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Multiple Layer Service Dependent Security-Aware Packet Scheduling Algorithm

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ABSTRACT
This paper provides the detailed information about the multiple layer based service-level dependent security-aware packet scheduling algorithm in mobile ad-hoc networks for reducing degradation of the performance of packet scheduling algorithm based on the consideration of the packet dependencies among multiple layers. This paper describes how multiple layer based service dependent security-aware packet scheduling algorithm improves the correlation of packet dependencies between multiple layers and enhancing the packet level security.

Keywords: Service-level, Dependent, Dependencies, Correlation.

1. INTRODUCTION

Dynamic networks like MANET are mostly used for providing various services. In these networks, the performance degradation of services plays an important role for managing the services efficiently. The dynamic security mechanisms are provided for transmitting the data packets securely by using scheduling algorithms.In which, inter and intra-service dependencies between the packets along with security level are considered for packet transmission. For this purpose, ISDSPS and IISDSPS algorithms are proposed effectively with less latency and communication overhead. However, the performance of services is affected due to time duration across different layers of networks. The correlation of the dependencies between the packets across multiple layers is not considered in multiple layer scenarios. Therefore, the correlation of the dependencies across multiple layers is required for reducing the packet scheduling performance degradation. Hence, in this paper, multiple layer based service dependent security-aware packet scheduling algorithm is proposed including with the inter-intra service dependencies of packets. In this approach, a causality graph is constructed based on the Service-Layer Dependency Graph (SLDG) for evaluating the fault propagation among different services. In addition, the scalability issue is addressed by using the network tomography method. In addition, the spatial correlation is utilized between services to effectively narrow down the possible states of individual services. In this paper, intra-inter and multiple layer service dependent security-aware packet scheduling algorithm is described in brief.

2. NETWORK TOMOGRAPHY MODEL

The network tomography is utilized for fault diagnosis at the network layer level (Lawrence, E., et al. 2006). The major objective of the network tomography is inferring the link-level properties from the network topology and e2e client-service measurements. The faults are diagnosed by the large linear system which represents the relation between path and link properties must be solved. The problem is formulated based on the spatial correlation as,

$$Y = AX \qquad (1)$$

Where, Y is the e2e client-service measurements matrix, A is the routing matrix, and X is the internal states of the links. However, the issue in network tomography is that fundamentally underconstrained such that in the network-level performance diagnosis there exists in the system whose status cannot be determined uniquely. Therefore, the proposed model of dependencies among different services and the measured service performance are described in terms of their success probabilities perceived by clients. Hence, the proposed approach is designed based on the network tomography model.

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3. INTRA-INTER AND MULTIPLE LAYER SERVICE DEPENDENT SECURITY-AWARE PACKET SCHEDULING ALGORITHM (IIMLSDSPS)

In this section, our proposed inter-intra and multiple layer based service dependent security-aware packet scheduling algorithm is described. Initially, the ISAPS algorithm is performed based on the dependence discovery method by using dependence graph model.In this section, the proposed IIMLSDSPS approach is explained briefly.

3.1 System Model

In our proposed system, the set of clients, $C = \{1, \ldots, |C|\}$ are monitored for their successes or failures while accessing different services. For service dependencies, two system-level graphs are utilized such as Directed Acyclic Graph (DAG) and Service-Layer Dependency Graph (SLDG). The Directed Acyclic Graph (DAG) is provided for representing the local dependency graph for client services.

3.2 Service-Level Dependency Graph (SLDG)

The Service-Level Dependency Graph (SLDG) is utilized for representing the global dependency graph for client services. The global SLDG $SLDG =< S, D >$ is defined as the union of all local dependency graphs $(DG =< S_i, D_i)$ for clients i. Here, $S = \bigcup_{i \in C} S_i$, and $D = \bigcup_{i \in C} D_i$ are represents the all possible service dependencies required for all requests of clients. The model of SLDG is given in figure 1.

