

[MS-DFSC]: Distributed File System (DFS): Referral Protocol Specification

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1 Introduction

The Distributed File System (DFS): Referral Protocol allows file system clients to resolve names from a namespace distributed across many servers and geographies into local names on specific file servers. After names have been resolved, clients can directly access files on the identified servers by using file system protocols such as the [Server Message Block \(SMB\) Protocol](#) (as specified in [MS-SMB]), Network File System (NFS) (for more information, see [\[RFC3530\]](#)), and NetWare Core Protocol (NCP) (for more information, see [NOVELL]).

1.1 Glossary

The following terms are defined in [\[MS-GLOS\]](#):

- 8.3 name**
- anonymous user**
- binary large object (BLOB)**
- Distributed File System (DFS)**
- Distributed File System (DFS) client**
- Distributed File System (DFS) client target failback**
- Distributed File System (DFS) client target failover**
- Distributed File System (DFS) in-site referral mode**
- Distributed File System (DFS) interlink**
- Distributed File System (DFS) link**
- Distributed File System (DFS) link target**
- Distributed File System (DFS) metadata**
- Distributed File System (DFS) namespace**
- Distributed File System (DFS) namespace, domain-based**
- Distributed File System (DFS) namespace, standalone**
- Distributed File System (DFS) path**
- Distributed File System (DFS) referral**
- Distributed File System (DFS) referral site costing**
- Distributed File System (DFS) root**
- Distributed File System (DFS root target)**
- directory object**
- directory service (DS)**
- Distributed File System (DFS)**
- domain**
- domain controller (DC)**
- domain name**
- forest**
- Internet host name**
- NetBIOS name**
- Server Message Block (SMB)**
- share**
- site**
- Unicode**
- Universal Naming Convention (UNC)**

The following terms are specific to this document:

DFS namespace name: The second path component of a **DFS path**. In the **DFS path** \\MyDomain\MyDfs\MyDir, the DFS namespace name is MyDfs.

DFS server: A server computer that runs the **DFS** service required to respond to **DFS referral** requests. Also interchangeably used to refer to the **DFS** service itself.

DFS target: Either a **DFS root target** server or a **DFS link target** server.

host name: The name of a computer used for identification and access purposes by both humans and other computers in a network.

share name: The name of a **share**.

site cost: An administrator-defined numerical value meant to indicate the bandwidth or actual monetary cost of transmitting data between two **sites**. Only a comparison between two site cost values is meaningful, with a lower **site** preferred to a higher site cost.

target set: A consecutive list of referral entries. A **DFS referral** response consists of **DFS targets** that are grouped into sets based on various policies. One policy groups **DFS targets** into two sets: one consisting of all **DFS targets** in the same **site** as the **DFS client**, and the other consisting of all remaining **DFS targets**. Another policy creates **DFS target** sets, where each set contains **DFS targets** that have the same **site cost** from the **DFS client's** perspective, in increasing order of cost. By assigning non-default priorities to **DFS targets**, other policies are possible. For more information, see [\[MSDFS\]](#).

MAY, SHOULD, MUST, SHOULD NOT, MUST NOT: These terms (in all caps) are used as described in [\[RFC2119\]](#). All statements of optional behavior use either MAY, SHOULD, or SHOULD NOT.

1.2 References

1.2.1 Normative References

We conduct frequent surveys of the normative references to assure their continued availability. If you have any issue with finding a normative reference, please contact dochelp@microsoft.com. We will assist you in finding the relevant information. Please check the archive site, <http://msdn2.microsoft.com/en-us/library/E4BD6494-06AD-4aed-9823-445E921C9624>, as an additional source.

[MS-ADTS] Microsoft Corporation, "[Active Directory Technical Specification](#)", July 2006.

[MS-CIFS] Microsoft Corporation, "[Common Internet File System \(CIFS\) Protocol Specification](#)", September 2009.

[MS-DFSNM] Microsoft Corporation, "[Distributed File System \(DFS\): Namespace Management Protocol Specification](#)", July 2006.

[MS-DRDM] Microsoft Corporation, "[Directory Replication and Data Management \(DRDM\) Remote Protocol Specification](#)", July 2007.

[MS-ERREF] Microsoft Corporation, "[Windows Error Codes](#)", January 2007.

[MS-NRPC] Microsoft Corporation, "[Netlogon Remote Protocol Specification](#)", March 2007.

[MS-SMB] Microsoft Corporation, "[Server Message Block \(SMB\) Protocol Specification](#)", July 2006.

[MS-SMB2] Microsoft Corporation, "[Server Message Block \(SMB\) Version 2 Protocol Specification](#)", July 2006.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997, <http://www.ietf.org/rfc/rfc2119.txt>

[UNICODE] The Unicode Consortium, "Unicode Home Page", 2006, <http://www.unicode.org/>

1.2.2 Informative References

[KB831201] Microsoft Corporation, "An update for Windows Server 2003 and Windows 2000 Server makes it possible to put the logon server at the top of the DFS referrals list", Version 9.0, April 2010, <http://support.microsoft.com/kb/831201>

[MS-GLOS] Microsoft Corporation, "[Windows Protocols Master Glossary](#)", March 2007.

[MSDFS] Microsoft Corporation, "How DFS Works", March 2003, <http://technet.microsoft.com/en-us/library/cc782417%28WS.10%29.aspx>

[MSFSMT] Microsoft Corporation, "Microsoft File Server Migration Toolkit 1.2", June 2009, <http://www.microsoft.com/downloads/details.aspx?FamilyID=d00e3eae-930a-42b0-b595-66f462f5d87b&DisplayLang=en>

[NOVELL] Chappell, L.A. and Hakes, D.E., "Novell's Guide to NetWare LAN Analysis, 2nd Edition", Novell Press, June 1994, ISBN: 0782113621.

[RFC1034] Mockapetris, P., "Domain Names - Concepts and Facilities", STD 13, RFC 1034, November 1987, <http://www.ietf.org/rfc/rfc1034.txt>

[RFC2165] Veizades, J., Guttman, E., Perkins, C., and Kaplan, S., "Service Location Protocol", RFC 2165, June 1997, <http://www.ietf.org/rfc/rfc2165.txt>

[RFC3530] Shepler, S., Callaghan, B., Robinson, D., et al., "Network File System (NFS) version 4 Protocol", RFC 3530, April 2003, <http://www.ietf.org/rfc/rfc3530.txt>

1.3 Overview

The Distributed File System (DFS) enables file system clients to access remote file **shares** by using a **DFS path** (or virtual name) for the share, which is then transparently resolved to an actual **share name** on an actual file server. There is quite a bit of flexibility in this mapping. For example, **DFS** can enable the grouping of a set of shares located on different file servers into a unified namespace. DFS name resolution can also be used to transparently recover from a file server failure and to resolve a share to a geographically optimal file server for the specific client that is requesting access. Without DFS, users of a network file system, such as **Server Message Block (SMB)**, are required to know the names of all file servers, and shares that reside on those file servers, for which they require access. With DFS, users can navigate a unified namespace to access files and folders without knowledge of the names of individual file servers and shares that host the data. For more information about DFS, including DFS terminology, usage models, and the Microsoft DFS implementation, see [\[MSDFS\]](#).

After the DFS path has been resolved to an actual path, clients can directly access files on the identified servers by using standard remote file system protocols, such as the [Server Message Block \(SMB\) Protocol](#) (as specified in [\[MS-SMB\]](#)), [Server Message Block \(SMB\) Version 2 Protocol](#) (as specified in [\[MS-SMB2\]](#)), Network File System (NFS) (as specified in [\[RFC3530\]](#)), and NCP, as specified in [\[NOVELL\]](#).

The DFS: Referral Protocol supports two types of namespaces: **domain-based namespaces**, which offer high availability and load balancing, and stand-alone namespaces, which reside on a single **DFS root target** server and do not require **domain** infrastructure. In **stand-alone DFS**

namespaces, clients issue root referral requests and link referral requests directly to the DFS root target server.

For domain-based namespaces, clients issue **DFS referral** requests to **domain controllers (DCs)** to discover the existence of domains and the existence of **DFS namespaces**. Clients issue referral requests to DCs in order to discover the DFS root target servers hosting specific DFS namespaces. Clients can also issue referral requests to DFS root target servers to discover other DFS root target servers that host a DFS namespace. Clients issue referral requests to DFS root target servers to discover the locations of **DFS link targets** (shares on file servers). After the components of a DFS path have been resolved to specific targets, clients then issue file system requests directly to file servers, using the appropriate remote file system protocol for that server.

In crossing DFS namespaces, clients may attempt to issue file system requests against **DFS links**. File servers can notify the client of the requirement for name resolution by using designated error messages in file system protocols. Clients then issue referral requests to resolve DFS links into DFS link targets, as specified in section [3.1.5.1](#). With newly resolved paths, clients then reissue file system requests directly to the appropriate file servers. The DFS links in a DFS namespace can also include paths that point to other DFS namespaces. A DFS link that points to another DFS namespace is called a **DFS interlink**. For DFS interlinks, if the target is a domain-based DFS namespace, there cannot be more than one target for the link. However, multiple stand-alone DFS namespace targets are supported as DFS interlink targets.

The DFS: Referral Protocol is a command/acknowledge protocol that sends out a sequence of referral requests to eventually resolve the DFS path to an actual path. There are five types of referral requests, as specified in section [2.2.2](#):

- Domain referrals, which identify the domains in the **forest** to which the **DFS client** is joined and the domains in other forests, which are part of a trust relationship with the DFS client's forest.
- DC referrals, which identify the DCs of a specific domain.
- Root referrals, which identify the DFS root targets of a specific DFS namespace.
- Link referrals, which identify the DFS link targets of a specific link in a DFS namespace.
- Sysvol referrals, which identify the DCs that host a domain's SYSVOL or NETLOGON shares.

Domain-joined clients issue all five types of referral requests, while non-domain-joined clients issue only **DFS root** and DFS link referral requests. Optionally, clients can also be used to administer DFS namespaces (see [\[MS-DFSNM\]](#)).

Clients can maintain local caches of information that are received through referral requests to avoid future referral requests and to improve the performance of DFS resource access, as specified in section [3.1.1](#).

1.4 Relationship to Other Protocols

The DFS: Referral Protocol relies on the [Server Message Block \(SMB\) Protocol](#), (as specified in [MS-SMB]) or the [Server Message Block \(SMB\) Version 2 Protocol](#) (as specified in [MS-SMB2]), or the Common Internet File System Protocol (as specified in [\[MS-CIFS\]](#)) as its transport layer.

The DFS topology and configuration of DFS namespaces named by referral requests are maintained by the [Distributed File System \(DFS\): Namespace Management Protocol](#) (as specified in [MS-DFSNM]).

The DFS: Referral protocol depends on the Netlogon Remote Protocol Specification (as specified in [\[MS-NRPC\]](#)) to determine the **site** of the client from the IP address.

The DFS: Referral Protocol allows SMB (as specified in [MS-SMB] and [MS-SMB2]) file system clients to resolve names from a namespace distributed across many servers and geographies into local names on specific file servers. After names have been resolved, clients can directly access files on the identified servers by using file system protocols, such as the SMB Protocol, the SMB Version 2.0 Protocol, the Common Internet File System Protocol, NFS (as specified in [RFC3530](#)), and NCP (as specified in [NOVELL]).

The DFS: Referral Protocol does not specify a replication protocol for file and directory content between DFS root targets or DFS link targets, nor does it interact with any such protocol. While replication may be used in a deployment of the DFS: Referral Protocol, it is equally reasonable for the respective targets to have differing content. Enforcing appropriate consistency for file and directory content is a deployment-specific consideration.

All protocols that use SMB to access files on remote machines depend on DFS if those files are located on shares in a DFS namespace.

1.5 Prerequisites/Preconditions

1.5.1 Common Requirements

The SMB DFS referral request uses the TRANS2_GET_DFS_REFERRAL SMB message, as specified in [\[MS-SMB\]](#). This is available only in SMB versions beginning with NT LAN Manager 0.12. The SMB2 DFS referral request uses the FSCTL_DFS_GET_REFERRALS IOCTL, as specified in [\[MS-SMB2\]](#).

The DFS: Referral Protocol requires that the DFS namespace, which is accessed by both the DFS client and the **DFS metadata** used by the DFS: Referral Protocol, has already been set up—possibly through the [Distributed File System \(DFS\): Namespace Management Protocol](#), as specified in [MS-DFSNM]. The protocol also requires that the shares are already set up for a DFS namespace's DFS root and link targets, along with SYSVOL/NETLOGON referral targets when used in domain environments. These shares can be set up as specified in [\[MS-SRVS\]](#).

The Distributed File System (DFS): Referral Protocol defines no security parameters beyond those of its SMBtransport.

1.5.2 Client

DFS clients that issue referral requests may or may not be joined to a domain. DFS namespaces accessed by the DFS client can be domain-based DFS namespaces or stand-alone DFS namespaces.

1.5.3 DC or DFS Root Target Server

To permit the **DFS targets** in the referral response to be ordered on the basis of **site cost** between the client site and a DFS target site, a server joined to a domain is required to determine the site cost of a client from the client's IP address, as specified in [\[MS-NRPC\]](#) section 3.5.5.3.8. If the server intends to support **DFS referral site costing**, it is required to have the ability to perform the site cost queries between the client and the DFS targets, as specified in [\[MS-DRDM\]](#) section 4.1.

The **DFS server** uses the DFS metadata of a DFS namespace to process referral requests. For domain-based DFS namespaces, the server is required to access the DFS metadata stored in the **object** of the DFS namespace. Location and format of the DFS metadata is specified in [\[MS-DFSNM\]](#) section 2.3.

1.6 Applicability Statement

The DFS: Referral Protocol is applicable for scenarios in which files that are stored across one or more shares— possibly including one or more file servers—and the share administrator would like to provide one or more of the following capabilities.

- A unified namespace across multiple shares, such that from a client's perspective there is no need to know about individual share namespaces.
- A fault-tolerant namespace, such that failure of a share causes the client to fail over to an alternate share.
- A geographically optimized namespace, such that the client will automatically access the share that contains the geographically "lowest cost" copy of the files.
- A share name that is logically independent of the file server or the actual name of the share on the file server.

1.7 Versioning and Capability Negotiation

A client specifies the highest DFS referral version supported in the **MaxReferralLevel** field of the [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) message.

A server responds with the highest DFS referral version supported by both the client and the server in the **VersionNumber** field of each referral entry, as specified in [section 2.2.4](#).

1.8 Vendor-Extensible Fields

There are no vendor-extensible fields defined in the DFS: Referral Protocol.

This protocol uses NTSTATUS values taken from the NTSTATUS number space, as specified in [\[MS-ERREF\]](#). Vendors SHOULD [<1>](#) reuse those values with their indicated meaning. Choosing any other value runs the risk of a collision in the future.

1.9 Standards Assignments

None.

2 Messages

2.1 Transport

The DFS: Referral Protocol uses either the Server Message Block (SMB) Protocol (as specified in [\[MS-SMB\]](#)) or the Server Message Block (SMB) Version 2 Protocol (as specified in [\[MS-SMB2\]](#)) as its transport protocol. The specific version of the SMB protocol used for the transport is chosen in the SMB layer. For more information, see [\[MS-CIFS\]](#) section 3.4.4.9.

When the SMB Protocol (version 1, as specified in [\[MS-SMB\]](#)) is used as the transport, the referral request is sent in the form of a `REQ_GET_DFS_REFERRAL` structure in the `Trans2_Parameters` block of the [TRANS2_GET_DFS_REFERRAL request](#) within an [SMB_COM_TRANSACTION2](#) message, and the referral response is received in a [TRANS2_GET_DFS_REFERRAL response](#) within an `SMB_COM_TRANSACTION2` response. The `TRANS2_GET_DFS_REFERRAL` request and response messages are specified in [\[MS-CIFS\]](#) sections [2.2.6.16.1](#) and [2.2.6.16.2](#). The `SMB_COM_TRANSACTION2` message is specified in [\[MS-SMB\]](#) section 2.2.4.4.

The underlying SMB protocol implementation MUST support the DFS flags in SMB packets as specified in [\[MS-SMB\]](#). The assignments used by the SMB Protocol that are relevant to the DFS: Referral Protocol are as follows.

Parameter	Value	Reference
<code>TRANS2_GET_DFS_REFERRAL</code> subcommand type for the <code>SMB_COM_TRANSACTION2</code> packet.	0x0010	[MS-SMB] section 2.2.4.4 and [MS-CIFS] section 2.2.6.16.1
<code>CAP_DFS</code> bit in the <code>SMB_COM_NEGOTIATE</code> Server Response extension.	0x00001000	[MS-SMB] section 2.2.4.5.2.1
<code>SMB_SHARE_IS_IN_DFS</code> bit in the OptionalSupport field of the <code>SMB_COM_TREE_CONNECT_ANDX</code> response.	0x0002	[MS-SMB] section 2.2.4.7.2
<code>SMB_FLAGS2_DFS</code> bit in the Flags2 field of the SMB header.	0x1000	[MS-SMB] section 2.2.3.1

When the SMB Version 2.0 Protocol is used as the transport, the referral request is sent as an `SMB2_IOCTL` request message with `REQ_GET_DFS_REFERRAL` structure as the buffer. The `SMB2_DFS` referral request uses the `FSCTL_DFS_GET_REFERRALS` IOCTL, as specified in [\[MS-SMB2\]](#). To respond to a referral request, the DFS: Referral Protocol server provides a buffer to the `SMB Version 2.0` Protocol as a response, and the `SMB Version 2.0` Protocol implementation MUST transfer it using the `IOCTL` response message. The `SMB2_IOCTL` request message is specified in [\[MS-SMB2\]](#) section 2.2.31 and the `SMB2_IOCTL` response message is specified in [\[MS-SMB2\]](#) section 2.2.32.

2.2 Message Syntax

This section describes the contents of the two SMB messages used by the DFS: Referral Protocol. These messages are [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) and [RESP_GET_DFS_REFERRAL \(section 2.2.3\)](#).

2.2.1 Common Conventions

All paths in [REQ_GET_DFS_REFERRAL](#) and [RESP_GET_DFS_REFERRAL](#) messages MUST be encoded with exactly one leading backslash, not two leading backslashes as is common to user-visible **UNC**

paths. For example, the UNC path "\\server\namespace\directory\subdirectory\file" would be encoded as "\server\namespace\directory\subdirectory\file".

All strings in REQ_GET_DFS_REFERRAL (section 2.2.2) and RESP_GET_DFS_REFERRAL (section 2.2.3) messages MUST be encoded as null-terminated strings of UTF-16 characters, as specified in [\[UNICODE\]](#). Constructs of the form "<value>" in strings are placeholders to be replaced with client or server-specified values. For example, the string description "\<domain>\<namespace>" would take the form "\contoso\templates" when populated with the values "contoso" for the <domain> placeholder and "templates" for the <namespace> placeholder.

All 16-bit and 32-bit integers in REQ_GET_DFS_REFERRAL and RESP_GET_DFS_REFERRAL messages MUST be encoded as unsigned little-endian values.

2.2.1.1 Host Name

"Host name" refers to the <servername> component of the UNC Path specified in section [2.2.1.3](#).

2.2.1.2 Share Name

"Share name" refers to the <share> component of the UNC Path specified in section [2.2.1.3](#).

2.2.1.3 UNC Path

A UNC path can be used to access network resources, and MUST be in the format specified by the Universal Naming Convention.

<servername>, <share> and <filename> are referred to as "pathname components" or "path components". A valid UNC path MUST contain two or more path components. <servername> is referred to as the "first pathname component", <share> as the "second pathname component", and so on. The last component of the path is also referred to as the "leaf component".

The size and valid characters for a path component are defined by the protocol used to access the resource and the type of resource being accessed. The only limitation placed on path components by **DFS** is that path components MUST be at least one character in length and MUST NOT contain a backslash (\) or a null.

2.2.1.4 DFS Root

A DFS root MUST be in one of the following UNC path formats.

