LR-WPAN technologies. An approach to industrial applications.

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***Abstract*— Wireless communication supposed a great both - quantitative and qualitative, jump in the management of the information, allowing the access and interchange of it without the need of a physical cable connection. The wireless transmission of voice and information has remained in constant evolution, arising new standards like Bluetooth™, Wibree™ or Zigbee™ developed under the IEEE 802.15 norm.**

These newest wireless technologies are oriented to systems of communication of short-medium distance and optimized for a low cost and minor consume, with the aim of its integration in mobile devices or embedded systems, being stablished as the technology of the future for small nets or systems of captation of information.

Wireless connectivity has become recognized as a flexible and reliable medium for data communications across a broad range of applications - not only where a wired communication is difficult or impossible by physical or economic causes, like remote sensing and control, security systems, AMRs, …, and its extension to industrial, enviromental or home applications; due to the potential that the WSNs presents to operate in demanding environments providing clear advantages in cost, size, power, flexibility, and distributed intelligence.

In this paper, the role of the LR-WPAN technologies for industrial applications is presented and discussed.

Keywords: WPAN, Wireless, Bluetooth, Wibree, Zigbee, Industrial applications.

I. INTRODUCTION

Wireless connectivity is fast becoming recognized as a flexible and reliable medium for data communications across a broad range of applications: industrial, medical, home and buildings applications, … RF can take over where wired communication is difficult or impossible. Embedded or stand-alone radios can talk to distant controllers, security systems, HVAC systems and more.

Also, because of the growing demand for distributed and remote sensing, data acquisition and control, the role of wireless communications only gets bigger. Sensor manufacturers are integrating RF systems in the same enclosure as their sensing devices. Data logger vendors are beginning to turn to wireless communications to enhance their products. And wireless networks are taking their place right next to traditional hardwired configurations. The industry is moving toward the implementation of networks of wireless sensors that can operate in demanding environments and provide clear advantages in cost, size, power, flexibility, and distributed intelligence.

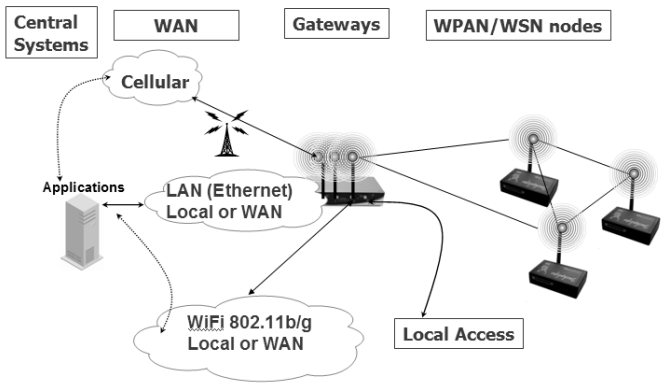

Figure 1. Wireless sensor network scenario

Data rates are fast enough for the majority of applications, the multipoint networking capabilities gives them a high potential for distributed control and the relative low power consumption enables RF for battery-powered applications.

We have seen that there are many advantages to eliminating cables in remote monitoring applications, but there are also many challenges: security, reliability, integration and power consumptions are all challenges that must be overcome before there is widespread adoption of wireless measurement systems in the industry and consumer applications.

II. WIRELESS TECHNOLOGIES

Among the newest wireless technologies (fig. 2), three wireless standards are likely to dominate the majority of remote sensing and control applications –Zigbee, Wibree&Bluetooth and Wi-Fi. Today Bluetooth and Wi-Fi dominate – Bluetooth for connections between portable devices and Wi-Fi for connections to fixed access points and IP infrastructure. Zigbee is emerging and can play a big role in a near future. In addition to these standards, for wide area

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connections mobile phone networks can offer additional features. GPRS/UMTS and Wi-Fi would fit as the end-point or gateways by excellence.

The above mentioned technologies gathers hardware, software and interoperability requirements, defining a global standard of wireless communication that makes possible the transmission of information among different equipments by means of a link of radio frequency.

The principal aims that are tried to obtain by these technologies are:

- To facilitate the communications among mobile and fixed equipments.
- To eliminate cables and conectors among these.
- To offer the possibility of creating small wireless nets and to facilitate the synchronization of information.

