A Local Customizable Gateway in General-Purpose IoT Framework

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Abstract. In the emergence of the Internet of Things, the local gateway plays an important role because it connects devices over heterogeneous networks and provides local intelligence. In this paper, we propose a structure of a general-purpose gateway which provides customizable connectivity for a wide range of devices and services such as home appliances, environment sensors, and web-page parsers. In addition, the gateway has an interface to communicate with the IoTtalk platform which has a graphical user interface for device management and enables users create new network applications by programming in Python. The gateway is also implemented on Android platform.

Keywords: Customizable gateway · IoT framework

1 Introduction

The Internet of Things can link different kinds of devices and services including sensors, wearables, home appliances, vehicles, servers and databases. Various intelligent systems such as smart home, smart city, digital healthcare, etc., and be constructed in this way. Since the application scenarios are variant, the access technologies and communication protocols for IoT are quite diverse. As such, devices using different protocols cannot directly communicate with each other even if they are physically approximate. Therefore, a gateway is often deployed to break the barrier.

In addition to providing connectivity, such a gateway plays important roles in IoT eco-system because it has various functions: (1) provides the intermediate connection to the Internet for low-cost and low power devices; (2) acts as an access filter for those have security concerns and thus cannot directly connect to IP networks; and (3) provides the local intelligence and preprocessing of sensors' raw data.

There are numerous existing works [2] discussing different aspects of IoT. Some works [3–5] focus on local gateways. Zhu et al. [3] proposed a prototype bridging wireless sensor networks into IoT. Guoqiang et al. [4] designed and implemented a more flexible gateway. Wu et al. [5] aimed to network application development.

To our best knowledge, there is no existing works that consider a structure of a general purpose IoT gateway. Therefore, this paper proposes an architecture that can connect Physical devices, internal sensors, remote information and a powerful IoT

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management platform, IoTtalk [1] altogether. IoTtalk is a IoT cloud platform which allows users to create various IoT automation links in Python. Combining the gateway and the cloud service together, many innovative applications such as voice-based remote control, or a cloud-based health monitoring system collecting data from wearable devices become possible.

The rest of the paper is organized as follows. Section 2 details the architecture and the functions of each component. Section 3 shows the implementation case. The whole paper is concluded in Sect. 4.

2 System Architecture

This section describes the system architecture of the proposed general-purpose IoT gateway. We first present the components and their functions, and then an example shows how the gateway works as a voice-based remote control system.

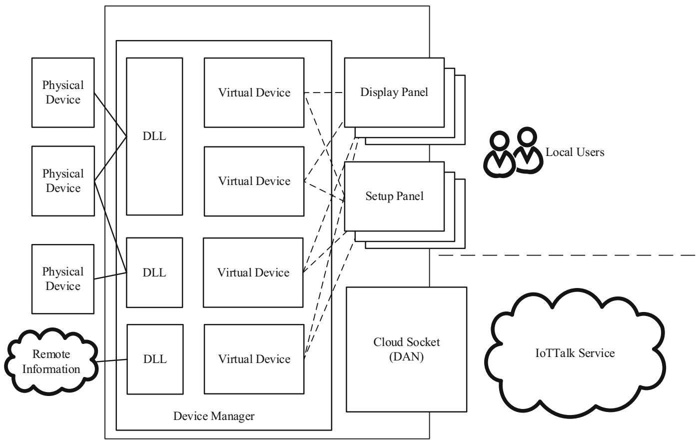


Fig. 1. The proposed architecture of a local customizable gateway in generate-purpose IoT framework.

2.1 Functions of Components

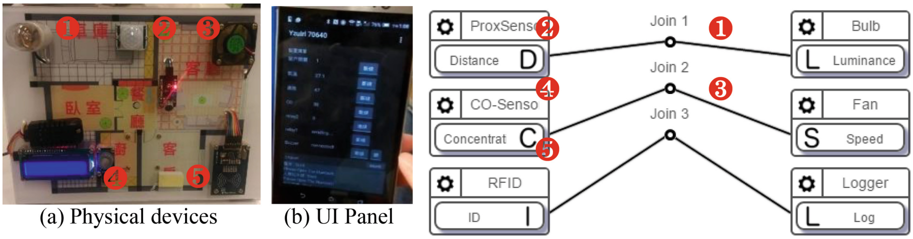
As shown in Fig. 1, the detail operation of each component is as follows. Physical devices, remote information or internal sensors are accessed by the gateway's dynamic linking libraries (DLLs) which implement the communication and data-fetching processes. DLLs are accessed by virtual devices (VDs), which provides a unified standardized APIs for higher-level management. They inherit an identical prototype object which contains common functions (e.g., start, stop, pause, resume, etc.) for Device Manager (DM) to control the operations and lifecycles. Based on the requirement of users, DM activates different VDs and their respective Setup-Panels and Display-Panels. These two Panels serve as the user interface and respectively provide the setup and the visualization interfaces of each VD. These two types of panels can be designed specifically to reflect different conditions and characteristics of VDs, or choose from existing components. Finally, the cloud socket access the information of VDs and synchronize them with the cloud services. By connecting to the IoTtalk platform, local physical devices can exchange data with remote services over the internet. Device users and service providers can easily develop different kinds of network applications using the Python programming language. The information can be further processed, which makes automation, big-data analysis and other broader applications possible.

2.2 Lifecycle and Mechanism

The following example shows the operation of the general purpose IoT gateway. Assume that the gateway is run on a setup box to provide, say, an intelligent smart-home application. The setup box uses standard Bluetooth library to connect local home appliances such as smart plugs, utilizes internal function to fetch the voice commands from users, and uses TCP/IP sockets to acquire current air quality condition from the Internet. Encapsulated into three virtual devices, users can customize the visualization of each VD independently and form a console. For example, using line graph to show the current temperature, and using buttons to control air-conditioners. Through DAN, the information of voice-command can be submitted to online IoTtalk services, and then trigger other devices. This gateway can save the software development and integration effort from device manufacturers, and better bridge more local sensors to cloud IoT services.

3 Implementation

The prototype of the gateway is implemented on Android system. Run on smartphone or setup box, our system supports BLE devices, acquires information from internal GPS/accelerator sensors, and can fetch information through web API such as Yahoo weather and XML standardized standards, and connects IoTtalk via HTTP-based RESTFul APIs. We have implemented several UI panels for different purposes. The sensed value can be represented by texts, line graphs or different graph icons. The physical setup, the UI and some network applications of the implemented system are shown in Fig. 2. The 5 VDs are a light bulb, a proximity sensor, a fan, a carbon monoxide sensor and an RFID reader labeled from 1 to 5, respectively. Their information is displayed on the UI panel and transferred to the IoTtalk platform via the gateway. On the IoTtalk platform, we build models and create corresponding devices features for each VD. Using several lines of Python codes, we develop 3 network applications: (1) If the proximity sensor detects an object nearby, then turn on the light; (2) If the concentration of carbon monoxide rises, then increase the speed of the fan; (3) When the RFID reader recognizes an ID, log the ID and time to the cloud.



(a) Physical devices (b) UI Panel

Fig. 2. The implemented system.

4 Conclusion

This paper discusses the structure of a general-purpose gateway for integrating local devices into a universal IoTtalk cloud services. By encapsulating different local devices, local sensors and remote resources into virtual devices, the gateway can provide an organized and customizable interface for users and remote cloud services. This structure can be applied on different IoT areas, such as healthcare, smart-home and smart cities.

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