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Dual Stack Transition Mechanism (DSTM)

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Abstract

During the initial deployment of IPv6, hosts in native IPv6 networks will need to maintain connectivity with hosts and/or applications who can only be reached through IPv4. The Dual Stack Transition Mechanism (DSTM) provides a method to assure this connectivity based on the use of IPv4-over-IPv6 tunnels and the temporal allocation of a global IPv4 address to hosts requiring such communication. This document defines the processes and architecture required for this transition mechanism.

Table of Contents:

1. Introduction

The initial deployment of IPv6 will require a tightly coupled use of IPv4 addresses to support the interoperation of IPv6 and IPv4 within an IPv6-only Network. Nodes will still need to communicate with IPv4 nodes that do not have a dual IP layer supporting both IPv4 and IPv6. The Dual Stack Transition Mechanism (DSTM) is based on the use of IPv4-over-IPv6 tunnels to carry IPv4 traffic within an IPv6-only network and provides a method to allocate a temporary IPv4 Address to IPv6/IPv4 nodes.

DSTM is targeted to help the interoperation of IPv6 newly deployed networks with existing IPv4 networks. Since the IPv4 globally routable address space available is becoming a scarce resource, it is assumed that users will deploy IPv6 to reduce the need and reliability on IPv4 within a portion of their networks. Under this premise, supporting native IPv4 and native IPv6 simultaneously largely increases the complexity of network administration (address plan, routing infrastructure). It is proposed, in this case, to configure the network only for IPv6. In this specific scenario, DHCPv4[7] can not be directly used to assign IPv4 addresses to IPv6 nodes, since no IPv4 connectivity is maintained in the network.

When DSTM is deployed in a network, an IPv4 address is allocated to a dual stack node if the connexion can not be established using IPv6. This allows either IPv6 nodes to communicate with IPv4-only nodes, or IPv4-only applications to run on an IPv6 node without modification. This allocation mechanism is coupled with the ability to perform IPv4-over-IPv6 (4over6) tunnelling, hiding IPv4 packets inside the native IPv6 domain. This simplifies network management: only the IPv6 routing plan is managed inside the network.

The DSTM architecture is composed of an address server (DSTM server), a gateway and a number of nodes (DSTM nodes). The address server is in charge of IPv4 address allocation to client nodes. This allocation is very simple since there is no localization purpose in this address. The DSTM server has just to guarantee the uniqueness of the IPv4 address for a period of time. The gateway, or Tunnel End Point (TEP), can be seen as a border router between the IPv6-only domain and an IPv4 internet or intranet. This node performs encapsulation/decapsulation of packets to assure bi-directional forwarding between both networks. Finally, in order to assure IPv4 connectivity, nodes in the IPv6-only domain should be able to dynamically configure their IPv4 stack (by asking the server for a temporary address) and must be capable to establish 4over6 tunnels towards a Tunnel End Point. The exact details on how DSTM nodes communicate with the DSTM Server is out of the scope of this proposal and will be described in other documents.

This specification begins by the definition of the terminology (section 2). Section 3 provides a technical overview of the DSTM methodology as a transition mechanism. In section 4, the requirements for DSTM nodes is presented. Section 5 describes the DSTM server requirements. Finally, section 6 provides the DSTM Applicability Statement.

2. Terminology

2.1 IPv6 DSTM Terminology

DSTM Domain	The network areas on an Intranet where IPv6 nodes use DSTM to assure IPv4 communication. An IPv4 address allocation server may be deployed inside the domain to manage an IPv4 address pool. IPv4 routing access may not be maintained within a DSTM domain.
DSTM Server	A process in charge of managing the IPv4 address space that will be allocated to DSTM Nodes.
Tunnel End Point	Destination of IPv6 flows containing IPv4 packets. It assures the forwarding function between the DSTM domain and a given IPv4 network.
4over6 Tunnelling	Encapsulation of IPv4 packets over IPv6. Used for carrying IPv4 flows from one node to another in a DSTM Domain.
DSTM Client	A process on a DSTM Node who manages the temporary IPv4 address allocated by the DSTM Server.
DSTM Node	A node that implements both IPv4 and IPv6 stacks, 4over6 tunnelling and is a DSTM client. A DSTM node generates only IPv6 packets on the network.

IPv6 Protocol Terms: See [1]

IPv6 Transition Terms: See [6]

DHCPv6 Terms: See [2]

2.2 Specification Language

In this document, several words are used to signify the requirements of the specification, in accordance with RFC 2119 [4]. These words are often capitalized.

MUST — This word, or the adjective "required", means that the definition is an absolute requirement of the specification.

