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Internet of Things Platform for Distributed Brokers Based on MQTT

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Abstract—

The Internet of Things has many distinct kinds of services that span vast regions. For the vast majority of Internet of Things applications, sending a deluge of tiny data packets over vast distances is essential. The transfer procedures need to be simplified for this reason. Among the many possible transmission mechanisms, MQ Telemetry Transport stands out. Our proposed architecture for a decentralized MQTT broker is a virtual ring. This design adheres to the requirements established in ISO/IEC JTC 1/SC 41, which pertain to an Internet of Things Data Exchange Platform. Using a performance analysis based on queuing models, this article illustrates the superiority of a distributed broker architecture that uses a virtual ring network for real-time communication and outlines its functionality.

Key word :

Among the keywords that may be found in this article's index are Internet of Things, data exchange platform, MQTT, standardization, and Internet of Things platform.

Introduction :

It's common knowledge that several kinds of communication technologies are essential to IoT services [1]. For Internet of Things (IoT) services to function well over a wide area, networks must facilitate the free flow of data and permit the coexistence of IoT with older services. For the most part, IoT services include the sensors communicating with the actuator across the network in tiny data blocks. As a result, lay down the blueprints for low-overhead protocols with simple communication flows. Several articles [2]-[4] outline the key aspects of the IoT Data Exchange Platform (IoT DEP), which was suggested for this purpose by the international standards body ISO/IEC JTC1/SC41. The IoT DEP's concepts for interoperability provide a detailed description of overlapping networks at service nodes. Technologies developed for the Information Centric Network (ICN) facilitate communication between endpoints, including servers and end devices [5]. These interface nodes and terminals are constructed as a middleware module that integrates with conventional communication infrastructure using a socket interface. The MQ Telemetry Transport (MQTT) protocol is anticipated to be the one used for access between endpoints and interworking points [5]. Interconnection nodes act as MQTT brokers, allowing devices to communicate with one other. The authors use a queuing analysis to propose and evaluate methods using these brokers in this research. We also propose virtual ring topologies and cyclic communications based on shared memory for real-time communication within these interworking locations.

IoT Data Extraction and Prediction

In 2018, the structure of ISO/IEC 30161, "Internet of Things (IoT) - Requirements of IoT data exchange platform for different IoT services," is shown in Figure 1. This standard was discussed as a potential worldwide norm in ISO/IEC JTC 1/SC 41. Endpoints, such as servers and end devices, are able to access the network via the edge of an IoT DEP network. To provide IoT services, virtualized IoT DEP networks just serve as a covering over the preexisting Internet backbone. In addition, common communication infrastructure, including IP routers, is connected to interworking stations. A network of virtual routes is set up connecting the different points of connection to enable IoT service edge-to-edge communication.

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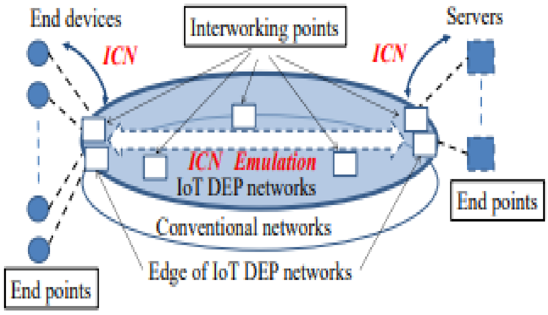

Fig. 1.The architecture of IoT DEP.

ICN technology include a wide range of processes. There are two main types of these mechanisms: synchronous and asynchronous [5]. Examples of synchronous methods include content-centric networks (CCNs) [6, 7] and the pairing of data requests with appropriate responses. A packet of "interest" represents a request in a CCN, whereas a packet of "data" represents a response. As an example of an asynchronous mechanism, consider MQTT [8], [9], where each request and answer are executed separately. A "publish" packet in MQTT is used to transmit data, while a "subscription" packet is used to receive data. An asynchronous method is used to invoke these packets. For example, IoT DEP offers lightweight access via mechanisms like Domain Name System (DNS) access sequences, TCP three-way-handshake processes, or a substantial protocol overhead, like HTTP, since ICN technologies do not need complex communication sequences.

