Demo Abstract: Hallway Monitoring with Sensor Networks

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Abstract

We present a sensor network that monitors a hallway. It consists of 180 load sensors connected to 30 wireless sensor nodes, where the setup is of extremely low cost and easily transferred to other settings. Our network serves as a testbed for in-network data processing algorithms, for which it is highly suitable due to the many correlated sensors.

Categories and Subject Descriptors

C.2.4 [**Distributed Systems**]: Distributed applications; C.3 [**Special-Purpose and Application-Based Systems**]: real-time and embedded systems

General Terms

Design, Experimentation.

Keywords

Sensor Networks, Monitoring, Testbeds.

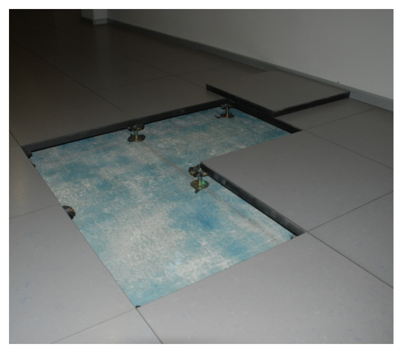
1 Introduction

Building testbeds for protocol and application evaluation has become common in the sensor network research field. This became possible due to both dropping hardware costs and the maturing of operating systems running on the nodes, simplifying the development process. However, building real-world applications with actual sensor data processing is still a challenging task. First, the installation of specialized sensors often requires a significant amount of additional work. Second, such sensors may also cost much more than the nodes themselves—and thus are often not affordable for ordinary sensor network testbeds.

The design, development, and evaluation of higher-level algorithms where sensor nodes can share their local knowledge to obtain global goals requires appropriate sensor data. To carry out such tests, we developed a hallway monitoring system, consisting of 180 load sensors deployed beneath the hallway floor. The sensors are connected to nodes, which in turn can then exchange the measured values. The sensors are highly correlated, therefore serving as an ideal testbed for any algorithm performing data aggregation or in-network data analysis, such as distributed tracking algorithms.

The floor consists of square floor tiles with a side length of 60 cm each, which are installed on small metal columns. The setup is shown in Figure 1. We install one load sensor on each of these columns. Therefore the corners of four floor tiles rest on each sensor, and vice versa each floor tile is monitored by four sensors. Every six load sensors are connected to a sensor node, which is also installed beneath the floor. Altogether, the setup consists of 180 load sensors and 30 sensor nodes. The hallway has a width of 3 meters (corresponding to 5 tiles), and a length of 21.6 meters.

(a) The installation site.



(b) Floor tiles rest on columns.

Figure 1. Hallway monitoring scenario.

There have already been similar constructions. Addlesee et al. [1] present a design with 3x3 tiles placed on load cells. However, load cells are much more expensive than our approach. Also the authors do not consider a sensor network scenario. Mori et al. [3, 4] present both a sensing room with pressure sensors on the floor and also the furniture, and a sensing floor which they use to identify people via their gaits. Again, there is no distributed in-network analysis by small devices like sensor nodes.

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In contrast to the previous descriptions, we present a both simple and highly affordable solution for hallway monitoring. In addition, our construction allows for the design of sophisticated algorithms running on tiny sensor nodes. The next section describes an example construction built of 4 floor tiles, which we will demonstrate at SENSYS.

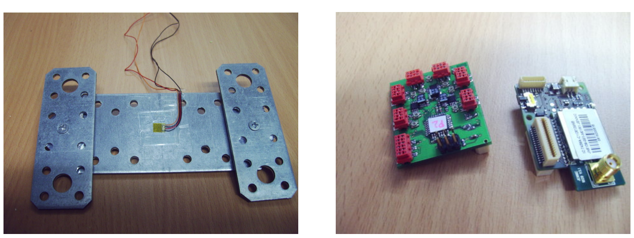
2 Demonstration

Our demonstration presents the idea of the above-described hallway monitoring system. We show a construction of 2x2 tiles, deployed on a 3x3 grid of nine load sensors. The load sensors are in turn attached to two sensor nodes. These share the measured values via their radio.

2.1 Load Sensor

We present a simple—and most notably low-cost—mechanism of building a single load sensor for our application. We use strain gauges, which are able to measure minimal strains in the objects to which they have been glued to. These strain gauges are supplied with a voltage of a few Volts, whereby they provide an output voltage of just a few millivolts. Whenever the attached material is strained or deformed, even by a few nanometers, the output current changes. Such sensors cost only a few Euros (around 10 Euros apiece in our case).

The strain gauges are attached to small steel plates with a size of approx. 10x4 cm, at a cost of less than 1 Euro. The advantage of steel is that it is flexible enough to be strained by the weight of a person, but also solid enough not to be permanently deformed. Installing the steel plates under the floor is surprisingly difficult. Strain gauges measure strains in different directions. If strain is applied from perpendicular directions, they annihilate each other, and the sensor does not measure any force. Hence, we enhanced the construction to deal with this issue. We use two additional steel plates, each with a spacer. The final construction is shown in Figure 2(a).



(a) A single load sensor. (b) Amplifier and iSense node.

Figure 2. Load sensor and connection to sensor node.

2.2 Sensor Nodes

Since the strain gauges have an output of just a few millivolts, they can not be measured using ordinary ADCs. We use an additional amplifier circuit to which up to six strain gauges can be attached. The circuit can power the sensors, and also read out and amplify the sensor output. It bears an Atmega48, which provides multiple ADC ports to read out the sensor values. The circuit has been designed to be used directly with our iSense sensor node platform [2], and communicates with the Atmega48 on the amplifier circuit via SPI. The boards are shown in Figure 2(b).

The iSense nodes are then used for the implementation of high-level data processing algorithms. For example, by exchanging actual data over the radio, the nodes can track people walking through the hallway.

2.3 Construction

We built a small construction of four wood tiles, arranged in a 2x2 field. We attached one load sensor under each corner, so that the sensors form a 3x3 grid. The sensors are attached to the two amplifier circuits, which in turn are connected to the iSense sensor nodes. The floor tiles with the load sensors as the under-construction is shown in Figure 3.

Figure 3. Construction with floor tiles and load sensors.

2.4 Demo

In the demonstration, we connect a sensor node to a PC, and let it collect and process the measured data from the other sensor nodes. The data is then visualized on screen, showing how values change when people walk over the construction. It can be seen how the data reflects the current situation, and also how the combined data of four sensors per tile is useful for later real-world sensor network applications—and accordingly sophisticated algorithms.

Acknowledgements

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