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Transport Subsystem for the Simple Network Management Protocol (SNMP) draft-ietf-isms-tmsm-06

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Abstract

This document defines a Transport Subsystem, extending the Simple Network Management Protocol (SNMP) architecture defined in RFC 3411. This document defines a subsystem to contain Transport Models, comparable to other subsystems in the RFC3411 architecture. As work is being done to expand the transport to include secure transport such as SSH and TLS, using a subsystem will enable consistent design

and modularity of such Transport Models. This document identifies and describes some key aspects that need to be considered for any Transport Model for SNMP.

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1. Introduction

This document defines a Transport Subsystem, extending the Simple Network Management Protocol (SNMP) architecture defined in [RFC3411]. This document identifies and describes some key aspects that need to be considered for any Transport Model for SNMP.

1.1. The Internet-Standard Management Framework

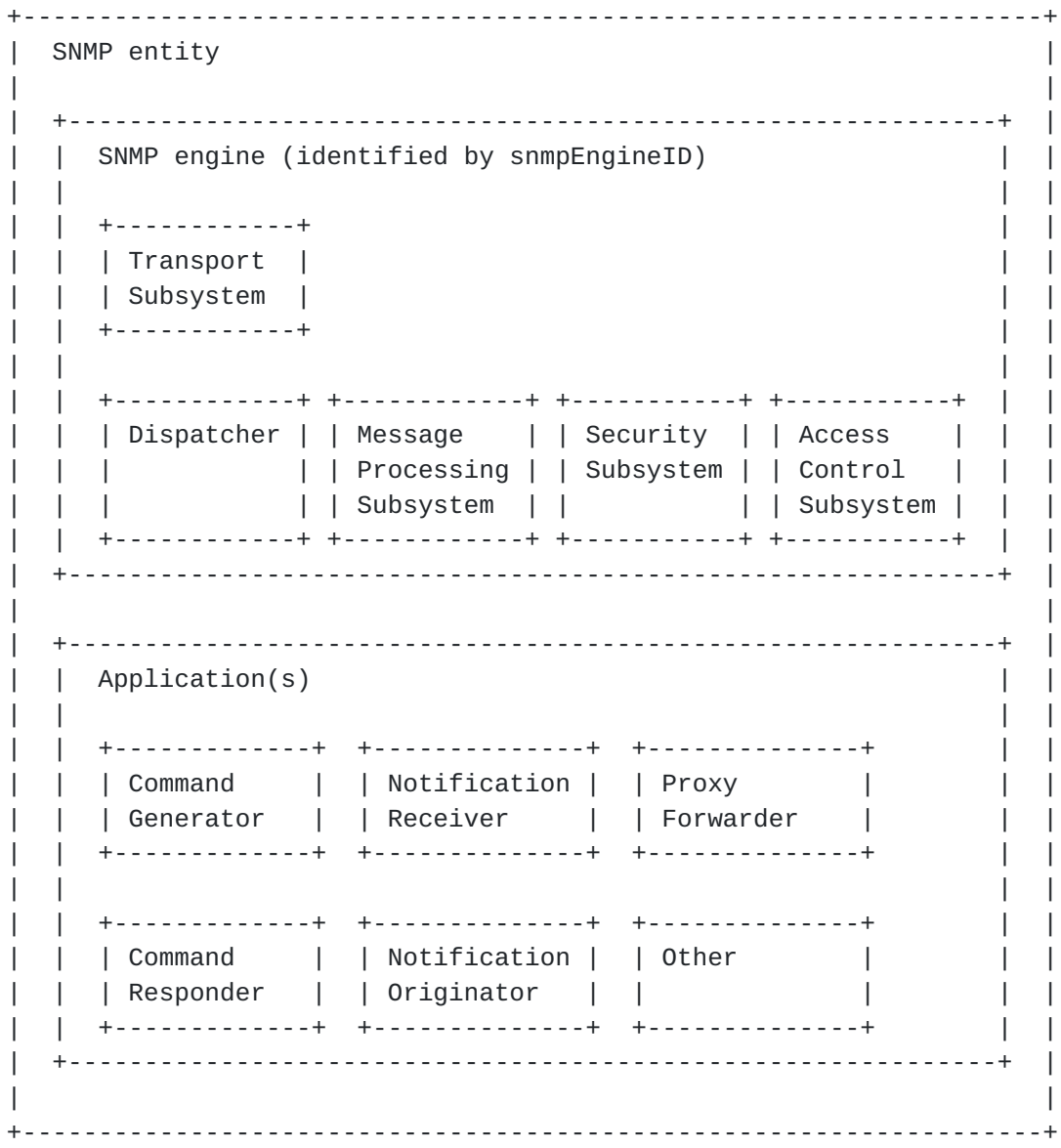
For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

1.2. Where this Extension Fits

It is expected that readers of this document will have read RFC3410 and RFC3411, and have a general understanding of the functionality defined in RFCs 3412-3418.

The "Transport Subsystem" is an additional component for the SNMP Engine depicted in RFC3411, section 3.1.

The following diagram depicts its place in the RFC3411 architecture.:



The transport mappings defined in RFC3417 do not provide lower-layer security functionality, and thus do not provide transport-specific security parameters. This document updates RFC3411 and RFC3417 by defining an architectural extension and ASIs that transport mappings (models) can use to pass transport-specific security parameters to other subsystems, including transport-specific security parameters translated into the transport-independent securityName and securityLevel.

1.3. Conventions

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 RFC 2119 [RFC2119].

The key words "must", "must not", "required", "shall", "shall not", "should", "should not", "recommended", "may", and "optional" in this document are not to be interpreted as described in RFC2119. They will usually, but not always, be used in a context relating to compatibility with the RFC3411 architecture or the subsystem defined here, but which might have no impact on on-the-wire compatibility. These terms are used as guidance for designers of proposed IETF models to make the designs compatible with RFC3411 subsystems and Abstract Service Interfaces (see section 3.2). Implementers are free to implement differently. Some usages of these lowercase terms are simply normal English usage.

2. Motivation

Just as there are multiple ways to secure one's home or business, in a continuum of alternatives, there are multiple ways to secure a network management protocol. Let's consider three general approaches.

In the first approach, an individual could sit on his front porch waiting for intruders. In the second approach, he could hire an employee , schedule the employee, position the employee to guard what he wants protected, hire a second guard to cover if the first gets sick, and so on. In the third approach, he could hire a security company, tell them what he wants protected, and they could hire employees, train them, position the guards, schedule the guards, send a replacement when a guard cannot make it, etc., thus providing the desired security, with no significant effort on his part other than identifying requirements and verifying the quality of the service being provided.

The User-based Security Model (USM) as defined in [RFC3414] largely uses the first approach - it provides its own security. It utilizes existing mechanisms (e.g., SHA), but provides all the coordination. USM provides for the authentication of a principal, message encryption, data integrity checking, timeliness checking, etc.

USM was designed to be independent of other existing security infrastructures. USM therefore requires a separate principal and key management infrastructure. Operators have reported that deploying another principal and key management infrastructure in order to use SNMPv3 is a deterrent to deploying SNMPv3. It is possible to use

external mechanisms to handle the distribution of keys for use by USM. The more important issue is that operators wanted to leverage a single user base that wasn't specific to SNMP.

