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SNMP Optimizations for Constrained Devices
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Abstract

Simple Network Management Protocol (SNMP) is a widely deployed application protocol for network management and in particular network monitoring. This document describe the applicability of SNMP to constrained devices, e.g., nodes in Low-power and Lossy Networks. We discuss SNMP implementation techniques and we provide deployment considerations. Our discussion also covers the applicability of MIB modules to constrained devices.

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1. Introduction

The Simple Network Management Protocol (SNMP) is a datagram-oriented protocol operating in the application layer of the Internet protocol suite. The underlying framework consists of four basic components [RFC3410]:

- several (typically many) managed nodes, each with an SNMP entity which provides remote access to management instrumentation (traditionally called an agent),
- at least one SNMP entity with management applications (typically called a manager),
- a management protocol used to convey management information between the SNMP entities, and
- management information.

The SNMP protocol is used to convey management information between SNMP entities such as managers and agents. SNMP is datagram-oriented and the implementations of SNMP can be very lightweight. The protocol is widely deployed for monitoring and troubleshooting purposes and it may fit constrained devices very well. The following features make SNMP suitable for constrained devices on Low-power and Lossy Networks (LLNs):

- Protocol Maturity: SNMPv3 is a full IETF standard having a high degree of technical maturity with significant experiences in implementation and operation.
- Data Naming: SNMP provides a hierarchical namespace utilizing object identifiers (OIDs) for data naming purposes. The data accessible via SNMP is described by Management Information Bases (MIB modules). These MIB modules can either be standardized or specific to certain enterprises.
- Network Management: SNMP is widely used for network management and it is the Internet community's de facto network management and monitoring protocol. As a consequence, it makes sense to utilize SNMP also for the management and in particular monitoring of resource constrained networks. Network management is also stated as one of the goals in [RFC4919].
- Data Retrieval: SNMP employs a trap-directed polling scheme in which data is being requested by a manager from the agents. In addition, SNMP supports a push model in which data is sent from agents to the managers without a prior request. Trap-directed

polling refers to a mode where polling is used with relatively long polling intervals but agents can send notifications in order to notify a manager of events that might require changes to the polling strategy.

- Security: SNMPv3 can provide both message-level and transport-level security. SNMPv3 defines User based Security model (USM) [RFC3414] for message-driven security; and transport-based security model (TSM) [RFC5591] for transport-driven security. TSM makes it possible to use existing security protocols such as Transport Layer Security (TLS) [RFC5246] and the Datagram Transport Layer Security (DTLS) Protocol [RFC4347] with SNMPv3. The modular design of SNMPv3 also allows new security and access control protocols to be added to it.

- Access control: SNMP provides standard mechanisms to control access to information [RFC3415].

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].

2. SNMP Features and Overhead Considerations

This section first explains some less widely known SNMP concepts before discussing message sizes.

2.1. SNMP Contexts

Each SNMP entity is composed of a single SNMP engine, which is identified by an SNMP engine identifier. A context is a collection of management information accessible by an SNMP entity. An SNMP entity has access to one or more contexts where each context is uniquely identified by its context name. In order to identify an individual item of management information within a management domain, the SNMP entity's context is identified first (using the contextEngineID and contextName) and this is followed by the object type and instance. For further details, see [RFC3411].

2.2. SNMP Proxies

The term 'proxy' in SNMP has a restrictive meaning. A proxy refers to a proxy forwarder application which forwards SNMP messages to other SNMP engines and forwards the response to such previously forwarded messages back to SNMP engine from which the original message was received [RFC3413]. The forwarding decision is based on contexts and it is taken irrespectively of the management objects being accessed. Thus, an SNMP proxy can be used to forward messages from one transport to another, or to translate SNMP messages from one version to another version.

