

# Design and Implement of SD-Anycast Routing Protocol

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**Abstract:** *Basing on the analysis of the studying situation of current routing protocol , this thesis presents a SD-Anycast protocol algorithm, and the routing principle and measure parameter of the protocol is given. By designing packet header, routing maintaining and node dealing modules, it implements this protocol in NS2. Lastly, some quantificational experiments indicate that this routing protocol algorithm has the superiority in some aspect, such as on one way delay, output and load balance, etc.*

**Keyword:** Anycast, routing, delay, output

## 1 Preface

With the exploding development of the network scale and the frequent change of the network technique, the content of the network services is becoming expanding, integrating and complicating. The requirement of the current network service exceeds the capability of the network services. Though it has no effect on some classical network services such as Email, web exploring and etc., it has serious impact on the services which is strict to the requirement of the real time, such as network video, IP telephone and online large entertainment games and etc. In order to support plentiful network services, it is necessary to add some quantitative and qualitative IP services.

Anycast services and its correlation technique is becoming criterial, more and more O.S. offer support to the correlation technique of the IPv6. With the internet scale enlarging, Anycast is becoming the best choice in many application fields. Routing is the primary issue of the Anycast service, and the routing protocol has a direct effect on the usability and efficiency of the Anycast service. This paper presents a Anycast routing protocol——SD-Anycast, and introduces the design and implementation of it.

## 2 Protocol Design

### 2.1 correlation definition

**Def.1 Address Domain:** the router set whose received requirement frequent from a certain Anycast address is larger than a threshold.

$$Z(A) = \{R | f_R(A) > \lambda\} \quad (1)$$

In above formula, A denotes an Anycast address, R denotes a router, Z(A) denotes the domain of address A,  $f_R(A)$  denotes the requirement frequent of the address A on router R,  $\lambda$  is a constant ,denoting the threshold of the requirement frequent.

Only the router whose received requirement frequent is relatively large is allowed to enclose

the domain of  $Z(A)$ , and this method can decrease the occupation of the network resource.

**Def.2 Group Member Sub-Domain:** the router set that Anycast address requirement is forwarded to an identical group member.

$$D_i(A) = \{R \mid h_R(A) = i; R \in Z(A)\} \quad (2)$$

In above formula,  $i$  denotes a member of the Anycast address  $A$ ,  $D_i(A)$  denotes the subdomain of  $i$ ,  $h_R(A)$  denotes the group member which router  $R$  chooses in address  $A$ .

The relation of the  $Z(A)$  and  $D_i(A)$  is shown as formula (3),  $k$  denoting the total number of group member of address  $A$ .

$$Z(A) = \bigcup_{i=1}^k D_i(A) \quad (3)$$

## 2.2 routing principle

The members of a identical Anycast address support the same service, and they have a competitive relation on an identical router. The router which group members compete to get victory will be enclosed in this member's subdomain. Each group member of one Anycast address group does its best to expand its subdomain, and the router which is enclosed in this subdomain will forwards the requirement which the destination is just this Anycast address to this member.

The key issue of this method is how to choose the measure parameter and the criterion of getting victory. Here,  $C(i)$  denotes the measure parameter of the member  $i$ , and the criterion is that the difference between  $C(i)$  and  $C_{\max}$  which is the maximum of the measure parameter is larger than  $\eta$ . Thus, the common formula of this Anycast routing protocol basing on expanding method is shown as below:

If  $C(i) - C_{\max} > \eta$  Then

$$D_i(A) = D_i(A) \cup R$$

End If

In above formula, if  $\eta \geq 0$ , it denotes the single path routing, Otherwise, denotes multiple path routing.  $CS(i)$  is the static measure parameter, and  $CD(i)$  denotes the dynamic measure parameter. If  $C(i) = CS(i)$ , it denotes static routing. If  $C(i) = CD(i)$ , it denotes dynamic routing. Using above formula, we can integrate the formula expression of various routing table maintaining protocols. Controlling the value of  $\eta$  and  $C(i)$ , it can implement the dynamic switch among various protocols.

Each group member of an identical Anycast address distributing dispersedly, it will be easy to bring the router around group member into its subdomain when we serve the formula  $\eta=0$  as its controlling parameter of single path routing. But the routers which is distributed on the border area of the members will change the subdomain frequently. In order to avoid this switch ,it will choose the formula  $\eta>0$  as its controlling parameter of single path routing.