A solution based on the second approach might use a USM-compliant architecture, but combine the authentication mechanism with an external mechanism, such as RADIUS [RFC2865], to provide the authentication service. It might be possible to utilize an external protocol to encrypt a message, to check timeliness, to check data integrity, etc. It is difficult to cobble together a number of subcontracted services and coordinate them however, because it is difficult to build solid security bindings between the various services, and potential for gaps in the security is significant.

A solution based on the third approach might utilize one or more lower-layer security mechanisms to provide the message-oriented security services required. These would include authentication of the sender, encryption, timeliness checking, and data integrity checking. There are a number of IETF standards available or in development to address these problems through security layers at the transport layer or application layer, among them TLS [RFC4366], SASL [RFC4422], and SSH [RFC4251].

From an operational perspective, it is highly desirable to use security mechanisms that can unify the administrative security management for SNMPv3, command line interfaces (CLIs) and other management interfaces. The use of security services provided by lower layers is the approach commonly used for the CLI, and is also the approach being proposed for NETCONF [RFC4741].

This document defines a Transport Subsystem extension to the RFC3411 architecture based on the third approach. This extension specifies how other lower layer protocols with common security infrastructures can be used underneath the SNMP protocol and the desired goal of unified administrative security can be met.

This extension allows security to be provided by an external protocol connected to the SNMP engine through an SNMP Transport Model [RFC3417]. Such a Transport Model would then enable the use of existing security mechanisms such as (TLS) [RFC4366] or SSH [RFC4251] within the RFC3411 architecture.

There are a number of Internet security protocols and mechanisms that are in wide spread use. Many of them try to provide a generic infrastructure to be used by many different application layer protocols. The motivation behind the Transport Subsystem is to leverage these protocols where it seems useful.

There are a number of challenges to be addressed to map the security provided by a secure transport into the SNMP architecture so that SNMP continues to provide interoperability with existing implementations. These challenges are described in detail in this document. For some key issues, design choices are described that might be made to provide a workable solution that meets operational requirements and fits into the SNMP architecture defined in [RFC3411].

3. Requirements of a Transport Model

3.1. Message Security Requirements

Transport security protocols SHOULD provide protection against the following message-oriented threats [RFC3411]:

1. modification of information
2. masquerade
3. message stream modification
4. disclosure

These threats are described in section 1.4 of [RFC3411]. It is not required to protect against denial of service or traffic analysis, but it should not make those threats significantly worse.

3.1.1. Security Protocol Requirements

There are a number of standard protocols that could be proposed as possible solutions within the Transport Subsystem. Some factors SHOULD be considered when selecting a protocol.

Using a protocol in a manner for which it was not designed has numerous problems. The advertised security characteristics of a protocol might depend on it being used as designed; when used in other ways, it might not deliver the expected security characteristics. It is recommended that any proposed model include a description of the applicability of the Transport Model.

A Transport Model SHOULD require no modifications to the underlying protocol. Modifying the protocol might change its security characteristics in ways that would impact other existing usages. If a change is necessary, the change SHOULD be an extension that has no impact on the existing usages. Any Transport Model SHOULD include a description of potential impact on other usages of the protocol.

Transport Models MUST be able to coexist with each other.

3.2. SNMP Requirements

3.2.1. Architectural Modularity Requirements

SNMP version 3 (SNMPv3) is based on a modular architecture (defined in [RFC3411] section 3) to allow the evolution of the SNMP protocol standards over time, and to minimize side effects between subsystems when changes are made.

The RFC3411 architecture includes a Security Subsystem for enabling different methods of providing security services, a Message Processing Subsystem permitting different message versions to be handled by a single engine, Applications(s) to support different types of application processors, and an Access Control Subsystem for allowing multiple approaches to access control. The RFC3411 architecture does not include a subsystem for Transport Models, despite the fact there are multiple transport mappings already defined for SNMP. This document addresses the need for a Transport Subsystem compatible with the RFC3411 architecture. As work is being done to expand the transport to include secure transport such as SSH and TLS, using a subsystem will enable consistent design and modularity of such Transport Models.

The design of this Transport Subsystem accepts the goals of the RFC3411 architecture defined in section 1.5 of [RFC3411]. This Transport Subsystem uses a modular design that will permit Transport Models to be advanced through the standards process independently of other Transport Models, and independent of other modular SNMP components as much as possible.

Parameters have been added to the ASIs to pass model-independent transport address information.

IETF standards typically require one mandatory to implement solution, with the capability of adding new mechanisms in the future. Part of the motivation of developing Transport Models is to develop support for secure transport protocols, such as a Transport Model that utilizes the Secure Shell protocol. Any Transport Model SHOULD define one minimum-compliance security mechanism, such as certificates, to ensure a basic level of interoperability, but should also be able to support additional existing and new mechanisms.

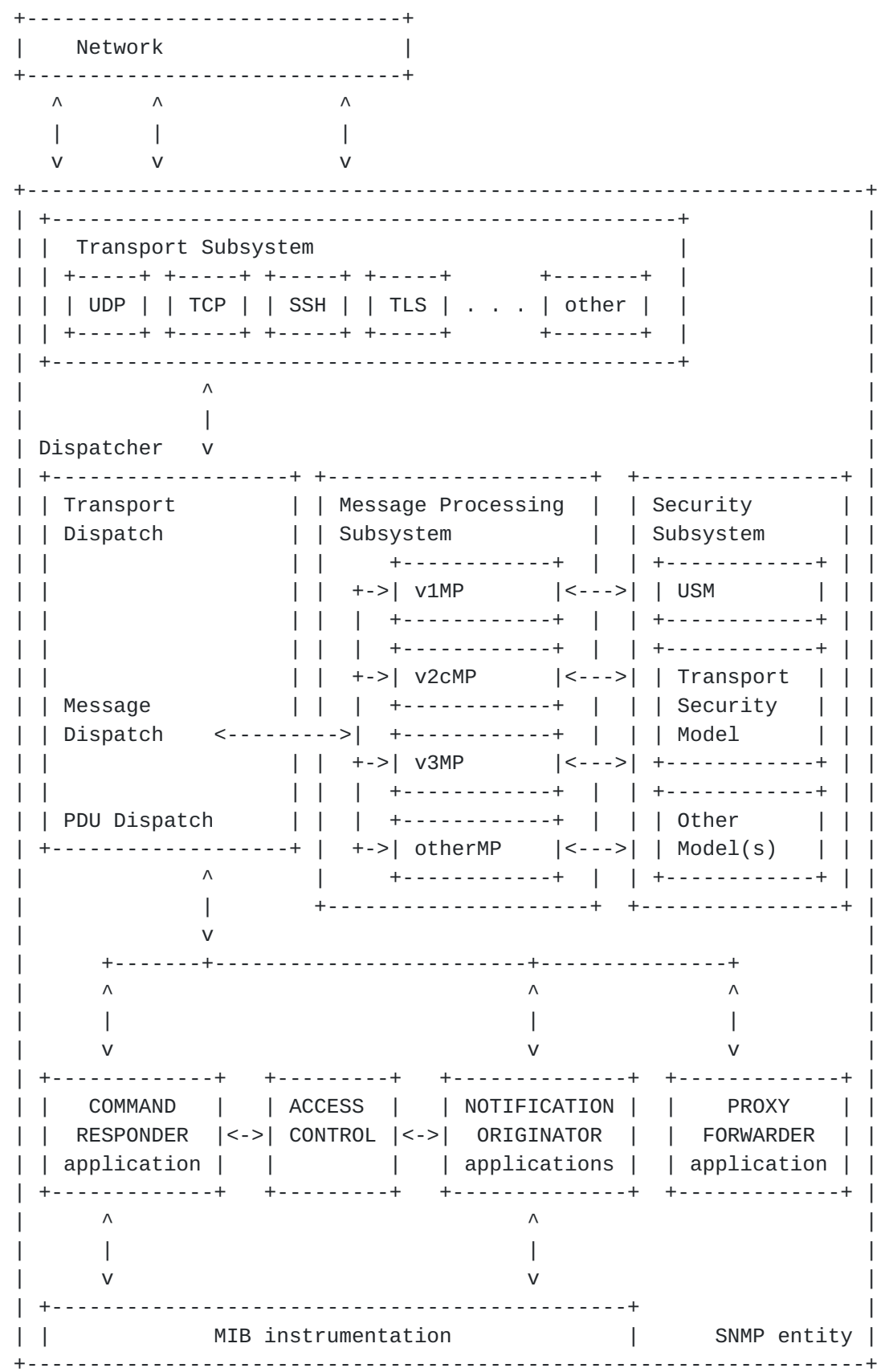
The Transport Subsystem permits multiple transport protocols to be "plugged into" the RFC3411 architecture, supported by corresponding Transport Models, including models that are security-aware.

