OPNET MODELER SIMULATION TESTING OF THE NEW MODEL USED TO COOPERATION BETWEEN QOS AND SECURITY MECHANISMS

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Abstract. *In this article the performance analysis of the new model, used to integration between QoS and Security, is introduced. OPNET modeler simulation testing of the new model with comparation with the standard model is presented. This new model enables the process of cooperation between QoS and Security in MANET. The introduction how the model is implemented to the simulation OPNET modeler is also showed. Model provides possibilities to integration and cooperation of QoS and security by the cross layer design (CLD) with modified security service vector (SSV). An overview of the simulation tested of the new model, comparative study in mobile ad-hoc networks, describe requirements and directions for adapted solutions are presented. Main idea of the testing is to show how QoS and Security related services could be provided simultaneously with using minimal interfering with each service.*

Keywords

MANET, security, Quality of Service, modified security Service Vector.

1. Introduction

Mobile Ad Hoc Network (MANET) is a collection of mobile nodes with wireless interfaces that communicate with each other by wireless links with self-configuring features. MANET is defined also as a mobile network without any centralized management. MANET nodes can establish and maintain connections as needed without any fixed infrastructure.

Mobile nodes operate as not only end terminal but also as an intermediate router. MANET is characterized as a dynamic network with the ability of the nodes to join or leave the network at randomly set times and ways [1]. In MANET, the research communities and organizations are oriented to following categories:

- Quality of Service (QoS),
- Security,
- Cross Layer Design.

The notion of 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, etc., [1]. In MANET, QoS is essential to satisfy the communication constraints. Research in the field of QoS is oriented to areas of QoS Models, QoS Resource Reservation Signalling, QoS Routing and QoS Medium Access Control (MAC) [2]. Security issues are detected in many different areas. Security solves the problem of protected communication between mobile nodes in a hostile environment [4]. In MANET, there are solved problems of physical security, key management, secure routing and intrusion detection [3]. The cross-layer design (CLD) approach is a new dynamic area of research into MANET networks. This approach provides new possibilities to increase the performance and adaptability of MANET [5].

Today in the research literature, security mechanisms are interpreted only as a dimension QoS. The problem was the absence of the mechanism to the process of integration QoS and security. There have been designed a few concepts of providing security as a dimension of QoS has called variant security. The term Quality of Security Service (QoSS) has been coined by authors Irvine at al. [6]. A Security Service Vector (SSV) has been presented to describe functional requirements of security policies. SSV was proposed to represent the level of services within the range of security services and mechanisms [7]. In this article, we analyze the behaviour of the new model used to cooperation between QoS and security mechanisms in OPNET modeler environment. The main advantage of this model is that the model provides the ability for different services and not only for QoS and security in MANET.

2. New Model to Cooperation of the QoS and Security in MANET

In OPNET, we have designed and implemented the new model that enables the process of cooperating security and QoS as a one parameter via modified Security Service Vector (SSV) and Cross Layer model (CLD) in MANET [8], [9]. Model enables the cooperation of the five blocks (Fig. 1).

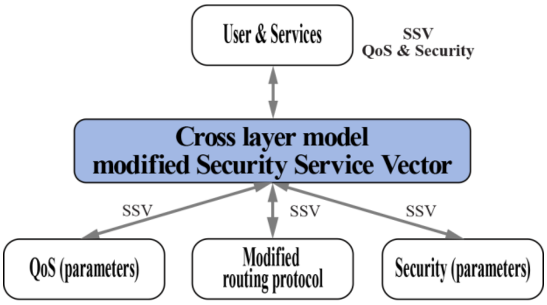

Fig. 1: The new model used to QoS and security integration model with cross layer interface and modifies security service vector.