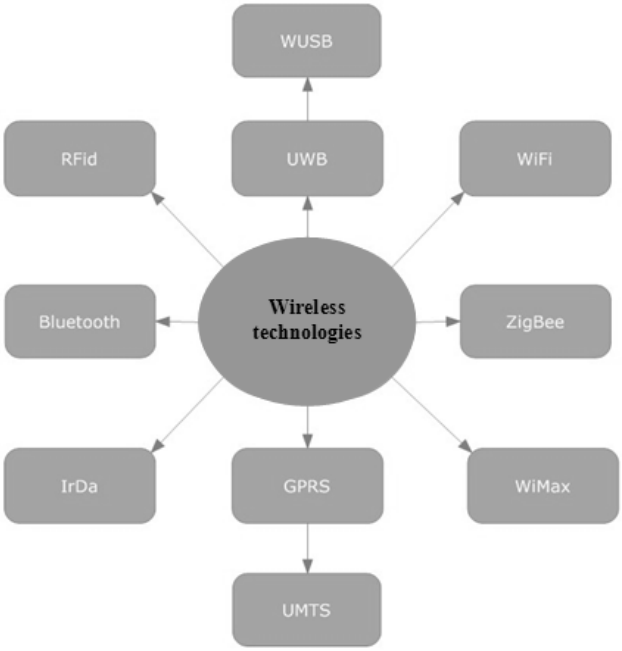

Figure 2. Main wireless technologies

Four primary parameters dictate the requirements of short range wireless technology for the vast majority of use cases:

- the range over which the device needs to operate,
- the amount of data that needs to be transferred,
- the frequency of these transfers – how often data needs to be sent, and
- the power available – typically whether it is battery or mains powered.

III. LOW RATE WPAN TECHNOLOGIES

Bluetooth™ is a technology oriented to systems of communication of short-medium distance and optimized for a low cost and minor consume, with the aim of its integration in mobile devices or embedded systems, being stablished as the technology for small nets or systems of captation of information. Bluetooth is already the world's most successful short range radio technology. Bluetooth's main features are listed below.

1) Topologies of connection

The connection between Bluetooth™ devices follows a master-slave scheme, supporting up to eight devices connected simultaneously in what is the basic structure of communication, called piconet. Also it is possible that the same device can take part of more than one piconet though it cannot be "active" in any more of one simultaneously; it is called a dispersed net or scatternet (fig.3).

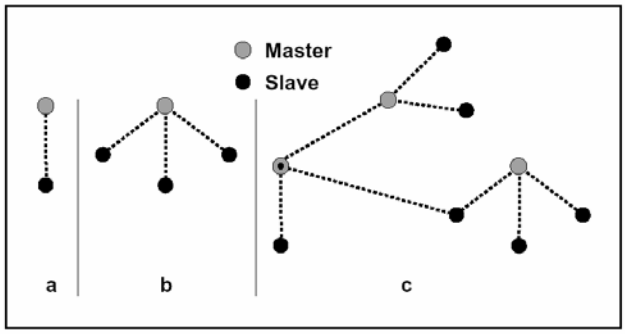

Figure 3. (a) Piconet with only one slave, (b) with several slaves, (c) scatternet configuration.

2) Types of links

In the Bluetooth™ Specification there are defined two types of links to support applications of voice and information: an asynchronous link without connection (ACL, Asynchronous ConnectionLess) and a synchronous link orientated to connection (SCO, Synchronous Connection Oriented). The links ACL support traffic of information without guarantee of delivery. The links SCO support voice in real time and multimedia traffic, using a reserved bandwidth.

3) Immunity to interferences

The radio link is very robust by itself. The spread spectrum is a technology of digital codification in which the signal is distributed or expanded. The result is a more robust signal, which is less capable of deterioration because of electromagnetic noises and other sources of interferences. Besides, the frequency hopping system make the wireless transmissions become moreover sure against scouts.

4) Security in Bluetooth ™

The Bluetooth™ Specification includes numerous characteristics of security. Uses functions at the level of link, as the authentication and the coding that cover the functionality and the application of the devices.

Wibree's main application is to provide an ultra low power radio within the 2.4GHz band, which comes built within Bluetooth chips (from June 2007 it became part of the

Bluetooth SIG family of standards). The low power of Wibree makes if suitable for a host of battery powered devices which can cover from sensor monitoring and control to Human Interface Devices (HID). Its ability to cohabit with a Bluetooth radio will ensure that it quickly achieves a critical mass in the market.