The SNMP proxy cannot be used for translation of SNMP requests into operations of a non-SNMP management protocol and it cannot be used for supporting aggregated objects. Proxies depend on context information and the forwarding of messages is independent of the objects being accessed. To support aggregated objects, where the value of one object depends upon multiple other remote items, special MIB modules and sub-agent protocols are used instead of proxies.

2.3. SNMP Subagents

In order to support modular systems, SNMP agents often do not implement all MIB objects internally. Instead, the SNMP agent is delegating the access to the instrumentation to other processes, called subagents. A special purpose protocol is used between the SNMP agent and its subagents. The Agent Extensibility Protocol (AgentX) is a standard subagent access protocol [RFC2741]

2.4. Maximum Message Sizes

An SNMPv3 message contains the msgMaxSize field, which is used to communicate the maximum message size a sender is able to receive. The response to a request should not exceed the maximum message size of the requesting SNMP entity. The minimum required maximum message size to implement is transport model specific. For SNMP over UDP, the size is 484 octets.

2.5. SNMP Message Formats

SNMPv1 [RFC1157] is the first version of SNMP and it reached the IETF full standard status in 1990. The protocol operation consisted of Get and Get-Next, for data retrieval, Trap for event notification, the Set for configuration. SNMPv1 security uses clear-text community string authentication, which is easy to break. Access control is provided with SNMP MIB views. SNMPv2c is an improvement over SNMPv1 which introduced new data retrieval and event notificaiton operations, i.e., Get-Bulk and Inform. It also introduced improved error handling for Set operations. SNMPv2c could only reach Experimental status.

SNMPv3, STD 62, [RFC3411] [RFC3412] [RFC3413] [RFC3414] [RFC3415] [RFC3416] [RFC3417] [RFC3418], supports all the aforementioned data retrieval and configuration options of SNMPv1 and SNMPv2c. The SNMPv3 framework is modular in order to enhance extensibility. Moreover, SNMPv3 supports authentication and data integrity and an additional privacy option for confidentiality. After SNMPv3 became a full standard, SNMPv1 and SNMPv2c were declared Historic due to their weak security features. However, SNMPv3 can coexist with the earlier versions of SNMP [RFC3584].

2.6. SNMPv3 Security Overhead

SNMP security can be supported by two different approaches, i.e., message-driven security and transport-driven security. With message-driven security, SNMP provides its own security where the security parameters are passed within each SNMP message. On the other hand, transport-driven security enables operators to leverage existing secure transport protocols. Security is provided at the transport layer, usually establishling a security session.

The User-based Security Model [RFC3414] is a shared secret scheme, which provides message-driven security. Although it utilizes existing mechanisms, it is designed to not depend on other security infrastructures. As a consequence, it provides its own security processing and has its own key management infrastructure. The operator configures secrets (authentication and encryption keys) in

the SNMP engines. Messages can be authenticated, or authenticated and encrypted.

The Transport Security Model (TSM) [RFC5591] enables operators to leverage existing security infrastructures. TSM allows security to be provided by an external secure transport protocol and as such enables the use of existing security mechanisms, such as Transport Layer Security (TLS) [RFC5246], Datagram Transport Layer Security (DTLS) Protocol [RFC4347], and the Secure Shell (SSH) Protocol [RFC4251].

In transport-driven protocols, DTLS, which is UDP based, can be considered for constrained networks since it does not require TCP. [RFC5953] details how DTLS can be used with SNMPv3/TSM. The DTLS transport protocol involves an initial handshake to establish a session. Upon successful session establishment, the security related session parameters are cached in the client and the server for the duration of the session instead of being sent in all messages.

The minimum message size for SNMPv3 with USM (SNMPv3/USM) is 67 octets whereas the minimum message size for SNMPv3 with TSM (SNMPv3/TSM) utilizing DTLS is 46 octets (59 octets if the DTLS header is included). The minimum message size for the historic SNMPv1 message format is 20 byte. The details of the calculation can be found in Appendix A. TSM may involve additional session establishment costs consisting of the initial handshake and the caching of transport parameters. The tradeoff between the message size and session overhead should be kept in mind while designing applications.