The main block of our model is block *Cross layer model + modified Security Service Vector*. CLD is used to create an interactive environment between users and the system and, at a time, is used to support interactions between the routing protocol and modified security service vector (SSV). 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 or provide information about what type of service can nodes provide. Block *Security (parameters)* represents a mechanism to provide security-related services and also defines the necessary parameters used to providing of requested services. Block *User&Service* enables the interaction between the user and the system that means the user can define parameters for the type of service, which has to be achieved for services. 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 part of the new model is modified SSV and cross layer model or interface (CLD). Processing of the modified SSV is classified into two parts: user and system parts. The user part deals with 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]. In this model, users can specify the required parameters and using 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 has implemented 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). A main functionality of modified SSV is shown in Fig. 2.

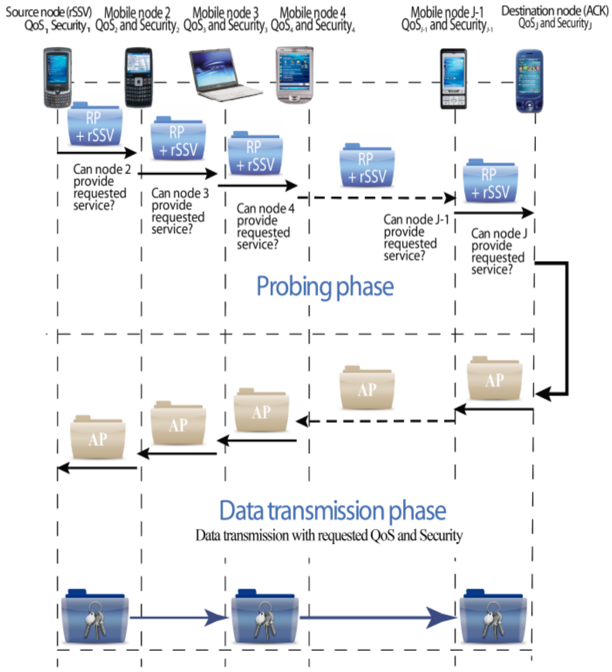

Fig. 2: Main functionalities of modified SSV in MANET.

CLD is used to process of bidirectional collection relevant data from the application or network layer by modified SSV (Fig. 3), [10]. These data are used for a routing process by the DSR routing protocol. Model also enables cooperation between QoS and security mechanisms by the new designed cross layer model and modified SSV.

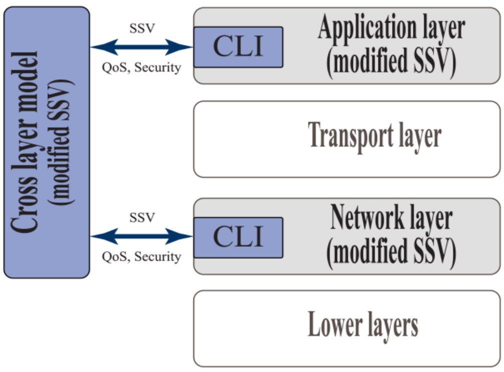

Fig. 3: New cross layer model to process of collecting SSV data (QoS and security) in MANET.

3. Simulations and Results

In order to simulate of processing of the designed model, the three simulation scenarios have been used. Model DSR was used to simulation of the networks without implemented modified SSV and CLD and data are transmitted by each layer of the layer model. These simulations provide the reference values. Model DSR+SSV was used to simulation of the model with implemented modified SSV. In this model, data are transmitted by each layer without implemented CLD model. The last model DSR+SSV_CLD provides our new model with implemented modified SSV and CLD interface.

3.1. OPNET Modeler Simulations Scenarios

In OPNET Modeler [11], two simulation scenarios were developed in order to verify the activities of the designed model. In the first experiment is monitored how increasing in traffic, by applying the new designed model with modified SSV and CLD, can affect behaviour of the network. The burden in this case is seen as the number of randomly selected nodes [%] to generating traffic (packets), thus becoming simultaneously the source, routing and destination nodes. In the second experiment was analyzed how the process of increasing of the nodes that could affect the parameters of delay and total packet processing time. Randomly generated in each simulation were sets of nodes (20 %, 40 %, 60 %, 80 %) that could not provide user specified requirement for services. In this case, only two scenarios were compared, namely DSR+SSV and DSR+SSV_CLD.

