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Message querying telemetry transfer on IoT applications to enhance technology: a systematic review

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ABSTRACT

More things are connected to the Internet, making the internet of things (IoT) develop significantly. But IoT also has weaknesses in communication, one of which can be overcome by utilizing message querying telemetry transfer (MQTT) because there are too many benefits of MQTT. Because there have been many published studies regarding MQTT, this study aims to conduct a review utilizing preferred reporting items for systematic reviews and meta-analyses (PRISMA) on the application of MQTT in IoT applications to enhance technology. The results of using PRISMA were 57 papers selected from this process, which starts from the identification stage, screening, eligibility, and included. The last author found components that can be discussed to enhance technology. In this discussion, several topics will be used to enhance technology, such as; smart technology, security, MQTT performance for IoT, monitoring systems, MQTT comparison, enhancement or optimization. This paper is expected to help academia and industry related to MQTT research that can help IoT to enhance technology quality.

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1. INTRODUCTION

There have been enough uses for the internet of things (IoT) devices because they have lightweight capabilities and affordable prices. Many of their applications in IoT devices can connect and communicate with each other using the Internet because they have the services needed by most people. This technology develops through things related to the Internet, so its application is easy and fast. These technologies sometimes have additional reasons for being “smart”, usually having relationships such as home automation, smart agriculture, smart cities, health systems, smart gardening, smart grids, smart vehicles, and smart culture. A British technology pioneer named Kevin Ashton 1999 gave terms by naming the "internet of things" [1]. The "things" principle is currently developing very significantly. The main goal is to make information by sensing without anyone's help. In the IoT, it is predictable that the integration of all "things" is realized by building intelligent interfaces between the functions of device utilization. IoT can utilize IoT gateways to connect points between applications and smart IoT devices for connection. Smart for sensing and collecting data from the environment is the task of the IoT. This evolution continues to grow, especially those that utilize; actuators, sensors, and other micro components [2].

People rapidly push towards IoT based on increasing the quality of life through connections for everything, starting from many personal devices to other devices out there, for example, medical devices (e.g. medical aids), burglar alarms, car fire alarms and massive sensor use. The many facilities that IoT can use

have weaknesses and advantages that must be re-studied or appropriately resolved. Because any technology has a new face to always enhance and improvise [3]. In its utilization, IoT is widely used in; smart farming [4] [5], smart health [6], [7], smart building [8], [9], and smart cities [10], [11].

Many have used IoT [12] devices, from researchers to industry, because it is one of the tools for the industrial revolution. Energy savings [13], are needed because the number of devices increases, especially when it connects with communication. One of the important components sent IoT is communication. Many communication protocols focus on providing low power (lightweight). One of them can take advantage of message querying telemetry transfer (MQTT) [14]. The MQTT protocol adheres to the principle system of IoT or device-to-device association. Some of the main causes behind the rapid development of MQTT are to provide communication bandwidth and reduce battery failure [15].

However, building a suitable model for MQTT because it has the advantage of several brokers is a new challenge. The difference between using MQTT, such as having security in a distributed architecture, is different from using a centralized distribution, one of which is how data is sent from publishers. They are mainly connected to two different brokers because a traditional MQTT is very concerned about the authentication mechanisms [16]. After learning about IoT and its functions using MQTT, motivation author to provide assistance to conduct a review of this study. Completing surveys is very important because it opens new minds for researchers to innovate and update in terms of technique.

There are many studies to review IoT for technology. But some studies only focus on the usefulness of IoT and have not conducted a study that directly examines the improvement of IoT when using MQTT. This protocol is very light and suitable for lightweight technologies such as IoT. Still, a rare systematic review focused on how MQTT for IoT applications enhance technology. The aims of this study such as; systematic review and meta-analyses on MQTT for IoT applications to enhance technology, identification of recent papers (2019-2022), and discussion of existing issues about the recent paper.

Due to this, the author aims to conduct a systematic review that focuses on IoT applications utilizing MQTT to focus on its manufacture to enhance the quality of technology. The scope of the systematic review does not discuss other communication protocols. It only focuses on MQTT as the protocol that will create. Usually, systematic reviews can utilize [17], [18], preferred reporting items for systematic reviews and meta-analyses (PRISMA). But the function of these two methods has their respective advantages. In this study, the author will focus on PRISMA. This method is also very transparent and complete to perform a systematic review.

Therefore, the author will carry out a systematic review utilizing PRISMA, which has explained the basics and knowledge of MQTT for IoT applications in part 1. Part 2 will describe some systematic reviews to see similar research studies and their differences. Part 3 is the method that will be used in PRISMA. Part 4 is the result and discussion of the results of PRISMA. The last is section 5 for conclusions on the current results and their descriptions.

