Performance Analysis of SNMP over SSH

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IFIP/IEEE DSOM 2006

Outline of the Talk

Background: IETF ISMS Working Group

- SNMPv3/USM was designed to have its own user and key management infrastructure
- Operators reported that deploying another user and key management infrastructure introduces significant costs and is a reason for not deploying SNMPv3
- The ISMS working group of the IETF was chartered in September 2004 to address this issue
- After discussing various proposals, the working group was re-chartered in September 2005 to focus on SNMP over SSH and RADIUS integration

Motivation and Research Goals

- SNMPv3/USMS uses message-based security:
  - every message contains all needed security information
  - keys are not bound to a lifetime of a session
- SNMPv3/SSH uses session-based security:
  - session establishment phase (session key negotiation)
  - no per message security information needed
  - SSH requires usage of the TCP
- Research goals:
  - understand the performance tradeoffs
  - provide "running code" experience to the working group
  - explore possible alternatives (e.g., TLS or DTLS)

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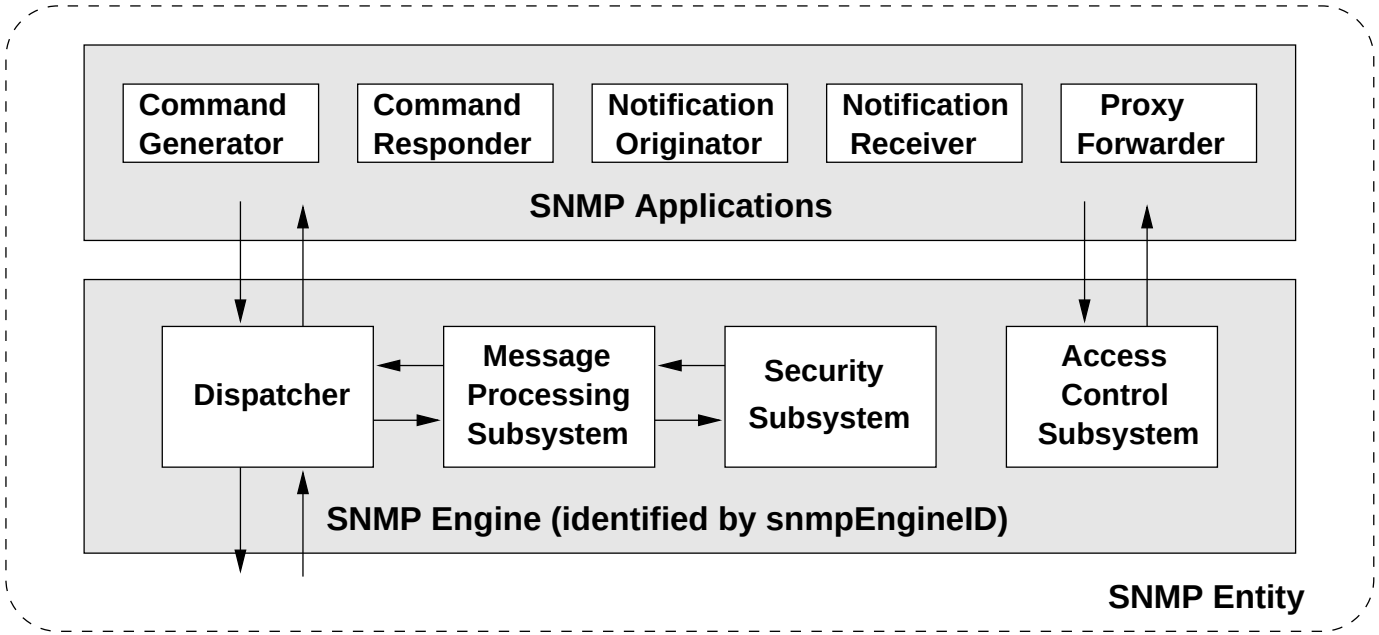
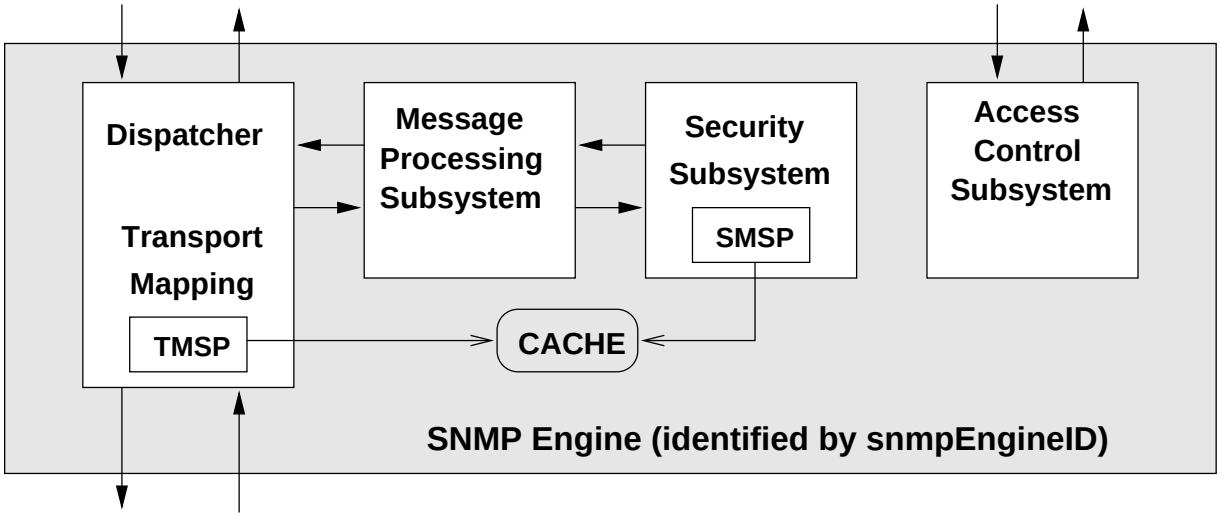
SNMP Architecture [1]