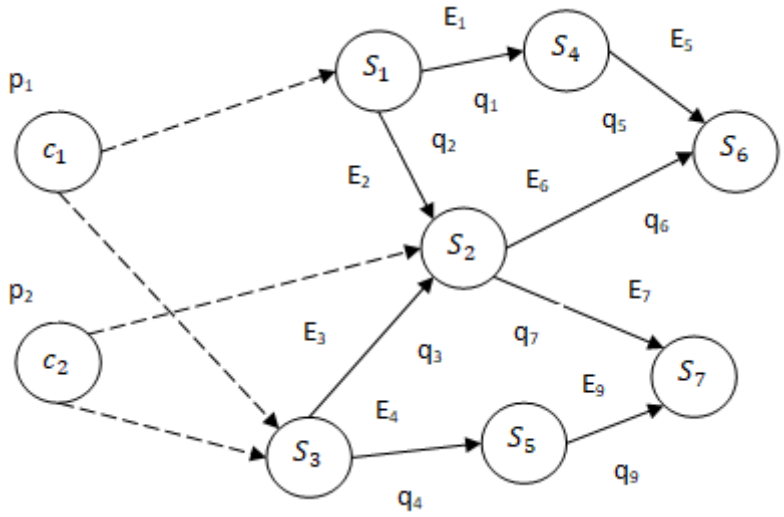

Figure-1: Example of SLDG

3.3 Monitoring Model

The measurements are gathered for evaluating the following probabilities.

- p_i for $i \in C$ is the success probability of e2e client-service dependency i. The vector of all p_i represents the monitored values.
- q_j for $j = (x, y) \in D$ is the success probability of the inter-service dependency between the services $x \; and \; y$. The vector of all q_j represents the internal states.

The client request is satisfied by assuming the all inter-service dependencies in the local dependency graph are successful. Hence, $p_i = 1 - \prod_{j \in D_i}(1 - q_j)$ and for all $i \in C$, $y_i = ln(1 - p_i)$ is defined and for all $j \in D$, $x_j = ln(1 - q_j)$ is defined. Hence, we have $Y = (y_1, \ldots, y|C|)$ and $X = (x_1, \ldots, x|D|)$.

3.4 Tomography based Algorithm

The proposed algorithm has two steps such as one is used for building the hypotheses list and the other is used for rating those dependencies of packets for determining the internal states of services efficiently (Tati, S., et al. 2011). In the first step, the network tomography is used for enumerating the all possible

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dependencies of packets for reducing the performance degradation in services. The linear equation $Y = AX$ is used for providing solution for our proposed approach. The $(|C| \times 1)Y$ matrix is used for representing success probabilities of clients; the element $\{a_{ij}\}$ in the $(|C| \times |D|)$ dependency matrix A is 1 if $j \in D_i$ otherwise zero, and the $(|D| \times 1)$ matrix X is used for representing the internal states of the services. Consider, the linear system is underconstrained. Therefore, number of solutions is obtained for a given input. These solutions are listed as possible dependencies of packets in the hypotheses list.

In the second step, these possible dependencies of packets are ranked by using particular characteristics of services and the other constraints at the service layer. One of the characteristics that the spatial correlation of the nodes is used which provides the services. The second possible constraint is the policies which are deployed across the networks. These policies are precluded the particular services from running on certain nodes or precluded two services from interacting. The different dependencies of packets are ranked in the hypotheses list by using these additional constraints.

Therefore, the highly correlated dependencies of packets are collected and the high security level is provided for packet transmission. Thus, the packets are scheduled based on the proposed IIMLSDSPS approach which reduces the performance degradation of the algorithm.

