COMMUNICATIONS

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FUNCTIONALITY VALIDATION OF THE NEW QOS AND SECURITY INTEGRATION MODEL FOR MANET

In this article, the simulation testbed of the new designed model for cooperation between QoS and security is introduced. The field of research about QoS and security provide dynamically developed and important areas of the research and up to now no protocol or mechanisms have been designed to this process. The cooperation is based on using a Cross Layer Design model (CLD) and modified Security Service Vector (SSV). A main idea of testbed is the indication how could security and QoS be integrated as a parameter to the MANET via this model. We also show how this model can affect the functionalities of the whole MANET.

Keywords: MANET, QoS, Security, Security Service Vector.

1. Introduction

In this article the simulation testbed of the new QoS and security integration model for mobile ad-hoc network (MANET) is introduced. The MANET is characterized as a set of mobile nodes and devices connected to each other through wireless. A basic feature of abstinence is very solid infrastructure nodes which are able to create and maintain a connection between them. Research in the field of MANET is oriented to following areas: QoS, Security and Cross Layer Design.

Quality of Service (QoS) is a dynamically evolving field of research dealing with different areas. In literature, research is oriented to *QoS models*, *QoS resource reservation signalling, QoS routing and QoS Medium Access Control (MAC)* [1]. There are many definitions of the term QoS [2]. From network point of view, the QoS is a guarantee provided by the network to satisfy a set of predetermined service performance constraints for the user in terms of the end-to-end delay statistics, available bandwidth, probability of packet loss, and so on [2] and [3].

Security is also a dynamically evolving field. The major role of security mechanism is the ensuring of services: Confidentiality, Authentication, Availability, Integrity and Non-repudiation. Research communities in MANET's solve problems of *Secure Routing, Key Management and Intrusion Detection System* [4].

The main idea of Cross Layer Design (CLD) is to increase the performance and adaptability of MANET. Cross-layering tries to share information among different layers, which can be used as inputs for algorithms, for decision processes, for computations, and adaptations [5]. Based on research the three main CLD architec-tures have been designed: *Direct communication between layers, Shared database architectures, Heap architectures or Completely novel approaches.*

Optimized Network Engineering Tools (OPNET) Modeler [6] is a useful tool for simulation and design of different type networks and related technologies. OPNET modeler provides a wide range of different types of simulation models of devices, communication technologies, wired and mobile network protocols and technologies. OPNET Modeler combines the C/C++ programming language and PROTO-C language. PROTO-C is characterized as a finite state transition diagrams (FSM) to implement different simulation models and supporting technologies. OPNET modeler provides fairly straight-forward tools to simulation study using standard models. Developing new models or modifying existing ones is a challenging and often frustrating undertaking [6].

2. Main motivation for the validation of the new model in OPNET modeler

The main ideas of the integration model are to provide QoS and security mechanisms at the same time, and that user or services have the possibilities to interact with system via CLD. Integration provides also the proper functionalities of QoS and security mechanisms. Our model enables cooperation between QoS and security mechanism and also between users and system by modified security service vector. The goal of the simulation testbed in OPNET modeler is to show that the proposed model does not affect the activity of the network and greatly contributes to the integration between QoS and security.

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3. New QoS and security integration model for MANET

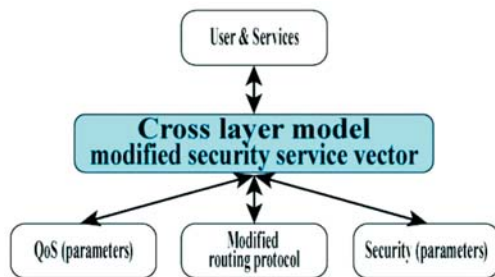In this section the new QoS and Security integration model for MANET is introduced.

*Fig. 1 The new QoS and security integration model
with cross layer interface and modified security service vector*

The model provides the ability of mutual cooperation between QoS and security related systems and algorithms by a new cross layer interface (model) with modified security service vector. Our new model is displayed in Fig. 1. The model includes all components for interactions between the user and system to integrate security as one parameter. *A block cross layer model and modified security service* vector is a block where the Cross layer model (CLD) is used to create interactive environment between users and the system and also provides support interactions between the routing protocol and modified security service vector (SSV). *The block QoS (parameters)* represents a mechanism for delivering of QoS in MANET network environments. It defines and specifies the QoS parameters necessary to provide the required services. *The block Security (parameters)* represents a mechanism to provide security-related services and also defines the necessary parameters used to process services providing. *The block User&Service* enables the interaction between the user and the system. *The block Modified routing protocol* represents the routing protocol with implemented modified SSV algorithm for selecting the optimal way based on user defined requirements (QoS and security).