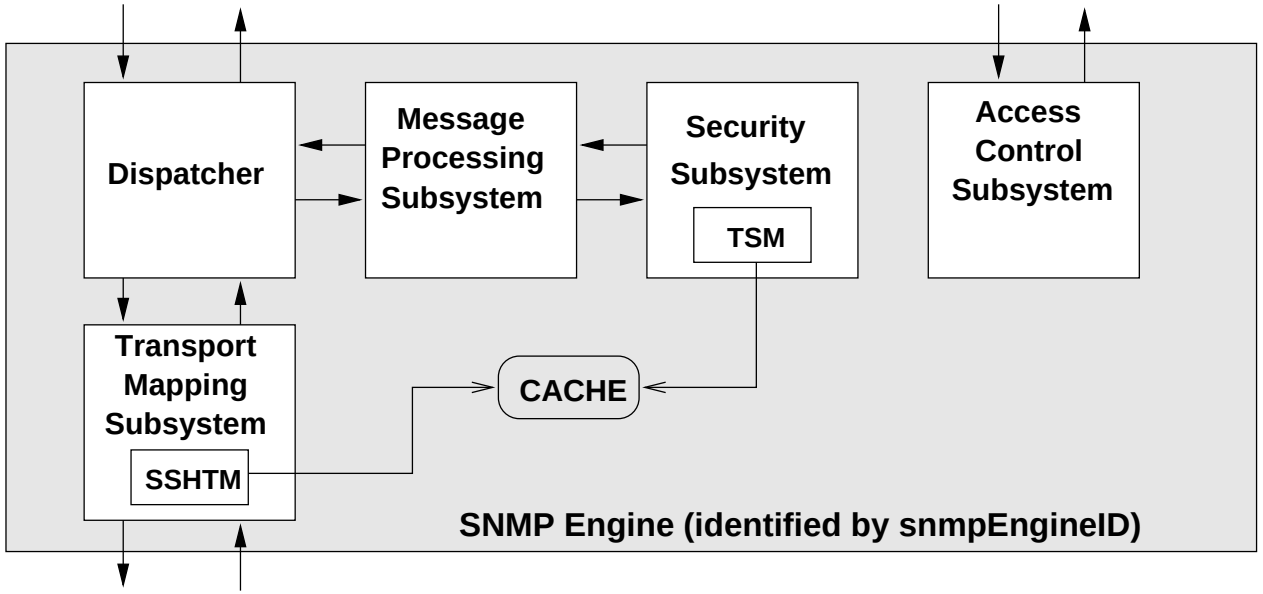
- Suitable for message-based transports (USM) - all security information is carried in every message
- Support for session-based transports (SSH, TLS, etc.) requires the addition of a transport mapping security model

Extension of the SNMP Architecture (paper)



- Transport Mapping Security Processor (TMSP) performs the actual security processing
- Security Model Security Processing (SMSP) realizes the security model required by SNMPv3
- Our focus is on the secure transport mapping