3. SNMP Agent Implementation Considerations

This section covers SNMP agent implementation considerations for constrained devices.

3.1. Access Control

The Local Configuration Datastore (LCD), which contains access rights and policies of an SNMP entity, need not be configured remotely. It is recommended to have permanent access control tables on the nodes. The implementers should keep the authorization tables as compact as possible to reduce the memory and code size overhead. Compact permanent authorization tables on the nodes can, for example, provide read-only and read-write access to the management instrumentation on the node at almost zero processing cost since the SNMP agents may not support instance level access control granularity to further reduce performance cost.

A minimal View-based Access Control Model (VACM) implementation only provides a static view granting access to all MIB objects. The access rights are statically configured to either grant full read access or full read and write access. There is only support for the default context. Such a simplified implementation processes the isAccessAllowed() ASI [RFC3415] as follows:

1) If the viewType is "write", the securityName is "w" (for any securityModel and any securityLevel), and the contextName is "", then grant access to the requested variable.

2) Otherwise, if the viewType is either "read" or "notifiy", the securityName is "r" (for any securityModel and any securityLevel), and the contextName is "", then grant access to the requested variable.

3) Otherwise, return an errorIndication (noAccessEntry) to the calling module.

An implementation should provide the following MIB objects (note that all values are permanent):

```
   vacmContextName."" = ""

   vacmGroupName.0."r" = "r"
   vacmGroupName.0."w" = "w"
   vacmSecurityToGroupStorageType.0."r" = 5 (readOnly)
   vacmSecurityToGroupStorageType.0."w" = 5 (readOnly)
   vacmSecurityToGroupStatus.0."r" = 1 (active)
   vacmSecurityToGroupStatus.0."w" = 1 (active)

   vacmAccessContextMatch."r"."".0.1 = 1 (exact)
   vacmAccessContextMatch."w"."".0.1 = 1 (exact)
   vacmAccessReadViewName."r"."".0.1 = "a"
   vacmAccessReadViewName."w"."".0.1 = "a"
   vacmAccessWriteViewName."r"."".0.1 = "a"
   vacmAccessWriteViewName."w"."".0.1 = "a"
   vacmAccessNotifyViewName."r"."".0.1 = "a"
   vacmAccessNotifyViewName."w"."".0.1 = "a"
   vacmAccessStorageType."r"."".0.1 = 5 (readOnly)
   vacmAccessStorageType."w"."".0.1 = 5 (readOnly)
   vacmAccessStatus."r"."".0.1 = 1 (active)
   vacmAccessStatus."w"."".0.1 = 1 (active)

   vacmViewTreeFamilyMask."a".2.1.3 = ""
   vacmViewTreeFamilyType."a".2.1.3 = 1 (included)
   vacmViewTreeFamilyStorageType."a".2.1.3 = 5 (readOnly)
   vacmViewTreeFamilyStatus."a".2.1.3 = 1 (active)
```

4. SNMP Manager Implementation Considerations

This section covers SNMP manager implementation considerations for 6LoWPAN.

4.1. Polling, Pushing, and Trap-directed Polling

In Sensor networks, polling can be reactive or proactive. Data gathering or event reporting sensors may 'push' their information towards the managers or they may wait for a manager to 'pull' the information through a request.

When the demand for data is relatively high, push mechanisms are deployed in order to save energy cost where the data flows from managed entities towards the managers. SNMP notifications are a realization the push based model in which data is sent to the manager without a prior request. Data can be reported periodically from the SNMP agent to the manager through SNMP notifications and the notifications can take the advantage of SNMP security and access control features to ensure the access to legitimate users along with confidentiality and integrity of the data. The SNMP Inform PDU requires a response back from the receiving manager and it can be used in applications in which reliability is important.

