A Cross Layer Design for providing Routing and Qos in Mobile IPv6 Networks-ROMA

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Abstract

In this Paper we provide a solution to conflict between QOS and Routing in Mobile IP networks and name this solution MIP with ROMA (Reza rOuting MAlekian). Initially a set of requirements are established for a new solution. The fundamental idea is developed based on exercising routing optimization according to quality of service requirements and network conditions. We develop the MIP (Mobile IP) protocol stack with Cross-layer design technique. This design implies that new data flow collects the necessary parameters. This data is passed to a new data entity in the network layer of the MIP protocol stack.

Keywords: Optimize Routing, Cross layer, ROMA, position analysis, Routing analysis.

1. Introduction

A problem of RO is that packets sent by the CN (Correspondent Node) still use the triangle route until the CN receives the binding update message. An important implication arises when using protocols such as RSVP for providing Qos guarantees for communication between CN and MN (Mobile Node).

The RSVP's PATH and RESV messages contain a description of which resource reservations are being requested. This flow description contains a list of packet header fields that a router can use to distinguish packets for which the requested Qos must be provided from all other packets that might pass through the router.

The following problems arise when RSVP is used in conjunction with MIP or MIP with RO:

1) Routers will not be able to recognize a PATH message encapsulated while tunneled from HA to the MN as Shown in Figure 4, and thus will not record the information required for reservations to be involved in resource reservation.

2) Even if the first issue is resolved, the resources will not be reserved along the triangle route from the CN to the MN.

Since RSVP protocol issues PATH messages periodically, eventually resources will be reserved along the direct route to The MN, but unnecessary delay and resource consumption will still result, and the desired Qos guarantees may not be achieved since packets sent along the triangle route receive different treatment than those sent directly.

3) Another challenge to real time traffic introduced by MIP is the fact that MNs change their locations. Because RSVP reserve resources only along a specific path, the fact that the path from sender to MN can change relatively frequently implies that new

reservations will be required every time a MN changes network.

If RO is used, the MN must reserve resources from its CoA back to the original sender. Whether this can be considered an important or not, depends on the relative locations of the sender, the HA , and the MN's current network.

2. A Cross layer Architecture for MIP-ROMA

On the standard layering architecture, Qos problems are caused by lack of information from transport layer congestion and link utilization. The mobility problems are related to the effects of handoff on transport layer connection and Qos signaling. Wireless link problems can be caused by packet corruption and losses that are perceived by TCP as congestion indications, resulting in poor performance.

Based on a cross-layer design [1,2] , proper information exchange between different layers of the MIP protocol stack is required. This exchange includes the actual status of wireless links from the access network and the characteristic established by internet service provider in the core networks, which are performing the RO or Qos establishment.

Providing Qos over optimal path becomes very challenging when there is no sufficient information for choosing the optimal path at the network layer where MIP is acting in.

Hybrid wired-wireless MIP networks although relatively new, are a merge of two older technologies. these two technologies being wireless network and internet are both implemented based on a standard layering architecture. In this traditional layering standard, based on the predefined and strict interface between the layers, the internal information in each layer is hidden from the neighboring layers.

In MIP, a path from the source to the destination consists of wired in the internet and wireless links in access network. MAC layer in protocol stack contains the information regarding the links, but hides this information from the network layer. In other for MIP, to choose the optimal path based on the links condition, it has to have access to this information.

Considering IP protocol stack, providing Qos and RO in MIP at network layer, requires information from service layer about Qos requirements and from data link layer regarding the link conditions and available resources.

To be able to take network condition into account for selecting the optimal path, there is an absolute need for collecting information regarding these conditions. This data can not be collected without a cross layer design [3,4].

The whole idea behind cross layer design is to combine the knowledge available in different parts of the network and create an environment, which can be highly efficient. This means sharing state information between modules in the system. Breaking the boundary to some extent between the different layers of standard model leads to a cross layer design. This will make information sharing possible. This information can be served decision making when it is necessary for achieving a higher network performance.

3. Cross layer information flow

In the abstract level collection of the Qos parameters from all the layers of the TCP/IP protocol stack needs a new interface. Information from application, transport, network and different link layer using a cross layer interface. Any entity in the network layer can access this data for future analysis.

To realize this concept, one may consider an actual storage where all the layers can store the detailed information and any layer can access this data for further analysis. This approach, although simple introduces extra signaling and function calls. While respecting the same concept, in order to avoid introducing new signaling in the new realization of the above concept, the information flow uses the modified version of the existing signaling of the protocols involved in mobility, routing and resource reservation. Figure 1 shows the Qos information flow in the new realization of cross layer design technique.

