

[MS-WSO]: Windows System Overview

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This document provides an overview of the Windows System Overview Protocol Family. It is intended for use in conjunction with the Microsoft Protocol Technical Documents, publicly available standard specifications, network programming art, and Microsoft Windows distributed systems concepts. It assumes that the reader is either familiar with the aforementioned material or has immediate access to it.

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Abstract

The Windows Protocols system includes the set of protocols that are part of the Microsoft Communications Protocol Program (MCP). This includes protocols implemented in a Microsoft Windows 2000 Professional, Windows XP, Windows Vista, or successor desktop operating system that are used to interoperate or communicate with a Microsoft Server operating system product. This document provides a system overview for protocols and systems described in the protocols technical documents (TDs), Protocol Family system documents (PFSDs), and Defined Tasks system documents (DTSDs) that are included in the MCP program. It provides a system overview of how these systems and protocols relate to each other.

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Contents

1 Introduction	8
1.1 Glossary	9
1.2 References	13
1.2.1 Normative References	13
1.2.2 Informative References	19
2 Overview	25
2.1 System Summary	25
2.2 Architectural Description Methodology	26
2.3 List of Windows Protocol Systems and Tasks	26
2.4 Relevant Standards	30
3 Foundation	31
3.1 Background Knowledge and System-Specific Concepts	31
3.1.1 Networking and Transport Concepts	31
3.1.1.1 Remote Procedure Calls	32
3.1.1.1.1 Remote Procedure Call Model	32
3.1.1.1.2 Programming Model	33
3.1.1.1.3 Distributed Systems Model	34
3.1.1.1.4 How RPC Works	36
3.1.1.1.5 Microsoft RPC Components	37
3.1.1.1.6 Microsoft RPC Security Model	37
3.1.1.2 RPC over HTTP Protocol	38
3.1.1.2.1 Protocol Stack	38
3.1.1.2.2 Logical Dependencies	39
3.1.1.3 Distributed Component Object Model	39
3.1.1.4 Named Pipes	39
3.1.1.5 Obsolete - HTTP Retry With Extension	40
3.1.1.5.1 Extension Overview	40
3.1.1.5.2 Message Syntax	40
3.1.1.5.2.1 Retry With Status Code 449	40
3.1.1.5.2.2 Ms-Echo-Request Header	41
3.1.1.5.2.3 Ms-Echo-Reply Header	41
3.1.1.5.3 Message Processing Events and Sequencing Rules	41
3.1.1.5.4 Example - 449 Response and Echo Reply	42
3.1.1.6 Secure End-to-End IP Communication	43
3.1.1.6.1 IPsec overview	43
3.1.1.6.2 Security Associations	44
3.1.1.6.3 Security Policy Database Structure	44
3.1.1.6.4 IPsec Policy Specification Formats	45
3.1.1.6.5 IPsec Encapsulations	45
3.1.1.6.6 IP Over HTTP Proxy Traversal	46
3.1.1.7 Windows Name Resolution	46
3.1.1.7.1 DNS client configuration	47
3.1.1.7.2 Invocation of Name Resolution Protocols in Windows	47
3.1.1.7.3 Effective DNS suffix search list	48
3.1.1.7.4 DNS Devolution	48
3.1.1.7.5 Prior to a DNS query	49
3.1.1.7.6 Name Resolution Policy Table (NRPT) processing and issuing DNS queries..	49
3.1.1.7.7 Returning DNS responses	50

3.1.1.7.8	DNS Dynamic Updates	50
3.1.2	Identity and Security Concepts	51
3.1.2.1	Identity	51
3.1.2.1.1	Security Principal	51
3.1.2.1.2	Accounts	51
3.1.2.1.2.1	User accounts	52
3.1.2.1.2.2	Computer Accounts.....	53
3.1.2.1.3	Security Identifiers (SIDs).....	53
3.1.2.1.4	Groups.....	55
3.1.2.1.4.1	Group Types	56
3.1.2.1.4.2	Group Scope	56
3.1.2.1.4.3	Nested Groups	57
3.1.2.1.5	Account Domains	58
3.1.2.1.5.1	Local Domains and Account Database	58
3.1.2.1.5.2	Remote Domains and Domain Controllers	59
3.1.2.1.5.3	Domain Membership	59
3.1.2.1.5.4	Effect on Accounts	60
3.1.2.1.6	Globally Unique Identifiers (GUIDs)	60
3.1.2.1.6.1	Uniqueness	60
3.1.2.1.6.2	Internal Structure.....	60
3.1.2.1.6.3	Quality of Random Bits.....	61
3.1.2.2	Authentication.....	62
3.1.2.2.1	GSS Authentication Model	63
3.1.2.2.2	History of the Windows Authentication Model.....	63
3.1.2.2.3	Authentication Protocols.....	63
3.1.2.2.3.1	Kerberos	64
3.1.2.2.3.2	NT LAN Manager (NTLM)	64
3.1.2.2.3.3	Secure Sockets Layer (SSL) and Transport Layer Security (TLS).....	64
3.1.2.2.3.4	Simple and Protected GSS-API Negotiation Mechanism (SPNEGO)	64
3.1.2.3	Authorization	65
3.1.2.3.1	Resource Managers	65
3.1.2.3.2	Security Descriptors	65
3.1.2.3.3	Discretionary Access Control Lists (DACLS) and Access Control Entries (ACEs)	65
3.1.2.3.4	Access Rights	68
3.1.2.3.5	Authorization	68
3.1.2.3.6	Inheritance.....	69
3.1.2.3.7	System Access Control Lists	69
3.1.2.3.8	Windows Integrity Mechanism.....	69
3.1.2.4	Impersonation and Delegation.....	70
3.1.2.4.1	RPC Impersonation.....	70
3.1.2.4.2	SMB Impersonation	71
3.1.2.4.3	Cloaking.....	72
3.1.2.4.4	Impersonation Tokens	73
3.1.2.4.4.1	GatherGroupMembershipForSystem	74
3.1.2.4.4.2	AddPrivilegesToToken	75
3.1.2.4.5	Impersonation Levels.....	75
3.1.2.4.6	Setting the Impersonation Level.....	76
3.1.2.4.7	Windows API Impersonation Functions	77
3.1.3	File, Print, and Fax Concepts.....	77
3.1.3.1	File Access Services and Print Services Commonalities	78
3.1.3.1.1	Remote File Systems	78
3.1.3.2	Network Printing and Internet Printing	80

