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DNS Server Selection on Multi-Homed Hosts
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Abstract

A multi-homed host may receive DNS server configuration information from multiple physical and/or virtual network interfaces. In split DNS scenarios not all DNS servers are able to provide the same information. When the multi-homed host needs to utilize DNS, it has to select which of the servers to contact to. This document describes problems of split DNS for multi-homed hosts and also a method for selecting the DNS server with help of DNS suffix information received dynamically for each network interface. The method is useful in split DNS scenarios where private names are used and where correct DNS server selection is mandatory for successful DNS resolution.

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This Internet-Draft will expire on August 30, 2010.

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1. Introduction

A multi-homed host faces several problems over single-homed host as described in [I-D.ietf-mif-problem-statement]. This document studies in detail problems split DNS may cause for multi-homed hosts and for which optimized behaviour should be defined. The problems are mostly the same in IPv4 and IPv6 domains.

In the split DNS scenario different DNS servers have different information. Therefore DNS related information, which otherwise could be consider global for a single-homed host, in a multi-homed host has to be handled as local to a network interface. DNS record synthesis, as described in DNS64 [I-D.ietf-behave-dns64] and Bump-In-the-Stack [RFC2767], can be consider as one manifestation of split DNS.

An obvious solution for the problem would be for network administrators to cease utilizing any form of split DNS, or have split DNS used only in deployments where hosts are not allowed to multi-home. However, currently split DNS is deployed and multi-homed hosts have to cope with that.

If an application is bound to utilize only a specific network interface at a time, it essentially makes the host behave single-interface way for that particular application and avoids the problems of split DNS, if also application's DNS requests are handled strictly with DNS service available in that particular network interface. If all applications in a host are bound to use only single network interface at a time, even if the used network interfaces were different, the problems are generally avoided. Please see MIF current practices [I-D.ietf-mif-current-practices] for more information. The procedure described in chapter 3 applies when applications are allowed to utilize multiple interfaces in parallel.

An example of an application that would benefit from multi-homing is a web browser, which commonly accesses many different destinations and should be able to dynamically communicate over different network interfaces.

The solution presented in this memo is intended to be fully backwards compatible and one that can be fully ignored by hosts and networks that are not experiencing the described problem scenarios or that does not implement the solution.

In deployments where split DNS is used, selection of the correct destination and source addresses for the actual IP connection is crucial, as the resolved destination's IP address may be only usable on the network interface over which it was resolved on. However, the

actual IP address selection logic is not at the scope of this document.

1.1. Requirements Language

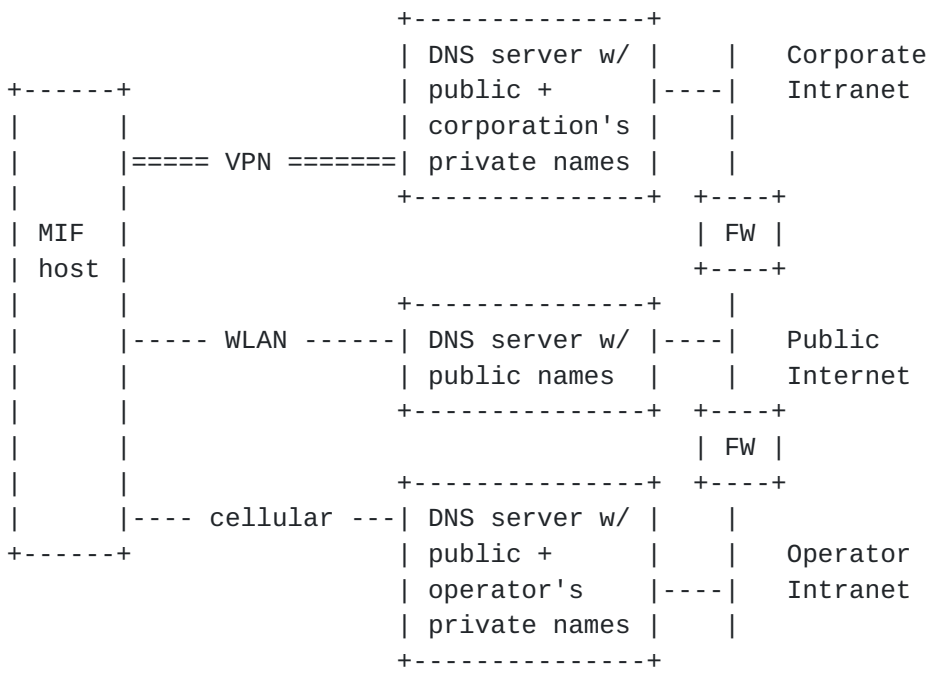
The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2. Problem description for split DNS with multi-homed hosts