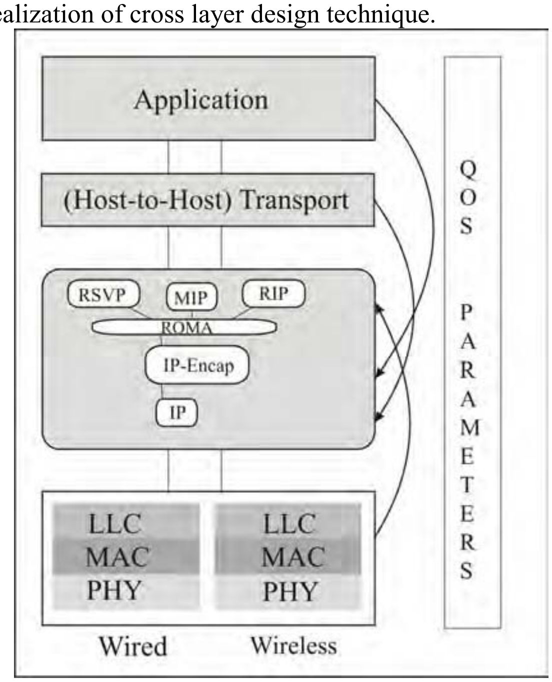

Figure1) Cross layer information flow

to implement the MIP-ROMA solution new data members were added to the messages of MIP, RSVP [5] and Routing protocol.

The mobility (MIP) and routing signaling will be more Qos aware and resource reservation (RSVP) signaling will be more routing concerned.

4. ROMA Entity

The ROMA entity shown in Figure 1, consist of several components.

The ROMA Entity includes a Finite State Machine (FSM), a set of state variables and necessary algorithms. This entity also collects the Qos parameters. ROMA interacts with IP encapsulation module from one side and RSVP, MIP and Routing protocol from the other side. The FSM is responsible for managing the state transition based on different events in the network and invoking algorithms for selecting the optimal path in proper state.

ROMA is responsible for retrieving and temporarily storing the Qos requirements and network conditions, and analyzing them to find the optimal path. This ROMA is detailed in the following components:

Input and output stream to interact with MIP, Routing, Resource Reservation and IP Encapsulation modules.

Temporary storage for Qos requirements and network conditions

Finite State Machine

Position Analysis algorithm

Routing Analysis algorithm

5. Algorithm

This algorithm has two phases (position analysis and routing analysis) and these phases select optimal path.

5.1. Position analysis

This phase discover the relative position of mobile node, foreign agent and home agent. Figure 2 explain position analysis.

Position analysis is about making the primary decision on routing path based on the relative distance of correspondent node, mobile node and home agent. The three elements can have 6 position based on their form each other. The distance between nodes is based on the hub count extracted from routing table and routing update message.

In the case 1 and 2, CN and HA are in the same network thus triangle path is optimal.

In the case of 3 and 4, CN and MN are in same network thus optimized routing is optimal.

In the case of 5 and 6 HA and MN are in the same network thus no need for further analysis as the MN is at home.

In the below we show pseudo code of position analysis algorithm. Initially it retrieves the network and subnet prefix of the IP address of the three nodes. The analysis includes verifying whether the nodes are in the same network or subnet.