IOT COMMUNICATION USING ICN TECHNOLOGIES

IoT communications are categorized into three types, as shown in Figure 3. End devices, e.g., various sensors, generate data and report to the servers with a notification, as shown in Case 1. The servers are invoked to obtain data and the end response required by the data according to the requests from the servers, as shown in Case 2. Finally, the servers invoke control to the end devices, e.g., actuators, as shown in Case 3.

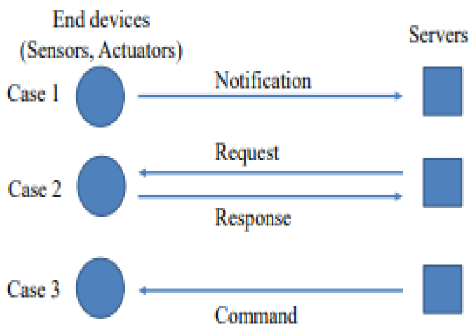

Fig. 2. Communication types among IoT end points.

In IoT services, most communication types are similar to Case 1 because a significant number of sensors should be installed to monitor various situations. Therefore, MQTT provides simpler communication sequences than the sequences of a CCN, because a CCN specifies sequences based on Case 2 [14]. Communication operations among the interworking points in IoT DEP based on MQTT are proposed in the following section.

NEW ARCHITECTURE FOR LARCH-SCALE DEPLOYMENT When IoT

services are deployed across wide-area

With IoT DEP networks, there are a lot of nodes that need to function together. Cooperation among dispersed MQTT brokers becomes an issue when using MQTT between these locations. Several methods for resolving this issue have been proposed [10]–[13]. A "flooding approach" that involves broadcasting messages among brokers is one possible option. On the other hand, this strategy has the potential to boost network traffic. Consequently, this part proposes a novel architecture, the virtual ring method, based on MQTT, for large-scale deployment via IoT DEP. Figure 3 shows the logical ring that connects the interworking points in Figure 2, which is an architectural feature of this design. In order to make this ring network virtual, lower-layer protocols like VLAN are used. This design deviates from the norm when it comes to distributed brokering and does not need any particular routing protocols. A VLAN may identify the ring network, as seen in Figure 4. Distributed brokers are one example of an interworking point; other examples include shared memory blocks and access control. Ring operations like multiplexing, copying, and terminating are under the supervision of an access control block. In the part that follows, we will go over these procedures. These interworking points are linked to end points, such as end devices and servers, in accordance with the MQTT protocols. A loop is used to reference data managed by the MQTT protocol among the shared memory, as seen in Figure 5. This diagram shows the provisioning of two VLANs. To prevent endless looping, each interworking point defines the starting and ending locations of the connection and owns a VLAN.

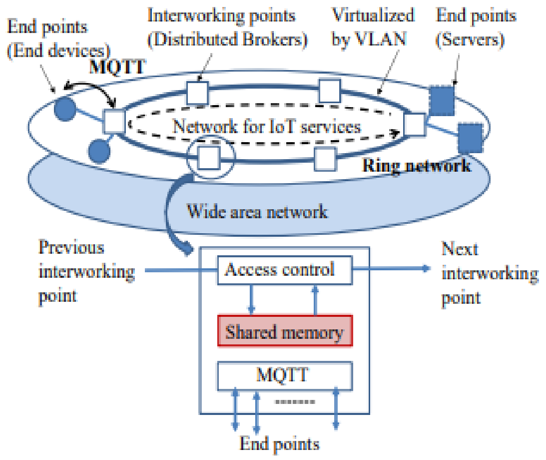

Fig. 3. Architecture of the proposed scheme for distributed brokers.