- \\<ServerName>\<DFSName>
- \\<DomainName>\<DFSName>

<ServerName > is the **host name** (as specified in section [2.2.1.1](#)) of a DFS root target (as specified in section [2.2.1.6](#)) of the DFS namespace; <DomainName> is the **domain name** of the domain that hosts the domain-based DFS namespace; and <DFSName> is the **DFS namespace name**. Stand-alone DFS namespaces MUST be referred to only by the first path format; domain-based DFS namespaces MUST be referred to in either format, although the second format is preferred.

2.2.1.5 DFS Link

A DFS link MUST be in one of the following UNC path formats.

- \\<ServerName>\<DFSName>\<LinkPath>

- \\<DomainName>\<DFSName>\<LinkPath>

<ServerName> is the host name of a DFS root target of the DFS namespace; <DomainName> is the domain name of the domain that hosts the domain-based DFS namespace; <DFSName> is the DFS namespace name, <LinkPath> is the path of the DFS link relative to the DFS root target share. For example, if the full path used to access a DFS-based resource is \\contoso\share1\x\y\mydata.txt, the DFS root target share is \\contoso\share1 and the link path is x\y\mydata.txt. Stand-alone DFS namespaces MUST be referred to only by the first format; domain-based DFS namespaces MUST be referred to in either format, although the second format is preferred.

2.2.1.6 DFS Root Target

A DFS root target is a UNC path that MUST be in the following format.

- \\<servername>\<sharename>

<servername> is the host name of a DFS root target server and <sharename> is the sharename corresponding to a DFS namespace on the DFS root target server.

2.2.1.7 DFS Link Target

A DFS link target is any UNC path that resolves to a directory.

2.2.1.8 DFS Target

A DFS target is either a DFS root target or a DFS link target.

2.2.2 REQ_GET_DFS_REFERRAL

DFS referral requests are sent in the form of an REQ_GET_DFS_REFERRAL message, by using an appropriate transport as specified in section 2.1.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
MaxReferralLevel																RequestFileName (variable)															
...																															

MaxReferralLevel (2 bytes): A 16-bit integer that indicates the highest DFS referral version understood by the client. The DFS referral versions specified by this document are 1 through 4 inclusive. A DFS client MUST support DFS referral version 1 through the version number set in this field. The referral response messages are referral version dependent and are specified in sections 2.2.4.1 through 2.2.4.4.

RequestFileName (variable): A null-terminated **Unicode** string specifying the path to be resolved. The specified path MUST NOT be case-sensitive. Its format depends on the type of referral request, as specified in section 3.1.4.2.

2.2.3 RESP_GET_DFS_REFERRAL

A DFS server responds to a DFS client referral request with the RESP_GET_DFS_REFERRAL message. The fixed-length portion of this message is referred to as the "referral header" in this document. The format of this message is as follows.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
PathConsumed																NumberOfReferrals															
ReferralHeaderFlags																															
ReferralEntries (variable)																															
...																															
StringBuffer (variable)																															
...																															
Padding (variable)																															
...																															

PathConsumed (2 bytes): A 16-bit integer indicating the number of bytes—not characters—in the prefix of the referral request path that is matched in the referral response.

NumberOfReferrals (2 bytes): A 16-bit integer indicating the number of referral entries immediately following the referral header.

ReferralHeaderFlags (4 bytes): A 32-bit field representing a series of flags that are combined by using the bitwise OR operation. Only the R, S, and T bits are defined and used. The other bits MUST be set to 0 by the server and ignored upon receipt by the client.

Value	Meaning
R 0x00000001	R (ReferralServers): The R bit indicates whether all of the targets in the referral entries returned are DFS root targets capable of handling DFS referral requests.
S 0x00000002	S (StorageServers): The S bit indicates whether all of the targets in the referral response can be accessed without requiring further referral requests.
T 0x00000004	T (TargetFailback): The T bit indicates whether DFS client target failback is enabled for all targets in this referral response. This value MUST be set to 0 by the server and ignored by the client for all DFS referral versions except DFS referral version 4.

ReferralEntries (variable): As many [DFS_REFERRAL_V1](#), [DFS_REFERRAL_V2](#), [DFS_REFERRAL_V3](#), or [DFS_REFERRAL_V4](#) structures as indicated by the **NumberOfReferrals** field.

StringBuffer (variable): A list of zero or more null-terminated Unicode character strings.

Padding (variable): Zero or more response padding bytes. The padding, if present, is for alignment purposes and carries no data.

2.2.4 Referral Entry Types

The DFS: Referral Protocol defines four structures used to encode referral entries: [DFS_REFERRAL_V1 \(section 2.2.4.1\)](#), [DFS_REFERRAL_V2 \(section 2.2.4.2\)](#), [DFS_REFERRAL_V3 \(section 2.2.4.3\)](#), and [DFS_REFERRAL_V4 \(section 2.2.4.4\)](#).

All referral entries in a [RESP_GET_DFS_REFERRAL](#) message MUST use the same referral entry structure. As a consequence, all referral entries in a [RESP_GET_DFS_REFERRAL](#) message MUST have the same value in their respective **VersionNumber** fields. The **VersionNumber** field defines the version number of the entire referral response.

The **VersionNumber** field also provides a more descriptive name to a referral entry or referral response. It is conventional to refer to a "version *N*" referral entry or a "version *N*" referral response, meaning a referral entry with a **VersionNumber** of *N* (of type [DFS_REFERRAL_V*N*](#)) or a referral response containing entries with a **VersionNumber** of *N*, respectively.

Each referral entry structure has a 16-bit **Size** field. The **Size** field indicates the total size, in bytes, of the referral entry. Clients MUST add the value of the **Size** field in a referral entry to the offset of that referral entry to find the offset of the next referral entry in the [RESP_GET_DFS_REFERRAL](#) message.

The [DFS_REFERRAL_V2](#), [DFS_REFERRAL_V3](#), and [DFS_REFERRAL_V4](#) structures contain fields with offsets to strings. Clients MUST add the string offset to the offset of the beginning of the referral entry to find the offset of the string in the [RESP_GET_DFS_REFERRAL](#) message. The strings referenced from the fields of a referral entry MUST follow the last referral entry in the [RESP_GET_DFS_REFERRAL](#) message.

Examples of referral response packets of DFS referral versions 2 and 3 are specified in [section 4](#).

2.2.4.1 DFS_REFERRAL_V1

The format of the version 1 referral entry is as follows.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
VersionNumber																Size															
ServerType																ReferralEntryFlags															
ShareName (variable)																															
...																															

VersionNumber (2 bytes): A 16-bit integer indicating the version number of the referral entry. MUST always be 0x0001 for [DFS_REFERRAL_V1](#).

Size (2 bytes): A 16-bit integer indicating the total size of the referral entry in bytes.

ServerType (2 bytes): A 16-bit integer indicating the type of server hosting the target.

Value	Meaning
0x0000	Non-root targets returned.
0x0001	Root targets returned.

ReferralEntryFlags (2 bytes): A series of bit flags. MUST be set to 0x0000 and ignored on receipt.

ShareName (variable): A null-terminated Unicode character string that specifies a DFS target.

2.2.4.2 DFS_REFERRAL_V2

The format of the version 2 referral entry is as follows.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
VersionNumber																Size															
ServerType																ReferralEntryFlags															
Proximity																															
TimeToLive																															
DFSPathOffset																DFSAlternatePathOffset															
NetworkAddressOffset																															

VersionNumber (2 bytes): A 16-bit integer indicating the version number of the referral entry. MUST always be 0x0002 for DFS_REFERRAL_V2.

Size (2 bytes): A 16-bit integer indicating the total size of the referral entry in bytes.

ServerType (2 bytes): A 16-bit integer indicating the type of server hosting the target.

Value	Meaning
0x0000	Non-root targets returned.
0x0001	Root targets returned.

ReferralEntryFlags (2 bytes): MUST be set to 0x0000 by the server and ignored on receipt by the client.

Proximity (4 bytes): MUST be set to 0x00000000 by the server and ignored by the client.

TimeToLive (4 bytes): A 32-bit integer indicating the time-out value, in seconds, of the DFS root or DFS link.

DFSPathOffset (2 bytes): A 16-bit integer indicating the offset, in bytes, from the beginning of this referral entry to the DFS path that corresponds to the DFS root or the DFS link for which target information is returned.

DFSAlternatePathOffset (2 bytes): A 16-bit integer indicating the offset, in bytes, from the beginning of this referral entry to the DFS path that corresponds to the DFS root or the DFS link for which target information is returned.

NetworkAddressOffset (2 bytes): A 16-bit integer indicating the offset, in bytes, from the beginning of this referral entry to the network address of the DFS target that corresponds to this entry.

2.2.4.3 DFS_REFERRAL_V3

The format of the common elements of a version 3 referral entry is as follows. The entry continues in section [2.2.4.3.1](#) or [2.2.4.3.2](#), dependent on the value of the NameListReferral flag in the ReferralEntryFlags field.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
VersionNumber																Size															
ServerType																ReferralEntryFlags															
TimeToLive																															

VersionNumber (2 bytes): A 16-bit integer indicating the version number of the referral entry. MUST be set to 0x0003, specifying DFS_REFERRAL_V3.

Size (2 bytes): A 16-bit integer indicating the total size of the referral entry, in bytes.

ServerType (2 bytes): A 16-bit integer indicating the type of server hosting the target.

Value	Meaning
0x0000	Non-root targets returned.
0x0001	Root targets returned.

ReferralEntryFlags (2 bytes): A 16-bit field representing a series of flags that are combined by using the bitwise OR operation. Only the NameListReferral bit is defined for DFS_REFERRAL_V3. The other bits MUST be set to zero by the server.

Value	Meaning
NameListReferral 0x0002	MUST be set for a domain referral response or a DC referral response.

TimeToLive (4 bytes): A 32-bit integer indicating the time-out value, in seconds, of the DFS root or DFS link.

The following subsections define the remainder of the structure, which is dependent on whether the NameListReferral flag in the **ReferralEntryFlags** field has a value of 0 or 1 in.

2.2.4.3.1 NameListReferral Flag Set to 0

When the NameListReferral flag in the **ReferralEntryFlags** field is 0, the remainder of the version 3 referral entry MUST be formatted as follows.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
DFSPathOffset																DFSAlternatePathOffset															
NetworkAddressOffset																ServiceSiteGuid															
...																															
...																															
...																															
...																															

DFSPathOffset (2 bytes): A 16-bit integer indicating the offset, in bytes, from the beginning of this referral entry to the DFS path that corresponds to the DFS root or DFS link for which target information is returned. The DFS path MUST be a null-terminated string.

DFSAlternatePathOffset (2 bytes): A 16-bit integer indicating the offset, in bytes, from the beginning of this referral entry to the DFS path that corresponds to the DFS root or DFS link for which target information is returned.

NetworkAddressOffset (2 bytes): A 16-bit integer indicating the offset, in bytes, from the beginning of this referral entry to the network address of the DFS target that corresponds to this entry. The DFS path MUST be a null-terminated string.

ServiceSiteGuid (16 bytes): These 16 bytes MUST always be set to 0 by the server and ignored by the client. For historical reasons, this field was defined in early implementations but never used.

2.2.4.3.2 NameListReferral Flag Set to 1

When the NameListReferral flag in the **ReferralEntryFlags** field is 1, the remainder of the version 3 referral entry MUST be formatted as follows.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SpecialNameOffset																NumberOfExpandedNames															
ExpandedNameOffset																Padding (variable)															

...

SpecialNameOffset (2 bytes): A 16-bit integer indicating the offset, in bytes, from the beginning of the referral entry to a domain name.

NumberOfExpandedNames (2 bytes): A 16-bit integer indicating the number of DCs being returned for a DC referral request. MUST be set to 0 for a domain referral response.

ExpandedNameOffset (2 bytes): A 16-bit integer indicating the offset, in bytes, from the beginning of this referral entry to the first DC name string returned in response to a DC referral request.

Padding (variable): The server MAY insert zero or 16 padding bytes that MUST be ignored by the client. <2>

2.2.4.4 DFS_REFERRAL_V4

The format of the version 4 referral entry MUST be exactly the same as the format of the [DFS_REFERRAL_V3](#) referral entry, with two exceptions.

The value of the **VersionNumber** field MUST be 0x0004 for DFS_REFERRAL_V4.

The **ReferralEntryFlags** field contains an additional flag that can be set as follows.

Value	Meaning
T 0x0004	T (TargetSetBoundary): This bit is set if the target corresponding to this referral entry is the first target of a target set . The first referral entry MUST have this bit set in a DFS version 4 referral response.

The other bits of the **ReferralEntryFlags** field MUST be set to 0 by the server and ignored upon receipt by the client.

3 Protocol Details

The following sections specify details of the Distributed File System (DFS): Referral Protocol, including abstract data models, higher-layer triggered events, and message processing events and sequencing rules.

3.1 DFS Client Details

In this section, unless stated otherwise, the term "client" refers to a DFS client. [<3>](#)

3.1.1 Abstract Data Model

This section describes a conceptual model of possible data organization that an implementation maintains to participate in this protocol. The organization is provided to explain how the protocol behaves. This document does not mandate that implementations adhere to this model as long as their external behavior is consistent with that described in this document.

Because the DFS clients effectively block an application from accessing a specific file share until the DFS: Referral Protocol can map the DFS root name to an actual file server path, it is advantageous to cache DFS referral responses. Because of this, clients may maintain local caches of information received through referral requests to avoid future referral requests and to improve the performance of DFS resource access. [<4>](#)

- **BootstrapDC:** Applicable only for a computer joined to a domain. This contains the name of a DC from which the DFS client will obtain a list of domain referral entries, in addition to a list of DC host names for a domain.
- **DomainCache:** Applicable only for a computer joined to a domain. This cache contains a list of trusted domains in both NetBIOS and fully qualified domain name forms, in addition to a list of DC host names for each domain. Conceptually, this is an array of tuples of the form `<DomainName, DCHint, DCList>`. Cache lookup involves finding a DomainCache entry with a matching DomainName. This can be used to check for a valid domain name or to find a DC host name for a given domain name. DCHint identifies a DC host name from DCList that should be the DC that was last successfully used by the DFS client.
- **ReferralCache:** This cache contains root, link, and sysvol referral responses. A hit on a ReferralCache entry indicates that the path in a name resolution operation is a DFS Root, DFS link, or a SYSVOL/NETLOGON share.

A ReferralCache entry conceptually contains entries indexed by a DFS path prefix, DFSPathPrefix. An entry is a tuple of the form `<DFSPathPrefix, RootOrLink, TTL, TargetFailback, TargetHint, TargetList>`.

DFSPathPrefix is the DFS path that corresponds to a DFS root or a DFS link, and is the same as the string pointed to by the **DFSPathOffset** of a [DFS_REFERRAL_V2](#), [DFS_REFERRAL_V3](#) or [DFS_REFERRAL_V4](#) referral entry.

RootOrLink identifies whether the entry contains DFS root targets or DFS link targets. It reflects the value from the **ServerType** field of a referral entry (as specified in sections [2.2.4.1](#), [2.2.4.2](#), [2.2.4.3](#), and [2.2.4.4](#)).

TargetFailback is used only for DFS_REFERRAL_V4 and contains the value from the TargetFailback bit of the referral header (as specified in section [2.2.3](#)).

TTL contains a value derived from the **TimeToLive** field of a referral entry (as specified in sections [2.2.4.1](#), [2.2.4.2](#), [2.2.4.3](#), and [2.2.4.4](#)). This is the time stamp at which a ReferralCache

entry is considered to be expired. An implementation is free to come up with soft and hard time-outs based on the **TimeToLive** field of the referral entry, for example. The soft time-out may be used to initiate a ReferralCache entry refresh operation while permitting the use of the ReferralCache entry; the hard time-out limit may be used to fail any operation using the ReferralCache entry should all attempts to refresh it fail. <5>

TargetHint identifies a target in TargetList that was last successfully used by the DFS client. TargetList consists of tuples of the form <TargetPath, TargetSetBoundary>, where TargetPath is the string pointed to by the **NetworkAddressOffset** field (as specified in sections 2.2.4.2, 2.2.4.3, and 2.2.4.4). TargetSetBoundary is only present in V4 referrals and reflects the value from the TargetSetBoundary of the referral entry (as specified in section 2.2.4.4).

3.1.2 Timers

BootstrapDCTimer: This timer is applicable only to a domain-joined client. This timer is used to regularly update the value of BootstrapDC with the name of the domain controller (DC) in the domain of the client.

3.1.3 Initialization

A client MUST initialize BootstrapDC and BootstrapDCTimer after joining a domain. <6>

3.1.4 Higher-Layer Triggered Events

3.1.4.1 User/Application Initiated I/O Operation on a UNC Path

The calling application provides:

- Implementation-specific information on the I/O operation to be performed.
- **Path** indicating the UNC path on which the I/O operation is to be performed.
- **UserCredentials** to be used for performing I/O operation on the UNC path.
- **MaxOutputSize** indicating the maximum output buffer size, in bytes.

When the DFS client receives an I/O operation with a UNC path, it MUST normalize the UNC path to the protocol format with one leading backslash (as specified in section 2.2.1) and perform a name resolution. See the following flowcharts for an illustration of the process. In some cases, individual steps have a description of the condition at entry of the step inside square brackets [like this].

The following flowcharts show the steps taken by a DFS client to resolve a DFS path.

