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**Title:** IPv6 ANYCAST ROUTING PROTOCOL WITH MULTI-PRIORITY SENDING

**Abstract:** A method of implementing a IPv6 Anycast routing protocol by modifying the existing Protocol Independent Multicast Sparse Mode (PIM-SM) is provided.
IPv6 Anycast Routing Protocol with Multi-Anycast Senders

Field of Invention

The present invention relates to a method for establishing data communications between multiple senders and a receiver selected from a group of receivers with a common address, wherein the receiver has the least load in the group.

Background of Invention

Internet Protocol version 6 (IPv6) is a network layer for packet-switched internetworks. The IPv6 has three types of IP addresses i.e. unicast, multicast and anycast.

A unicast address is a unique identifier for each network interface. Packets with the same destination address are sent to the same node. On the other hand, a multicast address is assigned to a group of nodes. Therefore, all group members have the same multicast address and packets for this address are sent to all the members of the group simultaneously.

Anycast on the other hand is like a hybrid between a unicast and a multicast. In anycast, an identical address is assigned to a group of nodes providing a specific service, which is similar to multicast addressing. However, an anycast packet (i.e., one that has an anycast address as its destination) is delivered to only one of nodes in the group, corresponding to the packet’s destination address, a characteristic similar to that of a unicast.

Anycasting is therefore more advantageous, as it is not limited to only one sender and receiver as in unicasting and there is no load burden on all receivers as in multicasting. However, a standard routing protocol is not available for IPv6 based anycasting, and this is a hindrance to the widespread use of anycasting.

Therefore, there is a need for a standard IPv6 Anycasting routing protocol to be established.
Summary of Invention

An anycast address is indistinguishable from an unicast address. An anycast mechanism combines the mechanisms of both unicast and multicast, wherein it builds its anycast membership similar to that of a multicast protocol, but it sends its packets to only one node in the group resembling an unicast protocol.

In an anycast mechanism, when multiple senders attempt to send packets to the nearest receiver, it increases the load over this receiver i.e. the best receiver.

Therefore, it is the objective of the present invention is to provide for a new IPv6 Anycast Routing protocol to reduce the load over the best receiver and provide service to the client with the shortest time by amending the existing Protocol Independent Multicast Sparse Mode (PIM-SM) to build a IPv6 Anycast routing protocol, and also to introduce a new variable in the routing table called the Best Metric Value.

Description of Drawings

Figure 1 is a diagram of the design of IPv6 Anycast protocol according to present invention.

Figure 2 is a flow chart of the steps involved in building and updating a RP routing table.

Figure 3 is a diagram illustrating a scenario when two anycast senders forward anycast packets to different receivers.

Figure 4 is a diagram illustrating a scenario when four anycast senders forward anycast packets to different receivers.

Figure 5 is a diagram of the method to update the routing table each time a sender sends an anycast traffic.
Detailed Description

The present invention will now be detailed with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however be embodied in other different forms and should not be construed as being limited to the embodiments discussed herein, rather these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art. In the following description of the present invention, known methods and functions will be omitted as it would be already known to those skilled in the art.

A new IPv6 Anycast protocol is proposed by modifying the existing PIM-SM. In the present design the Rendezvous Point sends the traffic to the best receiver based with the Best Metric Value. The proposed design comprises the steps of

a. Building the anycast membership tree (RP tree)
b. Building and updating the routing table in RP
c. Forwarding the anycast traffic

Building Anycast Membership Tree (RP Tree)

Figure 1, shows the proposed IPv6 Anycast protocol design. Each router advertises itself to the other nodes in the same segment, according to neighbour discovery. This helps the routers to determine the presence of other routers in the same segment. A Rendezvous Point Tree (RP Tree) consists of anycast receivers (AR1, AR2), anycast routers (R1, R2) and Rendezvous Point (RP). The anycast receivers (AR1, AR2) will send a Multicast Listener Delivery (MLD) report messages to the respective routers (R1, R2) when the anycast receiver wishes to join the RP tree. Upon receiving the MLD each router (R1, R2) will set the multicast address field of the report message to the anycast address that the receivers (AR1, AR2) wishes to join. The report message also contains the metric value of the receiver which sent the report. The routers then send a join message to the Rendezvous Point.
Building And Updating The Routing Table In RP

The Rendezvous Point will start building its routing table when it receives the join message from the anycast routers. The routing table contains the Best Metric Factor (BMF), wherein metric is the distance between the anycast sender and the best receiver. It also denotes the load over the best anycast receiver. BMF is a combination of factors between the actual metric of the receivers and the status of the receivers i.e. whether the receiver is busy or free.

