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A State-of-the-Art Literature Survey on Application Layer Protocol of IoT

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ABSTRACT: The non-living Objects in the world are renewed into intelligent with the help of Intelligent of Things (IoT) Technology. The conversion of natural objects into smart desires a set of process/layers is called as IoT Protocols. There are five different layers in IoT for sensing and accessing the value from sensor, transferring the value thru network, managing and connecting the end devices with the handy applications. Among these five different processes, integration of all the smart objects is a complex task. To tackle this kind of problem in constrained environment of IoT, IETF started a working group named as CoRE. The purpose of CoRE working group is to structure a set of policy for integrating devices and to act upon the security at the time of booting process. CoRE defined an application layer protocol called CoAP(Constrained Application Protocol) for integration of all the end point devices of IoT. This paper reviews the existing researches based on the performance issues raise at the time of integrating end devices using Application layer Protocol CoAP.

KEYWORDS: CoAP, IoT, Protocol, CoRE, Smart Devices, Application Layer

I. INTRODUCTION

Today's world goes behind the concept of connecting all objects in the world without need of human intervention. Internet of Things(IoT) is established practically with the help of Machine to Machine (M2M) Communication. The IoT is also referred as "a universal network of connected devices having identities and virtual personalities operating in smart spaces and using intelligent interfaces to communicate within social, environ-mental, and user contexts" [1].

In Future, the visualization of IoT is realize in the fashion of linking daily objects with the help of Communication Networks and Cloud based server [2]. Current Communications and security approaches of Internet is not suited for the IoT, working groups were formed by the Institute of Electrical and Electronics Engineers (IEEE) and the Internet Engineering Task Force (IETF). The Communication protocols of IoT are discussed by the IEEE and IETF and designed a Standardized Protocol Stack [3] and illustrated in Figure 1. Following are the important factors of the IoT Protocol Stack.

- IEEE 802.15.4 form the rules and support the Low energy communications [4][5]]
- IEEE 802.15.4 transmit maximum of 102 bytes. But IPv6 used 1280 bytes as the maximum transmission unit. The adaptation layer of IoT protocol stack addresses this issue ie transmit the IPv6 packets over IEEE 802.15.4. This layer also tackle the issues of packet fragmentation, reassembly and other functionalities [6][7][8].
- Transmitting over adaptation layer (6LoWPAN) requires the Routing Protocol for Low-Power and Lossy Networks (RPL)[9]. The framework for particular application profiles are also maintained by RPL.
- The topmost layer of IoT protocol stack is called application layer. It used the protocol CoAP. Its purpose to tackle the issue of interoperability in multivendor environment [10]

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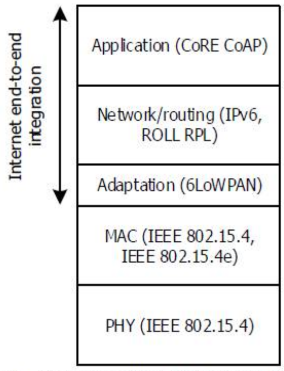

Figure 1. Communication Protocols in the IoT

II. LITERATURE REVIEW

In [11] Angelo Capossele el al, says that the growing number of applications based on Internet of Things (IoT) technologies is pushing towards standardized protocol stacks for machine-to-machine (M2M) communication and the adoption of standard-based security solutions, such as the Datagram Transport Layer Security (DTLS). Despite the huge diffusion of DTLS, there is a lack of optimized implementations tailored to resource constrained devices. High energy consumption and long delays of current implementations limit their effective usage in real-life deployments. They established how to integrate the DTLS protocol inside the Constrained Application Protocol (CoAP), exploiting Elliptic Curve Cryptography (ECC) optimizations and minimizing ROM occupancy. They implemented their solution on an off-the-shelf mote platform and evaluated its performance. Results shown that their ECC optimizations outperform priors scalar multiplication in state of the art for class 1 mote platforms, and improved network lifetime by a factor of up to 6.5 with respect to a standard-based not optimized implementation.

