An IoT platform "My-IoT" and its enhancement

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Abstract— This paper presents a new IoT platform called *My-IoT* and an edge-cloud collaborative computing environment that can easily be downloaded from and executed on the platform. As platform enhancements, an AI computing framework and promising devices for edge computers, such as GPU, FPGA, etc., are discussed.

I. Motivation

Although the necessity of introducing IoT (Internet of Things) technology is pointed out in various fields, its design, implementation, and operation costs are critical. In general, companies and organizations (or *users*) consider introducing IoT systems with their business position to create and improve new digital services. Therefore, the applicable scope differs depending on the user environment, even in the same industry and field, because of their wide range of applications (*diversity of IoT systems*). To avoid the cost issue, system designers (or *providers*) tend to provide general purpose or standard systems (*Uniformity of IoT systems*). The "diversity of required IoT systems" and the "uniformity of provided IoT systems" are contradictory requirements, so we call it *IoT gap*. We have developed a new IoT platform called "*My-IoT Platform*" to solve this issue. The aim is to significantly reduce the costs of development, implementation, and operation of IoT systems and to provide a community place where users and providers can agilely build systems and value verification.

II. My-IoT Platform

A. Concept

The ultimate goal for the My-IoT platform is to make it possible for users to develop, operate, and enhance their own IoT systems, i.e., a kind of DIY (Do It Yourself) style system design for IoT applications. Our major considerations are: 1) how to easily establish edge-cloud communication, 2) how to easily develop (and reuse) edge and cloud applications, and 3) how to easily (and also remotely) deploy them. To answer the three technical questions, we have developed a framework using Node-RED edge-programming environment and AWS cloud solution (for 1 and 2) and an IoT device/application management system called *My-IoT Store* (for 3). The My-IoT platform provides a cooperative system design environment to IoT users and providers that can be used to make an IoT ecosystem.

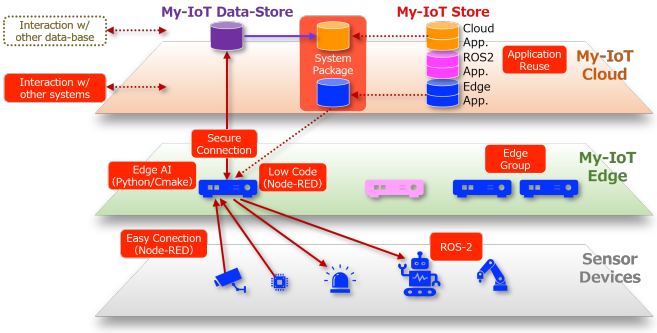

Fig. 1. Overview of My-IoT platform

B. System Architecture

Fig. 1 shows the overview of the My-IoT platform. The My-IoT platform works on Amazon Web Services (AWS), a cloud service provided by Amazon, as a backend, and the various My-IoT functions are built using AWS services. In the My-IoT platform, developers design *edge applications* and *cloud applications* work on My-IoT edge and My-IoT cloud computers, respectively. Moreover, the developer makes these applications available to users by registering on *My-IoT Store* from a web browser.

The My-IoT platform employs Node-RED to ease edge application development for users. Two dedicated Node-RED nodes, "*My-IoT out*" and "*My-IoT in*", are provided for data exchange between My-IoT edge and My-IoT cloud. On the other hand, cloud application is constructed with AWS Lambda and API Gateway, which run on the backend of the My-IoT platform. Since many practical samples are prepared, users may divert them for smooth development.

The My-IoT store keeps various edge applications and cloud applications registered by developers. The store is also a web application servicing the functions and resources of the My-IoT platform. System users operate from IoT system construction to resource management and daily operations themselves by accessing the My-IoT store from a web browser. Various data received from the edge computer is accumulated in a cloud database called *My-IoT data store*. These data are available only within the registered subscriber group (or *tenant*) and are accessed from edge applications, cloud applications, and My-IoT APIs.

C. How to use the My-IoT Platform

An IoT application designed and managed in the My-IoT platform is called *package*, i.e., a set of edge and cloud applications that can communicate and cooperate. Users can select and combine edge and cloud applications registered in the My-IoT store to configure a package for the desired feature. Of course, it is allowed to design and register new edge and cloud applications. The communication between the edge and cloud applications is defined using *connector*. Therefore, it is ensured that the edge-cloud communications are successfully established as long as appropriate connectors are used. After the package installation to edge and cloud computers, the configured new IoT application is built and starts running automatically. The *My-IoT store dashboard* observes the many operating statuses of remote edge computers, e.g., edge connection status, package installation status, alert information, and errors occurring on edge computers.

III. Enhancements toward High-Performance IoT Platform

A. Edge-cloud Cooperative AI Computing Environment

The need for AI processing at the edge computer has increased, and achieving high performance and low power consumption is a critical demand [1]. Raspberry Pi is the official edge computer in the My-IoT platform; however, it may not perform the required performance and power consumption requirements according to advanced applications. In conventional standard IoT processing, cloud computers wait to receive the entire data from the edge computer. When a large amount of data is used, this waiting cost causes a longer execution time for the application and may lose the real-time property. To solve this issue, the paper [2] introduced an *edge-cloud collaborative AI computing environment* implemented by using the My-IoT platform. This AI inference framework employs distributed processing where the edge and cloud computers cooperate tightly. The framework of the environment divides AI processing (inference) between edge and cloud computers, i.e., A CNN layer is defined as the partition point that splits the whole CNN model into two parts, and the front and end parts are deployed onto the edge and cloud computers. Since we can offload a heavy part of CNN inferences onto the cloud, the performance and energy efficiency issues on edge computing devices can be solved. The framework on the My-IoT platform shown in Fig.2 is an enhanced design of [2], introducing parallel connector implementation to reduce communication overhead significantly.

B. Emerging Edge-Device Supports (On-going)

Two useful enhancements for the My-IoT platform have proceeded to enable flexible edge computing for various conditions/constraints.

One enhancement is to utilize GPU code and FPGA configuration in addition to CPU code. Edge computing with GPU and FPGA has recently become general and utilized because of their high performance [1][3]. In this enhancement, proper

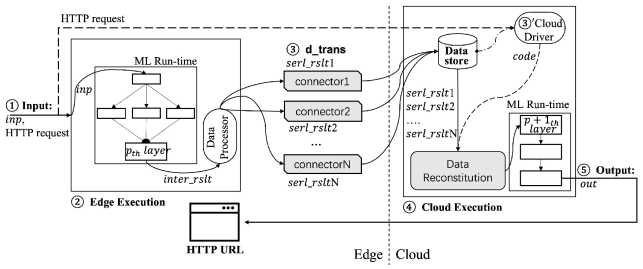

Fig. 2. Edge-cloud cooperative AI processing using My-IoT platform

edge applications are automatically selected and installed without awareness of the device type, i.e., CPU, GPU, and FPGA, or users may explicitly change devices according to constraints such as execution effectiveness, power consumption, etc.

Another is to utilize smartphones and MCUs (Microcontroller Units) as edge computers. Since the My-IoT edge runtime on the device works with various sensors and small/low-power properties, it is versatile, cost-effective, and helpful for human living and industries.

IV. Conclusions

In this paper, we described the IoT gaps that prohibit the spread of IoT systems and introduced the My-IoT platform as the solution. We also described implementing an edge-cloud collaborative computing environment for AI processing as an application development. Furthermore, the enhancement of the operating mechanism that utilizes several edge-computing resources based on GPUs and FPGAs was outlined. Future works include deepening and implementing these enhancements to the My-IoT platform.

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