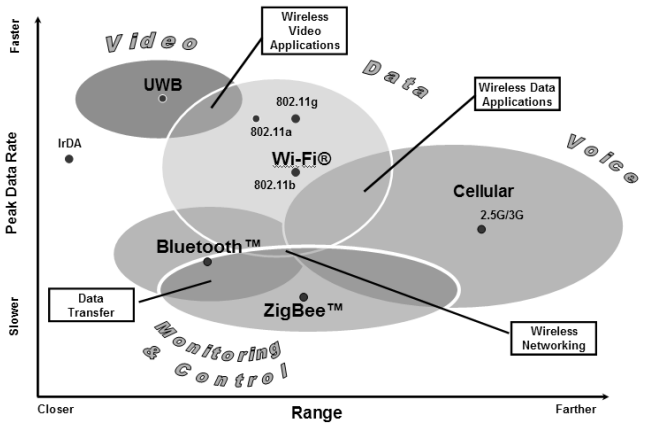

Figure 4. Wireless technologies. Application diagram.

Zigbee is a networking protocol that rides on top of the IEEE 802.15.4 radio protocol. Its main features are:

- Supported networks: point-point and point-multipoint/star and mesh.
- Types of nodes: coordinator, end node and routers.
- Reliable Delivery: CSMA/CA (Carrier Sense, Multiple Access, Collision Avoidance), MAC-level retries/acknowledgments, mesh level retries/ACKs.
- 64-bit IEEE and 16-bit short addressing.
- 16 DSSS(direct sequence spread spectrum) RF channels.

TABLE I. WIRELESS STANDARDS MAIN FEATURES COMPARISON.

Feature(s)	IEEE 802.11b	Bluetooth	Zigbee
Battery Life	Hours	Days	Years
Complexity	Very Complex	Complex	Simple
Nodes/Master	32	7	64000
Latency	Enumeration up to 3 seconds.	Enumeration up to 10 seconds	Enumeration up to 30 miliseconds
Range	100m-1000m	10m-100m	70m-1600m
Extendability	Roaming possible	No	Yes
RF Data Rate	11Mbps	1Mbps	250Kbps
Security	Authentication Service Set ID (SSID)	64-bit, 128-bit	128-bit AES and Application Layer user defined.

The technology for making wireless sensor nodes is largely in place. The low cost of the RF devices plus the good features in range, data rate, ad-hoc networks, … of the newest WPAN technologies are allowing them to penetrate in a massive way in all kind of applications, but the key element that is missing is a standarized means of passing the data among them in a mixed scenario, where different technologies are sensing in the same plant. Most use a proprietary method to record the information. These formats need to be standardised. At this point, the IEEE 1451 performs the way to achieve this issue.

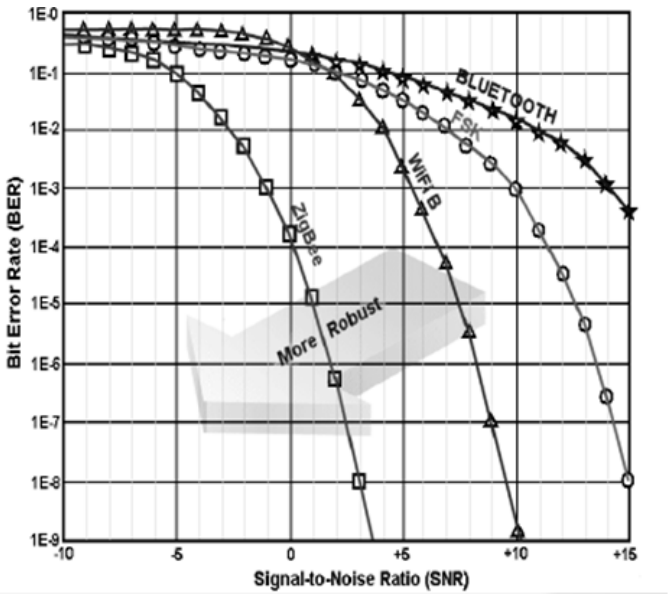

Figure 5. *BER vs SNR for main WPAN technologies*

IV. IEEE 1451. STANDARD FOR A SMART TRANSDUCER INTERFACE FOR SENSORS AND ACTUATORS.

Transducers, defined here as sensors or actuators, serve a wide variety of industry's needs, manufacturing, industrial control, automotive, aerospace, building, and biomedicine are but a few. Since the transducer market is very diverse, transducer manufacturers are seeking ways to build low-cost, networked smart transducers.

Many sensor control networks or fieldbus implementations are currently available, each with its own strengths and weaknesses for a specific application class. Interfacing the smart transducers to all of these control networks and supporting the wide variety of protocols require very significant efforts and are costly to transducer manufacturers.

