Performance Analysis of SNMP over SSH

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Outline of the Talk

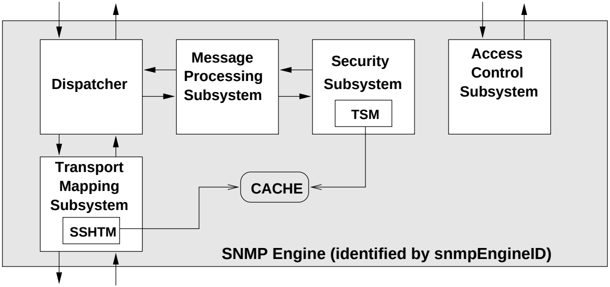
1. Motivation and Goals

2. Prototype Implementation

3. Experiments and Results

4. Conclusions

Extension of the SNMP Architecture



Dispatcher
Message Processing Subsystem
Security Subsystem
TSM
Access Control Subsystem
Transport Mapping Subsystem
SSHTM
CACHE
SNMP Engine (identified by snmpEngineID)

- Goals:
  - understand performance tradeoffs
  - provide "running code" experience to the working group
  - explore possible alternatives (e.g., TLS or DTLS)

Prototype Implementation

- NET-SNMP - open source C implementation of SNMP
- LibSSH - open source C library for SSH
- openssl - open source C library for TLS
- New transport domain (SSHDomain) defined by implementing the NET-SNMP transport interface functions
- Pluggable Authentication Modules (PAM) [5] support enables runtime configuration how credentials are verified
- SNMPv2c over SSH (passing the SSH user identity as a securityName)
- $\approx$ 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

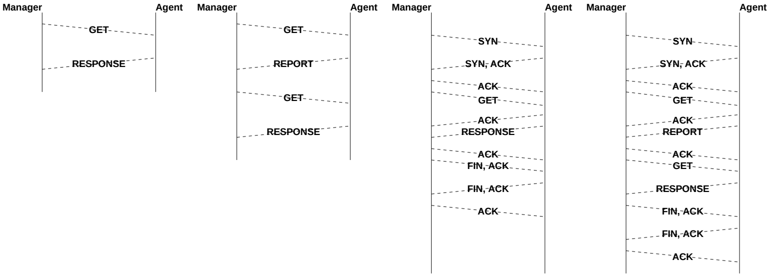
- `meat`: 2 x Intel Xeon 3GHz CPU, 2GB RAM, connected to the switched lab network via 1Gbps interface, running Debian Linux 2.6.15.1
- `veggie`: 2 x Intel Xeon 3GHz CPU, 1GB RAM, connected to the switched lab network via 1Gbps interface, running Debian Linux 2.6.12.6 XEN
- `turtle`: Ultra Sparc IIi, 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**

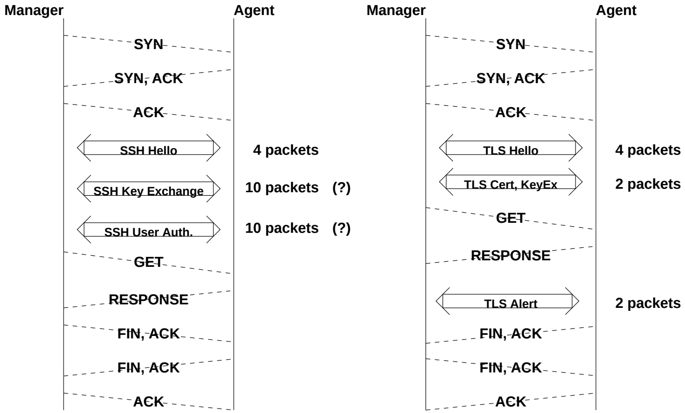
- Overhead of SSH session establishment was measured using response time of `snmpget` operation
- SNMPv2c/SSH introduces significant overhead for session establishment
- SNMPv2c/TLS uses less packets but exchanges similar amount of data
- However, overhead can be amortized over long sessions. . .

