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Problem Statement for Default Address Selection in Multi-Prefix Environments: Operational Issues of RFC 3484 Default Rules

Status of This Memo

Abstract

A single physical link can have multiple prefixes assigned to it. In that environment, end hosts might have multiple IP addresses and be required to use them selectively. RFC 3484 defines default source and destination address selection rules and is implemented in a variety of OSs. But, it has been too difficult to use operationally for several reasons. In some environments where multiple prefixes are assigned on a single physical link, the host using the default address selection rules will experience some trouble in communication. This document describes the possible problems that end hosts could encounter in an environment with multiple prefixes.

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1. Introduction

In IPv6, a single physical link can have multiple prefixes assigned to it. In such cases, an end host may have multiple IP addresses assigned to an interface on that link. In the IPv4-IPv6 dual-stack environment or in a site connected to both a Unique Local Address (ULA) [RFC4193] and globally routable networks, an end host typically has multiple IP addresses. These are examples of the networks that we focus on in this document. In such an environment, an end host may encounter some communication troubles.

Inappropriate source address selection at the end host causes unexpected asymmetric routing, filtering by a router, or discarding of packets because there is no route to the host.

Considering a multi-prefix environment, destination address selection is also important for correct or better communication establishment.

RFC 3484 [RFC3484] defines default source and destination address selection algorithms and is implemented in a variety of OSs. But, it has been too difficult to use operationally for several reasons, such as lack of an autoconfiguration method. There are some problematic cases where the hosts using the default address selection rules encounter communication troubles.

This document describes the possibilities of incorrect address selection that lead to dropping packets and communication failure.

1.1. Scope of This Document

As other mechanisms already exist, the multi-homing techniques for achieving redundancy are basically out of our scope.

We focus on an end-site network environment and unmanaged hosts in such an environment. This is because address selection behavior at these kinds of hosts is difficult to manipulate, owing to the users' lack of knowledge, hosts' location, or massiveness of the hosts.

The scope of this document is to sort out problematic cases related to address selection. It includes problems that can be solved in the framework of RFC 3484 and problems that cannot. For the latter, RFC 3484 might be modified to meet their needs, or another address selection solution might be necessary. For the former, an additional mechanism that mitigates the operational difficulty might be necessary.

This document also includes simple solution analysis for each problematic case. This analysis basically just focuses on whether or not the case can be solved in the framework of RFC 3484. If not, some possible solutions are described. Even if a case can be solved in the framework of RFC 3484, as mentioned above, it does not necessarily mean that there is no operational difficulty. For example, in the environment stated above, it is not a feasible solution to configure each host's policy table by hand. So, for such a solution, the difficulty of configuration is yet another common problem.