Matthias Thoma et al [12] , stated that RESTful services gained a lot of attention recently, even in the enterprise world, which is traditionally more web-service centric. Data centric RESfFul services, as previously mainly known in web environments, established themselves as a second paradigm complementing functional WSDL-based SOA. In the Internet of Things, and in particular when talking about sensor motes, the Constraint Application Protocol (CoAP) is currently in the focus of both research and industry. In the enterprise world a protocol called OData (Open Data Proto-col) is becoming the future RESTful data access standard. To integrate sensor motes seamlessly into enterprise networks, an embedded OData implementation on top of CoAP is desirable, not requiring an intermediary gateway device. They established an embedded OData implementation. They were reviewed that the OData protocol in terms of performance and energy consumption, considering different data encodings, and compare it to a pure CoAP implementation. They were able to communicate that the additional resources needed for an OData/JSON implementation are reasonable when aiming for enterprise interoperability, where OData is suggested to solve both the semantic and technical interoperability problems in Connected Systems

In [13], Ajit A. Chavan et al defined that the Internet of Things is future trend that assure to enhance and upgrades our everyday living by utilizing intelligent objects and sensors collectively. These devices are supposed to make use of constrained application protocol (CoAP) to communicate at application layer. Communication security is mainstay of constrained environments. Confidential communication within constrained devices will be carried out by secure CoAP (CoAPs) which makes use of DTLS protocol. To cope with constrained devices we use integration of CoAP and DTLS compressed by following 6LoWPAN standards. Compressed DTLS minimizes packet size and possibly avoids fragmentation. In addition to this they used the raw public key concept over DTLS to authenticate the multivendor constrained devices. Evaluation results shown that CoAPs with Raw Public Key provides communication security and authentication portability in multivendor environment at minimal energy consumption. CoAPs with Raw Public Key improves the interoperability as well as lifetime of network.

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In [14], August Betzler et al proposed that the CoAP is a lightweight RESTful application layer protocol devised for the IoT. Operating on top of UDP, CoAP must handle congestion control by itself. The core CoAP specification defines a basic congestion control mechanism, but it is not capable of adapting to network conditions. However, IoT scenarios exhibit significant resource constraints, which pose new challenges on the design of congestion control mechanisms. They introduced CoCoA, an advanced congestion control mechanism for CoAP being standardized by the Internet Engineering Task Force CoRE working group. CoCoA initiated a novel round-trip time estimation technique, together with a variable backoff factor and aging mechanisms in order to provide dynamic and controlled retransmission timeout adaptation suitable for the peculiarities of IoT communications. They conducted a comparative performance analysis of CoCoA and a variety of alternative algorithms including state-of-the-art mechanisms developed for TCP. The study is based on experiments carried out in real testbeds. Results shown that, in contrast to the alternative methods considered, CoCoA consistently outperforms the default CoAP congestion control mechanism in all evaluated scenarios.

Björn Konieczek et al [15] proposed that in the recent past, the development of applications and protocols for the Internet of Things (IoT) made a big leap forward. New approaches have emerged to adopt IoT technologies in the realm of industrial automation. This development is also referred to as Industrial Internet of Things (IIoT) or Industry 4.0. It is predicted for the number of smart interconnected devices participating in automation systems to grow significantly in the future. However, the industrial domain introduces new requirements for IoT technologies regarding the timeliness of interactions. Current IoT protocols, like the Constrained Application Protocol (CoAP), do not yet provide real-time behavior for the inter-device communication. In their previous work, they have already proposed a real-time extension for CoAP that enables deterministic network behavior through a TDMA-based approach. They have shown that the proposed mechanisms for time synchronization, time slot management, and access control can be realized purely software-based. However, a central instance is needed as a time server. This introduces a Single Point of Failure (SPoF) to the system, limiting the robustness and scalability of the approach. They introduced a concept for a distributed time server for CoAP. The proposed concept includes a refined time synchronization mechanism as well as strategies to select multiple time servers and share information between them. Furthermore, the described amendments to the real-time extension are integrated into the lightweight platform-independent jCoAP communication stack and evaluated in a multi-device real-world test bed.

In [16], Jung June Lee et al proposed that the Constrained Application Protocol (CoAP) was developed to support the communication between resource constrained nodes via low-power links. As an Internet protocol, CoAP needs congestion control primarily to stabilize the networking operation. They introduced a new round trip time based adaptive congestion control scheme, which improves CoAP by utilizing the retransmission count information in estimating the retransmission timeout. An experiment is conducted based on Californium CoAP framework and real devices. The results exposed that the proposed scheme significantly improves CoAP in terms of throughput and rate of successful transaction.