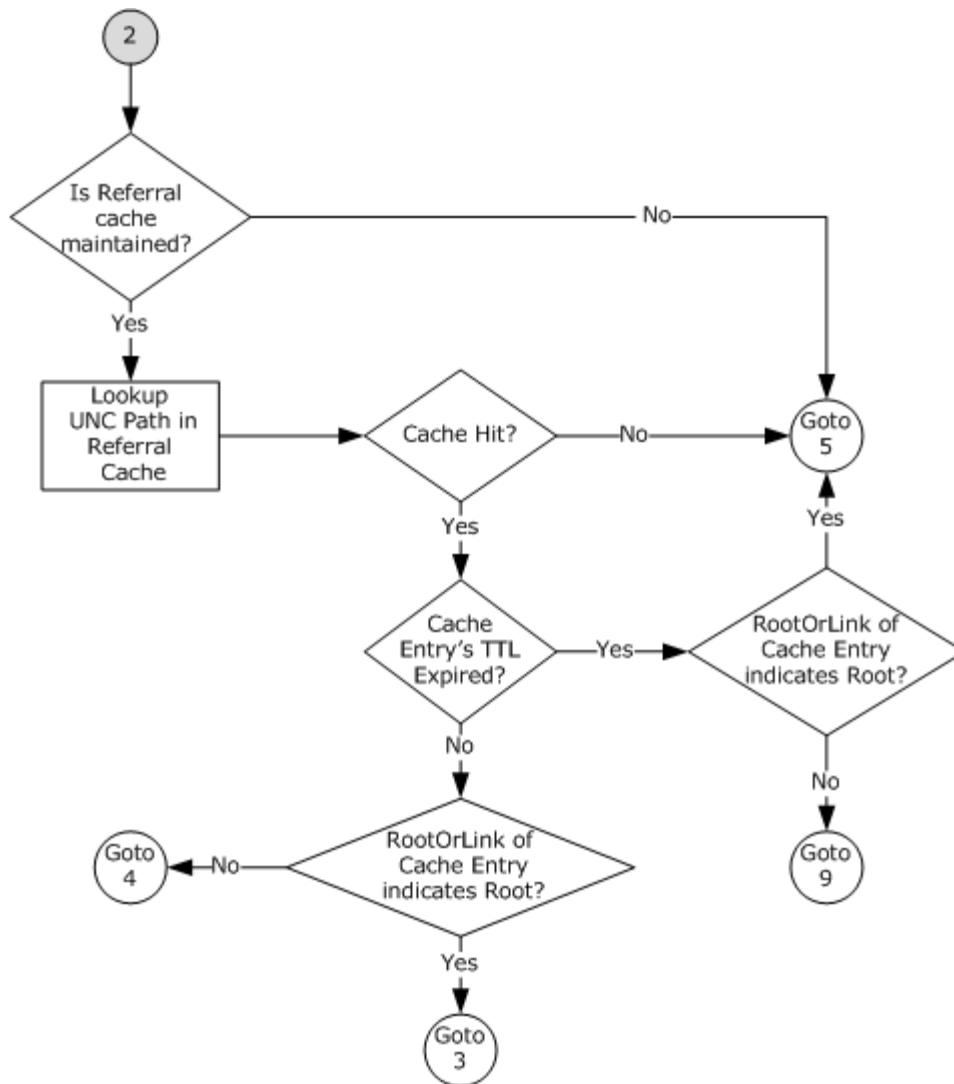


Figure 1: DFS path resolution - initial steps

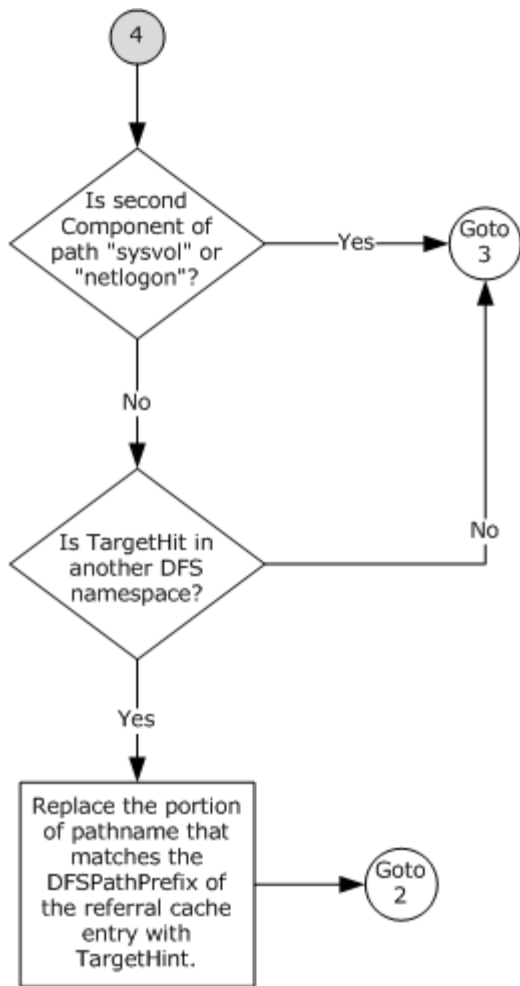


Figure 2: DFS path resolution - connection 4

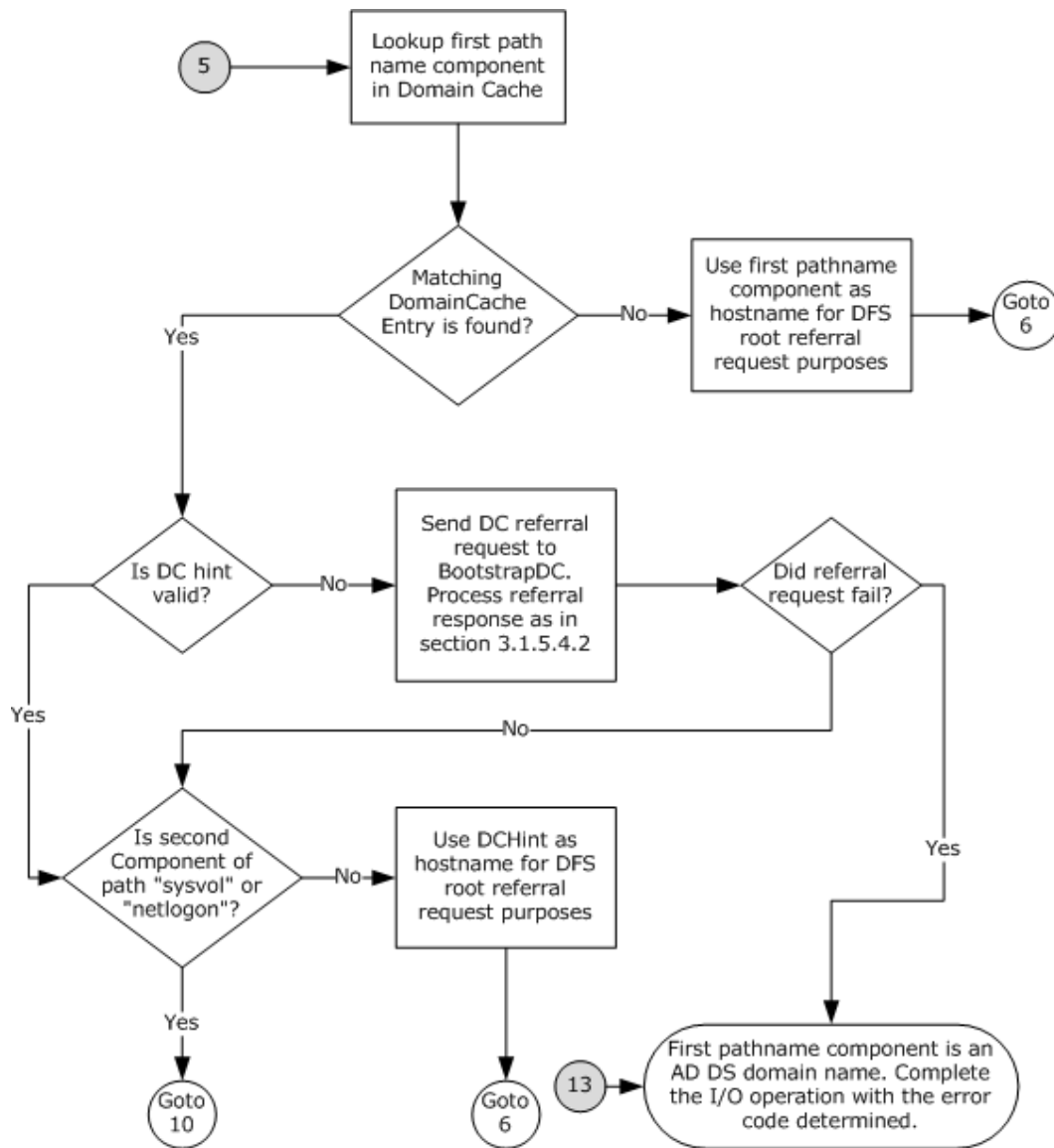


Figure 3: DFS path resolution - connection 5

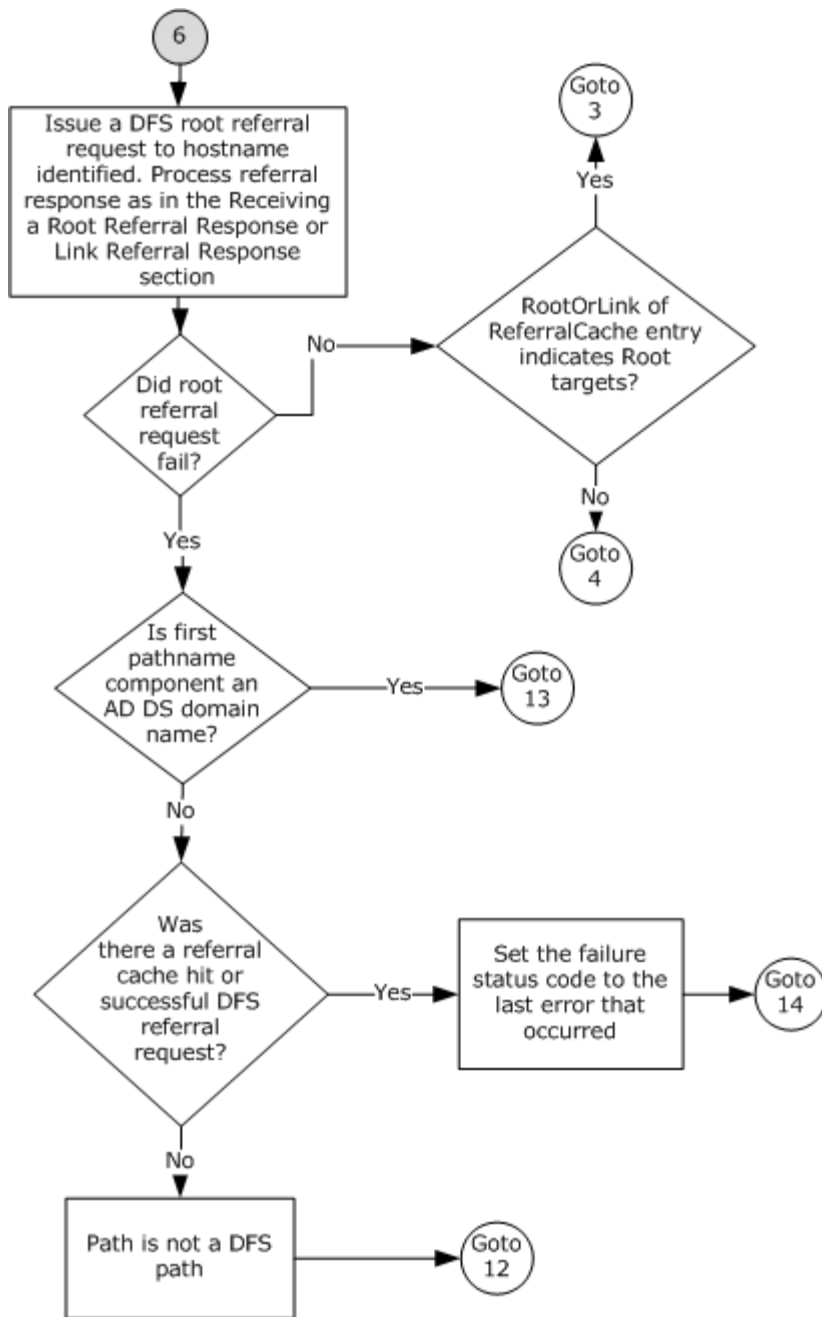


Figure 4: DFS path resolution - connection 6

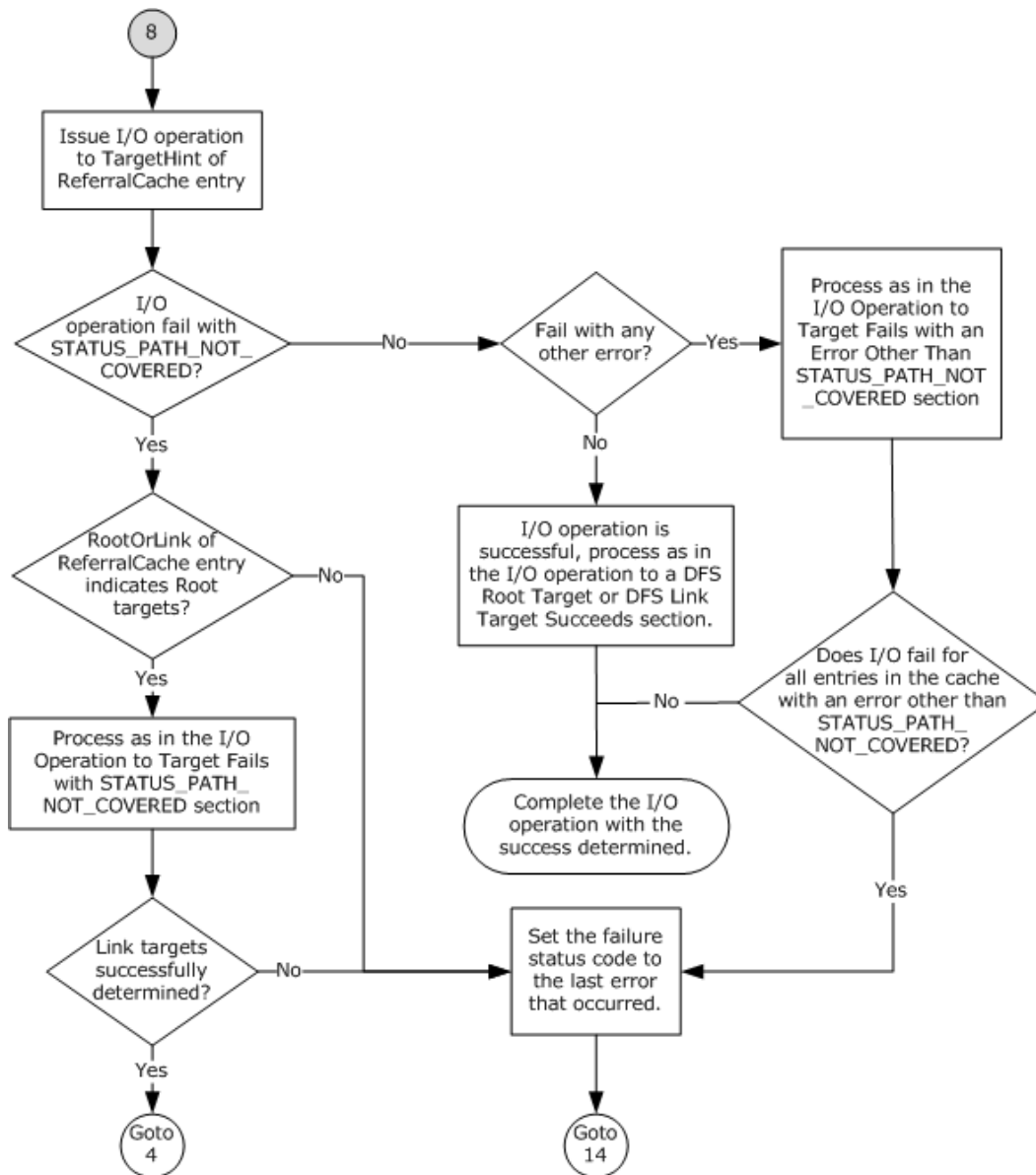


Figure 5: DFS path resolution - connection 8

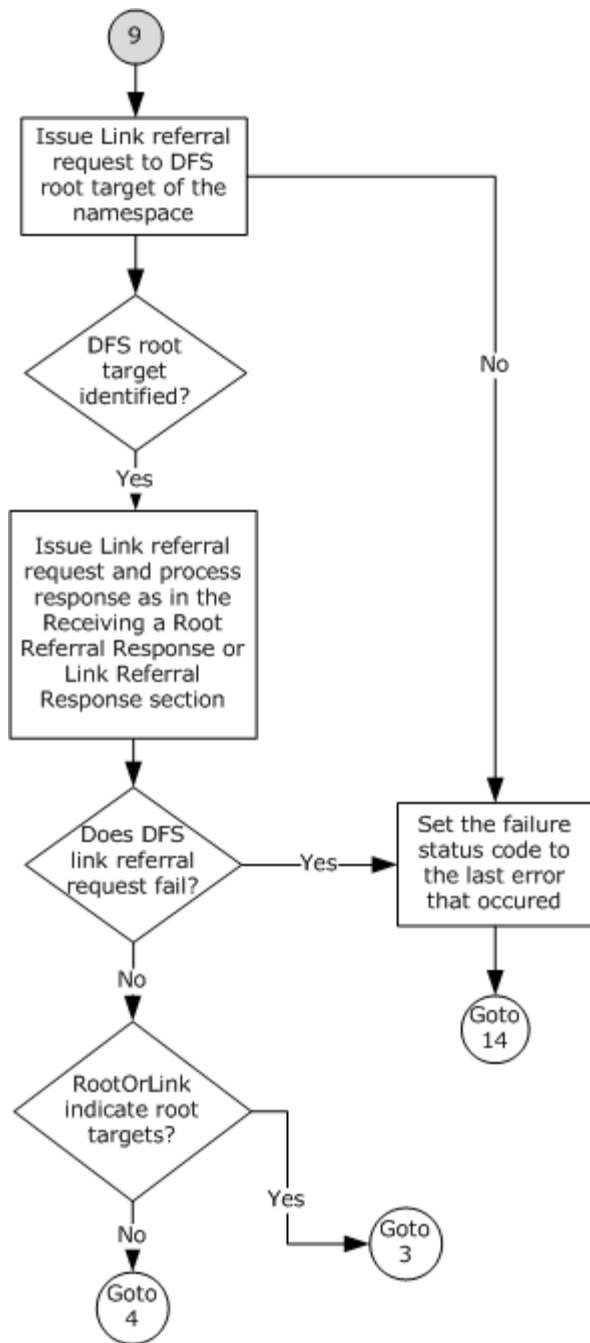


Figure 6: DFS path resolution - connection 9

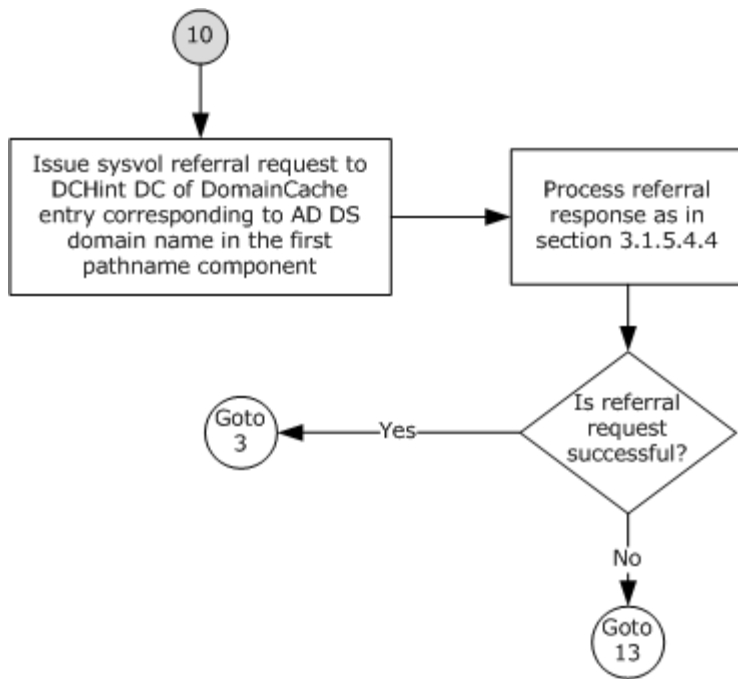


Figure 7: DFS path resolution - connection 10

The following procedure specifies a possible implementation for resolving a UNC path. This example uses a cache to avoid repeated referral requests, thereby improving the performance of the DFS client. A lookup in ReferralCache involves searching for an entry with DFSPathPrefix that is a complete prefix of the path being looked up. Whole path components are used in the match. Also, the ReferralCache entry with the longest match is used. For the lookup path of `\MyDomain\MyDfs\MyDir\file1`, if there are two ReferralCache entries, one for `\MyDomain\MyDfs` and another for `\MyDomain\MyDfs\MyDir`, the latter is the longest match. This document does not mandate that implementations adhere to this model, as long as their external behavior is consistent with the behavior described.

1. If the path has only one path component (for example, `\abc`), go to step 12.
2. Look up the path in ReferralCache if a cache is being maintained. If no cache is being maintained, go to step 5.
 1. If no matching entry is found in ReferralCache, go to step 5.
 2. If an entry's TTL has expired:
 - If RootOrLink indicates DFS root targets, go to step 5.
 - If RootOrLink indicates DFS link targets, go to step 9.
 3. If an entry contains DFS link targets as indicated by RootOrLink, go to step 4; otherwise, go to step 3.
3. [ReferralCache hit, unexpired TTL] Replace the portion of the path that matches DFSPathPrefix of the ReferralCache entry with the DFS target path of TargetHint of the ReferralCache entry. For example, if the path is `\MyDomain\MyDfs\MyDir` and the ReferralCache entry contains

\MyDomain\MyDfs with a DFS target path of \someserver\someshare\somepath, the effective path becomes \someserver\someshare\somepath\MyDir. Go to step 8.