The RP routing table contains four fields:

i. Anycast address
ii. Route
iii. Metric
iv. BMF

The anycast address in the routing table contains the anycast address related to the anycast receiver. The route denotes the next hop or the next router which will be used to send the anycast packet to the associated anycast address from RP. Metric indicates the distance of the receiver from the rendezvous point. BMF in the routing table is variable used to determine the best receiver in terms of load and distance of attached link.

Referring to Figure 2, the RP will set the BMF values of R1 and R2 at 22 and 20 respectively, which is also the original metric value (i.e. the distance between the rendezvous point and the receiver) of the receiver upon receiving the join messages from the routers. RP then proceeds to determine the Lowest Best Metric Value and Highest Best Metric Value. When an anycast sender sends a traffic, the RP will send the traffic to the receiver with the LBMF via the respective router. In this example according to Figure 1, the receiver with the LBMF is AR2 since its BMF is 20. Therefore the RP will route the traffic to R2 and send the traffic to AR2.
Once the sender starts to send the traffic to the chosen receiver, the RP will update the value of the LBMF according to the following function (1):

\[ \text{LBMF} = \text{HBMF} + 1 \]  

(1)

The updated value of the LBMF ensures that the same receiver is not selected for a new traffic should another anycast sender try to send a anycast packet. This effectively reduces the load on the best receiver when there is a multiple sender.

**Forwarding The Anycast Traffic**

Figure 3 depicts a scenario when multiple senders attempt to send the anycast traffic to the best receiver, which will be used to explicate the method of forwarding the anycast traffic. First Anycast Sender 1 (AS1) sends the anycast packet to the anycast address AA. The Sender Router (SR) encapsulates the packet with a RP unicast address when it receives the packet from AS1. SR then forwards the packet based on the unicast routing to RP. RP then receives the packet and encapsulated anycast packet, and decapsulates it in order to obtain the anycast packet.

Using Figure 2 as an example of a routing table before updating, we can determine that RP will forward the anycast packet to AR2, because the BMF for AR2 is 20 indicating that AR2 has now the LBMF. Therefore, the RP selects R2 as the route for the anycast traffic.

Now, RP will update the routing table and set the value if LBMF when the anycast traffic has been forwarded from AS1 to the LBMF, which in this case is AR2, using function (1). An example of the updated routing table is as shown in figure 3. From the table, we now obtain the new BMF value of each AR i.e. AR1 = 22 and AR2 = 23. Therefore, the new AR with the LBMF is AR1.

AS2 will follow the same procedure as above to send an anycast packet. However, if the initial receiver with LBMF i.e. AR2 is still busy with AS1, then AS2 will forward the packet
to the LBMF according to the updated routing table i.e. AR1. Therefore, RP will choose R1 as the route for the current anycast traffic.

To further depict the advantages of the present invention, and to clearly indicate the improvement in the performance according to the present invention, an example according to Figure 4 and 5 will now be discussed. Figure 4 is a diagram of a scenario when the number of AS is increased to more than two. Figure 5 is an example of the updating of the routing table when each new sender tries to sent anycast traffic.

The anycast senders sends their traffic to the receivers AR1 and AR2 sequentially. The sequence listed below details the means by which the anycast traffic will be forwarded from the sender to the receiver according to the present example.

a. The initial value of BMF or AR1 and AR2 are 22 and 20 respectively. This denotes that AR2 is the LBMF receiver
b. AS1 sends its anycast packet to SR1. SR1 will encapsulates the anycast packet with RP unicast address and forwards the packet based on unicast routing to RP.

c. RP receives the encapsulated anycast packet and proceeds to decapsulate it to obtain the anycast packet.
d. RP selects AR2 as the receiver due to its BMF value. Therefore, RP selects R2 as the route for the anycast traffic.
e. RP updates routing table as illustrated in Figure 5. The receiver with LMBF is now set as AR1.

