Performance Analysis of SNMP in OLSRv2-routed MANETs

Ulrich Herberg
Trusted Systems Innovation Group
Fujitsu Laboratories of America, USA
ulrich@herberg.name

Robert G. Cole
US Army CERDEC
Aberdeen Proving Ground, MD, USA
robert.g.cole@us.army.mil

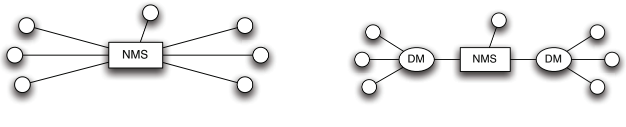
Jiazi Yi
Hipercom@LIX
Ecole Polytechnique, France
yi.jiazi@gmail.com

Abstract—**Mobile Ad Hoc NETworks (MANETs) are generally thought of as infrastructure-less and largely "un-managed". Yet, while the network may be un-managed, monitoring performance and setting configuration parameters post-deployment, remains important in order to ensure proper "tuning" and maintenance of a MANET. While SNMP is sometimes considered too "heavy" for MANETs, it remains the predominant management and monitoring protocol in the Internet. This paper evaluates SNMP in an OLSRv2-routed MANET, with the purpose of investigating performance metrics. In order to address concerns both regarding SNMP being "heavy", as well as regarding the burden of performance reports obtained via SNMP polling in MANETs, the utility of performance reporting extensions to the DISMAN capabilities set is studied. The obtained results show that a significant benefit can be obtained by deploying these performance reporting extensions in an SNMP managed MANET.**

I. INTRODUCTION

Mobile Ad Hoc Network (MANET) routing protocols are commonly assumed to be entirely self-managing: routers perceive the topology of a MANET by way of control message exchanges, with changes to the topology being reflected in routing tables of each router. Usually, no operator intervention is required; variable parameters for the routing protocol are either negotiated in the control traffic exchange, or are of only local importance to each router. Still, external management and monitoring of a MANET routing protocol may be desired, for optimizing routing protocol operation, *e.g.,* to attain a more stable perceived topology or a lower control traffic overhead.

This paper evaluates the performance of the Simple Network Management Protocol (SNMP), the prevailing management and monitoring protocol in the Internet, in the context of an OLSRv2 [1] routed MANET. OLSRv2 is currently in the process of being standardized by the MANET Working Group of the IETF (Internet Engineering Task Force). Further, this paper analyzes the benefits of a performance reporting Management Information Base (MIB) module, *i.e.,* the REPORT-MIB, for reducing network management overhead, while maintaining fine grained performance reports in MANETs. The REPORT-MIB extends the collective capabilities for SNMP distributed network management defined collectively through the Distributed Management (DISMAN) architecture [2] from the IETF.



(a)

(b)

Fig. 1. DISMAN architecture offloading burden on centralized NMS.

Surveys of performance aspects of SNMP exist, *e.g.,* [3], yet – to the best of the authors' knowledge – none consider performance in MANETs. Reasons for the lack of research in this area may be twofold: (i) SNMP may be considered too "heavy" for MANETs, yet as no alternative "light-weight" management protocol has been standardized, SNMP remains the (Internet) management protocol. (ii) Despite the 'S' in SNMP meaning "simple", SNMP is composed by a large corpus of RFCs, rendering a fully compliant implementation of SNMP for network simulators difficult. Analysis of SNMP management of MANETs is timely as little to no operational experience exists.

Operational experience in SNMP-based network management is entirely based upon the management of rather high-speed and static networks like the Internet. This experience has resulted in a) bandwidth in-efficient polling practices for device monitoring over Wide Area Networks (WANs) due to the prevalence of available bandwidth, and b) infrequent polling intervals per monitored object due to the relatively static nature of the network topology [4]. As these practices became more prominent, it became apparent that monolithic Network Management Systems (NMS) were not scalable, hence the development of the DISMAN architecture in the late 1990's at the IETF [2], [5]. DISMAN offloads the management burden from the centralized NMS by delegating a specific set of capabilities to Distributed Managers (DMs), *i.e.,* see Figure 1. The specific capabilities defined within DISMAN include remote execution of event triggers (*i.e.,* the EVENT-MIB), definition of not-yet defined MIB objects (*i.e.,* the EXPRESSION-MIB), remote logging of notifications (*i.e.,* the NOTIFICATION-MIB), remote operations (*e.g.,* the ping and traceroute MIB modules), and delegation of management functions (*i.e.,* the SCRIPT-MIB). These MIB modules collectively define the functionality within the DMs in the DISMAN architecture.

