Patient health monitoring system over DDS protocol

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Abstract: Continuous monitoring of biomedical parameters and/or vital signs of a patient is thus of major importance. The development of the patient monitoring system in real time monitoring is increasingly important. The Internet of things for patient monitoring almost widely uses MQTT and CoAP protocol to collect and send data to hospital or nursing station. However, traffic may be delayed and burst which is not suitable for real-time monitoring. In this paper, we proposed that the patient monitoring system in real time should be use Data Distribution Service (DDS) protocol instead of use MQTT or CoAP, with no broker architecture of DDS, data flow directly from publishers to subscribers. Moreover, the H.264 Scalable Video Coding should be used to encode a video signal, due to the adaptation of bit rate is low complexity, which suitably use in publish-subscribe model.

1. Introduction

The Internet of Things (loT) is a concept that any device can connect to any other device through the Internet. Nowsaday, the most widely used application protocols in the loT are MQTT[1], CoAP[2]. Both Message Queue Telemetry Transport (MQTT) and Data Distribution Service (DDS)[3] are implementations of publish-subscribe architecture. The advantage of the pub-sub model are providing a flexibility and scalability, more than one publisher can publish messages to a topic, and more than one subscriber can consume messages from a topic. Moreover,it allows messages to be broadcast to multiple subscribers.

In the patient monitoring system, vital sign signals are measured and delivered to the hospital or nursing station, the accurate and reliable data is very important which impacts every decision made along the patient care continuum. Almost the patient monitoring application ,use MQTT protocol and CoAP Protocol, [4] which are not proper use for real time data such as ECG signal or video signal.

The goal of this paper is to present that the patient monitoring system should be use Data Distribution Service (DDS) protocol instead of use MQTT or CoAP, with a broker-less architecture of DDS, it is suitable to monitor a vital signal in real time. In addition, the encoding of video signal ought to use the H.264 Scalable Video Coding (H.264 SVC) because of the video source can quickly and flexibly reduce. A bit rate adaptation is low complexity, thus it appropriate to use in the pub-sub model.

The outline of this paper will be arranged as follows. In section II, the overviews of DDS protocol is discussed and MQTT protocol overviews is described in section III. Next, the proposed algorithm and experimental work are given in section IV and V, consequencly. Finally the conclusion is presented in section VI.

2. Overviews of DDS Protocol

Data Distribution Service (DDS) is a publish-subscribe communication model for real-time M2M communications that has been developed by Object Management Group (OMG). DDS delivers data among nodes in real-time, provides best-effort and reliable communication using a quality of services (QoS) mechanism [3]. In contrast to other popular application protocol likes MQTT, DDS protocol does not require "central node" as known as a broker, hence, no need for network configuration to enable communication of all IoT devices. Moreover, with a broker-less architecture, it suits well to the real-time constraints for IoT.

DDS uses the Data-Centric Publish-Subscribe (DCPS) model, based on the concept of a "global data space" that can access to all interested applications. DDS is composed of the Domain which is a logical network for Topic transmissions, DomainParticipant which is an object for joining the DDS Domain and Endpoint which is an object performing the Topic transmissions. DDS defines four types of Endpoint that are Publisher, Subscriber, DataWriter and DataReader.

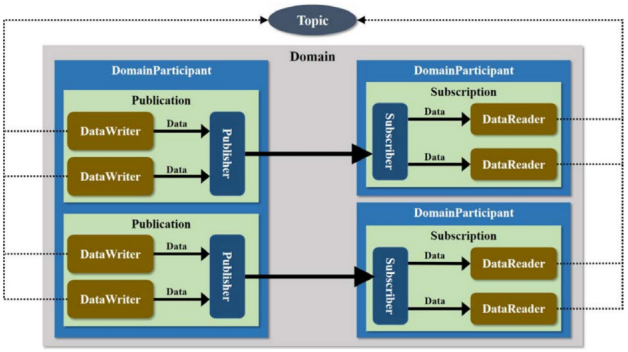

Fig. 1: Composition of DDS [9]

