Poster Abstract: Architecture of a scalable wireless sensor network for pollution monitoring

Karl Baumgartner
University of Applied Sciences of Western Switzerland
IICT
CH-1401 Yverdon
+41 (0)24 557 64 72
karl.baumgartner@heig-vd.ch

Stephan Robert
University of Applied Sciences of Western Switzerland
IICT
CH-1401 Yverdon
+41 (0)79 567 98 35
stephan.robert@heig-vd.ch

ABSTRACT

Pollution is nowadays emerging as a major threat for the human being. Cities' sizes are increasing, as well as the number of inhabitants living in urban areas. Therefore, air pollution monitoring becomes an important concern for the scientific and political world. This paper describes a scalable architecture for monitoring air pollution in large areas where collected data will be represented through an Internet interface. The proposed solution is based on the presence of multiple sinks in the Wireless Sensor Network (WSN).

Keywords

Wireless sensor network, ad-hoc network, Cluster-based routing, Pollution monitoring, collecting data.

1. INTRODUCTION

Environmental monitoring has generated a large amount of information for scientists. The purpose of this experience is to improve our knowledge about the impact on nature of human being. Data are collected by sensors, which are usually measuring temperature, humidity or air pressure. However, any sort of gas may be monitored for the need of a specific project. Fifteen years ago, the only suitable way to centralize information coming from sensors was the use of cables. This was an important barrier to the development of sensor networks. Nowadays, Wireless Sensor Networks have permitted new way of research. The nodes are organized on an ad-hoc wireless architecture (no fixed infrastructure is employed). Sensor networks often have a root point called sink where data are collected. The radio coverage of each node is usually not large enough to reach a sink. Hence, the nodes have implemented a protocol called Multi-hop routing to allow them to send information to the sink via other nodes [1]. The large size of our sensor network forces us to employ multiple sinks.

This poster describes and discusses an architecture for implementing a solution to centralize data from the multiple sink. We proposed a solution and practical tools which collects the sensor measurements and dispatches them through a TCP/IP-based network. The node sink is connected to an embedded computer via the RS232 port where the data are temporary stored inside a database. Then, the data saved in every sinks are sent to the centralized database server.

Existing solutions have already been described. In [2], where an argument against data centralization is given, multi-hop routing is not used and the data are only accessible from a specific location. This type of architecture may be set up for military operation or disaster recovery for instance. Furthermore, there is an interesting discussion about Multiple-sink sensor networks in [3] where a logical graph model has been developed to adapt a mono-sink architecture to a multi-sink architecture, which decreases significantly the energy consumption of each node. However, no new protocol has been effectively designed.

2. Hardware

The most important element of the project infrastructure is the nodes which should implement the wireless communication to the sensors. We want to use materiel which supports TinyOS and have a low consumption. Tinynode 584 with its extension board (Figure 1) manufactured by Shockfish matches exactly our needs.

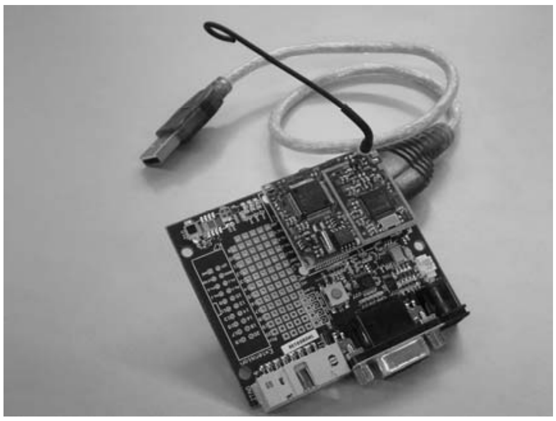

Figure 1: Tinynode and Standard Extension Board

The microcontroller is an MSP430F1611 (Texas Instrument) with 10 kB of RAM, 48 kB of flash and 128 B of memory. The CPU is a low power 16-bit RISC with 16 bit register. Wireless transceiver: Xemic XE1205 with the following key features: RF output power up to 15 dBm (programmable), high sensibility down to -121 dBm at 1.2 kbit/s, bit rate up to 152.3 kbit/s, continuous phase 2-level modulation, operate in the 433, 868 and 915 MHz (but tinynode 584 only use the 868), low-consumption and many other useful features as RSSI (Received Signal Strength Indicator). Furthermore, this material is optimized to run TinyOS and is based on an ultra low power 3 V design. The interface RS-232 and Jtag (principally used for debugging) are present on the extension board.

