Demo Abstract: Hamilton - A Cost-Effective, Low Power Networked Sensor for Indoor Environment Monitoring

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ABSTRACT

Operating buildings can be challenging, especially with poor instrumentation of the indoor environment. There are several wireless sensor platforms on the market but most are too difficult to deploy en-masse, requiring the end-user to program devices, or manage infrastructure. Many rely on smart-phones and do not work when unattended. The Hamilton wireless sensor node is a full-stack solution providing a low-cost and low-power high-resolution sensor that operates for more than five years on a battery, along with all the cloud infrastructure required to interact with the data. It is pre-programmed and ready to use, but the firmware can be easily modified by using the standard C language.

CCS CONCEPTS

• **Computer systems organization** → **Sensor networks**; • **Networks** → *Network experimentation*; Transport protocols;

KEYWORDS

Sensor Network, Low Power Network, Transport Layer, Link Layer, Transmission Control Protocol, IEEE 802.15.4

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1 INTRODUCTION

Deployment of a large number of embedded networked sensors in a building has the potential to provide useful indoor data more easily and at a finer granularity. For a large deployment in practice, a networked sensor should be easy-to-use, low-cost, and low-power. Recently, low power but highly capable Cortex-M SoCs (System-on-Chip) have become available on the market, permitting a low-cost highly-integrated wireless sensor design. RIOT-OS [3], a recent low power embedded OS, provides a multi-threading and standard C language-based firmware development environment, making embedded programming easier than using conventional embedded OSs [4, 7]. Development of fast time-series database and plotting techniques enables easy storage and visualization of sensor data through the cloud [1].

This demo presents Hamilton, a networked sensor for indoor monitoring. It is an easy-to-use, low-cost, and low-power full stack solution, which incorporates the aforementioned latest technologies. It has a default firmware so that a user can obtain various sensor data once she turns on a Hamilton device.

2 RELATED WORK

Many networked sensors have been developed over the last two decades. Each networked sensor has its own design goal while reflecting the latest hardware technology at the time. TelosB [8] is one of the most popular networked sensors, which has been benchmarked in a number of studies. It integrates every component (an IEEE 802.15.4 radio, a 16-bit MCU, sensors, USB interface) on a single board with careful power gating, which makes it a low power, easy-to-use, and robust networked sensor. Epic [5] also uses a 16-bit MCU and an IEEE 802.15.4 radio but takes a different approach, called building block approach, to facilitate all of prototype, pilot, and production phases.

After Cortex family was introduced, networked sensors started trying to use 32-bit CPUs for faster processing and more memory space. Egs and Opal [6], designed for medical and environment monitoring applications, respectively, use Cortex-M3. This work shows that compared to TelosB, a 32-bit platform can save both time and power when doing a complex computation, but its current consumption in the idle mode is much higher. Wandstem [9] shows that a 32-bit (Cortex-M3) board can provide lower idle current than TelosB. In addition, Firestorm [2] reveals that a 32-bit (Cortex-M4) networked sensor can be applied to the maker space by providing abundant extension pins like Arduino, both IEEE 802.15.4 and BLE radios, and extremely low power.

3 HARDWARE

In view of real application, a key missing aspect in the previous work is a thorough cost analysis including all the manufacturing process. In addition, an extensible board design with many I/O pins is good for embedded developers to try various things, but not for real users who want to apply networked sensors directly without much labor. Lastly, the previous work focuses on a hardware device rather than a full stack solution, which leaves significant amount of additional work to actually see desirable data from the screen.

To fill the gap, our design approaches for Hamilton are (1) adopting the latest low power and highly integrated off-the-shelf components, such as SoC, integrated balun, and chip antenna, for low assembly cost, (2) including useful sensors for indoor monitoring,

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