Demo Abstract: Swarm Gateway

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ABSTRACT

The gateway is a key component for sensor network deployments and the Internet of Things. Sensor deployments often tend towards low-power communication protocols such as Bluetooth Low Energy or IEEE 802.15.4. Gateways are essential to connect these devices to the Internet at large. Over time though, gateways have gained additional responsibilities as well. Sensors expect gateways to handle device-specific data translation and local processing while also providing services, such as time synchronization, to the low-power device. As a centralized computing resource, the gateway is also an obvious location for running local applications which interact with sensor data and control nearby actuators. Today, vendors and researchers often create their own device-specific gateways to handle these responsibilities.

We propose a generic gateway platform capable of supporting the needs of many devices. In our architecture, devices provide a pointer, such as a URL, to descriptions of their interfaces. The gateway can download the interface descriptions and use them to determine how to interact with the device, translating its data to a usable format and enabling local services to communicate with it. The translated data is provided to services including user applications, local logging, device status monitoring, and cloud applications. By simultaneously supporting communication with many sensors, our gateway architecture can simplify future sensor network deployments and enable intelligent building applications.

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1. INTRODUCTION

Resource monitoring in buildings requires a sensor infrastructure to measure key attributes, including ambient conditions, air quality, energy consumption, occupancy, space utilization, and other building properties. When integrating sensing into existing buildings, providing a networking strategy that efficiently enables both data collection (for long-term monitoring, validation of implemented policies, and fault detection) and control (for intelligently actuating HVAC systems, conserving energy, and improving building function for occupants) is often a primary challenge. Hard-wiring sensors is effective for new buildings, but often only permits local control loops and is cost-prohibitive for retrofits. Connecting sensors to WiFi or in a mesh network is often difficult to commission and is energy-expensive, leading to short sensor lifetimes. We advocate for an alternative approach: a network of mains-powered gateways that facilitate single-hop communication from sensors. This provides a flexible network infrastructure for supporting a wide range of in-building sensors and embedded devices, including heavily constrained energy-harvesting devices. Further, the gateway infrastructure provides a useful platform for processing, storing, and actuating on the sensor data.

We present a gateway architecture for low-power building based sensors that emphasizes providing a common infrastructure to support a diverse set of sensors and to enable devices to be easily supported as deployments and applications change. Fundamental to this design is the decoupling of data comprehension from communication on the gateway. Devices communicate over one of several standard wireless protocols and simply provide a pointer to information about themselves, in particular how to communicate with and interpret data from the device. The pointer we use is a URL that hosts small code snippets that provide this functionality. By providing this abstraction layer, a device can identify itself to a gateway by providing this URL, and the device-agnostic gateway can transparently begin supporting the previously unknown device. This architecture prioritizes making data streams quickly and easily available on the gateway while minimizing the protocol requirements for devices. This is in contrast to other Internet of Things gateways that focus on cloud publishing and homogeneous device interfaces.

Our gateway platform also provides many broadly applicable services, including forwarding data to cloud applications, local data logging, device status monitoring, local web interfaces, and gateway discovery. These are modular services that can be selectively enabled and modified as deployment needs change. Further, the distributed network of gateways provides a platform for local control when appropriate. Applications that process, interpret, and actuate based on local sensor data facilitate stronger privacy properties, are more resistant to network failures, and aid low-latency operation.

By designing our gateway platform to be reusable with minimal

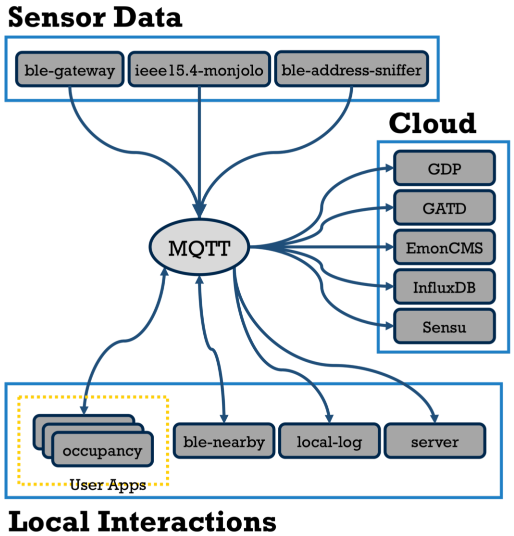

Figure 1: **Gateway architecture.** Data is collected from sensors through various protocols, processed by local services, and distributed to other gateway services via MQTT. Data can be to various cloud applications for visualization, monitoring, and logging, with example services shown. Locally running applications can also make use of the data for low-latency control of nearby actuators.