MUST NOT — This phrase means that the definition is an absolute prohibition of the specification.

SHOULD — This word, or the adjective "recommended", means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications must be understood and carefully weighed before choosing a different course. Unexpected results may result otherwise.

MAY — This word, or the adjective "optional", means that this item is one of an allowed set of alternatives. An implementation which does not include this option MUST be prepared to interoperate with another implementation which does include the option.

silently discard — The implementation discards the packet without further processing, and without indicating an error to the sender. The implementation SHOULD provide the capability of logging the error, including the contents of the discarded packet, and SHOULD record the event in a statistics counter.

3. DSTM Overview and Assumptions

DSTM, as discussed in the introduction, is a method that uses existing protocols. This document does not specify a new protocol. However, DSTM defines node, server and TEP behaviours as well as the properties of the temporary addresses allocation mechanism.

The motivation for DSTM is to provide IPv6 hosts a means to acquire an IPv4 address, for communications with IPv4-only hosts or through IPv4 applications.

The core assumption within this mechanism is that it is totally transparent to applications, which can continue to work with IPv4

addresses. It is also transparent to the network, where only IPv6

packets are carried. It is the authors' viewpoint that the user, in this case, has deployed IPv6 to support end to end computing without translation. This aspect is fundamental during a transition process to guarantee that every existing application will continue to work (e.g. IPsec, H.323), despite the presence of IPv4 addresses in the payload of a packet.

The following assumptions describe the model used by DSTM:

- A DSTM domain is within an Intranet not on the Internet.

- IPv6 nodes do not maintain an IPv4 address except on a temporary basis, to communicate with IPv4-only nodes and/or IPv4 applications.

- The temporary IPv4 address allocation is performed by the DSTM server. Different protocols (DHCPv6 being the logical choice) can be used for the allocation process. Native IPv6 communication between server and client is one restriction in this matter.

- As an extension to the address allocation process, the DSTM server may also provide a range of port numbers to be used by the client. This would allow the use of the same IPv4 address by several DSTM nodes at the same time, reducing the size of the required IPv4 address pool.

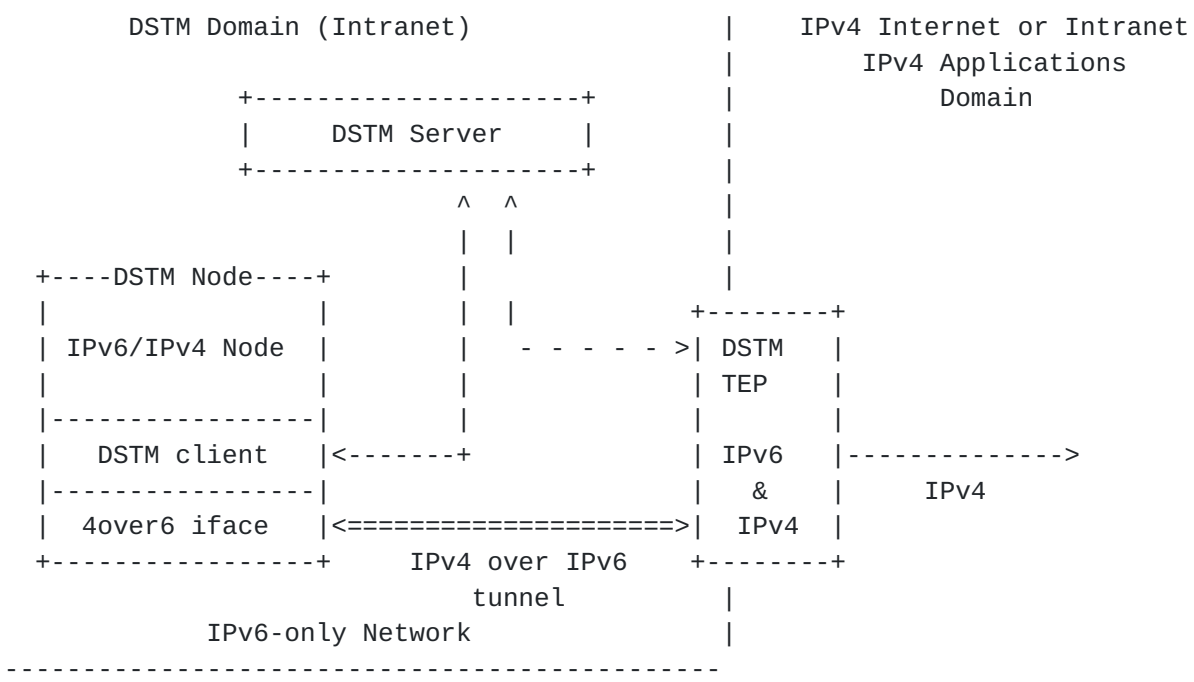
- Inside a DSTM domain, IPv4 routing tables are kept to a minimum on behalf of IPv6 routing, hence, reducing the network management required for IPv4 during transition.