The main idea of the model is based in the current use of QoS and security mechanisms as well as the interaction between users and systems in order to provide the type of service. Integration itself is necessary for proper functioning of both mechanisms in terms of QoS and security. The model also provides users with the possibilities to specify requirements for new services in MANET.

The main part of the model is modified SSV and cross layer model or interface (CLD) [7]. The modified SSV is based on the security service vector designed especially for wired IP networks [8]. A main idea of the modified SSV is shown in Fig. 2. Modification of the SSV is defined into two parts: user and system. The user part deals with a process of collecting the relevant data about requested services. In our case, these data are created by QoS and security parameters. Parameters can represent different QoS and

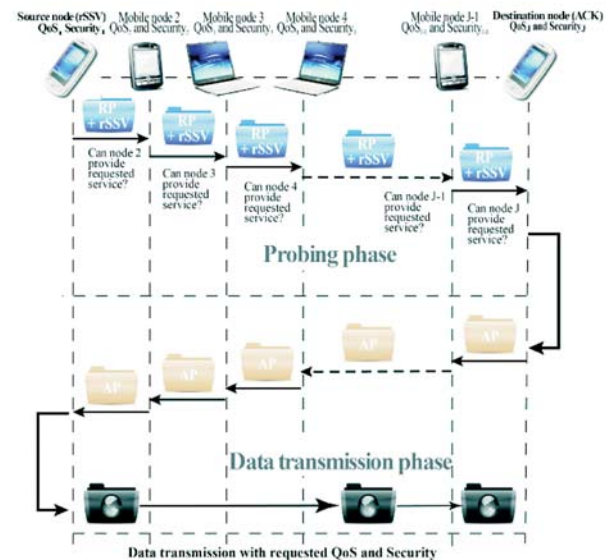security parameters or mechanisms for providing QoS and security processes [9].

Fig. 2 The modified SSV model in MANET

In this model, users can specify the required parameters and the using of this approach can actively affect the system (routing) processes. The system part of our modification represents the new method of processing collected data and also deals with routing processes of the routing protocol. Each MANET node includes the algorithm to process the routing packet (RP). Algorithms analyze the routing information stored in RP and analyze the information about requested parameters, QoS and security (rSSV) [7], [9]. CLD is used to process bidirectional collection of relevant data from application or network layer by the modified SSV. These data are used for routing which uses the DSR routing protocol. This model enables cooperation between QoS and security mechanisms by the new designed cross layer model and modified SSV.

The main idea of CLD is depicted in Fig. 3. In the case of a source node, the user defines the SSV attributes via CLI inter-
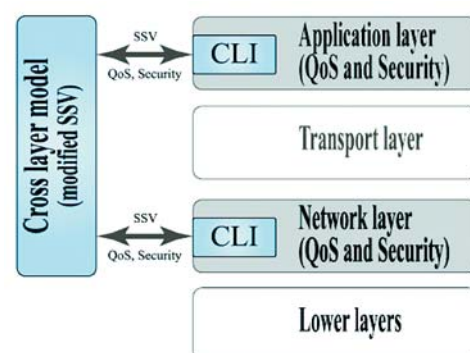

Fig. 3 The new cross layer interface for MANET

face located on the application layer and CLD interface sends these data to the network layer where they are stored to the modified route cache [9]. In the case of a routing node, the CLI analyses the incoming packet and reads information about the SSV stored in the packet. If the modified route caches do not include the information about security and QoS from the application layer, the CLD interface activates recollecting process of these data from the application layer. In the case of a destination node, the CLD collects data about requested QoS and security from the routing packet and from the modified route cache.

4. Simulation setup and experiments

The main ideas of the testbeds were to verify possibilities of implementing and testing a new designed model in MANET terminals. All behaviour of the proposed model was simulated in OPNET modeler 16.0. The three simulation scenarios were used to evaluate effectiveness of integrating a new model with CLD and modified SSV (Table 1):

- *The model where the nodes used the routing protocol DSR without modified SSV and CLD (DSR)* – data are transmitted by each layer without CLD and modified SSV.
- *The model where the nodes used the modified routing protocol with the implemented modified SSV (DSR+SSV)* – data are transmitted by each layer without CLD with implemented modified SSV.
- *The model where the nodes used the modified routing protocol with the implemented modified SSV and CLD (DSR+SSV_CLD)* – data are transmitted by new CLD interface and modified SSV is implemented.

