Comparative Analysis of Modern Wireless Communication Systems Relevant to Smart Metering

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Abstract – **In this paper a comparative analysis of modern wireless communication systems relevant to smart metering is presented. Several of the most widely used standards are compared and their advantages towards the smart metering system are presented. Electrical parameters of possible protocol implementation using readily available modules are given as well.**

Keywords – ***wireless communication system, Zigbee, WiFi, bluetooth, smart metering*.**

I. Introduction

The combination of the electronic meters with two-way communications technology for information, monitor and control is commonly referred to as Advanced Metering Infrastructure (AMI). Previous systems which utilized one way communication and were referred to as AMR (Automated Meter Reading) Systems. AMI has developed over time, from its roots as a meter reading substitute (AMR) to today's two-way communication and data system. The evolution from AMR to AMI is shown in Figure 1.

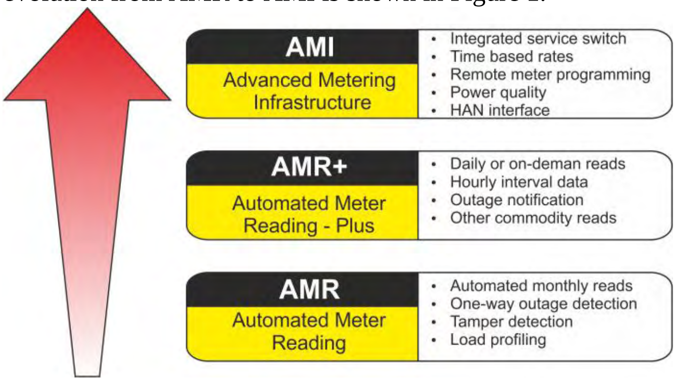

Fig. 1. Smart meters communication technology evolution

There are many different smart meters on the market today, and most of them use some kind of propriety protocol to communicate with the service provider. The current trend however is to standardise the communication. Which communication protocol the future smart meters will use is still not decided. The scope of the article is to present some of the possible communication systems that has high probability to win the contest.

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Experiments with a four modules were conducted. Some of the electrical parameter of the modules are given in Section III of the current article.

II. Wireless communication protocols used in the Smart Metering

A. *WiFi (802.11)*

Smart Grid solutions are being driven by the desire for more efficient energy usage worldwide. The Smart Grid communications network will be a heterogeneous network based on many different standards. Wi-Fi® technology will certainly be part of any future Smart Grid. [1].

Wi-Fi offers many benefits for Smart Grid applications:

• Mature technology with an established worldwide testing network

• Suitable for personal-area, home-area, and even wide-area networking

• Government-grade WPA2™ security

• Portfolio includes low bandwidth/low power designs, high-gain/high performance systems and points in between – all can interoperate

• Advanced mechanisms for reliability, robustness and manageability

• Continued technology innovation now and in the future, leveraging an interoperable set of baseline standards

• Economies of scale drive cost effectiveness

A key advantage of Wi-Fi for the WAN Smart Grid is its use of free, unlicensed spectrum. This makes it practical for a city or utility to own and operate a large private wireless network for Smart Grid. Cellular data networks can provide the required service, but are usually owned and operated by large carriers who pay for the frequency licenses.

The Smart Energy Profile helps build a framework for Smart Grid Applications. Version 2.0 of the Smart Energy Profile was specified by NIST as a PHY independent protocol, which therefore could be implemented in Wi-Fi systems. The only work required for an implementer would be to port SEP 2.0 software to Wi-Fi-based devices.

Fig. 2. Tested Wi-Fi module

B. Bluetooth (802.15.1)

Until recently, Bluetooth was used mainly for connecting mobile /personal/ devices (mobile phones, mice and keyboards, barcode scanners and so on.). However in 2010 the Bluetooth Special Interest Group has formed a Smart Energy Study Group to explore application in smart electric grids. CSR, Broadcom and Emerson Electric are the initial members of the group.

The Bluetooth technology continues to evolve, building on its inherent strengths—small-form factor radio, low power, low cost, built-in security, robustness, ease-of-use, and ad hoc networking abilities. This evolution now provides manufacturers and consumers with three options for connecting wirelessly – Classic Bluetooth technology for use in a wide range of consumer electronics; Bluetooth high speed technology for the transfer of video, music and photos between phones, cameras, camcorders, PCs and TVs; and Bluetooth low energy for low power sensor devices and new web services within the healthcare, fitness, security, home entertainment, automotive and automation industries [5].

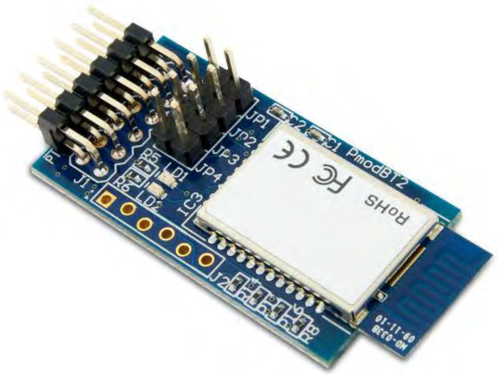

Fig. 3. Tested Bluetooth module

C. ZigBee (802.15.4)

ZigBee is a low-power wireless communications technology designed for monitoring and control of devices, and is maintained and published by the ZigBee Alliance [7]. Home automation is one of the key market areas. Zigbee works on top of the IEEE 802.15.4 standard [8], in the unlicensed 2.4 GHz or 915/868 MHz bands. An important feature of ZigBee is the possibility to handle mesh-networking, thereby extending the range and making a Zigbee network self-healing. The Zigbee Smart Energy Profile [9] (numbered 0x0109) was defined in cooperation with the Homeplug Alliance in order to further enhance earlier HAN (Home Area Network) specifications. The profile defines device descriptions for simple meter reading, demand response, PEV charging, meter prepayment, etc. Recently a collaborative effort between the Zigbee Alliance and the DLMS UA was announced to define a method to tunnel standard DLMS/COSEM messages with metering data through ZigBee Smart Energy networks. Considering the low power requirements, robustness, availability of cheap Zigbee "kits" and the specific profile for metering applications, Zigbee has a lot of potential in home area networks.

