Abstract

This draft defines a new method of using the netconf pub/sub model in the RATS interaction procedure, to increase its flexibility, efficiency and scalability.

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This Internet-Draft will expire on April 23, 2020.

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1. Introduction

Remote attestation is for acquiring the evidence about various integrity information from remote endpoints to assess its trustworthiness (aka, behave in the expected manner). These evidence should be about: system component identity, composition of system components, roots of trust, system component integrity, system component configuration, operational state and so on.

[I-D.richardson-rats-usecases] describes possible use cases which remote attestation are using for different industries, like: network devices, FIDO authentication for online transaction, Cryptographic Key Attestation for mobile devices, and so on.

[I-D.birkholz-rats-architecture] lays a foundation of RATS architecture about the key RATS roles (i.e., Relying Party, Verifier, Attester and asserter) and the messages they exchange, as well as some key concepts. Based on it, [I-D.birkholz-rats-reference-interaction-model] specifies a basic challenge-response-based interaction model for the remote attestation procedure, which a complete remote attestation procedure is triggered by a challenge message originated from the verifier, and finished when the attester sends its response message back. This is a very generic interaction model with wide adoption. This document proposes an alternative interaction model for Remote attestation procedure, by
customizing the IETF NETCONF pub/sub model [RFC8639][RFC8640][RFC8641]. With its nature of asynchronous communication, the new pub/sub model for remote attestation procedure is optimal for large-scale and loosely coupled distributed systems, especially for the network devices, which has the advantages as: loose coupling, scalability, time delivery sensitivity, supporting filtering capability, and so on. The pub/sub model can be used independently, or together with the challenge-response model to complement each other as a whole. Note that in which way these models are combined together are currently out of the scope of this draft.

In summary, by utilizing the pub/sub model in remote attestation procedure, the gained benefits are as below:

- **Flexibility**: the verifier does not need to send the challenge message every time. The whole thing of the verifier is to subscribe a topic to the attester and then to anticipate the period or timely on-change notification from the attester about its integrity evidence.

- **Efficiency**: once the verifier has subscribed its interested topics related with its triggering condition to the attester, it will get all the condition triggered notifications on time, which are the integrity related evidence for remote attestation in fact. It will ensure any integrity change/deviation of the remote endpoint to be detected with the minimum latency.

- **Scalability**: it will save a lot of challenge messages by replacing with single subscription message for one topic stream, and decrease the total number of stateful connection between the verifier and attester, especially for a very large scale network. Thus, the scalability of the solution will increase.

This document is organized as follows. **Section 2** defines conventions and acronyms used. **Section 3** discusses pub/sub model of remote attestation procedure.

### 2. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

This document uses terminology defined in [I-D.birkholz-rats-architecture][I-D.birkholz-rats-reference-interaction-model] for security related and RATS scoped terminology.
3. Pub/sub Model for Remote Attestation Procedure

3.1. Solution Overview

The following sequence diagram illustrates the reference remote attestation procedure by utilizing the netconf pub/sub model defined by this document.
Figure 1: Pub/sub model of Remote Attestation
In short, the basic idea of pub/sub model for remote attestation is the verifier subscribes its interested event streams about the integrity evidence to the attester. After the subscription succeeds, the attester sends the subscribed integrity evidence back to the verifier. During subscription, the verifier may also specify how the attester returns the subscribed information, that is, the update trigger as periodic subscription or on-change subscription. And when the selection filters are applied to the subscription, only the information that pass the filter will be distributed out.

More detailed, the key steps of the remote attestation workflow with this model can be summarized as below (using the network devices as the example):

- The verifier subscribes its interested event streams about the integrity evidence to the attester. More specifically:
  - The event stream here refers to various integrity evidence information related to device trustworthiness. The basic event streams may include: software integrity information (including PCR values and system boot logs) of each layer of the trust chain recorded during device booting time; device identity certificates & Attestation Key certificate; operating system, application dynamic integrity information (e.g., IMA logs) and the device configuration information recorded during device running time.
  - Periodic subscription is mainly used by the verifier for the general and non-critical information collection, which are not strictly time sensitive and aims for collecting the latest integrity evidence and checking the possible deviation. In contrary, on-change subscription is basically used to monitor the critical integrity evidence (e.g., integrity values and log files during device booting time, or integrity values of some key service processes). If these integrity values change, notifications are sent immediately.
  - The selection filters may be applied to the subscription, so that only the event records that pass the filter will be distributed out. Some specific examples include: event records of a component (e.g., line card) in the composite device, the event records in a specific time period that includes a start time and an end time, and so on.

- Consider how to send the existing parameters (i.e., nonce, hash signature algorithm, and specified TPM name, etc.) carried in the challenge message of the previous challenge-response model to the attester through the subscription message of the new sub/pub model.
in advance, and the follow-up usage of them. A very important point is how to ensure that the nonce carried in every notification message is different, and both the attester and the verifier know the correct value in advance.

