Evaluation Form – Technical Background Review

Student Name: Shadman Ahmed

Project Advisor: Vijay Madisetti

Team Name: Team 1: IntelliBus

Team Members: Thomas Talbot, Noah Chong, Yue Pan

_______ / 30 Technical Content

- Current state-of-the-art and commercial products
- Underlying technology
- Implementation of the technology
- Overall quality of the technical summary

_______ / 30 Use of Technical Reference Sources

- Appropriate number of sources (at least six)
- Sufficient number of source types (at least four)
- Quality of the sources
- Appropriate citations in body of text
- Reference list in proper format

_______ / 40 Effectiveness of Writing, Organization, and Development of Content

- Introductory paragraph
- Clear flow of information
- Organization
- Grammar, spelling, punctuation
- Style, readability, audience appropriateness, conformance to standards

_______ / 100 Total - Technical Review Paper

Shadman Ahmed

Project Advisor: Vijay Madisetti

Team 1: IntelliBus

Cloud Services for IoT Device Management

Introduction

Internet of Things (IoT) devices are used in various applications and provides needed solutions to connect, collect, store, and analyze data. In order to provide these solutions for large, distributed mesh IoT networks, cloud-based computational services and solutions are utilized to connect, monitor, manage and control thousands of IoT devices and its data in a scalable and secure platform. This technical review paper summarizes commercially available cloud computing solutions for IoT device management, explains the underlying technology and provides methods of implementation for ideal IoT devices.

Commercial Cloud Computing Solutions for IoT Devices

IoT cloud services are offered by many vendors and this section covers two popular commercial cloud providers and their platforms and services: Amazon Web Services (AWS) and Microsoft Azure.

Amazon Web Services (AWS) offers an extensive library of IoT services and platforms. AWS offers *IoT Device Management* as a IoT control service. This service provides and handles tracking, monitoring, and management of device fleets [1]. The AWS IoT Device Management service allows for fast device registration for new devices added into the network ecosystem. It allows users to securely add devices into a registry and assigns authentication certificates and access policies to other AWS head-end systems [1]. IoT Device Management also provides fleet provisioning to automate deployment of firmware and configurations to active devices in the field [2]. The AWS IoT Device Management service costs are broken down into multiple parts. Bulk registration of devices into the ecosystem costs $0.10 per 1,000 devices registered [3]. Device jobs for active devices in the field, such as firmware or configuration updates, cost $0.003 per remote action a month for the first 250,000 actions and $0.0015 per remote action per month for over 250,000 actions [3].

Azure *IoT Hub* is a competing cloud service for IoT device management offered by Microsoft. IoT Hub provides a cloud-hosted back-end solution that can connect to any IoT device for authentication, device management and scaled provisioning [4]. IoT Hub allows users to query on-demand statuses of edge IoT devices without any code. IoT Hub utilizes bidirectional communication with IoT devices to query device states, send messages and commands, and track delivery with acknowledgements [4]. IoT Hub maintains *device twins* for each IoT device. Device twins are JavaScript Object Notation (JSON) documents that contain metadata, configurations, and conditions for the IoT device [5]. IoT Hub presents user interfaceable tools to configure and deploy device twins to IoT devices. IoT Hub also offers *Device Update* service to allow users to publish, distribute and manage over-the-air (OTA) firmware updates to devices in the field [4]. Azure IoT Hub costs are broken down into multiple tiers of usage for IoT devices (referred to as a IoT Hub Unit). Basic tier usage costs start at $10.00 per IoT Hub Unit per month for 400,000 messages per day per IoT Hub Unit [6]. IoT Hub Device Provisioning services for IoT Hub device management costs $0.213 per 1,000 operations [6].

Technology of Cloud IoT Management

IoT services provided by cloud vendors are modular and utilize messages for upstream and downstream data flow to and from IoT devices. Upstream data refers to payloads, such as sensors readings or device state, that flow up to a device gateway [7]. Downstream data flow refers to payloads, such as firmware updates or device twins, that flow down to IoT devices from the device gateway [7]. A device gateways is a set of resources and services that handle upstream and downstream data to and from IoT devices. AWS IoT Core and Azure IoT Hub services have device gateways that leverage this message passing interface to provide extensive cloud platforms and services for IoT devices. Device gateways are then able to communicate through Application Programming Interfaces (API) to other resources that handle Device Registration, Rules Engines (like firmware update commands) and Device Shadows (like device twins) [7]. These modular groups of resources make up the AWS and Azure IoT platforms and services solutions.

