Requirements Analysis for OPC UA over CoAP
draft-wang-core-opcua-transmition-requirements-01

Abstract

   Constrained Application Protocol (CoAP) is a application protocol
   for use with constrained nodes and constrained networks that is
   attractive to be applied In the Industrial Internet of Things (IIoT).
   OPC Unified Architecture (OPC UA) defines a semantic-based
   information model for industrial control system that can satisfy the
   requirements of Industry 4.0, which is based on semantic information
   exchange. This document analyses requirements for transmitting OPC
   UA over CoAP.

Status of this Memo

Table of Contents

1. Introduction

   CoAP is a web application protocol designed for resource constrained
   devices and constrained networks that has been widely used in
   machine-to-machine (M2M) communications [RFC7252].The purpose of
   applying CoAP to the Industrial Internet of Things (IIoT) is to
   provide connectivity for the devices. Whereas the communication of
   Industry 4.0 not only requires data value transmission, but also
   requires semantic information exchange. Driven by this, to use CoAP
   in the IIoT, there is a need to provide good support for messages
   transmission of the application layer in the automation field.
   According to the definition of Industry 4.0 for communication, CoAP
   needs to support the exchange of semantic information, namely the
   semantic information model. For the current protocols supporting
   semantic information model in the IIoT, the information model
   defined by OPC UA [IEC TR 62541-1] is very promising and its

interactive model is similar to the interactive model of CoAP, so it
can be applied as a branch of the CoAP message payload.

2. Architecture of OPC UA over CoAP

To meet the needs of IIoT, the architecture of OPC UA over CoAP can
be mainly divided into the following two:

1) Figure 1 presents a logical layered structure of OPC UA
Information Model over CoAP. In the transport layer, DTLS runs on
top of UDP to secure transmission. Then, the middle layer utilizes
the message mode defined in the CoAP protocol. Last, the information
model of OPC UA [IEC TR 62541-5] is defined as an application of
CoAP at the top. In such a hierarchical structure, the semantic-
based data information in OPC UA can be transmitted in resources-
constrained scenarios, so that CoAP can meet the requirements of
semantic information transmission.

```
              + - - - - - - - - - - - - - - - +
              |   OPC UA Information Model  |
              + - - - - - - - - - - - - - - - +
              + - - - - - - - - - - - - - - - +
              |              CoAP              |
              + - - - - - - - - - - - - - - - +
              + - - - - - - - - - - - - - - - +
              |              UDP              |
              + - - - - - - - - - - - - - - - +
```
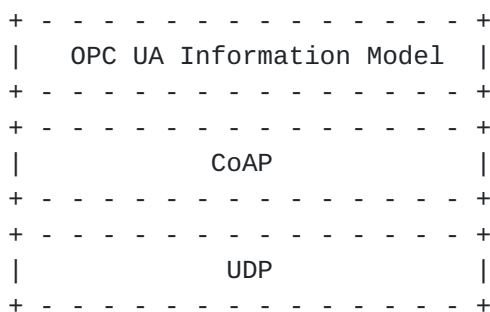
            Figure 1: OPC UA Information Model over CoAP

2) In order to take full advantage of the service sets defined by
OPC UA, this document proposes the other architecture for OPC UA

```
              + - - - - - - - - - - - - - - - +
              |   OPC UA Information Model  |
              + - - - - - - - - - - - - - - - +
              |         OPC UA Services       |
              + - - - - - - - - - - - - - - - +
              + - - - - - - - - - - - - - - - +
              |              CoAP              |
              + - - - - - - - - - - - - - - - +
              + - - - - - - - - - - - - - - - +
              |              UDP              |
              + - - - - - - - - - - - - - - - +
```

       Figure 2: OPC UA Information Model and Services over CoAP

transmission over CoAP. As shown in Figure 2, the information model of OPC UA is defined as the application of CoAP, moreover, the connection establishment, creating session, publish/subscribe and other functions related to data information interaction are all implemented by the service sets defined by OPC UA. CoAP is mainly responsible for the definition of message format and runs over UDP to keep the implementation lightweight.
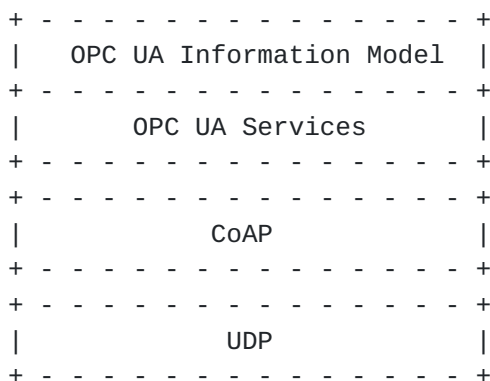
3. Requirements for OPC UA over CoAP

3.1. Encoding

CoAP messages are encoded in a simple binary format that starts with a fixed-size 4-byte header. The header is followed by a variable-length Token value, which can be between 0 and 8 bytes long. Following the Token value comes a sequence of zero or more CoAP Options in Type-Length-Value (TLV) format, optionally followed by a payload that takes up the rest of the datagram. In addition, the OPC UA protocol coding mainly includes two ways that are binary and XML. Therefore, in order to transmit the information model of OPC UA over CoAP, specific frame formats of CoAP need to be designed to support two kinds of coding modes of OPC UA.