- Once an IPv6 node has obtained an IPv4 address (and maybe a port range), 4over6 tunnelling is used to forward packets from the node to a DSTM TEP, where the packet is decapsulated and forwarded using IPv4. As part of the address allocation process, the DSTM server SHOULD provide the client with the IPv6 address of the TEP to be used.

- Existing IPv4 applications do not need to be modified to run on DSTM nodes.

- A DSTM Node can communicate with any IPv4-only host, as long as the destination address is reachable from the TEP used by the node.

A schematic overview of DSTM is as follows:



For an IPv6 node to participate in DSTM it MUST have a dual IP layer, supporting both an IPv4 and an IPv6 stack. DSTM is not a solution for IPv6 ONLY nodes.

4. DSTM Node Requirements.

4.1 Configuration of the IPv4 stack

As long as communications can take place in native IPv6, no IPv4 address is given to the DSTM node. The host can detect the need of an IPv4 address by different methods: when a query to the DNS resolver results in an IPv4 destination address, when an application opens an IPv4 socket, or when an IPv4 packet is sent to the kernel and no interface is ready to forward that packet.

When the first IPv4 packet needs to be sent, the DSTM client MUST contact the DSTM server. This document does not specify any particular mechanism for DSTM client/server communication. Following this message exchange, the client obtains from the server a temporary IPv4 address as well as the IPv6 address of a TEP. If allowed by the implementation, the server MAY also provide the port range to be used. This information is used to configure the 4over6 interface. It is at this point that the IPv4 stack is configured.

4.2 IPv4 packet forwarding

In the absence of an IPv4 routing infrastructure, a DSTM node can not directly send IPv4 packets on the network. It has to encapsulate them into IPv6 packets and send them to a Tunnel End Point (which can be seen as a particular DSTM node) that will decapsulate the packet and forward them into the IPv4 network.

On a DSTM node, this encapsulation is done by a 4over6 interface. All IPv4 traffic can be directed to that interface by an IPv4 routing table entry. The exact details of the 4over6 interface and the associated routing table entries are implementation dependant.

4.3 DSTM processing of IPv4 packets

When a DSTM Node needs to send an IPv4 packet, it is sent to the 4over6 interface. If the 4over6 interface is not configured (it does not have an IPv4 address), the process SHOULD be blocked and the DSTM Server SHOULD be contacted to get a temporary address. Once an address is allocated, it is used as the IPv4 source address for all the packets leaving the interface. The other fields of the IPv4 packet are normally filled.

4.4 IPv6 packet construction

When the 4over6 interface encapsulates an IPv4 packet into an IPv6 packet, it has to determine the IPv6 destination address. Usually, this will be the address of a TEP. At the node, the address of the TEP can be either statically configured or dynamically acquired when the DSTM node obtains an IPv4 address from the DSTM Server.

The IPv6 address of the TEP SHOULD be provided by the DSTM server when the DSTM node receives a temporary IPv4 address (section 5). However, a DSTM node MAY manually configure the TEP during early deployment of DSTM. This will not scale and is not recommended as a long term transition solution.

The next header type for encapsulation of IPv4 is 4 (as for IPv4 tunnelling over IPv4). When a tunnelled packet arrives to the IPv6 destination, the IPv6 header is removed and the packet is processed by the IPv4 layer. The IPv4 packet will then be forwarded by the TEP using the IPv4 infrastructure. The TEP SHOULD cache the association between the IPv4 and IPv6 source addresses.

The IPv6 source address of an encapsulated packet SHOULD be the IPv6 address of the physical interface on which the IPv6 packet will be sent.

5. DSTM Server Requirements

The DSTM server is in charge of the temporary IPv4 address allocation. This allocation is very simple since there is no localization purpose in this address. The DSTM server has just to guarantee the uniqueness of the IPv4 address for a period of time. To reduce the need of IPv4 addresses, some implementations MAY include a port range as part of the allocation process. This would allow the use of the same IPv4 address by several nodes simultaneously.

The DTSM server MUST memorize the mapping between the IPv6 address of the node requesting an address and the allocated IPv4 address. The IPv4 address is allocated by the server for a fixed amount of time. This duration MUST be included in the response. If the client needs the IPv4 address for a longer period of time, the client MUST renew the lease.