The use of notifications is recommended for data flows from sensors to the manager and also for the scenarios where multiple nodes generate the same information.

4.2. Support for SNMP Proxies

The SNMP proxy forwarder application resides on an intermediate SNMP entity (e.g. an SNMP entity on a management server or an edge router in case of 6LoWPAN). The proxy forwarder registers each context to which it wishes to forward messages. After the remote context is registered, the managers send messages to the proxy forwarder's engine with the context information of the remote host. The proxy forwarder forwards the message to the remote context. Upon reception of a response from the remote host, it forwards the response back to the manager.

In 6LoWPAN networks proxies may be used to change message encoding, or they may be used to translate between SNMP versions, or they may be used to change the security domain at the 6LoWPAN side of the network.

5. SNMP Deployment Considerations

Following are a list of considerations for deployment of SNMP in 6LoWPANs.

5.1. Naming Issues

In order to reduce the message overhead, the managers are advised to use short values for Engine Identifiers. The minimum length for an Engine Identifier is 5 octets. The managers may generate and assign the Engine identifiers using the 16-bit short address or the 64-bit IEEE EUI-64 addresses of a node. Context name is an administratively assigned octet string that names a context. In order to reduce the message size overhead the length of the string should be kept short. The default context is identified by a a zero-length context name.

5.2. SNMP Protocol Operations

SNMP supports four basic data retrieval operations i.e. GetRequest-PDU, GetNextRequest-PDU, GetBulkRequest-PDU [RFC3416]. The GetRequest-PDU is useful for retrieving well known scalar data, whereas the GetNextRequest-PDU and GetBulkRequest-PDU operations are particularly advantageous for retrieving dynamically changing tabular data. The SNMPv2-Trap-PDU and InformRequest-PDU can be used for push-based data retrieval, in which periodic or event-based notifications are sent to the managers.

During the processing of a GetBulkRequest-PDU operation, the agent can decide the number of objects to include in response. For requesting objects the manager has to consider the underlying packet size constraints. Also, the number of objects in the variable-binding in request messages and max-repeaters field of GetBulk operation should be selected keeping the constraint in mind.

5.3. Timeouts and Retransmissions

In 6LoWPANs, the SNMP message may be fragmented or may encounter more latency because of underlying wireless link. The value of timeouts should be adjusted on the manager side by considering the link characteristics so that SNMP does not timeout between queries. In some cases the number of retries may also be adjusted to cater for link characteristics.

5.4. Polling Intervals

Similarly, in order to reduce the amount of polling, the polling interval should be increased for less time critical data. 6LoWPANs are energy constrained networks and excessive polling is not

recommended.

5.5. Caching Issues

Caching the important information can save the transmission cost e.g. caching the snmpEngineID would save the traffic overhead of EngineID discovery mechanisms. It is recommended that the EngineID should be cached in order to reduce the transmission cost. In case of TSM, caching the transport parameters can reduce the message sizes.

6. Applicable MIB Modules

This section describes some MIB modules relevant for constrained devices and it provides guidelines for authors of MIB modules that can be used efficiently in constrained networks.

6.1. Applicable Standardized MIB Modules

Below is a list of MIB modules that may be applicable to a constrained device:

- The SNMPv2-MIB [RFC3418] MUST be implemented as it provides basic information about the SNMP agent and crucial objects that allow to detect continuities.

- The IF-MIB [RFC2863] SHOULD be implemented in order to provide basic statistics about the network interfaces of the constrained device. [TODO: Define what is really essential from the IF-MIB.]

- Devices supporting IPv4 or IPv6 SHOULD implement the IP-MIB [RFC4293]. [TODO: Define what is really essential from the IP-MIB.]

- Devices supporting UDP SHOULD implement the UDP-MIB [RFC2013]. [TODO: Define what is really essential from the UDP-MIB.]

