Smart Sensors with PC Connection in Wireless Networks

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Abstract: Paper deals with present state in the development of wireless smart sensor networks – (nodes), trends and new challenges from this interesting area. The high priority of this smart instrumentation there is the best operating ability sensor nodes with suitable protocol communication (for instance Zig Bee). New type of smart sensors nodes with wireless connection bring some advantages and also disadvantages. There are problems with communication protocols, interaction between different nodes, and main problems there are the power supply of the sensor instrumentation nodes. To the main advantages of smart instrumentation belong local signal processing with duplex communication, compact devices form, function auto testing and data validation, possibility to connecting to ILAN and wireless ILAN. Some experience with wireless sensors (ZigBee nodes and USB sensors) on communication with PIC microcomputer will be presented and will be shown the interesting possibilities for another development.

Key-Words: - microcomputer, smart sensor, wireless instrumentation, ZigBee, sensor node, USB sensor, measurement,

1 Introduction

The rapid development and emergence of smart sensors even intelligent instrumentation and field network technologies have made the networking of smart transducers (sensors and actuators) a very economical and attractive solution for a broad range of measurement and control applications.

Traditional sensor network nodes (also called "motes") have been built around low-end 8-bit microcontrollers and simple single channel radios. These limitations were imposed by constraints on cost, power consumption and physical size [AL-ALI, etc., 2005], [BOND, 2005].

ZigBee is a PAN technology based on the IEEE 802.15.4 standard, unlike Bluetooth or wireless USB devices, Wireless communication protocols like 802.11, ZigBee and Bluetooth are all ad hoc protocols which provide convenient interoperability but also exposed the communication system to significant security risk. ZigBee is connected with a Direct Sequence Spread Spectrum (DSSS) protocol, a self-configuring protocol which means that everyone knows where it is and a “denial of service” attack is easy to do. Frequency Hopping Spread Spectrum (FHSS) – the communication spectrum is spread over different frequencies, it keeps randomly hopping and the code is hidden. This technique has been the backbone of the military's communication security technique because it adds security and ensures that noise interference at any one frequency does not block the communications.

The range is also short and must rely on multi-hop which is complex and a recipe for disaster in a process plant, see Fig. 1 and Fig. 2.

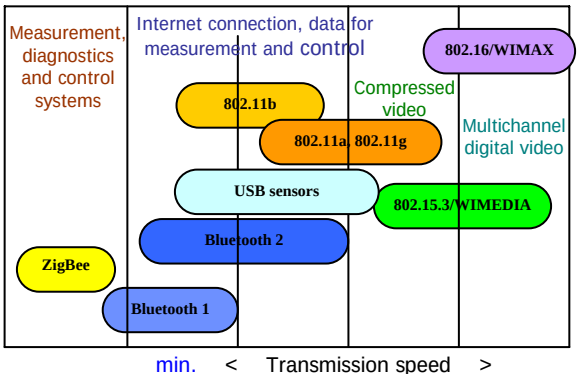


Figure 1. Comparison of wireless technologies

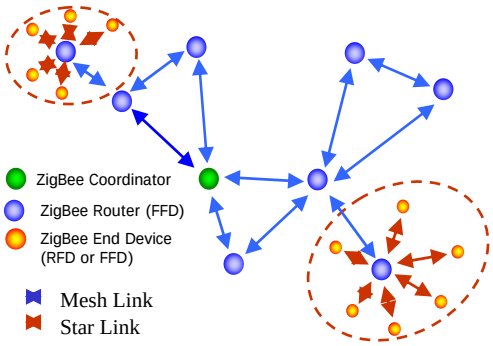


Figure 2. Example of ZigBee sensor node with RFD and FFD devices

ZigBee devices have the ability to form a mesh network between nodes. These protocols also have significant overhead that consumes both power and bandwidth. The IEEE 1451 standard as an another example of sensor net provides a basic communications link for sensor nodes, but provides no methods specific to programming a node's data processing resources. An interface must be defined for dynamic programming of sensor nodes.

Smart Dust began as a concept for millimeter-scale wireless sensor nodes (1994). In 1998 macro versions of smart dust motes were demonstrated, which inspired tremendous innovation and application in the embedded software community.

In 2001 the first autonomous millimeter scale motes were demonstrated using MEMS and IC technology. Nano-enabled motes, if not completely nano-motes, were demonstrated in 2003.

Commercialization of these three different technology scales appears to be proceeding with a lag of three or four years.

2 Problem Formulation

Rapid development of industrial applications imposes more challenges on traditional sensors that only provide raw signal. As a trend, smart sensor network there are getting more attention in industrial areas for the values they can bring into the system. One way or another, sensor data will ultimately be used for control purpose. Smart sensor and smart sensor networks will go beyond raw signal and/or data, and provide certain level of information and/or knowledge, which can significantly improve the overall control system performance and reduce reliability [JURIAN, LITA, 2008], .

Embedded Networked Sensing Systems will become a pervasive resource for society - they will monitor contaminants in soil, air and water; support detailed characterization of carbon cycling and endangered ecosystems; and serve as early warning systems for critical civil infrastructure.

3 Problem Solution

The power consumption in wireless sensor networks is one of the main issues when designing sensor nodes. Furthermore the available energy density of batteries for a given battery size and the difficulty of recharging possibilities limits the life cycle of sensor nodes.