This chapter describes two multi-homing related split DNS problem scenarios for which the procedure described in chapter 3 is targeted at. (DISCUSS: Even more more known problem scenarios caused by split DNS for multi-homed hosts?)

2.1. Private fully qualified domain names

A multi-homed host may be connecting to one or more networks that are using private fully qualified domain names. As an example, the host may have simultaneously open a wireless LAN (WLAN) connection to open Internet, cellular connection to an operator network, and virtual private network (VPN) connection to a corporate network. When an application initiates connection to an FQDN, the host needs to be able to choose the right network interface for making successful DNS query. This is illustrated in figure 1. If the FQDN is for a public name, in figure 1 scenario it could be resolved with any DNS server of any network interface, but if the FQDN would be corporation's or operator's service's private name, the host would need to be able to correctly select the right network interface for DNS procedures, i.e. already before destination's IP address is known.

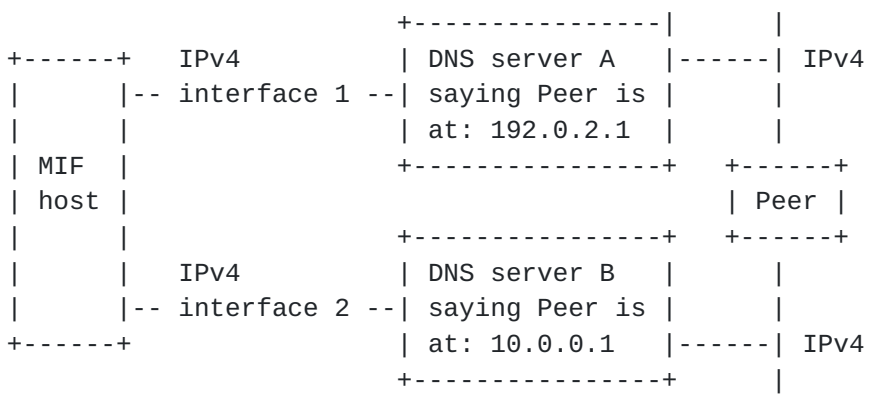


Split DNS and private names illustrated

Figure 1

2.2. Network interface specific IP addresses

In the second problem an FQDN as such is valid and resolvable via different network interfaces, but to different and not necessarily globally reachable IP addresses, as illustrated in figure 2. This is not so much a problem when a host is single-homed, but for multi-homed host this results in additional challenges: the host's source and destination address selection mechanism must ensure the destination's IP address is only used in combination with source IP addresses of the network interface the name was resolved on.