Mobile Ad-Hoc Networks (MANETs) pose numerous challenges to existing SNMP management deployments and best practices. First, the dynamics of MANETs are orders of magnitude more complex than deployed, fixed infrastructure based Internets. Links within MANETs may have lifetimes of only 60 seconds or less. Management of MANETs will require an NMS to be capable of fine-grained monitoring (*i.e.,* high speed polling) and will require SNMP agents which place a priority handling within their operating systems to update state and performance group objects within their local MIB modules. Second, MANETs' dependence on wireless, on-the-move communications results in low bandwidth links which cannot support high polling rates. These diametrically opposing forces can only be accommodated by a) improved priority handling of object updates within local MIB modules, b) higher polling rates within management deployments, and c) reliance upon, and extensions to, the DISMAN capabilities. In this paper, the later two capabilities are addressed by analyzing the impact of higher polling rates on the MANET and the development of the REPORT-MIB as an extension to the DISMAN capability set. The discussion and analysis of the first issue is deferred to a later paper when having gained experience of development and deployment of these new MIB-modules for MANET management.

A. Paper Outline

Section II provides a brief overview of OLSRv2. Section III describes the motivation for monitoring and controlling OLSRv2 routed MANETs. Section IV presents a management architecture for OLSRv2, including the role of the performance reporting MIB module, *e.g.,* the REPORT-MIB, in extending the DISMAN capability set. Section V details the performance analysis of SNMP and the REPORT-MIB in highly dynamic OLSRv2-based MANETs. This paper is concluded in section VI.

II. OVERVIEW OF OLSRV2

The Optimized Link State Routing Protocol version 2 (OLSRv2) [6], [7], [8], [1] is a successor to the widely deployed OLSR [9] routing protocol for MANETs. OLSRv2 retains the same basic algorithms as its predecessor, however offers various improvements, *e.g.,* a modular and flexible architecture, and in particular a flexible message format [6] by way of TLVs, allowing extensions, such as for security, to be developed as add-ons to the basic protocol whilst retaining backwards and forwards compatibility. OLSRv2 contains three basic processes: Neighborhood Discovery, MultiPoint Relay (MPR) Flooding and Link State Advertisements. The basic operation of OLSRv2 is detailed below:

- *Neighborhood Discovery (NHDP)*
  The process, whereby each router discovers the routers which are in direct communication range of itself (1-hop neighbors), and detects with which of these it can establish bi-directional communication, as well as detects its 2-hop neighbors. This, by way of a periodic HELLO message exchange, as specified in [8].

- *MPR Flooding*
  The process whereby each router is able to, efficiently, conduct network-wide broadcasts. Each router designates, from among its bi-directional neighbors, a subset (MPR set) such that a message transmitted by the router and relayed by the MPR set is received by all its 2-hop neighbors. MPR selection is encoded in outgoing HELLOs.

- *Link State Advertisement*
  The process whereby routers are determining which link state information to advertise through the network. Each router must advertise links between itself and its MPR-selector-set, in order to allow all routers to calculate shortest paths. Such link state advertisements, carried in TC messages, are broadcast through the network using the MPR Flooding process. As a router selects MPRs only from among bi-directional neighbors, links advertised in TCs are also bi-directional. TC messages are sent periodically, however certain events may trigger non-periodic TCs.

III. PROBLEM STATEMENT

OLSRv2 imposes few constraints on valid router configuration parameters. Still, external monitoring and management may be desirable in an OLSRv2 network. A network may benefit from having its control message emission tuned according to the network dynamics: in a mostly static network, *i.e.* a network in which the topology remains stable over long durations, the control message emission frequency could be decreased in order to consume less bandwidth or less energy. Conversely, of course, in a highly dynamic network, the emission frequency could be increased for improved responsiveness.

