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# Development of automatic medical internet of things system (MIoT) for robotic surgery with multi-protocol approach using COAP and MQTT protocols

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***Abstract*---**Modern medical devices serving as blessings to patients worldwide as IoT systems are becoming pillar for healthcare professionals. IoT research is growing in the direction of automation of patient care systems to automation of robotic surgeries. Industrial IoT is serving numerous sectors like medical, agriculture, manufacturing and many more sectors. Hence, this paper presents the architecture for medical device sensors and devices which can be automated for fast response to incoming IoT protocol. We developed the multiprotocol communication approach where CoAP and MQTT protocols can respond to medical system control panel request by extracting the common message parameters. This can be helpful for several medical systems which need automation and quick response systems can be developed using proposed approach.

***Keywords*---**industrial IoT, medical IoT, robotic surgery, automatic pain management, CoAP, MQTT protocol.

## Introduction

History demonstrated that the evolution of humanity goes hand in hand with the development and application of science and technology in the field of medicine and healthcare. Decades ago, information technology applications in the medical area were invented to collect, monitor and control the patient status remotely,


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decision-making treatment for patients [1]. The usage of the IOT technology in the healthcare applications ensures the health care industries to enhance the quality of the care and minimize the expense with the automation and the resource optimization provided by it. The IOT in the medical imaging enables to have identification and the corrective measures to be taken in the real time with the auto analyzing of the imaging apparatus parameters at ease [2]. Digitization reaching too many areas in the medical technology has also paved its way for the monitoring and the management of the medical equipment's, the internet of things in the medical imaging would reduce the waiting time and the vexation for the patients as well as the physicians. So the paper presents the review on the internet of things based medical imaging technology for the health care applications providing the significance of the internet of things in the medical imaging technology. Internet of Things (IoT) is a term associated with the use of IP (Internet Protocol) address sensors [3,4].

It can connect to the internet and collect sensor data. The information is analyzed and a decision is made automatically. With an IoT medical device, your doctor can monitor the patient's health, health, and wellbeing. Physiological medical devices and methods can be easily traced. Timely monitoring of the patient's physiological parameters can be helpful to avoid early health problems. [5]. Due to the rising popularity of the Internet of Things (IoT), interconnected infrastructures with better flexibility and efficiency are being developed for industry 4.0. The use of IoT in industry 4.0 introduces a new term "Industrial IoT (IIoT)", which allows remote monitoring of wide-ranging industrial processes. IIoT tends to function with a large number of heterogeneous devices; therefore, data interoperability is the biggest challenge in achieving seamless real-time communication. Industrial IoT (IIoT) has become an important component for the implementation in industry 4.0 as it integrates the physical, social and cyber objects/things with industry and behaves intelligently to serve it's people. Up-till now, industries from different sectors i.e. logistics, transportation, and manufacturing are the major players of the IIoT market.

**Literature Review**

Industrial IoT sectors are growing in many verticles like manufacturing, healthcare, agricultural as well as in robotics applications. The core IoT architectures are similar in all applications and MQTT, CoAP, XMPP etc protocols can homogeneously assist such applications. Medical Internet of Things (MIoT) plays a vital role in improving people's health, protection, and treatment. Rather than going to the hospital, it is possible to remotely track patients' health-related criteria and move them to medical data centers using cloud storage. There is also an exponential rise in the amount of data handled by MIoT devices. This means higher disclosure of confidential data; consequently, data protection and privacy obtained from MIoT devices are major unresolved concerns. As classification systems are growing rapidly, the need to apply machine learning algorithms to large-scale industrial data is also expanding. In this paper, we classify medical data into disease-free individuals from affected ones.