4. [ReferralCache hit, unexpired TTL, RootOrLink=link]
 1. If the second component of the path is "SYSVOL" or "NETLOGON" go to step 3.
 2. Check if TargetHint is in another DFS namespace by using its first two path components to do a lookup in the ReferralCache, or by issuing a DFS root referral request as specified in step 6, when no entry is found in the ReferralCache:
 - If the RootOrLink element of the target referred to by the resulting ReferralCache entry's TargetHint indicates root targets, then the TargetHint is in another DFS namespace. Go to step 11.
 - If the TargetHint is not in another DFS namespace, go to step 3.
5. [ReferralCache miss] [ReferralCache hit, expired TTL, RootOrLink=root] Look up the first path component in DomainCache.
 1. If no matching DomainCache entry is found, use the first path component as the host name for DFS root referral request purposes. Go to step 6.
 2. If a matching DomainCache entry is found:
 1. If DCHint is not valid, send DC referral request, as specified in section [3.1.4.2](#), providing "DC", **BootstrapDC**, **UserCredentials**, **MaxOutputSizeeff**, and **Path** as parameters. The processing of the referral response is specified in section [3.1.5.4.2](#). If the referral request fails, go to step 13.
 2. If the second path component is "SYSVOL" or "NETLOGON", go to step 10.
 3. Use DCHint as host name for DFS root referral request purposes.
6. [DFS Root referral request] Issue a DFS root referral request, as specified in section [3.1.4.2](#), providing "ROOT", the first path component, **UserCredentials**, **MaxOutputSize**, and **Path** as parameters. The processing of the referral response is as specified in section [3.1.5.4.3](#). On DFS root referral request failure:
 1. If the first path component is a domain name, go to step 13.
 2. If there was a ReferralCache hit or a successful DFS referral request at any time during the processing of this I/O request, the path is in a DFS namespace. Go to step 14.
 3. The path is not a DFS path and no further processing is required. Go to step 12.
7. [DFS root referral success] If ReferralCache entry's RootOrLink indicates root targets, go to step 3; otherwise, go to step 4.
8. [I/O request, path fully resolved] Issue I/O operation to TargetHint of ReferralCache entry.
 1. If the I/O operation fails with STATUS_PATH_NOT_COVERED.
 - If the RootOrLink of ReferralCache entry indicates link targets, set the failure status to the last error that occurred and go to step 14.

- If the RootOrLink of ReferralCache entry indicates root targets, the process is as specified in section [3.1.5.1](#). If the link target cannot be successfully determined, set the failure status to the last error that occurred and go to step 14.
 - Link target determined successfully. Go to step 4.
2. If the I/O operation fails with an error other than STATUS_PATH_NOT_COVERED, then the process is as specified in section [3.1.5.2](#). If I/O to all targets in TargetList of ReferralCache entry failed with an error other than STATUS_PATH_NOT_COVERED, set the failure status to the last error that occurred and go to step 14.
 3. If the I/O operation is successful, the process is as specified in section [3.1.5.3](#). Complete the I/O operation and user/application-initiated I/O request with success.
9. [ReferralCache hit, expired TTL, RootOrLink=link] The link referral request must be issued to a DFS root target of the namespace. Find the ReferralCache entry corresponding to the first two path components, issuing a DFS root referral request as specified in step 6, if required. If no DFS root target can be identified, it is a root referral failure; set the failure status to the last error that occurred and go to step 14. Otherwise, issue a DFS link referral request, as specified in section [3.1.4.2](#), providing "LINK", DFS root target, **UserCredentials**, **MaxOutputSize**, and **Pathf** as parameters, and process the DFS referral response as specified in section [3.1.5.4.3](#). If the DFS Link referral request fails, set the failure status to the last error that occurred and go to step 14. Otherwise:
1. If the RootOrLink of the refreshed ReferralCache entry indicates DFS root targets, go to step 3.
 2. If the RootOrLink of the refreshed ReferralCache entry indicates DFS link targets, go to step 4.
- 10.[sysvol referral request] Issue a sysvol referral request, as specified in section [3.1.4.2](#), providing 'SYSVOL', the DCHint DC of the DomainCache entry that corresponds to the domain name in the first path component, **UserCredentials**, **MaxOutputSize**, and **Path** as parameters. The processing of the referral response is as specified in section [3.1.5.4.4](#). If the referral request is successful, go to step 3; otherwise, go to step 13.
- 11.[interlink] Replace the portion of the path that matches the DFSPathPrefix of the ReferralCache entry with TargetHint. For example, if the path is \MyDomain\MyDfs\MyLink\MyDir and the referral entry contains \MyDomain\MyDfs\MyLink with a DFS target path of \someserver\someshare\somepath, the effective path becomes \someserver\someshare\somepath\MyDir. Go to step 2.
- 12.[not DFS] The path does not correspond to a DFS namespace or a SYSVOL/NETLOGON share. The user/application initiated I/O request is handled by the local operating system.<7>
- 13.[Cannot get DC for domain] The first path component is a domain name. Fail the I/O operation and user/application-initiated I/O request with the last error code that occurred before the jump to this step.
- 14.[DFS path] The path is known to be in a DFS namespace, but the DFS root referral request or DFS Link referral request has failed. Complete the user/application-initiated I/O request with the error code that occurred before the jump to this step.

3.1.4.2 Sending a DFS Referral Request to the Server

This interface is only used internally by the DFS client to send a DFS referral request to a specific server. The caller provides the following:

- **Type:** A string identifying the type of the referral request.
- **HostName:** The name of the server from which to query referrals.
- **UserCredentials:** An opaque implementation-specific entity that identifies the credentials to be used when authenticating to the remote server.
- **MaxOutputSize:** The maximum output buffer response size, in bytes.
- **Path:** The path for which referral information is to be queried.

The client MUST initiate a server session with the SMB server, as specified in [\[MS-CIFS\]](#) section 3.4.4.7, by passing **HostName** and **UserCredentials** as input parameters and receiving an opaque **ClientGenericContext**, as specified in [\[MS-CIFS\]](#) section 3.4.

The client MUST then query the DFS referral, as specified in [\[MS-CIFS\]](#) section 3.4.4.9, by passing **ClientGenericContextf**, **HostName**, **UserCredentials**, **MaxOutputSize**, an updated **Path** according to the format of the RequestFileName in the table that follows, and an appropriate MaxReferralLevel value corresponding to the Type as specified in the following table:

Type	RequestFileName	MaxReferralLevel
DOMAIN	An empty string (containing just the null terminator).	3 or higher
DC	"\ <domain>" "<domain>",="" <domain>="" a="" be="" can="" domain="" either="" forms.<="" fully="" in="" is="" name="" netbios="" or="" qualified="" td="" that="" where=""> <td>3 or higher</td> </domain>">	3 or higher
SYSVOL	Either "<domain>\SYSVOL" or "<domain>\NETLOGON", where <domain> is a domain name that can be in either NetBIOS or fully qualified domain name forms.	No restriction
ROOT	Of the form either "<domain>\<dfsname>" or "<server>\<dfsname>", where <domain> is the name of the domain that hosts the DFS namespace, <dfsname> is the name of a DFS namespace, and <server> is a DFS root target host name.	No restriction
LINK	Of the form either "<domain>\<dfsname>\<linkpath>" or "<server>\<dfsname>\<linkpath>", where <domain> is the name of the domain that hosts the DFS namespace, <dfsname> is the name of a DFS namespace, <server> is a DFS root target host name, <linkpath> is a path that may have a DFS link.	No restriction

The client MUST wait synchronously for the completion of the referral request and pass the referral response received from the server to the caller. If the request fails with STATUS_DFS_UNAVAILABLE, the client MUST return the same error code to the caller.

3.1.5 Message Processing Events and Sequencing Rules

3.1.5.1 I/O Operation to Target Fails with STATUS_PATH_NOT_COVERED

When an I/O operation issued to a DFS root target server in Step 8 of section [3.1.4.1](#) fails with STATUS_PATH_NOT_COVERED (0xC0000257), it indicates that the portion of the DFS namespace accessed by the client is not contained in the DFS root target server.

To identify the DFS link targets that contain the required portion of the DFS namespace, the client MUST look up the path used for the I/O operation in ReferralCache. On a cache miss, it MUST issue a DFS link referral request, as specified in section [3.1.4.2](#), providing "LINK", the DFS root target

server specified by TargetHint of ReferralCache entry corresponding to the DFS namespace, **UserCredentials**, **MaxOutputSize**, and **Path** as parameters. The Path parameter MUST be set to the path in the I/O operation issued to the DFS root target in step 8 of section [3.1.4.1](#). If successful, it MUST create a new ReferralCache entry with RootOrLink set to indicate link targets. [<8>](#)

When an I/O operation that is issued to a link target fails with STATUS_PATH_NOT_COVERED (0xC0000257), the client MUST fail the original I/O request.

3.1.5.2 I/O Operation to Target Fails with an Error Other Than STATUS_PATH_NOT_COVERED

When an I/O operation issued to the target server identified by the TargetHint of the ReferralCache entry used returns an NTSTATUS value with the **Sev** field set to 2 or 3, as specified in [\[MS-ERREF\]](#) section 2.3, and the NTSTATUS value is not equal to STATUS_PATH_NOT_COVERED (0xC0000257), the next target, if any, from TargetList of ReferralCache entry MAY [<9>](#) be selected. When the next target is not selected, or when all the targets in ReferralCache entry have been tried, the client MUST fail the user/application-initiated I/O operation and return the same NTSTATUS value that was returned to the client.

If a target was selected from the TargetList, the I/O operation MUST be issued to the selected target. This is known as "**DFS client target failover**". Also, as a performance optimization for future operations that use the same ReferralCache entry, the TargetHint of the selected ReferralCache entry MUST have its value set to the selected target.

3.1.5.3 I/O Operation to a DFS Root Target or DFS Link Target Succeeds

When the operation issued to a DFS root target or DFS link target returns an NTSTATUS value with the **Sev** field set to 0 or 1, as specified in [\[MS-ERREF\]](#) section 2.3, the DFS client MUST complete the user/application-initiated I/O operation with the NTSTATUS value that was returned to the client.

3.1.5.4 Receiving a Referral Response

The DFS client receives the referral response in the form of [RESP_GET_DFS_REFERRAL](#) (section [2.2.3](#)). If the **NumberOfReferrals** field is at least 1, the client MUST determine the version number of the referral response by accessing the **VersionNumber** field of the first referral entry immediately following the referral header and interpreting the referral entry as specified in section [2.2.4](#).

The **NumberOfReferrals** field in the referral header contains the number of referral entries in the response. The first referral entry immediately follows the referral header in the [RESP_GET_DFS_REFERRAL](#) message (section 2.2.3). From a given referral entry, the next referral entry is accessed by adding the **Size** field of the referral entry to the address of the given referral entry. The client MUST ignore the Padding field if present.

When a DFS path resolves to multiple referral entries, and the client supplies a buffer insufficiently large to hold the entries, the client can experience a non-deterministic server response.

If a DFS referral request fails with STATUS_BUFFER_OVERFLOW (0x80000005), the client SHOULD retry the referral request with a bigger buffer size. [<10>](#) Response data buffer size is determined as specified in section [3.2.5.1](#).

3.1.5.4.1 Receiving a Domain Referral Response

This is applicable only to a domain-joined computer. The client receives this response for the domain referral request that it issued to BootstrapDC (as specified in section [3.1.6](#)). The domain referral response MUST be version 3 or later; otherwise, the client MUST ignore the referral response.

The client MUST discard referral responses that do not have the NameListReferral bit of each referral entry set. The other bits of **ReferralEntryFlags** in the referral entry MUST be ignored. The client can access the null-terminated Unicode domain name contained in a referral entry by adding the value in the **SpecialNameOffset** field of the referral entry to the address of the referral entry.

The client MUST add the domain names received in the referral response to DomainCache, if empty. If DomainCache already has domain names, the client MUST add only those domain names to DomainCache that are not already in it. The client MAY remove those domain names from DomainCache that are not in the referral response. [<11>](#)

The DFS client MUST NOT modify the DomainCache on a domain referral failure.

3.1.5.4.2 Receiving a DC Referral Response

This is applicable only to a domain-joined computer. The DFS client receives this referral response for the DC referral request that it sent in step 5.2 of section [3.1.4.1](#). The DC referral response MUST be version 3 or later; otherwise, the client MUST ignore the referral response.

The client MUST verify that the **NumberOfReferrals** field of the referral header is 1 and that the NameListReferral bit is set in the referral entry. The other bits of **ReferralEntryFlags** in the referral entry MUST be ignored. The **NumberOfExpandedNames** in the referral entry contains the number of DC names returned. The client MUST use the value in the **NumberOfExpandedNames** field to determine how many names are present in the list at **ExpandedNameOffset**. The client can access the first null-terminated Unicode DC name string that is returned by adding the value in the **ExpandedNameOffset** field to the address of the referral entry. Immediately following the null termination of a DC name is the next DC name returned. The client can access the null-terminated Unicode domain name that corresponds to the referral response by adding the value in the **SpecialNameOffset** to the address of the referral entry.

The client MUST add the list of DCs determined for a domain name to DCList of the DomainCache entry that corresponds to the domain name. If the DomainCache entry's DCList is not empty, the client MUST replace it with the DC list from the referral response and set DCHint to the first DC in the new DCList.

3.1.5.4.3 Receiving a Root Referral Response or Link Referral Response

This section describes the processing that occurs when the client gets a referral response after sending a DFS root referral request in step 6 of section [3.1.4.1](#) or a link referral request in either step 9 of section [3.1.4.1](#) or in section [3.1.5.1](#).

If the referral request is successful, but the **NumberOfReferrals** field in the referral header (as specified in section [2.2.3](#)) is 0, the DFS server could not find suitable targets to return to the client. In this case, the client MUST fail the original I/O operation with an implementation-defined error. [<12>](#)

If the root referral request was sent to a DC (steps 5.4 and 6 of section [3.1.4.1](#)), and it fails with an error, the client MUST issue a referral request to the next DC from the DCList of the DomainCache entry, as in step 6 of section [3.1.4.1](#). If all DCs from the DCList have been tried, the DFS client MUST fail the original I/O operation with an implementation-defined error. [<13>](#)

If the domain name is not valid, the DFS client MUST fail the original I/O operation with an implementation-defined error. <14>

When the root referral request sent to a DC is successful, the client SHOULD set the DCHint of the DomainCache entry used to that DC. The DCHint serves as an optimization and avoids having to determine an available and accessible DC for every operation that uses a given DomainCache entry.

If the client sends a DFS root referral request and receives a referral response with the **ServerType** field of the referral response entry (as specified in section 2.2.4) set to 0x0000, a link referral response is being returned. This can happen when server accessed has been consolidated using the Microsoft File Server Migration Toolkit. For more information, see [MSFSMT]. <15>

The client can access the null-terminated Unicode DFS target path contained in a referral entry by adding the value in the **NetworkAddressOffset** field (as specified in section 2.2.3) of the referral entry to the address of the referral entry. The client can access the null-terminated Unicode DFS root or link path that corresponds to the referral response by adding the value in the **DFSPathOffset** field (as specified in section 2.2.3) of the referral entry to the address of the referral entry.

If this response is due to a referral request that was sent in step 6 of section 3.1.4.1 or section 3.1.5.1 on a ReferralCache miss, the client MUST create a new ReferralCache entry from the referral response and set TargetHint to the first target in TargetList. For a DFS referral version 4 response, the client MUST set TargetSetBoundary of each target in TargetList to the value of the TargetSetBoundary bit of the referral entry (see section 2.2.4.4). The client MUST set the value of RootOrLink in ReferralCache entry based on the **ServerType** field of the referral entry.

If this response is due to a referral request that was sent in step 2.2 in section 3.1.4.1 to refresh an existing but expired ReferralCache entry, the client MUST perform the following steps:

- If the targets contained in the TargetList of the ReferralCache entry and those returned in the referral response are equivalent, the client MUST NOT update the TargetList in the ReferralCache entry. The equivalence check operation is specified as follows:
 - DFS referral version 4 response: The number of target sets is the same, and each target set in the ReferralCache entry and the referral response contain the same targets, independent of their order with the target set.
 - DFS referral version 1, 2, or 3 response: The ReferralCache entry and the referral response contain the same targets, independent of their order.
- Update the TTL and TargetFailback in the ReferralCache entry from the referral response.
- If the target specified by the TargetHint is not present in the referral response, set the TargetHint to point to the first target of the TargetList in ReferralCache.
- If the TargetFailback is set in the ReferralCache entry, and if the TargetHint is not in the first target set of the TargetList, set the TargetHint to point to the first target in the first target set of the TargetList. This is referred to as a DFS client target failback. Target failback may also be performed at instances other than just at ReferralCache entry refresh time based on an implementation-defined policy.

If an attempt to refresh an existing but expired ReferralCache entry fails, an implementation-defined error behavior MAY be used. For example, the client may initiate ReferralCache entry refresh at the end of a soft time-out period (as specified in section 3.1.1) while permitting the use of the entry and either discard it at the end of a hard time-out period (as specified in section 3.1.1) or fail the I/O operations that use the ReferralCache entry. <16>

3.1.5.4.4 Receiving a sysvol Referral Response

The client receives this referral response for the sysvol referral request that it sent in step 10 of section [3.1.4.1](#).

This referral response MUST be handled in the same manner as that of a root/link referral response, as specified in section [3.1.5.4.3](#).

3.1.6 Timer Events

BootstrapDCTimer: When this timer fires, the DFS client MUST update BootstrapDC with the name of a DC in the domain of the client. It MUST then issue a domain referral (as specified in section [2.2.2](#)) to the Bootstrap DC. It MUST then restart the timer.

3.1.7 Other Local Events

On joining a domain, the client updates its BootstrapDC, issues a domain referral to the BootstrapDC, and enables the BootstrapDCTimer, as specified in section [3.1.6](#). On leaving a domain to join a workgroup, the client disables the BootstrapDCTimer.

3.2 DFS Root Target Server Details

A DFS root target server hosts the DFS root of a DFS namespace. This section specifies how a DFS root target server processes and responds to DFS referral requests from DFS clients. If the server is also a DC, it MUST also conform to the specification in section [3.3](#).

DFS root target servers respond to DFS root referral requests and DFS link referral requests. [<17>](#)

3.2.1 Abstract Data Model

This section describes a conceptual model of possible data organization that an implementation maintains to participate in this protocol. The organization is provided to explain how the protocol behaves. This document does not mandate that implementations adhere to this model as long as their external behavior is consistent with that described in this document. The following state MUST be maintained at the DFS Server:

HomeDomain: Applicable only for a computer joined to a domain. MUST be the name of a domain to which the computer is joined. Maintained both in NetBIOS and fully qualified domain name forms. This is used to access the DFS metadata of a domain-based DFS namespace hosted by the server.

DFSNamespaceList: MUST be a list of domain-based and stand-alone DFS root targets hosted by the server. Used while processing DFS referral requests from DFS clients.

DFSMetadataCache: Cache that MUST contain the DFS metadata of DFS namespaces for which the server is a root target. The cache MUST be maintained as specified in [\[MS-DFSNM\]](#) section 3.1.

3.2.1.1 Algorithm for sorting target sites in referral response based on site location

The DFS server places the target servers in the referral response in the following order:

- Targets in the same site as the client are listed at the top of the referral response in random order.
- Targets outside the client's site are appended to the response in random order.

3.2.1.2 Algorithm for sorting target sites in referral response based on site cost

The server performs the following actions:

- Partition the targets into target sets, based on targets of equal site cost relative to the client.
- Sort the target sets from lowest to highest site cost.
- Place the targets within each target set in a random order.

3.2.2 Timers

None.

3.2.3 Initialization

When the DFS server is started:

- It MUST notify the SMB server for reasons as specified in [\[MS-CIFS\]](#) section 3.3.4.3 and [\[MS-SMB2\]](#) section 3.3.4.8. The exact means of how this is accomplished is outside the scope of this specification.
- It MUST initialize HomeDomain with the domain name of the domain to which it is joined, if any.
- It MUST initialize DFSNamespaceList to the list of domain-based and stand-alone DFS namespaces that it hosts. This list can be obtained from DFS metadata (as specified in [\[MS-DFSNTM\]](#)), a configuration file, a configuration store (such as the Microsoft Windows® registry), or from other implementation-defined means.

3.2.4 Higher-Layer Triggered Events

3.2.4.1 Handling a Path Normalization Request

As specified in [\[MS-SMB2\]](#) section 3.3.5.9 and [\[MS-SMB\]](#) section 3.3.5.5, the SMB server invokes the DFS server to normalize the path name.

- If the DFS namespace initialization (as specified in section [3.2.3](#)) corresponding to the share in the path is not yet complete, the DFS server MUST fail the path normalization request with STATUS_DFS_UNAVAILABLE.
- Otherwise, the DFS server matches the path name against DFS metadata. If the path matches or contains a DFS link, the DFS server MUST respond to the path normalization request with STATUS_PATH_NOT_COVERED, indicating to the client to resolve the path by using a DFS link referral request. Otherwise, the DFS server MUST change the path name to a path relative to the root of the namespace and return STATUS_SUCCESS. For example, if the path name is "\\MyDomain\MyDfs\MyDir\file1", then the DFS server MUST change the path name to "MyDir\file1".