The RFC3411 architecture and the Security Subsystem assume that a Security Model is called by a Message Processing Model and will

perform multiple security functions within the Security Subsystem. A Transport Model that supports a secure transport protocol might perform similar security functions within the Transport Subsystem. A Transport Model might perform the translation of transport security parameters to/from security-model-independent parameters.

To accommodate this, an implementation-specific cache of transport-specific information will be described (not shown), and the data flows between the Transport Subsystem and the Transport Dispatch, between the Message Dispatch and the Message Processing Subsystem, and between the Message Processing Subsystem and the Security Subsystem will be extended to pass security-model-independent values. New Security Models may also be defined that understand how to work with the modified ASIs and the cache. One such Security Mode, the Transport Security Model, is defined in

The following diagram depicts the SNMPv3 architecture including the new Transport Subsystem defined in this document, and a new Transport Security Model defined in [I-D.ietf-isms-transport-security-model].


Network
Transport Subsystem
UDP
TCP
SSH
TLS
. . .
other
Dispatcher
Transport Dispatch
Message Dispatch
PDU Dispatch
Message Processing Subsystem
v1MP
v2cMP
v3MP
otherMP
Security Subsystem
USM
Transport Security Model
Other Model(s)
COMMAND RESPONDER application
ACCESS CONTROL
NOTIFICATION ORIGINATOR applications
PROXY FORWARDER application
MIB instrumentation
SNMP entity

3.2.1.1. Processing Differences between USM and Secure Transport

USM and secure transports differ is the processing order and responsibilities within the RFC3411 architecture. While the steps are the same, they occur in a different order, and may be done by different subsystems. The following lists illustrate the difference in the flow and the responsibility for different processing steps for incoming messages when using USM and when using a secure transport. (Note that these lists are simplified for illustrative purposes, and do not represent all details of processing. Transport Models must provide the detailed elements of procedure.)

With USM and other Security Models, security processing starts when the Message Processing Model decodes portions of the ASN.1 message to extract an opaque block of security parameters and header parameters that identify which Security Model should process the message to perform authentication, decryption, timeliness checking, integrity checking, and translation of parameters to model-independent parameters. A secure transport performs those security functions on the message, before the ASN.1 is decoded.

Step 6 cannot occur until after decryption occurs. Step 6 and beyond are the same for USM and a secure transport.

3.2.1.1.1. USM and the RFC3411 Architecture

1) decode the ASN.1 header (Message Processing Model)
2) determine the SNMP Security Model and parameters (Message Processing Model)
3) verify securityLevel. [Security Model]
4) translate parameters to model-independent parameters (Security Model)
5) authenticate and decrypt message. [Security Model]
6) determine the pduType in the decrypted portions (Message Processing Model), and
7) pass on the decrypted portions with model-independent parameters.

3.2.1.2. Transport Subsystem and the RFC3411 Architecture

1) authenticate and decrypt message. [Transport Model]
2) translate parameters to model-independent parameters (Transport Model)
3) decode the ASN.1 header (Message Processing Model)
4) determine the SNMP Security Model and parameters (Message Processing Model)

5) verify securityLevel [Security Model]
6) determine the pduType in the decrypted portions (Message Processing Model), and
7) pass on the decrypted portions with model-independent security parameters

If a message is secured using a secure transport layer, then the Transport Model should provide the translation from the authenticated identity (e.g., an SSH user name) to the securityName in step 3.

3.2.1.3. Passing Information between Engines

A secure Transport Model will establish an authenticated and/or encrypted tunnel between the Transport Models of two SNMP engines. After a transport layer tunnel is established, then SNMP messages can be sent through the tunnel from one SNMP engine to the other SNMP engine. Transport Models MAY support sending multiple SNMP messages through the same tunnel.

3.2.2. Access Control Requirements

RFC3411 made some design decisions related to the support of an Access Control Subsystem. These include a securityName and securityLevel mapping, the separation of Authentication and Authorization, and the passing of model-independent security parameters.

3.2.2.1. securityName and securityLevel Mapping

For SNMP access control to function properly, Security Models MUST establish a securityLevel and a securityName, which is the security-model-independent identifier for a principal. The Message Processing Subsystem relies on a Security Model, such as USM, to play a role in security that goes beyond protecting the message - it provides a mapping between the security-model-specific principal to a security-model independent securityName which can be used for subsequent processing, such as for access control.

The securityName MUST be mapped from the mechanism-specific authenticated identity, and this mapping must be done for incoming messages before the Security Model passes securityName to the Message Processing Model via the processIncoming ASI. This translation from a mechanism-specific authenticated identity to a securityName might be done by the Transport Model, and the securityName is then provided to the Security Model via the tmStateReference to be passed to the Message Processing Model.

If the type of authentication provided by the transport layer (e.g.,

TLS) is considered adequate to secure and/or encrypt the message, but inadequate to provide the desired granularity of access control (e.g., user-based), then a second authentication (e.g., one provided via a RADIUS server) MAY be used to provide the authentication identity which is mapped to the securityName. This approach would require a good analysis of the potential for man-in-the-middle attacks or masquerade possibilities.