f. AS2 follows steps (b) to send its anycast packet.
g. RP selects AR1 as the receiver with LBMF and forwards the anycast packet from AS2 to R1.
h. RP updates routing table as illustrated in Figure 5. The receiver with LBMF is now set as AR2.
i. Both the AR are now busy with the senders AS1 and AS2
j. AS3 decides to send an anycast packet and acts according to step (b)
k. RP now selects AR2 as the receiver with LBMF and forwards the anycast packet from AS3 to R2
l. RP updates routing table as illustrated in Figure 5. The receiver with LMBF is now set as AR1.
m. AS4 decides to send an anycast packet and acts according to step (b)
n. RP now selects AR1 as the receiver with LBMF and forwards the anycast packet from AS4 to R1.

In anycasting, it is known that the traffic is forwarded to the nearest of the multiple receivers in a group, where all the receivers share a common address. From the foregoing description it can be seen that according to the present invention the possibility of a single receiver being over loaded with the anycast traffic from multiple sender because it is topologically nearest is reduced. Moreover, the invention provides a new protocol that can be used as a IPv6 Anycast routing protocol, which helps the more widespread use of Anycast in IPv6.

It will be apparent to those skilled in the art that various modification and variations can be made to the structure of the present invention without departing from the scope of the invention. In view of this, it is intended that the present invention covers modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.
Claims

1. A method for implementing anycast routing with multi-anycast sender comprising the steps of:
   a. building an anycast membership tree;
   b. building and updating a routing table; and
   c. forwarding the anycast traffic.

2. A method according to claim 1, wherein the step of building an anycast membership tree further comprises the steps of
   sending an advertisement to advertise the presence of each anycast router and
   also to discover the presence of other routers in the same segment; and
   building a Rendezvous Point (RP) Tree, wherein comprising the steps of:
      sending a Multicast Listener Delivery (MLD) report message to the
      respective anycast routers when a anycast receiver wishes to join the RP tree,
      setting the multicast address of the MLD report message to the
      anycast address that the anycast receivers wishes to join, and wherein the
      multicast address is set to the anycast address by the anycast router, and
      sending joining message to Rendezvous Point, wherein the message is
      sent by anycast routers.

3. A method according to claim 1, wherein the step of building and updating a routing table further comprises the steps of:
   receiving the join message from the anycast routers;
   building a routing table;
   setting the Best Metric Value (BMF) as the original metric value of each
   anycast receiver; and
   calculating the Lowest Best Metric Value (LBMF) and the Highest Best
   Metric Value (HBMF).

4. A method according to claim 1, wherein the step of forwarding the anycast traffic
   further comprises the steps of:
   sending a packet to a sender router, which encapsulates the packet with RP
   unicast address, wherein the packet is sent by an anycast sender;
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sending packets to RP from the sender router;
decapsulating the packet upon receipt by the RP;
forwarding the packet to anycast receiver with LBMF from the RP; and
updating the routing table.

5 5. A method according to claim 4, wherein the RP updates the routing table using the function LBMF = HBMF + 1
Figure 1

Figure 2
Figure 3

Figure 4
### Initial Values of the routing table (AS1 sends to AR2)

<table>
<thead>
<tr>
<th>Addr</th>
<th>Route</th>
<th>Metric</th>
<th>DMRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>AR2</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

### 1st updating in the routing table (AS2 sends to AR1)

<table>
<thead>
<tr>
<th>Addr</th>
<th>Route</th>
<th>Metric</th>
<th>DMRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>AR1</td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>

### 2nd updating in the routing table (AS3 sends to AR2)

<table>
<thead>
<tr>
<th>Addr</th>
<th>Route</th>
<th>Metric</th>
<th>DMRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>AR2</td>
<td>20</td>
<td>22</td>
</tr>
</tbody>
</table>

### 3rd updating in the routing table (AS4 sends to AR1)

<table>
<thead>
<tr>
<th>Addr</th>
<th>Route</th>
<th>Metric</th>
<th>DMRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>AR1</td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>

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**Figure 5**