A Proactive Service Model Facilitating Stream Data Fusion and Correlation

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ABSTRACT

Stream data from devices and sensors is considered a typical kind of big data. Though being promising, they have a good prospect only when we can reasonably correlate and effectively use them. Herein, services come back to the spotlight. The paper reports some of the authors’ efforts in promoting service-based fusion and correlation of such stream data in a real setting – monitoring and optimized coordination of individual devices in a power plant. This paper advocates a decentralized and service-based approach to dynamically correlating the sensor data and proactively generating higher-level events between sensors and applications. A novel service model for transforming and correlating massive stream data is proposed. This service model shows potential in realizing various middle-way programmable nodes to form larger-granularity and software-defined ‘sensors’ in an IoT context.

KEYWORDS

IoT Service, Proactive Data Service, Sensor Data, Service Hyperlink, Stream Data, Stream Data Correlation

1. MOTIVATION

IoT (Internet of Things) allows industry devices to be sensed and controlled remotely, resulting in better efficiency, accuracy and economic benefit. With the new wave of the forth industry revolution, the IoT-based integration of physical systems and information systems is gaining momentum. The massive real-time IoT data opens up a new horizon of industry automation with decentralized sensing, reasoning and response (Cheng et al., 2016). Let us examine a partial but typical scenario of such

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change with an example of anomaly detection in a power plant. In a power plant, there are hundreds of machines running continuously and many thousands of sensors deployed to monitor machine status in real-time. The status attributes correlate with each other in multiple ways, and indicate equipment status and anomalies. Let us take the primary air fan (PAF) unit as an example. A PAF is currently equipped with 44 sensors, which continuously generate stream data, such as temperature and vibration of fan bearing. Figure 1 shows a partial process to detect anomalies in a PAF.

If the air pressure decreases by 4kPa, an air pressure decrease can be identified. An air pressure decrease may cause fan stall, fan surge, or temporarily nothing. With the decrease, a fan stall can be further identified if the bearing vibration increases by over 0.045mm/s and the motor electricity decreases by over 5A, all at the same time. A fan surge can be confirmed if an air pressure decrease happens and the motor electricity decreases by over 20A. Traditionally, model-based approaches are commonly used by predefining a set of rules based on such analysis as stated above. However, the correlations among sensors can be dynamic and time-varying, which affect the results of anomaly detection. As Figure 1 implies, the predefined rules only consider a part of sensor correlations, neglecting some sensors (showed as gray ovals) that potentially interrelate at run-time. For example, when air pressure decreases by 4kPa and degree of valve control decreases by 10%, the pressure decrease is actually normal. And when air pressure decreases by 4kPa and the motor electricity decreases by over 20A, a fan surge will mostly happen instead of fan stall. In this case, fixed rules cannot capture anomalies accurately due to dynamic and time-varying sensor correlations. It is meaningful to take these dynamic factors into consideration to achieve more efficient and effective anomaly detection. Data-driven analysis can find out and set up new correlations among sensors, and we want to use such analysis results to refine the fixed rules at runtime, and enrich the rule set afterwards. The lower right part of Figure 1 illustrates more possibilities brought up by such dynamic correlation for more elaborate anomaly detection.

We advocate a decentralized and service-based approach to dynamically correlating the sensor data and generating higher-level events between sensors and applications (Han, Liu, Su, Zhu, & Zhang, 2016). Service-oriented paradigm has been seen as a mainstream approach for building large-scale distributed software systems. To decouple data to be shared from their sources, the concept of “data as service” or “data service” is proposed, which can provide semantically richer view and advanced querying functionality. The abstraction of sensor data services also gives us good opportunities to examine ways to build business applications in an IoT environment. Traditional business applications

Figure 1. Possible anomalies due to air pressure decrease: A real case
On Measuring Cloud-Based Push Services
www.igi-global.com/article/on-measuring-cloud-based-push-services/144872?camid=4v1a

Rapid Development of Adaptable Situation-Aware Service-based Systems
www.igi-global.com/chapter/rapid-development-adaptable-situation-aware/41520?camid=4v1a