overhead for the device, we've developed a range of devices it can support, including a plug-load power meter, an environmental sensor (capable of temperature, humidity, light, and pressure sensing) a motion sensor, and an energy-harvesting light sensor. The gateway architecture can also support third-party devices by augmenting them with a beacon that provides a pointer for their device-specific configuration information.

2. GATEWAY DESIGN

The architecture of our gateway platform is shown in Figure 1. Multiple services run on the gateway connected by an MQTT broker which transfers messages locally between them. The gateway is capable of collecting data from sensors through various networking protocols including Bluetooth Low Energy (BLE) and IEEE 802.15.4. Collected data can be processed locally or aggregated and sent to various cloud-based applications.

In order to accept data from arbitrary sensors, the gateway expects each sensor to transmit a pointer to a URL containing an interface description for the device data. This process is demonstrated in Figure 2. In the BLE protocol, for example, devices periodically broadcast a URL encoded as an Eddystone packet [1]. The gateway fetches a file named "parse.js" located at that URL and executes it within a sandbox to parse sensor data. Raw BLE advertisements are fed into the sandbox and the "parse.js" code interprets the data as the sensor designer intended. The parsed output is formatted in the JSON format, with an emphasis on human-readable key names. The gateway does not enforce a certain schema. The formatted data is sent to an MQTT message broker running on the gateway which can distribute the data stream to the built-in and configurable processors or application which can then operate on that data stream.

Adding a new device to the gateway infrastructure requires implementing a BLE advertisement with a Eddystone URL and a "parse.js" file for communicating with the device. This allows the gateway to automatically handle data from newly created or deployed devices, without any updates to the gateway itself.

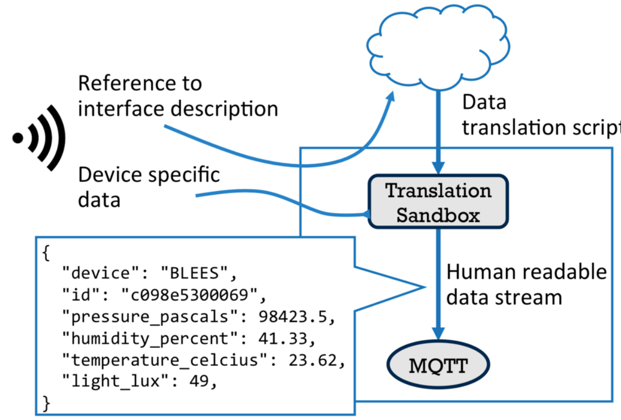

Figure 2: **Sensor data translation.** Each sensor presents a URL which points at interface description code. The code can be run within a sandbox to parse raw sensor data and generate human-readable data which is distributed to other processes on the gateway.

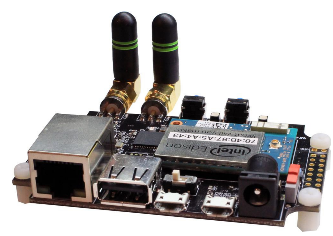

Figure 3: **Gateway hardware.** The gateway platform provides the Linux operating system provisioned with Ethernet, WiFi, BLE, IEEE 802.15.4, USB, and a micro SD card.

The gateway hardware, shown in Figure 3, is a Linux environment based around the Intel Edison [2], which runs the gateway architecture. It includes various radios for communication with sensors, multiple Internet connection methods, and additional storage space.

3. DEMO

The demonstration will consist of the gateway architecture running on our Intel Edison based gateway platform and a suite of BLE based sensors that are fully supported by the gateway. Additionally, an off-the-shelf light bulb and an AC relay both augmented with BLE beacons will demonstrate the extensibility of the platform. Data collected with the gateway will be visualized in real-time with Grafana, an open-source graphing platform, and recent data will be locally viewable within a web browser. Support for local applications will be demonstrated by controlling the light bulb when motion is detected by the sensors.

4. ACKNOWLEDGMENTS

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5. REFERENCES

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