The application can write data to the data-bus via DataWriter to interact with the Publisher, The association of DataWriter and Publisher indicates that the application is going to publish the specified data. Data are stored in specified data objects, which called Topic that composed of data type and topic name. The topic name is used to identify Topics, and must be unique in the Domain. Data can be read by the other application via Data Reader, which employed by a Subscriber that receives publish data, based on the same Topics, a DataWriter and a DataReader are related and connected publishing and subscribing applications. On the DDS models, all interactions as reads

and writes to the global data space, data flow directly from publishers to subscribers, thus, there is no broker.

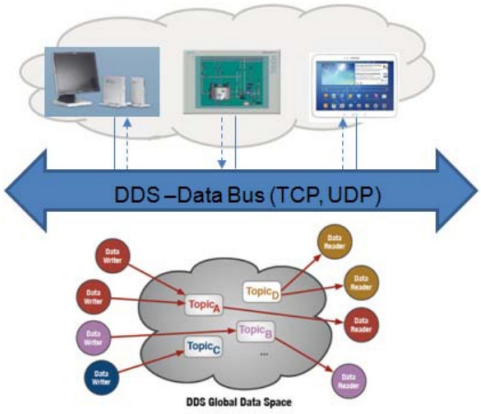

Figure 2. DDS-Data bus [10]

3. MQTT overviews

MQTT is a lightweight messaging application protocol designed to be open, simple, lightweight and easy to implement. It is based on the pub-sub architecture. MQTT devices do not connect directly with each other, but via a broker. When a client publishes a message M with a specific topic T to the broker, next, the broker receives a publishing, it forwards the message to the subscriber which subscribed to the topic T. then all subscriber will receive the message M. The design of a MQTT system is shown in Fig. 3.

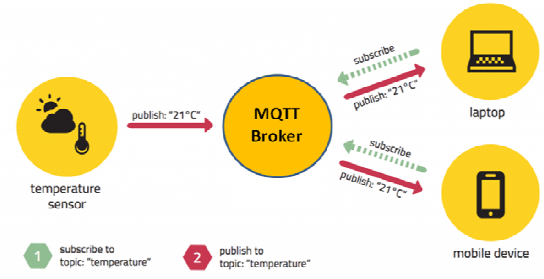

Fig. 3. MQTT communication [11]

4. Proposed Scheme

In the application, patient monitoring system, vital sign signals are measured and delivered to the hospital or nursing station. In addition, motion sensor, door sensor, light sensor is used to monitor the other activity in a home, assume that the patient maybe suffers from falling down, then push all the collected data to the nursing station. Almost the patient monitoring application ,use MQTT protocol and CoAP Protocol, [4] which are not suitable for real time data such as ECG signal or video signal. In this paper, we aim to suggest the patient monitoring system with Data Distribution Service (DDS) protocol, with this scheme, a broker-less architecture, it is appropriate to the real time monitoring.

Moreover, the H.264 Scalable Video Coding (H.264 SVC) [5] is chosen for encoding a video signal since a SVC source can quickly and flexibly reduce. The adaptation of bit rate is low complexity, which suitably use in publish-subscribe model [6,7] where more nursing station with a different network capacity are subscribing the same video. Figure 4. illustrate the example of snapshots with different background traffic throughput with DDS protocol compare with MPEG2. [6]

Figure 4. a snapshots with different traffic throughput

5. Experimental Work

5.1 Experimental set up

The experiment of the proposed scheme is more efficient and easier to implement by running OpenDDS [8], an open source C++, on Raspberry Pi Model B which has a specification as a 900MHz quad-core ARM Cortex-A7 CPU, 1GB RAM and Ethernet port. The software tool used to measure and monitor such as Wire-shark, Jperf and RTI Analyzer. As shown in Fig.5, the experimental test-bed is composed of three Raspberry Pi that are connected using a wireless network with 54Mbps speed. The first one act for a DDS publisher and MQTT publisher, the next one represent to a MQTT broker and the last one stand for background traffic generator by using Jperf and use nine Ubuntu PC as a subscriber.