3.2.5 Message Processing Events and Sequencing Rules

3.2.5.1 Receiving a DFS Referral Request

The server receives DFS referral requests from clients when they need to resolve DFS paths into file server paths.

The **MaxReferralLevel** field of the [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) message contains the highest DFS referral version understood by the client. The server MUST respond to a REQ_GET_DFS_REFERRAL with a version number less than or equal to the value specified by the client. It SHOULD respond with the highest version number that it supports that can meet this constraint. [<18>](#)

The server MUST determine the maximum response data buffer size specified by the client. The source of this information depends on the transport protocol used by the client, as follows:

- If the transport protocol is SMB [\[MS-SMB\]](#), the TRANS2_GET_DFS_REFERRAL SMB packet, as specified in [\[MS-CIFS\]](#) section 2.2.6.16.1, contains this information. It is passed to the DFS server as specified in [\[MS-CIFS\]](#) section 3.3.5.38.
- If the transport protocol is SMB2 [\[MS-SMB2\]](#), the SMB2 I/O control (IOCTL) request packet, as specified in [\[MS-SMB2\]](#) section 2.2.31, contains this information. It is passed to the DFS server as specified in [\[MS-SMB2\]](#) section 3.3.5.15.2.

The server MUST restrict the referral response to the response data buffer size. It MUST NOT return partial referral entries. If the response data buffer size does not permit at least one complete referral entry, the server MUST fail the referral request with STATUS_BUFFER_OVERFLOW (0x80000005). The server MAY [<19>](#) set the **Padding** field with a variable number of padding bytes for alignment purposes.

Processing of individual referral requests is explained in the following sections.

3.2.5.2 Receiving a Domain Referral Request

A server that is not running on a DC MUST fail this request with a STATUS_INVALID_PARAMETER (0xC000000D) return code.

3.2.5.3 Receiving a DC Referral Request

A server that is not running on a DC MUST fail this request with a STATUS_INVALID_PARAMETER (0xC000000D) return code.

3.2.5.4 Receiving a sysvol Referral Request

A server that is not running on a DC MUST fail this request with a STATUS_NOT_FOUND (0xC0000225) return code. [<20>](#)

3.2.5.5 Receiving a Root Referral Request or Link Referral Request

If the DFS namespace for which referral is sought, as identified by the second path component, is not present in DFSNamespaceList, the server SHOULD fail the referral request with a STATUS_NOT_FOUND (0xC0000225) return code. [<21>](#)

If the DFS referral request path has more than two components, the server MUST attempt to find a DFS link in the DFSNamespaceList, which is a complete prefix of the DFS referral request path. For example, if the DFS referral request path is "\MyServer\MyDfs\dir1\link1\dir2", the DFS link "\MyServer\MyDfs\dir1\link1" is a complete prefix of the DFS referral request path. On the other hand, the same DFS link is not a complete prefix of the DFS referral request path "\MyServer\MyDfs\dir1\link2\dir2". The server MUST do the comparison in a case-insensitive manner, taking into account the situation of a DFS referral request path whose first path component is in the fully qualified domain name form when the DFS root or DFS link's first path component is in the NetBIOS form (or vice versa). NetBIOS and fully qualified domain names MUST be supported for a DFS referral request path.

If a DFS link that is a complete prefix of the DFS referral request path is identified, the server MUST return a DFS link referral response; otherwise, if it has a match for the DFS root, it MUST return a root referral response.

For a domain-based DFS namespace, the server MUST use the DFS metadata in the object of the DFS namespace (as specified in [\[MS-DFSNM\]](#) section 2.3) to respond to the DFS referral request. The DFS metadata is set as specified in [\[MS-DFSNM\]](#) section 3.1.4.1. When the server maintains DFSMetadataCache, it MAY use the cached information to respond to referral requests. The relevant fields in the DFS metadata for a domain-based DFS namespace are as follows:

- The DFSNamespaceRootBLOB contains DFS root information.
- The DFSNamespaceLinkBLOB contains DFS link information.
- The **Prefix** and **ShortPrefix** fields of a DFS DFSRootOrLinkIDBLOB MUST contain a DFS root or a DFS link name.
- The **ReferralTTL** field of a DFSNamespaceRootBLOB or a DFSNamespaceLinkBLOB MUST contain the time-out associated with the DFS root or link.
- The DFSTargetListBLOB of a DFSNamespaceRootBLOB or a DFSNamespaceLinkBLOB MUST contain DFS root or DFS link target information.
- The PKT_ENTRY_TYPE_COST_BASED_SITE_SELECTION bit in the **Type** field of a DFSRootOrLinkIDBLOB of a DFSNamespaceRootBLOB MUST be set to indicate that the DFS referral site costing is enabled for the DFS namespace.
- The PKT_ENTRY_TYPE_TARGET_FAILBACK and PKT_ENTRY_TYPE_INSITE_ONLY bits in the **Type** field of a DFSRootOrLinkIDBLOB of a DFSNamespaceRootBLOB or a DFSNamespaceLinkBLOB MUST be set to indicate that the DFS client target failback and **DFS in-site referral mode** are enabled for the DFS root or DFS link.
- The PKT_ENTRY_TYPE_OUTSIDE_MY_DOM bit of the **Type** field in a DFSRootOrLinkIDBLOB of a DFSNamespaceLinkBLOB MUST be set for a DFS interlink.
- When not used as a time stamp, the **TargetTimeStamp** field of a TargetEntryBLOB MUST contain the DFS root or DFS link target priority information. The **PriorityClass** and **PriorityRank** fields in such a **TargetTimeStamp** field MUST contain the priority class and priority rank of the target respectively.

The server SHOULD do the following once it has identified the DFS root targets or DFS link targets that correspond to the DFS root or DFS link to be used for the DFS referral response.

- From the IP address of the client, determine the site of the client as specified in [\[MS-NRPC\]](#) section 3.5.5.3.8.
- Determine the site of each target. For a domain-based DFS namespace, the server SHOULD NOT use the SiteInformationBLOB in the DFS metadata. The site of a DFS target SHOULD instead be determined from the IP address of the DFS target as specified in [\[MS-NRPC\]](#) section 3.5.5.3.8. The server MUST use the host name of the target—the first component in the path— to determine the IP address of the target. [<22>](#)
- If the server supports DFS referral site costing, and site costing is enabled for the DFS namespace, determine the site cost from the client's site to the target's site (as specified in [\[MS-DRDM\]](#) section 4.1.9 if they are not in the same site. If the client's site, the target's site, or the site cost between them cannot be determined, the cost assigned to that target is implementation specific. [<23>](#)

If the server does not support DFS target priority as specified in [\[MS-DFSNM\]](#) section 2.2.2.7 or if all the targets have the default priority, the server MUST proceed as follows:

- If DFS referral site costing is disabled or not supported, sort the targets based on the site location as specified in section [3.2.1.1](#).
- If DFS referral site costing is enabled, sort the targets based on the site cost as specified in section [3.2.1.2](#).
- If the DFS_PROPERTY_FLAG_INSITE_REFERRALS flag in **NameSpaceElement.Properties** (as specified in [\[MS-DFSNM\]](#) section 3.1.1.3) is set for the root of DFS namespace, the root and link referrals SHOULD<24> return only targets that are in the same site as the client. If no root or link targets exist in the same site as the client, then no referral is returned and the client cannot access that portion of the namespace.
- If the DFS_PROPERTY_FLAG_INSITE_REFERRALS flag is not set in **NameSpaceElement.Properties** for the root of DFS namespace but is set for a link, then the link referrals MUST return only targets that are in the same site as the client. If no link targets exist in the same site as the client, then no referral is returned and the client cannot access the link.

A server that supports DFS referral version 4 MUST also support DFS target priority.

If the server supports DFS target priority and if at least one DFS target has a nondefault priority, the server MUST perform the following:

- At a coarse-grained level, lay out the targets into 3 groups based on the priority class. For more information on priority class, see [\[MS-DFSNM\]](#) section 2.2.2.7.
 - Targets in the DfsGlobalHighPriorityClass priority class. This will be referred to as group 1 for identification purposes.
 - Targets in the DfsSiteCostHighPriorityClass, DfsSiteCostNormalPriorityClass, and DfsSiteCostLowPriorityClass priority classes. This will be referred to as group 2 for identification purposes.
 - Targets in the DfsGlobalLowPriorityClass priority class. This will be referred to as group 3 for identification purposes.
- If DFS referral site costing is enabled, sort the targets within each group based on the site cost as specified in section [3.2.1.2](#).
- If DFS in-site referral mode is enabled for the DFS namespace, the server MUST remove all targets that are not in the same site of the client from group 2.
- Further sort targets having the same site cost in group 2 on the basis of priority class in the order of DfsSiteCostHighPriorityClass first, followed by DfsSiteCostNormalPriorityClass, and finally DfsSiteCostLowPriorityClass.
- Within each of the three groups, further sort targets that have the same site cost and priority class in order of decreasing priority rank, with 0 (0x0000) being the highest priority rank and 31 (0x001F) being the lowest priority rank. The server SHOULD create target sets that consist of targets that have the same site cost, priority class, and priority rank.
- The server SHOULD randomly reorder targets in each target set on a per-DFS referral response basis, to enable load-sharing across the targets.

Because there are three dimensions available for the sorting of targets—site cost, priority class and priority rank—additional implementation defined sorting policies MAY be used within each of the three groups previously specified. <25>

After the sorted list of targets is available, noting that the list may be empty due to DFS in-site referral mode, the server still MUST initialize the RESP_GET_DFS_REFERRAL referral header as follows:

- For a DFS root referral response, the **PathConsumed** field MUST be set to the length, in bytes, of the first two path components in the referral request. For a DFS link referral response, **PathConsumed** MUST be set to the length, in bytes, of the DFS referral request path prefix that matches the DFS link. This field MUST consist of the length of the whole path components in their entirety. For example, if the referral request path is "\MyDomain\MyDfs\dir1\link1\dir2\file1" and "\MyDomain\MyDfs\dir\link1" is a DFS link, **PathConsumed** is 50 (2 bytes for each of the 25 characters).
- **NumberOfReferrals** MUST be set to the number of complete DFS referral entries that can be returned in the response buffer provided by the DFS referral request. The server MAY silently drop targets that will not fit in the buffer. However, if the buffer size is insufficient to return even one referral entry, the server MUST fail the referral request, as specified in section 3.2.5.1. <26>
- If DFS root targets are returned or if a DFS interlink is returned, the ReferralServers bit of the referral entry MUST be set to 1. In all other cases, it MUST be set to 0.
- If DFS root targets are returned or if a DFS interlink is returned, the StorageServers bit of the referral entry MUST be set to 1. In all other cases, it MUST be set to 0.
- For a DFS referral version 4 response, the **TargetFailback** field MUST be set to 0x0001 in a DFS root referral response if DFS client target failback is enabled for the DFS root. For link referrals, the **TargetFailback** field MUST be set to 0x0001 if DFS client target failback is enabled either for the link itself or for the DFS root. In all other cases, the **TargetFailback** field MUST be set to 0x0000.
- All other fields are reserved and SHOULD be set to 0. <27>

The server MUST add one referral entry structure for each target returned and initialize each referral entry as follows:

- The **VersionNumber** field MUST be set to the minimum of the highest DFS referral version supported by the server and the value specified in the **MaxReferralLevel** field of [REQ_GET_DFS_REFERRAL](#).
- The **Size** field MUST be set to the total size of the referral entry, in bytes. The **Size** field of a referral entry structure MUST include the size, in bytes, of all immediately following strings so that a client can find the next referral entry in the message. The **Size** field of a referral entry structure MUST NOT include the size of referenced strings located after the last referral entry in the message.
- The **ServerType** field MUST be set to 0x0001 if root targets are returned. In all other cases, the **ServerType** field MUST be set to 0x0000.
- The **NameListReferral** field MUST be set to 0.
- For DFS referral version 4 responses, the TargetSetBoundary bit MUST be set to 1 for each target that is the first target in a target set, and MUST be set to 0 for all other targets.

- The **TimeToLive** field MUST be set to the time-out value associated with the DFS root or DFS link. When there is more than one referral entry, the **TimeToLive** field of each referral entry MUST be the same.
- For a DFS root referral response:
 - The **DFSPathOffset** field MUST be set to the offset, in bytes, from the beginning of the referral entry to a string that contains the first two path components of the DFS referral request path.
- For a link referral response:
 - The **DFSPathOffset** field MUST be set to the offset, in bytes, from the beginning of the referral entry to a string that contains the DFS referral request path prefix that matches a DFS link.
 - The **DFSAlternatePathOffset** field MUST be set as specified in section [2.2.4.3.1](#). This path MAY either be the same as the path as pointed to by the **DFSAlternatePathOffset** field or be an **8.3 name**. In the former case, the string referenced MAY be the same as that in **DFSAlternatePathOffset** or a duplicate copy. [<28>](#)
 - The **NetworkAddressOffset** field MUST be set to the offset, in bytes, from the beginning of the referral entry to a string that contains the DFS target for the entry.
 - All other fields are reserved and MUST be set to 0.

Servers MAY return fully qualified DNS host names in responses to root referral requests and link referral requests. [<29>](#)

3.2.6 Timer Events

None.

3.2.7 Other Local Events

None.

3.3 Domain Controller Details

This section specifies how a DFS server on a DC processes and responds to DFS referral requests from DFS clients. It is applicable only to DFS servers running on DCs. [<30>](#)

A DFS server on a DC MUST respond to domain, DC, sysvol, root, and link-referral requests.

If that DFS server is also hosting DFS root targets, then in addition to the requirements in this section, it MUST also conform to the requirements in section [3.2](#) while processing referral requests for those DFS root targets.

3.3.1 Abstract Data Model

This section describes a conceptual model of possible data organization that an implementation maintains to participate in this protocol. The organization is provided to explain how the protocol behaves. This document does not mandate that implementations adhere to this model as long as their external behavior is consistent with that described in this document. The following state MUST be maintained at the DFS server running on a DC:

SelfFirst: Indicates whether or not this DC returns itself as the first target in DC and sysvol referrals made to it. The default is false (the DC does not return itself as the first target).

3.3.2 Timers

None.

3.3.3 Initialization

SelfFirst MUST be initialized with the setting on the domain controller (DC) that indicates whether it returns itself as the first target in DC and sysvol referrals made to it. [<31>](#)

3.3.4 Higher-Layer Triggered Events

Servers receive and act upon DFS referral requests. No other higher-layer triggered events are used.

3.3.5 Message Processing Events and Sequencing Rules

3.3.5.1 Receiving a DFS Referral Request

For more information about DFS referral requests, see section [3.2.5.1](#). The processing of individual referral requests is explained in the following sections.

3.3.5.2 Receiving a Domain Referral Request

The server MUST return a list of domains, for the forest in which the DC exists, in both NetBIOS and fully qualified domain name forms. It SHOULD include the domains in other forests, which are part of a trust relationship with the DFS client's forest. [<32>](#)

To process a domain referral, the client MUST support DFS referral version 3 or DFS referral version 4. If the requested DFS referral version is less than 3, the server SHOULD fail the referral with the STATUS_UNSUCCESSFUL (0xC0000001) return code. [<33>](#)

Because there is no difference between DFS referral versions 3 and 4 for a domain referral response, a server that supports DFS referral version 4 MUST return a DFS referral version 3 response even if the DFS client specified DFS referral version 4.

When the number of domains is more than can fit in the response buffer and the response buffer is less than 56 KB, the following sequence of messages MUST occur:

- The server fails the referral request with STATUS_BUFFER_OVERFLOW (0x80000005).
- The client retries by doubling the buffer size up to a maximum of 56 KB.

Otherwise the server fills the response buffer as follows:

- MUST return both the NetBIOS and fully qualified names of a domain or return no entry for the domain.
- MUST include the NetBIOS and fully qualified name of the local domain to which it is joined. This ensures that a client in the same domain as the server will always be able to access SYSVOL and NETLOGON paths correctly. SHOULD include all other domains. [<34>](#)
- MUST return only complete names and not truncate a name to fit in the response buffer.

- MUST return the data equal to the requested buffer size or 56 KB of data, whichever is less.
- Entries in the referral response can be in random order.

The server MUST initialize the [RESP_GET_DFS_REFERRAL](#) referral header for the response as follows:

- **PathConsumed** MUST be set to 0.
- **NumberOfReferrals** MUST be set to the number of complete referral entries that can fit in the response buffer provided by the DFS referral request. The server MAY discard excess referral response entries and MAY return a STATUS_BUFFER_OVERFLOW (0x80000005) error if the response buffer is too small.
- The **ReferralServers** and **StorageServers** fields are set to 0.

The server MUST add one referral entry structure for each of the NetBIOS and fully qualified domain names returned and initialize each referral entry as follows:

- The **VersionNumber** field MUST be set to 0x0003.
- The **Size** field MUST be set to the total size of the referral entry in bytes, including any padding at the end of the structure. The **Size** field of a referral entry structure MUST include the size, in bytes, of all immediately following strings so that a client can find the next referral entry in the message. The **Size** field of a referral entry structure MUST NOT include the size of referenced strings located after the last referral entry in the message.
- The **NameListReferral** bit of the **ReferralEntryFlags** field MUST be set to 1.
- The **TimeToLive** field MAY be set to a non-zero cache time-out value in seconds. [<35>](#) When there is more than one referral entry, the **TimeToLive** field of each referral entry MUST be the same.
- The **SpecialNameOffset** field MUST be set to the offset in bytes from the beginning of the referral entry to the string that contains the domain name for the entry. The domain name MUST be a null-terminated string of the form "[\<domain>](#)", where [<domain>](#) MUST be the domain name that corresponds to the referral entry.
- The **ExpandedNameOffset** field MUST be set to 0.
- All other fields SHOULD be set to 0.

3.3.5.3 Receiving a DC Referral Request

The domain name in the referral request MUST be either a domain in the current forest or a domain in a trusted forest. The server MUST fail DC referral requests for other domain names with a STATUS_INVALID_PARAMETER (0xC000000D) return code.

DC referrals require that the DFS referral version be 3 or higher, as specified in section [3.1.4.2](#). If the requested DFS referral version is less than 3, the server SHOULD [<36>](#) fail the referral request with the STATUS_UNSUCCESSFUL (0xC0000001) return code.

Because there is no difference between DFS referral versions 3 and 4 for a DC referral response, a server that supports DFS referral version 4 MAY return a DFS referral version 3 response even if the DFS client specified DFS referral version 4. [<37>](#)

For a valid domain name, the server MUST return as many complete DC names as can fit in the response buffer. The format of the DC names returned MUST correspond to the format of the domain name in the referral request.

- If the request contains a fully qualified domain name, the response MUST contain a fully qualified DC host name.
- If the request contains a NetBIOS domain name, the response MUST contain a NetBIOS DC host name.

The server MUST initialize the [RESP_GET_DFS_REFERRAL](#) referral header for the response as follows:

- The **PathConsumed** field MUST be set to 0.
- The **NumberOfReferrals** field MUST be set to 1, independent of the number of DC names returned.
- The ReferralServers and StorageServers bits MUST be set to 0.

The server MUST place exactly one referral entry structure in the referral response. The server MUST initialize this referral entry as follows.

- The **VersionNumber** field MUST be set to 0x0003.
- The **Size** field MUST be set to the total size of the referral entry in bytes, including any padding at the end of the structure. The **Size** field of a referral entry structure MUST NOT include the size of referenced strings located after the referral entry in the message.
- The **NameListReferral** bit of the **ReferralEntryFlags** field MUST be set to 1.
- The **TimeToLive** field MAY be set to a nonzero cache time-out value in seconds. [<38>](#) When there is more than one referral entry, the **TimeToLive** field of each referral entry MUST be the same.
- The **SpecialNameOffset** field MUST be set to the offset in bytes from the beginning of the referral entry to the string that contains the domain name for the referral response. The domain name MUST be a null-terminated string of the form "[\<domain>](#)", where [<domain>](#) MUST be the domain name specified in the DC referral request.
- The **NumberOfExpandedNames** field MUST be set to the number of DCs returned.
- The **ExpandedNameOffset** field MUST be set to the offset in bytes from the beginning of the referral entry to the first null-terminated DC Unicode string. If multiple DC name strings are being returned in response to a DC referral request, each DC name immediately follows its null-terminated predecessor without any padding and MUST be prefixed with a backslash character ("[\"](#)"). The total number of consecutive name strings MUST be equal to the value of the **NumberOfExpandedNames** field.
- All other fields SHOULD be set to 0.