3.2. Application Sublayer Optimization

For information exchange, the document [draft-ietf-core-coap-pubsub-00] defines the corresponding application sublayer, OPC UA also defines a number of specific communication patterns. For example, in the publish/subscribe mode defined by OPC UA, when the client needs to obtain a data periodically, it will initiate a subscription request to the server. In addition, the server will send the data to the client periodically as it receives the request from the client successfully. Correspondingly, in the publish/subscribe specification of CoAP, it introduces Broker mechanism in which the client sends the state information to the Broker and the Broker provides storage and forwarding function to implement the publish/subscribe function. Comparing above two protocols, their achieving methods have a difference on communication mode of the publish/subscribe function. Therefore, it is necessary to optimize the application sublayer of CoAP to support some particular communication modes of OPC UA.

3.3. Consistency

The interactive model of CoAP is the client/server model. However, in M2M scenarios, CoAP entities often act as both servers and clients. Compared to OPC UA, though the interactive model is also

the client/server model, there is a set of supported services in the OPC UA server. Consequently, for the great difference of the server definition of these two protocols, we need to tackle with the consistency and integration issues between the CoAP server and the OPC UA server.

3.4. Reliability

One of the main design goals of CoAP is to satisfy some special requirements such as communication in the constrained scenarios that address power consumption. Hence, in order to reduce network overhead and avoid network congestion, CoAP is designed to run over UDP, which is a good choice to achieve inter-network data exchange in use of the IP architecture. However, UDP is a connectionless transport layer protocol that provides unreliable information transmission services. In the field of IIoT, we need to ensure the reliability of data transmission to avoid losing some important data information. Moreover, CoAP addresses transmission reliability by defining a message as requiring acknowledgment, obviously this is not enough to meet the high reliability requirements in the field of IIoT, so the reliability of COAP remains to be optimized.

3.5. Transmission Methods

For OPC UA over CoAP, one of the important issues that needs to be addressed is how to transmit messages. The connection between OPC UA client and server is stateful, the connection status need to be maintained in the process of message interaction, while CoAP is a stateless connection, so that the message transmission of the two protocols is different. Fortunately, the transport layer protocol of OPC UA supports TCP and HTTP, in addition, the CoAP protocol can be considered that it is improved for constrained scenarios based on HTTP. Therefore, a solution can be found for the messages transmission by using the similarity of two protocols in HTTP.

4. Security Considerations

The security of CoAP includes four modes in which three modes implemented based on the Datagram Transport Layer Security (DTLS) except the non-security mode. However, the security architecture of OPC UA is built on the application layer and the communication layer above the transport layer. Specifically, the application layer adopts the authentication and authorization and the communication layer achieves the security of OPC UA [IEC TR 62541-2] through secure channel encryption. Though OPC UA has four modes, the security model of OPC UA is realized based on Transport Layer Security (TLS). Actually, DTLS is an addition to TLS to solve the

unreliable transmission feature of UDP. Currently, some documents
show that CoAP needs to support TLS. Therefore, the security of the
two protocols can be implemented jointly.

5. IANA Considerations

This memo includes no request to IANA.

6. References

6.1. Normative References

[RFC7252]   Shelby, Z., Hartke, K., and C. Bormann, "The Constrained
            Application Protocol", RFC 7252, June 2014,
            <https://tools.ietf.org/html/rfc7252>.

6.2. Informative References

[IEC TR 62541-1]
            IEC, "OPC unified architecture-Part1: Overview and concepts-
            IEC 62541", 2016, <
            https://webstore.iec.ch/preview/info_iec62541-
            1%7Bed2.0%7Den.pdf>.

[IEC TR 62541-5]
            IEC, "OPC unified architecture-Part5: Information Model-IEC
            62541", 2015, <
            https://webstore.iec.ch/preview/info_iec62541-
            5%7Bed2.0%7Db.pdf>.

[I-D.koster-core-coap-pubsub]
            Koster, M., Keranen, A., and J. Jimenez, "Publish-
            Subscribe Broker for the Constrained Application Protocol
            (CoAP)", draft-ietf-core-coap-pubsub-00 (work in
            progress), Qctober 2016.

[IEC TR 62541-2]
            IEC, "OPC unified architecture-Part2: Security Model-IEC
            62541", 2016, <
            https://webstore.iec.ch/preview/info_iec62541-
            2%7Bed2.0%7Db.pdf>.

Authors' Addresses

   Heng Wang
   Chongqing University of Posts and Telecommunications
   2 Chongwen Road
   Chongqing, 400065
   China

   Phone: (86)-23-6248-7845
   Email: wangheng@cqupt.edu.cn

   Chenggen Pu
   Chongqing University of Posts and Telecommunications
   2 Chongwen Road
   Chongqing, 400065
   China

   Phone: (86)-23-6246-1061
   Email: mentospcg@163.com

   Ping Wang
   Chongqing University of Posts and Telecommunications
   2 Chongwen Road
   Chongqing, 400065
   China

   Phone: (86)-23-6246-1061
   Email: wangping@cqupt.edu.cn

   Yi Yang
   Chongqing University of Posts and Telecommunications
   2 Chongwen Road
   Chongqing, 400065
   China

   Phone: (86)-23-6246-1061
   Email: 15023705316@163.com

   Daijing Xiong
   Chongqing University of Posts and Telecommunications
   2 Chongwen Road
   Chongqing, 400065
   China

      Phone: (86)-23-6246-1061
      Email: 15111825021@163.com