- Devices supporting IPv6 over 802.15.4 (6LoWPAN) SHOULD implement the LOWPAN-MIB. [TODO: There is no LOWPAN-MIB yet.]

- Devices supporting the RPL routing protocol SHOULD implement the RPL-MIB. [TODO: There is no RPL-MIB yet.]

- Devices supporting sensors MAY implement the ENTITY-SENSOR-MIB [RFC3433], which defines objects for reading physical sensors (e.g., the current value of the sensor, the operational status of a sensor, or the data units precision associated with a sensor). The ENTITY-SENSOR-MIB depends on the ENTITY-MIB [RFC4133]. [TODO: Define what is really essential from the ENTITY-MIB.]

6.2. MIB Design Guidelines for Low Overhead

When defining MIB modules, the MIB designers should avoid using long OIDs by avoiding unnecessary data hierarchies. Moreover, complex indexing schemes should be avoided in order to keep the overhead resulting from instance identifiers as small as possible.

7. Conclusion

SNMP can be very useful protocol for constrained devices with significant implementation and operational experiences. The SNMP standards allow for memory and CPU efficient implementations. The utilization of secure transports such as DTLS can reduce the overhead of message-based security mechanisms.

8. IANA Consideration

TBD

9. Security Considerations

TBD

10. References

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Appendix A. Calculation of Minimum Message Sizes

A simple way to estimate the size (in octets) of an SNMP variable binding is the following formula (where |OID| denotes the number of subidentifier of an OID):

sizeof(VarBind) = (2 + |OID|) + (2 + 2)

The assumption here is that every OID subidentifier encodes into a single octet. An additional octet is needed for the OID tag and the OID length. Since most values are 32-bit numbers, we calculate one octet for the value tag, one octet for the value length, and 2 octets on average for the value itself. While the BER encoding of 32-bit unsigned numbers may require 5 octets, in general small numbers tend to dominate due to their usage in enumerations or many error counters staying close to zero. For sysUpTime.0 (1.3.6.1.2.1.1.3.0), we calculate 15 octets as the typical varbind encoding size of sysUpTime.0.

For the PDU sequence [RFC3416], we calculate the following:

PDU	2 octets
request-id	3 octets
error-status	3 octets
error-index	3 octets
variable-bindings	2 octets
	---
	13 octets

A PDU carrying a sysUpTime.0 varbind thus requires about 13+15 = 28 octets.

For the ScopedPDU sequence used by SNMPv3 [RFC3412], we calculate the following:

ScopedPDU	2 octets
contextEngineID	7 octets
contextName	2 octets
PDU	13 octets
	---
	24 octets

A scoped PDU carrying a sysUpTime.0 varbind thus requires about 24+15 = 39 octets.

For the HeaderData sequence used by SNMPv3 [RFC3412], we calculate the following:

```
  HeaderData                    2 octets
    msgID                       3 octets
    msgMaxSize                  4 octets
    msgFlags                    3 octets
    msgSecurityModel            3 octets
                               ---------
                              15 octets
```

A.1. SNMPv3/USM Minimum Message Size

The minimum size of an SNMPv3/USM message can be calculated as follows:

```
  SNMPv3Message (USM)           2 octets
    msgVersion                  3 octets
    msgGlobalData (HeaderData) 15 octets
    msgSecurityParameters      24 octets  (UsmSecurityParameters)
    msgData (ScopedPDU)        24 octets
                               ---------
                               67 octets

  UsmSecurityParameters         2 octets
    msgAuthoritativeEngineID    7 octets
    msgAuthoritativeEngineBoots 3 octets
    msgAuthoritativeEngineTime  3 octets
    msgUserName                 3 octets
    msgAuthenticationParameters 2 octets
    msgPrivacyParameters        2 octets
                               ---------
                               22 octets
```

A complete SNMPv3/USM message to retrieve sysUpTime.0 therefore requires 67+15 = 82 octets.