2. Problem Statement

2.1. Source Address Selection

2.1.1. Multiple Routers on a Single Interface

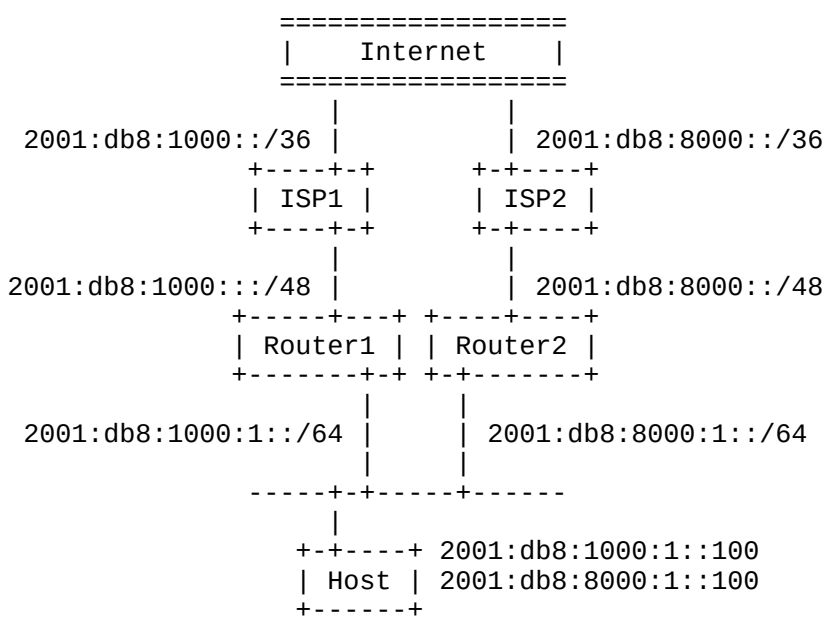

Figure 1

Generally speaking, there is no interaction between next-hop determination and address selection. In this example, when a host starts a new connection and sends a packet via Router1, the host does not necessarily choose address 2001:db8:1000:1::100 given by Router1 as the source address. This causes the same problem as described in the next section, "Ingress Filtering Problem".

Solution analysis:

As this case depends on next-hop selection, controlling the address selection behavior at the Host alone doesn't solve the entire problem. One possible solution for this case is adopting source-address-based routing at Router1 and Router2. Another solution may be using static routing at Router1, Router2, and the Host, and using the corresponding static address selection policy at the Host.

2.1.2. Ingress Filtering Problem

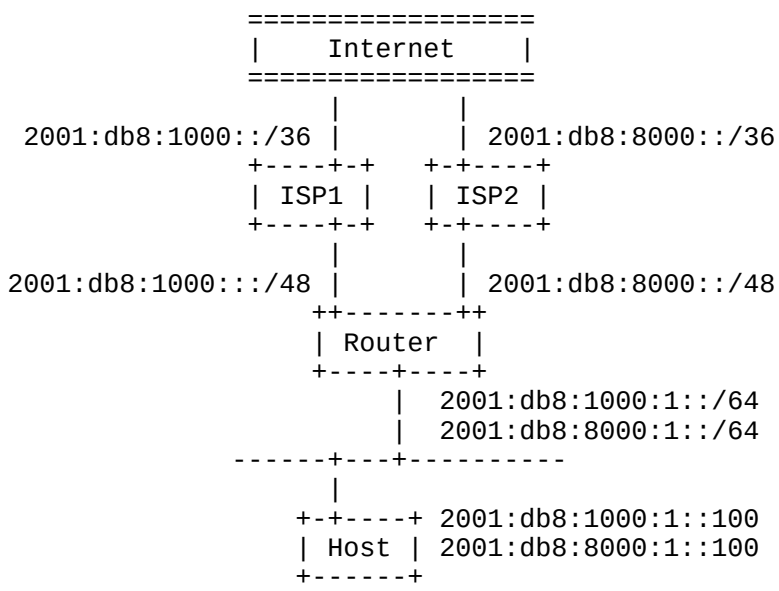

Figure 2

When a relatively small site, which we call a "customer network", is attached to two upstream ISPs, each ISP delegates a network address block, which is usually /48, and a host has multiple IPv6 addresses.

When the source address of an outgoing packet is not the one that is delegated by an upstream ISP, there is a possibility that the packet will be dropped at the ISP by its ingress filter. Ingress filtering is becoming more popular among ISPs to mitigate the damage of denial-of-service (DoS) attacks.

In this example, when the router chooses the default route to ISP2 and the host chooses 2001:db8:1000:1::100 as the source address for packets sent to a host (2001:db8:2000::1) somewhere on the Internet, the packets may be dropped at ISP2 because of ingress filtering.

Solution analysis:

One possible solution for this case is adopting source-address-based routing at the Router. Another solution may be using static routing at the Router, and using the corresponding static address selection policy at the Host.

2.1.3. Half-Closed Network Problem

You can see a second typical source address selection problem in a multi-homed site with global half-closed connectivity, as shown in the figure below. In this case, Host-A is in a multi-homed network and has two IPv6 addresses, one delegated from each of the upstream ISPs. Note that ISP2 is a closed network and does not have connectivity to the Internet.

