Proposal for Embedded Ethernet Wireless Gateway Board

In order to fully utilize current wireless sensors networks (WSN), data needs to be collected and organized so that it can be studied. Data may be gathered in field research, such as farmers crops, and stored into a database to be analyzed. The University of California at Berkeley has created small ad-hoc\(^1\) wireless sensors (Motes)\(^2\) that can monitor their surroundings, and relay the data back to a base node. The base node is usually connected through a RS-232 serial port to a desktop computer, which can then forward the data onto a standard Ethernet\(^3\) network. This use of a PC to interface the sensor network\(^4\) and the Ethernet network is expensive, and also consumes a huge amount of power and space.

Only recently has an alternative to the desktop computer interface been developed, and as of August 2003, it is still not available for purchase. The device is called the Stargate, and will have several interfaces, including Ethernet, PCMCIA, and RS-232. When this device does become available, it will have several drawbacks such as the cost and the overall size of approximately 8 cm by 10 cm. The manufacturers of the Stargate estimate its final cost to be in the range of $400 to $500.

The University of Vermont (UVM) has developed wireless sensors which perform the same sort of tasks as the Motes from Berkeley. These sensors also require a gateway connection to a standard Ethernet network. It is possible to interface with a RS-232 serial port on the desktop computer, but this is a clumsy method of attaching the wireless nodes to the wired network.

The work proposes the design of a Wireless Gateway Board (WGB). The objective of the proposed work is to provide a means of connecting a WSN to the Internet. The WGB is a small embedded Ethernet board will access the data stored on the wireless sensor, and forward it over the Ethernet network to a PC, so that it can be organized in a database for future use.

The wireless gateway board will be capable of using the new IEEE standard (802.3af), Power over Ethernet (PoE). PoE utilizes pins 4, 5, 7, and 8 of ordinary Category 5 network cable. This cable is composed of 4 pairs of wire, and normally uses 1, 2, 3, and 6 for data at 10/100 Mbit/s. PoE has the advantage of allowing the power supply for the device to be placed at the same location as the data equipment. An example of a situation that would support this new technology is the placement of the gateway board on the roof of a building. The wireless sensor board that connects to the gateway board would benefit

\(^1\) ad-hoc networks are not centralized. Data can hop around through any route to get to a destination. This is also called a “peer-to-peer” network.
\(^2\) Motes are small wireless sensor boards, based on the Atmega128L microcontroller. More info at www.xbow.com.
\(^3\) Ethernet is a shared network that connects multiple computers together, typically at speeds of 10Mbit, 100Mbit or 1Gbit. Traditional Ethernet uses Carrier Sense Multiple Access with Collision Detection CSMA/CD.
\(^4\) A sensor network is a group of sensors (nodes) that communicate among each other using wireless radios. The Motes, and the UVM wireless sensors both operate at 433MHz, part of the ISM Band. Ex. in fig 1.
from the high altitude line-of-site location on the roof. A single cable could be run from the roof to any room in the building where the data and power equipment are located.

Many devices currently claim to have PoE capability, but most are not compliant with the actual standard, which calls for 48V DC. Common voltages are 5V, 12V, or 24V for non-standard compliant PoE. The wireless gateway board will use a 48V to 5V DC-DC converter, so that it can be deployed up to 100 m from the power source.

The proposed wireless gateway board will be very small, at only 3cm wide, by 6cm long. The small footprint is achieved using a two board design. One board will contain the Ethernet hardware, and the other board will contain the microcontroller hardware. The two board design also aides in development of the gateway by allowing the two separate boards to function independently so that the proper operation of each can be verified.

By using a two board layout, the Ethernet board can be easily adopted to meet different sensor architectures. For the UVM WSN, PIC Microcontrollers manufactured by Microchip Technology Inc. are used for the wireless sensors. A similar microcontroller will be used on the gateway board so that data can be transferred more efficiently from the wireless sensors. If the design of the UVM wireless sensors changes to include a different microcontroller, only the microcontroller board of the wireless Ethernet gateway will need to be modified to accommodate the change. Motorola, Atmel, and Cygnal all manufacture microcontrollers that would be well suited as wireless sensors. To anticipate possible changes that might occur as the UVM WSN evolves, a microcontroller board for the Cygnal 8051 chip will be designed.

One of the major problems with current wireless sensors networks is cost. Wireless networks are significantly cheaper to deploy than a wired alternative, but they still need to become more affordable for widespread use to occur. The wireless gateway board will be very inexpensive to manufacture, even in low quantities. This is due not only to its relative simplicity to a full desktop computer, but also to the specific choice of inexpensive parts.

The size of a WSN will be limited by the range of the radios on the nodes and the amount of data each node is capable of forwarding before becoming saturated. Scenarios, such as three WSN, each 100 meters in diameter, but over 2 Km apart, demand a hierarchal network. One that can forward data over long distances, but also use extremely low power over short distance.

Wired Ethernet has some of the same limitations of wired sensor networks, since it has to be connected to the rest of the network through copper wiring. The wiring might have to be pulled through conduit, or hung from poles, either method is slow, and expensive. Wireless Ethernet is classified by the 802.11b standard, and uses the radio spectrum at 2.4GHz to transmit data. Low cost wired Ethernet to wireless Ethernet bridges are available, and are capable of sending data 10Km or more under optimum conditions. This benefit is at the expense of significant power consumption, on the order of 5 to 50 times more than the WSN.
The wireless gateway board will allow data to be reliably relayed from a wireless sensor network, to a wired or wireless high-speed Ethernet network, and ultimately to a database on a desktop computer.

Once the data has been entered into a database it can be used for nearly any application. The most convenient method would be a web interface, possibly driven by PHP\(^5\). Any user that requires information that the database is storing could view it in a table or graph form which would be generated by the web server. Any number of variables could be isolated or compared using a menu-based web interface.

\(^5\) PHP is a widely-used general-purpose scripting language that is especially suited for Web development and can be embedded into HTML. More information at: http://www.php.net