3.1.3.3	Fax Services and Print Services Distinctions	80
3.1.4	Systems Management Concepts	81
3.1.4.1	Managed Host	81
3.1.4.2	Managed Object	81
3.1.4.3	Group Policy	81
3.1.5	Application Services Concepts	82
3.1.6	Web Services Concepts	82
3.1.7	Digital Rights Management and Rights Management Services	83
3.2	System Purposes	85
3.3	System Use Cases	86
3.3.1	Networking and Transport Protocols Use Cases	86
3.3.2	Identity and Security Protocols Use Cases	88
3.3.3	File, Print, and Fax Protocols Use Cases	90
3.3.4	Systems Management Protocols Use Cases	91
3.3.5	Application Services Use Cases	92
3.3.6	General Use Cases.....	94
4	System Context	97
4.1	System Environment	97
4.2	System Assumptions and Preconditions	98
4.3	System Relationships	100
4.3.1	Black Box Relationship Diagrams.....	100
4.3.1.1	Black Box Relationship for the File, Print, and Fax Protocols	100
4.3.1.2	Black Box Relationship for the Systems Management Protocols	101
4.3.2	System Dependencies	102
4.3.3	System Influences	102
4.4	System Applicability	103
4.5	System Versioning and Capability Negotiation	103
4.6	System Vendor-Extensible Fields	103
5	System Architecture	104
5.1	Abstract Data Model.....	104
5.2	White Box Relationships	104
5.2.1	File, Print, and Fax Protocols.....	104
5.2.1.1	Protocol Layering for File, Print, and Fax.....	106
5.2.2	System Management Protocols.....	107
5.2.2.1	The Windows Protocols System Management System	107
5.2.2.2	The EventLog system	109
6	System Details	111
6.1	Architectural Details.....	111
6.1.1	System Document Examples.....	111
6.1.1.1	Networking and Transports Protocols	111
6.1.1.2	Identity and Security Protocols.....	112
6.1.1.3	File, Print, and Fax Protocols	115
6.1.1.4	Systems Management Protocols	116
6.1.1.5	Application Services	117
6.1.1.6	General Protocols	119
6.2	Communication Details.....	121
6.3	Transport Requirements	123
6.4	Timers.....	124
6.5	Non-Timer Events	125
6.6	Initialization and Reinitialization Procedures	126

6.7	Status and Error Returns	127
7	Appendix A: Product Behavior	128
8	Appendix B: Protocols Affected by Group Policy	131
9	Appendix C: Standards and Other Specifications Implemented in Windows	134
9.1	Standards Implemented	134
9.2	Standards Extended	167
9.3	Other Specifications Implemented in Windows.....	169
10	Appendix D: ADM and ADMX Files.....	170
11	Appendix E: NTFS Alternate Streams.....	172
11.1	NTFS Streams	172
11.2	NTFS Attribute Types.....	172
11.3	NTFS Reserved File Names.....	173
11.4	NTFS Stream Names	174
11.5	NTFS Stream Types.....	175
11.6	Known Alternate Stream Names	175
11.6.1	Zone.Identifier Stream Name.....	175
11.6.2	Outlook Express Properties Stream Name.....	175
11.6.3	Document Properties Stream Name	175
11.6.4	Encryptable Thumbnails Stream Name	176
11.6.5	Internet Explorer Favicon Stream Name	176
11.6.6	Macintosh Supported Stream Names.....	176
11.6.7	XPRESS Stream Name	176
12	Change Tracking.....	177
13	Index	178

1 Introduction

Microsoft works with many other companies and industry initiatives to enable Microsoft products to interoperate with other networks and network services. Network protocols are developed and promoted by a variety of formal standards bodies, industry consortia, and individual companies worldwide. Microsoft actively participates and contributes to the standardization process in many standards bodies and develops implementations to make the Windows operating system interoperable with other products that implement these protocols.

Microsoft makes available specific client-server protocols that are implemented in Windows, together with whatever intellectual property rights it may have in those protocols, consistent with its obligations under the antitrust case settlement. Some of those protocols are documented and published on Microsoft websites such as the Microsoft Developer Network (MSDN), or through standards organizations or other third-party sources. Communications protocols are available for licensing through the Microsoft Communications Protocol Program (MCP) and other programs, and through a royalty-free implementation license.

This document provides a system overview for the protocols and systems described in the protocols technical documents (TDs), in the Protocol Family system documents (PFSDs), and in the Defined Tasks system documents (DTSDs) that are included in the MCP program. It provides a system overview of how these systems and protocols relate to one another.