3.2.3. Security Parameter Passing Requirements

RFC3411 section 4 describes abstract data flows between the subsystems, models and applications within the architecture. Abstract Service Interfaces describe the flow of data, passing model-independent information between subsystems within an engine. The RFC3411 architecture has no ASI parameters for passing security information between the Transport Subsystem and the dispatcher, or between the dispatcher and the Message Processing Model. This document defines or modifies ASIs for this purpose.

The security parameters include a model-independent identifier of the security "principal" (the securityName), the Security Model used to perform the authentication, and which authentication and privacy services were (should be) applied to the message (securityLevel).

A Message Processing Model might unpack SNMP-specific security parameters from an incoming message before calling a specific Security Model to authenticate and decrypt an incoming message, perform integrity checking, and translate security-model-specific parameters into model-independent parameters. When using a secure Transport Model, security parameters might be provided through means other than carrying them in the SNMP message; the parameters for incoming messages might be extracted from the transport layer by the Transport Model before the message is passed to the Message Processing Subsystem.

This document describes a cache mechanism (see Section 5), into which the Transport Model puts information about the transport and security parameters applied to a transport connection or an incoming message, and a Security Model may extract that information from the cache. A tmStateReference is passed as an extra parameter in the ASIs of the Transport Subsystem and the Message Processing and Security Subsystems, to identify the relevant cache. This approach of passing a model-independent reference is consistent with the securityStateReference cache already being passed around in the RFC3411 ASIs.

For outgoing messages, even when a secure Transport Model will provide the security services, a Message Processing Model might have

a Security Model actually create the message from its component parts. Whether there are any security services provided by the Security Model for an outgoing message is security-model-dependent. For incoming messages, even when a secure Transport Model provides security services, a Security Model might provide some security functionality that can only be provided after the message version or other parameters are extracted from the message.

3.2.4. Separation of Authentication and Authorization

The RFC3411 architecture defines a separation of authentication and authorization (access control), and a Transport Model that provides security services should take care to not violate this separation. A Transport Model must not specify how the securityModel and securityName could be dynamically mapped to an access control mechanism, such as a VACM-style groupName.

The RECOMMENDED approach is to pass the model-independent security parameters via the isAccessAllowed ASI, and perform the mapping from the model-independent security parameters to an access-control-model-dependent policy within the Access Control Model. The isAccessAllowed ASI is used for passing the securityModel, securityName, and securityLevel parameters that are independent of any specific security model and any specific access control model to the Access Control Subsystem.

The mapping of (securityModel, securityName, securityLevel) to an access-control-model-specific policy should be handled within a specific access control model. This mapping should not be done in the Transport or Security Subsystems, to be consistent with the modularity of the RFC3411 architecture. This separation was a deliberate decision of the SNMPv3 WG, to allow support for authentication protocols which did not provide authorization (access control) capabilities, and to support authorization schemes, such as VACM, that do not perform their own authentication.

The View-based Access Control Model uses the securityModel and the securityName as inputs to check for access rights. It determines the groupName as a function of securityModel and securityName. Providing a binding outside the Access Control Subsystem might create dependencies that could make it harder to develop alternate models of access control, such as one built on UNIX groups or Windows domains.

To provide support for protocols which simultaneously send information for authentication and authorization (access control), such as RADIUS [RFC2865], access-control-model-specific information might be cached or otherwise made available to the Access Control Subsystem, e.g., via a MIB table similar to the

vacmSecurityToGroupTable, so the Access Control Subsystem can create an appropriate binding between the access-control-model-independent securityModel and securityName and an access-control-model-specific policy. This would be highly undesirable, however, if it creates a dependency between a Transport Model or a Security Model and an Access Control Model.

3.3. Session Requirements

Some secure transports might have a notion of sessions, while other secure transports might provide channels or other session-like mechanism. Throughout this document, the term session is used in a broad sense to cover sessions, channels, and session-like mechanisms. Session refers to an association between two SNMP engines that permits the transmission of one or more SNMP messages within the lifetime of the session. How the session is actually established, opened, closed, or maintained is specific to a particular Transport Model.

Sessions are not part of the SNMP architecture defined in [RFC3411], but are considered desirable because the cost of authentication can be amortized over potentially many transactions.

The architecture defined in [RFC3411] does not include a session selector in the Abstract Service Interfaces, and neither is that done for the Transport Subsystem, so an SNMP application has no mechanism to select a session using the ASIs except by passing a unique combination of transportDomain, transportAddress, securityName, securityModel, and securityLevel. Implementers, of course, might provide non-standard mechanisms to select sessions. The transportDomain and transportAddress identify the transport connection to a remote network node; the securityName identifies which security principal to communicate with at that address (e.g., different NMS applications), and the securityModel and securityLevel might permit selection of different sets of security properties for different purposes (e.g., encrypted SETs vs. non-encrypted GETs).

All Transport Models should discuss the impact of sessions on SNMP usage, including how to establish/open a transport session (i.e., how it maps to the concepts of session-like mechanisms of the underlying protocol), how to behave when a session cannot be established, how to close a session properly, how to behave when a session is closed improperly, the session security properties, session establishment overhead, and session maintenance overhead.

To reduce redundancy, this document describes aspects that are expected to be common to all Transport Model sessions.

3.3.1. Session Establishment Requirements

SNMP applications must provide the transportDomain, transportAddress, securityName, securityModel, and securityLevel to be used for a session.

SNMP Applications might have no knowledge of whether the session that will be used to carry commands was initially established as a notification session, or a request-response session, and SHOULD NOT make any assumptions based on knowing the direction of the session. If an administrator or Transport Model designer wants to differentiate a session established for different purposes, such as a notification session versus a request-response session, the application can use different securityNames or transport addresses (e.g., port 161 vs. port 162) for different purposes.

An SNMP engine containing an application that initiates communication, e.g., a Command Generator or Notification Originator, must be able to attempt to establish a session for delivery if a session does not yet exist. If a session cannot be established then the message is discarded.

Sessions are usually established by the Transport Model when no appropriate session is found for an outgoing message, but sessions might be established in advance to support features such as notifications. How sessions are established in advance is beyond the scope of this document.

Sessions are initiated by notification originators when there is no currently established connection that can be used to send the notification. For a client-server security protocol, this might require provisioning authentication credentials on the agent, either statically or dynamically, so the client/agent can successfully authenticate to a notification receiver.

A Transport Model must be able to determine whether a session does or does not exist, and must be able to determine which session has the appropriate security characteristics (transportDomain, transportAddress, securityName, securityModel, and securityLevel) for an outgoing message.

A Transport Model implementation MAY reuse an already established session with the appropriate transportDomain, transportAddress, securityName, securityModel, and securityLevel characteristics for delivery of a message containing a different pduType than originally caused the session to be created. For example, an implementation that has an existing session originally established to receive a request MAY use that session to send an outgoing notification, and

MAY use a session that was originally established to send a notification to send a request. Responses SHOULD be returned using the same session that carried the corresponding request message. Reuse of sessions is not required for conformance.

If a session can be reused for a different pduType, but a receiver is not prepared to accept different pduTypes over the same session, then the message MAY be dropped by the receiver.

