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Indoor Air Quality Monitoring though Software Defined Infrastructures

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***Abstract*—In this demonstration we use a prototype of a Wireless Sensor Node along with a Software Defined Infrastructure to monitor the quality of the air in different classrooms at a University. Specifically, a number of wireless nodes are deployed in different classrooms. Each node has a number of sensors to monitor the air quality in the room. A number of relay nodes forward the data to a vCPE, which delivers the data to a Smart Edge. In the vCPE and the Smart Edge, a monitoring and analytic system, called MonArch, is used for collection, storage and analytic purposes of the monitoring data.**

I. INTRODUCTION

With the continuous development of cloud computing and Internet of Things (IoT) technologies, cloud computing infrastructure has become heterogeneous and multi-tiered. Traditional cloud computing infrastructure contains only data centers that reside geographically far away from users. These data centers contains large numbers of compute, network and storage resources. However, deploying applications on top of traditional data centers can introduce high communication latency due to the physical distance. To address this issue and improve content delivery for applications, cloud infrastructure has become multi-tiered, where the first tier is the traditional cloud data centers, and the second and third tiers are smaller but fast and agile data centers/ computing devices that are geographically closer to user.

In the Smart Application and Virtual Infrastructure (SAVI) project, we envision the cloud to have a three-tiers infrastructure. Tier 1 has core data centers that are traditional data centers discussed above. Tier 2 has Smart Edges that are agile data centers residing closer to end users. In addition to the traditional compute, network and storage resources, Smart Edges also provide other heterogeneous resources such as programmable hardware (FPGA), GPUs, Software Defined Radio (SDR), and wireless access point. The Smart Edge is mainly to deliver quality applications that require high responsiveness and have requirements that can only be satisfied with a heterogeneous data center close to the end users. Finally Tier 3 has sensors and virtual Customer Premises Equipment (vCPE). Sensors continuously monitor the physical world. These sensors includes mobile sensors such as smartphones, car sensors and sensor that are installed statically such as temperature, light, carbon-dioxide sensors inside buildings. vCPE extends cloud management and functionalities to the customers premise to support various demands from customers.

Fig. 1: vCPE

The proposed demonstration focuses on Tier 3 and the integration of a Wireless Sensor Network and SAVI. A number of prototypes are deployed in different University classrooms. Each prototype monitors the air quality in the room. All the data a forwarded to SAVI for processing and storage, though MonArch [1].

II. SYSTEM MODULES

The proposed demonstration is a smart classroom monitoring system supporting real time air quality measurements.

The system consist of three different modules.

A. Sensor and relay nodes

The prototype consists of a sensor unit and a wireless communication unit. Each prototype can act as sensor and/ or relay node [2].

The sensor node has a sensor that monitors air quality (in ppm) and a wireless transmitter/ receiver. All the data from the sensor are forwarded to the wireless transmitter/ receiver. Then the data are forwarded to one of the neighbor nodes following a routing protocol [3], [4].

The relay node forwards all the data to the destination node. Relay nodes follows the principles of the designed routing protocol. In this demonstration, the relay nodes forward the data to the neighbor node that is closer to the destination.

Both sensor and relay nodes are static and we assume we know their relative location.

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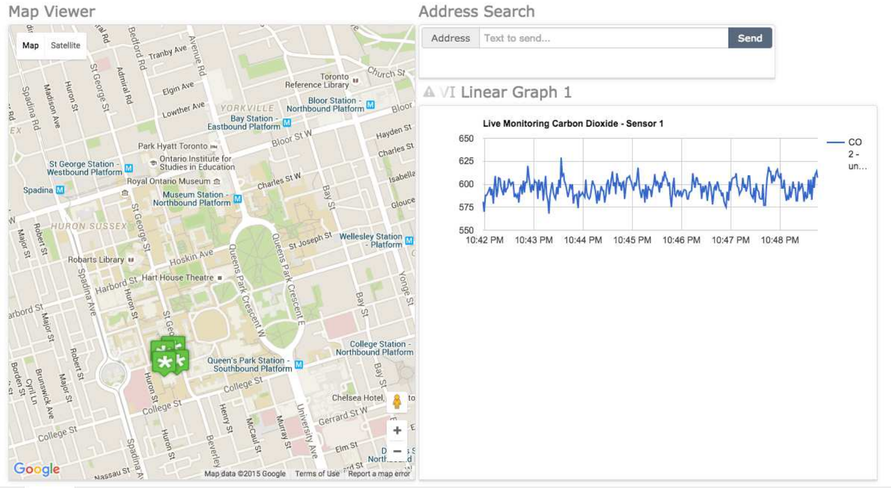

Fig. 2: Sensor Data Visualization GUI

B. vCPE

To deploy the indoor monitoring system on the vCPE, shown in Figure 1, we connect the destination node of the wireless sensor network to the vCPE machine. Then, we run the control room software and the MonArch User Agent in the vCPE so that data are aggregated and sent to the Smart Edge node for storage. One of the features of the vCPE is to provide uninterrupted service even when there is a network disruption between itself and data centers. This feature is provided for this use case as well. To achieve uninterrupted service, an Apache Kafka instance is deployed locally on the vCPE. Sensor data are collected by the MonArch User agent and submitted to the local Kafka instance. Then on the Smart Edge size, the sensor data are aggregated into the top level Kafka which is part of the MonArch system. In this case, when there is a network disruption between the vCPE and the Smart Edge, data are still collected and sent to the local Kafka instance. When the network recovers, the queued monitoring data will be sent to the Smart Edge and aggregated to the top level Kafka. As a result, there will no data lost. If the monitoring data stored in the Smart Edge are continuously visualized in a GUI, the sensor data generated during the networking disconnection period will be shown when the connection restores.

C. MonArch

MonArch is a scalable and extensible monitoring and analytic system. It provides data collection, storage, and analytic capability. As IoT continues to develop rapidly, an increasing number of sensors will be deployed. To manage the large size and variety of sensor data, scalability of data collection, storage, and analytic is both crucial and challenging. MonArch provides scalable solution for integrated collection and processing of sensor data. MonArch provide both online and offline data analytic capability. An anomaly detection analytic algorithm is also provided in the MonArch system and can be used for real time detection of anomaly in sensor data. The MonArch system can be easily extended to monitor new types of monitoring data using a User Agent, which is a general data collection agent that often locates close to the data collection point to acquire, format, and submit monitoring data to the MonArch storage and analytic cluster. Extensibility provided by MonArch is important for sensor monitoring as it minimize the work and code changes required to starting monitoring new types of sensors, which are developed and deployed everyday.

III. DEMONSTRATION DESCRIPTION

During the demonstration, four sensor nodes are placed at the corners of the room with two relay nodes and one destination node. The nodes are powered with two AA batteries. The destination is connected to the vCPE. The vCPE is connected to the SAVI servers.

When the sensor nodes start transmitting data, all the data are forwarded to the vCPE. Then, the vCPE forwards the data to the SAVI servers for the processing. During the demonstration, the connectivity between the vCPE and the servers will be lost. In this case, the vCPE stores all the necessary data locally. When connectivity returns, all the data are plotted through the GUI, without any interruption or loss of data. Figure 2 shows an example of the developed GUI. On the left side is the location of the prototype in the campus and on the right side is the reported data of one of the sensors.

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