Algorithm: IIMLSDSPS

Input: packet count, bandwidth, packet size, arrival rate, deadline, target service and security level

1. Check the schedulability condition

$$st_i + pt_i \leq dl_i$$

$$\forall p_q, o_q < o_i,\ w_q = 1:\ st_q + pt_q \leq dl_q$$

2. Clustering the real time service packets based on similarity measurement

$$D(U) = \sqrt{\sum_{s=1}^{n} |p(T_s) - p(C_s)|^2}$$

3. Prioritizing intra dependency clusters and packets within the intra dependency cluster
4. Find correlation of dependencies of packets using spatial correlation approach

$$Y = AX$$

5. Find the probability of e2e client-service measurements and inter-service dependencies of packets
6. Check whether there is any packet in inter service dependency cluster is related to intra service dependency cluster

$$S_{ID} = \min(Euclidean\ distance\ between\ two\ packets\ from\ each\ cluster)$$

7. If yes, then give same priority as that of intra service dependency cluster packets
8. Calculate the start time of each prioritized packets intra service dependency

$$st_i = a_i + \sum_{o_k < o_i, w_k = 1} pt_k + r$$

9. Calculate the total processing time of packets with respect to deadline time

$$pt_i = t_i + dt_i + so_i$$

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10. Provide security level to each packets

$$\max_{p_i \in p(T_s)} \sum_{i=1}^{m} z_i$$

$$\max_{p_i \in p(T_s)} \left\{ \sum_{i=1}^{m} z_i \, s_i / \sum_{i=1}^{m} z_i \right\}$$

11. Scheduling the packets

4. PERFORMANCE EVALUATION

The performance of the proposed security-aware packet scheduling algorithms is evaluated by using Network Simulator-2 (NS2). Consider, the number of nodes is 200 and the packet size is 5KB. The comparison is performed based on the performance metrics such as guarantee ratio, average security level, packet delivery ratio, and end-to-end delay. The parameters utilized for comparison are such as deadline of packets and packet arrival rate. Algorithms considered for comparison are ISDSPS, IISDSPS, and IIMLSDSPS.

4.1 Guarantee Ratio (%)

The Guarantee Ratio (GR) is computed as follows,

$$GR\ (\%) = \frac{Total\ number\ of\ packets\ guaranteed\ to\ meet\ their\ deadlines}{Total\ number\ of\ packets} \times 100\%$$

Deadline versus Guarantee Ratio (%)

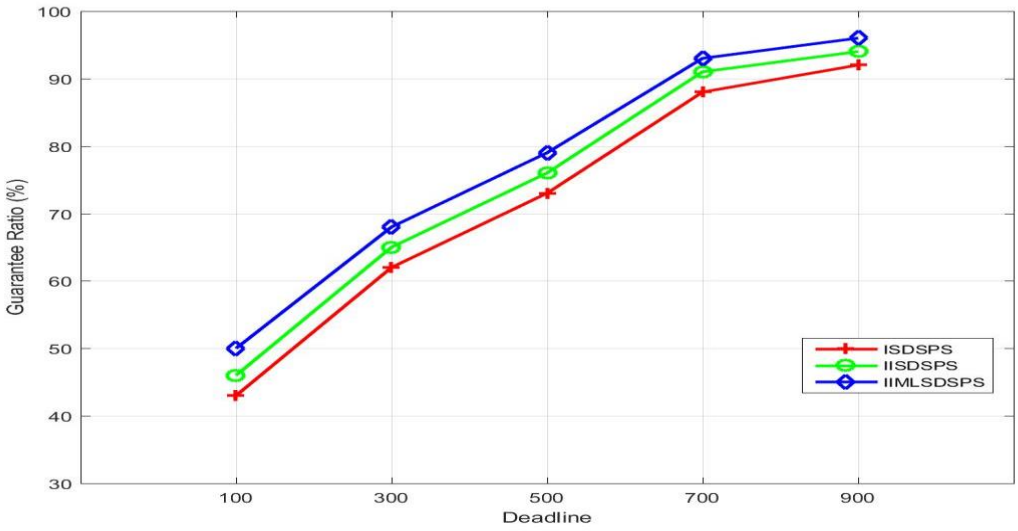

Figure-2: Deadline versus Guarantee Ratio (%)

Figure 2 shows that the result of guarantee ratio comparison in terms of deadline. From the graph, it is proved that, if the deadline increases then the guarantee ratio (%) is also increases. The major reason for achieving high guarantee ratio is that when packets have loose deadlines, they can more easily be delivered before their deadlines. Thus, the guarantee ratio is increased. The proposed IIMLSDSPS has higher guarantee ratio than the other algorithms.