Extension of the SNMP Architecture (today)



- A separate Transport Mapping Subsystem was defined which can implement different transport models (UDPTM, TCPTM, SSHTM, TLSTM, ...) [2]
- A generic Transport Security Model (TSM) [3] hooks into a secure transport such as SSHTM [4]

Prototype Implementation

- NET-SNMP - open source C implementation of SNMP
- LibSSH - open source C library for SSH
- openssl - open source C library for TLS
- A new transport domain (SSHDomain) was defined and the transport independent functions were implemented
- An interface to the Pluggable Authentication Modules for Linux (PAM) [5] enables a system administrator to choose how credentials of a user are verified
- Implementation passes the authenticated SSH user identitiy as a security model neutral security name to the Access Control Subsystem
- Prototype consists of 1200 lines of C code (for the SSH portion)

Optimizing the Prototype

- Initial results were extremely frustrating.
- Careful analysis revealed two optimizations:
- TCP's Nagle algorithm was disabled immediately after the TCP connection establishment - improved the performance of a single `snmpget` operation from 800*ms* to 16*ms*
- SSH Window Adjustments - the `libssh` library was tuned to send window adjustment messages only when necessary - decreased the overhead and the latency for long sessions

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Experimental Setup

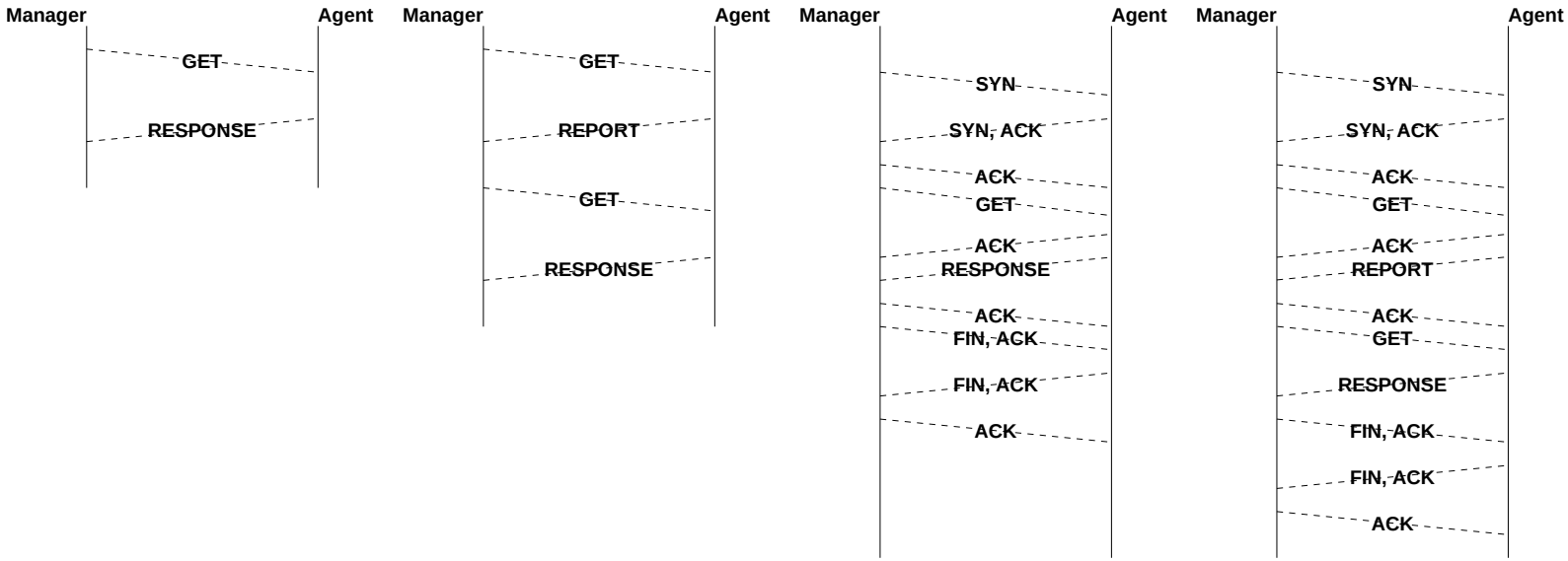
- `meat`: 2 x Intel Xeon 3GHz CPU, 2GB RAM, connected to the switched lab network via 1Gbps interface, running Debian Linux 2.6.15.1
- `veggie`: 2 x Intel Xeon 3GHz CPU, 1GB RAM, connected to the switched lab network via 1Gbps interface, running Debian Linux 2.6.12.6 XEN
- `turtle`: Ultra Sparc IIi, 128 MB RAM, connected to the switched lab network via 10Mbps interface, running Debian Linux 2.6.13
- `gettimeofday()` system call, `pmap` utility, `tc` utility, `tcpdump` utility