This example requires a more "global view" of the network, than that of a single OLSRv2 router – *i.e.* entails that a Network Management System (NMS) is able to inquire as to various performance values of the network and to set various router parameters. Thus, a first-order task is to identify suitable management data for an OLSRv2 routed MANET, and to describe these by way of MIB modules for use by an SNMP NMS. A second-order task is to develop a performance reporting MIB module in order to provide fine grained performance measurements in variable MANETs while minimizing SNMP overhead in the MANET.

IV. OLSRV2 MANAGEMENT ARCHITECTURE

The OLSRv2 management system architecture consists of three MIB modules: NHDP-MIB [10], OLSRv2-MIB [11], and the REPORT-MIB [12]. Both the NHDP-MIB and the OLSRv2-MIB consist of different groups, allowing (i) changing protocol parameters, and (ii) monitoring the router state.

As is standard for SNMP management architectures, a Network Management System interacts with the various components of the device models directly over the network. Experience in managing static IP networks has resulted in best practices which encourage low polling frequencies and low priority handling of MIB module objects in agent operating systems. However, MANET management will require frequent polling for object values which will generate bandwidth-consuming message exchanges – prohibitive in a MANET where connectivity often is wireless. In order to specifically address these issues of performance management over low bandwidth and high latency networks, the proposed OLSRv2 management system architecture includes a new *DISMAN capability*, denoted REPORT-MIB [12]. This new DISMAN capability is located directly on the managed devices, and offers remote generation of performance reports established via the management application. The REPORT-MIB polls (locally) for the current values of the relevant objects necessary for the generation of the fine grained performance reporting. Hence, the bulk of the SNMP traffic is removed from the MANET and is isolated to local interaction.

[13] provides further details regarding the MIB modules and how they allow monitoring performance of NHDP and OLSRv2.

V. PERFORMANCE STUDY OF SNMP FOR OLSRV2

In order to understand the implications when running SNMP in an OLSRv2 routed dynamic MANET, this section presents a performance study of SNMP in the NS2 simulator.

A. Simulation Settings

Simulations have been conducted with JOLSRv2 [14], a Java implementation of OLSRv2 and SNMP4J [15], a Java implementation of SNMP, hooked into NS2 using AgentJ [16]. The scenario parameters in table I have been used in the simulation. Each presented data point represents an average over 10 simulation runs of randomly generated scenarios, each corresponding to these parameters.

TABLE I
NS2 PARAMETERS

Parameter	Value
Mobility scenario	Random walk
Grid size	1000m x 1000m
Number of routers	10 - 50
Mean speed	10 m/s
Communication range	250m
Radio propagation model	Two-ray ground
Simulation time	270 secs
Interface type	802.11b
Radio frequency	2.4 GHz
OLSRv2 parameters	Proposed default values of [1]

In all scenarios, one router is positioned at exactly the center of the simulated area. This router runs an SNMP manager. All other routers run an SNMP agent, providing the NHDP-MIB [10], the OLSRv2-MIB [11] and the REPORT-MIB [12].

For the first set of simulations, the SNMP manager continuously sends requests for an NHDP parameter to all other routers, one by one. The manager starts sending these requests using UDP, after 10s, in order to allow routing tables to converge. Each request has a 500ms timeout, *i.e.,* the manager aborts the request if no response has been received after 500ms, and proceeds to send a request to the the next router. 25 seconds after the first request is sent, all routers have been interrogated and either responded or timed out (50 routers · 500ms timeout). The manager, then, restarts interrogating the first router again – resulting in each router being interrogated 25 times during the simulation.

Simulations are run using SNMPv2c, SNMPv3 without authentication or privacy ("SNMPv3"), SNMPv3 with SHA authentication only ("SNMPv3 (SHA)"), SNMPv3 with authentication and privacy ("SNMPv3 (SHADES)" and "SNMPv3 (SHAAES128)").