To securely store this information in the cloud, we introduce a novel Adaptive Neuro-Fuzzy Inference System (ANFIS) for data protection to improve and determine the degree of security like breaches, data integrity, etc [6]. The Internet of Things (IoT) can create disruptive innovation in healthcare. Thus, during COVID-19 Pandemic, there is a need to study different applications of IoT enabled healthcare. For this, a brief study is required for research directions. In the current scenario, advanced information technologies have opened a new door to innovation in our daily lives. Out of these information technologies, the Internet of Things is an emerging technology that provides enhancement and better solutions in the medical field, like proper medical record-keeping, sampling, integration of devices, and causes of diseases. IoT's sensor-based technology provides an excellent capability to reduce the risk of surgery during complicated cases and helpful for COVID-19 type pandemic [7]. The product of this work is based on the creation of a medical IoT platform that serves to control citizens to access public or private space to prevent the spread of the covid-19 pandemic. Since this platform is secure and intelligent, author opted for using the CoAP communication protocols to ensure communication between the nodes. Author used the AES/RSA-SHA256 encryption algorithm to ensure data security and protection from any attacks [8].

Medical IoT has been a revolutionary force due to its usage resulting in lower costs, improved service delivery and higher patient care quality. Despite these benefits, the adoption rate of medical IoT is still very low. There has not been enough research addressing reasons for low adoption of medical IoT. Possible factors may influence adoption and usage of medical IoT using Unified Theory of Acceptance and Use of Technology (UTAUT) combined with Perceived Risk (PR) to evaluate social factors influencing user adoption intention and behavior. These variables predict over 69% of medical IoT system acceptance and usage, but PR was not a significant factor [9]. Smart healthcare is among the most significant IoT applications. The Internet of Things (IoT) revolutionizes our viable needs that include the healthcare system. This review paper presents an overview of the two extensively used application layer protocols for IoHT systems: MQTT and CoAP.

However, the choice of a standard and efficacious application layer protocol out of the two is a challenging task since it requires knowledge about the area of application and its messaging requirements. Hence, it is important to introduce their characteristics comparatively along with the selection of appropriate simulator tools to test, analyze, and validate the preexisting concepts and optimize the performance of prototypes [10]. World is living an overwhelming explosion of smart devices: electronic gadgets, appliances, meters, cars, sensors, camera and even traffic lights, that are connected to the Internet to extend their capabilities, constituting what is known as Internet of Things (IoT). In these environments, the application layer is decisive for the quality of the connection, which has dependencies to the transport layer, mainly when secure communications are used. This paper analyses the performance offered by these two most popular protocols for the application layer: Constrained Application Protocol (CoAP) and Message Queue Telemetry Transport (MQTT). This analysis aims to examine the features and capabilities of the two protocols and to determine their feasibility to operate under constrained devices taking into account security support and diverse network conditions, unlike the previous works [11].

Lightweight constrained application protocol (CoAP) has emerged as a common communication protocol for resource-constrained equipment in distribution internet of things (IoT). CoAP introduces two modes for data transmission, i.e., non-confirmed mode for reducing transmission delay and confirmed mode for reducing packet-loss ratio, which can be dynamically selected to satisfy the service requirements. However, there are still some challenges in dynamic CoAP mode selection, including incomplete information and differentiated quality of service (QoS) requirements of distributed IoT services. In this paper, we propose a upper confidence bound (UCB)-based dynamic CoAP mode selection algorithm for data transmission to address these challenges [12]. The Constrained Application Protocol (CoAP) is a standard communication protocol for resource-constrained devices in the Internet of Things (IoT).

Many IoT deployments require proxies to support asynchronous communication between edge devices and the back-end. This allows (non-trusted) proxies to access sensitive parts of CoAP messages. Object Security for Constrained RESTful Environments (OSCORE) is a recent standard protocol that provides end-to-end security for CoAP messages at the application layer. Unlike the commonly used standard Datagram Transport Layer Security (DTLS), OSCORE efficiently provides selective integrity protection and encryption on different parts of CoAP messages. Thus, OSCORE enables end-to-end security through intermediary (non-trusted) proxies, while still allowing them to perform their expected services, with considerable security and privacy improvements [13]. As the biomedical data is being transferred over the network, there are possibilities of breach in the security of the biomedical data. For solving and improving the security issues, an inventive approach is to integrate cloud and the IoT. For the integration of IoT and cloud, the key factors to reckon are: validation methods and IoT framework, which must be reliable and secure. This chapter is an exhaustive analysis of the IoT, Cloud, Cloud model, integration of Cloud with IoT, and its applications in biomedical [14].