4.2 Average Security Level

The average security level is defined for representing the security of accepted packets.

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Deadline versus Average Security Level

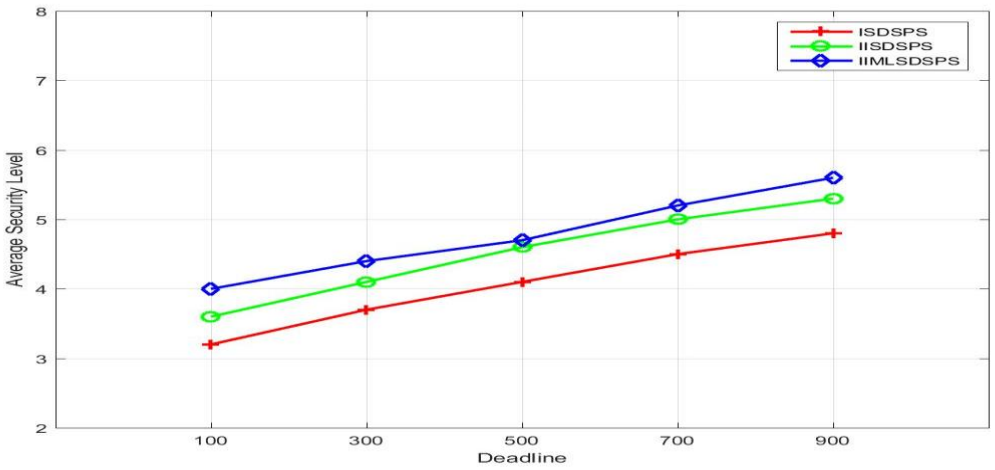

Figure-3: Deadline versus Average Security Level

Figure 3 shows that the result of average security level comparison in terms of deadline. From the graph, it is proved that, if the deadline increases then the average security level is also increases. The major reason for achieving high average security level is that ISDSPS cannot effectively adjust the security levels of accepted packets due to the lacking of the ability for adapting to the system workload changes. Thus, the average security level is increased. The proposed IIMLSDSPS has higher security levels than the other algorithms by satisfying the user's requirements.

4.3 Packet Delivery Ratio (PDR)

The packet delivery ratio is defined as the fraction of number of delivered data packets to the destination and is measured as follows,

$$PDR = \frac{Total\ number\ of\ received\ packets}{Total\ number\ of\ transmitted\ packets}$$

