

Hardware Platforms for IEEE 802.15.4 Wireless Sensor Networks: A Survey

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Abstract: Selection of hardware platform for implementation of wireless Personal Area Network (WPAN) for a specific application is a challenging task. There exists several severe constraints like, the processor power, power consumption, size and battery life etc. The nodes in the WPAN are the devices with few sensors, a microcontroller and a radio. These nodes are expected to collect process and transmit data to the coordinator. The nodes are battery powered and expected to serve long time, may be few years without replacement of the batteries. IEEE 802.15.4 technology is low power, low data rate technology, suitable for implementing most of the applications in the consumer sector. Thorough study of the various existing platforms is needed to select a proper hardware platform to implement any application. Here in this paper, the authors attempt to provide the comparative study of the some of the existing hardware platforms to help the researchers and product developers to select a suitable hardware platform for a specific application without spending much time in literature study.

Keywords: Hardware Platform, IEEE 802.15.4, ISM Band, Low Power, WPAN.

1. INTRODUCTION

The IEEE 802.15.4 is an emerging standard for Low Rate WPAN. The main goal of this standard is to provide low power, cost effective, flexible and scalable Wireless Networks [1]. The networks transfer the data at 250kbps and support 65,536 nodes. The number of nodes supported by the network will be increased in near future. The rapid progress in wireless technologies with low cost and great mobility is ensuring applications of this technology in many contexts[2]. Now- a-days, IEEE 802.15.4 WPANs are widely used in a large number of applications, like healthcare, surveillance, Industrial automation, smart home, remote metering, structural health monitoring, mall automation and the number of applications utilizing IEEE 802.15.4 is exponentially increasing in consumer field[3],[4]. This standard operates in the unlicensed 2.4 GHz, 915 MHz and 868 MHz ISM bands. The radio uses DSSS which is managed by the digital stream into the modulator. Conventional DSSS is employed in the 868 and 915 MHz bands, while an orthogonal signaling scheme that transmits four bits per symbol is employed in the 2.4 GHz band. The raw, over-the-air data rate is 250 kbit/s per channel in the 2.4 GHz band, 40 kbit/s in 915 MHz band and 20 kbit/s in the 868 MHz band. Transmission range is between 10 and 75 metres. AA size batteries used in most of the products and two AA size cells last for 5 years in some of the consumer applications. The future trends in IEEE 802.15.4 technological developments are projected in three phases: Phase.1 (2012-2015) ZigBee based Set-Top Box/Gateway with RF

Remote Control. Phase.2 (2013-2018): Security, Home Care and Energy Management. Phase3: (2015-2020) Integrated environmental awareness, Home comfort, safety and security gadgets. By 2018, more than 400 million IEEE 802.15.4 and/or ZigBee smart energy related devices will be in use worldwide. The Smart Home market is huge and expected to have 600 million homes with 100 devices per home 60 billion nodes by the end of 2014 and By 2018, more than 400 million IEEE 802.15.4 and/or ZigBee smart energy related devices will be in use worldwide [5]. So more and more number of applications are using this WSN technology in home automation.

2. HARDWARE PLATFORMS

Some of the hardware platforms, we have studied are presented here in a concise manner, with important specifications highlighted.

A. MICAz [6]

The MICAz development platform, MOTE-KIT2400, is a comprehensive 8 node kit for commercial Mote development. It uses Crossbow's new MICAz MPR2400CA Processor/Radio board. It is designed for deeply embedded sensor networks. It is a 2.4 GHz, IEEE 802.15.4 compliant Mote module used for enabling low power, wireless sensor networks. It offers a 250 kbps high data rate and it utilizes a direct sequence spread spectrum radio that is resistant to RF interference and provides inherent data security. The MICAz runs on TinyOS 1.1.7 and higher.

B. Neomote [7]

The NeoMote is designed for field deployments. I offer ultra-low power, highly reliable, true systems-level solutions for a broad suite of real-time sensing and control applications. It incorporates a highly-configurable system-on-chip 32-bit ARM Cortex™-M3 microprocessor unit, memory, analog, and digital peripheral with industry-leading, ultra reliable, IPv6-based, low power true-mesh Wireless sensor network (WSN) technology. A unique array of configurable system blocks features modern control of all modalities of signal acquisition and signal processing, enabling monitoring and control with high accuracy, high bandwidth, and high flexibility. The system features a fully configurable digital system able to dynamically configure up to 60 GPIOs with interfaces such as USB, SPI, UART and I2C. Innovative IEEE802.15.4-compliant radio design by *Dust Networks* enables multi-year long battery life on a pair of AA batteries.