Tab.1: Delay of MANET [ms] analysis depending on the number of traffic generating nodes [%].

Area	Number of nodes	Model	Ratio of traffic generating nodes [%]				
			20 %	40 %	60 %	80 %	100 %
500×500 m^2	10	DSR	3,16	3,52	3,16	4,31	4,14
		DSR+SSV	3,38	4,53	5,45	5,12	4,58
		DSR+ SSV_CLD	3,17	3,41	4,35	4,43	4,17
	20	DSR	2,39	2,92	3,06	4,22	5,12
		DSR+SSV	2,97	3,83	3,93	4,31	6,16
		DSR+SSV_CLD	2,53	2,95	3,38	4,25	5,14
	30	DSR	3,45	4,04	4,09	5,93	6,19
		DSR+SSV	4,19	4,25	4,83	7,26	6,81
		DSR+SSV_CLD	4,16	3,84	4,37	6,53	6,59
	40	DSR	1,92	2,27	2,64	2,22	2,68
		DSR+SSV	2,43	2,63	2,84	2,95	3,02
		DSR+SSV_CLD	1,98	2,42	2,67	2,69	2,73
	50	DSR	1,42	1,95	2,69	4,26	5,23
		DSR+SSV	1,95	2,16	3,58	4,87	6,26
		DSR+SSV_CLD	1,63	1,96	3,07	4,37	6,24
1000×1000 m^2	60	DSR	1,65	3,03	7,02	8,21	8,55
		DSR+SSV	1,84	3,40	8,07	9,87	9,10
		DSR+SSV_CLD	1,71	3,20	7,85	9,54	8,78
	70	DSR	0,97	2,26	2,40	3,67	7,69
		DSR+SSV	0,99	2,62	2,82	3,88	8,16
		DSR+SSV_CLD	0,94	2,33	2,50	3,76	7,92
	80	DSR	1,05	2,04	2,45	2,51	2,81
		DSR+SSV	1,32	2,36	2,60	2,75	3,24
		DSR+SSV_CLD	1,10	2,26	2,46	2,61	2,91
	90	DSR	2,42	2,26	3,44	3,15	3,51
		DSR+SSV	2,57	2,42	3,87	3,62	4,14
		DSR+SSV_CLD	2,54	2,32	3,58	3,82	4,03
	100	DSR	2,89	3,00	3,35	3,52	3,91
		DSR+SSV	3,41	3,32	3,74	3,82	4,01
		DSR+SSV_CLD	3,03	3,17	3,49	3,62	3,81

During all simulations, two parameters were analyzed: Delay of MANET and Total packet processing delay.

Tab.2: Total processing delay of MANET [ms] depending on the number of traffic generating nodes [%].

Area	Number of nodes	Model	Ratio of traffic generating nodes [%]				
			20 %	40 %	60 %	80 %	100 %
500×500 m^{-1}	10	DSR	1,65	2,04	2,35	2,41	2,58
		DSR+SSV	2,32	2,33	2,66	2,58	2,86
		DSR+SSV_CLD	2,01	2,09	2,47	2,49	2,61
	20	DSR	2,00	2,06	2,10	2,01	2,03
		DSR+SSV	2,10	2,22	2,21	2,13	2,24
		DSR+SSV_CLD	2,07	2,16	2,16	2,04	2,11
	30	DSR	1,88	2,49	2,40	2,97	3,32
		DSR+SSV	2,19	2,75	2,62	3,40	3,79
		DSR+SSV_CLD	2,07	2,16	2,47	3,15	3,45
	40	DSR	1,29	1,85	2,17	2,45	3,16
		DSR+SSV	1,70	1,93	2,62	2,84	3,32
		DSR+SSV_CLD	1,30	1,73	2,16	2,75	3,24
	50	DSR	1,52	2,12	2,52	3,01	3,87
		DSR+SSV	1,70	2,47	2,75	3,33	3,99
		DSR+SSV_CLD	1,66	2,15	2,54	3,07	3,79
1000×1000 m^{-1}	60	DSR	1,83	2,62	3,57	3,95	3,78
		DSR+SSV	2,19	2,90	3,97	4,14	4,18
		DSR+SSV_CLD	1,90	2,73	3,73	4,00	3,96
	70	DSR	1,50	2,30	3,21	4,10	3,22
		DSR+SSV	1,74	2,42	3,55	4,33	3,84
		DSR+SSV_CLD	1,44	2,05	3,23	4,11	3,29
	80	DSR	1,59	2,81	2,47	2,04	2,33
		DSR+SSV	1,69	2,93	2,72	2,34	2,66
		DSR+SSV_CLD	1,67	2,82	2,47	2,04	2,46
	90	DSR	2,40	2,53	2,59	2,66	2,86
		DSR+SSV	2,64	2,66	2,79	2,95	3,00
		DSR+SSV_CLD	2,49	2,59	2,70	2,80	2,89
	100	DSR	2,44	2,63	2,69	2,66	3,25
		DSR+SSV	2,80	3,09	3,10	2,95	3,76
		DSR+SSV_CLD	2,66	2,82	2,76	2,80	3,39