The three parameters were used to check functionality of the proposed model with the integrated modified SSV and CLD, namely:

- *Time to processing* – means the process time necessary to process all operations of data on nodes. Time is measured from the time of creation, from the application layer or from arrival on the physical layer.

OPNET modeler simulation parameters   Table 1

Parameters	Values
Number of nodes	10 - 100
Simulation areas	500×500 m^2 (for 10–50 nodes) 1000×1000m^2 (for 60–100 nodes)
Simulation period	1000 s
Number of simulations	100
Number of collected values per simulation	1000
Speed of nodes	0-2 m.s^{-1}
Mobility model	Random waypoint model
Space model	Free space

- *Delay of MANET* – represents the value of the average end-to-end delay measured from the network layer on the source node, where the MANET packet is created, to the delivery of the packet to the destination node. This parameter also includes the processing time which is necessary for all SSV processes during source-destination transport.
- *Total packet processing delay* – this parameter represents the average delay in MANET networks from sending a packet to the adoption of the packet on the IP layer of the target node. The parameter does not reflect the time needed to processing information SSV.

In the first experiment, the processing time on source, routing and destination nodes was analyzed. This parameter represents the time required for processing and creating the modified packet. The term processing, in the case of the source node, means the time since the creation of the requirements to transmit data at the application layer to the time of the packet departure from the physical layer. It is the time of data arrival at the physical layer and of return to the physical layer in the case of a routing node. It is also the time that is necessary to perform required activities in the case of a destination node.

In the second experiment, the parameter delay of MANET was simulated and analyzed. This parameter gives the information how long it takes to deliver a MANET packet from the source to destination nodes. It provides good information about the time necessary to deliver a MANET packet from the source to destination nodes and includes the time for CLD and for carrying out the activities of the modified SSV.

The third experiment shows how the processing of modified SSV and CLD affect the total packet processing delay that represents the time necessary to transmission of the packet from the source to a destination node through the MANET network. This transmission depends on dynamic source routing protocol (DSR) with the implemented modified SSV and CLD algorithms.

5. Simulation Results

The results of monitoring the processing time depending on the type of node (first experiment) are shown in Fig. 4. The processing time parameter is monitored on the source, routing and destination nodes. Based on the collected results, we can conclude that in all cases (source, routing, destination nodes), the better results were obtained for model DSR+SSV_CLD in comparison with DSR and DSR+SSV. For example, in the case of the source node, the implementation of the DSR+SSV increased the value of the processing time by 11.70 % as compared with DSR. When DSR + SSV_CLD were applied, the values of the processing time were reduced by 19.09 % as against the DSR and by 24.89 % when compared with DSR+SSV.

When the DSR+SSV was implemented into the destination node the processing time increased by 12.37 % as compared with DSR under the same conditions. In the case of the destination
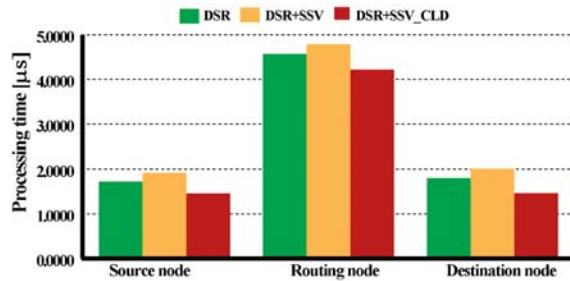
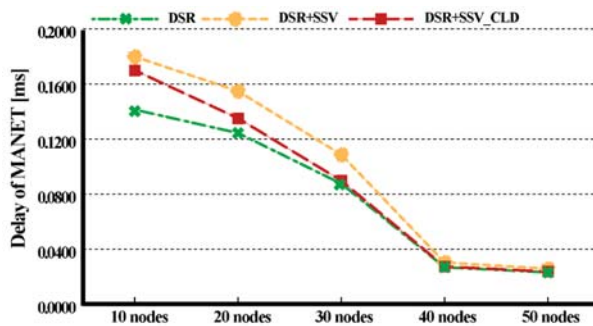*Fig. 4 Processing time for source, routing and destination nodes*