The server MUST sort the targets as follows:

- If Distributed File System (DFS) referral site costing is disabled or not supported, sort the targets based on the site location, as specified in section [3.2.1.1](#).
- If DFS referral site costing is enabled, sort the targets based on the site cost, as specified in section [3.2.1.2](#). [<39>](#)

If **SelfFirst** is enabled, the server MUST place itself at the top of the DC referral response.

3.3.5.4 Receiving a sysvol Referral Request

The domain name in the referral request MUST be either a domain in the current forest or a domain in another trusted forest. The DFS server MUST fail sysvol referral requests with other domain names with a STATUS_NOT_FOUND (0xC0000225) return code.

The DFS server MUST determine the list of DCs for the domain name specified in the sysvol referral request from directory services and then generate a list of DCs to return in the referral response that MUST be in either of the following forms, where <dcname> is a DC in the domain specified in the first path component of the referral request:

- "\\<dcname>\SYSVOL" if the second component of referral request path is "SYSVOL".
- "\\<dcname>\NETLOGON" if the second component of referral request path is "NETLOGON".

The format of the <dcname> returned MUST correspond to the format of the domain name in the referral request.

- If the request contains a fully qualified domain name, the response MUST contain fully qualified DC host names.
- If the request contains a NetBIOS domain name, the response MUST contain NetBIOS DC host names.

A server MUST fail referral requests with more than two path components with a STATUS_NOT_FOUND (0xC0000225) return code.

Servers MAY support DFS referral site costing for sysvol referral requests. <40>

After the candidate list of targets is available, the server SHOULD do the following:

- From the IP address of the client, determine the site of the client, as specified in [\[MS-NRPC\]](#), section [3.5.5.3.8](#).
- From the first path component of a target (the host name), determine its site.
- If the server supports DFS referral site costing, determine the site cost from the client site to the target's site if they are not in the same site. If the client site, the target site, or the site cost between them cannot be determined, the cost assigned to that target is implementation-specific. <41>

The server MUST sort the targets as follows:

- If DFS referral site costing is disabled or not supported, sort the targets based on the site location as specified in section [3.2.1.1](#).
- If DFS referral site costing is enabled <42>, sort the targets based on the site cost as specified in section [3.2.1.2](#).

If **SelfFirst** is enabled, the server MUST place itself at the top of the sysvol referral response.

The server MUST initialize the [RESP_GET_DFS_REFERRAL](#) referral header as follows for the response.

- The **PathConsumed** field MUST be set to length in bytes of the DFS referral request path.

- The **NumberOfReferrals** field MUST be set to the number of complete DFS referral entries that can be returned in the response buffer provided by the DFS referral request. The server MAY silently drop targets that will not fit in the buffer. However, if the buffer size is insufficient to return even one referral entry, the server MUST fail the request with STATUS_BUFFER_OVERFLOW (0x80000005).
- The **ReferralServers** field MUST be set to 0 and the **StorageServers** field MUST be set to 1.
- For DFS referral version 3 responses, the **TargetFailback** field MUST be set to 0. For DFS referral version 4 responses, the **TargetFailback** field MAY be set to 1. <43>
- All other fields SHOULD be set to 0.

The server MUST add one referral entry structure for each target returned. The server MUST initialize each referral entry as follows.

- The **VersionNumber** field MUST be set to the minimum of the highest DFS referral version supported by the server and the value specified in the **MaxReferralLevel** field of REQ_GET_DFS_REFERRAL.
- The **Size** field MUST be set to the total size of the referral entry in bytes. The **Size** field of a referral entry structure MUST include the size, in bytes, of all immediately following strings so that a client can find the next referral entry in the message. The **Size** field of a referral entry structure MUST NOT include the size of referenced strings located after the last referral entry in the message.
- The **NameListReferral** field MUST be set to 0.
- For a version 4 DFS referral response, the **TargetSetBoundary** MUST be set to 1 if the target is the first target of a target set, and MUST be set to 0 if the target is other than the first target of a target set.
- The **TimeToLive** field SHOULD be set to a nonzero time-out value in seconds. <44> When there is more than one referral entry, the **TimeToLive** field of each referral entry MUST be the same.
- The **DFSPathOffset** field MUST be set to the offset in bytes from the beginning of the referral entry to the string that contains the DFS referral request path.
- The **DFSAlternatePathOffset** field MUST be set to the offset in bytes from the beginning of the referral entry to the string that contains the DFS referral request path. This path MAY either be the same as the path as pointed to by the **DFSAlternatePathOffset** field or be an 8.3 name. In the former case, the string referenced MAY be the same as that in the **DFSAlternatePathOffset** field or a duplicate copy. <45>
- The **NetworkAddressOffset** field MUST be set to the offset in bytes from the beginning of the referral entry to the string that contains the target.
- All other fields MUST be set to 0.

3.3.5.5 Receiving a Root Referral Request or Link Referral Request

Root referral requests and link referral requests MUST be handled as specified in section 3.2.5.5, with the following exception: a DC MUST process root referral requests and link referral requests for domain-based DFS namespaces in the domain for which it is a DC. The name of the DFS namespace in the second component of the DFS referral request path MUST be validated against the domain-based DFS namespaces in the domain of the DC and if the namespace does not exist, the DFS server SHOULD fail the referral request with a STATUS_NO_SUCH_FILE (0xC000000F) return

code.<46> This MUST be done by searching the name attribute in the objects under the DFS configuration container of the directory service.

3.3.6 Timer Events

None.

3.3.7 Other Local Events

None.

4 Protocol Examples

4.1 Domain Referral

The following sequence diagram shows a domain referral.

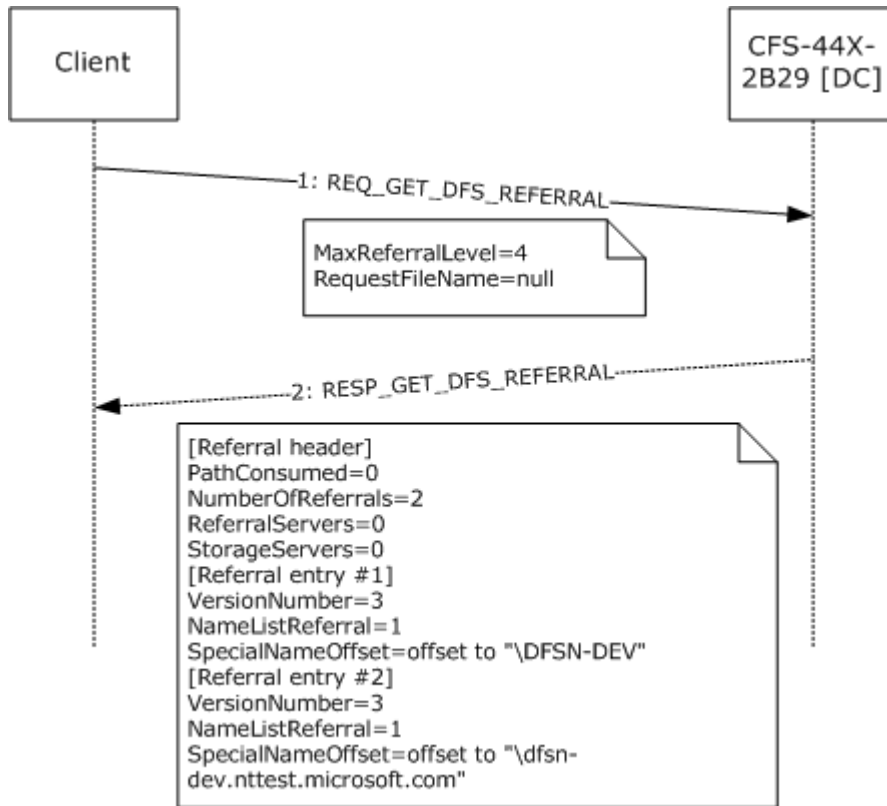


Figure 8: Domain referral sequence

1. The client sends a [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) to CFS-44X-2B29, a DC in the DFSN-DEV.NTTEST.MICROSOFT.COM domain. The highest DFS referral version understood by the client is 4, as indicated by the **MaxReferralLevel** field of REQ_GET_DFS_REFERRAL. The DFS path specified in the DFS referral request is a 0-length string, indicating a domain referral. To illustrate the effect of a client specifying a referral version that is later than what the server supports, the client's referral version is shown as 4 in this example.
2. The DC's response has two referral entries, PathConsumed is 0, ReferralServers and StorageServers bits are set to 0. Each referral entry has the **VersionNumber** field set to 3. While the client's referral version in the request was 4, the server has replied with version 3. The NameListReferral bit is set to 1 in each referral entry. The strings pointed to by the **SpecialNameOffset** field of the individual referral entries are domain names.

4.2 DC Referral

The following sequence diagram shows a DC referral.

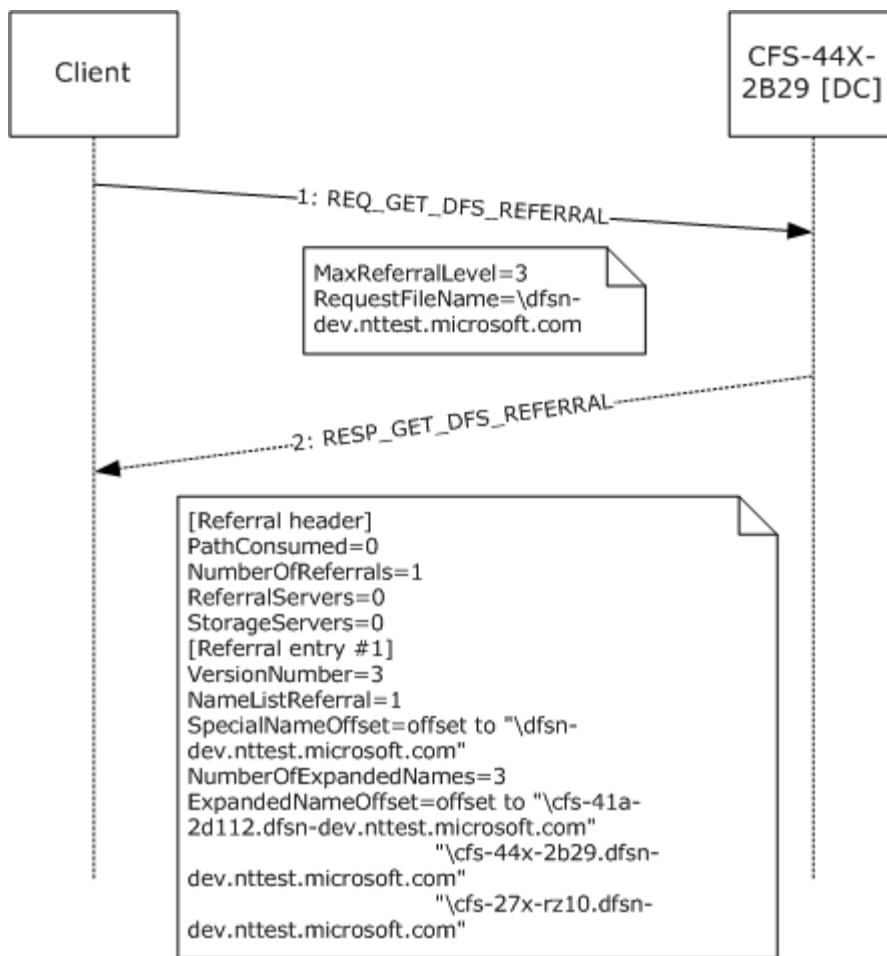


Figure 9: Domain controller referral

1. The client sends a [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) to CFS-44X-2B29, a DC in the DFSN-DEV domain. The highest DFS referral version understood by the client is 3, as indicated by the **MaxReferralLevel** field of REQ_GET_DFS_REFERRAL. The DFS path specified in the DFS referral request is the string \dfs-dev.nttest.microsoft.com, indicating a DC referral.
2. The DC's response has one referral entry, PathConsumed is 0, ReferralServers and StorageServers bits are set to 0. The referral entry has the **VersionNumber** field set to 3. The NameListReferral bit is set to 1 in the referral entry. The string pointed to by the **SpecialNameOffset** field of the referral entry is the domain name for which the DC list returned. The **NumberOfExpandedNames** field is set to 3, indicating that there are three DCs in the DC list returned. The **ExpandedNameOffset** field in the referral entry points to a sequence of three strings, each of which is a DC name. The DC names returned are in fully qualified domain name format, because the domain name in the request is also in the fully qualified domain name format.

4.3 Domain-Based DFS Root Referral

The following sequence diagram shows a root referral for a domain-based DFS namespace.

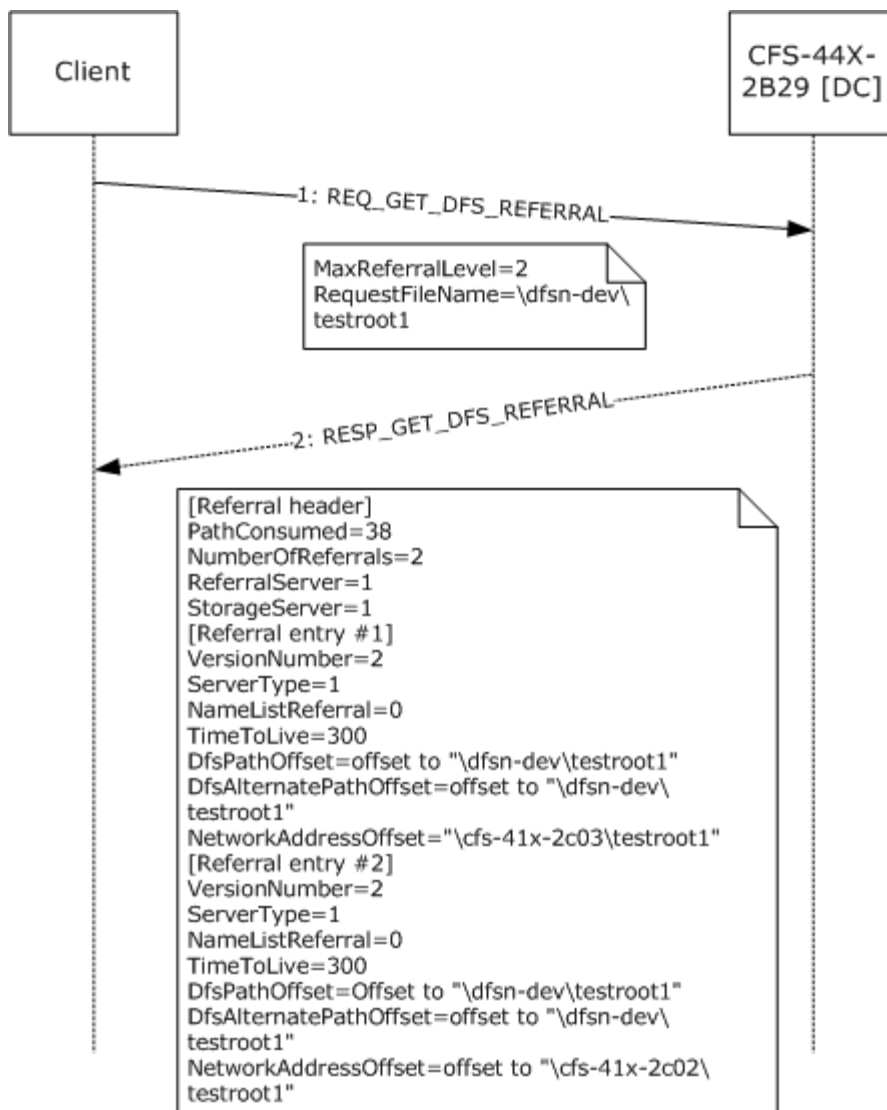


Figure 10: Domain-based DFS root referral

1. The client sends a [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) to CFS-44X-2B29, a DC in the DFSN-DEV domain. The highest DFS referral version understood by the client is 2, as indicated by the **MaxReferralLevel** field of REQ_GET_DFS_REFERRAL. The DFS path specified in the DFS referral request is \\dfs-dev\testroot1, a domain-based DFS namespace in the DFSN-DEV domain.
2. The DC's referral response contains two referral entries, each having referral version 2. The ReferralServers and StorageServers bits are set to 1 and the **ServerType** field is set to 1 in the response since DFS root targets are returned. The strings pointed to by the **NetworkAddressOffset** field of the individual referral entries are the DFS root targets for the domain-based DFS namespace.

4.4 Domain-Based DFS Link Referral

The following sequence diagram shows a DFS link referral for a domain-based DFS namespace.

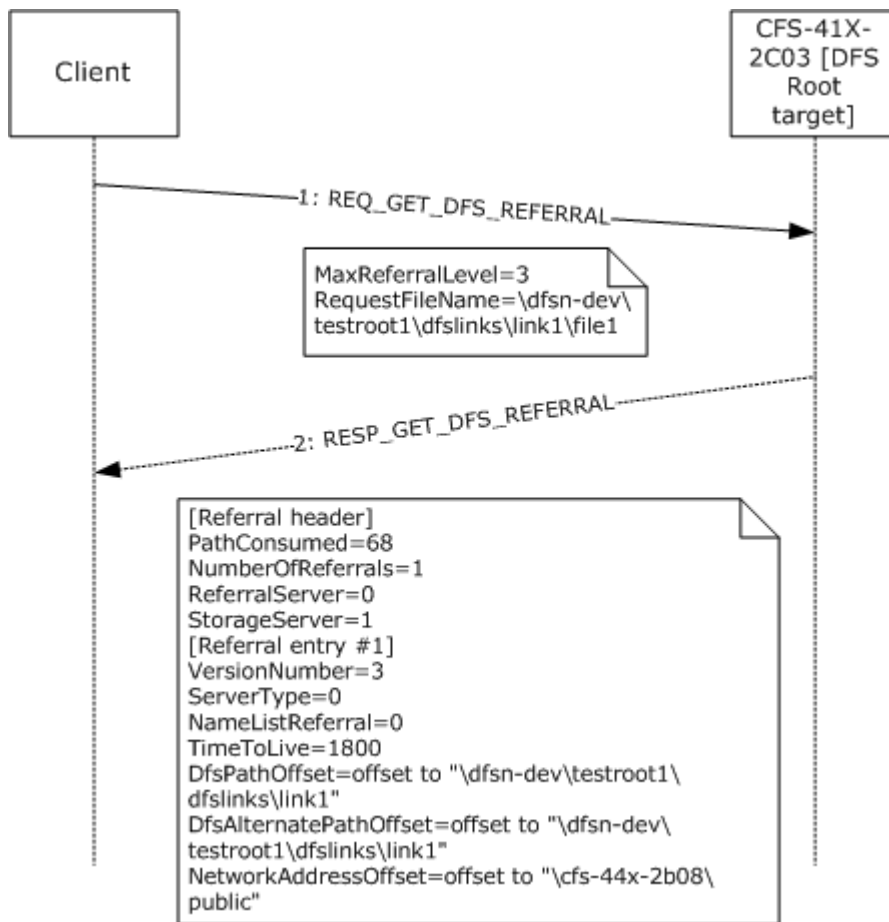


Figure 11: Domain-based DFS link referral

1. The client sends a [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) to CFS-41X-2C03, a DFS root target for the domain-based DFS namespace \\dfs-dev\testroot1 in the DFSN-DEV domain. The highest DFS referral version understood by the client is 3, as indicated by the **MaxReferralLevel** field of REQ_GET_DFS_REFERRAL. The DFS path specified in the DFS referral request is \dfs-dev\testroot1\dfslinks\link1\file1, a path to a file in the DFS namespace.
2. The DFS root target's referral response contains one referral entry having referral version 3. The ReferralServers bit is set to 0 and StorageServers bit is set to 1 indicating that the target is not another DFS root. The **ServerType** field is set to 0 in the response because a DFS link target is returned. The string pointed to by the **NetworkAddressOffset** field of the referral entry is the DFS link target.