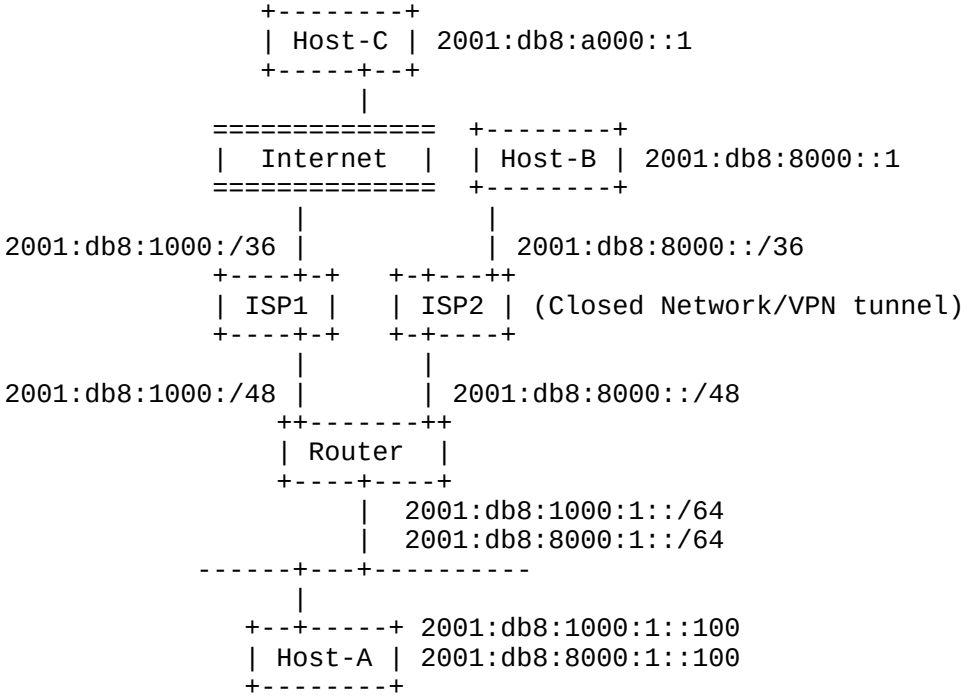

Figure 3

You do not need two physical network connections here. The connection from the Router to ISP2 can be a logical link over ISP1 and the Internet.

When Host-A starts the connection to Host-B in ISP2, the source address of a packet that has been sent will be the one delegated from ISP2 (that is, 2001:db8:8000:1::100) because of rule 8 (longest matching prefix) in RFC 3484.

Host-C is located somewhere on the Internet and has IPv6 address 2001:db8:a000::1. When Host-A sends a packet to Host-C, the longest matching algorithm chooses 2001:db8:8000:1::100 for the source

address. In this case, the packet goes through ISP1 and may be filtered by ISP1's ingress filter. Even if the packet is not filtered by ISP1, a return packet from Host-C cannot possibly be delivered to Host-A because the return packet is destined for 2001:db8:8000:1::100, which is closed from the Internet.

The important point is that each host chooses a correct source address for a given destination address. To solve this kind of network-policy-based address selection problem, it is likely that delivering additional information to a node provides a better solution than using algorithms that are local to the node.

Solution analysis:
This problem can be solved in the RFC 3484 framework. For example, configuring some address selection policies into Host-A's RFC 3484 policy table can solve this problem.