2. CONCEPTS

2.1. Related topics

Many studies have reviewed MQTT applied in IoT, some of which will be discussed in this section. Beniwal and Singhrova [2], present a systematic review focusing on IoT gateways. Jahantigh *et al.* [19], conduct an in-depth investigation of cloud computing and IoT, with its problems and challenges. Yan *et al.* [20], recently focused on the smart gateway, especially in the second generation. The study investigates further and classifies them into several categories. Hintaw *et al.* [21], because MQTT is a protocol often used in IoT applications, there are problems such as disclosing information, identity spoofing, denial of service, increased data tampering, and increased privileges. Many studies suggest various security mechanisms and techniques for this problem. But in this systematic review, the authors are not focused on improving it but on how MQTT can enhance IoT quality. Kurdi and Thayananthan [16], the study focuses on reviewing and challenging the use of security, authentication mechanisms, and the procedures required for implementing MQTT. In contrast to this systematic review, it is not focused on security but on what MQTT can apply to study for improvement in the IoT field. Mishra and Kertesz [22], conducted a quantitative evaluation by presenting some important things about the protocol of the MQTT. The authors compared such as superior, main, and weaknesses in the MQTT protocol. Few studies have carried out systematic reviews and have been carried out in recent years. Another thing is that few studies have reviewed MQTT to enhance technology and use systematic reviews. This study uses PRISMA for several studies focusing on MQTT for IoT applications to enhance technology. The author will discuss the stages of conducting PRISMA research to carry out several stages in the next stage.

2.2. MQTT and IoT

In a communication on the IoT deploy several radio technologies such as (IEEE 802.11), RFID, (IEEE 802.15), (IEEE 802.16), (IEEE 802.3), and others, which are used in the most basic of communication [23]. Figure 1 is an image of several protocols used based on TCP/IP Model. Figure 1 shows several communication protocols used in the TCP/IP Model, which, in basic communication, there are still other communications using LoRaWAN, SigFox, or Cellular/4G/5G [22]. Which MQTT is publish/subscribe protocol. This protocol has a client/server model that can create a client to communicate with the endpoint. In this protocol, there are two types of clients have been identified. A client sent a message is called the publisher. While on other Clients who work as recipients are called subscribers. But these two types of clients did not communicate directly. Both clients use a central point that functions as a server and is called a broker for exchanging messages. The broker here helps receive messages sent by publishers and pass them on to the subscribers [24]. MQTT widely uses IoT applications because they have evolved, especially in MQTT brokers, reflecting recent moves, especially in IoT systems [22].

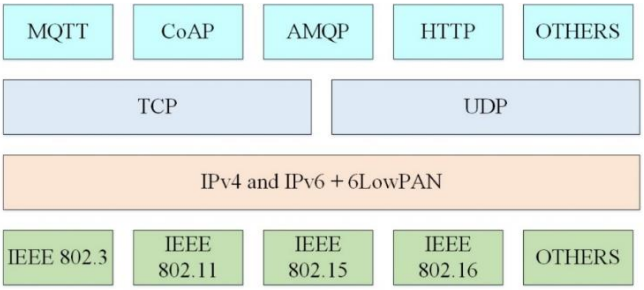

Figure 1. IoT protocols [23]

2.3. PRISMA method

At this stage in achieving the goals, this study will focus on PRISMA, a recommended framework to help carry out a systematic review and report [18]. As a new strategy, researchers conducted in January 2022 a focused search on MQTT utilizing a search focused on scientific articles. After that, in March 2022, a new search was carried out in the same place using the MQTT database to search for papers published in 2019-2022. Sorting this database must look at its relevance and scope so that it can affect the academic world because this database must focus on publishers such as IEEE, ACM, and MDPI. Besides being widely used in the systematic review.

In this study, search for the term "Search String" in several fields (“MQTT” OR “message queuing telemetry transport”) AND (“internet of things” OR “IoT”) AND (“internet of things applications” OR “IoT applications”) AND (“enchance technology” OR “improve technology). The advanced stage (following the pattern of [25]) is that papers are validated so that they are considered valid if: i) the paper taken is not a study, review, or challenge in the future, case studies that are considered if appropriate to the topic; ii) are closely related to the topic and research objectives; iii) presents an improvement in technology by utilizing MQTT on IoT Applications; and iv) published papers must be in English. By utilizing the PRISMA model [18], using PRISMA, here find a meta-analysis of several existing studies.

This systematic review method does not use statistical models, only searches based on recent reviews. Figure 2 shows the results of the first PRISMA Flow identification, which got 2,488 papers carried out at the identification stage. The screening was carried out to get 1,247 papers, then the eligibility stage with 249 results, then the final stage, which got selected articles in this study in the form of 57 study papers that can be done as a study that will enhance technology in IoT applications. The flowchart of PRISMA [18], (pattern inspired by previous [25]) is presented in Figure 2.