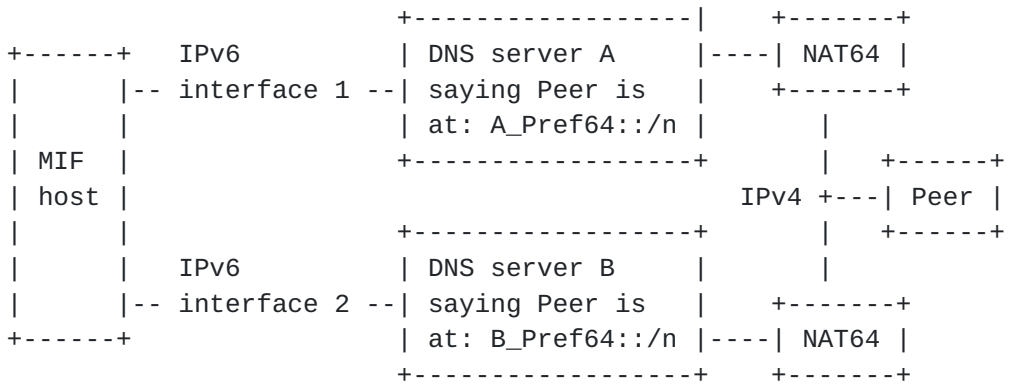


Split DSN and different IP addresses for an FQDN on interfaces 1 and 2.

Figure 2

Similar situation can happen when IPv6 protocol translation is used in combination with AAAA record synthesis proceduce [I-D.ietf-behave-dns64]. A synthesised AAAA record is guaranteed to be valid only on a network interface it was synthesized on. Figure 3 illustrates a scenario where the peer's IPv4 address is synthesized into different IPv6 addresses by DNS servers A and B. The same problem can happen in the IPv4 domain as well if A record synthesis is done, for example as described in Bump-In-the-Stack [RFC2767].

For a related problem for dual-stack hosts in a network with DNS64, where IPv4 should be prioritized over synthesized IPv6, please see [I-D.wing-behave-dns64-config].



AAAA synthesis results in interface specific IPv6 addresses.

Figure 3

More complex scenario is an FQDN, which in addition to resolving into network interface specific IP addresses, identifies on different network interfaces completely different peer entities with potentially different set of service offering. In even more complex scenario, an FQDN identifies unique peer entity, but one that provides different services on its different network interfaces. The solution described in this document is not able to tackle these higher layer issues.

A thing worth noting is that interface specific IP addresses can cause problems also for a single-homed host, if the host retains its DNS cache during movement from one network interface to another, and thus on the new network interface host has cache entries invalid for that network interface. Because of this the cached DNS information should be considered network interface local instead of node global.

3. DNS server selection procedure

This chapter documents a possible procedure a host may utilize for DNS server selection on multi-homing scenarios.

Essentially, the host shall build dynamically for each DNS query a list of DNS servers it will try to contact to. The host shall cycle through the list until a positive reply is received, or until all selected DNS servers have been contacted or timed out. (DISCUSS: What about those DNS servers that instead of negative answer always return positive reply with an IP address of some default HTTP server, which purpose is just to say 'page not found'?)

When building the list, the host shall prioritize DNS servers in a optimal way for the query at hand. Host can utilize any information it may have, e.g. possible user's preferences, host's general preferences between network interfaces, differences on trust levels of network interfaces (see Security Considerations), DNS suffix information possibly available, or any other piece of information.

For the scenario where an FQDN maps to same service but different IP addresses on different network interfaces, the source address selection algorithm must be able to pick a source address from the network interface that was used for DNS resolution.

In private FQDN deployments a negative reply from a DNS server implies only that the DNS server at hand is not able to serve the query. However, it is not probable that the secondary DNS servers on the same network interface would be able to serve either, due likely being in the same administrative domain. Therefore the next DNS server host contacts should be from another network interface.

A host may optimize its behaviour by sending DNS requests in parallel to multiple DNS servers of different network interfaces, but this approach is not always practical:

- It may unnecessary trigger activation of a radio and thus increase battery consumption.
- It may unnecessarily reveal private names to outsiders.
- It may be a privacy issue as it would reveal all names host is resolving to all DNS servers.

3.1. DNS suffixes as hints

To help prioritize DNS servers in an optimal way, a host may learn which DNS servers are most likely able to successfully serve requests related to specific DNS suffixes.