This document is organized into the following sections:

- The Introduction (section 1) describes what is covered in this document, provides a list of terms defined in this document and pointers to terms used in this document but defined elsewhere in the documentation set, and provides a list of references that apply to the overall Windows Protocols System. Note that the term "domain" as used herein applies exclusively to **Active Directory Domain Services (AD DS)**.
- The [Overview \(section 2\)](#) introduces the Windows Protocols System. It provides a high-level map of how the systems and individual protocols in MCP relate to each other.
- [Foundation \(section 3\)](#) presents the background information that the reader would reasonably be required to know to understand and implement the diverse set of protocols that exist in the MCP document set. It includes concepts related to each of the categories of protocols, purposes of the Windows Protocols System, and a list of the use cases described in each System Document.
- [System Context \(section 4\)](#) describes the Windows environment for the MCP protocols and black box diagrams that depict the relationships of the protocol family systems with external components and the Windows environment.
- [System Architecture \(section 5\)](#) describes the white box relationships, including the protocol layering of the MCP protocols at the system level and the interrelationships among its components, consumers, and dependencies. It lists the abstract data model elements that are shared at the system level in each of the protocol family and tasks systems.
- [System Details \(section 6\)](#) lists the examples covered in the Architectural Details sections in the System Documents.
- [Appendix A: Product Behavior \(section 7\)](#) provides additional information for specific versions of Windows.
- [Appendix B: Protocols Affected by Group Policy \(section 8\)](#) lists the protocols impacted by group policy settings.

- [Appendix C: Standards and Other Specifications Implemented in Windows \(section 9\)](#) lists the standards implemented in Windows.
- [Appendix D: ADM and ADMX Files \(section 10\)](#) lists the **administrative template files** that shipped in Windows operating systems, categorized by the version of Windows in which they were shipped, and documents their availability on the download center.
- [Appendix E: NTFS Alternate Streams \(section 11\)](#) lists NTFS reserved attribute names, reserved file names found on a NTFS volume, and alternate data streams used by NTFS.

1.1 Glossary

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

Active Directory
application
application protocol
attribute
Authenticated IP (AuthIP)
authentication
authentication header (AH)
certificate
certification authority (CA)
certificate revocation lists (CRL)
certificate template
client
directory
directory object
directory service (DS)
Distributed File System (DFS)
domain
domain controller (DC)
Domain Name System (DNS)
Dynamic Host Configuration Protocol (DHCP)
endpoint
Encapsulating Security Payload (ESP)
Enroll/enrollment
extended mode (EM)
fully qualified domain name (FQDN)
Group Policy
GUID
health policy server
HTTP proxy
Hypertext Transfer Protocol (HTTP)
Hypertext Transfer Protocol over Secure Sockets Layer (HTTPS)
impersonation
information level
Internet Key Exchange (IKE)
Internet Protocol security (IPsec)
Internet Protocol version 4 (IPv4)
Internet Protocol version 6 (IPv6)
Kerberos
Lightweight Directory Access Protocol (LDAP)

main mode (MM)
main mode security association (MM SA)
metafile
named pipe
NetBIOS
Network Access Protection (NAP)
Network Access Protection (NAP) client
Network Data Representation (NDR)
player
policy
print client
printer driver
print job
print queue
print server
protocol data unit (PDU)
quick mode security association (QM SA)
relative identifier (RID)
Remote Desktop Protocol (RDP)
remote procedure call (RPC)
schema object
security account manager (SAM) built-in database
security association (SA)
security identifier (SID)
security policy database (SPD)
security protocol
server
Server Message Block (SMB)
shell
smart card
SOAP
statement of health (SoH)
statement of health response (SoHR)
system health validator (SHV)
terminal server
Terminal Services
transaction
transaction manager
Transport Layer Security (TLS)
trust
tunnel
Universal Naming Convention (UNC)

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

Collaboration Client
ILS Server

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

game session

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

**participant
resource
resource manager (RM)**

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

**fax job
fax queue**

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

**file server
SMB Access Protocols**

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

negotiation filter association (NFA)

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

Name Resolution Policy Table (NRPT)

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

integrity level

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

DirectPlay System

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

**message
outgoing queue
queue
queue manager**

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

**asynchronous messaging
network address**

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

content

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

hosted cache

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

print spooler

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

Multipoint Communication Service (MCS)

The following terms are defined in [\[MS-RDPCR2\]](#):

desktop

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

dynamic virtual channel, virtual channel Remote Desktop Protocol (RDP) client

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

Static Virtual Channel

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

license

The following terms are defined in [\[MS-SMB2\]](#):

Local object store

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

Internet Locator Service (ILS)

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

clipboard redirection firewall

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

downstream server (DSS) update upstream server (USS)

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

client computer metadata target group

The following terms are defined in [\[RFC2753\]](#):

policy enforcement point (PEP) Policy Decision Point (PDP)

The following terms are defined in [\[RFC4301\]](#):

Security Parameter Index (SPI)

The following terms are specific to this document:

Administrative template files: Administrative template files define registry-based policy settings and property pages that the Group Policy Object Editor displays. These files take two forms, namely flat text files known as ADM files and XML-based files known as ADMX files.

BranchCache™: A Content Caching and Retrieval feature, which enables content from file and web servers on a wide area network (WAN) to be cached on computers at a local branch office. Available in 2 modes: Hosted Cache and Distributed Cache.

Hosted Cache: A centralized cache composed of blocks of data added by peers.

Distributed Cache: A cache composed of blocks of data hosted on multiple peers acting in cooperation.

MAY, SHOULD, MUST, SHOULD NOT, MUST NOT: These terms (in all caps) are used as described in [\[RFC2119\]](#). Note that in [\[RFC2119\]](#) terms, most of these specifications should be imperative, to ensure interoperability. All statements of optional behavior use either MAY, SHOULD, or SHOULD NOT.