Time Sequence Diagrams (v2c / v3/USM)



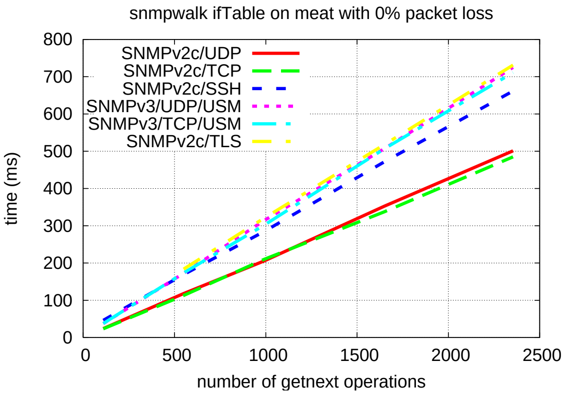
- USM requires one SNMP round trip for engineID discovery and clock synchronization (`REPORT` PDU)
- TCP adds connection establishment and teardown overhead

Time Sequence Diagrams (v2c SSH / TLS)



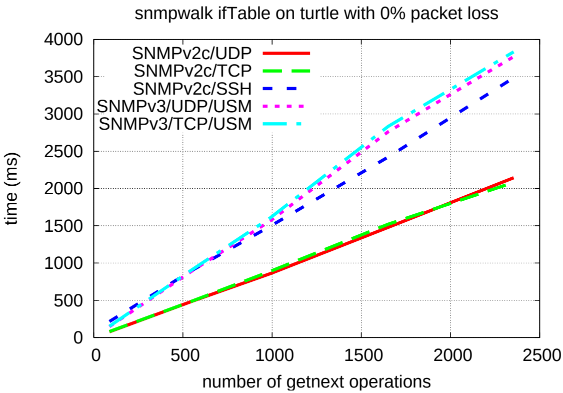
- SSH requires more messages than TLS
- TLS initiates TCP teardown from the agent

Latency Without Packet Loss (fast machine)



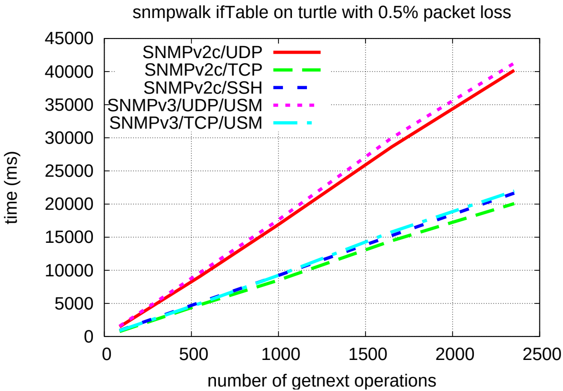
- Overhead of `snmpwalk` and `snmpbulkwalk` operations
- Marginal difference between TCP and UDP
- Initially SSH performs worse than USM due to session establishment overhead

Latency Without Packet Loss (slow machine)



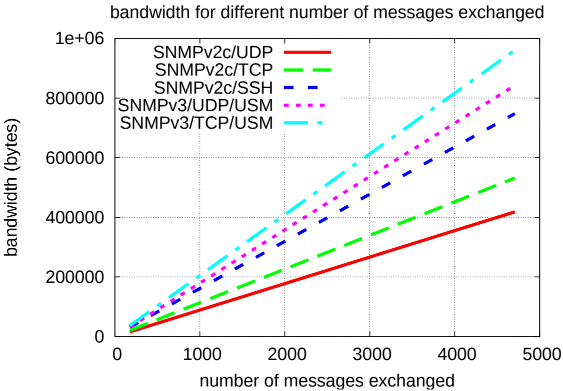
- The slope of the curves does not change on a slower machine
- The dimension of the y-axis changes significantly

Latency With Packet Loss (slow machine)



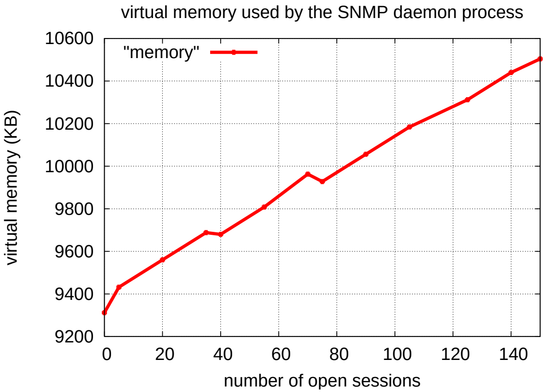
- SNMP/SSH and SNMP/TCP perform better than SNMP/UDP
- Poor retransmission algorithm of SNMP/UDP in the NET-SNMP implementation

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 over SSH 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)
- Ongoing work:
  - Support for the Transport Security Model
  - Implementation of SNMP over TLS and DTLS and comparison with SNMP over SSH and SNMPv3/USM
  - Support for notifications

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References

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