3.3.2. Session Maintenance Requirements

A Transport Model can tear down sessions as needed. It might be necessary for some implementations to tear down sessions as the result of resource constraints, for example.

The decision to tear down a session is implementation-dependent. While it is possible for an implementation to automatically tear down each session once an operation has completed, this is not recommended for anticipated performance reasons. How an implementation determines that an operation has completed, including all potential error paths, is implementation-dependent.

The elements of procedure describe when cached information can be discarded, in some circumstances, and the timing of cache cleanup might have security implications, but cache memory management is an implementation issue.

If a Transport Model defines MIB module objects to maintain session state information, then the Transport Model MUST define what SHOULD happen to the objects when a related session is torn down, since this will impact interoperability of the MIB module.

3.3.3. Message security versus session security

A Transport Model session is associated with state information that is maintained for its lifetime. This state information allows for the application of various security services to multiple messages. Cryptographic keys established at the beginning of the session SHOULD be used to provide authentication, integrity checking, and encryption services for data that is communicated during the session. The cryptographic protocols used to establish keys for a Transport Model session SHOULD ensure that fresh new session keys are generated for each session. In addition sequence information might be maintained in the session which can be used to prevent the replay and reordering of messages within a session. If each session uses new keys, then a cross-session replay attack will be unsuccessful; that is, an attacker cannot successfully replay on one session a message he observed from another session. A good security protocol will also

protect against replay attacks _within_ a session; that is, an attacker cannot successfully replay a message observed earlier in the same session.

A Transport Model session will have a single transportDomain, transportAddress, securityModel, securityName and securityLevel associated with it. If an exchange between communicating engines requires a different securityLevel or is on behalf of a different securityName, or uses a different securityModel, then another session would be needed. An immediate consequence of this is that implementations SHOULD be able to maintain some reasonable number of concurrent sessions.

For Transport Models, securityName should be specified during session setup, and associated with the session identifier.

SNMPv3 was designed to support multiple levels of security, selectable on a per-message basis by an SNMP application, because, for example, there is not much value in using encryption for a Commander Generator to poll for potentially non-sensitive performance data on thousands of interfaces every ten minutes; the encryption might add significant overhead to processing of the messages.

Some Transport Models might support only specific authentication and encryption services, such as requiring all messages to be carried using both authentication and encryption, regardless of the security level requested by an SNMP application. A Transport Model may upgrade the requested security level, i.e. noAuthNoPriv and authNoPriv MAY be sent over an authenticated and encrypted session.

4. Scenario Diagrams for the Transport Subsystem

RFC3411 section 4.6 provides scenario diagrams to illustrate how an outgoing message is created, and how an incoming message is processed. Both diagrams are incomplete, however. In section 4.6.1, the diagram doesn't show an ASI for sending an SNMP request to the network or for receiving an SNMP response message from the network. In section 4.6.2, the diagram doesn't show the ASIs to receive an SNMP message from the network, or to send an SNMP message to the network.

4.1. Command Generator or Notification Originator

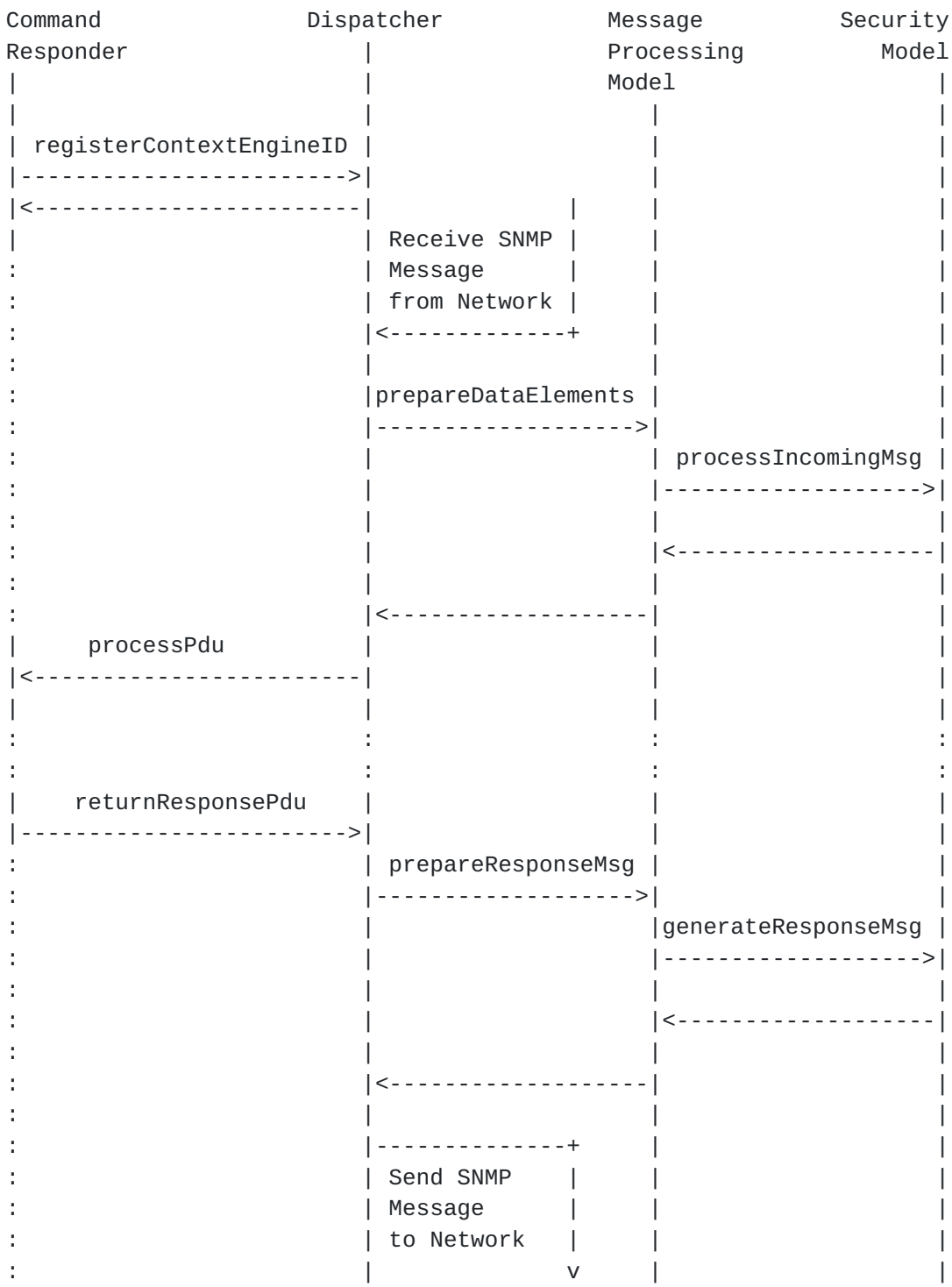
This diagram from RFC3411 4.6.1 shows how a Command Generator or Notification Originator application [RFC3413] requests that a PDU be sent, and how the response is returned (asynchronously) to that application.

This document defines a sendMessage ASI to send SNMP messages to the network, and a receiveMessage ASI to receive SNMP messages from the network.