Any specification that does not explicitly use one of these terms is mandatory, exactly as if it used MUST.

1.2 References

References to Microsoft Open Specifications documentation do not include a publishing year because links are to the latest version of the documents, which are updated frequently. References to other documents include a publishing year when one is available.

The following references provide useful content that covers aspects of the Windows Security Model in greater depth:

- Brown, Keith, "Programming Windows Security", Addison-Wesley Professional, 2000, ISBN 0201604426.
- Howard, Michael and LeBlanc, David, "Writing Secure Code", Microsoft Press, 2002, ISBN 0735617228.
- Russinovich, Mark E. and Solomon, David A., "Microsoft Windows Internals, 4th ed.", Microsoft Press, 2005, ISBN 0735619174.

To provide background on security requirements, the National Computer Security Center, part of the United States Department of Defense (DoD), published the Trusted Computer System Evaluation Criteria as DoD 5200.28-STD. This has been supplanted by profiles written to the Common Criteria.

The Common Criteria is an ISO standard (ISO/IEC 15408) formal method of specifying requirements for security computer systems. Microsoft Windows uses profiles published by the DoD through the National Information Assurance Partnership (NIAP) program. For more information about NIAP, including the profiles themselves, see "Introducing NIAP" [\[NIAP\]](#) by The National Security Agency.

Microsoft websites (see Microsoft Corporation [\[MSFT\]](#)) contain a number of articles about security in Windows. Developer documentation on the MSDN home page [\[MSDN\]](#) by Microsoft also contains more in-depth information.

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.

[C706] The Open Group, "DCE 1.1: Remote Procedure Call", C706, August 1997, <http://www.opengroup.org/public/pubs/catalog/c706.htm>

[FIPS140] FIPS PUBS, "Security Requirements for Cryptographic Modules", FIPS PUB 140, December 2002, <http://csrc.nist.gov/publications/fips/fips140-2/fips1402.pdf>

[MC-DPLNAT] Microsoft Corporation, "[DirectPlay 8 Protocol: NAT Locator](#)".

[MC-NMF] Microsoft Corporation, "[.NET Message Framing Protocol](#)".

[MS-ADCAP] Microsoft Corporation, "[Active Directory Web Services: Custom Action Protocol](#)".

[MS-ADDM] Microsoft Corporation, "[Active Directory Web Services: Data Model and Common Elements](#)".

[MS-ADSO] Microsoft Corporation, "[Active Directory System Overview](#)".

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

[MS-APDS] Microsoft Corporation, "[Authentication Protocol Domain Support](#)".

[MS-AUTHSO] Microsoft Corporation, "[Windows Authentication Services System Overview](#)".

[MS-BPAU] Microsoft Corporation, "[Background Intelligent Transfer Service \(BITS\) Peer-Caching: Peer Authentication Protocol](#)".

[MS-BPDP] Microsoft Corporation, "[Background Intelligent Transfer Service \(BITS\) Peer-Caching: Peer Discovery Protocol](#)".

[MS-BRWS] Microsoft Corporation, "[Common Internet File System \(CIFS\) Browser Protocol](#)".

[MS-CAESO] Microsoft Corporation, "[Certificate Autoenrollment System Overview](#)".

[MS-CASO] Microsoft Corporation, "[Certification Authority System Overview](#)".

[MS-CER] Microsoft Corporation, "[Corporate Error Reporting Version 1.0 Protocol](#)".

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

[MS-COM] Microsoft Corporation, "[Component Object Model Plus \(COM+\) Protocol](#)".

[MS-CSRA] Microsoft Corporation, "[Certificate Services Remote Administration Protocol](#)".

[MS-CSSO] Microsoft Corporation, "[Collaboration Services System Overview](#)".

[MS-DCOM] Microsoft Corporation, "[Distributed Component Object Model \(DCOM\) Remote Protocol](#)".

[MS-DFSC] Microsoft Corporation, "[Distributed File System \(DFS\): Referral Protocol](#)".

[MS-DISO] Microsoft Corporation, "[Domain Interactions System Overview](#)".

[MS-DLTW] Microsoft Corporation, "[Distributed Link Tracking: Workstation Protocol](#)".

[MS-DPDX] Microsoft Corporation, "[DirectPlay DXDiag Usage Protocol](#)".

[MS-DPWSSN] Microsoft Corporation, "[Devices Profile for Web Services \(DPWS\): Size Negotiation Extension](#)".

[MS-DRM] Microsoft Corporation, "[Digital Rights Management License Protocol](#)".

[MS-DSML] Microsoft Corporation, "[Directory Services Markup Language \(DSML\) 2.0 Protocol Extensions](#)".

[MS-DRSR] Microsoft Corporation, "[Directory Replication Service \(DRS\) Remote Protocol](#)".

[MS-DTCO] Microsoft Corporation, "[MSDTC Connection Manager: OleTx Transaction Protocol](#)".

[MS-DTYP] Microsoft Corporation, "[Windows Data Types](#)".

[MS-EMFPLUS] Microsoft Corporation, "[Enhanced Metafile Format Plus Extensions](#)".

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

[MS-EVEN] Microsoft Corporation, "[EventLog Remoting Protocol](#)".

[MS-EVEN6] Microsoft Corporation, "[EventLog Remoting Protocol Version 6.0](#)".

[MS-FASP] Microsoft Corporation, "[Firewall and Advanced Security Protocol](#)".

[MS-FAX] Microsoft Corporation, "[Fax Server and Client Remote Protocol](#)".

[MS-FSCC] Microsoft Corporation, "[File System Control Codes](#)".

