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Reference Interaction Model for Challenge-Response-based Remote Attestation
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Abstract

This document defines an interaction model for a basic remote attestation procedure. Additionally, the required information elements are illustrated.

Status of This Memo

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1. Introduction

Remote attestation procedures (RATS) are a combination of activities, in which a Verifier creates assertions about claims of integrity and about the characteristics of other system entities by the appraisal of corresponding signed claims (evidence). In this document, a reference interaction model for a generic challenge-response-based remote attestation procedure is provided. The minimum set of components, roles and information elements that have to be conveyed between Verifier and Attester are defined as a standard reference to derive more complex RATS from.

1.1. Requirements notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119, BCP 14 [RFC2119].

2. Disambiguation

The term "Remote Attestation" is a common expression and often associated with certain properties. The term "Remote" in this context does not necessarily refer to a remote system entity in the scope of network topologies or the Internet. It rather refers to a

decoupled system or different computing context, which also could be present locally as components of a composite device. Examples include: a Trusted Execution Environment (TEE), Baseboard Management Controllers (BMCs), as well as other physical or logical protected/ isolated execution environments.

3. Scope

This document focuses on a generic interaction model between Verifiers and Attesters. Complementary processes, functions and activities that are required for a complete semantic binding of RATS are not in scope. Examples include: identity establishment, key enrollment, and certificate revocation. Furthermore, any processes and activities that go beyond carrying out the remote attestation process are out of scope. For instance, using the result of a remote attestation that is emitted by the Verifier, such as triggering remediation actions and recovery processes, as well as the remediation actions and recovery processes themselves, are out of scope.

4. Component Roles

The Reference Interaction Model for Challenge-Response-based Remote Attestation is based on the standard roles defined in [I-D.birkholz-rats-architecture]:

Attester: The role that designates the subject of the remote attestation. A system entity that is the provider of evidence takes on the role of an Attester.

Verifier: The role that designates the system entity and that is the appraiser of evidence provided by the Attester. A system entity that is the consumer of evidence takes on the role of a Verifier.

5. Prerequisites

Identity: An Attester must have a unique Identity in such a way that a Verifier can uniquely identify an Attester. This Identity MUST be part of the signed claims (attestation evidence) that the Attester conveys to the Verifier.

Secret: A Secret that is present on the Attester and that a Verifier can identify by its Secret ID, e.g. a public key. This Secret MUST be established before a remote attestation procedure can take place. How this Secret is established is out of scope for this reference model.

6. Remote Attestation Interaction Model

This section defines the information elements that have to be conveyed via a protocol, enabling the conveyance of Evidence between Verifier and Attester, as well as the interaction model for a generic challenge-response scheme.

6.1. Information Elements

Nonce: mandatory

The Nonce (number used once) is a number intended to be unique and intended to be effectively infeasible to guess. In this reference interaction model it MUST be provided by the Verifier and MUST be used as a proof of freshness, with respect to conveyed evidence ensuring that the result of an attestation activity was created recently (i. e. triggered by the challenge emitted by the Verifier). As such, the Nonce MUST be part of the signed evidence sent by the Attester to the Verifier.

Secret ID: mandatory

An identifier that MUST be associated with the Secret which is used to sign the evidence.

Evidence: mandatory

The signed claims that are required to enable integrity proving of the corresponding characteristics of the Attester. Examples of

claims included in attestation evidence are claims about sensor data, policies that are active on the system entity, versions of composite firmware of a platform, running software, routing tables, or information about a local time source. Attestation evidence must be cryptographically bound to the Verifier-provided Nonce, the Identity of the Attester, as well as to the Secret identified by the Secret ID.

Claim Selection: optional

An Attester MAY provide a selection of claims that are relevant to the appraisal conducted by the Verifier in order to prove correctness of the (integrity) claims created by the Attester. Usually, all available claims that are available to the Attester SHOULD be conveyed. This claim selection can be composed as complementary signed claims or can be encapsulated claims in the signed evidence that composes the evidence about integrity. This information element is optional in order to enable a Verifier to narrow down or increase the amount of received evidence. An

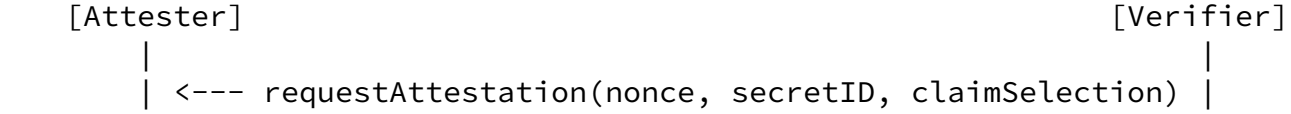
Attester MAY decide whether or not to provide the requested claims or not. In either case, the claim selection MUST be cryptographically bound to the signed claim set. An example for a claim selection is that a Verifier can request from an Attester (signed) Reference Integrity Measurements (RIMs), which represent a claim about the intended platform operational state of the Attester.