2.1.4. Combined Use of Global and ULA

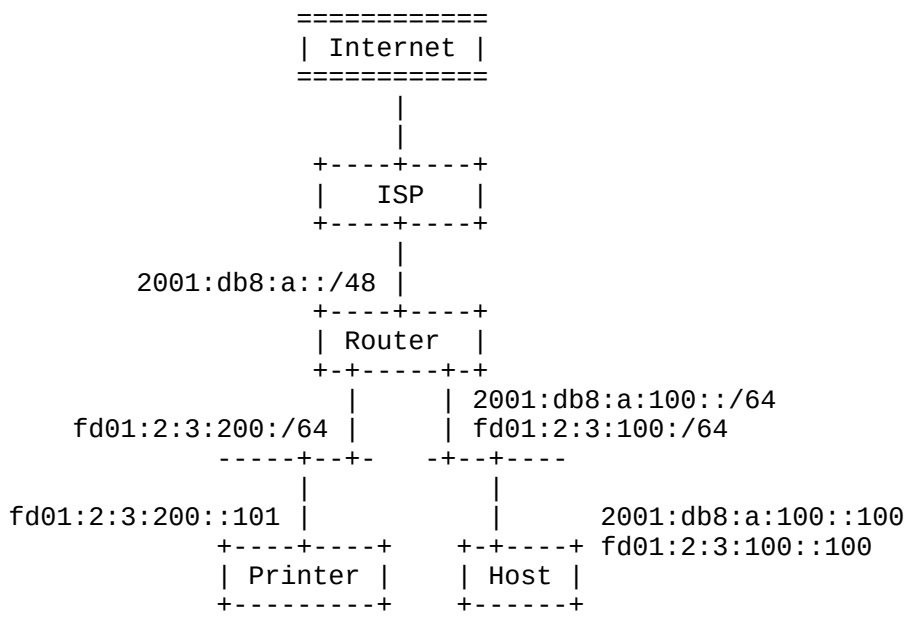

Figure 4

As RFC 4864 [RFC4864] describes, using a ULA may be beneficial in some scenarios. If the ULA is used for internal communication, packets with the ULA need to be filtered at the Router.

This case does not presently create an address selection problem because of the dissimilarity between the ULA and the global unicast address. The longest matching rule of RFC 3484 chooses the correct address for both intra-site and extra-site communication.

In the future, however, there is a possibility that the longest matching rule will not be able to choose the correct address anymore. That is the moment when the assignment of those global unicast addresses starts, where the first bit is 1. In RFC 4291 [RFC4291], almost all address spaces of IPv6, including those whose first bit is 1, are assigned as global unicast addresses.

Namely, when we start to assign a part of the address block 8000::/1 as the global unicast address and that part is used somewhere in the Internet, the longest matching rule ceases to function properly for the people trying to connect to the servers with those addresses.

For example, when the destination host has an IPv6 address 8000::1, and the originating host has 2001:db8:a:100::100 and fd01:2:3:100::100, the source address will be fd01:2:3:100::100, because the longest matching bit length is 0 for 2001:db8:a:100::100 and 1 for fd01:2:3:100::100, respectively.

Solution analysis:

This problem can be solved in the RFC 3484 framework. For example, configuring some address selection policies into the Host's RFC 3484 policy table can solve this problem. Another solution is to modify RFC 3484 and define ULA's scope smaller than the global scope.

2.1.5. Site Renumbering

RFC 4192 [RFC4192] describes a recommended procedure for renumbering a network from one prefix to another. An autoconfigured address has a lifetime, so by stopping advertisement of the old prefix, the autoconfigured address is eventually invalidated.

However, invalidating the old prefix takes a long time. You cannot stop routing to the old prefix as long as the old prefix is not removed from the host. This can be a tough issue for ISP network administrators.

There is a technique of advertising the prefix with the preferred lifetime zero; however, RFC 4862 [RFC4862], Section 5.5.4, does not absolutely prohibit the use of a deprecated address for a new outgoing connection due to limitations on the capabilities of applications.

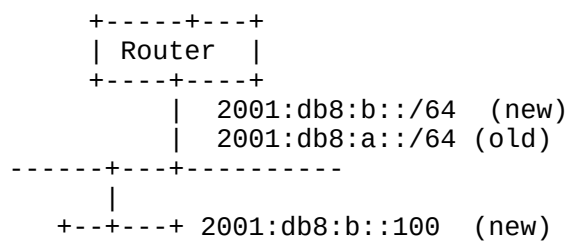

Figure 5

Solution analysis:
This problem can be mitigated in the RFC 3484 framework. For example, configuring some address selection policies into the Host's RFC 3484 policy table can solve this problem.