[MS-FSRM] Microsoft Corporation, "[File Server Resource Manager Protocol](#)".

[MS-FSSO] Microsoft Corporation, "[File Access Services System Overview](#)".

[MS-GPSO] Microsoft Corporation, "[Group Policy System Overview](#)".

[MS-HCEP] Microsoft Corporation, "[Health Certificate Enrollment Protocol](#)".

[MS-ICPR] Microsoft Corporation, "[ICertPassage Remote Protocol](#)".

[MS-IMSA] Microsoft Corporation, "[Internet Information Services \(IIS\) IMSAdminBaseW Remote Protocol](#)".

[MS-IPHTTPS] Microsoft Corporation, "[IP over HTTPS \(IP-HTTPS\) Tunneling Protocol](#)".

[MS-IRP] Microsoft Corporation, "[Internet Information Services \(IIS\) Inetinfo Remote Protocol](#)".

[MS-KILE] Microsoft Corporation, "[Kerberos Protocol Extensions](#)".

[MS-LLTD] Microsoft Corporation, "[Link Layer Topology Discovery \(LLTD\) Protocol](#)".

[MS-LWSSP] Microsoft Corporation, "[Lightweight Web Services Security Profile](#)".

[MS-MGSO] Microsoft Corporation, "[Multiplayer Games System Overview](#)".

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2 Overview

This section provides an overview of the protocol families, defined tasks, and individual protocols that make up the Windows Protocols System.

2.1 System Summary

Protocols of the Windows Protocols System are part of the Microsoft Communications Protocol Program (MCP), which includes protocols implemented in a Windows 2000 Professional operating system, Windows XP operating system, Windows Vista operating system, or Windows 7 operating system, and are used to operate or communicate with a Microsoft server-side operating system product.

Microsoft client-server communications uses both industry-standard protocols and protocols licensed under the MCP program. Protocols included in the MCP program are either an extension of an industry standard protocol (such as the Kerberos Interactive Logon Protocol Extensions) or a Microsoft protocol. Most MCP protocols are extensions to industry-standard protocols.

In cases where the MCP protocol is an extension of an industry standard protocol, the MCP documentation describes the nature and intent of the extension. In general, it does not describe the portion of the protocol that is already defined in the standards documentation. For Microsoft protocols, the MCP documentation defines the complete protocol.

The MCP program licenses protocols for the following MCP licensing tasks:

- Authentication Services Server
- Certificate Services Server
- Collaboration Server
- Digital Rights Management Server
- File Server
- General Server
- Health Certificate Server
- Media Streaming Server
- Multiplayer Games Server
- Print/Fax Server
- Proxy/Firewall/NAT Server
- Rights Management Server
- Systems Management Server
- Terminal Server
- Virtual Private Network Server
- Web Server
- Windows Update Services Server

For the most up-to-date list of MCPP tasks and associated protocols, please refer to the MCPP website at <http://www.microsoft.com/about/legal/intellectualproperty/protocols/mcpp.msp>. Microsoft updates this website regularly to include updated and new MCPP protocols as detailed in the MCPP license agreement.

2.2 Architectural Description Methodology

The purpose of the Microsoft Protocol Family System Documents and the Technical Documents (Protocol Specifications) is to enable interoperability with Windows **client** operating systems and selected Windows **server** scenarios.

The documentation of the overall architecture of a System is an important aid to the reader's understanding of the intent and design of the System. There is a considerable body of literature regarding the documentation of software architectures. Although there is significant overlap among the various methods, there are also significant differences. A reader of the Microsoft Protocol Family System Documents (PFSD) would benefit from being familiar with at least one other approach. See [\[UML\]](#), [\[SEIClements\]](#), and [\[Rozanski2005\]](#) for recommended reading.

The Microsoft Protocol Family System Documents make use of UML. In UML terms, the design, use case, state machine, activity, and interaction views are used in various places.

See [\[UML\]](#) chapter 3 for information about these views and diagrams. Note, though, that UML is a tool for describing architectures; it is not a methodology.

See [\[Rozanski2005\]](#) and [\[SEIClements\]](#) for descriptions of methodologies that can make use of UML.

Also see [\[RUP\]](#), [\[xADL\]](#), [\[IEEE1471\]](#), [\[ISO/IEC-10746\]](#), [\[Kruchten1996\]](#), and [\[Matevska-Meyer2004\]](#) for more suggestions about the documentation of software architectures.

2.3 List of Windows Protocol Systems and Tasks

This section summarizes the protocol family systems and defined tasks systems that are part of the overall Windows Protocols System.

The Active Directory System (see [\[MS-ADSO\]](#)) is a distributed **directory service (DS)** based on the industry-standard LDAP protocol (except for the differences noted in [\[MS-ADTS\]](#) section 3.1.1.3). This directory service stores and organizes **directory objects** in a hierarchical data store. Each directory object is a collection of attributes, each of which contains one or more values.

The **Active Directory** System provides the foundation for **authentication** services and identity management in a **domain** environment. A directory service contains one or more servers, known as directory servers, in which the directory objects can be created, queried for, modified, and deleted. The directory servers replicate the directory objects so that the changes made to a given object on one server are visible on other servers in the directory service. Note that throughout this document, the term "domain" refers exclusively to a domain in the context of Active Directory Domain Services (AD DS).