4.2. Command Responder

This diagram shows how a Command Responder or Notification Receiver application registers for handling a pduType, how a PDU is dispatched to the application after an SNMP message is received, and how the Response is (asynchronously) sent back to the network.

This document defines the sendMessage and receiveMessage ASIs for this purpose.



5. Cached Information and References

The RFC3411 architecture uses caches to store dynamic model-specific information, and uses references in the ASIs to indicate in a model-independent manner which cached information flows between subsystems.

There are two levels of state that might need to be maintained: the security state in a request-response pair, and potentially long-term state relating to transport and security.

This state is maintained in caches. To simplify the elements of procedure, the release of state information is not always explicitly specified. As a general rule, if state information is available when a message being processed gets discarded, the state related to that message should also be discarded, and if state information is available when a relationship between engines is severed, such as the closing of a transport session, the state information for that relationship might also be discarded.

This document differentiates the tmStateReference from the securityStateReference. This document does not specify an implementation strategy, only an abstract description of the data that flows between subsystems. An implementation might use one cache and one reference to serve both functions, but an implementer must be aware of the cache-release issues to prevent the cache from being released before a security or Transport Model has had an opportunity to extract the information it needs.

5.1. securityStateReference

From RFC3411: "For each message received, the Security Model caches the state information such that a Response message can be generated using the same security information, even if the Local Configuration Datastore is altered between the time of the incoming request and the outgoing response." To enable this, an abstract securityStateReference data element, defined in RFC3411 section A.1.5, is passed from the Security Model to the Message Processing Model.

The information saved should include the model-independent parameters (transportDomain, transportAddress, securityName, securityModel, and securityLevel), related security parameters, and other information needed to match the response with the request. The related security parameters may include transport-specific security information.

The Message Processing Model has the responsibility for explicitly releasing the securityStateReference when such data is no longer needed. The securityStateReference cached data may be implicitly released via the generation of a response, or explicitly released by using the stateRelease ASI, as defined in RFC 3411 section 4.5.1."

If the Transport Model connection is closed between the time a Request is received and a Response message is being prepared, then the Response message MAY be discarded.

5.2. tmStateReference

For each message or transport session, information about the message security is stored in a cache, which may include model- and mechanism-specific parameters. The tmStateReference is passed between subsystems to provide a handle for the cache. A Transport Model may store transport-specific parameters in the cache for subsequent usage. Since the contents of a cache are meaningful only within an implementation, and not on-the-wire, the format of the cache is implementation-specific.

The state referenced by tmStateReference might be saved in a Local Configuration Datastore (LCD) to make it available across multiple messages, as compared to securityStateReference which is designed to be saved only for the life of a request-response pair of messages. It is expected that an LCD will allow lookup based on the combination of transportDomain, transportAddress, securityName, securityModel, and securityLevel, and that the cache contain these values to reference entries in the LCD.

6. Abstract Service Interfaces

Abstract service interfaces have been defined by RFC 3411 to describe the conceptual data flows between the various subsystems within an SNMP entity, and to help keep the subsystems independent of each other except for the common parameters.

This document follows the example of RFC3411 regarding the release of state information, and regarding error indications.

1) The release of state information is not always explicitly specified in a transport model. As a general rule, if state information is available when a message gets discarded, the message-state information should also be released, and if state information is available when a session is closed, the session state information should also be released.

2) An error indication in statusInformation may include an OID and value for an incremented counter and a value for securityLevel, and values for contextEngineID and contextName for the counter, and the securityStateReference if the information is available at the point where the error is detected.

6.1. sendMessage ASI

The sendMessage ASI is used to pass a message from the Dispatcher to the appropriate Transport Model for sending.

If present and valid, the tmStateReference refers to a cache containing transport-model-specific parameters for the transport and transport security. How the information in the cache is used is transport-model-dependent and implementation-dependent. How a tmStateReference is determined to be present and valid is implementation-dependent.

This may sound underspecified, but keep in mind that a transport model might be something like SNMP over UDP over IPv6, where no security is provided, so it might have no mechanisms for utilizing a securityName and securityLevel.

```
statusInformation =
sendMessage(
IN   destTransportDomain           -- transport domain to be used
IN   destTransportAddress          -- transport address to be used
IN   outgoingMessage               -- the message to send
IN   outgoingMessageLength         -- its length
IN   tmStateReference              -- reference to transport state
 )
```

6.2. Other Outgoing ASIs

A tmStateReference parameter has been added to the prepareOutgoingMessage, generateRequestMsg, and generateResponseMsg ASIs as an OUT parameter.

```
statusInformation =          -- success or errorIndication
prepareOutgoingMessage(
IN  transportDomain          -- transport domain to be used
IN  transportAddress         -- transport address to be used
IN  messageProcessingModel   -- typically, SNMP version
IN  securityModel            -- Security Model to use
IN  securityName             -- on behalf of this principal
IN  securityLevel            -- Level of Security requested
IN  contextEngineID          -- data from/at this entity
IN  contextName              -- data from/in this context
IN  pduVersion               -- the version of the PDU
IN  PDU                      -- SNMP Protocol Data Unit
IN  expectResponse           -- TRUE or FALSE
IN  sendPduHandle            -- the handle for matching
                                incoming responses
OUT  destTransportDomain     -- destination transport domain
OUT  destTransportAddress    -- destination transport address
OUT  outgoingMessage         -- the message to send
OUT  outgoingMessageLength   -- its length
OUT  tmStateReference        -- (NEW) reference to transport state
            )
```

The tmStateReference parameter of generateRequestMsg or generateResponseMsg is passed in the return parameters of the Security Subsystem to the Message Processing Subsystem. If a cache exists for a session identifiable from transportDomain, transportAddress, securityModel, securityName, and securityLevel, then an appropriate Security Model might create a tmStateReference to the cache and pass that as an OUT parameter.

If one does not exist, the Security Model might create a cache referenced by tmStateReference. This information might include transportDomain, transportAddress, the securityModel, the securityLevel, and the securityName, plus any model or mechanism-specific details. The contents of the cache may be incomplete until the Transport Model has established a session. What information is passed, and how this information is determined, is implementation and security-model-specific.

The prepareOutgoingMessage ASI passes tmStateReference from the Message Processing Subsystem to the dispatcher. How or if the Message Processing Subsystem modifies or utilizes the contents of the cache is message-processing-model-specific.

This may sound underspecified, but keep in mind that a message processing model might have access to all the information from the cache and from the message, and have no need to call a Security Model to do any processing; an application might choose a Security Model such as USM to authenticate and secure the SNMP message, but also utilize a secure transport such as that provided by the SSH Transport Model to send the message to its destination.

6.3. The receiveMessage ASI

If one does not exist, the Transport Model might create a cache referenced by tmStateReference. If present, this information might include transportDomain, transportAddress, securityLevel, and securityName, plus model or mechanism-specific details. How this information is determined is implementation and transport-model-specific.

This may sound underspecified, but keep in mind that a transport model might be something like SNMP over UDP over IPv6, where no security is provided, so it might have no mechanisms for determining a securityName and securityLevel.