SNMP/SSH Session Establishment Overhead

Protocol	Time (`meat`)	Time (`turtle`)	Data	Packets
v2c/UDP	1.03 ms	0.70 ms	232 bytes	2
v2c/TCP	1.13 ms	1.00 ms	824 bytes	10
v3/USM/UDP	1.97 ms	2.28 ms	668 bytes	4
v3/USM/TCP	2.03 ms	3.03 ms	1312 bytes	12
v2c/SSH	**16.17 ms**	**91.62 ms**	**4388 bytes**	**32**
v2c/TLS	**18.00 ms**		**4109 bytes**	**16**

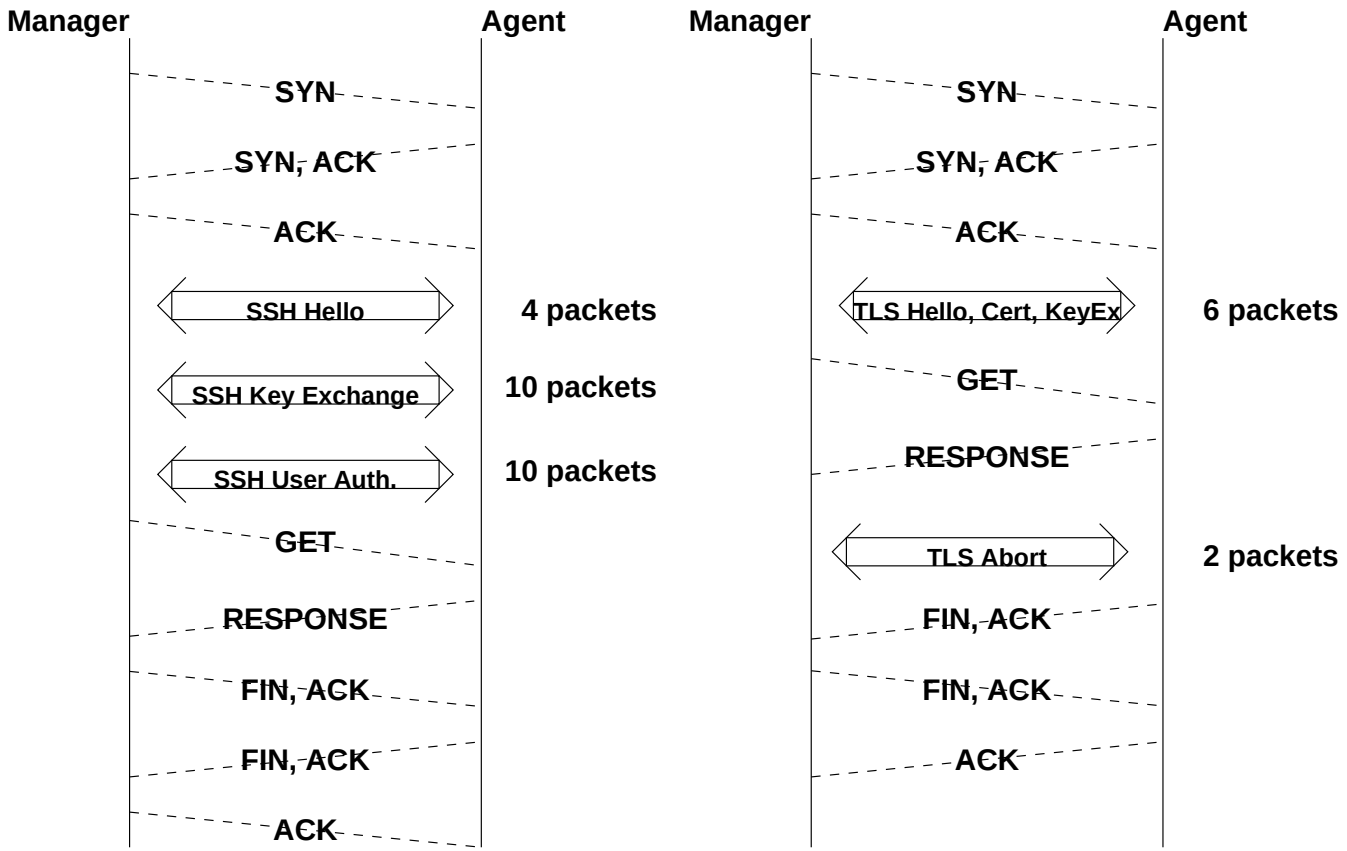
- Overhead of SSH session establishment was measured using response time of `snmpget` operation
- SNMPv2c/SSH introduces significant overhead for session establishment
- SNMPv2c/TLS uses less packets but exchanges similar amount of data
- However, overhead can be amortized over long sessions...