The Authentication Services System (see [\[MS-AUTHSO\]](#)) includes several authentication tasks between client and server computers and domain controllers. It contains the components necessary for authentication for several specific tasks of interactive logon, HTTP web access, file system services, and remote operations. Authentication is the action of proving identity to a network service or a resource provider. Authentication plays a central role in Windows as a basis for proof of identity and for the ability to control access through authorization. The authentication process can use services provided by clients, servers, and domain controllers. The servers and domain controllers work in conjunction in order to provide management of accounts; the client provides services to manage the credentials to be used to prove identity to the server computer. Domain controllers

provide **directory** services, specifically Active Directory, which is the default Windows technology for storing identity information.

The Certificate Autoenrollment System (see [\[MS-CAESO\]](#)) includes one task for automatically enrolling and renewing digital certificates. System administrators usually perform this task manually. Autoenrollment automatically handles certificate enrollment and the re-enrollment of expired certificates. Microsoft networks and protocols often require the use of digital certificates for encryption and authentication. The implementation of the Computer Certificate Autoenrollment Task enables a system to enroll and re-enroll certificates automatically. Autoenrollment handles all of the details for enrollment and re-enrollment of certificates. Autoenrollment serves a central role in client and server relationships that rely on certificate enrollment. Autoenrollment determines what policies are available for certificate enrollment, the set of certificates specified through these policies, and what certificates can be issued based on the templates in these policies.

The Certification Authority System (see [\[MS-CASO\]](#)) uses public key cryptography to issue certificates that can be used for a variety of purposes, including for encryption and authentication. A **certification authority (CA)** issues certificates and confirms to other entities that the certificate is valid. Certificates from the CA can be issued to people, computers, and applications. Certificate holders can use the private key to digitally encrypt data, to digitally sign documents, and to identify themselves. A public key infrastructure (PKI) supports public key cryptography within and between organizations. A PKI consists of digital certificates, key pairs, CAs, and other registration authorities. A certificate is a digital statement issued by a CA which vouches for the identity of the certificate holder. It binds a public key and a collection of **attributes** to the certificate holder. The certificate can be freely shared with other entities.

The Collaboration Services System (see [\[MS-CSSO\]](#)) includes two sets of logical procedures (defined tasks) that are necessary for collaboration clients to locate each other on a network using the directory facilities provided by an ILS server. The software used for collaboration includes applications such as application sharing, email, whiteboarding, sharing a calendar, instant messaging, text chat, and remote desktop. Microsoft NetMeeting is an example of the Microsoft implementation of collaboration software. One of the common tasks used in collaboration applications includes methods that allow clients to locate each other. One of the solutions is to register the location of the clients in a central store so that other collaboration clients can find them. The Collaboration Services System tasks use the Telephony API Internet Locator Service Data block protocol specified in [\[MS-TAIL\]](#) as the key protocol for communications with the central store.

The Content Caching and Retrieval System (see [\[MS-CCRSO\]](#)) supports content retrieval scenarios such as accessing content from a file or web server. The File Access Services System includes the protocols that enable network file access and sharing in Windows operating environments. This system describes the additional protocols, data structures, and mechanisms, such as security, that are required to enable a system of content caching and retrieval to interoperate with Windows systems. If for any reason the content caching and retrieval of data is unavailable or fails, normal file access continues without caching.

The Domain Interactions System (see [\[MS-DISO\]](#)) includes the Windows protocols that are used together to maintain a relationship with the domain. These include protocols that are used to communicate with a domain controller and maintain state, protocols that are used to augment authentication and authorization actions, and protocols that are used to interact with domain controllers. Windows networks are often configured with a domain controller that provides the centralized storage of accounts and the administration of many machines. Many network related operations depend on domains in order to complete various tasks. The Domain Interactions System describes some of these tasks, which include:

- Locating a domain controller using DNS and NetBIOS.
- Joining a domain using a predefined account.

- Joining a domain by creating an account via the **security account manager (SAM)** RPC interface.
- Joining a domain by creating an account via the **Lightweight Directory Access Protocol (LDAP)**.
- Removing a domain member.

The File Access Services System (see [\[MS-FSSO\]](#)) includes the protocols that enable network file access and sharing in Windows operating environments. File Access Services allow a client computer to discover, access, and share files that are hosted on, and made available by, a server computer. Most businesses and many personal computing environments have a requirement for file hierarchies stored in a file system (**object store**) on one computer to be accessed and manipulated by applications on other computers. This scenario is typically referred to as file sharing or remote file access. A key goal is to ensure application compatibility by providing broadly the same semantics to clients as if the shared object store were local to them. This compatibility would not be provided by sharing the files through a protocol with more limited semantics, such as FTP or HTTP. The File Access Services System addresses the need for ensured compatibility.

The Group Policy System (see [\[MS-GPSO\]](#)) enables a **Group Policy** client to retrieve policy settings from a Group Policy server and it enables administrative tools to retrieve, create, **update**, and delete policy settings. Group Policy enables administrators to define and manage desired computer configurations or policy settings for a large number of users and computers within an Active Directory environment. Administrators can define policy settings once and rely on Windows to enforce that policy.

The Message Queuing System (see [\[MS-MQSO\]](#)) is a communications service that enables reliable and secure asynchronous messaging between applications over a variety of deployment topologies. The Message Queuing System temporarily decouples the act of sending a **message** from the act of receiving the message, which allows the applications to communicate even if their execution lifetimes do not overlap. Applications send messages to a queue and/or receive messages from a queue. The queue provides persistence of the messages, which enables them to survive across application restarts. This abstraction enables an application to send messages even if the receiving application is not executing or is unreachable due to a network outage.