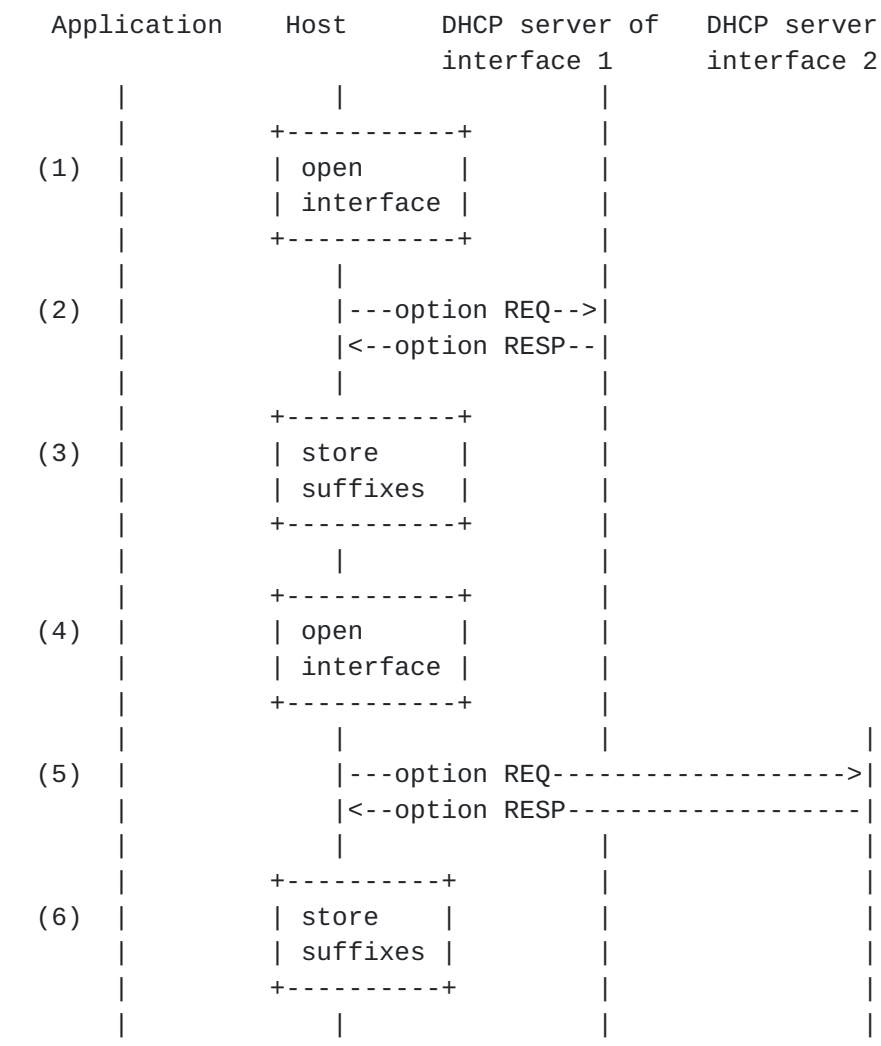
By default, a host should assume all information is available via all DNS servers of any network interface.

When a resource record is to be resolved, a host shall give highest precedence to the DNS servers explicitly known to serve matching suffixes and then to the DNS servers of the network interface(s) advertising corresponding DNS suffix.

For example, when a resolution of an FQDN has been requested and the host is prioritizing DNS servers of different network interfaces, the host may prioritize higher DNS server(s) of the network interface(s) with matching DNS suffix than it otherwise would have.

3.1.1. Learning of the DNS suffixes on existing networks

A host can learn the DNS suffixes of attached network interfaces from DHCP search list options; DHCPv4 Domain Search Option number 119 [RFC3397] and DHCPv6 Domain Search List Option number 24 [RFC3646]. This is illustrated in example figure 4 below.