Time Sequence Diagrams (v2c / v3/USM)



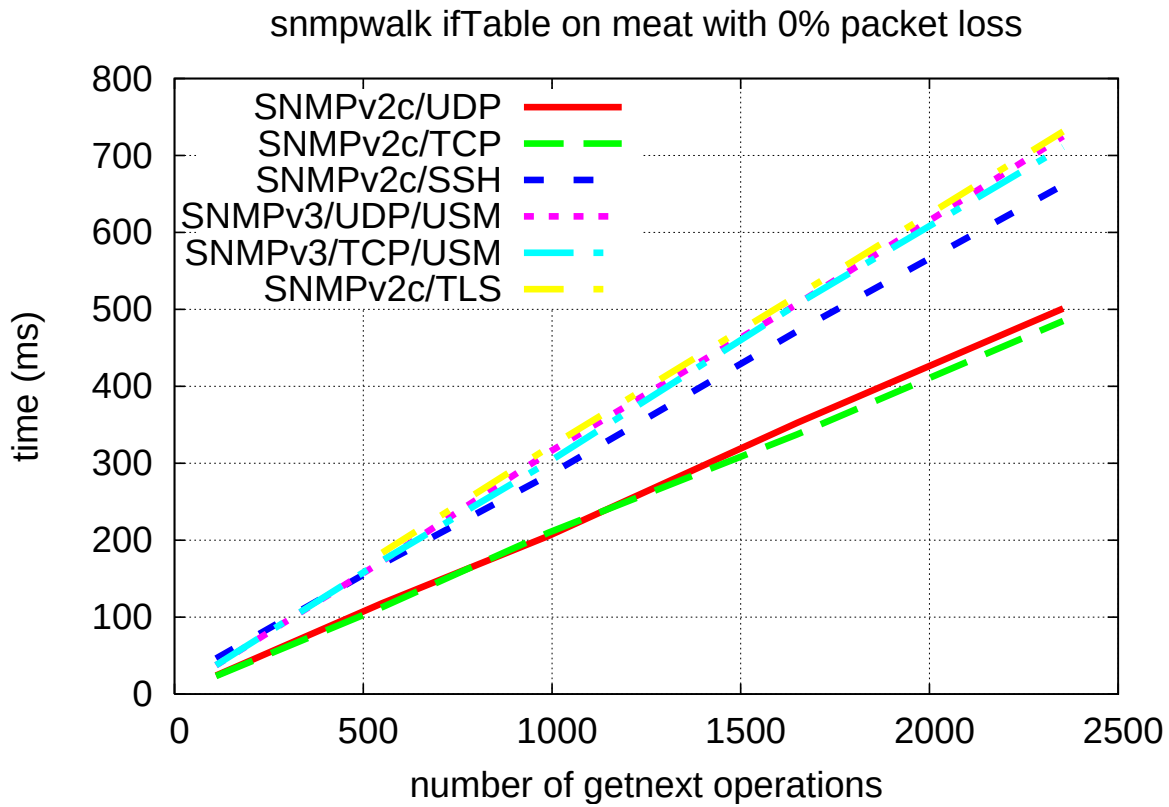
- USM requires one SNMP round trip for engineID discovery and clock synchronization (`REPORT` PDU)
- TCP adds connection establishment and teardown overhead

Time Sequence Diagrams (v2c SSH / TLS)



