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A Novel Cross Layer Framework Design To Avoid Fragmentation At Intermediate Router

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Abstract: The segments which are a divided data packets do not have a specific segment size but mostly the default packet (segment) size is 1500 bytes. Which may be found less than the segment size of certain router on the path specified to the host destination, where unfortunately the maximum transmission unite (MTU) of each router differs from one to another, according to the protocol used and the type of network causing the segment to be fragmented by an intermediate router. This paper presents a novel cross layer design to eliminate fragmentation process from occurring at intermediate router, by providing information on the minimum MTU from source to destination in advanced to avoid the fragmentation process, that occurs when a segment (packet) is larger than the MTU of an intermediate router. The idea is to maintain information on minimum MTU allowance in forwarding table of every router. Therefore, for the purpose of maintaining information on MTU, the work proposes a routing table with four columns to perform path routing along with the minimum MTU on the path instead of the existing three columns forwarding table. which does not provide information on the MTU allowance.

Keywords: Cross Layer design, Segmentation, MTU, Fragmentation, Routing table.

1 Introduction:

The world is connected by a big network called internet, each device of the network differs from other devices, these devices are connected with two different protocol first one called internet protocol version 4 (IPv4) where the second one is called internet protocol version 6 (IPv6), of course the IPv6 is an advance version of the IPv4 with huge improvements and solutions for different issues. The internet protocol version 4 has been in service since the time of its creation the services it does is quite good, but the enormous increase of users who require IP addresses became an issue to the developers as it was estimated that by 2008 to 2018 the world will run out of IP addresses. thus the internet engineer task force (IETF) worked on the issue that resulted in complete change from IPv4 to the IPv6 which offers better structure in different issues of the IPv4 such as (A) IP address (B) IP data format (C) fragmentation etc. One of these issues is addressed in our research paper called fragmentation where MTU of each router plays a key to whether the fragmentation process would occur or not, depending on the MTU of the intermediate router. This work concern will be only on the fragmentation process and what could be done to avoid such process.

2 Related work:

A key problem in IPv4 today is address fragmentation; one entity is represented by multiple non-contiguous IP address blocks in the routing table. Address fragmentation increases routing table size, therefore degrades scalability. Existing address allocation practices are a major contributor to address fragmentation [1]. In order to assist in avoiding IP fragmentation at the endpoints of the TCP connection, the selection of the MSS value was changed to the minimum buffer size and the MTU of the outgoing interface (- 40). MSS numbers are 40 bytes smaller than MTU numbers because MSS is just the TCP data size, which does not include the 20 byte IP header and the 20 byte TCP header. MSS is based on default header sizes; the sender stack must subtract the appropriate values for the IP header and the TCP header depending on what TCP or IP options are being used, TCP MSS as described above takes care of fragmentation at the two endpoints of a TCP connection, but it doesn't handle the case where there is a smaller MTU link in the middle between these two endpoints [2]. When a packet of data is sent to the transport layer a process called segmentation occurs and certain packet size is provided to maintain stability of data transfer. Not all link-layer protocols can carry network-layer packets of the same size; some protocols can carry big data grams, whereas other protocols can carry only little packets. For example, Ethernet frames can carry up to 1.500 bytes of data, whereas frames for some wide-area links can carry no more than 576 bytes [3]. A fragment series, or simply a series, is an ordered collection of fragments resulted from a single original datagram. When fragmentation occurs, each fragment becomes a valid IP packet. All the fragments have their own IP header. Most of the fields of the IP header of the fragments are inherited from the original datagram IP header. The fields of interest are the ID field, Flags, and Offset [4]. The MSS is usually of 1500bytes. Standard Ethernet Frames are 1518 bytes, including the MAC header and the CRC trailer. Jumbo frames, supported by many Gigabit NIC and switch manufacturers, increase the size of an Ethernet frame to 9000 bytes. While jumbo frames do relieve both interrupt latency and stack processing pressures by allowing larger packets across the network at one time [5].