Routing in the IPv4 realm MUST ensure that the pool of IPv4 global addresses managed by a DSTM server is routed to one or more TEPs in the DSTM domain. When allocating an address to a DSTM Node, the server message SHOULD include the IPv6 address of the TEP in charge of the allocated address. Additionally, the DSTM Server MAY be in charge of configuring the IPv4/IPv6 mapping table at the TEP, if it can not be constructed dynamically or dynamic construction is disabled for security reasons.

The communication between the DSTM client and the server MUST be in IPv6. Describing the different methods that can be used to assure such communication is out of scope and will be described in other documents.

The DSTM server MAY allocate a temporary IPv4 address without a request from he client.

The DSTM server SHOULD be able to authenticate the DSTM client.

6. Applicability Statement

DSTM is to be used in a network domain where IPv6 routing is enabled and ALL nodes within that domain are able communicate using IPv6. In this case, IPv4 support can be tuned off: the burden of maintaining an IPv4 addressing plan and supporting IPv4 routing are removed. However, given the huge number of IPv4-only hosts and applications in the Internet, it is clear that during early phases of IPv6 deployment a number of hosts inside IPv6-only domains still require IPv4 connectivity.

The need for IPv4 connectivity inside a domain can be greatly reduced if ALGs (Application Level Gateways) are properly used. Popular services, such as http or smtp can take advantage of this possibility. DSTM can be deployed where no other solutions, such as ALGs, can be implemented. DSTM allows Dual IP-layer nodes to obtain an IPv4 address and offers a default route (though a 4over6 tunnel) to an IPv4 gateway. Any IPv4-only application can run over an IPv6-only network if such a scheme is used and, if DSTM is configured to allocate Global IPv4 addresses, hosts inside that domain will be able to communicate with any other host on the Internet.

DSTM may be deployed in several phases. As a first step, IPv4 connectivity may be assured by manually configuring tunnels from Dual-IP nodes to a Tunnel End Point (TEP). In a second phase, when address allocation or tunnel set up protocols become available (DHCPv6 [2], TSP [11]), it would be possible to dynamically configure the IPv4 stack of Dual-IP nodes when needed. If enough IPv4 address space is available, a static address may be allocated for the whole lifetime of the requesting node, reducing the complexity of address management.

Whenever IPv4 address availability becomes a problem, the full capacities of DSTM can be deployed. Address Allocation protocols in DSTM must support dynamic allocation of addresses, in which addresses are allocated only for small periods of time, based on the real needs of the requesting host. Thus, on a large time scale, several hosts share the same IPv4 address.

Since the address allocation process in DSTM is triggered only when IPv4 connectivity is strictly necessary, the size of the IPv4 address pool required by the mechanism should decrease with time (as more hosts and applications become IPv6 aware). However, if the lack of IPv4 address space continues, DSTM may be extended to include the 'ports option' [12], allowing simultaneous use of the same address by several hosts, but increasing complexity.

An alternative use of DSTM concerns what has been called "the VPN scenario" [10]. It concentrates on the situation where a DSTM node is outside its home domain. Supposing that the node can easily obtain an IPv6 address on the visited network but no IPv4 configuration is possible, the DSTM node can negotiate with its home DSTM server and TEP for IPv4 connectivity. If address allocation succeeds, the nomad node will forward all its IPv4 traffic to the TEP at its home network using a 4over6 tunnel. Even if the path is not optimal, the node obtains access to private IPv4 resources in its home domain and may obtain global IPv4 connectivity.

The main difference between the intranet scenario and the VPN

scenario of DSTM is security. In the VPN scenario, the DSTM server MUST authenticate the DSTM host. This authentication cannot rely on

the IPv6 address since the address depends on the visited network, but can be based on some shared secret. The cost of DSTM-VPN is minimal, it requires home sites to have an access to the IPv6 Internet through native links or tunnels and the installation of a DSTM server and a TEP.

7. Security Considerations

The DSTM mechanism can use all of the defined security specifications for each functional part of its operation. For DNS, the DNS Security Extensions/Update can be used [9]. Concerning address allocation, when connections are initiated by the DSTM nodes, the risk of Denial of Service attacks (DOS) based on address pool exaustion is limited since DSTM is used in an intranet environement. In this scenario, If DHCPv6 is deployed, the DHCPv6 Authentication Message can be used [2]. Also, since the TEPs are inside an intranet, they can not be used as an open relays. Finally, for IPv4 communications on DSTM nodes, once the node has an IPv4 address, IPsec [3] can be used since DSTM does not break secure end-to-end communications at any point.

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