Demonstration Abstract: Extensible Modular Wireless Sensor and Actuator Network and IoT Platform with Plug&Play Module Connection

Konstantin Mikhaylov, Juha Petäjäjärvi, Marko Mäkeläinen, Anton Paatelma, and Tuomo Hänninen

Centre for Wireless Communications, P.O.Box 4500, FI-90014, University of Oulu

{konstantin.mikhaylov, juha.petajajarvi, marko.makelainen, anton.paatelma, tuomo.hanninen}@ee.oulu.fi

ABSTRACT

Efficiency and flexibility are among the key requirements for Wireless Sensor and Actuator Networks (WSAN) of Internet of Things (IoT) era. In this work we present and demonstrate a novel WSAN and IoT platform. The new nodes are constructed by stacking together the different hardware modules encapsulating power sources, processing units, wired and wireless transceivers, sensors and actuators, or sets of those. Once a node is built, its processing unit can automatically identify all the connected hardware modules, obtain required software modules and tune node's operation accounting for its structure, available resources and active applications.

Categories and Subject Descriptors

C.3 [**Special-Purpose and Application-Based Systems**]: Microprocessor/Microcomputer Applications, Real-Time and Embedded Systems

C.2.1[**Computer-communication networks**]: Network Architecture and Design - *wireless communication*

B.4 [**Input/Output and Data Communications**]: Input/Output Devices, Interconnections (Subsystems)

General Terms

Design, Experimentation, Measurement, Verification, Algorithms

Keywords

Wireless Sensor Actuator Networks, WSN, Internet of Things, IoT, Architecture, Platform, Module, Plug-and-Play, Node

1. INTRODUCTION

The contemporary Wireless Sensor and Actuator Networks (WSANs) are subject to two opposite trends. On one hand, many real-life applications require thousands of nodes being installed throughout the area of interest to enable reliable detection of observed phenomena. For success of these applications low costs of manufacturing, deploying and maintenance are essential. To address this, engineers today rely on point solutions, built using specialized hardware (HW), custom software (SW) and proprietary communication protocols. This results in limited interoperability, low flexibility and poor extensibility of these designs. On the other hand, the nodes featuring generic architecture, communication and data encoding mechanisms can be somewhat less effective. But these enable easy extension, modification, and seamless integration of different systems and applications, which is especially important for success of multidisciplinary and multipurpose applications building up the Internet of Things (IoT).

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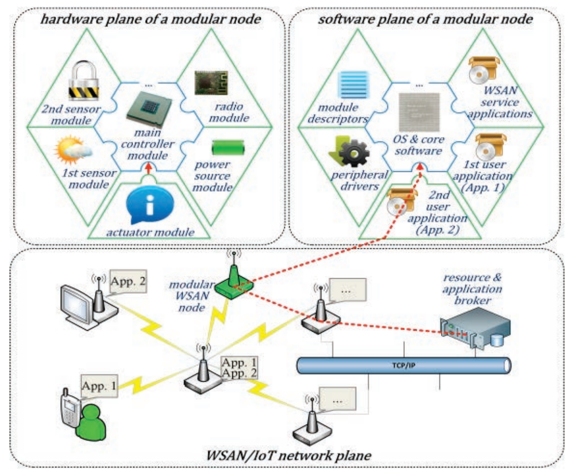

Figure 1. Illustration of the proposed concept.

In the current work we attempt to reconcile both trends by *demonstrating* the proof of concept prototype of a reconfigurable modular WSAN and IoT platform. According to our vision (see Figure 1), the new generation of WSAN nodes can be built by stacking together the *HW modules* encapsulating various *peripherals*, e.g., power supply sources, processing units, wireless transceivers. Once a node is assembled, the main processing unit (MPU) automatically detects the attached modules and peripherals available on each of those, as well as peripherals' data communication interfaces. If the MPU does not possess the *SW modules* necessary for working with a peripheral, it can either get the drivers from a module or download those from WSAN. Further, the data about the node's structure can be used e.g., at network level to optimize the operation of WSAN or at application layer while distributing the tasks between the nodes.

Although our system is not the first modular WSAN platform being reported (consider e.g., [1-3]), to the best of our knowledge, this is the first solution supporting connection of the full spectrum of various modules in Plug&Play (P&P) manner while enabling efficient energy and data interface management.