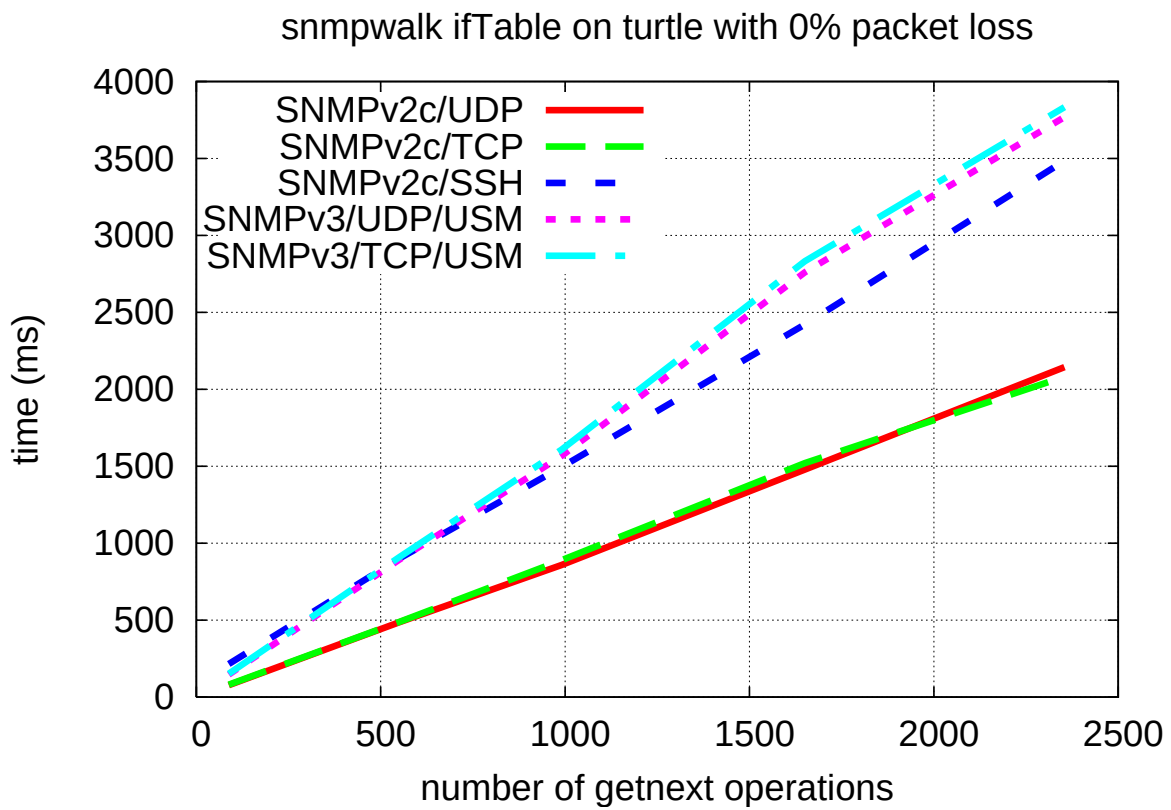
- SSH requires more messages than TLS
- TLS initiates TCP teardown from the agent

Latency Without Packet Loss (fast machine)



