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IoT-middleware requirements for context-sensitive processing of data to enable predictive maintenance through augmented reality

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Summary:

Increasing numbers of sensors and actuators are being used in IoT systems. This generates a huge volume of data. To extract valuable information for a company based on this rich source of data, a computerised processing of the data is essential. However, the user plays a crucial role in the evaluation. Information must therefore be context-sensitive and adapted to sensory needs.

Keywords: IoT, industrial IoT, MQTT, Augmented Reality, Data modelling.

Introduction

The number of devices connected to the internet is continuously increasing year by year. This trend is spread across different fields of application, like operation of industrial plants, automation of buildings, in healthcare and connecting smart homes. For companies in particular, the Industrial Internet of Things (IIoT) provides access to a strong and growing market [1]. This creates versatile integration possibilities for sensors and expands the fields of application for the Internet of Things (IoT). A large amount of data is generated through the communication of sensors, actuators, and IT systems. In recent years, various IoT standards have been developed; these include the specification of communication protocols for connectivity, data models and data structuring, device management and security requirements. These developments lead to a high degree of fragmentation in the context of IoT standardisation, highlighting a uniform data exchange between IoT systems as a major challenge.

This short paper aims to identify possibilities of IoT communication protocols to provide a user with contextual data of industrial equipment via an augmented reality interface.

Background

Operating industrial plants requires constant monitoring of devices. The highly dynamic nature of the complex interaction between different departments imposes special requirements for IT systems. Information about people, machines and the control of overarching processes must be extracted based on the available data. With the architecture of IoT-based systems, harmonisation of the connections between sensors, communication, application and processes is particularly important [2]. However, a digital transformation in this area is often extremely complicated due to the number of different system types and protocols. To enable seamless status monitoring at any point, interfaces are essential that meet the requirements of real-time and machine-to-machine communication. The authors [3] point out the importance of not overlooking humans as actors in the design of IoT standards and the development of more efficient machine-to-machine communication. An effective data interpretation can be presented to a consumer based on the contextual analysis of the available data.

Objective

Different system architectures and requirements of industrial machines complicate the implementation of IoT standards. Proprietary standards, applied data formats and the complexity of structured data, as well as security requirements for securing data transmission, pose significant challenges in this context [4]. With sensor networks usually involving a high number of interconnected sensors and actuators, which are also increasingly running on embedded devices, communication protocols designed to meet these requirements are therefore highly recommended. A variety of IoT protocols are available, namely Message Queue Telemetry Transport (MQTT), Constrained Application Protocol (CoAP) and Representational State Transfer (REST), all of which are used extensively in IoT applications [5]. The OASIS organisation has standardised the IoT protocol MQTT, which was developed as a lightweight and robust communication protocol that is well suited for IoT applications. Both communication and data exchange are based on the Publish/Subscribe principle. The architecture's central server (broker) enables connected clients to subscribe to topics. This way, clients can both send and receive messages to and from each other. Because of the simple structure, MQTT is notably easy to use and is currently supported by numerous systems [6]. Data transmitted via an MQTT broker can be ambiguous to the consumer if no information is provided about the characteristics of the data. As discussed in [7], MQTT by itself does not allow typification of data and association of metadata. However, a structured definition can be achieved through the hierarchical structure of a MQTT topic. The user can interpret the data on a topic by defining the topics in a well-structured format. By configuring the broker, a bridge functionality can be enabled with MQTT. The Broker simultaneously operates as a MQTT client. As a result, communication can be established with different MQTT networks and messages can be transmitted between different systems. In order to design this mechanism dynamically, the goal of this research is to separate the bridge functionality into an independent software component.

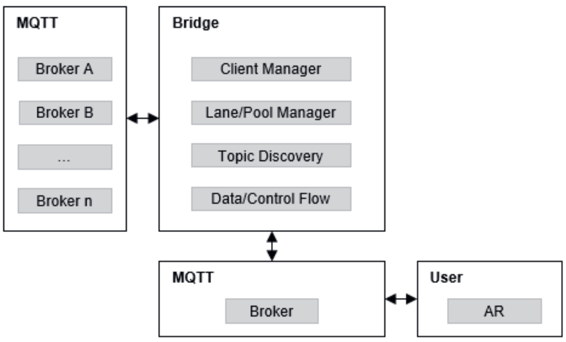

Fig. 1. Data and control flow of the MQTT bridge.

This enables the user to access sensor data from different MQTT networks. In the process, the user can consolidate the sensor data into structured data channels by remapping the topics.

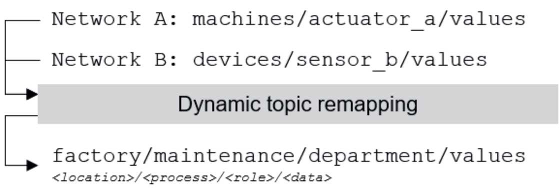

Fig. 2. Restructuring the MQTT data flow by remapping available topics.

A context-sensitive structuring of the data can be enabled and thus, as an example, a reference to spatial awareness, the role of a user or process classification can be achieved. A prototypical test bed consists of a RFID measurement cabinet and a head-mounted display through which a user can access streams of data. The RFID measurement cabinet is used to measure RFID transponder performance on different substrates. The MQTT IoT middleware transmits the measurement results in real-time in the user's context. Using augmented reality, this human-machine interface (HMI) enables the user to visualise the information in the real world in a user-friendly way.

Conclusion

IoT gateway or adapter solutions must still be used to merge IoT data from different systems. Achieving interoperability of IoT standards remains a major challenge due to different data models, communication protocols and system requirements. The concept of a virtual MQTT bridge enables the user to dynamically merge sensor data from different MQTT brokers and enrich it with additional sensor data.

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