3. RESULTS AND DISCUSSION

3.1. PRISMA result

This section is the result of the selected paper (see Figure 2) and will be explained by classifying the obtained studies as shown in Table 1. Then, where did this study come from in Table 2 (focus on the first author). The last is the distribution of years presented in Table 3. Furthermore, Table 4 explains the distribution of articles by year (2019-2022) (in research results, there are still those paper that uses the constraint application protocol (CoAP), but the focus remains on the results of using MQTT on IoT).

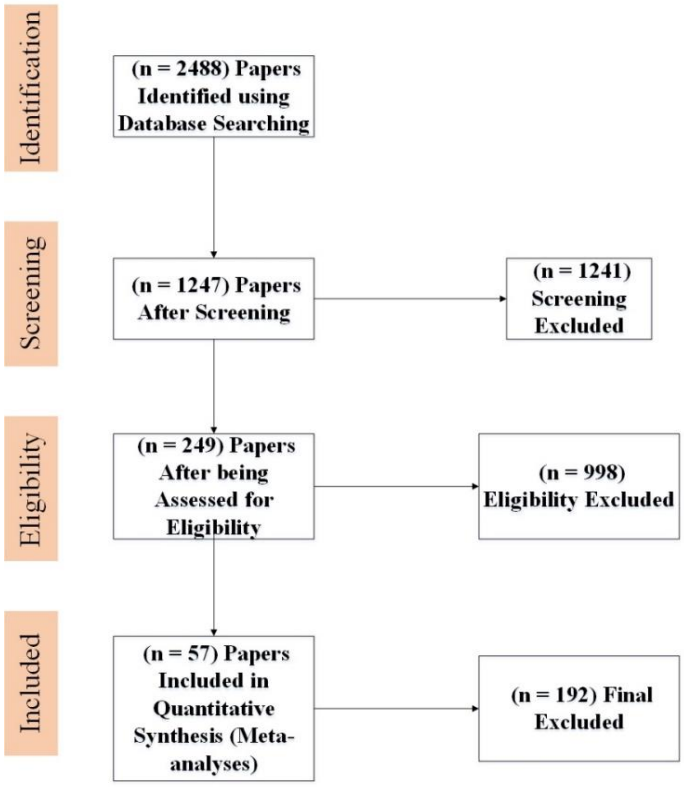

Figure 2. PRISMA flow diagram

Table 1. Articles result

No	Topic	References
1	Image notifications	[26]
2	Smart technology	[27]–[32]
3	Security (DoS attack or intrusion detection)	[33]–[46]
4	Positioning system	[47]
5	MQTT performance and evaluation for IoT	[48]–[53]
6	Interoperability solution	[54]
7	MQTT for healthcare	[55], [56]
8	Overhead analysis	[57]
9	Monitoring system	[58]–[66]
10	Geographical IoT	[67]
11	MQTT comparison, enhancement or optimization	[68]–[71]
12	Surveillance system	[72]
13	QoS IoT using MQTT	[73]
14	Development of modbus	[74], [75]
15	ICN system	[76]
16	Design and implementation	[77], [78]
17	Authentication scheme	[79], [80]
18	Machine learning techniques	[81]
19	Routing based protocol	[82]

As shown in Table 1, several topics have been discussed in 2019-2022, such as smart technology, security, MQTT performance for IoT, monitoring systems, MQTT comparison, enhancement or optimization. The author will further explain these topics in the discussion section. The results of this presentation are also useful in viewing articles about MQTT on IoT applications.

Furthermore, Table 2 shows the distribution (focus on the first author) of research on MQTT on IoT applications to enhance technology from papers mostly from India, as many as 10 papers. These results show that a lot of research conducted in the area can be used for academics and industry in conducting research benchmarks there. Table 3 shows publishers' distribution because most came from the IEEE and then continued with MDPI, ACM, and ScienceDirect. So that many related articles can be published in IEEE publishers. This indicates that the articles prefer IEEE articles in publishing related articles. Table 4 also

presents the distribution by year, and for the 2019-2022 period, the most research was still in 2019, but it can also be seen that for 2022, which is currently ongoing, many studies have been published.

Table 2. The articles based on country

Country	Number of publications
India	10
Italy	7
Indonesia	6
UK	4
Brazil	3
Japan	3
Taiwan	2
USA	2
Germany	2
Pakistan	2
China	2
France	2
South Korea	1
Saudi Arabia	1
Romania	1
Norway	1
Turkey	1
Thailand	1
Egypt	1
Serbia	1
Spain	1
Bulgaria	1
UAE	1
Malaysia	1
Total	57

Table 3. The articles based on publisher

Database	Result
IEEE	37
MDPI	11
ACM	7
ScienceDirect	2
Total	57

Table 4. The articles based on year published

Database	Result
2019	29
2020	18
2021	5
2022	5
Total	57

Suppose the author compares with similar research papers [5], which utilize PRISMA as a systematic review. In that case, this paper presents a summary of related research (IoT and MQTT). The results presented are more detailed and easier to use as references for related academics or industries. Results can also be used to enhance research or find related results supporting existing research.

