Demo: Modular Multi-radio Wireless Sensor Platform for IoT Trials with Plug&Play Module Connection

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ABSTRACT
In the paper we present and demonstrate the modular prototyping platform designed for trialing the Internet of Things (IoT) applications. The new devices are constructed by stacking together the various hardware modules encapsulating power sources, processing units, wired and wireless transceivers, sensors and actuators, or sets of those. The main processing unit automatically identifies all the attached modules and adjusts own operation accordingly. The demo will showcase how the platform can be used for building up multi-radio technology enabled wireless devices which will automatically form a heterogeneous wireless sensor and actuator network (WSAN). The possible use case scenarios and the ongoing research activities around the platform will be highlighted as well.

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, Data Communications Devices

General Terms
Design, Experimentation, Measurement, Verification, Algorithms

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

1. INTRODUCTION
The recent years have been characterized by significant progress in IoT related technologies. The pure theoretic concept a while ago became almost a reality today. Nonetheless, effective utilization of myriads devices with highly diversified requirements, communication interfaces, capabilities and tasks within one and the same network still has many unsolved research challenges. Despite this, in the current work we approach the problem from the engineering perspective and present a solution and architecture enabling easy and effective construction of the new IoT and WSAN devices. The proposed platform enables easy, time and cost effective trialing the new scenarios and technologies, and can serve as the basis for wide range of real-life applications.

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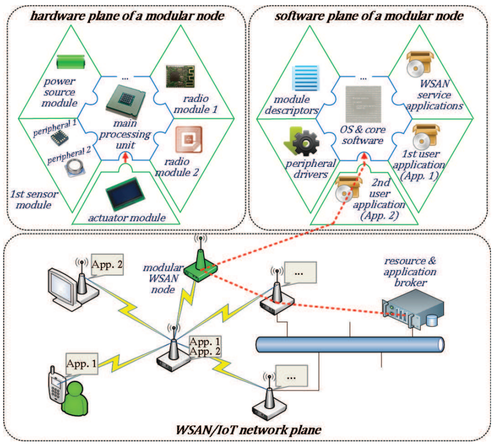

Figure 1. Illustration of the proposed concept

In the demo we present the proof of concept prototype of our platform. According to our vision (see Figure 1), the new nodes can be built by stacking together the hardware (HW) modules encapsulating various peripherals, like e.g. power supply sources, processing units, wireless transceivers, etc. Once a node is built, its *main processing unit* (MPU) automatically detects the attached modules, identifies the peripherals available on each module, and maps their data communication interfaces to the available pins of MPU. If the MPU does not possess the software (SW) modules necessary for working with a peripheral – these can be either obtained from a module or downloaded from WSAN. The same applies for the application-level SW. Since each module contains the data describing the hosted peripherals, an MPU always has complete information on its structure and can use these data to optimize own operation or to enable network-level optimizations and task distribution between the nodes.

2. TECHNOLOGY

Plug-and-Play (P&P) connection of modules is enabled by employing the developed *Intelligent Modular Periphery Interface* (IMPI) and the special module architecture. Unlike the existing platforms (e.g., [1-2]), our modules (see Figure 2) are addressed based on their order of connection. This eliminates address collisions and enables connection of multiple identical modules. The availability of numerous parallel communication interfaces enables an MPU to communicate with multiple peripherals simultaneously. The further details about IMPI, the details of technical solutions and parameters of the platform are available in [3-4].

To enable exploitation of HW dynamism and connection of multitude various HW modules the embedded SW featuring novel architecture has been designed and implemented. The core component of our SW is the *resource manager*, which identifies the connected modules, choses the communication technologies to be used, and decides which applications and services can be launched.

The server and a web-based graphical user interface (GUI) are used in the demo to obtain and display the data from the nodes and control their operation in real time.

3. DEMO SETUP

The demo setup is illustrated in Figure 3. In the demo we will show how the nodes of various structures can be assembled out of modules. Once ready and powered on, a node will automatically identify connected modules and use available wireless communication interfaces for connecting to the network and reporting its data to the server running on a laptop. The GUI will display the topology of the network, the set of modules composing selected node and the information about particular module (e.g., measurements from sensors, configuration of radio transceivers or status of actuators). Also the GUI can be used to give orders to the nodes and control their operation.

In the demo we will especially emphasize the wireless communication capabilities of the proposed platform. Namely, we will demonstrate how the platform can be used for building the nodes hosting multiple radio modules for the same (e.g., two or three IEEE 802.15.4 radio modules) or even different radio technologies (e.g., IEEE 802.15.4 and an ultra-wideband transceiver). In both cases, the nodes will automatically join the heterogeneous network.

4. RESEARCH ACTIVITIES

The proposed platform is currently widely used in the research activities of CWC. Namely, the platform is employed in experiments related to:

- studies of performance of ultra-wideband radios,
- wireless localization for robots,
- wide-area IoT technologies and
- heterogeneous WSAN and IoT.

Some preliminary results of these studies and the lessons learned will be presented during the demo as well.

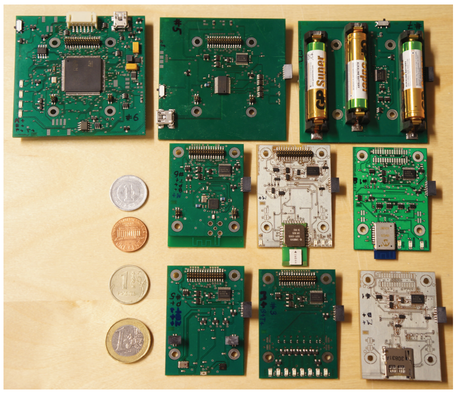

Figure 2. Module boards to be used in the demo (top row: main board and power boards, middle row – radio options, bottom row – sensors, actuators & memory)

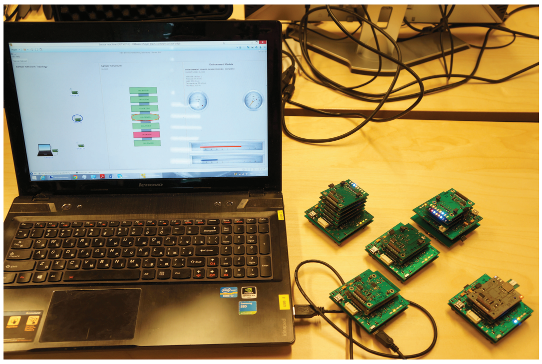

Figure 3. Demo setup: radio nodes featuring different structure and communication interfaces and the laptop-based graphical user interface displaying the network topology, structure of a node and the received module

5. REFERENCES

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