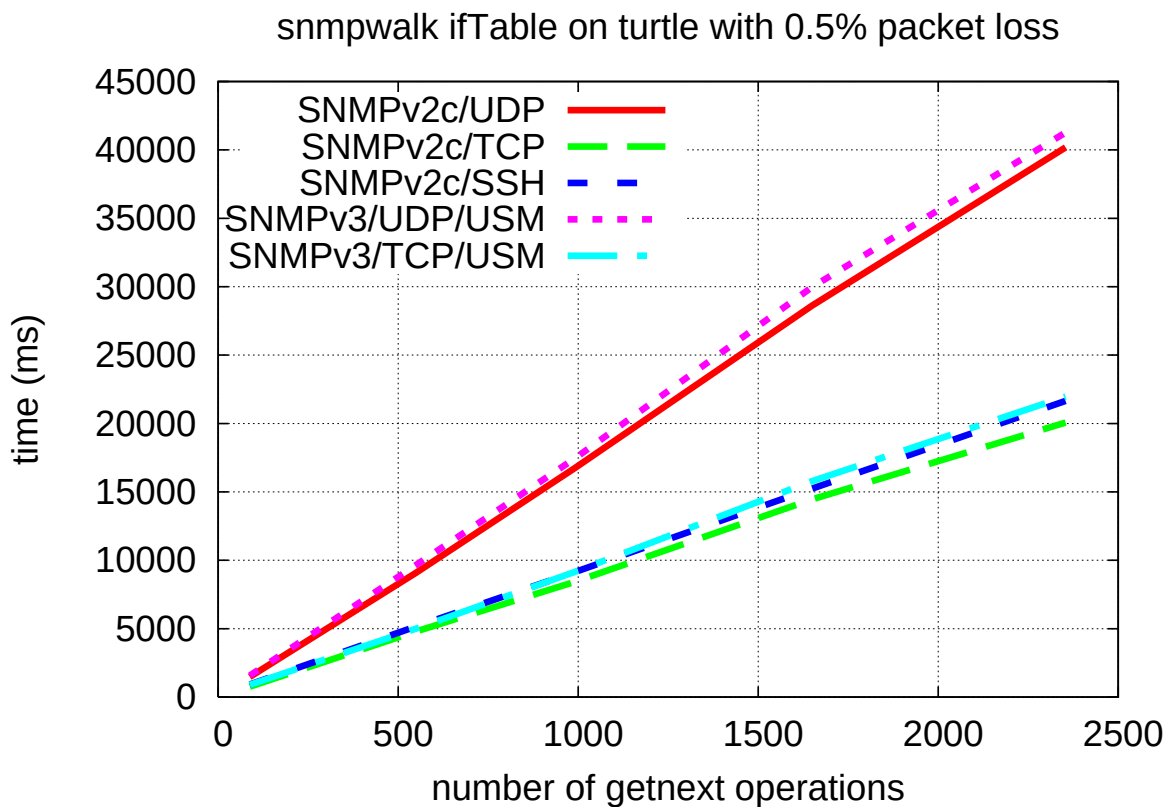
- Overhead of `snmpwalk` and `snmpbulkwalk` operations
- Marginal difference between TCP and UDP
- Initially SSH performs worse than USM due to session establishment overhead

Latency Without Packet Loss (slow machine)



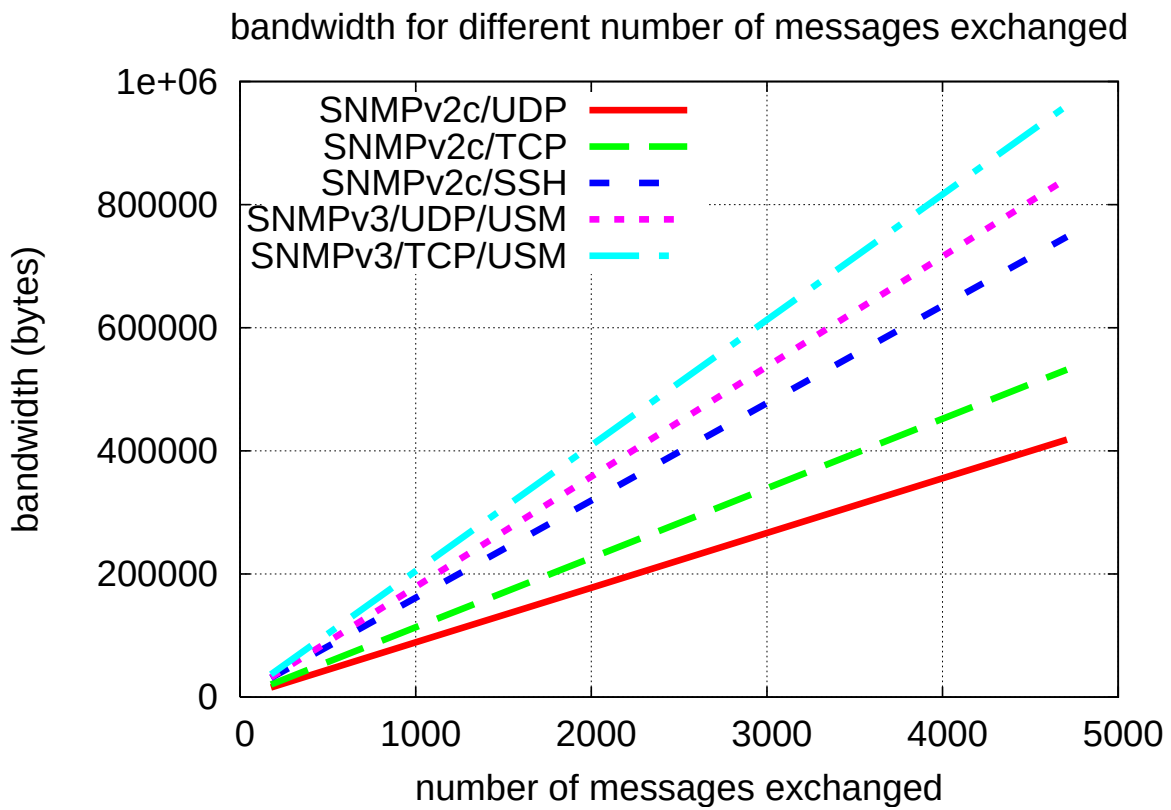
- The slope of the curves does not change on a slower machine
- The dimension of the y-axis changes significantly