The Media Streaming Server (MSS) System (see [\[MS-MSSO\]](#)) enables the creation, distribution, and playback of audio and video **content**. It enables administrators and content providers to create media solutions for various uses such as corporate communications, training and education, e-commerce, and commercial broadcast. The main physical components of MSS include a computer running a media encoder, a server running as a media server, and several client computers running media play clients. The encoder converts both live and prerecorded audio and video content to a media format, the server distributes the content over a network or the Internet, and the media player receives the content. In order to scale to and meet network demands, the system can also include cache and proxy servers, as well as distribution servers. For e-commerce scenarios, MSS enables scenarios ranging from live broadcast playback to on-demand playback and may require the support of Digital Rights Management components to provide the administrator with the ability to securely encrypt content that is being broadcast and downloaded.

The Multiplayer Games System (see [\[MS-MGSO\]](#)) is designed to transport game and user data to support multiplayer gaming scenarios. The protocols in this system provide game session management, as well as functionality for controlling options for sending data and voice. Control options for data include reliability, guaranteeing data delivery sequencing, and coalescence of packets. The DirectPlay System also provides functions for using network address translation (NAT).

The Network Policy and Access Services System (see [\[MS-NAPSO\]](#)) includes a variety of tasks that allow for the communication of information related to the health of a system, evaluation of health information, restricted network access, and correction of health state, and includes the following:

- **Network Address Protection (NAP) clients** collect and communicate their health status information to NAP health policy servers.
- NAP health policy servers determine the overall health compliance and the prescribed actions and remediation measures that a NAP client must take if it is found to be noncompliant with policy so that it can become compliant.
- NAP health policy servers collect and communicate prescribed actions and remediation measures to NAP clients.
- NAP health policy servers communicate network access restrictions to policy enforcement points for noncompliant NAP clients.
- NAP clients receive prescribed actions and remediation measures and correct their system health.

NAP is a distributed system of cooperating clients and servers, which collectively ensures that individual hosts and the corporate network as a whole are healthy. "Healthy" means that the systems have the updates and software installed and that they are configured in the manner prescribed by system health policies. The goal of the NAP System is to ensure that individual hosts and the IT infrastructure as a whole are robust and resistant to attacks and malware outbreaks.

The Print Services System (see [\[MS-PSSO\]](#)) provides functionality for managing a distributed print infrastructure of print clients, **print jobs**, and shared printers. One or more printers are shared among multiple print clients using a print server. Printers are represented as print queues that are located on print servers. A print client has one or more connections to print queues that are shared by one or more print servers, which comprise a simple hub-spoke server-client model. The Print Services System enables a large number of users to print to a small number of printers, enables an administrator to enforce which printers can be used by each user and when they can be used, and automates the process of installing and updating necessary **printer drivers** on numerous computers that send jobs to remote printers. The Print Services System can be deployed within a domain-based network, or in a home or workgroup environment. For Windows implementations, each print client can also act as a print server and share locally connected printers with other print clients.

The Rights Management Services (RMS) System (see [\[MS-RMSO\]](#)) provides protection of information through persistent usage policies. This enables usage rights to be enforced, such as by restricting copying, printing, or forwarding, after the information is accessed by an authorized recipient. RMS enables the enforcement of the corporate policy that governs the control and dissemination of confidential or proprietary information. Rights management allows individuals and administrators to encrypt and specify access permissions to various types of data, including documents and email messages. This helps to prevent sensitive information from being accessed and used by unauthorized people. After the permissions to content have been restricted by using rights management, the access and usage restrictions are enforced regardless of the location of the information, because the permissions are stored in the content itself.

The Transaction Processing Services System (see [\[MS-TPSO\]](#)) provides transaction processing services for systems that require transactions to be coordinated in a distributed system. Transaction processing is designed to maintain a computation system in a known, consistent state. It allows multiple individual operations to be linked together as a single, indivisible operation, known as an atomic transaction. Broadly speaking, **transaction** processing involves updating data, which may be distributed across multiple systems, so that either all of the changes happen or none of the changes happen. Resources may include data, such as rows in a database, or logical entities, such as the

execution state of a program. Resources that are changed by a transaction may be in separate systems.

The Terminal Services System (see [\[MS-TSSO\]](#)) provides functionality to securely connect remote clients and servers, to channel communication between components of remote clients and servers, and to manage servers. The Terminal Services System implements the **Remote Desktop Protocol (RDP)**, which is a multichannel protocol that allows users of a remote client to connect to a server over a network. This multichannel capability enables the use of separate channels, called virtual channels, to carry different types of data, which includes presentation data, highly encrypted data (such as keyboard and mouse user input), device communication, and licensing information.

The Windows Management Services (WMS) System (see [\[MS-WMSO\]](#)) provides an infrastructure that enables a user or application to remotely inspect, modify, and monitor an asset's resources. In WMS, resources are represented as objects, according to the Common Information Model (CIM), and it provides multiple network protocols for accessing resources. The protocols vary in their capabilities.

The Windows Server Update Services System (see [\[MS-WSUSO\]](#)) enables software update discovery by computers, the delivery of relevant updates to computers, update distribution controls for administrators, and the monitoring of software update activity between an update client and update server. A software update can be an update to an application or distribution of an application or driver for a hardware device. The Windows Server Update client is capable of detecting software updates that are applicable from the available set of updates on the server, of installing such updates, and of reporting installation activity back to the server. This system requires communication between the Windows Server Update Services client and server to enable clients to discover software updates that are available on the server. In addition, it also requires communication between servers to propagate software update information, the updates, and administrative intent in a hierarchical deployment of the system.

2.4 Relevant Standards

The Windows Protocols System implements and extends upon many standards. [Appendix C: Standards and Other Specifications Implemented in Windows \(section 9\)](#), provides a list with descriptions of all of the standards used or extended upon in Windows.

