Integration of Sensor Networks with Cloud Computing

Santiago Medina, Fernando Romero, Fernando G. Tinetti[1]

III-LIDI, Facultad de Informática Universidad Nacional de La Plata, La Plata, Argentina
[1] CIC – Comisión de Investigaciones Científicas de la Pcia. de Buenos Aires
{smedina,fromero,fernando}@lidi.info.unlp.edu.ar

Abstract. This article presents a possible approach for the integration of wireless sensor networks with applied IoT (Internet of Things) platforms related to Fog Computing concepts. Several ideas are presented related to: a) definition of the main characteristics to be considered in the deployment of sensor networks, b) evaluation of alternatives for combining wireless communication technologies and, c) experimentation with different IoT platforms for local data preprocessing that will then optimize the data flow of information to the cloud.

Keywords: Sensor Network, LoRa, WiFi, WSN.

1 Introduction

Wireless Sensor Networks (WSN) are one of the fastest growing and most widely applied data processing systems in recent years. WSN are an alternative concept of the MANET (Mobile ad hoc network), focused directly on the interaction with the environment where they are deployed rather than with people [1] [2].

One of the first development areas has been in military applications aimed at surveillance in conflict zones. Among some of the first projects with similarities to the current characteristics of sensor networks we could mention: a) The Chain Home Project, a ring of early warning radars that could detect and track aircraft during World War II, b) The SOSUS project, used in the cold war by the United States Army to track Soviet submarines, and c) The NORAD (North American Aerospace Defense Command) Project, also developed during the Cold War, for control and air defense in the United States.

The growth of Sensor Networks is directly related to the evolution in the development of microcontrollers and communication modules. Sensor network nodes are based on the combination of these two types of hardware. Microcontrollers usually centralize and convert the data generated by their connected sensors and, then, send them through a wireless communication module. Besides, communication devices are the basis of the network architecture as they provide the channels for the data flow. There are many wireless communication technologies used in the WSN, such as Bluetooth, WiFi, Zigbee, LoRa (Long Range), etc. Depending on the type of network to be deployed, the distances to be covered and the type of power available, a detailed analysis must be carried out to select the correct technology.

The application of WSN are varied and constantly growing, being military applications, control systems in agriculture, home automation, and climate sensor networks. Also, the WSN are directly related to the concept of IoT, interconnecting objects (*things*) that are part of our daily life to the Internet, integrating services that facilitate daily tasks of people. Connecting devices to the internet, specifically to Cloud Computing environments, generates a massive flow of data that can bring latency problems and increase several costs involved. In this context, Fog Computing introduces the idea of generating an intermediate instance of processing and control between the devices and the cloud in order to locally compute as much as possible with limited power and storage so as to reduce the data to be sent to the cloud [3] [4].

2 Main Tasks

The main aspects to consider in the deployment of a wireless sensor network connected to the cloud have to be specifically defined. Initially, it is necessary to test wireless communication technologies and analyze the platforms that allow the connection to the cloud with an intermediate level of processing and storage. We are currently working on two specific lines of work: low-power with long-range wireless technologies and IoT platforms.

Wireless technologies have evolved to the so-called LPWANs (Low Power Wide Area Networks). In LPWANs there are several options that allow including nodes in distances of the order of kilometers, while requiring low power consumption. We are analyzing LoRa, specifically in terms of communication integrity and reliability. LoRa, is a radio modulation technology developed by the company Semtech, which defines and owns the physical layer. The data communication layers (called LoRaWAN) are openly developed by a non-profit organization called the Lora Alliance. Semtech is responsible for marketing the devices [5] [6]. It enables long-range, low-power communication very well-suited for sensor networks.

There are several options for sensor data processing. Sending the collected data directly to the cloud imposes an eventually high network bandwidth as well as a proportional cloud data processing (and sometimes storage) facilities. In many applications, it is necessary to act according to the processing results, with its corresponding response time. More sensors usually imply more data, increasing costs for the application deploying and maintenance. We are approaching this problem by means of IoT platforms that run locally and are responsible for being part of the data processing. Thus, we expect to reduce the amount of data sent to the cloud as well as to reduce their value. In this way, the system is including tasks and processes related to the concept of Fog Computing. There are several platforms enabling to build the complete application including Fog Computing such as thinger.io, Node-RED, AWS Greengrass, as well as others [7] [8] [9]. Those platforms have similar operating concepts, they a) allow the creation and control of virtual devices that represent real nodes of the network, b) provide a context for managing data flow, and storage and handling of operations to be executed in the nodes.

3 Methodology

We are testing a basic network topology integrating two wireless communication technologies: WiFi and LoRa, as shown in Fig. 1. While long-range data transfers are provided by LoRa, small WiFi subnets are set up for relatively short-range data transfers (about 50 meters). WiFi subnets may include a relatively large number of Sensor Nodes as well as a single LoRa transceiver acting as a centralized subnet Router Node which also takes the role of network gateway role. Each sensor node is handled by a NodeMCU development board based on the ESP8266 [10]. Heltec WiFi LoRa 32 development board [11] was used for the Router Node, which is based on the ESP32 [12] and includes a LoRa SX1276 transceiver module. The whole network in Fig. 1 also includes a Master Node, which will have access to the cloud or to a standard serve-like computer with access to the cloud.