However, using digital communication schemes, networked transducers can eliminate a large number of lengthy parallel analog wiring and thus reduces the installation, maintenance and upgrade costs of measurement and control systems. And the use of microprocessors to handle the digital communication has also opened the opportunity for adding intelligence to sensors. One problem for transducer manufacturers though, is the large number of networks on the market today. Currently, it is too costly for transducer manufacturers to make unique smart transducers for each network on the market. Therefor a universally accepted transducer interface standard, the IEEE 1451 standard, is proposed to be developed to address these issues.

This standard is intended to make it easier for transducer manufacturers to develop smart devices and to interface those

devices to networks, systems, and instruments by incorporating existing and emerging sensor and networking technologies.

V. BASICS CONSIDERATIONS FOR WIRELESS SENSOR DEVICES

Finally we will expose some basics considerations for wireless sensor devices in industrial applications. Since they provide clear advantages in flexibility and distributed intelligence, the first proposal is to use stand alone monolithic IC's with RF capabilities and a few I/O ports. For many applications is enough to read only one or two signals per point of measure, and we can find in market RF modules with some analog or digital ports for general purpose that can be read/write directly by means of a connection with the device. Obviously, if accuracy and sample rate are enough, this is the simplest way to extend a wireless sensor network.

The second proposed system consists of an autonomous module for data acquisition with wireless capabilities. Normally by the integration or connection to a RF transceiver.

The core of this system will be control module based on a microprocessor system which will take charge of managing the acquisition, treatment and storage of the information that receives from the different sensors. Also it will manage the RF subsystem. A simplified block diagram of this system is shown in next figure.

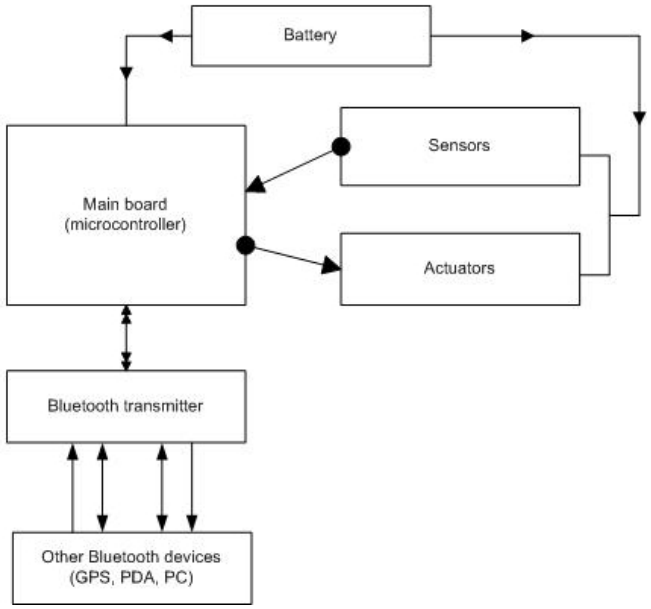

Figure 6. Simplified block diagram of an autonomous data acquisition system with Bluetooth.

The whole system has to be designed seeking to obtain a high autonomy of functioning, that is, to minimize the consumption and to maximize the capacity of storage, as well as seeking for a low weight, cost and size.

The integration in the module of wireless transmission not only contributes for the possibility of the remote monitoring or downloading the stored data, or a primary control action over the plant, or the possibility of reprogramming the system over the air, or to extend easily the number of sensors or variables to monitor without restrictions about its physical location. It also allows to interact with other similar systems, being able to establish distributed control topologies at different levels.

VI. CONCLUSIONS

Wireless connectivity has become recognized as a flexible and reliable medium for data communications across a broad range of applications - not only where a wired communication is difficult or impossible by physical or economic causes, like remote sensing and control, security systems, AMRs, …, and its extension to industrial, enviromental or home applications; due to the potential that the wireless sensor nodes presents to operate in demanding environments providing clear advantages in cost, size, power, flexibility, and distributed intelligence.

Many low rate wireless personal area network technologies are currently available. Three wireless standards are likely to dominate the majority of remote sensing and control applications: Zigbee, Wibree and Bluetooth, each with its own strengths and weaknesses for a specific application class. Its main feautes has been presented and discussed.

Another issue is interfacing the transducers to all of the existing control networks and supporting the wide variety of protocols. In this way the IEEE 1451 norm is intended to make easier to develop smart devices and to interface those devices to networks, systems, and instruments; providing a frame for achieving interoperability.

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