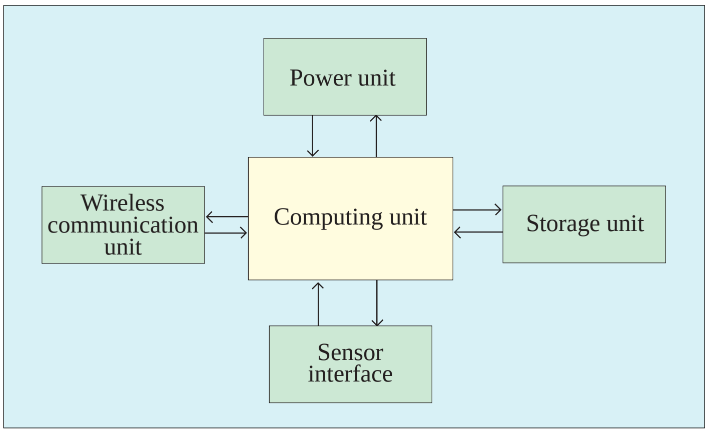

Figure 2: The architecture of the wireless sensor node consists of the power unit, the sensor interface, the wireless communication unit, the computing unit and the storage unit.

schemes at an effective bit rate of 76.8Kbps for 153.6kHz channel bandwidths. The transmit power can be adjusted to a maximum of 10dBm. The antenna interface is differential and suited for low cost PCB antennas. All necessary configuration data are programmed by a 14bit configuration word via a serial peripheral interface.

The multichannel operation and excellent receiver selectivity makes nRF903 suitable for wireless links where high-reliability is a key requirement. The transceiver operates from a single 3V DC supply and features power down and standby modes that make power saving easy and efficient.

The nRF903 allows its transmission power to be adjusted by its input current. This feature has the following advantages:

- Allows a node to adjust the number of neighboring nodes it can reach and hence allows the network to be scalable;
- Reduces energy consumption in communicating with relatively close neighbors;
- Assists in detecting collisions in the wireless channel;
- Determines the relative position of a node in the network.

The manager node mainly consists of a CPU, memory unit, RF transceiver module and communication unit. The CPU is used to process the data collected from the sensor nodes. The primary component of the CPU is an Atmel AT91RM9200 microprocessor. The AT91RM9200 is a complete SoC built around the ARM920T ARM thumb processor. It incorporates a rich set of system and application peripherals and standard interfaces, providing a single-chip solution for a wide range of compute-intensive applications that require maximum functionality at

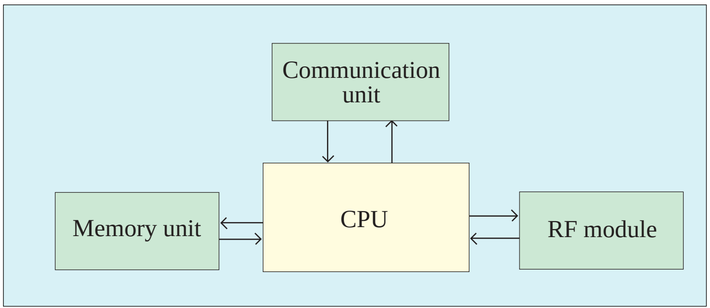

Figure 3: The hardware architecture of the manager node consists of a CPU, memory unit, RF transceiver module and communication unit.

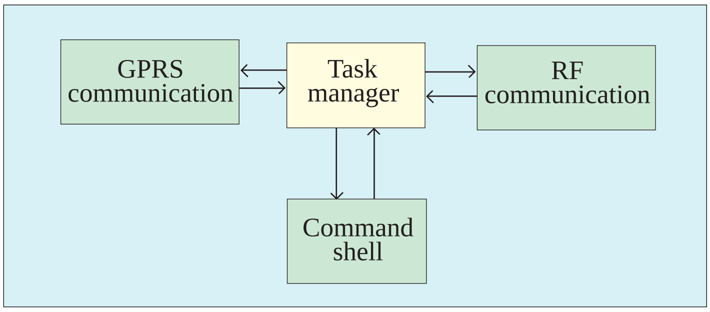

Figure 4: The software architecture of the manager node. The main system consists of the command shell, GPRS communication unit, RF communication unit and the task manager.

minimum power consumption and lowest cost.

The AT91RM9200 integrates variety of standard interfaces, including USB 2.0 Full Speed Host and Device and Ethernet 10/100 base-T media access controller (MAC), which provide connection to a range of external peripheral devices and a widely-used networking layer. Also, it provides an extensive set of peripherals that operate in accordance with several industry standards, such as those used in audio, telecom, flash card, infrared and smart card applications.

In order to communicate outside, the manager node has a GPRS communication unit, which mainly consists of a Sony-Ericsson GM47 module. The manager node can be connected to the GPRS network through this module. Users can observe the situation of the wireless sensor network with a GPRS mobile phone. An RF module of the manager node is used to communicate with the sensor nodes.

Aside from the hardware part, an embedded OS must be implemented in the manager node so that the CPU can process and manage the data collected from the sensor nodes. The main system consists of the command shell, GPRS communication unit, RF communication unit and the task manager.

Linux was adopted to meet the software demands. Linux comes equipped with a full TCP/IP stack and support for numerous other networking protocols. It is also equipped with a PPP stack, which supports the GPRS. Because of its open-source feature, application can easily be developed in the platform. □