For example, supposed group of Anycast  $A$  having two member  $S1$  and  $S2$  shown as figure1. The dashed line denotes the service area of  $S1$  and  $S2$ , and the routers which is located in area  $A12$  will receive the expanding packets from  $S1$  and  $S2$  both. In figure,  $R5$  receives the packets from  $S1$  and  $S2$ , and it will compare  $C1$  and  $C2$ , and choose a larger as the destination address of the Anycast address  $A$  in routing table. If  $C1 > C2$ ,  $R5$  will be enclosed by the subdomain of  $S1$ . Thus, the Anycast packet which  $R5$  is received will be forward along  $R4$ ,  $R1$ , and to  $S1$  lastly.

## 2.3 Measure Parameter

There are several group members which compete to offer the same service to a router. It will determine to join into the subdomain according to the whole performance of each group member, and the measure parameter is needed to cast the all factors which can effect the service performance. The factors which can effect the service performance can be divide into static one and dynamic one. The static factors is determined by link and the performance of the group member, including the hop number from source address to destination address, the performance of group member, router and link bandwidth and etc. Dynamic ones is determined by load status of the link and group member, including the load of group member, router and link and etc.

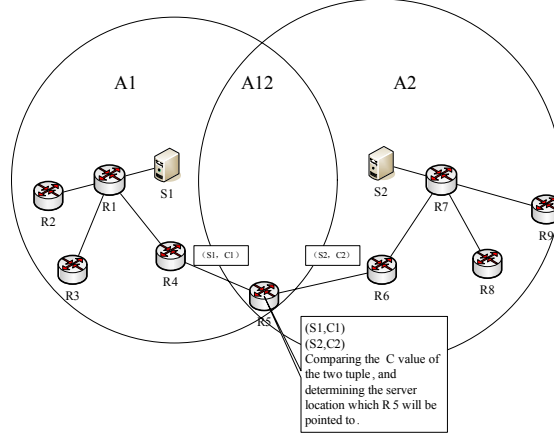


Figure 1 routing of SD-Anycast

Synthesizing each static factors ,we present a formula of the static measure parameter as below:

$$C_s(i) = \frac{\alpha_B * B_s(i)}{H(i)} (S_s(i) - \alpha_R * R_s(i)) \quad (4)$$

In above formula, BS(i) denotes the usable bandwidth of network path, RS(i) denotes correlation variable of router performance, SS(i) denotes the process ability of group member i, H(i) denotes hop number,  $\alpha_B$ 、 $\alpha_R$  are two constant. BS(i)(t) denotes the bandwidth of link t on path from router to group member i, rS(i)(t) denotes the process ability of the router t on path from router to group member i, and the formula of BS(i) and RS(i) is shown as below:

$$B_s(i) = \min(B_s(i)(t)) \quad (5)$$

$$R_s(i) = \sum_{t=1}^{H(i)} \frac{1}{r_s(i)(t)} \quad (6)$$

The variables in formula of static measure parameter is the performance parameter, and it is easy to be obtained ,because it doesn't need the occupation of the resource.

Similarly, making out the formula of dynamic measure parameter as below:

$$C_D(i) = \frac{\beta_B * \min(B_D(i)(t))}{H(i)} \left( S_D(i) - \beta_R * \sum_{t=1}^{H(i)} \frac{1}{r_D(i)(t)} \right) \quad (7)$$

In this formula, the variables of dynamic performance is difficult to be measured and need a lot of resource to be occupied. This is unrealizable, so the formula should be replaced by formula

(8):

$$C_D(i) = \frac{\beta * S_D(i)}{P(i)} \quad P(i) = \sum_{j=1}^{H(i)} P(j) \quad (8)$$

In above formula,  $S_D(i)$  denotes the dynamic process ability of group member  $i$ ,  $\beta$  is a constant,  $P(i)$  denotes the total delay of the links to group member  $i$ ,  $P(j)$  denotes the link delay to group member  $i$  in hop  $j$ .

Shown as formula (8), the measure parameters of algorithm are determined by link delay and dynamic process ability of the group member. The dynamic ability of member is effected by the hardware configure and the load of the member. The hardware configure will be fixation when it has been set. Thus , the dynamic process ability of member can be shown as formula (9)

$$S_D(i) = \frac{\alpha * Ss(i)}{O_D(i)(t)} \quad (9)$$

In above formula,  $Ss(i)$  denotes the static process ability of member  $i$ ,  $\alpha$  is a constant,  $O_D(i)(t)$  denotes the load of member  $i$  at time  $t$ .

The link delay can cast the dynamic process ability of network, and it is served as a main variable of calculation of dynamic measure parameter.

Shown as formula (8), the total delay of packet in network, is the sum of each link delay. When a packet transmits in network, it will cover some hops which is composed of node process delay, interface queue delay and link transmitting delay. i.e.