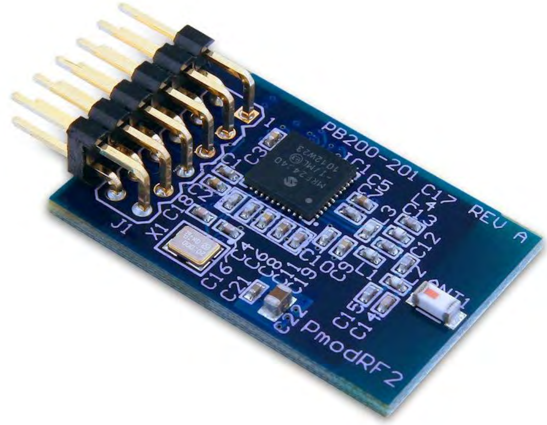

Fig. 4. Tested ZigBee module

D. KNX

KNX [6] is the result of the joint effort of three European consortia working on home and building control, namely Batibus, EIB and EHS. KNX was made into standard ISO/IEC 14543-3-x in November 2006. KNX provides application models for distributed automation, configuration and management schemes, device profiles and a communication system (media and protocol stack). Possible communication media are twisted pair cabling, RF, IP/Ethernet or sometimes PLC. Each bus device has some sort of certified BCU (Bus coupler unit) that is typically flush mounted for switches, displays and sensors. To manage network resources, KNX uses both point-to-point and multicast communication. When a device publishes a data-point (an input, output or parameter), it is assigned a multicast group address. A data-point in another device having the same address will then receive updates and be able to notify the local application. Thus all local applications in a group form a so-called "distributed application". KNX aims to provide a complete solution for home and building automation and is backed by a lot of manufacturers worldwide.

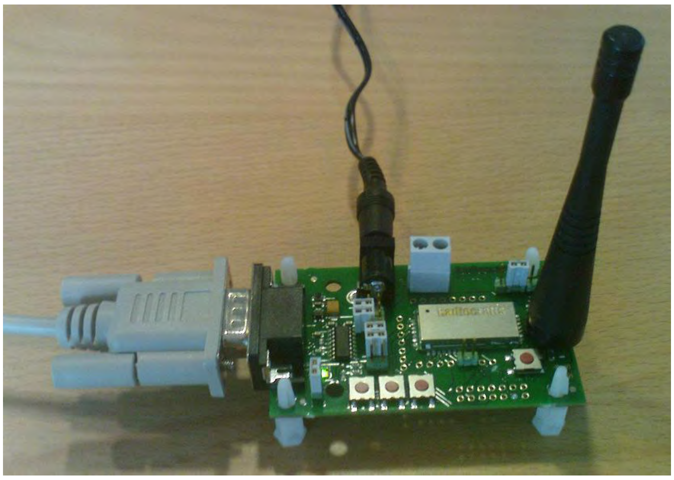

Fig. 5. Tested KNX module

E. EN 13757 / M-Bus

EN 13757 (Meter bus) is an European standard [4] for the remote interaction with utility meters and various sensors and actuators which was developed at the University of Paderborn. M-Bus uses a reduced OSI layer stack. Several physical media are supported including twisted pair and wireless M-Bus (in the ISM band). Primary focus of the standard is on simple, low-cost, battery powered devices. As this standard is already widely used in meters and reasonably future proof it is a good contender for local data exchange in the smart grid.

III. Comparison between Protocols

Comparison of some parameters for the discussed protocols is presented in Table 1, while some electrical parameters of modules used to realize the communication is given in Table 2.

TABLE I
COMPARISON OF THE DIFFERENT WIRELESS STANDARDS

standard	**WiFi**	**Bluetooth**	**ZigBee**	**KNX**
Frequency band	2.4GHz	2.4 ÷ 2.48GHz	868MHz	868.0÷ 870.0
Serial data rate	56Mbps	1Mbps	250kbps	32kbps
Number of RF channels	13	79	16	1
Channel bandwidth	22MHz	1MHz	0.3/0.6MHz	2MHZ
Interference immunity	FHSS	DSSS, OFDM, CCK	DSSS	-
Nominal range	10m	10-100m	100m	10-100m

TABLE II
COMPARISON OF THE POWER CHARACTERISTICS OF DIFFERENT WIRELESS STANDARDS

standard		**WiFi [10]**	**Bluetooth [11]**	**ZigBee [12]**	**RC1180-KNX [13]**
Supply voltage		3.3V	3.3V	2.1÷3.6 V	2.0÷3.9 V
Output power		+10dBm	+4dBm	+3dBm	+10dBm
Power consumption	Standby/ Idle	250 µA	25 mA	5.7 mA	0.3 µA
	Normal mode	80mA	3 mA	14.3mA	37mA
	Low power	10mA	8 mA	0.4 mA	-
	Sniff				
	Deep sleep	0.1 µA	26 µA	0.02 µA	-
Operating temperature range		-40C to +85C	-40C to +85C	-40C to +85C	-40C to +85C

IV. Conclusion

In this paper, an overview was given of communication standards relevant to the smart grid and smart house concepts. Of course, many more technologies are out there, but most of them lack wide acceptance, flexibility, or are still nascent or vendor-controlled. The latter is especially true in the home and building automation space.

Acknowledgement

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