2.1.6. Multicast Source Address Selection

This case is an example of site-local or global unicast prioritization. When you send a multicast packet across site borders, the source address of the multicast packet should be a globally routable address. The longest matching algorithm, however, selects a ULA if the sending host has both a ULA and a Global Unicast Address.

Solution analysis:
This problem can be solved in the RFC 3484 framework. For example, configuring some address selection policies into the sending host's RFC 3484 policy table can solve this problem.

2.1.7. Temporary Address Selection

RFC 3041 [RFC3041] defines a Temporary Address. The usage of a Temporary Address has both pros and cons. It is good for viewing web pages or communicating with the general public, but it is bad for a service that uses address-based authentication and for logging purposes.

If you could turn the temporary address on and off, that would be better. If you could switch its usage per service (destination address), that would also be better. The same situation can be found when using an HA (home address) and a CoA (care-of address) in a Mobile IPv6 [RFC3775] network.

Section 6 ("Future Work") of RFC 3041 discusses that an API extension might be necessary to achieve a better address selection mechanism with finer granularity.

Solution analysis:

This problem cannot be solved in the RFC 3484 framework. A possible solution is to make applications to select desirable addresses by using the IPv6 Socket API for Source Address Selection defined in RFC 5014 [RFC5014].

2.2. Destination Address Selection

2.2.1. IPv4 or IPv6 Prioritization

The default policy table gives IPv6 addresses higher precedence than IPv4 addresses. There seem to be many cases, however, where network administrators want to control the address selection policy of end hosts so that it is the other way around.

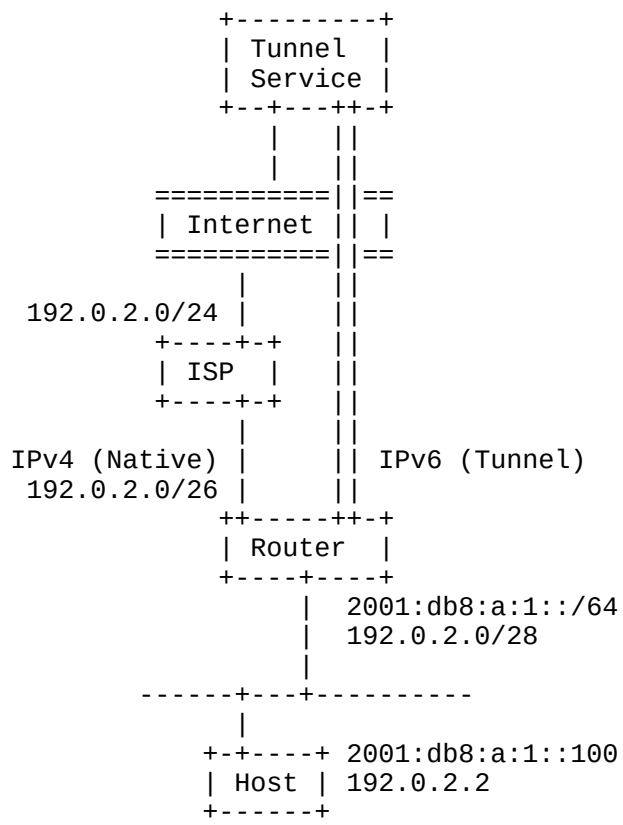

Figure 6

In the figure above, a site has native IPv4 and tunneled IPv6 connectivity. Therefore, the administrator may want to set a higher priority for using IPv4 than for using IPv6 because the quality of the tunnel network seems to be worse than that of the native transport.