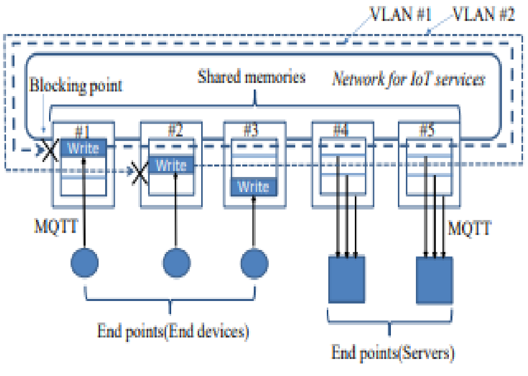

***Fig. 4. Communication among shared memory in distributed brokers*.**

in Fig. 5, end devices generate and transfer data to distributed Brokers according to the MQTT protocol. Data are stored in dedicated areas of the shared memory for each end device, and then transferred to other shared memory in distributed brokers in the ring. The transferred routes are identified using VLAN. In this figure, VLAN #1 is provisioned from Broker #1, and is blocked at the ingress point of this broker. By contrast, servers can refer to all of the areas in their shared memory.

DETAILED OPERATIONS AMONG INTERWORKING POINTS

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In the detailed operations among interworking points, distributed brokers of MQTT in the ring network are described as follows. These operations follow the architecture of communication using the shared memory, e.g., [15]. This architecture has been applied to real time communication of the industrial fields [16], [17].

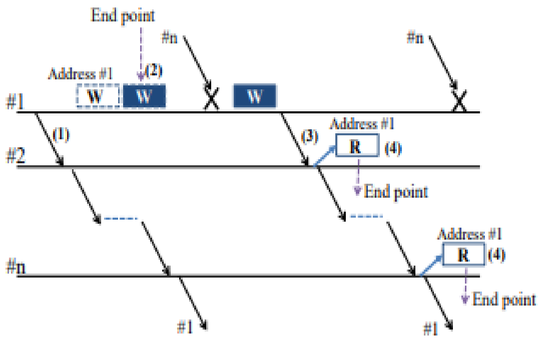

Fig. 6.The transfer mechanism among shared memory.

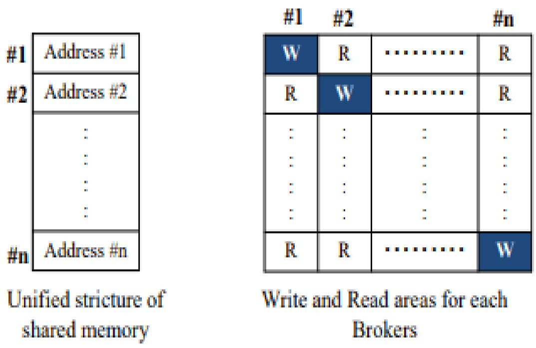

Fig. 7.The structure of the shared memory.

As seen in Figure 4, each end point communicates with a distributed broker via the shared memory in accordance with the MQTT standards. Figure 6 depicts the technique for transferring data between the shared memory. Figure 7 depicts the architecture of the shared memory. Here are the steps depicted in Figure 6. The dispersed brokers in the ring network exchange frames at regular intervals, as shown in Step (1). In Fig. 6, Broker #1 represents the originating broker and their ingress point is where these frames are booked. As shown in Figure 7 (Step (2)), data generated by an end point is stored in the shard memory at its allotted address. As seen in Figure 7, the shared memory is partitioned according to the distinct addresses assigned to each broker. Each of these components has its own designated writing or reading space. In Step (3), the next routed frame transfers this data. Other brokers have this data written in their read areas. Information kept in these regions may be read by the end points accommodated by these brokers (Step (4)). All components of the shared memory may have their data updated at regular intervals by these procedures.

PERFORMANCE EVALUATION

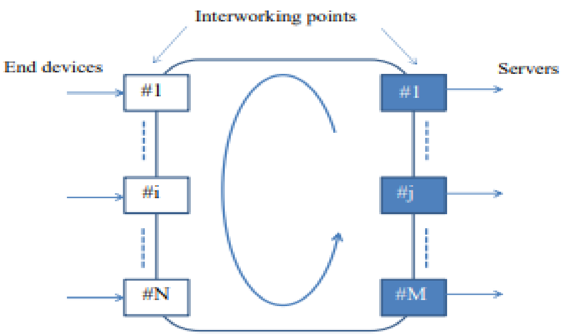

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Fig. 8.The model on performance evaluation of the Virtual ring approach.