A.2. SNMPv3/TSM Minimum Message Size

The minimum size of an SNMPv3/TSM message can be calculated as follows:

```
  SNMPv3Message (TSM)             2 octets
    msgVersion                    3 octets
    msgGlobalData (HeaderData)   15 octets
    msgSecurityParameters         2 octets  (TsmSecurityParameters)
    msgData (ScopedPDU)          24 octets
                                 ---------
                                 46 octets

  TsmSecurityParameters           2 octets
                                 ---------
                                  2 octets
```

A complete SNMPv3/TSM message to retrieve sysUpTime.0 therefore requires 46+15 = 61 octets. If the secure transport used by SNMPv3/TSM is DTLS, then the encoded message is wrapped in a DTLS record, which adds the following number of octets:

```
    type                          1 octets
    version                       2 octets
    epoch                         2 octets
    sequence_number               6 octets
    length                        2 octets
                                 ---------
                                 13 octets
```

The size of the resulting DTLS record is 61 + 13 = 74 octets.

A.3. SNMPv1/SNMPv2c Minimum Message Size

The minimum size of an SNMPv3/TSM message can be calculated as follows (assuming a one character community string):

```
  SNMPv1Message                   2 octets
    version                       3 octets
    community                     3 octets
    data (PDU)                   13 octets
                                 ---------
                                 21 octets
```

A complete SNMPv3/TSM message to retrieve sysUpTime.0 therefore requires 21+15 = 36 octets. Note, however, that SNMPv1/SNMPv2c does not provide security nor does it provide direct support for proxying.

Appendix B. Implementation and Deployment Models

There are four fundamentally different implementation / deployment models for SNMPv3 in constrained networks.

B.1. SNMP End-to-End Model

The SNMP manager talks SNMPv3 end-to-end to the 6LoWPAN nodes. In this model, existing management tools can be reused and only a few adaptations may be needed by specifying suitable deployment parameters through an applicability statement.

The characteristics of this solution can be summarized as follows:

+ Straightforward access to individual 6LoWPAN nodes

+ Reuse of existing deployed SNMP-based tools

o End-to-end security and end-to-end key management

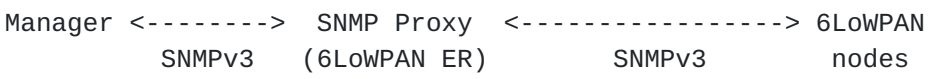
- Message size and potential fragmentation issues

- 6LoWPAN nodes must run an SNMP engine

- Trap-directed polling nature of SNMP has high energy costs

B.2. SNMP Proxy Model

The SNMP manager talks SNMPv3 to an SNMP proxy residing on a 6LoWPAN edge router (ER). Existing management tools (as long as they are proxy aware, which is not generally true) can be reused.



The characteristics of this solution can be summarized as follows:

+ Alternate transport encoding can reduce message sizes

o Indirect access to individual 6LoWPAN nodes

o Reuse of existing SNMP-based tools supporting proxies

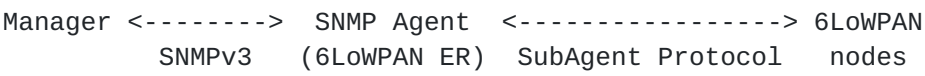
o Two security domains, different key management schemes

- 6LoWPAN nodes must run an SNMP engine

- Trap-directed polling nature of SNMP has high energy costs

B.3. SNMP Subagent Model

The SNMP manager talks SNMPv3 to an extensible SNMP agent residing on the 6LoWPAN edge router. This agent uses a subagent protocol (e.g., AgentX [RFC2741]). The current standard subagent protocol is not necessarily suitable for 6LoWPAN networks since it assumes a reliable stream-oriented transport and an adaptation of a subagent protocol may be required.