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. The processing time of all processes necessary for modified SSV during source-target transport is also taken into the delay of MANET. Total packet processing delay 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.

3.2. OPNET Modeler Simulations Setup

To verify the functionalities of the proposed model, we prepared 10 simulation scenarios in OPNET Modeler to check the effectiveness of operation of the modified SSV and CLD in MANET. The simulation scenarios were formed of 10−100 mobile nodes. Simulation areas for networks consisting of 10−50 nodes were 500×500 m^2 and for networks consisting of 60−100 nodes were 1000×1000 m^2. The free space propagation model with power set up to 1 mW was used for all simulations. The random mobility model was used to simulate the mobility of nodes. Speed was randomly changed from 0 to 2 m·s^{-1}. Simulation period has been in all cases 1000 seconds. At the beginning of the simulations, the initial value of movement was changed. This parameter gives a different initial position of individual nodes in the simulated project. The result of each simulation was a set of values that were then statistically processed and evaluated. Each sample was made up of a set of 100 values from each simulation (10000 values were recorded).

3.3. Simulation Results

In the first experiment, there was analyzed how affect changing of the number of nodes that generating the traffic [%] the behaviour of the network. In this case, the behaviour of the MANET was characterized by Delay of MANET and Total packet processing delay. Table 1 and Tab. 2 show the comparative study of these two parameters. Based on collected results, it can be concluded that the integration of modified SSV (DSR+SSV) into MANET layer model represented an increase in the values as compared with standard layer model (DSR). After applying CLD to MANET, the delay was reduced in comparison with DSR+SSV. These situations could be caused by density distribution of nodes and their mobility - the values depended on the distribution and movement of nodes and by the activity modified SSV and CLD. All delays would be increase mainly by decision algorithms of modified SSV and CLD on routing nodes.

Tab.3: Delay of MANET [ms] analysis depending on number of nodes incapable of providing the required services [%].

Area	Number of nodes	Model	Ratio of nodes that can't provide requested services [%]			
			20 %	**40 %**	**60 %**	**80 %**
500 × 500 m²	**10**	**DSR+SSV**	4,08	4,40	7,10	9,72
		DSR+SSV_CLD	3,74	5,93	6,25	9,18
	20	**DSR+SSV**	2,84	1,74	3,87	4,52
		DSR+SSV_CLD	2,53	1,39	3,26	3,92
	30	**DSR+SSV**	3,13	3,45	5,30	5,91
		DSR+SSV_CLD	2,75	3,29	4,86	5,64
	40	**DSR+SSV**	2,20	1,97	2,63	3,30
		DSR+SSV_CLD	1,86	1,81	2,45	2,99
	50	**DSR+SSV**	2,42	2,91	2,67	3,61
		DSR+SSV_CLD	1,78	2,42	2,57	2,80
1000 × 1000 m²	**60**	**DSR+SSV**	2,35	2,61	3,59	4,31
		DSR+SSV_CLD	2,29	2,25	3,06	4,10
	70	**DSR+SSV**	1,33	1,08	1,13	1,76
		DSR+SSV_CLD	1,18	0,95	1,01	1,59
	80	**DSR+SSV**	2,43	1,91	1,57	1,02
		DSR+SSV_CLD	2,13	1,73	1,40	8,89
	90	**DSR+SSV**	1,23	1,13	1,60	2,12
		DSR+SSV_CLD	1,09	1,05	1,28	1,80
	100	**DSR+SSV**	1,80	1,64	1,85	2,00
		DSR+SSV_CLD	1,47	1,47	1,75	1,85