Learning DNS suffixes

Figure 4

Flow explanations:

1. A host opens its first network interface

2. The host obtains DNS suffix information for the new interface 1 from DHCP server

3. The host stores the learned DNS suffixes for later use

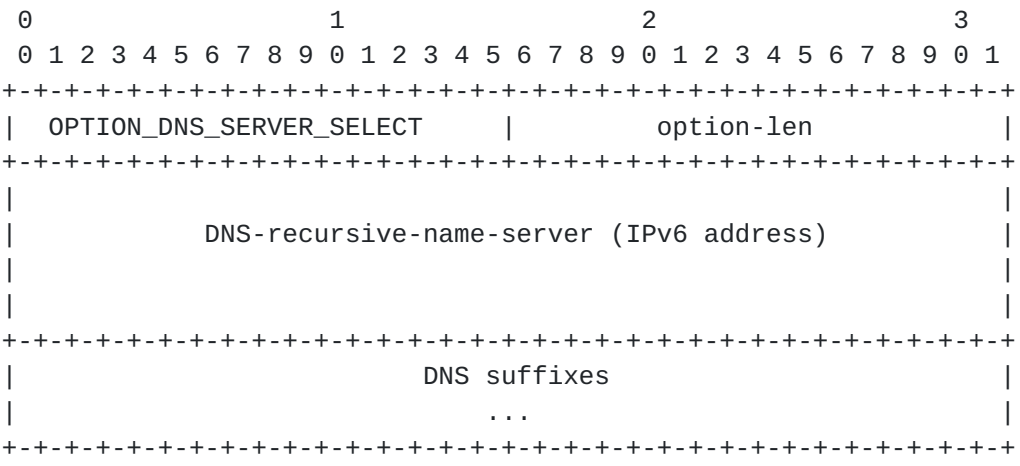
4. The host opens its seconds network interface 2

5. The host obtains DNS suffix, say 'example.com' information for the new interface 2 from DHCP server

6. The host stores the learned DNS suffixes for later use

3.1.2. Explicit DNS suffix configuration with DHCP

To avoid overloading of existing DHCP(v6) options, new DHCP(v6) options could be defined to assist in DNS server selection. The options would define which DNS server should be used for resolving names matching configured DNS suffixes. Below is description of the DHCPv6 option. DHCPv4 version is to be added in next revision, but would work similarly.



option-code: OPTION_DNS_SERVER_SELECT (TBD)

option-len: Lenght of the option in octets

DNS-recursive-name-server: An IPv6 address of a DNS server

DNS suffixes: The list of DNS suffixes MUST be encoded as specified in section "Representation and use of domain names" of <xref target="RFC3315"></xref>.

DHCPv6 option for explicit DNS suffix configuration

Figure 5

The OPTION_DNS_SERVER_SELECT contains one or more DNS suffixes the related DNS server has particular knowledge of (e.g. private suffixes). The option can occur multiple times in a single DHCPv6 message, if multiple DNS servers are to be configured.

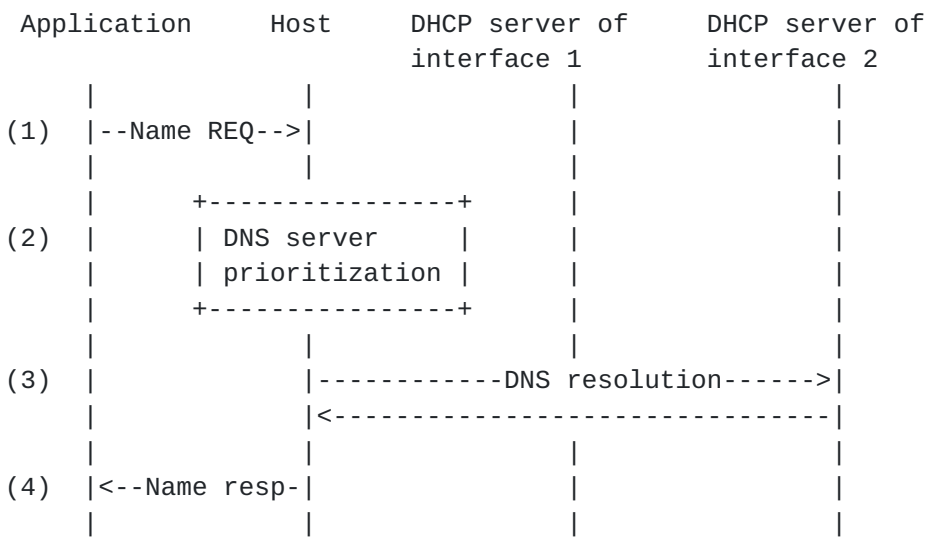
As the DNS options of [RFC3646], the OPTION_DNS_SERVER_SELECT option MUST NOT appear in any other than the following messages: Solicit, Advertise, Request, Renew, Rebind, Information-Request, and Reply.