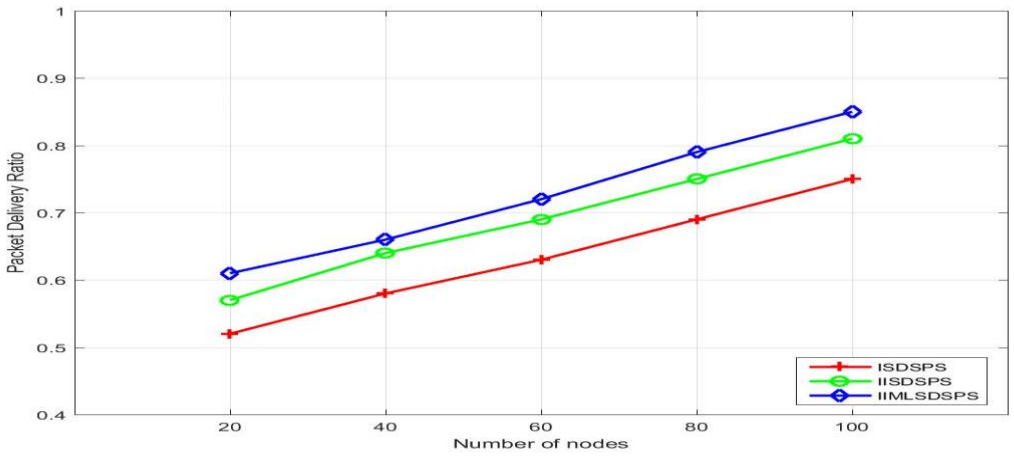

Figure-4: Number of Nodes versus Packet Delivery Ratio

Figure 4 shows that the comparison of packet delivery ratio. From the graph, it is proved that, when number of nodes increases the packet delivery ratio is also increases due to the proper schedulability and security,

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more number of transmitted packets is delivered to the destination successfully. The proposed IIMLSDSPS has higher packet delivery ratio than the other algorithms.

4.4 End-to-End Delay

The end-to-end delay is defined as the time period which is taken for the packet transmission from source to destination and is computed as,

$$End - to - end\ delay = \frac{Total\ delay\ of\ packets\ received\ by\ the\ destination}{Number\ of\ packets\ received\ by\ the\ destination}$$

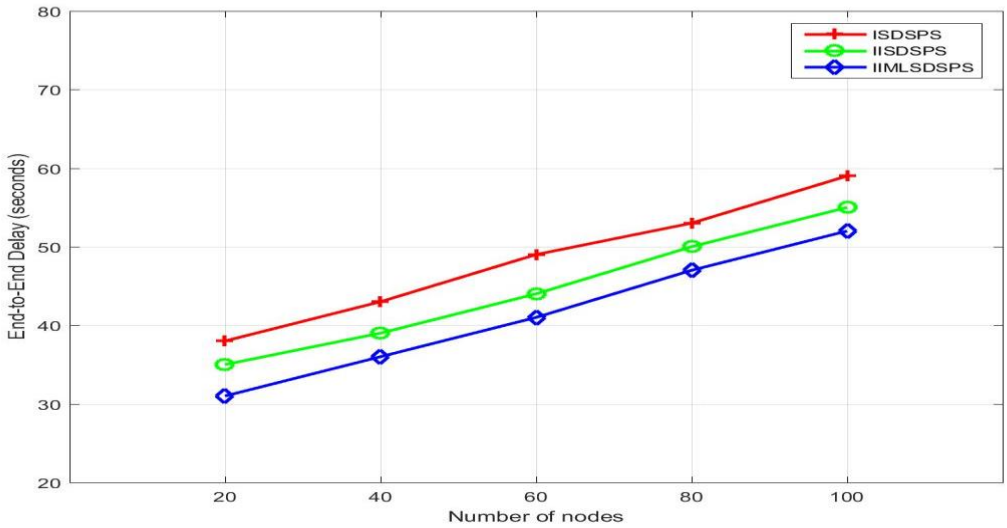

Figure-5: Number of Nodes versus End-to-End Delay (Seconds)

Figure 5 shows that the comparison of end-to-end delay. From the graph, it is proved that, when number of nodes increases the end-to-end delay is decreases due to the packets are scheduled based on their deadline time and service which provides the reduction in delay time. The proposed IIMLSDSPS has less end-to-end delay than the other algorithms.

5. CONCLUSION

In this paper, the issues of the correlation of dependencies of packets which are coming from multiple layers in mobile ad-hoc networks by using security-aware packet scheduling algorithm are considered. These issues are removed by introducing the multiple-layer based service-dependence discovery method which is combined with inter and intra-service dependence discovery algorithm and the service dependencies of packets are achieved by using service-level dependence graph (SLDG) as global dependency graph instead of dependence graph (DG). Moreover, the constraints for correlation of dependencies of packets are solved by constructing the hypothesis list and the correlation of dependencies are rated for improving the packet scheduling performance. Hence, the proposed IIMLSDSPS algorithm performs better than the IISDPS based algorithm. The experimental results are proved that the proposed IIMLSDSPS has better performance than the other algorithms.

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