4.5 Domain-Based DFS Root Referral Packet Trace

The following figure shows the network packet trace of a domain-based DFS root referral request. The [REQ_DFS_GET_REFERRAL](#) structure is at offset 0x7E in the hexadecimal dump shown.

MaxReferralLevel field is at offset 0x7E (=3) and **RequestFileName** is at offset 0x80 (=\\dfsn-dev\testroot1).

```
ETHERNET: EType - Internet IP (IPv4)
IP: Protocol = TCP - Transmission control; Packet ID - 48186; Total IP
Length = 154; Options = NO Options
TCP: Control Bits: .AP..., len: 114, seq:1634334697-1634334811,
ack:2251252280, win:64498, src: 2086 dst: 139 (NBT Session)
NBT: SS: Session Message, Len: 110
SMB: C transact2 NT Get DFS Referral
  SMB: Command = C transact2
    SMB: Word count = 15
    SMB: Total param count = 42
    SMB: Total data count = 0
    SMB: Max param count = 0
    SMB: Max data count = 4096
    SMB: Max setup words = 0 (0x0)
    SMB: Transact Flags Summary = 0 (0x0)
      SMB:.....0 = Leave session intact
      SMB:.....0. = Response required
    SMB: Transact timeout = 0 (0x0)
    SMB: Parameter count = 42 (0x2A)
    SMB: Parameter offset = 68 (0x44)
    SMB: Data count = 0 (0x0)
    SMB: Data offset = 0 (0x0)
    SMB: Setup count = 1
    SMB: Setup words
    SMB: Transact2 function = TRANS2_DFS_GET_REFERRAL
    SMB: Byte count = 45
    SMB: Parameter bytes
    SMB: Transaction parameters
      SMB: DFS Max Referral Level = 3 (0x3)
      SMB: DFS Request Filename = \\dfsn-dev\testroot1
00000: 00 D0 04 3C D8 00 00 B0 D0 C2 01 3C 08 00 45 00
00010: 00 9A BC 3A 40 00 80 06 76 EF 9D 3B FD 44 0A C1
00020: 21 F3 08 26 00 8B 61 69 F7 E9 86 2F 62 38 50 18
00030: FB F2 C7 C0 00 00 00 00 00 00 6E FF 53 4D 42 32 00
00040: 00 00 00 18 07 C8 00 00 00 00 00 00 00 00 00 00
00050: 00 00 02 20 B8 0B 00 38 40 01 0F 2A 00 00 00 00
00060: 00 00 10 00 00 00 00 00 00 00 00 00 00 2A 00 44
00070: 00 00 00 00 00 01 00 10 00 2D 00 00 00 00 03 00
00080: 5C 00 64 00 66 00 73 00 6E 00 2D 00 64 00 65 00
00090: 76 00 5C 00 74 00 65 00 73 00 74 00 72 00 6F 00
000A0: 6F 00 74 00 31 00 00
```

Figure 12: REQ_DFS_GET_REFERRAL packet trace

The following figure shows the network packet dump of a domain-based DFS root referral response. The referral response consists of the DFS referral header, [RESP_GET_DFS_REFERRAL](#) at offset 0x72 in the hexadecimal dump. The **PathConsumed** field is at offset 0x72 (=0x26) and the **NumberOfReferrals** field is at offset 0x74 (=2). The first referral entry, of type [DFS_REFERRAL_V3](#), starts at 0x7A and the second referral entry, also of type [DFS_REFERRAL_V3](#), starts at offset 0x9C. The referral header and the first referral entry have been marked in the hexadecimal dump for identification purposes. The hexadecimal dump shows that the two referral entries immediately follow one another and all the strings referenced in the referral entries are at the end of all the referral entries, starting at offset 0xBE in the hexadecimal dump.

The **NetworkAddressOffset** field of the first referral entry, containing the offset of the DFS root target from the start of the referral entry, is at offset 0x8A. It contains 0x94. The first referral entry is at offset 0x7A. Hence, the DFS root target that corresponds to the first referral entry is at offset

0x7A+0x94=0x10E. The null-terminated Unicode string at offset 0x10E in the hexadecimal dump is \cfs-41x-2c03\testroot1, one of the DFS root targets of the domain-based DFS namespace \\dfs-dev\testroot1.

```

ETHERNET: EType - Internet IP (IPv4)
IP: Protocol - TCP - Transmission control; Packet ID = 12850; Total IP Length - 352; Options = NO Options
TCP: control Bits: .AP..., len: 312, seq:2251252280-2251252592, ack:1634334811, win:64482,
src: 139 (NBT session) dst: 2086
NBT: SS: Session Message, Len: 308
SMB: R transact2 NT Get DFS Referral (response to frame 48)
  SMB: Command = C transact2
    SMB: Word count = 10
    SMB: Total parm count = 0
    SMB: Total data count = 252
    SMB: Parameter count = 0 (0x0)
    SMB: Parameter offset = 56 (0x38)
    SMB: Parameter Displacement = 0 (0x0)
    SMB: Data count = 252 (0xFC)
    SMB: Data offset = 56 (0x38)
    SMB: Data Displacement = (0x0)
    SMB: Setup count = 0
    SMB: Byte Count = 253
    SMB: Byte parameters
    SMB: Transaction data
      SMB: DFS Path consumed = 38 (0x26)
      SMB: DFS Number of Referrals = 2 (0x2)
      SMB: DFS Server Function = 3 (0x3)
        SMB: .....1 = Referral Server
        SMB: .....1 = Storage Server
      SMB: DFS version 3 Referral
        SMB: DFS Version Number = 3 (0x3)
        SMB: DFS Server Type = DFS root target
        SMB: DFS TimeToLive = 300 (0x12C)
        SMB: DFS Filename = \dfs-dev\testroot1
        SMB: DFS 8.3 Filename = \dfs-dev\teszroot1
        SMB: DFS Sharename = \cfs-41x-2c03\testroot1
      SMB: DFS Servicesire GUID = 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
      SMB: DFS version 3 Referral
        SMB: DFS Version Number = 3 (0x3)
        SMB: DFS Server Type = DFS root target
        SMB: DFS TimeToLive = 300 (0x12C)
        SMB: DFS Filename = \dfs-dev\testroot1
        SMB: DFS 8.3 Filename = \dfs-d\testroot1
        SMB: DFS Sharename = \cfs-41x-2c02\testroot1
      SMB: DFS Servicesite GUID = 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00000: 00 B0 D0 C2 01 3C 00 D0 04 3C 08 00 08 00 45 00
00010: 01 60 32 32 40 00 7E 06 02 32 0A C1 21 F3 9D 3B
00020: FD 44 00 88 08 26 86 2F 62 38 61 69 F8 5B 50 18
00030: FB E2 38 87 00 00 00 00 01 34 FF 53 4D 42 32 00
00040: 00 00 00 98 07 C8 00 00 00 00 00 00 00 00 00
00050: 00 00 02 20 B8 08 00 38 40 01 0A 00 00 FC 00 00
00060: 00 00 38 00 00 00 FC 00 38 00 00 00 00 00 FD
00070: 00 00 26 00 02 00 03 00 00 00 03 00 22 00 01 00
00080: 00 00 2C 01 00 00 44 00 6C 00 94 00 00 00 00 00
00090: 00 00 00 00 00 00 00 00 00 00 00 00 03 00 22 00
000A0: 01 00 00 00 2C 01 00 00 22 00 4A 00 02 00 00 00
000B0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 5C 00
000C0: 64 00 66 00 73 00 6E 00 2D 00 64 00 65 00 76 00
000D0: 5C 00 74 00 65 00 73 00 74 00 72 00 6F 00 6F 00
000E0: 74 00 31 00 00 00 5C 00 64 00 66 00 73 00 6E 00
000F0: 2D 00 64 00 65 00 76 00 5C 00 74 00 65 00 63 00
00100: 74 00 72 00 6F 00 6F 00 74 00 31 00 00 00 5C 00
00110: 63 00 66 00 73 00 2D 00 34 00 31 00 78 00 2D 00
00120: 32 00 63 00 30 00 33 00 5C 00 74 00 65 00 73 00
00130: 74 00 72 00 6F 00 6F 00 74 00 31 00 00 00 5C 00
00140: 63 00 66 00 73 00 2D 00 34 00 31 00 78 00 2D 00
00150: 32 00 63 00 30 00 32 00 5C 00 74 00 65 00 73 00
00160: 74 00 72 00 6F 00 6F 00 74 00 31 00 00 00

```

Figure 13: RESP_GET_DFS_REFERRAL packet trace

4.6 Standalone DFS Root Referral

The following sequence diagram shows a root referral for a stand-alone DFS namespace.

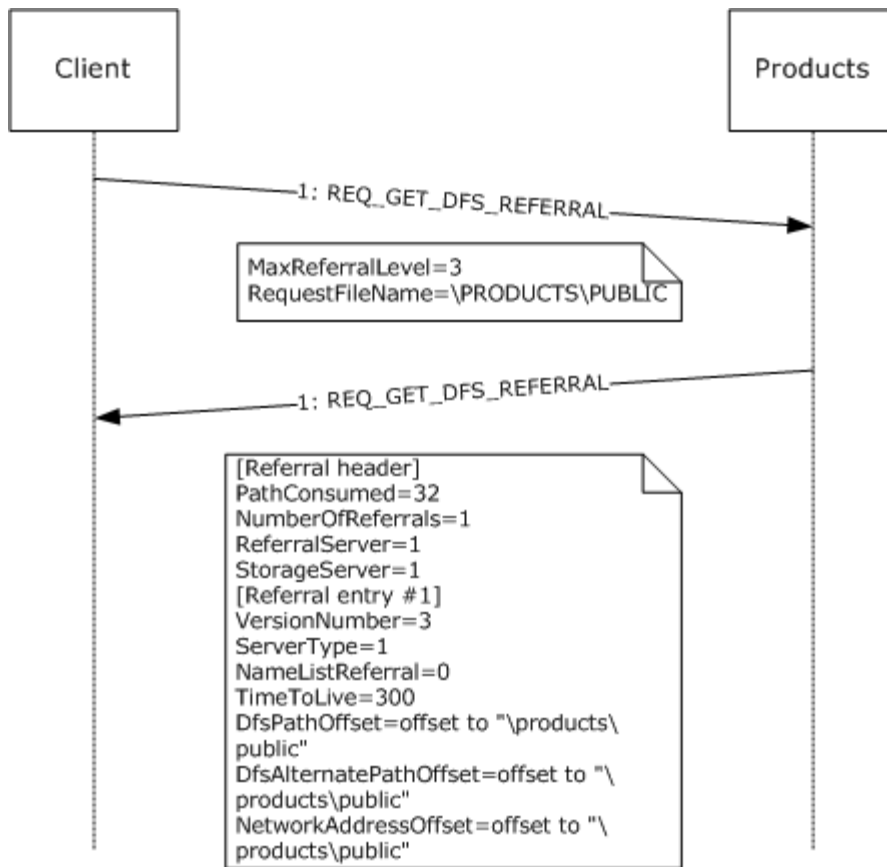


Figure 14: DFS root referral between client and server

The client sends a [REQ_GET_DFS_REFERRAL](#) to PRODUCTS. The latest DFS referral version understood by the client is 3, as indicated by the **MaxReferralLevel** field of REQ_GET_DFS_REFERRAL. The DFS path specified in the DFS referral request is \PRODUCTS\PUBLIC, a stand-alone DFS namespace.

The referral response contains one referral entry having a referral version 3. The ReferralServers and StorageServers bits are set to 1, and the **ServerType** field is set to 1 in the response since DFS root targets are returned. The strings pointed to by the **NetworkAddressOffset** field of the referral entry is the DFS root target for the stand-alone DFS namespace.

5 Security

5.1 Security Considerations for Implementers

None.

5.2 Index of Security Parameters

None.

6 Appendix A: Product Behavior

The information in this specification is applicable to the following Microsoft products or supplemental software. References to product versions include released service packs:

- Microsoft Windows NT® Workstation 4.0 operating system with Service Pack 2 (SP2)
- Microsoft Windows® 98 operating system
- Microsoft Windows® 2000 operating system
- Microsoft Windows® Millennium Edition operating system
- Windows® XP operating system
- Windows Server® 2003 operating system
- Windows Vista® operating system
- Windows Server® 2008 operating system
- Windows® 7 operating system
- Windows Server® 2008 R2 operating system

Exceptions, if any, are noted below. If a service pack or Quick Fix Engineering (QFE) number appears with the product version, behavior changed in that service pack or QFE. The new behavior also applies to subsequent service packs of the product unless otherwise specified. If a product edition appears with the product version, behavior is different in that product edition.

Unless otherwise specified, any statement of optional behavior in this specification that is prescribed using the terms SHOULD or SHOULD NOT implies product behavior in accordance with the SHOULD or SHOULD NOT prescription. Unless otherwise specified, the term MAY implies that the product does not follow the prescription.

[<1> Section 1.8:](#) Windows uses only the values specified in [\[MS-ERREF\]](#).

[<2> Section 2.2.4.3.2:](#) Windows 2000 Server and Windows Server 2003 will add 16 bytes of padding after [DFS_REFERRAL_V3](#) structures in all namelist referral responses. Windows Server 2008 and Windows Server 2008 R2 will add 16 bytes of padding for [DFS_REFERRAL_V3](#) structures in DC referral responses. Windows Server 2008 and Windows Server 2008 R2 will not add padding for [DFS_REFERRAL_V3](#) structures in domain referral responses.

[<3> Section 3.1:](#) DFS client functionality is available in the following Windows versions:

- Windows NT Workstation 4.0 SP2
- Windows 98 with **Active Directory** client
- Windows 2000
- Windows Millennium Edition
- Windows XP
- Windows Server 2003
- Windows Vista

- Windows Server 2008
- Windows 7
- Windows Server 2008 R2

The buffer size used by Windows DFS clients for all DFS referral requests (domain, DC, DFS root, DFS link and SYSVOL) is 8 KB. Windows DFS clients retry on STATUS_BUFFER_OVERFLOW (0x80000005) by doubling the buffer size up to a maximum of 56 KB.

<4> [Section 3.1.1:](#) Windows clients cache information from referral requests to reduce network traffic and reduce file access latencies.

<5> [Section 3.1.1:](#) The default **TimeToLive** value for root referrals is 300 seconds and the default **TimeToLive** value for link referrals is 1,800 seconds.

<6> [Section 3.1.3:](#) Windows clients (Windows 2000, Windows XP, Windows Server 2003, Windows Server 2008, Windows 7, and Windows Server 2008 R2) use 15 minutes as the default BootstrapDCTimer period. The interval is configurable in Windows by the HKEY_LOCAL_MACHINE\Software\Policies\Microsoft\System\DFSClient\DfsDcNameDelay registry setting.

<7> [Section 3.1.4.1:](#) The Windows client returns STATUS_MORE_PROCESSING_REQUIRED to the calling application to indicate that the path does not correspond to a DFS Namespace or a SYSVOL/NETLOGON share, and that the I/O operation is not complete. The I/O request is handled by the local operating system.

<8> [Section 3.1.5.1:](#) DFS link referral requests to the DFS root target server are issued by the following operating systems: Windows NT 4.0 SP2, Windows 98, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2. Windows 98 DFS clients issue DFS link referral requests to DCs when accessing a domain-based DFS namespace.

<9> [Section 3.1.5.2:](#) If an I/O operation to a target fails with one of the following error codes, as specified per version of Windows, the client will proceed to the next target. Unless otherwise noted, the code is used in Windows NT 4.0 SP2, Windows 2000, Windows XP, Windows XP SP1, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2.

Status Code	Support Notes
STATUS_BAD_NETWORK_NAME	
STATUS_BAD_NETWORK_PATH	
STATUS_CONNECTION_DISCONNECTED	Not used in Windows NT 4.0 SP2.
STATUS_CONNECTION_REFUSED	Used in Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2.
STATUS_CONNECTION_RESET	Used in Windows 7 and Windows Server 2008 R2.
STATUS_DEVICE_OFF_LINE	
STATUS_DFS_UNAVAILABLE	Not used in Windows NT 4.0 SP2.
STATUS_DISK_OPERATION_FAILED	
STATUS_DUPLICATE_NAME	Used in Windows Vista, Windows Server 2008, Windows 7,

Status Code	Support Notes
	and Windows Server 2008 R2.
STATUS_FS_DRIVER_REQUIRED	Used in Windows 7 and Windows Server 2008 R2.
STATUS_HOST_UNREACHABLE	Used in Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2.
STATUS_INSUFFICIENT_RESOURCES	Not used in Windows NT 4.0 SP2.
STATUS_INVALID_NETWORK_RESPONSE	
STATUS_IO_REPARSE_TAG_NOT_HANDLED	Used in Windows 7 and Windows Server 2008 R2.
STATUS_IO_TIMEOUT	
STATUS_NETLOGON_NOT_STARTED	Not used in Windows NT 4.0 SP2.
STATUS_NETWORK_BUSY	
STATUS_NETWORK_NAME_DELETED	
STATUS_NETWORK_UNREACHABLE	Not used in Windows NT 4.0 SP2.
STATUS_NO_SUCH_DEVICE	
STATUS_NO_SUCH_LOGON_SESSION	Not used in Windows NT 4.0 SP2, Windows 2000, and Windows XP RTM.
STATUS_REMOTE_NOT_LISTENING	
STATUS_REQUEST_NOT_ACCEPTED	
STATUS_SHARING_PAUSED	Not used in Windows NT 4.0 SP2.
STATUS_UNEXPECTED_NETWORK_ERROR	
STATUS_UNMAPPABLE_CHARACTER	Not used in Windows NT 4.0 SP2.
STATUS_USER_SESSION_DELETED	Not used in Windows NT 4.0 SP2 and Windows 2000.
STATUS_VIRTUAL_CIRCUIT_CLOSED	

<10> [Section 3.1.5.4](#): Windows DFS clients retry the referral request by doubling the buffer size, up to a maximum of 56 KB.

<11> [Section 3.1.5.4.1](#): Windows clients do not remove an existing domain name from DomainCache.

<12> [Section 3.1.5.4.3](#): The Windows client returns STATUS_OBJECT_PATH_NOT_FOUND.

<13> [Section 3.1.5.4.3](#): For I/O operations which have a domain name as the first component of the path, domain-joined Windows clients fail the original I/O operation when the root referral request to all the DCs for the domain fails. The Windows client returns STATUS_OBJECT_PATH_NOT_FOUND.

<14> [Section 3.1.5.4.3](#): For I/O operations that have a domain name as the first component of the path, domain-joined Windows clients fail the original I/O operation and return STATUS_OBJECT_PATH_NOT_FOUND.

<15> [Section 3.1.5.4.3](#): The Windows client handles this response in the same way that it handles link referrals that it receives in response to link referral requests.

<16> [Section 3.1.5.4.3](#): Windows Server 2003 and Windows XP DFS clients fail the I/O operation if the ReferralCache entry refresh fails. Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2 DFS clients use a soft time-out equal to the TTL and a hard time-out equal to 4*TTL.

<17> [Section 3.2](#): DFS server functionality is available only in the following Windows versions:

- Windows NT Server 4.0 SP2
- Windows 2000 Server
- Windows Server 2003
- Windows Server 2008
- Windows Server 2008 R2

Windows client operating systems, such as Windows NT 4.0 Professional, Windows 98, Windows 2000 Professional, Windows Millennium Edition, Windows XP, Windows Vista and Windows 7, do not implement the DFS server functionality.

<18> [Section 3.2.5.1](#): The highest DFS referral version supported by each version of Windows on which DFS server functionality is implemented, is as follows.

Windows server version	Highest DFS referral version
Windows NT 4.0	2
Windows 2000 Server	3
Windows Server 2003	3
Windows Server 2003 with SP1	4
Windows Server 2008	4
Windows Server 2008 R2	4

<19> [Section 3.2.5.1](#): Windows NT 4.0 SP2, Windows 2000, and Windows Server 2003 insert a variable number of padding bytes.

<20> [Section 3.2.5.4](#): Windows NT Workstation 4.0 SP2, Windows 2000, and Windows Server 2003 fail the referral request with a STATUS_NO_SUCH_DEVICE (0xC000000E) return code.

<21> [Section 3.2.5.5](#): Windows 2000 Server fails the referral request with a STATUS_NO_SUCH_DEVICE (0xC000000E) return code.