2. TECHNOLOGY

2.1 Hardware

The identification and P&P connection of modules are based on the developed Intelligent Modular Periphery Interface (IMPI) and special architecture of modules (see Figure 2). The IMPI has three sets of lines: a) input and output power supply lines b) IMP bus enabling detection of modules' connection order, identification and energy management, and c) data lines enabling direct communication with peripherals. Each module is equipped with single Module Control and Identification Unit (MCIU, MSP430G2453 are used as those in our demo) which stores the data about on-node peripherals and enables MPU (STM32F207 ARM-based controller in demo) to control modules. Note, that unlike the existing solutions, modules in IMPI are addressed based on their order of connection. The further details about the architecture, underlying mechanisms and technical solutions, and parameters of our platform are reported in [4-5].

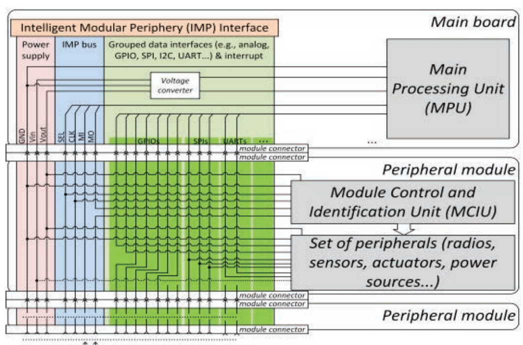

Figure 2. Hardware architecture of modular platform.

2.2 Software

The SW of our platform consists of two components. The first one is embedded SW of MPUs and MCIUs. The former ones run FreeRTOS operation system, which has been ported by us for the used microcontroller and extended by adding the drivers for IMPI, communication interfaces, and low-level drivers for the available on main board and implemented modules peripherals. The SW of MCIUs composes IMPI driver, peripheral control mechanisms and peripheral description data (PDD). Besides embedded software, specifically for the demo we have developed software server with graphical user interface (GUI, see Figure 3) for Linux. The server is interfaced to the sink node of the WSAN and receives the data from it using specific protocol. The GUI displays topology of the network, the modules available on each network node and enables accessing the data and controlling each module.

3. DEMONSTRATION

The major purpose of the demo is to present the platform and demonstrate its capabilities. We will show how the WSAN nodes featuring different functionalities (e.g., sink, sensor, actuator or dual-role) can be assembled from the hardware modules (see Figure 4). Once a node is powered, it will join the network and the GUI will display node's structure and start showing the data about node's modules. Then, the GUI can be used to give commands and change operation of particular modules (e.g., power on/off the peripherals or change their operation mode). The information about network topology will be shown as well, but for demo purposes we will limit the network to only 4-6 nodes located within direct communication range of sink.

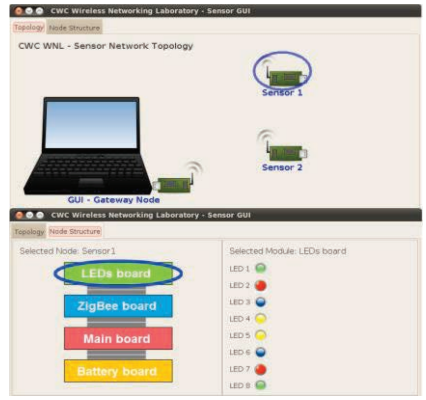

Figure 3. Example layouts of demo GUI for three nodes.

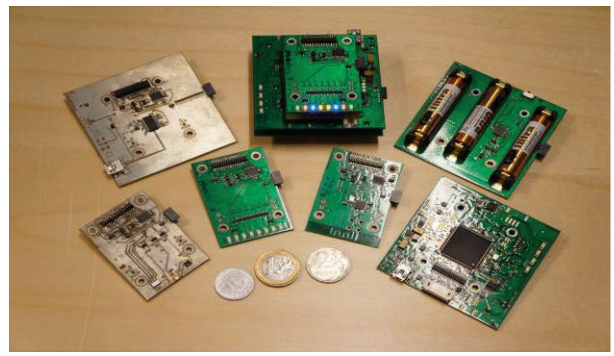

Figure 4. Example of hardware used in demo (left to right, top row: USB interface module, example of a build node - structure shown in Figure 3, battery module; bottom row: sensor, LED and radio modules, main board).

4. REFERENCES

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