3. Architecture

The architecture of this sensor network is described in Figure 2. The data coming from the sensor are routed to the sink node via the multi-hop routing protocol. Then, the sink nodes transmit the messages through the RS-232 interface to an embedded computer called sink computer (the sink node and the sink computer are geographically at the same location). Every sink computer is connected to the Internet network, which allows them to transmit the sensor information to a centralized database server. For this purpose, several different ways to do it are possible. It slightly depends on the geographical location of the sink and the physical available communication infrastructure. Four standard technologies have been used: GPRS access, ADSL access, Satellite access or direct connection with Ethernet.

For all these solutions, the TCP/IP stack has to be implemented. Consequently, an embedded PC implementing the TCP/IP stack has to be part of the sink. Also, the data will have to be buffered inside this computer in case of failure or disconnection of the TCP/IP network. For this reason, a database (Mysql) has been used. Finally, the port RS232 will interface between the embedded computer and the node. The programming language which has been used is Java, principally because of its portability. Furthermore a large number of APIs are available, which reduces the development time. Globally, the sinks collect the data coming from the ad-hoc network and store them into local databases. Periodically, data are sent to the centralized database server through the TCP/IP stack. During the whole process the integrity of data is guaranteed.

The database server collects the information coming from the multiple sinks. It is important to note that it is always the designated sinks that will set up the connection to the server. This is because the sinks will probably be hidden behind a Network Address Translation (NAT) server which shares a single IP address to many end users. Then, the General Manager is the tool used to control and manage the totality of the architecture. This application will be a kind of log centre. Every log message generated by the sink application will be automatically sent to it. Another functionality of General Manager is to control the Wireless Sensor Network where many parameters may be changed. And finally, the server database can be accessed easily and user-friendly from anywhere on the Internet.

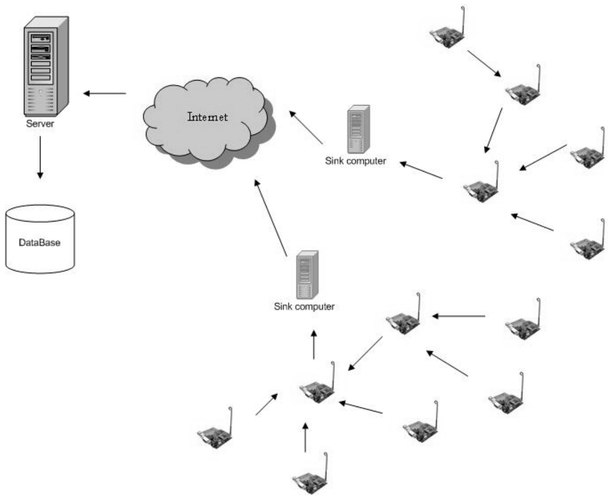

Figure 2: Architecture of data acquisition of the WSN using multiple sink and a centralized database

4. Conclusion

Our solution copes exactly for the requirement of such large network implementations. Another important innovation of our proposal concerns its adaptability to any sort of high level applications. The main difference with existing solutions is the presence of an embedded computer which shares the work and the intelligence with the centralized database server. The architecture has still to be tested with a real pollution monitoring application. The next step of this project is to integrate pollution sensors (NO_2 and O_3) with the TinyNodes.

5. Acknowledgment

This work was supported by the MICS (Mobile Information & Communication Systems) and the IICT (Institute for information and communication technologies)

6. References

[1] A. Woo, T. Tong, and D. Culler, "Taming the underlying challenges of reliable multihop routing in sensor networks", In Proceedings of the 1st international Conference on Embedded Networked Sensor Systems (Los Angeles, California, USA, November 05 - 07, 2003). SenSys '03. ACM Press, New York, NY, 14-27.

[2] C. Curino, M. Giani, M. Giorgetta, A. Giusti, A.L. Murphy, and G.P. Picco, "TinyLime: Bridging Mobile and Sensor Networks through Middleware", In Proceedings of the 3rd IEEE International Conference on Pervasive Computing and Communications (PerCom), Kauai Island, Hawaii, USA, March, IEEE Computer Society, pp. 61-72, 2005

[3] A. Das and D. Dutta, "Data acquisition in multiple-sink sensor networks", SIGMOBILE Mob. Comput. Commun. Rev. 9, 3 (Jul. 2005), 82-85.