*Fig. 5 Delay of MANET [ms] analysis depending
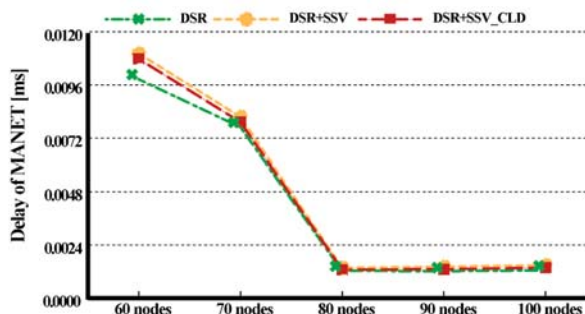on the number of nodes for 10–50 nodes*

*Fig. 6 Delay of MANET [ms] analysis depending
on the number of nodes for 60 -100 nodes*

*Fig. 7 Total packet processing delay of MANET [ms] analysis
depending on the number of nodes for 10-50 nodes*

*Fig. 8 Total packet processing delay of MANET [ms] analysis
depending on the number of nodes for 60-100 nodes*

node, implementation of the DSR+SSV_SSV represents a decrease of processing time when compared with DSR (by 16.80 %) and DSR_SSV (by 19.15 %). The implementation of CLD into the MANET model (DSR+SSV_CLD) provides reduction of the processing time compared with DSR model and model DSR+SSV.

The final results from second experiment, in which the delay of the MANET network was analysed and studied, are displayed in Fig. 5 and 6. The results showed that the delays of the MANET were increased after implementation of DSR+SSV_CLD by 20.21 % as compared with the standard DSR and by 27.24 % when usin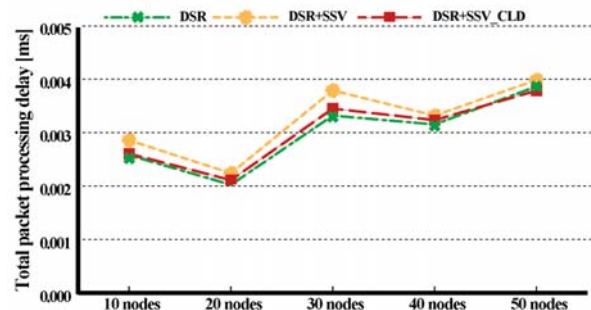g DSR+SSV. However, applying DSR + SSV_CLD reduced the delay by 5.52 % as compared with DSR+SSV. The lowest increase of the delay value was achieved for 50 nodes – the average delay after applying DSR + SSV_CLD increased only by 2.41 % and by 11.36 % using DSR + SSV as compared with the standard DSR protocol and applying DSR + SSV increased by 11.36 %.
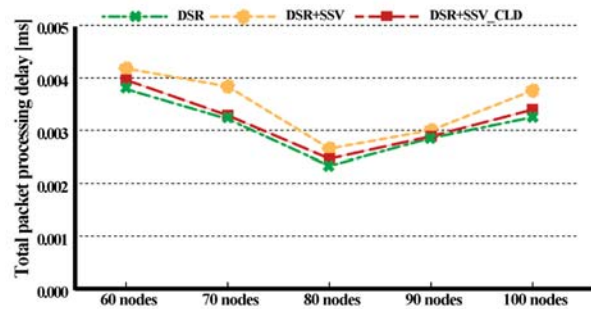
In the last experiment the total packet processing delay was analyzed. All the obtained results are displayed in Fig. 7 and 8. For example, when DSR+SSV_CLD were applied in MANET consisting of 50 nodes, the total packet processing delay was reduced by 3.13 % against the standard DSR protocol and the application of the SSV + DSR meant achieving an increase (about 3.16 %).

6. Conclusions

The new model has been designed for cooperation between QoS and security mechanisms in MANET. In order to test the functionalities of the new model, which includes the modified SSV and CLD, the simulation testbed analysis of three MANET models were presented. The models DSR, DSR+SSV, DSR+SSV_CLD were analysed. All simulations were simulated in OPNET modeler. Based on the collected results (see section Simulation Results) of processing time, delay and total packet processing delay, we can conclude that our designed integration model with CLD and modified SSV for MANET represents a insignificant increase of these

parameters in MANET. This model is also useful for the processing of QoS and security integration for MANET.

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