Latency With Packet Loss (slow machine)



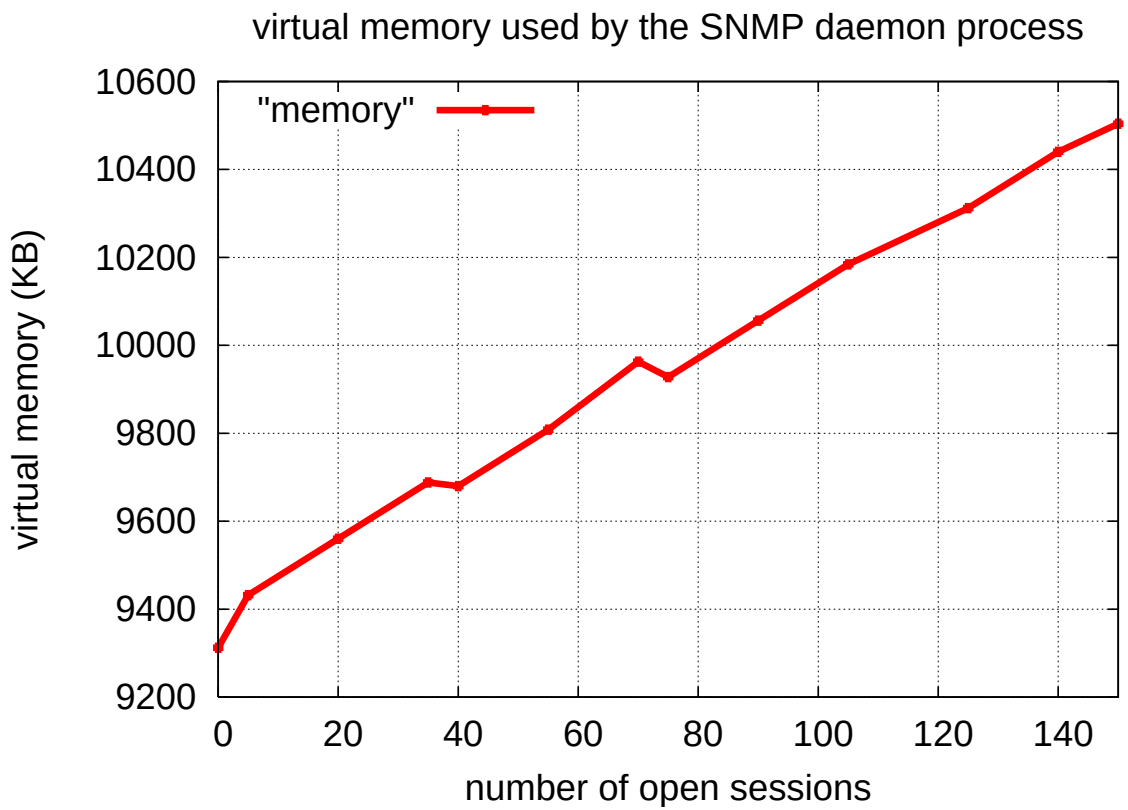
- SNMP/SSH and SNMP/TCP perform better than SNMP/UDP
- Poor retransmission algorithm of SNMP/UDP in the NET-SNMP implementation

Bandwidth Consumption



- SNMPv2/SSH requires less bandwidth compared to SNMPv3/USM because it does not carry security information in every message

Memory Usage



- Memory overhead for establishment of a session was measured using the `pmap` utility
- Virtual memory allocated to the SNMP daemon grows linearly with the increase of the number of open sessions

Conclusions

- SNMP/SSH is a new secure transport for SNMP that
  - uses session based security
  - reuses existing user/key infrastructure
  - offers better security (session keys, perfect forward secrecy)
- Performance analysis reveals
  - high overhead for short sessions
  - minimal overhead for long sessions
  - requires less bandwidth than SNMPv3/USM
  - outperforms SNMP/UDP under packet loss (NET-SNMP implementation)
- Can be used to transition from SNMPv1 and SNMPv2c to SNMPv3 more easily

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