For the second set of simulations, the impact of the REPORT-MIB, is investigated. For these simulations, the manager polls each router 20 times over a 10 second window to collect counter values for performance reports, corresponding to standard SNMP operation for data collection for performance monitoring. With the REPORT-MIB implemented locally on each router, the SNMP manager needs only to interact with the routers twice during this period: first, to set up the report control, and, second to collect the performance report from the local REPORT-MIB instance. The goal of these simulation studies is to measure the reduction of SNMP overhead when using the REPORT-MIB.

B. Simulation Results

Figure 2 depicts the accumulated SNMP traffic for the different SNMP versions and security mechanisms. Traffic grows linearly with the number of routers in the network. SNMPv2 exhibits a far lower overhead than SNMPv3. SNMPv3 with authentication only (SHA) exhibits a higher overhead than SNMPv3 without authentication, but less than both tested encrypted SNMPv3 variants.

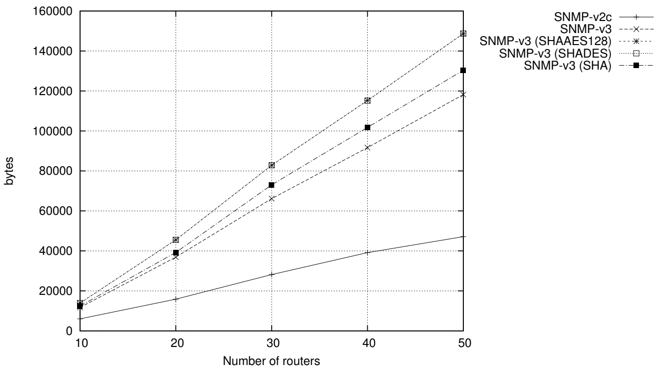


Fig. 2. Accumulated SNMP traffic overhead

SNMP messages for the different versions tested contain different amount of security related parameters, accounting for the differences in overhead incurred. Another reason for the different total SNMP traffic is the number of transmitted messages. Figure 3 compares SNMPv2c with the SHAAES128 variant of SNMPv3[1]. With SHAAES128, for each pair of routers exchanging SNMP messages, an additional initial message exchange has to be performed in order to provide replay protection. For the simulations presented in this paper, this initial exchange of parameters is only performed for the first request from the manager to an agent, not in any subsequent one – which explains why the plot in figure 3 for SNMPv3 show only slightly more frames set than SNMPv2.

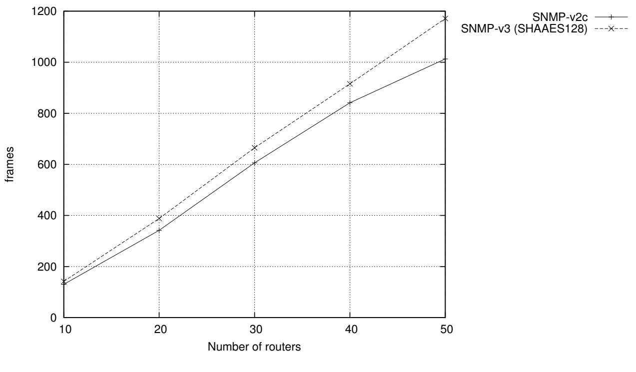


Fig. 3. Number of transmitted SNMP messages

Figure 4 depicts the frame collision ratio. As the amount of OLSRv2 control traffic and SNMP unicast traffic increases

[1] For the other encrypted variants the results are similar

with the number of routers in the network, so does the collision ratio. There is no significant difference between the different SNMP variants as the SNMP traffic makes up only a small fraction of the total traffic in the network. Note that this is no general observation: in the simulated scenarios, no concurrent SNMP message exchanges take place, and no other unicast data traffic is present in the network.