3 Proposed Cross layer framework design:

The study presents a novel framework which is designed to avoid the segmentation process at intermediate routers. The framework uses Cross layer design to exchange information on MTU allowance at an early stage in order for the segments to be set at a particular size maintained by maximum segment size (MSS). The segment size shall be less or equivalent to all intermediate routers on its path from source to destination. This study also proposes a routing table with added column called (MTU column) that contains the minimum MTU at intermediate routers. Adding a column to the existing table is a method out of multiple possible ways to find the minimum MTU at selected path. The information exchange starts from application layer which

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exchanges information (services) with network layer, information contains the entered IP address given by the user. The process begins by sending a copy of the IP address directly from application layer to network layer, without the need to pass the IP address through the next layer in the stack and wait for the IP to reach the network layer. This is done by adapting cross layer design, now considering the time saved while the original packet moves normally with the stack roles. at this point, it is important to note that the time needed for the process of path routing to be achieved and then submitting MTU allowance information to transport layer to automatically set the maximum segment size (MSS) less than the minimum MTU found in the path, is the time saved by using the cross layer design to exchange information. The process requires certain steps to achieve the desired result. Therefore, considering the possibility to avoid the fragmentation process is fascinating but there is more to this process than just avoiding the fragmentation, which is discuss more clear in section 5. For now, let`s assume that the minimum MTU found on certain path is (Token ring) 4096 bytes so MSS would be set at this particular size which means if we have a packet size of 10000 bytes it would be sent in three segments rather than seven segment Ethernet case, in such scenario several improvements can be achieved:

1- Improvements in throughput.
2- Channels less occupied.
3- Traffic decreased.
4- Faster data transfer.
5- Increasing the overall architecture performance.

In figure1 the process of information exchange between layers using the cross layer design is illustrated.

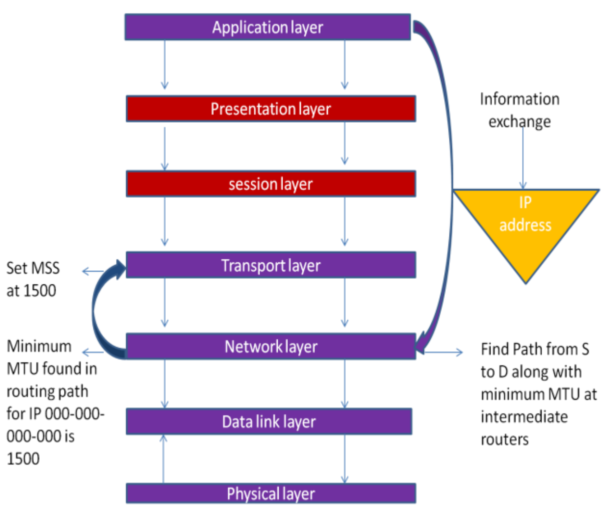

Figure 1 *shows information exchange among three layers to provide min MTU using OSI model.*

4 Routing table with MTU information exchange:

There are different number of routing protocols some the most popular protocols which are widely deployed in today`s routers are hop count routing protocols such as DSR, OLSR and AOD. Each router that maintain hop count protocol has a routing table consist of three columns,

- destination subnet.
- indicates the next router.
- indicated the number of hops.

Regardless the topology of each protocol our intention is to maintain a way for those routers to share the MTU of each as a part of their information exchange (advertisement), among all routers by any protocol. what matters to our work is obtaining a result of the MTU during the path routing which is done in network layer. For example, let's assume that a datagram is sent from source Y to destination D1, as illustrated in figure 4 there are multiple paths to D1 but the protocol uses the shortest path. As it is illustrated in figure2 that there are different paths to different routers but the routing table matric is forwarding the datagram after it chooses the shortest path with respect to the other factors that each protocol contains.