The Transport Model does not know the securityModel for an incoming message; this will be determined by the Message Processing Model in a message-processing-model-dependent manner.

The receiveMessage ASI is used to pass a message from the Transport Subsystem to the Dispatcher.

```
statusInformation =
receiveMessage(
IN   transportDomain              -- origin transport domain
IN   transportAddress             -- origin transport address
IN   incomingMessage              -- the message received
IN   incomingMessageLength        -- its length
IN   tmStateReference             -- reference to transport state
 )
```

6.4. Other Incoming ASIs

To support the Transport Subsystem, the tmStateReference is added to the prepareDataElements ASI (from the Dispatcher to the Message Processing Subsystem), and to the processIncomingMsg ASI (from the Message Processing Subsystem to the Security Model Subsystem). How or if a Message Processing Model or Security Model uses tmStateReference is message-processing-model-dependent and security-model-dependent.

```
result =                       -- SUCCESS or errorIndication
prepareDataElements(
IN   transportDomain           -- origin transport domain
IN   transportAddress          -- origin transport address
IN   wholeMsg                  -- as received from the network
IN   wholeMsgLength            -- as received from the network
IN   tmStateReference          -- (NEW) from the Transport Model
OUT  messageProcessingModel    -- typically, SNMP version
OUT  securityModel             -- Security Model to use
OUT  securityName              -- on behalf of this principal
OUT  securityLevel             -- Level of Security requested
OUT  contextEngineID           -- data from/at this entity
OUT  contextName               -- data from/in this context
OUT  pduVersion                -- the version of the PDU
OUT  PDU                       -- SNMP Protocol Data Unit
OUT  pduType                   -- SNMP PDU type
OUT  sendPduHandle             -- handle for matched request
OUT  maxSizeResponseScopedPDU  -- maximum size sender can accept
OUT  statusInformation         -- success or errorIndication
                               -- error counter OID/value if error
OUT  stateReference            -- reference to state information
                               -- to be used for possible Response
)
```

```
   statusInformation =  -- errorIndication or success
                            -- error counter OID/value if error
   processIncomingMsg(
   IN   messageProcessingModel    -- typically, SNMP version
   IN   maxMessageSize            -- of the sending SNMP entity
   IN   securityParameters        -- for the received message
   IN   securityModel             -- for the received message
   IN   securityLevel             -- Level of Security
   IN   wholeMsg                  -- as received on the wire
   IN   wholeMsgLength            -- length as received on the wire
   IN   tmStateReference          -- (NEW) from the Transport Model
   OUT  securityEngineID          -- authoritative SNMP entity
   OUT  securityName              -- identification of the principal
   OUT  scopedPDU,                -- message (plaintext) payload
   OUT  maxSizeResponseScopedPDU  -- maximum size sender can handle
   OUT  securityStateReference    -- reference to security state
    )                          -- information, needed for response
```

The tmStateReference parameter of prepareDataElements is passed from the dispatcher to the Message Processing Subsystem. How or if the Message Processing Subsystem modifies or utilizes the contents of the cache is message-processing-model-specific.

The processIncomingMessage ASI passes tmStateReference from the Message Processing Subsystem to the Security Subsystem.

If tmStateReference is present and valid, an appropriate Security Model might utilize the information in the cache. How or if the Security Subsystem utilizes the information in the cache is security-model-specific.

This may sound underspecified, but keep in mind that a message processing model might have access to all the information from the cache and from the message, and have no need to call a Security Model to do any processing. The Message Processing Model might determine that the USM Security Model is specified in an SNMPv3 message header; the USM Security Model has no need of values in the tmStateReference cache to authenticate and secure the SNMP message, but an application might have chosen to use a secure transport such as that provided by the SSH Transport Model to send the message to its destination.

7. Security Considerations

This document defines an architectural approach that permits SNMP to utilize transport layer security services. Each proposed Transport Model should discuss the security considerations of the Transport Model.

It is considered desirable by some industry segments that SNMP Transport Models should utilize transport layer security that addresses perfect forward secrecy at least for encryption keys. Perfect forward secrecy guarantees that compromise of long term secret keys does not result in disclosure of past session keys. Each proposed Transport Model should include a discussion in its security considerations of whether perfect forward security is appropriate for the Transport Model.

Since the cache and LCD will contain security-related parameters, implementers should store this information (in memory or in persistent storage) in a manner to protect it from unauthorized disclosure and/or modification.

Care must be taken to ensure that a SNMP engine is sending packets out over a transport using credentials that are legal for that engine to use on behalf of that user. Otherwise an engine that has multiple transports open might be "tricked" into sending a message through the wrong transport.

8. IANA Considerations

This document requires no action by IANA.

9. Acknowledgments

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The authors of submitted Security Model proposals: Chris Elliot, Wes Hardaker, David Harrington, Keith McCloghrie, Kaushik Narayan, David Perkins, Joseph Salowey, and Juergen Schoenwaelder.

The members of the Protocol Evaluation Team: Uri Blumenthal, Lakshminath Dondeti, Randy Presuhn, and Eric Rescorla.

WG members who committed to and performed detailed reviews: Jeffrey Hutzelman

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Appendix A. Parameter Table

Following is a Comma-separated-values (CSV) formatted matrix useful for tracking data flows into and out of the dispatcher, Transport, Message Processing, and Security Subsystems. This will be of most use to designers of models, to understand what information is available at which points in the processing, following the RFC3411 architecture (and this subsystem). Import this into your favorite spreadsheet or other CSV compatible application. You will need to remove lines feeds from the second, third, and fourth lines, which needed to be wrapped to fit into RFC line lengths.

A.1. ParameterList.csv

,Dispatcher,,,,Messaging,,,Security,,,Transport,

,sendPDU,returnResponse,processPDU,processResponse,

prepareOutgoingMessage,prepareResponseMessage,prepareDataElements,

generateRequest,processIncoming,generateResponse,

sendMessage,receiveMessage

transportDomain,In,,,,In,,In,,,,,In

transportAddress,In,,,,In,,In,,,,,In

destTransportDomain,,,,,Out,Out,,,,,In,

destTransportAddress,,,,,Out,Out,,,,,In,

messageProcessingModel,In,In,In,In,In,In,Out,In,In,In,,

securityModel,In,In,In,In,In,In,Out,In,In,In,,

securityName,In,In,In,In,In,In,Out,In,Out,In,,

securityLevel,In,In,In,In,In,In,Out,In,In,In,,

contextEngineID,In,In,In,In,In,In,Out,,,,,

contextName,In,In,In,In,In,In,Out,,,,,

expectResponse,In,,,,In,,,,,,,

PDU,In,In,In,In,In,In,Out,,,,,

pduVersion,In,In,In,In,In,In,Out,,,,,

statusInfo,Out,In,,In,,In,Out,Out,Out,Out,,

errorIndication,Out,Out,,,,,Out,,,,,

sendPduHandle,Out,,,In,In,,Out,,,,,

maxSizeResponsePDU,,In,In,,,In,Out,,Out,,,

stateReference,,In,In,,,In,Out,,,,,

wholeMessage,,,,,Out,Out,In,Out,In,Out,In,In

messageLength,,,,,Out,Out,In,Out,In,Out,In,In

maxMessageSize,,,,,,,,In,In,In,,

globalData,,,,,,,,In,,In,,

securityEngineID,,,,,,,,In,Out,In,,

scopedPDU,,,,,,,,In,Out,In,,

securityParameters,,,,,,,,Out,In,Out,,

securityStateReference,,,,,,,,,Out,In,,

pduType,,,,,,,Out,,,,,

tmStateReference,,,,,Out,Out,In,,In,,In,In

Appendix B. Why tmStateReference?