Messages between IoT devices and device gateways use two widely adopted application-level communication protocols: Message Queuing Telemetry Transport (MQTT) and Hypertext Transfer Protocol (HTTP). MQTT is an ISO/IEC 20922:2016 standard that leverages TCP/IP (or other network transport protocols) to provide light weight, open and simple publish/subscribe messaging transport [8]. HTTP is an RFC 2616 consensus standard issued by the Internet Engineering Task Force (IETF) in their published memorandum called Request for Comments (RFC). HTTP provides generic and stateless hypermedia information for virtually any digital data [9]. MQTT and HTTP are widely adopted and allow for rapid development and deployment to send and receive data from IoT devices.

Methods of Implementation for IoT Devices

Implementation of IoT management requires both hardware and software considerations. IoT devices must choose embedded systems that allow for network interfaces (known as sockets) with supported firmware for TCP/IP protocols. ARM based embedded devices have add-on boards for Wi-Fi and LTE which convert Radio Frequency signals to Serial communications that ARM processors can decode and handle [10]. This will allow the IoT device to poll and process hardware data and send MQTT or HTTP messages to cloud device gateways, while also receiving messages from cloud device gateways.

In the cloud, implementation for large numbers IoT devices and data are complex and require solutions architects to consider reliability, scalability, security, and cost for both physical IoT hardware and cloud services. Cloud resources are charged per request/action and need to be optimized to scale up or down based on usage, to manage cost and provide reliable service.

References

[1] Amazon Web Services, “AWS IoT Device Management,” *Amazon Web Services*, 2021. [Online]. Available: https://aws.amazon.com/iot-device-management. [Accessed Mar. 5, 2021].

[2] Amazon Web Services, “AWS IoT Core Developer Guide,” *Amazon Web Services*, pp. 675-676, 2021. [Online]. Available: https://docs.aws.amazon.com/iot/developerguide/iot-dg.pdf. [Accessed Mar. 5, 2021].

[3] Amazon Web Services, “AWS IoT Device Management Pricing”, *Amazon Web Services*, 2021. [Online]. Available: https://aws.amazon.com/iot-device-management/pricing. [Accessed Mar. 5, 2021].

[4] Microsoft Azure, “Azure IoT Hub,” *Microsoft Azure*, 2021. [Online]. Available: https://azure.microsoft.com/en-us/services/iot-hub. [Accessed Mar. 5, 2021].

[5] Microsoft Azure, “Understand and use device twins in IoT Hub”, in *IoT Hub Documentation*. Microsoft Azure, [online document], 2021. Available: https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-devguide-device-twins [Accessed Mar. 5, 2021]

[6] Microsoft Azure, “Azure IoT Hub pricing,” *Microsoft Azure*, 2021. [Online]. Available: https://azure.microsoft.com/en-us/pricing/details/iot-hub/. [Accessed Mar. 5, 2021].

[7] Arshdeep Bahga, and Vijay Madisetti, *Cloud Computing Solutions Architect A Hands-On Approach*. Columbia, SC: Arshdeep Bahga & Vijay Madisetti, 2019, pp. 391-392.

[8] *Information technology – Message Queuing Telemetry Transport (MQTT)*, ISO Standard ISO/IEC 20922:2016, June 2016. [Online]. Available: https://iso.org/standard/69466.html

[9] *Hyper Text Transfer Protocol – HTTP/1.1*, RFC 2616, June 1999. [Online]. Available: https://ietf.org/rfc/rfc2616.txt

[10] Jenny Hunter, “Using Adafruit ESP8266 Huzzah,” *os.mbed.com*, 2015. [Online]. Available: https://os.mbed.com/teams/Ece-4180-team-who/wiki/Using-Adafruit-ESP8266-Huzzah