C. Imote2[8]

The Imote2 is an advanced wireless sensor node platform developed at Intel Research as part of Platform

X. It is built around the low-power PXA271 X Scale CPU and also integrates an IEEE 802.15.4 compliant radio. The design is modular and stackable with interface connectors for expansion boards on both the top and bottom sides, providing a standard set of I/O signals as well as additional high-speed interfaces for application specific I/O. There is a number of accessories to assist developers in their work. Sensor boards are meant to enable sensing capabilities. Interface boards can behave as gateways between computer and mote and, depending on the TinyOS version, can enable programming over USB ports. JTAG programmers are mainly used in TinyOS-2 for flashing (programming) motes and gateways.

D. Iris [6]

Iris MoteWorks enables the development of custom sensor applications and is specifically optimized for low-power, battery-operated networks. MoteWorks is based on the open-source TinyOS operating system and provides reliable, ad-hoc mesh networking, over-the-air programming capabilities, cross development tools, server middleware for enterprise network integration and client user interface for analysis and configuration. It uses 2.4 GHz IEEE 802.15.4, Tiny Wireless Measurement System designed Specifically for Deeply Embedded Sensor Networks. 250 kbps, High Data Rate Radio, Wireless Communications with Every Node as Router Capability Expansion Connector for Light, Temperature, RH, Barometric Pressure, Acceleration/Seismic, Acoustic, Magnetic and other Sensor Boards.

E. Telos-B [6]

The TelosB platform was developed by UC Berkeley. This platform delivers low power consumption allowing for long battery life as well as fast wakeup from sleep state. Though the TPR2400 is an uncertified radio platform, it is fully compatible with the open-source TinyOS distribution. TPR2400 is powered by two AA batteries. If the TPR2400 is plugged into the USB port for programming or communication, power is provided from the host computer. If the TPR2400 is always attached to the USB port no battery pack is needed. TPR2400 provides users with the capability to interface with additional devices. The two expansion connectors and on board jumpers may be configured to control analog sensors, digital peripherals and LCD displays. Crossbow's TelosB mote (TPR2400) is an open source platform designed to enable cutting-edge experimentation for the research community. The TPR2400 bundles all the essentials for lab studies into a single platform including: USB programming capability, an IEEE 802.15.4 radio with integrated antenna, a low-power MCU with extended memory and an optional sensor suite (TPR2420), IEEE 802.15.4/ZigBee compliant RF transceiver, 2.4 to 2.4835GHz, a globally compatible ISM band, 250 kbps data rate, integrated onboard antenna. 8 MHz TI MSP430 microcontroller with 10kB RAM, Low current consumption, 1MB external flash for data logging. Programming and data collection can be done via USB. It has got optional sensor suite including integrated light,

temperature and humidity sensor (TPR2420). It Runs on TinyOS 1.1 or higher.

F. Lotus [6]

MEMSIC, Inc. introduced LOTUS, a high-performance wireless sensor platform. LOTUS is an advanced wireless node platform developed around the low power ARM7 Cortex M3 CPU and incorporates the best of IRIS, TelosB and Imote2 onto a single board. LOTUS is built on a modular and stackable design, incorporating connectors for expansion boards, and features several new capabilities that enhance the overall functionality of MEMSIC's wireless sensor networking products and solutions. LOTUS is backward compatible with MEMSIC's MDA and MTS range of Sensor Data Acquisition Boards. This latest MEMSIC mote platform meets the requirements of existing Imote2 and OEM customers requiring higher speed processing capability as well as applications requiring GSM/GPRS gateways. LOTUS features 32Bit/100MHz processor, 64kB SRAM, 512kB FLASH, 64MB serial FLASH memory, an integrated 802.15.4 compliant radio with on-board antenna and USB Client with on-board mini connector, and runs at 50mA on-state and 10uA in stand-by mode. LOTUS is factory configured to run RTOS (Real Time Operating System). Several other options are also available for LOTUS, including MEMSIC Kiel, RTOS, IAR Systems, Free RTOS, Mote Runner and TinyOS. The 51pin expansion connector supports Analog Inputs, Digital I/O, I²C, SPI and UART interfaces enabling ease of connection to a variety of external peripherals.

