Demo Abstract: Modular Approach in Sensor Board Design

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Abstract

Designing a new sensor board is costly, especially for a production in a small quantity. By modularizing common functionalities, a large portion of the sensor board can be reused. In this work, we propose an Extension Board, a sensor board which is modularized into 3 parts. Power module, and MCU and RF module are shared, and only sensing module is redesigned for each sensor board. Diverse sensing modules are produced. The process was simple and inexpensive.

Categories and Subject Descriptors

C.3 [**Special-Purpose and Application-Based Systems**]: Real-Time and Embedded Systems

General Terms

Design, Standardization

Keywords

Wireless Sensor Networks, Modularization

1 Introduction

Designing a new sensor board requires time and effort. In the case of a production in a small quantity, a design cost overwhelms the cost of hardware components. For example, in a research project or in a pilot project, it is not uncommon to spend weeks in circuit design and CAD artwork. Then thousands of dollars are spent for PCB, metal mask, and assembly, just to make tens of sensor boards whose material cost is in the order of tens of dollars. There exist common functionalities among different sensor boards. By modularizing sensor boards, the design effort of a new sensor board can be significantly reduced. Only the module unique to each sensor board needs be newly designed.

2 Architecture

We propose a modular approach in designing a sensor board. The new sensor board, named as an Extension Board, is modularized into 3 parts: power module, MCU and RF module, and sensing module. The block diagram is depicted in Figure 1. The sensing module is specific to each sensor board, and other modules are commonly shared. Figure 2 shows the assembled Extension Board. TinyOS [3] is used to operate it.

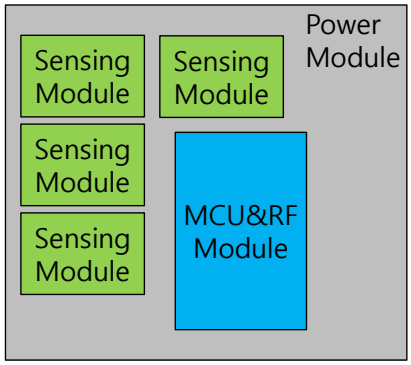

Figure 1. Block diagram of Extension Board

Figure 2. Assembled Extension Board with 3 sensing modules

2.1 Power Module

The power module works as a motherboard. Other modules can be plugged on top of this module. There is 1 slot for MCU and RF module. There are 4 slots for sensing modules as shown in Figure 1. A sensing module can be placed in any of 4 slots. Multiple sensing modules can be used together, as in Figure 2, where 3 sensing modules are attached. The power module provides power to the MCU and RF module, and to sensing modules. Either 5V DC or two AA batteries

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can be used. In Figure 2, 5V DC connector can be seen on the top right side of the board, and a battery holder can be seen on the left of the board. The power supply to sensing modules can be turned off by MCU for a low-power operation. Figure 4 shows the power module alone.

Figure 3. Enclosure

Figure 4. Power module

2.2 MCU and RF Module

The MCU and RF module controls sensing modules, and communicates wirelessly. To reprogram MCU, this module can be detached from the power module, and attached to a USB module so that it can be connected to a PC. Currently there are two types of MCU and RF modules. One is Kmote which is a TelosB clone, and the other is SonnoOne which uses RadioPulse Mango. Mango is an one-chip SoC using 8051 architecture and IEEE802.15.4 standard. Depending on the needs of a user and an application, either module can be used. Kmote and SonnoOne are shown in Figure 5.

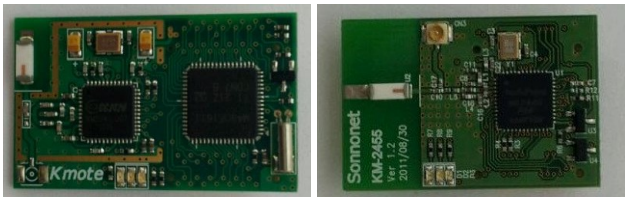

Figure 5. MCU and RF modules (Kmote which is TelosB clone, SonnoOne which uses Mango one-chip SoC)

2.3 Sensing Module

The sensing module contains a sensing part. A sensor and surrounding circuits are included in this module. Only a single sensor is included in each sensing module. When multiple sensors are needed, multiple sensing modules can be put onto the power module. When a sensor requires many pins to be connected to MCU, a sensing module can expand over multiple slots. We produced a few types of sensing modules: temperature and humidity, ambient light, VOCs, and acceleration. They can be seen in Figure 6. Even Bluetooth module is made as a form of sensing module. Any type of functionality can be made as a pluggable module, as long as it fits to the layout of the sensing module.

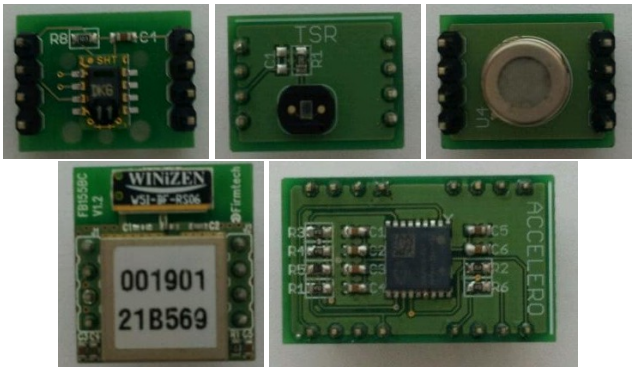

Figure 6. Sensing modules (temperature and humidity, ambient light, VOCs, Bluetooth, acceleration)

3 Related Work

In MICA [2] family, MCU and RF are modularized, and a sensing part can be made separately and plugged through a 51-pin connector. Multiple sensor boards can be stacked up, but there can be a conflict in pin usage among sensor boards. In an Extension Board, every slot has its own pins assigned, but only up to 4 sensor modules can be used. In EPIC [1], EPIC core can be placed on EPIC carrier. Multiple EPIC cores can be put together on one EPIC carrier. In a research project or a pilot project, it is common for MCU to be reprogrammed multiple times. In the Extension Board, MCU and RF module can be be easily detached from a power module and attached to a PC for easy reprogramming.

4 Discussion and Demo Scenario

The modularization of the Extension Board significantly reduced the time and the cost of designing a new sensor board. For a production in a large quantity, putting everything on a single module would be the best way to reduce the cost. It will be helpful to analyze the threshold where the integrated approach begins to yield a better economy. A plastic enclosure is also shared, which is shown in Figure 3. This reduces the burden and the cost of inventory management. However, sharing the plastic enclosure limits the form factor of a sensor board.

In a demo, diverse combinations of MCU and RF modules and sensing modules will be demonstrated. Regardless of the combination, sensor data will be displayed in a server program in a same way.

5 Acknowledgement

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