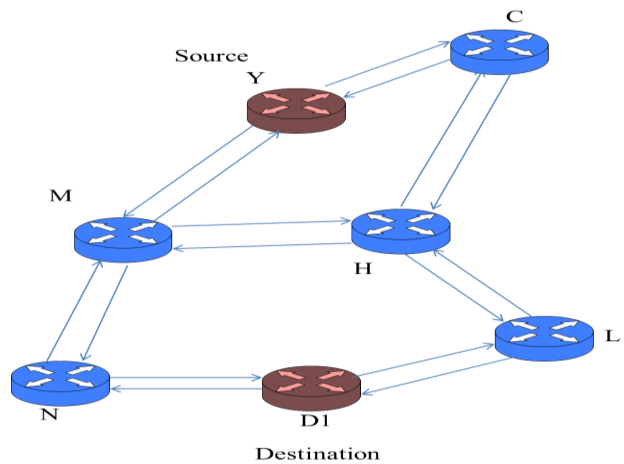

Figure 2 *shows routing process and intermediate routers*

The shortest path among all paths is determined according to the protocol used in each router. Eventually all mentioned protocols intend to reach the destination with the shortest path possible. A routing table is designed in table1 to understand how routing is done with respect to the routing paths in figure2. Note in the routing table there are two paths from the same neighbour router but each hope count is different, so the less hopes is the shortest path. Also note the only neighbour to Y is M and C other routers are subnet to Y. the source router Y exchanges information (advertisement) with M and C only.

Destination subnet	Next router	Number of hops to destination
D1	M	4
D1	C	4
H	C	2
D1	M	3
L	C	2

Table 1 *shows routing table (forwarding table) with three columns*

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Table 1 has three columns to perform the operations required but this table is unable to provide MTU because it was not designed to do such work. Therefore, for the MTU, it is required to add a new column to the existing once (column no.4) which can serve as MTU information provider during the time of information exchange (advertisement), which happens every 30 seconds as a part of the protocols existing. Furthermore, each router shall share its MTU with the neighbour routers as part of the information exchange. Keeping the minimum MTU of the router displayed, so when a routing process occurs the path routing can have along the way the minimum MTU in its path. Table2 illustrates the routing table with added column, which is the temporary storage for the minimum MTU from source to destination.

Destination subnet	Next router	Number of hops to destination	Minimum MTU
D1	M	4	1500
D1	C	4	2500
H	C	2	1500
D1	M	3	1500
L	C	2	576

***Table 2** shows routing table (forwarding table) with added column to find minimum MTU*

5 Result and Discussion:

Cross layer design can be a useful technique to exchange data from nonadjacent layers in order to pass information needed from one layer to another layer. Therefore, initializing a set of data services that can improve the overall architecture of the OSI model and TCP/IP. In the proposed framework the cross layer design is used to establish a relation between nonadjacent layers and to implement new services that would result in creating an early precaution ahead to avoid fragmentation at intermediate routers. The idea is simple it is known that OSI model and TCP/IP do not allow information exchange between layers except if they were neighbors, according to these roles cross layer design is the only solution to exchange layers' services at any level of the stack. The framework core idea is to provide information to the transport layer stating the minimum MTU on the path which was created by the network layer so that the information flow happens from lower layer to higher layer which is not possible and forbidden by the OSI model roles and TCP/IP roles. The need of applying cross layer has been a necessity as it saves time and improves the performance. The time duration that would be saved when a direct relation between application layer and network layer is performed is a very important aspect to consider because the uses of such time gab allows the process of finding the MTU to be performed without causing delay or decreasing the overall performance. Once the data with the specific IP address reaches the transport layer a data segmentation process is provided according to the information given on min MTU by network layer. The following points show more to the framework then just avoiding fragmentation process.

- During the entire process there will be no data transfer of the original data packet, the only part that would be transferred is a copy of the destination IP address taken from the data packet. The rest of the packet is passed from application layer to next layer according to the architecture roles until it reaches the transport layer.
- When the routing process takes place as mentioned the minimum MTU shall be considered. Let's suppose that the routers of certain path are capable of passing very high data packet then larger data packet (segment) carried which increases the performance and the transfer speed.
- The time saved by routing in advance is also another aspect to be considered where the packet would not need to perform any routing process at network layer because the path has been already found at the first stage of the process.

6 Conclusion:

This paper presents a novel cross layer framework design to prevent data fragmentation at intermediate routers. The proposed design exchanges information at nonadjacent layers starting by exchanging services between application layer and network layer. The application layer sends a copy of the IP address taken from the original payload to the network layer directly, where network layer performs path routing to find the path and the minimum MTU allowance on the selected path. Therefore, in order to find the minimum MTU, a routing table with four columns was proposed to provide information on MTU along with the path routing. When path routing along with minimum MTU is found information shall be passed from network layer to transport layer, so that the payload or the data packet will be segmented according to the minimum size allowance found on the path given from source to destination.

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