The delay in one hop can express as below:

$$P(j) = T_c(j) + T_q(j)(t) + T_t(j)(t) \quad (10)$$

- $T_c(j)$  denotes the total process time of single packet received and enqueued in router of hop  $j$ .
- $T_q(j)(t)$  denotes the interface queue delay of router in hop  $j$  at time  $t$ . i.e. the time that the enqueued packet spent before it is sent. The cause of interface delay produced is that several packets reach the router's interface at the same time, owing to the limit of the router's process ability , and it is necessary to adopt certain queue mechanism to send these data. Because of this , the router produces queue delay on its interface.
- $T_t(j)(t)$  denotes the transmitting delay that a packet is transmitted on link in hop  $j$ , and it is not neglectable. In total delay of packet, the delay can calculated as below:

$$T_t(j)(t) = \frac{L}{B_D(j)(t)} \quad (11)$$

$L$  denotes the length of packet,  $B_D(j)(t)$  denotes the usable bandwidth of link in hop  $j$  at time  $t$ .

According to the formula (9), (10) and (11), formula (8) can be changed into as below:

$$C_D(i) = \frac{\beta * S_D(i)}{\sum_{j=1}^{H(i)} P(j)} = \frac{\gamma * \frac{Ss(i)}{O_D(i)(t)}}{\sum_{j=1}^{H(i)} (T_c(j) + T_q(j)(t) + \frac{L}{B_D(j)(t)})} \quad (12)$$

$\gamma$  denotes the synthetic constant.

The calculating of measure parameters is the key step in the implementation of the routing algorithm, and the formula shown as above is suitable to other Anycast routing algorithm, and is common to them.

### 3 Protocol Implementation

Author constructs model in NS2, and measures the performance of SD-Anycast on delay, output and etc. According to designing the initial code, main circle, calculagraph process, link state DB, routing computing and routing table maintaining, and adding Expand, ASR packet and SDA-API which deal with such packet, it implements this protocol.

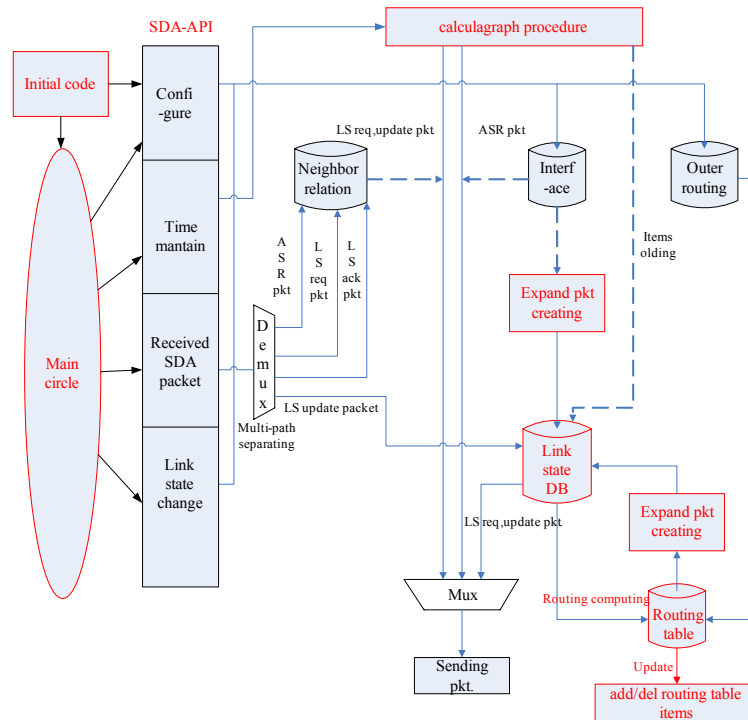


Figure 2 Data flow chat of system implementing

- Initial code: sending protocol packets , setting the initial items in routing table, initializing the SDA code.
- Main circle: reading the packet which the network interface received, tracing the passed time, adjusting and invoking the calculagraph procedure in SDA code to maintain the veracity of the link state DB and the validity of the router table items.
- Interface: the place that router sends the ASR packets which notice the situation of the server.
- Expand packet creating: sent by Anycast server interface firstly, forwarded by router interface, and updating the link state DB.
- LS update packet: updating link state DB.
- Update: modifying the routing table items
- Link state DB: according to routing computing modifying the routing table items with Update packet.
- SDA-API: offering the invoked interface to main circle to invoke other function modules.

Author designs some experiments to validate the performance, and some of them is shown as below:

(1) one-way-delay

Setting the link delay and process delay of inter-router randomly, it illustrates the owd of S1 with SD when the client sending packet interval equals 0.008s and the queuesize of S1 is 5, 8, 10, 15 and 20 .

