Metadata model for supporting hierarchical Edge Device arrangements in an IoT deployment

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***Abstract*— An increasing number of "Smart Devices" are coming online every year. These Smart Devices have the ability to communicate with other Smart Devices across the web, exchange information and make intelligent decisions. Measures to combat the added load brought on by these new connections have inadvertently resulted in increased network complexity. This paper considers why understanding that complexity is necessary, especially on the server side. Existing architectures are thereafter explored to gain insight into a possible solution. A metadata-based model is then proposed that would provide a central server with an overview of the network arrangement. The novelty of this model lies in its simplicity, scalability and technology agnosticism. An implementation of this model is then tested in a mix of real-world and simulated environments and evaluated. The results obtained indicate improvements in benchmarks along with performance gains with regards to network scaling.**

Keywords—Fog Networks, Edge Computing, Edge Gateways, Smart City, Internet of Things

I. Introduction

Before the advent of the technological revolution, household items simply performed the tasks they were built for. They were known as "dumb" things. Then a concept known as the Internet of Things (IoT) came along which made it possible for any end user device to have Internet connectivity. This allowed devices to connect to other devices and services for extended functionality [1].

In traditional IoT architectures, all data generated from connected devices are sent to a central server for storage and further analysis [2]. With added complexity brought on from new devices that are connecting to the network, additional load has been applied on the central servers orchestrating the communication between those devices. A new concept known as Edge Computing aims to combat this. It refers to the computational logic that is done close to or at the source of the generated data to alleviate the need for all data gathered to be sent to the central cloud [3].

The best way to understand the relationship between Edge Computing and central servers is to study a Smart City scenario [4]. Some of the notable use-cases of a Smart City include; building monitoring, waste management, smart parking and autonomous driving [5]. These are built with the intention of providing better value to residents [6].

A Smart City is a real-world instance where multiple layers of devices (arranged in a hierarchy) come together to form a Fog enabled IoT Network [7]. But with it also comes the issue of good governance.

Good governance within a complex system is maintained by trust among its participants [8]. If not for this, participant would refrain from engaging in the system, making it a failure. This applies for IoT Networks as well [8]. In any IoT Network this governance is upheld by certain fundamental characteristics [9]. While there are several, they can be combined together under three crucial umbrella factors namely; security, analytics and diagnostics [6].

It is by adhering to these factors that good governance within an IoT Network and by extension, its longevity, is maintained. The only way in which these factors can be adhered to is by accounting for each and every edge device and Edge Gateway within a particular network. This is done by having the main supervisory service (i.e.; the central server) keep constant track of what devices under its influence are doing [6].

In order to do so, it is imperative that the central server have a thorough understanding as to how the devices under its influence are arranged. Traditional IoT Networks are strong in this regard as they have a straightforward arrangement with devices in direct contact with the central server without the use of any intermediaries [10]. This is not the case in a hierarchical IoT Network as found in a Smart City. Accordingly, this paper aims to provide a solution that will enable a central server to understand a complex network arrangement as in a Smart City.

This paper is structured such that section II defines the problem & section III describes the architectural design followed by section IV which will delve into the implementation. Thereafter section V would discuss the testing used to prove the model's viability. This will be followed by section VI which will evaluate the results of those tests. The paper will finally conclude with section VII with comments and a discussion about future work.

II. Problem

When considering the aim of this paper, the question that arises is; does there currently exist a way for central servers to understand devices arranged in a complex, hierarchical structure? More specifically, a fog-enabled hierarchy with fog nodes arranged at different levels as observed in the Smart City scenario.

The purpose of this paper is to propose a model that would be able to answer that question and consequently fill the identified gap.

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