**Research Methodology**

IIoT is challenged by the data interoperability of heterogeneous devices due to different vendors. So, interoperability acts as a potential barrier to achieve seamless data acquisition. To resolve this issue, interoperability can be achieved by either pushing standards or integration approaches. For example, in industry, one of the well-known Machine to Machine (M2M) standards offering interoperability at different layers is the European Telecommunication Standard Institute (ETSI) [15,16]. Also, interoperability in Industrial IoT is performed using diverse integration approaches such as gateway and middleware [17]. There is a need to analyze the integration of different IoT application layer protocols due to the reason that application layer is the primary interface for data interoperability by interacting with different services and systems offered [18].

The proposed research aims to identify the various devices and associated sensors alongwith the type of IoT protocol. In this medical application study, we considered CoAP and MQTT protocols which can communicate by means of extracting common parameters from protocol payloads. The key-value pair will be formulated before segregation of protocol types. Further to that, as shown in Fig.

1 below, the incoming sensor request can be redirected to appropriate actuators by automatic activation in device control and monitoring panel.

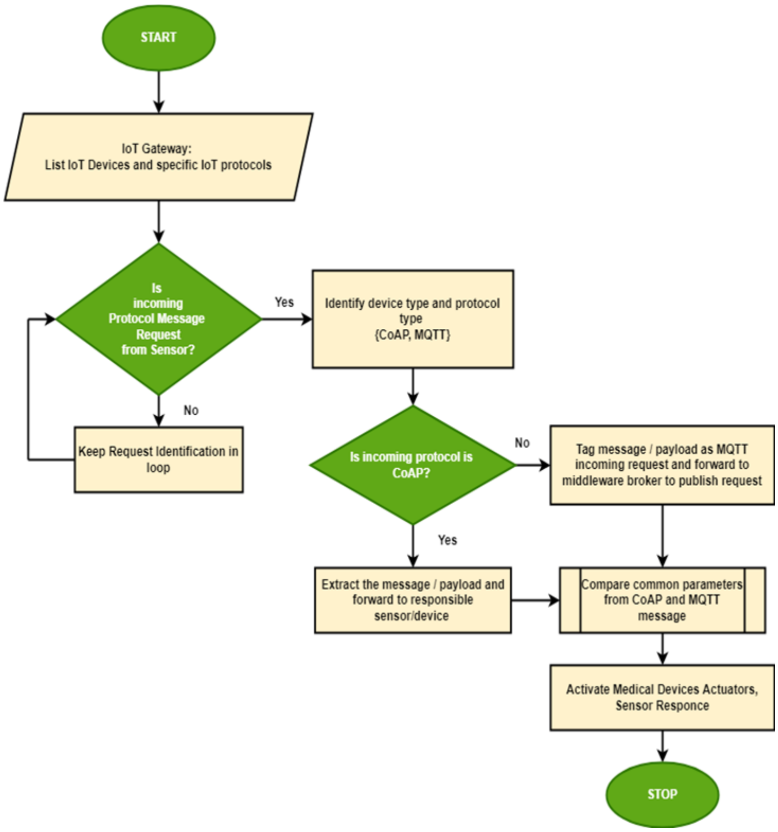


Fig. 1. Proposed IoT multi-protocol activation for automatic medical device sensor communication

The proposed approach can be very useful as an Industrial IoT application for healthcare sector where robotic surgeries or patient monitoring systems are required. The critical care units requires continuous monitoring, pain management systems is also one more prominent area where IIoT plays vital role.

## Conclusion

The paper depicted the newly developed multiprotocol architectural approach for industrial IoT which can be a great option for handling multiple IoT protocol tasks for healthcare applications. The system demonstrated the CoAP and MQTT IoT protocols can assist the medical devices to act as quick response devices. Such systems can be used for robotic surgeries where very precise decisions are required to handle the medical tools. Also, in case of automatic pain management systems for critical patients, this system can schedule the injection of pain killer medicine in a scheduled diffuser manner. There can be various use of proposed system in medical/surgical events which can be a future research scope.

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