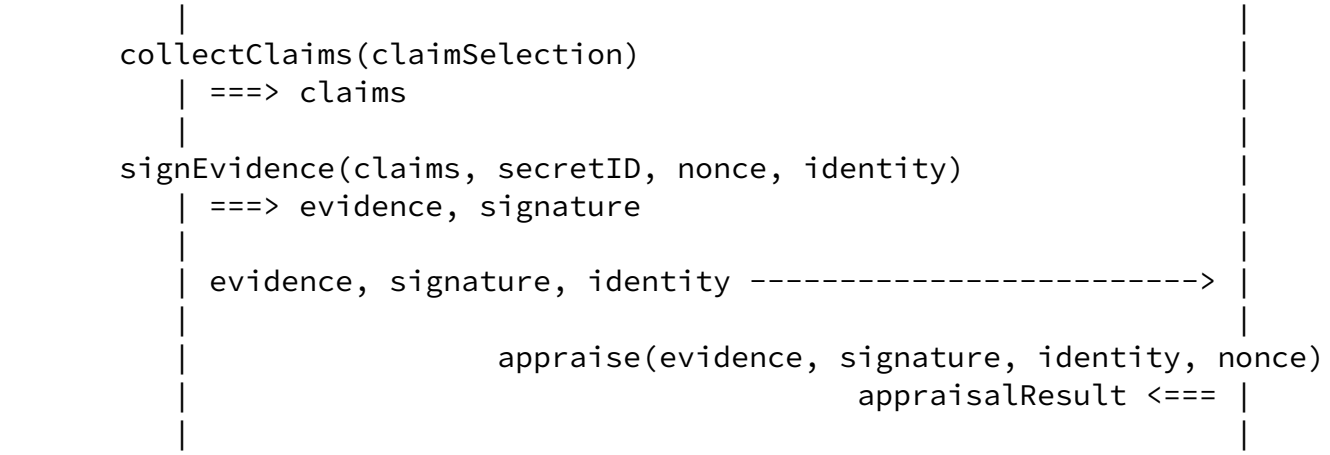
Identity: mandatory

A statement about a distinguishable Attester made by an entity without accompanying evidence of its validity, used as proof of identity.

7. Interaction Model

The following sequence diagram illustrates the reference remote attestation procedure defined by this document.





The remote attestation procedure is initiated by the Verifier, sending an attestation request to the Attester. The attestation request consists of a Nonce, a Secret ID, and a Claim Selection. The Nonce guarantees attestation freshness. The Secret ID selects the secret the Attester is requested to sign the Evidence with. The Claim Selection narrows down or increases the amount of received Evidence, if required. If the Claim Selection is empty, then by default all claims that are available on the system of the Attester SHOULD be signed and returned as Evidence. For example, the Verifier is only interested in particular information about the Attester, such as whether the device booted up in a known state, and not include information about all currently running software.

The Attester, after receiving the attestation request, collects the corresponding claims to compose the evidence the Verifier requested--or, in case the Verifier did not provide a claim selection, the Attester collects all information that can be used as complementary claims in the scope of the semantics of the remote attestation procedure. After that, the Attester signs the evidence with the secret identified by the secret ID, including the nonce and the identity information. Then the Attester sends the output back to the Verifier. Important at this point is that the nonce as well as the identity information must be cryptographically bound to the signature, i. e. it is not required for them to be present in plain text. For instance, those information can be part of the signature after a one-way function (e. g. a hash function) was applied to them. There is also a possibility to scramble the nonce or identity with other information that is known to both the Verifier and Attester. A

prominent example is the IP address of the Attester that usually is known by the Attester as well as the Verifier. This extra information can be used to scramble the Nonce in order to counter certain types of relay attacks. As soon as the Verifier receives the evidence, it appraises it, including the verification of the signature, the identity, the nonce, and the claims included in the evidence. This process is application-specific and can be done by e. g. comparing the claims to known (good), expected reference claims, such as Reference Integrity Measurements (RIMs), or evaluating it in other ways. The final output, the appraisal result (also referred to as attestation result), is a new claim about properties of the Attester, i. e. whether or not it is compliant to policies, or even can be "trusted".

8. Further Context

Depending on the use cases to cover there may be additional requirements.

8.1. Confidentiality

Use confidential communication to exchange attestation information. This requirement usually is present when communication happens over insecure channels, such as the public Internet. Speaking of a suitable communication protocol, TLS is a good candidate. In private networks, such as carrier management networks, it must be evaluated whether or not the transport medium is considered confidential.

8.2. Mutual Authentication

In particular use cases mutual authentication may be desirable in such a way that a Verifier also needs to prove its identity to the

Attester instead of only the Attester proving its identity to the Verifier.

8.3. Hardware-Enforcement/Support

In particular use cases hardware support can be desirable. Depending on the requirements those can be secure storage of cryptographic keys, crypto accelerators, or protected or isolated execution

environments. Well-known technologies are Hardware Security Modules (HSM), Physical Unclonable Functions (PUFs), Shielded Secrets, Trusted Executions Environments (TEEs), etc.

9. Security Considerations

There are always some.

10. Acknowledgements

Very likely.

11. Change Log

Initial draft -00

Changes from version 00 to version 01:

Added details to the flow diagram

12. References

12.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

12.2. Informative References

[I-D.birkholz-rats-architecture] Birkholz, H., Wiseman, M., Tschofenig, H., and N. Smith, "Architecture and Reference Terminology for Remote Attestation Procedures", draft-birkholz-rats-architecture-00 (work in progress), October 2018.

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