This appendix considers why a cache-based approach was selected for passing parameters.

There are four approaches that could be used for passing information between the Transport Model and a Security Model.

1. one could define an ASI to supplement the existing ASIs, or
2. one could add a header to encapsulate the SNMP message,
3. one could utilize fields already defined in the existing SNMPv3 message, or
4. one could pass the information in an implementation-specific cache or via a MIB module.

B.1. Define an Abstract Service Interface

Abstract Service Interfaces (ASIs) are defined by a set of primitives that specify the services provided and the abstract data elements that are to be passed when the services are invoked. Defining additional ASIs to pass the security and transport information from the Transport Subsystem to Security Subsystem has the advantage of being consistent with existing RFC3411/3412 practice, and helps to ensure that any Transport Model proposals pass the necessary data, and do not cause side effects by creating model-specific dependencies between itself and other models or other subsystems other than those that are clearly defined by an ASI.

B.2. Using an Encapsulating Header

A header could encapsulate the SNMP message to pass necessary information from the Transport Model to the dispatcher and then to a

Message Processing Model. The message header would be included in the wholeMessage ASI parameter, and would be removed by a corresponding Message Processing Model. This would imply the (one and only) messaging dispatcher would need to be modified to determine which SNMP message version was involved, and a new Message Processing Model would need to be developed that knew how to extract the header from the message and pass it to the Security Model.

B.3. Modifying Existing Fields in an SNMP Message

[RFC3412] defines the SNMPv3 message, which contains fields to pass security related parameters. The Transport Subsystem could use these fields in an SNMPv3 message, or comparable fields in other message formats to pass information between Transport Models in different SNMP engines, and to pass information between a Transport Model and a corresponding Message Processing Model.

If the fields in an incoming SNMPv3 message are changed by the Transport Model before passing it to the Security Model, then the Transport Model will need to decode the ASN.1 message, modify the fields, and re-encode the message in ASN.1 before passing the message on to the message dispatcher or to the transport layer. This would require an intimate knowledge of the message format and message versions so the Transport Model knew which fields could be modified. This would seriously violate the modularity of the architecture.

B.4. Using a Cache

This document describes a cache, into which the Transport Model puts information about the security applied to an incoming message, and a Security Model can extract that information from the cache. Given that there might be multiple TM-security caches, a tmStateReference is passed as an extra parameter in the ASIs between the Transport Subsystem and the Security Subsystem, so the Security Model knows which cache of information to consult.

This approach does create dependencies between a specific Transport Model and a corresponding specific Security Model. However, the approach of passing a model-independent reference to a model-dependent cache is consistent with the securityStateReference already being passed around in the RFC3411 ASIs.

Appendix C. Open Issues

NOTE to RFC editor: If this section is empty, then please remove this open issues section before publishing this document as an RFC. (If it is not empty, please send it back to the editor to resolve.

- MUST responses go back on the same session?
- How should we describe the case where a management system wants to keep session info available for inspection after a session has closed? see "Abstract Service Interfaces"
- Do Informs work correctly?
- How does a Transport Model know whether a message is a notification or a request/response?
- cache contents - do we define this?

Appendix D. Change Log

NOTE to RFC editor: Please remove this change log before publishing this document as an RFC.

Changes from revision -05- to -06-

mostly editorial changes
removed some paragraphs considered unnecessary
added Updates to header
modified some text to get the security details right
modified text re: ASIs so they are not API-like
cleaned up some diagrams
cleaned up RFC2119 language
added section numbers to citations to RFC3411
removed gun for political correctness

Changes from revision -04- to -05-

removed all objects from the MIB module.
changed document status to "Standard" rather than the xml2rfc default of informational.

changed mention of MD5 to SHA
moved addressing style to TDomain and TAddress
modified the diagrams as requested
removed the "layered stack" diagrams that compared USM and a Transport Model processing
removed discussion of speculative features that might exist in future Transport Models
removed openSession and closeSession ASIs, since those are model-dependent
removed the MIB module
removed the MIB boilerplate intro (this memo defines a SMIv2 MIB ...)
removed IANA considerations related to the now-gone MIB module
removed security considerations related to the MIB module

removed references needed for the MIB module
changed receiveMessage ASI to use origin transport domain/address
updated Parameter CSV appendix

Changes from revision -03- to -04-

changed title from Transport Mapping Security Model Architectural Extension to Transport Subsystem
modified the abstract and introduction
changed TMSM to TMS
changed MPSP to simply Security Model
changed SMSP to simply Security Model
changed TMSP to Transport Model
removed MPSP and TMSP and SMSP from Acronyms section
modified diagrams
removed most references to dispatcher functionality
worked to remove dependencies between transport and security models.
defined snmpTransportModel enumeration similar to snmpSecurityModel, etc.
eliminated all reference to SNMPv3 msgXXXX fields
changed tmSessionReference back to tmStateReference

Changes from revision -02- to -03-

- removed session table from MIB module
- removed sessionID from ASIs
- reorganized to put ASI discussions in EOP section, as was done in SSHSM
- changed user auth to client auth
- changed tmStateReference to tmSessionReference
- modified document to meet consensus positions published by JS
-
  * authoritative is model-specific
  * msgSecurityParameters usage is model-specific
  * msgFlags vs. securityLevel is model/implementation-specific
  * notifications must be able to cause creation of a session
  * security considerations must be model-specific
  * TDomain and TAddress are model-specific
  * MPSP changed to SMSP (Security Model security processing)

Changes from revision -01- to -02-

- wrote text for session establishment requirements section.
- wrote text for session maintenance requirements section.
- removed section on relation to SNMPv2-MIB
- updated MIB module to pass smilint

- Added Structure of the MIB module, and other expected MIB-related sections.
- updated author address
- corrected spelling
- removed msgFlags appendix
- Removed section on implementation considerations.
- started modifying the security boilerplate to address TMS and MIB security issues
- reorganized slightly to better separate requirements from proposed solution. This probably needs additional work.
- removed section with sample protocols and sample tmSessionReference.
- Added section for acronyms
- moved section comparing parameter passing techniques to appendix.
- Removed section on notification requirements.

Changes from revision -00-

- changed SSH references from I-Ds to RFCs
- removed parameters from tmSessionReference for DTLS that revealed lower layer info.
- Added TMS-MIB module
- Added Internet-Standard Management Framework boilerplate
- Added Structure of the MIB Module
- Added MIB security considerations boilerplate (to be completed)
- Added IANA Considerations
- Added ASI Parameter table
- Added discussion of Sessions
- Added Open issues and Change Log
- Rearranged sections

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