- Both configuration subscription and dynamic subscription are considered. More specifically:
  
  * Configure subscription is for the important security event stream. For example, it enables the monitoring the important integrity information by using the on-change mode.

  * Dynamic subscription is for the normal integrity information, that is, periodically receive those related information during NETCONF Session. The corresponding subscription RPC needs to be established dynamically. This way can reduce unnecessary NETCONF sessions.

- In addition to the update trigger of on-change, the other possible update trigger may be certain pre-defined events according to [I-D.bryskin-netconf-automation-yang], that is: When these events occur, the specified integrity information is triggered to be sent, which is the relevant event stream plus optional selection filter. The events may include: device startup completion, device upgrade completion, specific attack event, active/standby switchover, line card insertion/removal/switchover, certificate life cycle event (expiration), etc.

- The attester notification delivery mechanisms thus vary as the above subscription mechanisms of verifier vary.

The following sections describe the above key steps one by one.

### 3.2. Remote Attestation Event Stream Definition

The event streams here refers to various integrity evidence information related to device trustworthiness. The basic event streams may include: software integrity information (including PCR values and system boot logs) of each layer of the trust chain recorded during device booting time, device identity certificates & Attestation Key certificate generation, operating system and application dynamic integrity information (e.g., IMA logs) recorded during device running time.

The event streams are created and managed by the attester. And their formal definition should be conformed to the information model definition like Attestation Evidence or others in [I-D.birkholz-rats-information-model], and the claim data model
definition in [I-D.birkholz-rats-basic-yang-module] with YANG data format, and [I-D.ietf-rats-eat] with COSE data format.

3.3. Remote Attestation Subscription Definition

NETCONF pub/sub model provides several subscription types in which appropriate one or more types are chosen and possibly used together to meet the service requirements.

Particularly, periodic subscription is mainly used by the verifier for the general and non-critical information collection, which are not strictly time sensitive and aims for collecting the latest integrity information and checking the possible deviation. In contrary, on-change subscription is basically used to monitor the critical integrity evidence (e.g., integrity values and log files during device booting time, or integrity values of some key service processes). If these integrity values change, notifications are sent immediately.

Besides, both configuration subscription and dynamic subscription are considered. In which, configure subscription is for the important security data stream as it lasts even the NETCONF session is closed. For example, it enables the monitoring of the status of important security event stream by using the on-change mode. On the other hand, dynamic subscription is for the general security event stream, that is, periodically receive those related information during NETCONF Session. The corresponding subscription RPC needs to be established dynamically. This way can reduce unnecessary NETCONF sessions.

Furthermore, certain pre-defined events can be the update trigger too, that is: When these events occur, the specified integrity information is triggered to be sent, which is the relevant event stream plus optional selection filter. The events may include: device startup completion, device upgrade completion, specific attack event, active/standby switchover, line card insertion/removal/switchover, certificate life cycle event (expiration), etc.

3.4. Remote Attestation Selection Filters Definition

The selection filters may be applied to the subscription, so that only the event that pass the filter will be distributed out.

A concrete example of selection filter is limiting the delivered event stream to those originated from a specific component with id ("xxxxxxxxxxx") of a designated vendor ("xxx-vendor-device").
3.5. Remote Attestation Subscription Parameters Handling

Most of the parameters carried in the subscription message are not changed during the remote attestation procedure, like: hash signature algorithm, specified TPM name and so on. Their main goal is to enable the dynamic negotiation with the attester about what information the verifier needs and how to construct them together. A very important point is how to ensure that the nonce carried in every notification message is different, and both the attester and the verifier know the correct value in advance. For this purpose, the basic idea is to ensure that the nonce in two sides of the communication is synchronously changed, and the randomness of the nonce is maintained. Specifically, there may be several ways to do it:

- Verifier sends a seed with hash algorithm to the attester in the subscription message, and then perform the synchronization operation on both sides.

- In fact, the nonce does not need to be random every time. As long as the receive endpoint (here for verifier) can identify duplicated packets, other means may be used. For example: The timestamp and increasing count.

- The RATS TUDA mechanism [I-D.birkholz-rats-tuda] can also be used here to ensure the freshness of information.

3.6. Remote Attestation Notification Distribution

To be written.

3.7. Summary

Based on the above discussion, this section gives some examples to illustrate the overall application of sub/pub model to remote attestation procedure.

Below is a configured subscription example with on-change update trigger, with specific contents as:

- There are 3 integrity evidence related event streams as follows: pcr-trust-evidence, bios-log-trust-evidence and ima-log-trust-evidence. The subscribed one is pcr-trust-evidence.