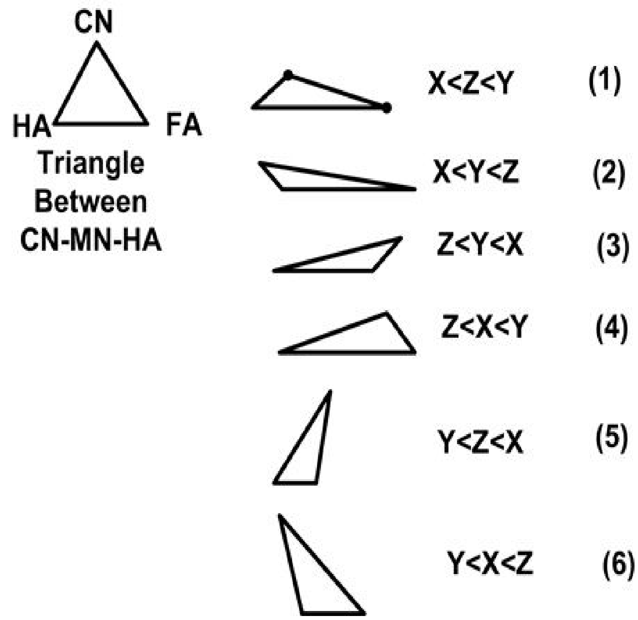

Figure 2) position analysis

```
Get the distance of CN and HA in X
Get the distance of HA and FA in Y
Get the distance of CN and FA in X

Fetch Network Prefix of CN IP address in A1
Fetch Network Prefix of HA IP address in A2
Fetch Network Prefix of FA IP address in A3
Fetch Network Prefix of CN IP address in SA1
Fetch Network Prefix of HA IP address in SA2
Fetch Network Prefix of FA IP address in SA3
IF SA1 = SA2 or A1 = A2
   Triangle Route is optimal
ELSE
     IF SA1 = SA3 or A1 = A3
          Direct Route is Optimal
      ELSE
           IF SA2 = SA3 or A2 = A3
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```
            Triangle Route is Optimal
         ELSE
            IF (X<Z & Z<Y) or (X<Y & Y<Z)
               Triangle Route is Optimal
            ELSE
               IF ( Z<Y & Y<X) or (Z<X &
X<Y)
                  Direct Route is Optimal
               ELSE
                  IF (Y<Z & Z<X) or(Y<X &
X<Z)
                     Triangle route is Optimal
                  ELSE
                     Perform Route Analysis
                  ENDIF
               ENDIF
            ENDIF
         ENDIF
      ENDIF
   ENDIF
```

5.1. Routing Analysis

In this phase evaluation of two paths against a service requirement to find out which path satisfies the service requirements while increasing the network performance. on each path total condition of wired link, wireless link and the delay and processing time in different devices are calculated and compared against service requirements.

In the below we shows the more detailed pseudo code of the routing analysis algorithm. The inputs to the algorithm are three arrays, holding the conditions of the direct path, condition of the triangle path and quality of service requirements respectively. The QOS requirements are stored in the array based on the order of their importance.

The index is the representative of weight of the requirement. When comparing the conditions of the link versus the requirements, the weight of each requirement (index) is added as a factor. This will ensure that the requirements with higher priorities are granted with higher priority.[6]

```
Let:
    DPC[0-n] be Direct path characteristics
    TPC[0-n] be Triangle path characteristics
    APR[0-n] be Application requirement in order
of priorities from 0 to n, when n is the highest
Priority
    Td be Traffic on Direct path
    Tt be Traffic on Triangle path
Initialize flag[n][2] to zero
For (i=0,i<n,i++)
        If(DPC[i,0] == APR[i])
                Set flag[I,0] to 1
        Else
                Set flag[I,0] to 0
        ENDIF
        IF( TPC[i,0] == APR[i])
                Set flag[i,1] to 1
        Else
                Set flag[i,1] to 0
        ENDIF
Endif
Dop, Top = 0
For (i=n,i>0,i--)
        If (flag[i,0]<flag[i,1])
                APR[i] can be granted by Triangle
path
                Top= Top+i
        Elseif (flag[i,1]<flag[i,0])
                PR[i] can be granted by Direct
path
                Dop=Dop+i
        Elseif(flag[I,0]==1)
                Both paths can satisfy APR[i]
                Dop=Dop+i
                Top=Top+i
        Else
                QOS cannot be granted
        Endif
Endfor
If(dop>top)
    Direct path is the optimal path
Elseif(Dop<Top)
    Triangle path is the optimal path
Elseif(Dop=0)
    No QOS characteristics of APR[0-n] can not
be granted
Elseif(Td>Tt)
    Direct path is the optimal path
Elseif(Td<Tt)
    Triangle path is the optimal path
Else
    Triangle path is the optimal path
Endif
```

6. Conclusions

By comparing tunneling and RO routing it was Observed that RO redirect traffic from HA-FA link to CN-FA link by adding control traffic overhead.

Furthermore, when the packet travel through the tunnel not only has to through a longer path, but also endures encapsulation and de-capsulation processing time at HA and FA. On the core network, the amount of traffic dropped is one of important aspects of network performance. As shown in table1, the maximum traffic dropped in the case of ROMA mechanism is decreased by 30% compared to RO and 47% compared to Tunneling mechanism.

Table1: Internet Performance Measurement

	Tunneling			RO			ROMA		
Statistics	Average	Max	Min	Average	Max	Min	Average	Max	Min
IPv6 Traffic Dropped (Packet/Sec)	0.1517	2.00	0.0	0.1517	1.50	0.00	0.0622	1.0556	0.00

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