The characteristics of this solution can be summarized as follows:

+ Alternate transport encoding can reduce message sizes

o Indirect access to individual 6LoWPAN nodes

o Reuse of existing SNMP-based tools supporting proxies

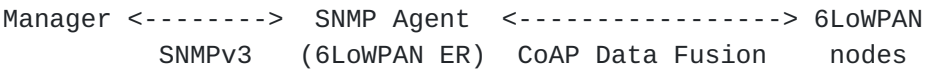
o Two security domains, different key management schemes

+ 6LoWPAN nodes must run an SNMP subagent

- Trap-directed polling nature of SNMP has high energy costs

B.4. SNMP Data-Fusion Model

The SNMP manager talks SNMPv3 to an SNMP agent residing on the 6LoWPAN edge router. This agent uses a different protocol (e.g., a protocol such as CoAP) to retrieve information from the 6LoWPAN network. In the ideal case, the protocol supports caching and in network data aggregation.



The characteristics of this solution can be summarized as follows:

+ Indirect access to individual 6LoWPAN nodes

+ Leveraging a cache-aware data fusion protocol

+ SNMP agent acting as a cache, no expensive polling

o Reuse of existing SNMP-based tools supporting contexts

o Two security domains, different key management schemes

Appendix C. Example: Contiki SNMP

Contiki-SNMP is an SNMP implementation for the Contiki operating system, designed to run on Atmel Raven boards (8-bit microcontroller running at 20 MHz with 16K of RAM and 128K of Flash). Contiki-SNMP supports SNMP messages up to 484 octets length. The currently supported message types are Get, GetNext, and Set. The currently supported message versions are SNMPv1 and SNMPv3/USM. The implementation provides an API to define and configure managed objects (MIB variables). The USM implementation supports HMAC-MD5-96 and CFB128-AES-128.

If both SNMPv1 and SNMPv3 are enabled, the code uses 31220 octets of ROM (around 24% of the available ROM) plus 235 octets of statically allocated RAM. With only SNMPv1 enabled, the code uses 8860 octets of ROM (around 7% of the available ROM) plus 43 bytes of statically allocated RAM. Leveraging the AES hardware support of the 802.15.4 transceiver will significantly reduce the footprint of the SNMPv3 option.

The heap usage is not more than 910 octets for processing an SNMPv1 message. About 16 octets are used for each managed object implemented. If a managed object is of a string-based type, additional heap storage space is used to store the value.

The maximum observed stack usage is show in Table 1.

Version	Security level	Max. stack size
SNMPv1	-	688 octets
SNMPv3	noAuthNoPriv	708 octets
SNMPv3	authNoPriv	1140 octets
SNMPv3	authPriv	1144 octets

Table 1: Maximum observed stack usage

For SNMPv3/USM noAuthNoPriv messages and SNMPv1 messages, the round-trip latency is dominated by the data transfer tim of the 802.15.4 radio. For SNMPv3/USM authPriv messages, the processing time is almost the same as the data transmission delay. The authNoPriv security level is slightly faster.

Appendix D. Change Log

D.1. Changes from -02 to -03

Broadened the scope of the document to discuss SNMP on constrained devices, not limited to 6LoWPAN networks.

1. Added a data fusion protocol scenario.

2. Reorganization of the text.

3. Reorganization of Section 2.4.

4. Addition of Appendix C.

5. Added details about minimal VACM implementation.

6. Started a discussion of relevant MIB modules.

D.2. Changes from -01 to -02

The draft now covers applicability of SNMPv3 for 6LoWPANs. The focus of the draft is shifted towards supporting SNMPv3 'as is' in 6LoWPANs.

1. Added SNMP Agent Implementation Considerations for 6LoWPANs.

2. Added SNMP Manager Implementation Considerations for 6LoWPANs.

3. Added the Deployment Considerations for 6LoWPANs.

4. Added the Applicable MIB modules for 6LoWPANs.

5. Moved SNMP Deployment Models to Appendix.

6. Removed the section on Packet Compression.

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