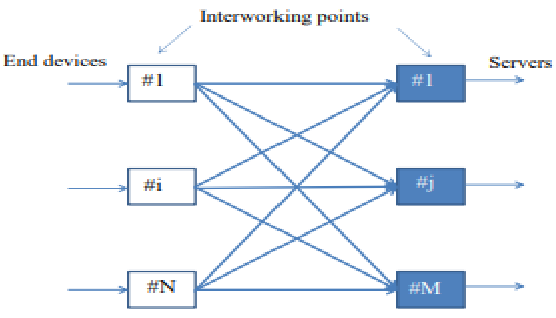

Fig. 9.The model on performance evaluation of the flooding approach.

In these figures, the numbers of interworking points that accommodate end devices and servers are denoted as M and N, respectively. This evaluation, shown in Figure, focuses on Case 1. Each interworking point accommodating the end devices receives data as packets generated randomly by the devices, the receiving rate of which is specified as follows:

$$\lambda_i \ (i = 1, \dots, N)$$

The average transmission time on a packet at this interworking point is as follows.

$$b_i \ (i = 1, \dots, N)$$

In the flooding approach, each transmission capacity

between interworking points, which accommodate the end device and the server, divides the total capacity of the virtual ring approach into sizes of M × N.

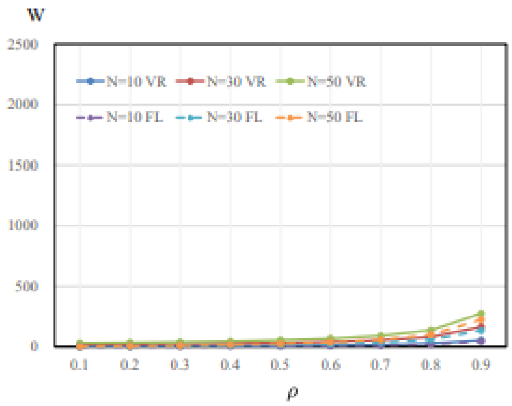

Fig. 10. The average delay in the small-scale case (M=1)

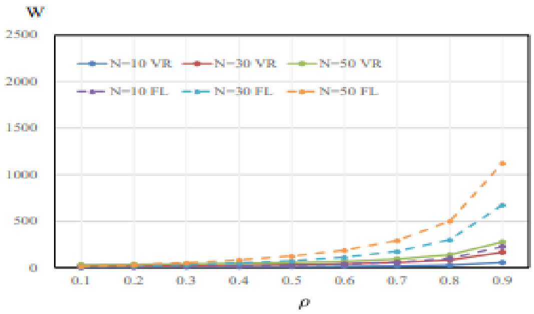

Fig. 11. The average delay in the small-scale case (M=10)

Here, we use queueing models to compare the average delays between these interworking points when various procedures are applied. When circulating frames reach the virtual ring's interworking point, models with multiple queue access can be used as polling systems and token passing mechanisms [18]. This is because packets from an end device can be transferred through this point. According to this method, which is called an exhaustive policy, when a frame reaches the interworking point that houses the end devices, it is presumed that all the information in this point is sent by this frame. When the situation is symmetrical, the average delay may be calculated using Eq. (1) [19].

CONCLUSIONS

In this study, the authors provide an Internet of Things (IoT) DEP framework that has been standardized in ISO/IEC JTC 1/SC 41. The framework serves as a communication platform for different types of IoT services. Furthermore, the IoT DEP is suggested for comprehensive operations. A virtual ring method was suggested and tested against a flooding method that relies on more traditional technology to link the platform's interworking points. The results of the queuing study led to the conclusion that, compared to floods, a virtual ring strategy is the better choice. Next, a prototype system based on the virtual ring method will be put into place.

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