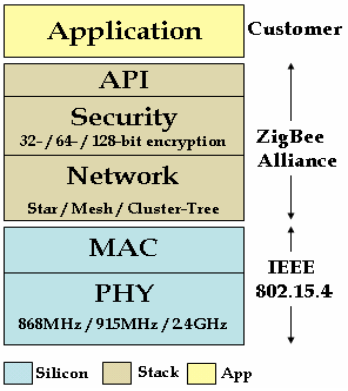


Figure 3 IEEE 802.15.4 & ZigBee layers of protocol stack.

Multiple access methods will help to expand the operational life cycle of sensor nodes by reducing their power consumption. ZigBee's RF power specification comes from IEEE 802.15.4, which specifies a minimum power output rating of 1 mW, with no specified maximum. The de facto 100 mW "high power" level relates to the European limit of 100 mW EIRP, including antenna gain (see Fig. 3). The much longer ranges make these products suitable for industrial applications in large factory settings and in outdoor installations. Wireless sensor networks (WSNs) dramatically reduce the cost of installing and commissioning instrumentation in industrial facilities [DECHAO, SHAOHUA, 2009].

Wireless sensor Mote technology consist there are devices that incorporate communications, processing, sensors, sensor fusion, and power source into a package currently about three cubic centimeters in size - networked autonomous sensor nodes. The Motes are simple, robust, and are designed to be built from readily available components.

On the next Figure 4 we can see the Zig Bee demo kit for basic experimental tasks and PDA Pocket LOOX with GPS module on the Department of Control Systems & Instrumentation laboratories of VŠB-TUO [SMUTNÝ, L. etc. 2006].

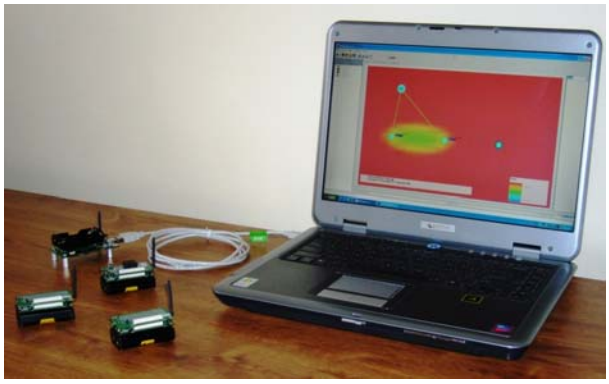


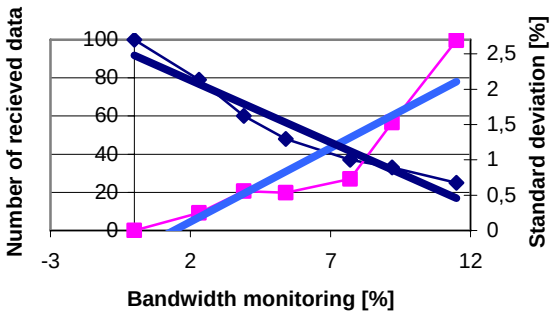
Figure 4 Wireless sensor system MOTE - Basic Kit with program support SCADA

MOTE-KIT400 is the basic experimental kit for basic task solution, with program support Tiny OS.

The radio technology used in such cases depends on the dimension of this monitored area, distance between sensors and base station with processing unit, the power constrain and also depends on the quantity of data acquired from the sensors. In function of these factors can be used short range transmission technologies such as ZigBee, Bluetooth, WiFi or, for long distances and better mobility, can be used GPRS and WiMax solutions.

The problems of right ratio between sampling hysteresis bandwidth and quality of data sets are shown on the Fig.5 for temperature an humidity wireless smart sensors. This results there were obtained with Crosbow Mote kit on Department CSI VSB-TU Ostrava [SMUTNÝ L., BALSANEK M., WOJCIASZYK, P. 2006].

The current trend in remote data acquisition, supervisory and control systems is to use wireless sensor network (WSN) distributed in the area monitored area.



Dependence of number received data (rhombs) and standard deviation (squares) with monotoring bandwidth
Linearisation of dependences (black, blue line)

Figure 5 Relationship between signal bandwidth and received data quality of temperature smart sensor

4 Conclusion

Wireless sensor networks are becoming a nexus of activity within the computer science community. The realization of a practical smart sensor system requires the synthesis of several technologies. Smart sensor combining with embedded metadata and wireless technology presents real opportunities for significant improvements in reliability, cost-benefits, and safety. Adding robust and self-construct network protocol for routing will further simplify testing installation process and increase test network reliability. One must bring together knowledge in the fields of sensors, data processing, distributed systems, and networks.

The smart sensor array design allows for a high population of nodes within a field because of the relatively low cost of the nodes. USB connection has been widely accepted as a serial bus for home applications. In an industrial context, USB is not diffused since it lacks transducers and some safety options, but the first USB sensors there are used now [DEPARI, etc., 2008].

By comparison of wireless technologies Bluetooth and ZigBee seems to fit better in industrial application scenarios where limited bursts of data need to be delivered in real-time in a noisy environment. Wi-Fi and USB connection (wire or wireless) seems to fit better in scenarios where huge amount of data need to be transmitted in a less noisy environment. Experiences from practical lab exercises on the Department of CSI VSB-TO Ostrava confirm increasing motivation of students, better interconnection of theoretical knowledge with practical experiences and skills.

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