Nan Chen et al [17], proposed that as the number of mobile devices per user increases, the need to connect/combine them grows. Current approaches focus on the use of cloud-hosted backend services which allow file and app-state synchronization but fail in providing true resource sharing among mobile devices. To enable true resource/service sharing, the mobile devices of a single user should be combined into a cloud of cooperating mobile devices. Instead of accessing the resources/services of an individual device, a user should be able to seamlessly access the combined resources/services of his/her device cloud. Enabling seamless access to the resources/services hosted on different mobile devices is therefore a key challenge. Exposing the resources/services of each mobile devices within the user's device cloud via Restful micro-services, is one possible approach. The authors were focussed on the use of the IoT protocol CoAP as an application layer protocol. To minimize the energy costs of communication, it was necessary to replace CoAP's standard transport protocol (UDP) with BLE 4.1. They demonstrated their performance of the CoAP protocol using BLE 4.1 on Android Lollipop.

G. Tanganelli et al [18], proposed that the Internet of Things (IoT) vision foresees billions of devices seamlessly integrated into information systems. In this context, the Constrained Application Protocol (CoAP) has been defined as a technology enabler to allow applications to interact with physical objects. In this work they presented CoAPthon, an open-source Python-based CoAP library, which aims at simplifying the development of CoAP-enabled IoT

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applications. The library offers software developers a simple and easy-to-use programming interface to exploit CoAP as a communication protocol for rapid prototyping and deployment of IoT systems. The CoAPthon library is fully compliant with the CoAP RFC and implements in addition popular extensions such as the block-wise transfer and resource observing.

Muhammad Rizal Khaefi and Dong-Seong Kim [19] proposed that a discovery scheme is needed to establish efficient connection between devices and services. Constrained Application Protocol (CoAP) uses resource discovery protocol by sending complete resources information using plain text format that produce large payload and lookup overhead in large-scale networks. Furthermore, current CoAP resource discovery protocol does not specify the IP address or hostname discovery operations, which means that either an external application would need to provide IP address/hostname or it need to be manually added into the firmware. A discovery scheme based on Partitioned Bloom niters (PBF) called CoAP-PBF is proposed to improve CoAP resource discovery by having each device sends resource summary with PBF. This approach improved CoAP efficiency because all devices receive compact, complete, and encrypted remote devices information. Partitioned hash method is applied to further reduce computational cost of PBF. Furthermore,their proposed schemes increased system's security because CoAP-PBF sends resource information in encrypted format. Their simulation results shown that the proposed scheme provide fast, light, and secure autonomous discovery in CoAP while maintain IP compatibility.

III. FINDINGS

This paper analyzed the research evolution performed by various authors on the topic of Energy Efficiency / Power Constraint mechanisms and QoS of application layer protocol (CoAP). Different approaches of CoAP in IoT are categorized in Fig.2

Proposed Methodology	Ref	Purpose	Energy Constraint	QoS
CoAP with DTLS	11	Security	Yes	No
CoAP with OData	12	Enterprise Interoperability	Yes	Yes
CoAP with DTLS and raw public key concept	13	Improving security	Yes	Yes
CoCoA	14	To provide dynamic and controlled retransmission timeout adaptation	Yes	Yes
CoAP with Distributed Time server (jCoAP)	15	Provide real time behaviour	No	No
CoAP+round trip time based adaptive congestion control	16	Provide Congestion Control	Yes	Yes
CoAP with BLE 4.1	17	Replacing CoAP with UDP	Yes	Yes
CoAPthon	18	open source Python-based CoAP Library –To simplify resource observe and Block Transfer	No	No
CoAP-PBF	19	To provide fast, light, and secure autonomous discovery	Yes	Yes

Table :1 – Analsis of proposed CoAP

IV. CONCLUSION

In this paper we have presented the taxonomy of performance issues of Application layer at the time of integrating end devices of IoT. This taxonomy should help researchers focus on underlying methods, schemes and open research issues needed to enhance the Energy Saving and QoS of CoAP in IoT. This paper densely reviewed research

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manuscripts on the topic of energy / power constraint quality of service enabled at the time of integrating smart objects in multivendor environment.

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