Solution analysis:
This problem can be solved in the RFC 3484 framework. For example, configuring some address selection policies into the Host's RFC 3484 policy table can solve this problem.

2.2.2. ULA and IPv4 Dual-Stack Environment

This is a special form of IPv4 and IPv6 prioritization. When an enterprise has IPv4 Internet connectivity but does not yet have IPv6 Internet connectivity, and the enterprise wants to provide site-local IPv6 connectivity, a ULA is the best choice for site-local IPv6

connectivity. Each employee host will have both an IPv4 global or private address and a ULA. Here, when this host tries to connect to Host-B that has registered both A and AAAA records in the DNS, the host will choose AAAA as the destination address and the ULA for the source address. This will clearly result in a connection failure.

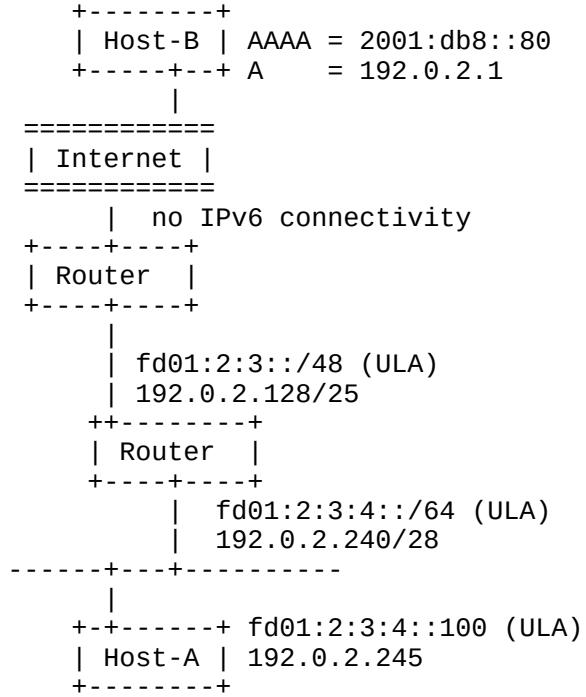

Figure 7

Solution analysis:

This problem can be solved in the RFC 3484 framework. For example, configuring some address selection policies into Host-A's RFC 3484 policy table can solve this problem.

2.2.3. ULA or Global Prioritization

Differentiating services by the client's source address is very common. IP-address-based authentication is a typical example of this. Another typical example is a web service that has pages for the public and internal pages for employees or involved parties. Yet another example is DNS zone splitting.

However, a ULA and an IPv6 global address both have global scope, and RFC 3484 default rules do not specify which address should be given priority. This point makes IPv6 implementation of address-based service differentiation a bit harder.