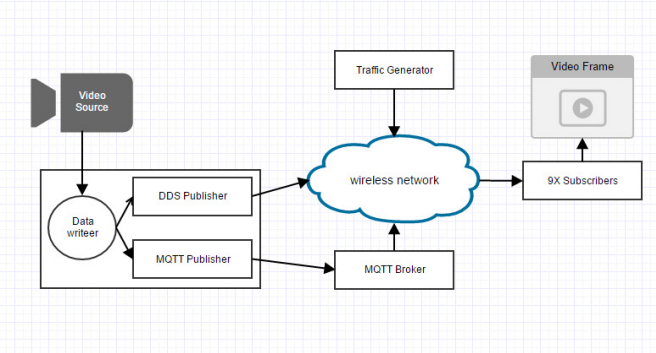

Fig 5. Experimental test-bed

5.2 Experimental result and analysis

In the experiment, we start examining the consumed bandwidth which measured by Wire-shark. The consumed bandwidth is very importance parameter in network performance, reducing the use of bandwidth increase a network performance in delay, jitter and packet loss. First , we compare sending MJPEG between by MQTT protocol and DDS protocol , then compare MJPEG with H.264 via DDS protocol by vary a number of subscribers as shown in Fig 6., from this result, it denotes that MJPEG over MQTT protocol use more bandwidth than the others.

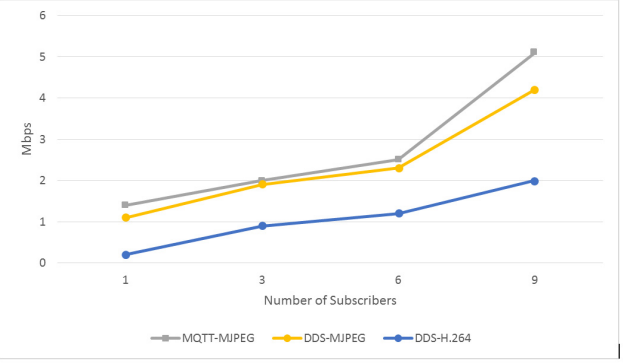

Fig 6. Consumed bandwidth

Next, we generate a background traffic by using Jperf about 80% of the available bandwidth, the result to frame jitter effect. In Fig 7., the jitter, packet delay variation, both with and without background traffic are illustrated with the difference protocol. From this figure, we can see that the background traffic has a significant effect, whereas, in case of no background traffic both delay and jitter had an acceptable performance. For the video broadcasting, the standard values are displayed on Fig 8. [12] The acceptable of jitter is less than 100 ms.

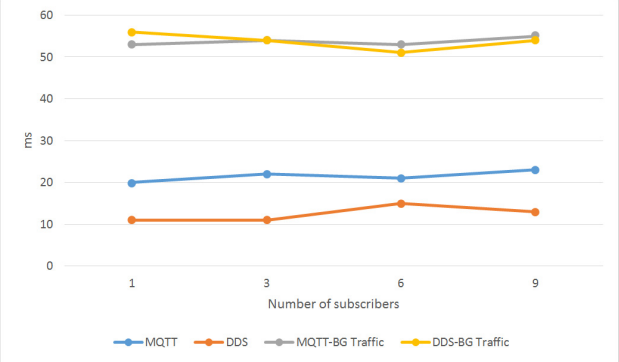

Fig 7. The jitter both with and without background traffic

Next the visual comparison with vary a number of subscriber is displayed in Fig 9. As shown in Fig 9., we found that background traffic does not affect to the quality of the picture but effect to delay of the picture. Some distortion appears in the case with 9 subscribers, it indicates that the number of subscribers is effected to a picture distortion.

