Poster: bPart - A Small and Versatile Bluetooth Low Energy Sensor Platform for Mobile Sensing

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1. BLE FOR MOBILE COMPUTING

This work presents the bPart, a highly integrated autonomous sensor platform for use with mobile phones and devices. It consists of a Bluetooth Low Energy (BLE) radio and several MEMS sensors, all integrated in a volume of less than 1cm³, including the battery. Aside from the wireless transceiver, the bPart features sensors for ambient illumination, 3D-acceleration, temperature and relative humidity. In addition, there is a button and a magnetic switch for binary input and a RGB-LED for user feedback. A secondary LED in the infrared spectrum enables camera-assisted identification and tracking of the node. Runtimes of several years are possible on the included CR2023 lithium coin cell, through the low energy radio, onboard power-conversion and low-power sleep modes. The latter is rated below 2µW and a single data packet consumes about 75µWs. Its low energy consumption makes the bPart suitable for operation with energy harvesting, which we have validated with a 33cm² solar cell in indoor lighting conditions.

Bluetooth Low Energy is an emerging standard for low power communication, which is quickly gaining a widespread adoption due to its close connection to the already familiar Bluetooth protocol. Released as an integral part in version 4.0 of the core specification [1], it uses a second protocol stack in parallel to the classical Bluetooth BR/EDR mode. Both options share the same physical interface and use the same hardware, but instead of high throughput for audio transmission, the BLE stack was optimized thoroughly for very low power consumption [2]. Single mode devices like the bPart only implement this part of the specification, usually embedded in a System-on-Chip. Dual mode devices in contrast, are usually less resource constrained and provide both protocol flavors, like smartphones or tablets. In fact, all major mobile and desktop operating systems support BLE by now and the number of capable device will soon reach billions [3]. This fact distinguishes the technology from other protocols with similar performance characteristics, like ZigBee, and enables the large-scale evaluation of several applications in the mobile computing domain. In the following, we describe some examples that we have already implemented using the bPart platform.

Tangible interaction – Due to its compact size, it is easy to integrate the node into small objects as tangible user interfaces. The embedded sensors and actuators provide different opportunities for interaction design. In this way, we were able to create physical controls for applications on the phone.

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Figure 1. bPart sensor node (2.1cm x 2.1cm x 0.4cm) next to an industrial grade sensor housing.

Indoor localization and physical web – A promising alternative to the connection oriented data transfer is the use of advertisement mode, where the bPart sends periodic radio beacons, encoding either geographical location or semantic information. A nearby mobile client can decode this information and approximate its distance, based on the received signal strength.

Activity tracking – The limited processing capabilities of the embedded CPU are complemeted by event-detection subsystems in the onboard sensors. The high-level APIs of BLE provide a persistent key-value store for easy and efficient data transfer.

Participatory sensing – The bPart supports easy configuration of both sampling and transmission intervals. In addition, it can store a limited number of sensor values on the board. A mobile user and his phone can fetch these values opportunistically, when he is in range, enabling data-collection and -analysis on the phone, as well as forwarding and aggregation of sensor-data to the backend.

Condition monitoring – The size, energy consumption and flexibility allow different industrial applications, where existing equipment is retrofitted with unobtrusive sensors. These are ranging from long-term monitoring, over logistics tracking, to live data acquisition and visualization for maintenance (Fig. 1).

While the bPart itself is a fully integrated solution, the concepts and architecture are easily adaptable to other sets of sensors. Code and schematics are available as open source. We plan to deploy and evaluate the node in long-term indoor and outdoor installations.

2. REFERENCES

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