A Reliable Edge Computing Architecture for Petrol Industry

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ABSTRACT

The existing monitoring and anomaly detection systems in the petrol industry, such as Supervisory Control and Data Acquisition (SCADA), are centralized and not efficient in terms of response time. In this study, we propose a scalable decentralized architecture based on edge computing, which is inexpensive, reliable and provide efficient response time.

1 INTRODUCTION

Edge computing refers to the enabling technologies that allow computation to be performed on the raw data closer to its origin. In contrast to cloud computing, an additional edge layer is added between the cloud and data source (e.g., Wireless Sensor Network (WSN)), which consists of cloudlets [2]. In simple terms, a cloudlet can be viewed as a "data center in a box". It is logically proximate (e.g, one-hop Wi-Fi) to the associated WSN to provide low end-to-end latency and high bandwidth. It can perform minimal cloud operations such as storage of the data, train machine learning (ML) models on the received data, real-time predictive analysis of the data and can mask transient cloud outages.

2 SYSTEM DESIGN AND USE CASE

Figure 1 presents the proposed 3-tier architecture, based on the edge computing paradigm, which consists of a WSN layer, an edge layer and a cloud layer. The WSN layer consists of sensor, actuator and gateway nodes to monitor the environment such oilfield, which has hazardous chemicals at high temperature and pressure. The edge layer consists of cloudlets to process data in the logical proximity and the cloud layer is used to monitor all the cloudlets. The functionality and interaction between the layers of the architecture are described as follows.

Each **sensor node** is equipped with one or more sensors of different types such as temperature, pressure, and acoustic sensor to monitor events such as pipeline leakages, pressure and temperature variations, and workers safety. It also consists of a microcontroller, battery, radio transceiver and lightweight operating system such as Contiki or TinyOS. If operating in a sensitive environment such as oilfield, all the nodes should be enclosed in ATEX (ATmosphere EXplosive) certified enclosures. Large number of inexpensive sensors can be deployed to provide spatial and temporal resolutions in the sensor readings [1],[3] . The data collected from the sensors is forwarded towards the **gateways** via short range communication. In addition to the characteristics of sensor nodes, gateways have more computation power and long-range communication to a nearby cloudlet. The main task of a gateway is to forward data to the cloudlet and commands to the sensor nodes and actuators from the cloudlet. A WSN can have more than one gateway and each gateway in the system has a connection with more than one cloudlet in order to address failures and the reliability issues.

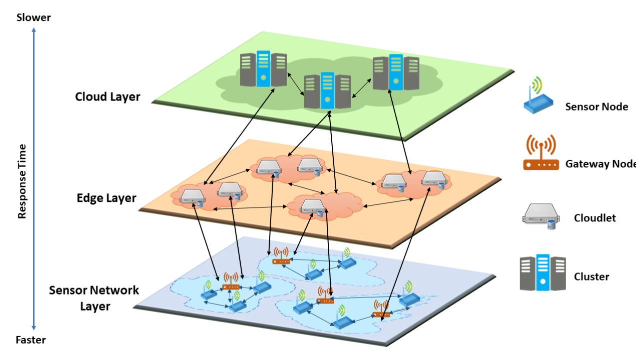

Figure 1: 3-Tier Architecture for Oil & Gas Industry.

After receiving data from the gateways, the **cloudlet** processes the data and if there is an anomaly it would alert the workers in the area and send a signal to actuators to take the corresponding actions. In case of network failure or delay in the communication with the cloud, the local facility would still be operational and would be able to perform the minimal task.

The **cloud** layer is responsible to collect data from all the cloudlets to analyze the data collectively to form a business model. It can make use of the Apache Hadoop to store and process such large scale data in an efficient way instead of a database. Additionally, it would also give a high-level overview of all the operations ongoing in the system.

As a use case, consider that the architecture is deployed in the oil refinery. The sensor nodes from a temperature sensitive field periodically send readings to the cloudlet via gateways. The cloudlet is training a predictive ML model based on temperature readings for that specific location. In case of the first anomaly (e.g, high temperature), the cloudlet would alert the whole area and would update its ML model based on the temperature readings. After some time, the trained model would start predicting the anomalies beforehand. This would not only help in predictive maintenance but also improve the safety of workers in the area and reduce the cost of downtime. In our **ongoing work** with Tüpraş, Turkey's leading oil refinery, we work on modeling and simulating the proposed architecture and comparing the performance with the existing SCADA system.

REFERENCES

[1] Milena Jovašević-Stojanović, Alena Bartonova, Dušan Topalović, Ivan Lazović, Boris Pokrić, and Zoran Ristovski. 2015. On the use of small and cheaper sensors and devices for indicative citizen-based monitoring of respirable particulate matter. *Environmental Pollution* 206 (2015), 696–704.

[2] Mahadev Satyanarayanan. 2017. The emergence of edge computing. *Computer* 50, 1 (2017), 30–39.

[3] Sunhee Yoon, Wei Ye, John Heidemann, Brian Littlefield, and Cyrus Shahabi. 2011. SWATS: Wireless sensor networks for steamflood and waterflood pipeline monitoring. *IEEE network* 25, 1 (2011), 50–56.