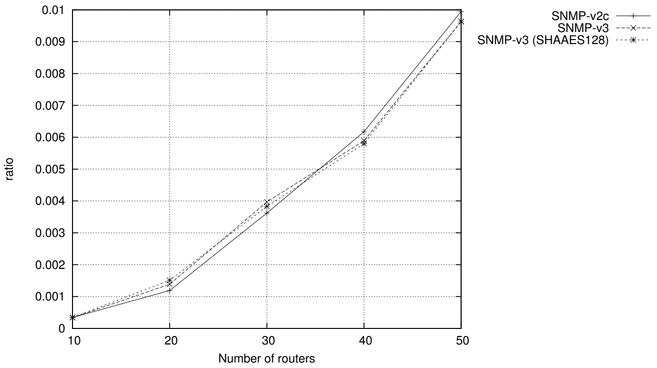


Fig. 4. MAC collision ratio

Figure 5 depicts the message exchange delay between transmission of the requests and the reception of a response by the manager. As the number of routers in the network increases, so does the message exchange delay across all SNMP variants.

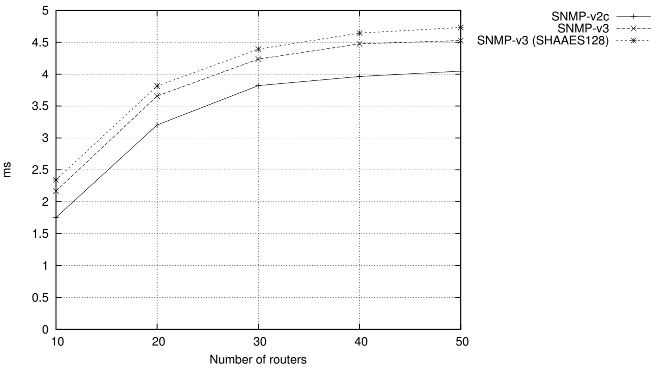


Fig. 5. Message exchange delay

Figure 6 depicts the delivery ratio for SNMP messages. With a low collision ratio (figure 4), the delivery ratio is relatively high, increasing network density. There is no significant difference observed between the different SNMP variants.

Beyond this basic understanding of the performance of SNMP in an OLSRv2-network, the impact of the REPORT-MIB as an SNMP performance management extension to the DISMAN capability set in MANETs is of interest. Figure 7 depicts the number of frames sent when polling (as in standard SNMP) is used, as well as when the REPORT-MIB is used. While the reduction in overhead with the REPORT-MIB is substantial, note that this results in reports being generated only after the equivalent of 20 polling intervals. The SNMP manager interacts with each router only twice per report (configure report collection, collect performance report). The results will depend in general on the relative relationship of the report duration to the polling intervals, the nature of the reports, as well as other aspects of the network.

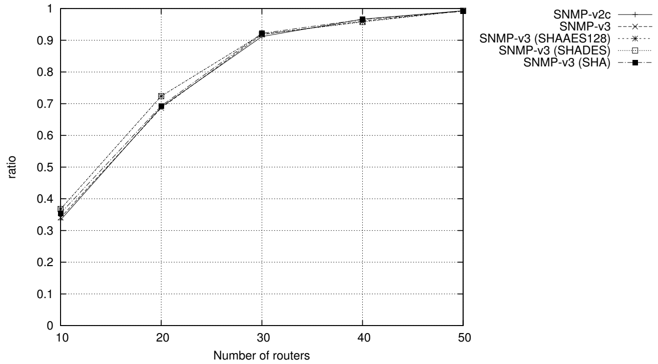


Fig. 6. Delivery ratio of SNMP messages

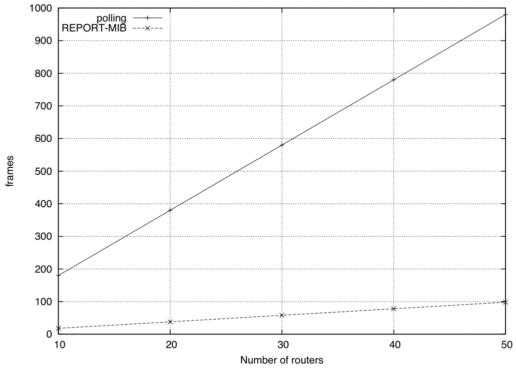


Fig. 7. The REPORT-MIB reduces the polling overhead in terms of frames

Higher polling rates will be required as the expected changes in the MANET increase in rate. For the simulated network configurations in this paper with a radio range of 250 m and a mean speed of 10 m/s, it is expected that the mean link associations in the MANET are on the order of 25 s. Clearly, the network management systems will have to be configured with polling rates in excess of 1 per 25s if the SNMP monitoring is to be capable of detecting dynamics of the network at such small time scales. The development of a REPORT-MIB will help to address one aspect of this challenge to SNMP NMS for MANET deployments.