Due backwards compatibility, the DHCPv6 message containing OPTION_DNS_SERVER_SELECT also very likely contains OPTION_DNS_SERVERS. In case both options contain same IPv6 addresses, only one copy of the IPv6 address SHALL be added to the DNS server list.

In the case of a DNS server replying negatively to a question having matching suffix, it will be for implementation to decide whether to consider that as authoritative response, or whether to ask also from other DNS servers. The implementation decision may be based, for example, on deployment or trust models.

3.1.3. Changes to DNS resolution procedures

When a DNS resolver in a host is requested by an application to do DNS resolution for an FQDN to an IP address, the host should look if any of the configured DNS servers are known to serve addresses for particular suffixes, or if any of the available network interfaces are known to advertise DNS suffixes matching to the FQDN. If there is a match, then explicitly configured DNS server(s) or DNS server(s) of the particular interface should be priorized higher, i.e. be used for name resolution procedures. This is illustrated in figure 6 below. To avoid accidental use of synthesized IPv6 addresses in the dual-stack case, a host may prioritize DNS servers' IPv4 addresses over IPv6 addresses.



Choosing interface based on DNS suffix

Figure 6

Flow explanations:

1. An application makes a request for resolving an FQDN, e.g. 'private.example.com'

2. A host creates list of DNS servers to contact to and uses configured DNS server information and stored DNS suffix information on priorization decisions.

3. The host has chosen interface 2, as from DHCP it was learned earlier that the interface 2 has DNS suffix 'example.com'. The host then resolves the requested name using interface 2's DNS server to IP 192.0.2.1

4. The host replies to application with resolved IP address 192.0.2.1

4. Considerations for network administrators

Due to the problems caused by split DNS for multi-homed hosts, network administrators should consider carefully deployment of split DNS.

Network administrators deploying split DNS should assist hosts in DNS server selection by configuring their DHCP servers with proper DNS suffix information, which hosts then can use as hints. To ensure hosts' source and destination IP address selection works correctly, network administrators should also consider deployment of additional technologies to help with that.

Network administrators can continue using DHCP DNS search list options as before, but administrators should take into account that multi-homed hosts may choose to use the DNS suffix information also for DNS server selection purposes.

5. Further considerations

Overloading of existing DNS search list options is not without problems, though: hosts would obviously use the DNS suffixes learned from search lists also for name resolution purposes. This may not be a problem in deployments where DNS search list options contain few DNS suffixes like 'example.com, private.example.com', but can become a problem if many suffixes are configured. To avoid overloading of existing options, this document proposes standardization of a completely new DHCP option.

6. Acknowledgements

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This document was prepared using xml2rfc template and related web-tool.

7. IANA Considerations

This memo includes no request to IANA.

8. Security Considerations

An attacker may try to lure traffic from multi-homed host to his network by advertising DNS suffixes attacker wishes to intercept or deny service of. The host's security should not be based on correct functionality of DNS server selection, but nevertheless risks of this attack can be mitigated by using DNSSEC and additionally properly prioritizing network interfaces with conflicting DNS suffix advertisements. The prioritization could be based on trust level of a network interface over which DNS suffix was learned from, like for example:

1. Managed tunnel interfaces (such as VPN) considered most trustworthy

2. Managed networks being on the middle

3. Unmanaged networks having lowest priority

Now, for example, if all of the three abovementioned networks would advertise 'corporation.com' DNS suffix, the host would prefer the VPN network interface for related DNS resolution requests.

9. References

9.1. Normative References

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9.2. Informative References

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[I-D.wing-behave-dns64-config] Wing, D., "DNS64 Resolvers and Dual-Stack Hosts", draft-wing-behave-dns64-config-02 (work in progress), February 2010.

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