G. Epic [9]

Epic is an open mote platform for application-driven design. Like most embedded systems, they are tightly coupled to their applications. This coupling can make it difficult for general-purpose platforms to address application-specific needs, forcing platform designers to repeatedly reimplement functionality. Inspired by the hierarchical nature of software and integrated circuit design. The Epic design is open source, and all design files are available.

H. SENSEnuts [10]

This platform will be useful for academic, research and industrial applications. Supported by user friendly GUI, seamlessly integrated with sensor node to monitor as well as program for various applications. The features are: Wireless micro-controller with 802.15.4 transceiver, Range of sensors for Environment, Modular design having Gateways, Radios & sensors devices, Self healing network, Supports multi-hopping, Easy to install and faster deployment, C based programming, Exhaustive set of easy to use APIs, Comprehensive Long term support, Flexible MAC protocol implementation, Protocol code development above layer 2. Application Domains include Environment monitoring, Security implementation, Home automation, Industrial control, Precision Agriculture, Smart cities.

I. Freescale [11]

Freescale Semiconductor's third-generation 2.4 GHz IEEE® 802.15.4 platform takes a leap forward in

processing power and system integration. A fully functional 32-bit TDMI ARM7™ processor with a combination of ROM, RAM and flash memory provides the highest level of integration and performance on the market today. It implements AES 128-bit hardware encryption/decryption.

J. SHIMMER [12]

Shimmer is designed for wearable and remote sensing applications. The shimmer is designed to be highly flexible and adaptable. It is frequently used in activity monitoring, sport science and intelligent building monitoring applications. It uses 24 MHz MSP 430 processor, which has 11 channels of 12 bit analog to digital converter. It can communicate using Bluetooth. It has got internal and external connectors for expansion modules. It has got integrated motion processor for on board 3D orientation estimation. Expansion header for alternative radio and JTAG debugging facility are available.

3. COMPARATIVE STUDY

A comparative study of various existing hardware platforms is presented in the Table.1

Table.1 Comparative Study-Processor and OS

S. no.	Platform	Processor	OS
A	MICAZ	MPR2400CA	TinyOS 1.1.7
B	Neo mote	32-bit ARM-Cortex-M3	TinyOS 1.1.7 and higher
C	Imote2	PXA271 X	TinyOS-2
D	Iris	ATmega1281	TinyOS
E	TelosB	TI MSP430	TinyOS 1.1.10
F	Lotus	ARM7 Cortex M3	TinyOS Free RTOS
G	Epic	TI MSP430	TinyOS
H	SENSEnuts	Jennic 5168	TinyOS
I	Freescale	ARM7	TinyOS
J	SHIMMER	MSP430	TinyOS

The sensor platform are compared with their application area and presented in Table.2.

Table.2. Comparative Study-Platform Vs Application

S.no	Platform	Applications
A	MICAZ	Indoor Building Monitoring and Security, Acoustic, Video, Vibration monitoring.
B	Neo mote	Signal acquisition, monitoring and control applications, Field deployment, Dust Networks.
C	Imote2	Digital Image Processing, Condition based maintenance Industrial Monitoring and analysis, Seismic and vibration monitoring.
D	Iris	Large Scale Sensor Network applications
E	TelosB	Platform for Low Power R&D, Temperature and Light monitoring.
F	Lotus	Industrial Monitoring, Acoustic, Video, Vibration Monitoring, Seis-

		mic and Vibration Monitoring, Condition based Maintenance
G	Epic	Environmental monitoring, Wireless AC meter reading,
H	SENSEnuts	Environment Monitoring, Security Applications, Home automation, Industrial Control, Precision Agriculture, Smart Cities.
I	Freescale	Energy Management, Hotel Guest Room Control, Building Environment Monitoring, Remote Monitoring, Medical Monitoring
J	SHIMMER	Human Health monitoring, Activities of daily living, connected health solutions, sports science, Intelligent Buildings, Structural Health monitoring.

4. CONCLUSION

A comparative study of currently available hardware platforms for IEEE 802.15.4 technology has been done. The sensor network platforms are compared with their Processor and Operating system and the platform and the suitable applications. SHIMMER motes, with their small form factor and integrated 3-dimensional accelerometer sensors, are best suited for wearable applications such as health monitoring, MicaZ and TelosB are the cheapest amongst all and can be used where low cost is a concern. RIS motes have an increased range, so they can be used where long distance communication is required.

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