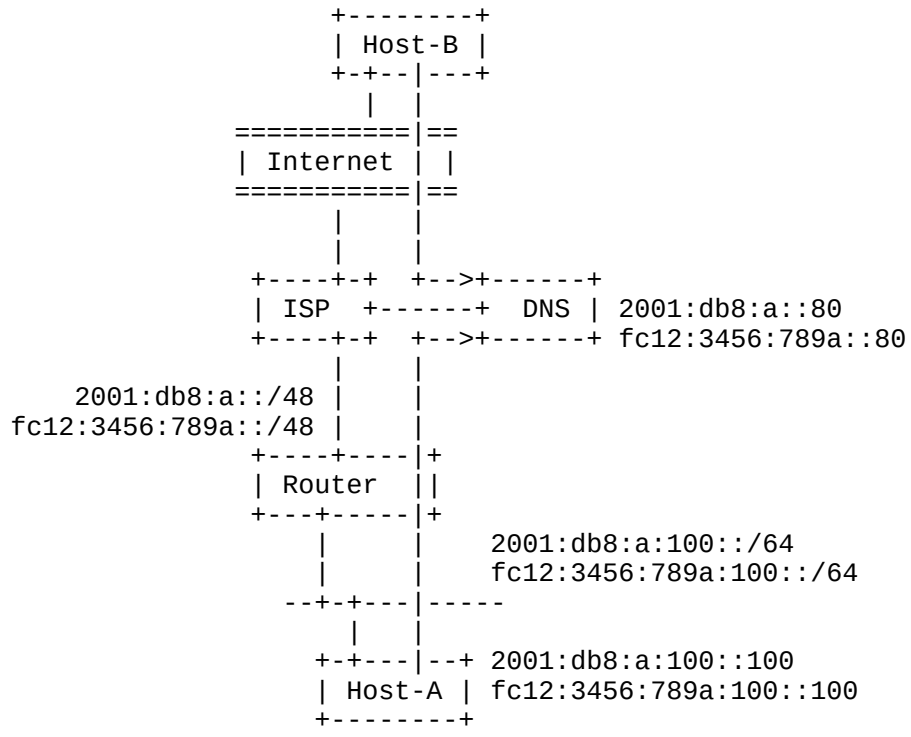

Figure 8

Solution analysis:
This problem can be solved in the RFC 3484 framework. For example, configuring some address selection policies into Host-A's RFC 3484 policy table can solve this problem.

3. Conclusion

We have covered problems related to destination or source address selection. These problems have their roots in the situation where end hosts have multiple IP addresses. In this situation, every end host must choose an appropriate destination and source address; this choice cannot be achieved only by routers.

It should be noted that end hosts must be informed about routing policies of their upstream networks for appropriate address selection. A site administrator must consider every possible address false-selection problem and take countermeasures beforehand.

4. Security Considerations

When an intermediate router performs policy routing (e.g., source-address-based routing), inappropriate address selection causes unexpected routing. For example, in the network described in Section 2.1.3, when Host-A uses a default address selection policy and chooses an inappropriate address, a packet sent to a VPN can be delivered to a location via the Internet. This issue can lead to packet eavesdropping or session hijack. However, sending the packet back to the correct path from the attacker to the node is not easy, so these two risks are not serious.

As documented in the Security Considerations section of RFC 3484, address selection algorithms expose a potential privacy concern. When a malicious host can make a target host perform address selection (for example, by sending an anycast or multicast packet), the malicious host can get knowledge of multiple addresses attached to the target host. In a case like Section 2.1.4, if an attacker can make the Host to send a multicast packet and the Host performs the default address selection algorithm, the attacker may be able to determine the ULAs attached to the host.

These security risks have roots in inappropriate address selection. Therefore, if a countermeasure is taken, and hosts always select an appropriate address that is suitable to a site’s network structure and routing, these risks can be avoided.

5. Normative References

[RFC3041] Narten, T. and R. Draves, "Privacy Extensions for Stateless Address Autoconfiguration in IPv6", RFC 3041, January 2001.

[RFC3484] Draves, R., "Default Address Selection for Internet Protocol version 6 (IPv6)", RFC 3484, February 2003.

[RFC3775] Johnson, D., Perkins, C., and J. Arkko, "Mobility Support in IPv6", RFC 3775, June 2004.

[RFC4192] Baker, F., Lear, E., and R. Droms, "Procedures for Renumbering an IPv6 Network without a Flag Day", RFC 4192, September 2005.

[RFC4193] Hinden, R. and B. Haberman, "Unique Local IPv6 Unicast Addresses", RFC 4193, October 2005.

[RFC4291] Hinden, R. and S. Deering, "IP Version 6 Addressing Architecture", RFC 4291, February 2006.

[RFC4862] Thomson, S., Narten, T., and T. Jinmei, "IPv6 Stateless Address Autoconfiguration", RFC 4862, September 2007.

[RFC4864] Van de Velde, G., Hain, T., Droms, R., Carpenter, B., and E. Klein, "Local Network Protection for IPv6", RFC 4864, May 2007.

[RFC5014] Nordmark, E., Chakrabarti, S., and J. Laganier, "IPv6 Socket API for Source Address Selection", RFC 5014, September 2007.

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