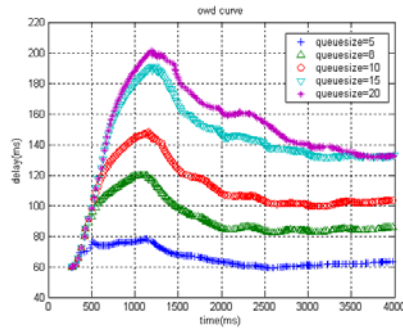


Figure 3 owd curve between SD-Anycast

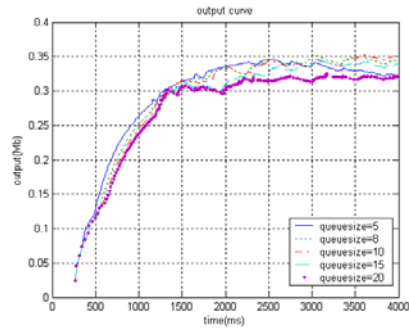


Figure 4 output curve between SD-Anycast

In figure 3, the owd of SD reaches the maximum between 1.0 and 1.5, thenceforth, the delay is decreasing, and tend to calm lastly. Owing to the network data stream is larger than the process ability of current path, producing the packet queue, increasing the link delay, it results in the increasing of packet owd. When the C value of second path is better than current path's, network will startup the routing updating to search a better server. Because of the diffluence of data, the owd of packet is decreasing. The process is repeated continually, the routing table updating will reach the best.

(2) Output

a) effect of the protocol

In figure 4, it illustrates the output of S1 with SD when the queuesize of S1 equals 5, 8, 10, 15 and 20. When queuesize equals 8, 10, 15 and 20, output tending to calm, the lost packet rate of SD is low comparing to other protocols and the output is increasing largely.

b) Effect of the server performance

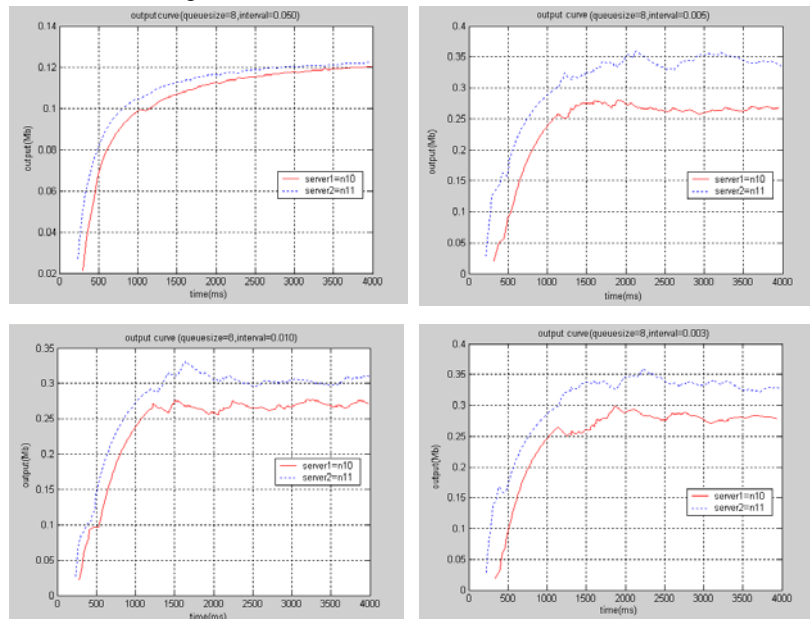


Figure 5 The contrast output curve of S1-S2 between SD-Anycast

Setting a different process ability to two servers, it shows the compare pictures of the output of S1 and S2 when the queuesize of S1 and S2 equals 8 and the sending interval equals 0.050s、0.010s、0.005s、0.003s.

In this experiment, owing to the performance of S1 is larger than S2's ,shown as figure, in low data stream network, the output has little effect on server performance , and mainly relates to the data rate which is sent to this server. With the increasing of the data stream on network, the better performance is, the larger output is. When the network stream reaches a threshold, the effect of server performance is shown the best. Thenceforth, the network stream increasing, the congestion appearing, the network routing updating frequently, the lost packet rate increasing, and the output of server is decreasing inversely. Because of the principle which the router will endeavor to send packets, the server that has a better performance will have a larger output.

## 4 Conclusion

The experiments make a conclusion that SD-Anycast routing protocol has a better performance on one way delay, output, load balance, comparing to traditional routing protocols. Firstly, the owd of SD is obviously lower than traditional protocols in same condition, and it shows its character of shortest delay. Secondly, SD has a low requirement of server performance, in same condition, having a better diffluent ability, increasing the lost packet rate, resulting in a better network output. Thirdly, in high data stream, SD can distribute the data according to the difference of the server performance, and it reaches an appropriate load situation on each server.

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