Main idea of the second experiment was to determine the impact of the increasing number of nodes that fail to provide the required services to activity of modified SSV algorithm and the activity of MANET network itself. The effect of delays in the MANET network on timely delivery of packets when transmitting from the source to the destination node was analyzed. Since the standard DSR protocol does not allow comparison of this information, only two types of simulations - using DSR routing protocol implemented with a modified SSV (SSV+DSR) and using a modified routing protocol implemented with a modified SSV and CLD (DSR+SSV_CLD) were compared.

Tab.4: Total processing delay of MANET [ms] analysis depending on the number of nodes incapable of providing the required services [%].

Area	Number of nodes	Model	Ratio of nodes that can't provide requested services [%]			
			20 %	**40 %**	**60 %**	**80 %**
500 × 500 m²	**10**	**DSR+SSV**	2,33	2,35	2,20	3,25
		DSR+SSV_CLD	2,14	1,99	1,96	2,80
	20	**DSR+SSV**	2,67	2,94	3,29	3,85
		DSR+SSV_CLD	2,05	2,37	3,10	2,88
	30	**DSR+SSV**	6,51	7,61	7,69	8,29
		DSR+SSV_CLD	5,75	6,05	6,35	7,25
	40	**DSR+SSV**	1,89	1,93	2,16	2,80
		DSR+SSV_CLD	1,75	1,58	1,95	2,66
	50	**DSR+SSV**	2,82	2,65	2,86	3,82
		DSR+SSV_CLD	2,55	2,34	2,56	3,58
1000 × 1000 m²	**60**	**DSR+SSV**	2,57	2,44	2,27	3,14
		DSR+SSV_CLD	2,41	2,29	2,15	2,99
	70	**DSR+SSV**	2,99	6,09	6,42	6,47
		DSR+SSV_CLD	2,91	5,51	5,50	5,58
	80	**DSR+SSV**	3,72	3,27	3,32	3,17
		DSR+SSV_CLD	3,16	3,01	3,20	2,99
	90	**DSR+SSV**	1,34	1,74	2,20	2,47
		DSR+SSV_CLD	1,19	1,55	1,93	2,35
	100	**DSR+SSV**	1,25	1,35	1,59	6,04
		DSR+SSV_CLD	1,14	1,25	1,38	4,98

Table 3 indicates values of the delay of MANET for different numbers of nodes that can't provide requested services and Tab. 4 total processing delay of MANET under the same conditions. In all cases, the DSR+SSV_CLD provides better results than model DSR+SSV.

4. Conclusion

In this article, the new model used to cooperation between QoS and security mechanism in MANET by OPNET modeler were introduced. The performance analysis of three MANET models is introduced and tested. We have analyzed model DSR which presents standard layer model, model DSR+SSV which presents a new model with integrated modified SSV and model DSR+SSV_CLD which include cooperation between modified SSV and CLD. Based on collected results for delay and total packet processing delay, we can conclude, that implementation of our model with integrated modified SSV and CLD to the MANET in OPNET modeler resulted in insignificant increase of these followed parameters.

On the other side, when only the modified SSV was implemented, the values of these followed parameters were increased dramatically. The implementation of CLD model to our new model with modified SSV represents a useful tool for reduction of the time necessary to processing of all operations on the all type of nodes in MANET networks. Deviations were caused by that activity modified SSV and physical parameters MANET network.

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