3.2. Discussion

In this section, there will be a discussion on the most researched topics (see Table 1). The growing trend in the number of papers on IoT applications utilizing MQTT in technology improvement and those observed since 2019 will be outlined in several discussions regarding the findings. Obtained from PRISMA. The author gives some snapshots like glossaries for the IoT and MQTT. In this discussion, several papers that have been widely researched and received attention for technological developments (see Table 1) by study in 2019-2022 based on Figure 3. As shown in Figure 3, the author will describe the topic in more detail by dividing it into several sections described in the following sub-chapters.

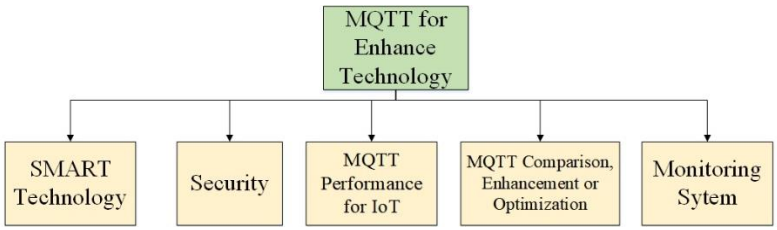

Figure 3. Various MQTT functions

3.2.1. Smart technology

The concept of IoT that can connect several objects, and other things and be integrated with the Internet is an attraction in itself. In many studies, MQTT helps IoT in "smart" concepts like smart agriculture and smart cities. Many studies have focused on smart technology because of its nature that can automate and facilitate other things. This concept has indeed become a material that researchers and industry often use. This is part of a technological improvement that has been successfully enhanced by utilizing the MQTT protocol. Apart from improving its quality, it also helps users implement the "smart" concept. Research on smart technology that utilizes MQTT is found in [27]–[32].

3.2.2. Security

MQTT is a protocol that is often used because it is lightweight and effortless to use if operated remotely. Because MQTT is widely used due to minimal bandwidth and low memory consumption, but also has some drawbacks stemming from several types of attacks [46]. Then there is a study on external attacks such as denial-of-service (DoS) [38], and intrusion is some examples of attacks on brokers [43]. Therefore a lot of research on security (DoS, intrusion detection) [33]–[46].

3.2.3. MQTT performance for IoT

Knowing performance is very important because IoT requires excellent performance compared to the lightweight nature of MQTT. Protocol research has been carried out by measuring the quality of service (QoS). Looking at the version of MQTT, it can also be seen that operations at different QoS levels can impact latency when sending data [48], because it feels MQTT is needed to measure its performance in helping IoT. Another performance measurement can also be made for smart cities [49]. MQTT performance is also considered in NB-IoT smart meter [50]. Then many other studies focus on analyzing the performance of MQTT [48]–[53].

3.2.4. Monitoring system

Monitoring is an important thing used in IoT because monitoring is real-time. It needs a supporting protocol to maximize IoT performance. In addition to utilizing sensors, IoT also uses MQTT. This protocol, for example, can be used for radon gas monitoring [58]. And also, can be used in soil humidity monitoring [59]. Furthermore, many more studies regarding monitoring systems [58]–[64].

3.2.5. MQTT comparison, enhancement or optimization

Performing comparison, enhancement, or optimization is made by several methods, protocols, and even technologies. Comparisons, optimizations, and enhancements are used to find out the improvements or changes to workability, especially MQTT, which should help IoT as a lightweight protocol. MQTT can perform message routing algorithms for optimizing communication between cloud microservices [68]. MQTT also enhances transparency among MQTT brokers [69]. Several other studies can compare, enhance or optimize MQTT [68]–[71].

4. CONCLUSION

This study seeks to review research on MQTT in IoT applications to enhance technology. This study conducted a systematic review using PRISMA, this method is very good and traceable in conducting a systematic review, but its use can be different. This paper focuses more on presenting results than is needed for academia and industry in conducting experiments and further systematic reviews. This method uses four stages: identification, screening, and feasibility, incl. At the identification stage to look for the latest papers (2019-2022), around 2,488 scientific papers were obtained, then the screening stage was 1,247, and the next stage was the feasibility of 249 papers. Finally, the authors get 57 papers that are eligible to be used in the

final stage. Recent articles often discuss topics in MQTT studies, such as smart technology, security, MQTT performance for IoT, monitoring systems, MQTT comparison, enhancement or optimization. This study has drawbacks because it does not provide statistical study methods. Further research is planned by looking for related studies by offering statistics on recent papers.

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