Traffic Class	Technology Attributes	QoS Metrics						
		Timeliness			Preciseness			Accuracy
		Response time Expected by Users	Delay (ms)	Jitter (ms)	n/a	Required Bandwidth (bps)	Loss Rate	Error Rate
Video Broadcasting	Real Time and Highly Asymmetric	2–5 Seconds Lip-synch: <100ms	<150	<100				
Typical Application		Coding Standard						
VCR Quality		MPEG-1		<100		1.2–1.5M	<0.001%	<0.001%
Video Quality slightly superior to that of broadcast TV (NTSC or PAL) with bit rate of 4M		MPEG-2				4–60 M		
HDTV requiring bit rate from 15–34 M				<50			<0.0001%	<0.0001%
Multimedia on Web		MPEG-4		<150		28.8–500K	<0.001%	<0.001%
Network Capacity								
Link: Refer to Appendix I				Router: Refer to Appendix II				

Fig 8. A QoS matric for video broadcasting [12]

Fig 9. A visual comparison with vary a subscriber

In DDS protocol, it supports QoS (Quality of service), QoS configuration 1 design for minimum delay, whereas QoS configuration 2 is more reliable than the others but consumed more bandwidth. Next, the same video with different DDS QoS configuration is set up. Packet size versus time is depicted in Fig 10. It shows that QoS configuration 2 consumed more bandwidth than Qos configuartion 1.

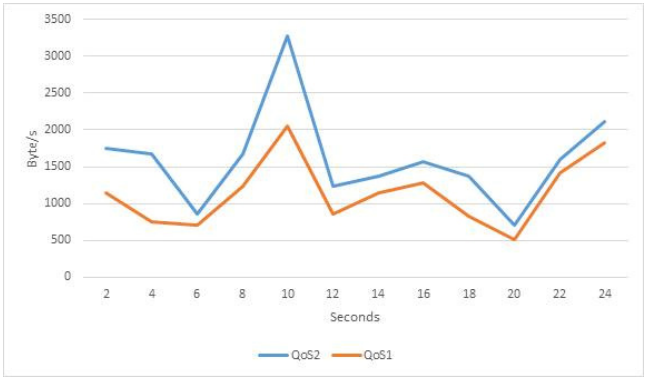

Fig 10. video with differrent DDS QoS configuration

Another parameter that very important is the end to end delay, the experimental result is illustrated in Fig 11., and we found that if there are no background traffic, the MQTT protocol and DDS protocol have a nearly delay. When we apply the background traffic, the MQTT protocol is a significantly more delay than DDS protocol, thus, the background bandwidth effect to end to end delay between publisher and subscriber.

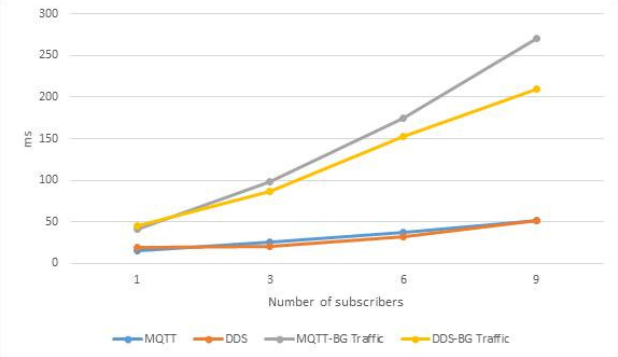

Fig 11. The delay in both with and without background traffic

The future work of this research, we will study about an adaptation of QoS level of DDS with the best configuration in any enviromental condition, and apply to use DDS over a personal area network such as Zigbee or Bluetooth.

6. Conclusion

In this paper aim to suggest using DDS protocol instead of MQTT in real time monitoring such as in the patient monitoring system which impacts every decision made along the patient care continuum. From the experimental result, the end to end delay, jitter and the consumed bandwidth of DDS protocol is obtained the better result than MQTT protocol. Furthermore, the H.264 Scalable Video Coding should be used to encode a video signal which also uses to monitor a patient. With this scheme, the hospital or nursing station will get the accurate and reliable vital signal data in real time and affect to suddenly care for patients.

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