<22> [Section 3.2.5.5](#): For historical reasons, Windows 2000 Server uses the SiteInformationBLOB in the DFS metadata of a domain-based DFS namespace to determine the site of a DFS target. Windows Server 2003, Windows Server 2008 and Windows Server 2008 R2 use the IP address of a DFS target to determine its site.

For interlinks, if the target is a domain-based DFS namespace, there cannot be more than one target for the link. Multiple stand-alone DFS namespace targets are supported as interlink targets. Therefore, there is no special handling for interlink targets. A referral response returns only the

immediate interlink targets, not the targets of the domain-based DFS namespace interlink target itself.

<23> [Section 3.2.5.5](#): Windows servers assign infinite cost to a target if it cannot identify either the target site or the target site cost from the client site.

Windows 2000 Server does not support DFS referral site costing. Windows Server 2003, Windows Server 2008 and Windows Server 2008 R2 support DFS referral site costing.

<24> [Section 3.2.5.5](#): DFS in-site referral mode is applied only to DFS link targets and not to DFS root targets in Windows 2000 Server. DFS in-site referral mode is applied to all targets in Windows Server 2003, Windows Server 2008, and Windows Server 2008 R2.

Windows 2000 Server does not support DFS referral site costing. Only Windows Server 2003, Windows Server 2008, and Windows Server 2008 R2 support DFS referral site costing.

Windows servers randomize the order of targets within each target set to spread client load across the targets on a per DFS referral response basis.

<25> [Section 3.2.5.5](#): Windows Server 2003 with SP1, Windows Server 2008 and Windows Server 2008 R2 sort targets having non-default priorities as described previously.

<26> [Section 3.2.5.5](#): Windows will silently drop targets that do not fit in the response buffer.

<27> [Section 3.2.5.5](#): Windows Server 2003 with SP1, Windows Server 2008 and Windows Server 2008 R2 set all other fields to 0. The earlier versions of Windows (Windows NT 4.0 SP2, Windows 2000, Windows Server 2003) allow the other fields to be any value.

<28> [Section 3.2.5.5](#): In Windows NT 4.0 SP2 and Windows 2000, set the **DFSAlternatePathOffset** field to point to an 8.3 string representation of the string pointed to by **DFSPathOffset** if it is not a legal 8.3 string. Otherwise, if **DFSPathOffset** points to a legal 8.3 string, **DFSAlternatePathOffset** points to a separate copy of the same string. Windows Server 2003, Windows Server 2008 and Windows Server 2008 R2 set the **DFSPathOffset** field and the **DFSAlternatePathOffset** field to point to separate copies of the identical string.

<29> [Section 3.2.5.5](#): By default, all Windows servers return DNS host names that are not fully qualified for targets. However, Windows servers can be configured to return fully qualified DNS host names of targets.

<30> [Section 3.3](#): DCs are supported only on Windows Server 2008 R2, Windows Server 2008, Windows Server 2003, and Windows 2000 Server.

<31> [Section 3.3.3](#): On Windows-based domain controllers, preferred logon is enabled with the PreferLogonDC registry setting (see [\[KB831201\]](#)).

<32> [Section 3.3.5.2](#): Windows Servers have a server-side limit of 56 KB on the maximum size of a domain referral response. Within that limit, the server attempts to return all the domain names that it has. If the size of the domain referral entries is greater than 56 KB, it retains only 56 KB.

<33> [Section 3.3.5.2](#): Windows Server 2008 and Windows Server 2008 with SP2 fail the DFS referral request when the value received in the **MaxReferralLevel** field of [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) is less than 3. The earlier versions of Windows (Windows NT 4.0 SP2, Windows 2000, Windows Server 2003) return the referral formatted in the requested version.

<34> [Section 3.3.5.2](#): Windows servers have a server-side limit of 56 KB on the maximum size of a domain referral response. Within that limit, the server attempts to return all the domain names that it has. If the size of the domain referral entries is greater than 56 KB, it retains only 56 KB.

<35> [Section 3.3.5.2](#): Windows returns a fixed value of 600 seconds.

<36> [Section 3.3.5.3](#): Windows NT Server 4.0 SP2, Windows 2000, and Windows Server 2003 do not fail the request if the **MaxReferralLevel** field of [REQ_GET_DFS_REFERRAL \(section 2.2.2\)](#) is less than 3, and the referral response is returned formatted appropriately for the requested version.

<37> [Section 3.3.5.3](#): Windows Server 2003 with SP1, Windows Server 2008 and Windows Server 2008 with SP2 return a DFS referral version 3 response even if the DFS client specified DFS referral version 4.

<38> [Section 3.3.5.3](#): Windows returns a fixed value of 600 seconds.

<39> [Section 3.3.5.3](#): On Windows-based domain controllers, Distributed File System (DFS) referral site costing is enabled by setting the SiteCostedReferrals value in the registry key HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Dfs\Parameters\ to 1.

<40> [Section 3.3.5.4](#): Windows 2000 Server does not support DFS referral site costing for sysvol referral responses. Windows Server 2003 and later versions, including Windows Server 2008 and Windows Server 2008 R2 can be configured to support DFS referral site costing for sysvol referral responses. DFS referral site costing is disabled by default in Windows Server 2003 and enabled by default in Windows Server 2008 and Windows Server 2008 R2. The registry value SiteCostedReferrals under the registry key HKEY_LOCAL_MACHINE\System\CurrentControlSet\Services\Dfs\Parameters must be set to 1 at service startup to enable DFS referral site costing for sysvol referral responses in Windows Server 2003 versions.

<41> [Section 3.3.5.4](#): Windows assigns infinite cost to a target if it cannot identify either the target site or the target site cost from the client site.

<42> [Section 3.3.5.4](#): On Windows-based domain controllers, DFS referral site costing is enabled by setting the SiteCostedReferrals value in the registry key HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Dfs\Parameters\ to 1.

<43> [Section 3.3.5.4](#): In Windows Server 2003 with SP1 and later versions, the registry value SysvolNetlogonTargetFailback under the registry key HKEY_LOCAL_MACHINE\System\CurrentControlSet\Services\Dfs\Parameters controls target failback for sysvol referrals.

<44> [Section 3.3.5.4](#): Windows sets the **TimeToLive** field to a fixed value of 900 seconds.

<45> [Section 3.3.5.4](#): In Windows NT 4.0 SP2 and Windows 2000, set the **DFSAlternatePathOffset** field to point to an 8.3 string representation of the string pointed to by **DFSPathOffset** if it is not a legal 8.3 string. Otherwise, if **DFSPathOffset** points to a legal 8.3 string, **DFSAlternatePathOffset** points to a separate copy of the same string. Windows Server 2003, Windows Server 2008 and Windows Server 2008 R2 set the **DFSPathOffset** field and the **DFSAlternatePathOffset** field to point to separate copies of the identical string.

<46> [Section 3.3.5.5](#): Windows 2000 Server fails the referral request with a STATUS_NO_SUCH_DEVICE (0xC000000E) return code. Windows Server 2003 fails the referral request with a STATUS_UNSUCCESSFUL (0xC0000001) return code.

7 Change Tracking

This section identifies changes that were made to the [MS-DFSC] protocol document between the January 2011 and February 2011 releases. Changes are classified as New, Major, Minor, Editorial, or No change.

The revision class **New** means that a new document is being released.

The revision class **Major** means that the technical content in the document was significantly revised. Major changes affect protocol interoperability or implementation. Examples of major changes are:

- A document revision that incorporates changes to interoperability requirements or functionality.
- An extensive rewrite, addition, or deletion of major portions of content.
- The removal of a document from the documentation set.
- Changes made for template compliance.

The revision class **Minor** means that the meaning of the technical content was clarified. Minor changes do not affect protocol interoperability or implementation. Examples of minor changes are updates to clarify ambiguity at the sentence, paragraph, or table level.

The revision class **Editorial** means that the language and formatting in the technical content was changed. Editorial changes apply to grammatical, formatting, and style issues.

The revision class **No change** means that no new technical or language changes were introduced. The technical content of the document is identical to the last released version, but minor editorial and formatting changes, as well as updates to the header and footer information, and to the revision summary, may have been made.

Major and minor changes can be described further using the following change types:

- New content added.
- Content updated.
- Content removed.
- New product behavior note added.
- Product behavior note updated.
- Product behavior note removed.
- New protocol syntax added.
- Protocol syntax updated.
- Protocol syntax removed.
- New content added due to protocol revision.
- Content updated due to protocol revision.
- Content removed due to protocol revision.
- New protocol syntax added due to protocol revision.

- Protocol syntax updated due to protocol revision.
- Protocol syntax removed due to protocol revision.
- New content added for template compliance.
- Content updated for template compliance.
- Content removed for template compliance.
- Obsolete document removed.

Editorial changes are always classified with the change type **Editorially updated**.

Some important terms used in the change type descriptions are defined as follows:

- **Protocol syntax** refers to data elements (such as packets, structures, enumerations, and methods) as well as interfaces.
- **Protocol revision** refers to changes made to a protocol that affect the bits that are sent over the wire.

The changes made to this document are listed in the following table. For more information, please contact protocol@microsoft.com.

Section	Tracking number (if applicable) and description	Major change (Y or N)	Change type
1.3 Overview	58633 Removed the statement that a DFS referral request can be accessed by the DFS client from a link on a resolved share.	N	Content updated.
1.4 Relationship to Other Protocols	59886 Specified the relationship between [MS-DFSC] and [MS-NRPC].	Y	Content updated.
1.4 Relationship to Other Protocols	58449 Specified that the DFS: Referral Protocol does not specify a replication protocol for file and directory content between DFS root targets or DFS link targets.	Y	Content updated.
1.5.1 Common Requirements	57079 Clarified the requirements for using the DFS namespace.	N	Content updated.
2.1 Transport	57078 Updated the description with details of the use of SMB protocols.	N	Content updated.
2.2.1 Common Conventions	58381 Changed description of address naming strings to indicate that they must start with one backslash, not two.	N	Content updated.

Section	Tracking number (if applicable) and description	Major change (Y or N)	Change type
2.2.2 REQ_GET_DFS_REFERRAL	57078 Removed the list of referral request types and added a reference to the "Sending a DFS referral request to the server" section.	N	Content updated.
2.2.2 REQ_GET_DFS_REFERRAL	56722 Updated description of how referral requests are sent.	N	Content updated.
2.2.3 RESP_GET_DFS_REFERRAL	58318 Updated description of Padding field and removed product behavior note on padding.	Y	Content updated.
2.2.4 Referral Entry Types	58335 Removed processing rules for setting the value of the Size field.	N	Content updated.
2.2.4.2 DFS_REFERRAL_V2	58635 Removed processing rules from definition of TimeToLive.	N	Content updated.
2.2.4.2 DFS_REFERRAL_V2	58636 Removed processing rules from definition of DFSAlternatePathOffset.	N	Content updated.
2.2.4.2 DFS_REFERRAL_V2	58336 Clarified the description of the NetworkAddressOffset field.	N	Content updated.
2.2.4.3.1 NameListReferral Flag Set to 0	58336 Clarified the description of the NetworkAddressOffset field.	N	Content updated.
3.1.1 Abstract Data Model	58425 Deleted the processing rules regarding a lookup in ReferralCache.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	57941 Updated process that client must use when it receives an I/O operation with a UNC path.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	57078 Updated the descriptions of I/O operations involving DFS referral requests with details of what the calling application provides.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	58425 Added processing rules from the "Abstract Data Model" section.	N	Content updated.
3.1.4.1	58640	N	Content

Section	Tracking number (if applicable) and description	Major change (Y or N)	Change type
User/Application Initiated I/O Operation on a UNC Path	Removed reference to CAP_DFS flag.		updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	58274 Updated diagrams and text with references to different steps and added information about failing the I/O operation with the last error code that occurred.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	59514 Clarified the description of the [not DFS] case.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	59554 Clarified the operation when an entry does not contain DFS link targets.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	59587 Clarified processing of the [ReferralCache miss] step.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60258 Updated processing for [I/O request, path fully resolved] when RootOrLink of ReferralCache entry indicates link targets.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60321 Updated processing for [I/O request, path fully resolved] when RootOrLink of ReferralCache entry indicates root targets.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60296 Updated processing for [I/O request, path fully resolved] when IO operation to all targets fails.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60259 Updated processing for [DFS path, Failure].	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60303 Added new product behavior note.	N	New product behavior note added.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60353 Added redirection information to the processing steps for [sysvol referral request].	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	59570 Removed RootOrLink=root from the step	Y	Content updated.

Section	Tracking number (if applicable) and description	Major change (Y or N)	Change type
Operation on a UNC Path	that describes replacing the portion of the path that matches DFSPathPrefix of the ReferralCache entry.		
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	59551 Changed the DFS path resolution - initial steps figure. Two decision boxes now read: "RootOrLink of Cache Entry indicates Root?"	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	59534 Changed the DFS path resolution - initial steps figure. Box pointed to by connection point 2 now reads: "Lookup UNC Path in Referral cache"	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60308 Updated ambiguous decision box rule in "DFS path resolution - connection 6".	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60310 Updated missing goto target for DFS root referral failure in "DFS path resolution - connection 6".	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60315 Updated missing qualifier on conditional branch box in DFS path resolution figure ("DFS path resolution - connection 8").	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60317 Updated non-actionable processing rule in DFS path resolution figure ("DFS path resolution - connection 8").	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60321 Updated processing for [I/O request, path fully resolved] when RootOrLink of ReferralCache entry indicates root targets.	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60329 Updated non-actionable processing rule in DFS Flow diagram in "DFS path resolution - connection 9".	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60330 Updated missing goto transition in DFS path resolution diagram in DFS Flow diagram in "DFS path resolution - connection 9".	N	Content updated.
3.1.4.1 User/Application Initiated I/O Operation on a UNC Path	60331 Updated missing goto transition out of decision box in DFS path diagram in DFS	N	Content updated.

Section	Tracking number (if applicable) and description	Major change (Y or N)	Change type
	Flow diagram in "DFS path resolution - connection 9".		
3.1.4.2 Sending a DFS Referral Request to the Server	57087 Added section.	N	New content added.
3.1.4.2 Sending a DFS Referral Request to the Server	58640 Added information about how the client handles STATUS_DFS_UNAVAILABLE error codes.	N	Content updated.
3.1.5.1 I/O Operation to Target Fails with STATUS_PATH_NOT_COVERED	58447 Clarified when the client must fail the original I/O request.	Y	Content updated.
3.1.5.2 I/O Operation to Target Fails with an Error Other Than STATUS_PATH_NOT_COVERED	58448 Clarified the description of I/O operation failure.	N	Content updated.
3.1.5.3 I/O Operation to a DFS Root Target or DFS Link Target Succeeds	58448 Clarified the use of the return value and added description of success codes.	N	Content updated.
3.1.5.4 Receiving a Referral Response	59834 Updated the description of DFS client retries with buffer size information.	N	Product behavior note updated.
3.1.5.4 Receiving a Referral Response	58318 Specified that the client MUST ignore the Padding field when receiving a referral response.	Y	Content updated.
3.1.5.4.2 Receiving a DC Referral Response	58860 Added procedure for determining number of entries in the returned list.	Y	Content updated.
3.1.5.4.3 Receiving a Root Referral Response or Link Referral Response	59841 Changed "MUST" to "SHOULD" in relation to when a successful root referral request is sent to a DC.	N	Content updated.
3.1.7 Other Local Events	58715 Revised text to note that when a client joins a domain the client updates its BootstrapDC.	Y	Content updated.
3.2.1.1 Algorithm for sorting target sites in referral response based on site location	57020 Moved subsection data from "Receiving a DFS Referral Request."	N	Content updated.
3.2.1.2	57020	N	Content

Section	Tracking number (if applicable) and description	Major change (Y or N)	Change type
Algorithm for sorting target sites in referral response based on site cost	Moved subsection data from "Receiving a DFS Referral Request".		updated.
3.2.4 Higher-Layer Triggered Events	57021 Removed the section contents leaving only the section title.	Y	Content updated.
3.2.4.1 Handling a Path Normalization Request	57021 Moved section from the "Message Processing Events and Sequencing Rules" section to the "Higher-Layer Triggered Events" section.	Y	Content updated.
3.2.4.1 Handling a Path Normalization Request	58739 Specified how a client resolves a path normalization request.	Y	Content updated.
3.2.5.1 Receiving a DFS Referral Request	58318 Specified that a server failed referral request can have padding bytes and provided a product behavior note on padding bytes.	Y	Content updated.
3.2.5.5 Receiving a Root Referral Request or Link Referral Request	57015 Updated relevant field list for DFS metadata.	N	Content updated.
3.2.5.5 Receiving a Root Referral Request or Link Referral Request	57020 Updated DFS referral procedures.	N	Content updated.
3.2.5.5 Receiving a Root Referral Request or Link Referral Request	58732 Removed text concerning padding from the "Size" field size setting.	Y	Content updated.
3.2.5.5 Receiving a Root Referral Request or Link Referral Request	58761 Changed "SHOULD" to "MUST" for DFS in-site referral mode target removal.	Y	Content updated.
3.2.5.5 Receiving a Root Referral Request or Link Referral Request	56723 Added information about the use of a DFS referral request path.	N	Content updated.
3.2.5.5 Receiving a Root Referral Request or Link Referral Request	58335 Updated the processing rules for the Size field with information on setting its value.	N	Content updated.
3.3.1 Abstract Data Model	58861 Clarified abstract data model and specified that the SelfFirst state MUST be maintained at the DFS server running on the DC.	Y	Content updated.
3.3.3 Initialization	58861 Added information about the SelfFirst	Y	Content updated.

Section	Tracking number (if applicable) and description	Major change (Y or N)	Change type
	state on the DC and a product behavior note.		
3.3.5.2 Receiving a Domain Referral Request	58771 Provided information on domains in other forests and added a product behavior note.	Y	Content updated.
3.3.5.2 Receiving a Domain Referral Request	58774 Add that NetBIOS and fully qualified domain names are returned for each referral entry the server MUST add.	Y	Content updated.
3.3.5.2 Receiving a Domain Referral Request	58785 Clarified that a server that supports DFS referral version 4 MUST return a DFS referral version 3 response and removed the related product behavior note.	Y	Content updated.
3.3.5.2 Receiving a Domain Referral Request	58773 Added that the NetBIOS and the local domain must be included when the server fills the response buffer.	Y	Content updated.
3.3.5.2 Receiving a Domain Referral Request	58335 Updated the processing rules for the Size field with information on setting its value.	N	Content updated.
3.3.5.3 Receiving a DC Referral Request	58860 Removed the statement that an implementation MUST use the value in the NumberOfExpandedNames field to determine how many names are present in the list at ExpandedNameOffset.	N	Content updated.
3.3.5.3 Receiving a DC Referral Request	57020 Updated references for new sections.	N	Content updated.
3.3.5.3 Receiving a DC Referral Request	58786 Updated DFS referral information with the required DFS referral version and a section reference.	N	Content updated.
3.3.5.3 Receiving a DC Referral Request	58789 Updated the processing rules regarding the targets sorting.	Y	Content updated.
3.3.5.3 Receiving a DC Referral Request	58861 Replaced "preferred logon is enabled" with "SelfFirst is enabled" and removed the associated product behavior note.	Y	Content updated.
3.3.5.3 Receiving a DC Referral Request	58335 Updated the processing rules of the Size field with information on setting its value.	N	Content updated.

Section	Tracking number (if applicable) and description	Major change (Y or N)	Change type
3.3.5.4 Receiving a sysvol Referral Request	58862 Clarified setting of Size field.	N	Content updated.
3.3.5.4 Receiving a sysvol Referral Request	58791 Changed reference from [MS-ADTS] to [MS-NRPC].	N	Content updated.
3.3.5.4 Receiving a sysvol Referral Request	57020 Updated the server procedure for sorting targets for when DFS referral site costing is enabled and disabled.	N	Content updated.
3.3.5.4 Receiving a sysvol Referral Request	58861 Replaced "preferred logon is enabled" with "SelfFirst is enabled" and removed the associated product behavior note.	Y	Content updated.
3.3.5.4 Receiving a sysvol Referral Request	58335 Updated processing rules for the Size field with information on setting its value.	N	Content updated.

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