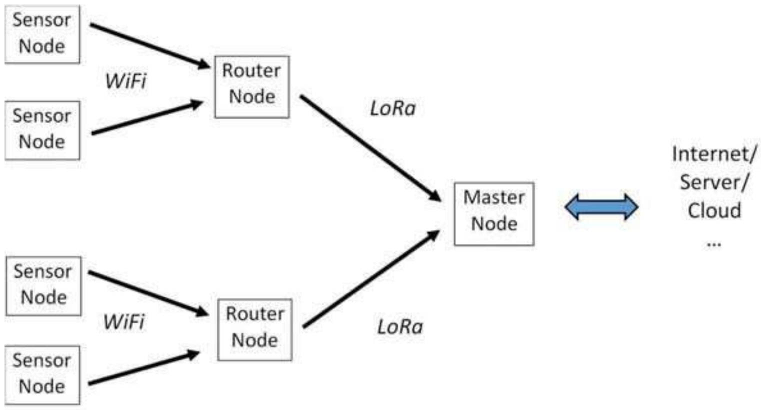

Fig. 1. Network Architecture.

The experiments were focused on identifying three data/network characteristics: transmission distance, integrity of the communication and energy consumption of the nodes [13]. A local instance of Thinger.io was used as an IoT platform directly integrated to the cloud. Thinger.io handles virtual devices as nodes and generates data flows for those nodes. It was tested specifically with a node Wi-Fi interconnection network. This platform allows a simple data management context on the devices as well as a specific communication API (Application-Programming Interface) [14]. For the completion of the tests, it is planned to integrate the Node-RED platform [15] for easier communication between the LoRa gateway and the Thinger.io server.

4 Main Tasks

We have presented a general approach for integrating WSN to the cloud. Even when the approach is not conceptually original, our focus is on defining and experimenting the main characteristics of fog computing-like deployments. We have started our work with a state-of-the-art proof-of-concept installation. Many of the technologies, hardware modules and APIs are relatively new and we are currently gaining experience on them, in our first experiments. The short-term immediate performance experiments will be oriented to characterize wireless communications details such as modules distances, rural and urban environments, average power consumption, and amount of data handled per node.

Once we effectively integrate an IoT platform to some cloud service/s we will start the performance analysis via experimentation work. Initially, some performance analysis will be focused on IoT, cloud computing, and general integration functionalities. Once defined the most important deployment functionalities, the experimentation focus will be shifted to timing parameters like communication latency and bandwidth and hardware computing and storage requirements.

References

1. Sohraby, K., Minoli, D., Znati T.: Wireless sensor networks: technology, protocols, and applications. John Wiley & Sons (2007).
2. Akyildiz, I., Vuran, M.: Wireless sensor networks (Vol. 4). John Wiley & Sons (2010).
3. Bonomi, Flavio, et al. "Fog computing and its role in the internet of things." Proceedings of the first edition of the MCC workshop on Mobile cloud computing (2012).
4. Asemani, Malihe, et al. "A Comprehensive Fog-Enabled Architecture for IoT Platforms." International Congress on High-Performance Computing and Big Data Analysis. Springer, Cham, (2019).
5. LoRa Documentation, www.semtech.com 11.
6. LoRaWAN Documentation, www.lora-alliance.org
7. Thinger.io Documentation, www.thiger.io
8. Node-RED Documentation, www.nodered.org
9. AWS GreenGrass, www.aws.amazon.com/es/greengrass/
10. ESP8266 Technical Reference Version 1.3, Espressif Systems, 2018. https://www.espressif.com/sites/default/files/documentation/esp8266-technical_reference_en.pdf
11. WIFI LoRa 32 Documentation, http://www.heltec.cn
12. ESP32 Datasheet Version 2.3, Espressif Systems, 2018. https://www.espressif.com/sites/default/files/documentation/esp32_datasheet_en.pdf
13. Medina, S., Romero, F., De Giusti, A. E., & Tinetti, F. G., "Experiencias de Análisis de Consumo Energético en Redes de Sensores". XXV Congreso Argentino de Ciencias de la Computación (La Plata, 2019).
14. Aghenta, Lawrence Oriaghe, and Mohammad Tariq Iqbal. "Low-Cost, Open Source IoT-Based SCADA System Design Using Thinger. IO and ESP32 Thing." Electronics 8.8 (2019).
15. Selvaperumal, Sathish Kumar, et al. "Integrated Wireless Monitoring System Using LoRa and Node-Red for University Building." Journal of Computational and Theoretical Nanoscience 16.8 (2019).