VI. CONCLUSION

The MANET routing protocol OLSRv2 does not require any operator intervention once deployed, however, it may still be desirable to monitor the performance of a network, and to tweak parameters for improving the performance of the routing protocol.

This paper evaluates the performance of SNMP in OLSRv2-routed MANETs. Moreover, this paper investigates the impact of performance reports collected through SNMP polling methods. As the topology of MANETs is much more dynamic than observed in the Internet, frequent polling may be required to get accurate values, which may generate a relatively large traffic overhead. This paper also discusses the benefits of the REPORT-MIB for reducing the management overhead.

REFERENCES

[1] T. Clausen, C. Dearlove, and P. Jacquet, “The Optimized Link-state Routing Protocol version 2,” July 2011, Internet Draft, work in progress, draft-ietf-manet-olsrv2-12.txt.

[2] IETF DISMAN WG Charter, “Charter of the working group,” http://www.ietf.org/html.charters/disman-charters.html.

[3] L. Andrey, O. Festor, A. Lahmadi, A. Pras, and J. Schönwälder, “Survey of SNMP performance analysis studies,” *International Journal of Network Management*, vol. 19, pp. 527–548, 2009.

[4] J. Schonwalder, A. Pras, M. Harvan, J. Schippers, and R. van de Meent, “SNMP traffic analysis: Approaches, tools, and first results,” in *Proceedings of the 10th IFIP/IEEE International Symposium on Integrated Network Management (IM)*, 2007.

[5] R. Lopes and J. Oliveira, “On the Use of Mobility in Distributed Network Management,” in *Proceedings of the 33rd IEEE Hawaii International Conference on System Science (HICSS)*, January 2000.

[6] T. Clausen, C. Dearlove, J. Dean, and C. Adjih, “Generalized MANET Packet/Message Format,” February 2009, RFC 5444.

[7] T. Clausen and C. Dearlove, “Representing Multi-Value Time in Mobile Ad Hoc Networks (MANETs),” March 2009, RFC 5497.

[8] T. Clausen, C. Dearlove, and J. Dean, “Mobile Ad Hoc Network (MANET) Neighborhood Discovery Protocol (NHDP),” April 2011, RFC 6130.

[9] T. Clausen and P. Jacquet, “Optimized Link State Routing Protocol (OLSR),” October 2003, RFC 3626.

[10] U. Herberg, R. Cole, and I. Chakeres, “Definition of Managed Objects for the Neighborhood Discovery Protocol,” July 2011, Internet Draft, work in progress, draft-ietf-manet-nhdp-mib-09.txt.

[11] U. Herberg, R. Cole, and T. Clausen, “Definition of Managed Objects for the Optimized Link State Routing Protocol version 2,” January 2011, Internet Draft, work in progress, draft-ietf-manet-olsrv2-mib-03.txt.

[12] R. Cole, J. Macker, and A. Morton, “Definition of Managed Objects for Performance Reporting,” February 2011, Internet Draft, work in progress, draft-ietf-manet-report-mib-01.txt.

[13] U. Herberg, T. Clausen, and R. Cole, “MANET Network Management and Performance Monitoring for NHDP and OLSRv2,” in *Proceedings of the 6th International Conference on Network and Services Management (CNSM)*, October 2010.

[14] U. Herberg, “JOLSRv2 – an OLSRv2 implementation in Java,” in *Proceedings of the 4th OLSR Interop workshop*, October 2008.

[15] “SNMP4J webpage,” http://www.snmp4j.org.

[16] U. Herberg and I. Taylor, “Development Framework for Supporting Java NS2 Routing Protocols,” in *Proceedings of the 2010 International Workshop on Future Engineering, Applications and Services (FEAS)*, May 2010.