- The other parameters of the subscription include: pcr-list: {{1, 3, 7}}, tcg-hash-algo-id: TPM_ALG_SHA256, nonce-value: 0x564ac291, TPM_ALG_ID-value: TPM_ALG_ECDSA, pub-key-id: 0x784a22bf, tpms: {"tpm1"}. 
o The selection filter is set as follows: a specific component with id ("xxxxxxxxxx") of a designated vendor ("xxx-vendor-device").

<edit-config>
  <subscriptions
    xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">
    <subscription>
      <id>100</id>
      <stream>pcr-trust-evidence</stream>
      <stream-subtree-filter>
        <xxx-vendor-device
          xmlns="urn:xxx:params:xml:ns:yang:xxx-vendor-device ">
          <device-id>xxxxxxxxxx</device-id>
          </xxx-vendor-device>
        </stream-subtree-filter>
      <pcr-list>
        <pcr>
          <pcr-indices>1</pcr-indices>
          <pcr-indices>3</pcr-indices>
          <pcr-indices>7</pcr-indices>
          <hash-algo>
            <tcg-hash-algo-id>TPM_ALG_SHA256</tcg-hash-algo-id>
            </hash-algo>
          </pcr>
        </pcr-list>
        <nonce-value>0x564ac291</nonce-value>
        <TPM_ALG_ID-value>TPM_ALG_ECDSA</TPM_ALG_ID-value>
        <pub-key-id>0x784a22bf</pub-key-id>
        <tpms>
          <tpm-name>tpm1</tpm-name>
        </tpms>
        <yp:on-change>
          <yp:dampening-period>100</yp:dampening-period>
        </yp:on-change>
    </subscription>
  </subscriptions>
</edit-config>

Figure 2: Configured On-change Subscription Message

Below is a dynamic subscription RPC example with periodic update trigger, with specific contents as:

o There are 3 integrity evidence related event streams as follows: pcr-trust-evidence, bios-log-trust-evidence and ima-log-trust-evidence. The subscribed one is bios-log-trust-evidence.
The other parameters of the dynamic subscription include: tpms: {"tpm1"}, last-entry-value: 0xa34568baac79, log-type: bios, pcr-list: {{2, 4, 8}}, tcg-hash-algo-id: TPM_ALG_SHA256.

The selection filter is set as follows: a specific component with id ("xxxxxxxxxx") of a designated vendor ("xxx-vendor-device").

Subscription period: 500 centiseconds.

<rpc netconf:message-id="101"
  xmlns:netconf="urn:ietf:params:xml:ns:netconf:base:1.0">
  <establish-subscription
    xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">
    <stream>bios-log-trust-evidence</stream>
    <stream-subtree-filter>
      <xxx-vendor-device
        xmlns="urn:xxx:params:xml:ns:yang:xxx-vendor-device ">
        <device-id>xxxxxxxxxx</device-id>
      </xxx-vendor-device>
    </stream-subtree-filter>
    <tpms>
      <tpm-name>tpm1</tpm-name>
    </tpms>
    <last-entry-value>0xa34568baac79</last-entry-value>
    <log-type>bios</log-type>
    <pcr-list>
      <pcr>
        <pcr-indices>2</pcr-indices>
        <pcr-indices>4</pcr-indices>
        <pcr-indices>8</pcr-indices>
        <hash-algo>
          <tcg-hash-algo-id>TPM_ALG_SHA256</tcg-hash-algo-id>
        </hash-algo>
      </pcr>
    </pcr-list>
    <yp:periodic>
      <yp:period>500</yp:period>
    </yp:periodic>
  </establish-subscription>
</rpc>

Figure 3: Dynamic Periodic Subscription Message

Below is a configured subscription RPC example with pre-defined events as the update trigger, with specific contents as:
There are 3 integrity evidence related event streams as follows: pcr-trust-evidence, bios-log-trust-evidence and ima-log-trust-evidence. The subscribed one is pcr-trust-evidence.

The other parameters of the subscription include: pcr-list: [{1, 3, 7}], tcg-hash-algo-id: TPM_ALG_SHA256, nonce-value: 0x564ac291, TPM_ALG_ID-value: TPM_ALG_ECDSA, pub-key-id: 0x784a22bf, tpms: {"tpm1"}.

The selection filter is set as follows: a specific component with id ("xxxxxxxxxx") of a designated vendor ("xxx-vendor-device").

The event which triggers the integrity evidence delivery is defined as: id: 1001, type: master-slave-swithover.

Figure 4: Configured Event-triggered Subscription Message

4. The YANG Module for Sub/pub Model Remote Attestation Procedures

4.1. Tree Format

To be written.

4.2. Raw Format

To be written.

5. Security Considerations

To be written.

6. Acknowledgements

Thanks to ...

7. IANA Considerations

To be written, possibly.

8. References

8.1. Normative References


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8.2. Informative References

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[I-D.birkholz-rats-tuda]


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