3 Foundation

This section describes the theoretical and practical information that is required to understand this document and this system.

3.1 Background Knowledge and System-Specific Concepts

This section summarizes:

- The background knowledge required to understand this document.
- The concepts that are specific to this system.

The Windows Protocols System documentation assumes that the reader has knowledge of publicly available standard specifications, network programming art, and Windows distributed systems concepts, such as:

- HTTP
- SOAP
- TCP/IP

Foundational knowledge of the following concepts, presented later in this section, is also assumed:

- Authentication and authorization
- Domain services
- Named pipes
- Remote procedure calls (RPC)

3.1.1 Networking and Transport Concepts

Microsoft provides a number of protocols at different layers of the OSI Networking Model. The following figure shows where the Microsoft networking protocols fit into this model.

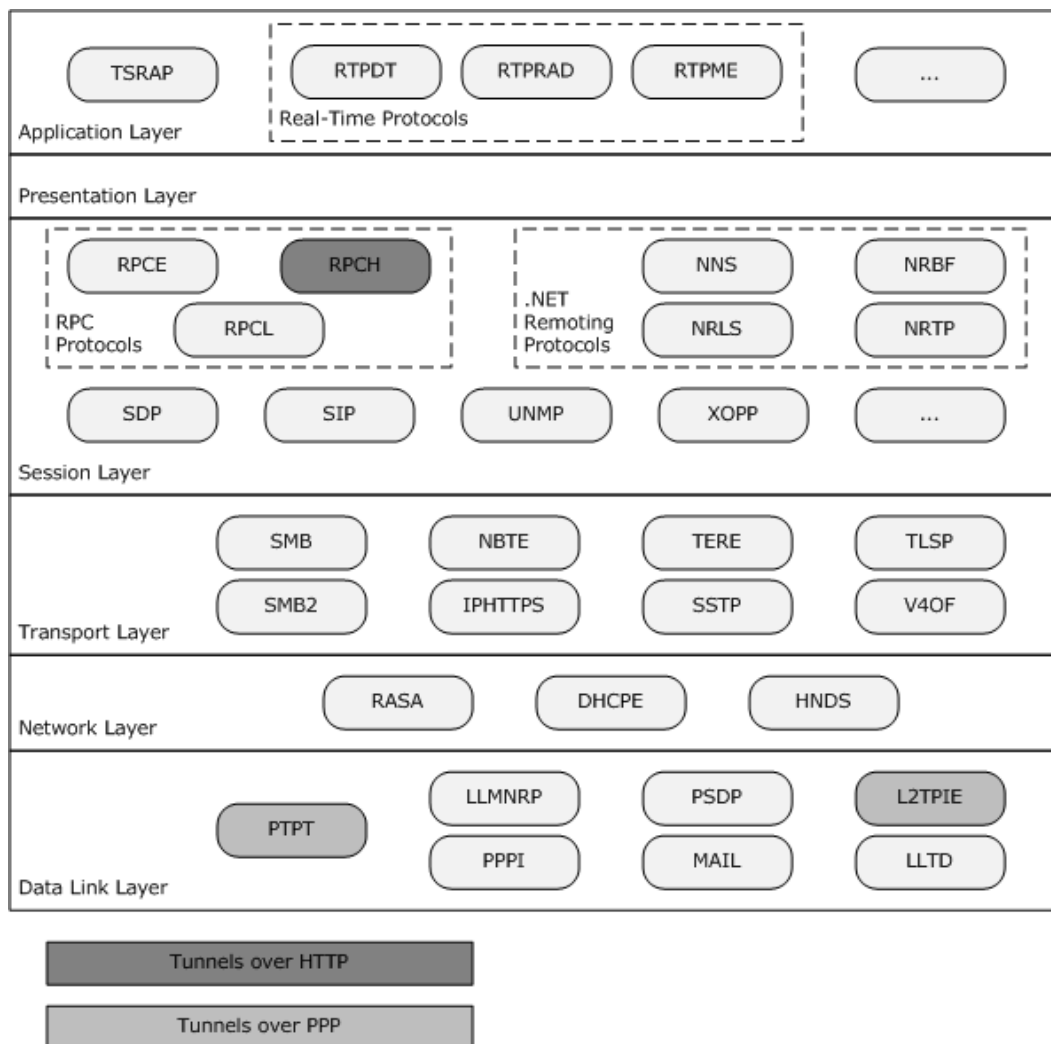


Figure 1: Microsoft networking protocols and the OSI Networking Model.

3.1.1.1 Remote Procedure Calls

This section provides an overview of remote procedure calls and how they are implemented in Windows.

3.1.1.1.1 Remote Procedure Call Model

A **remote procedure call (RPC)** is a secure inter-process communication (IPC) mechanism that enables data exchange and the invocation of functionality that resides in a different process. The different process can be on the same machine, on the local area network, or across the Internet. This section explains the RPC programming model and the model for distributed systems that can be implemented by using RPC.

RPC supports 64-bit editions of Windows. In Windows XP operating system, there are three types of processes: native 32-bit processes, native 64-bit processes, and 32-bit processes running under the 32-bit process emulator on a 64-bit system (often referred to as WOW6432 processes). RPC allows

developers to transparently communicate between different types of processes and it automatically manages process differences behind the scenes.

RPC was initially developed as an extension to Open Software Foundation (OSF) RPC (later it became the distributed Computer Environment also known as DCE RPC, as described in [\[C7061\]](#)). With the exception of some of its advanced features, the Microsoft implementation of RPC is interoperable with other vendors' implementations of OSF /DCE RPC.

This section also provides an overview of the RPC components and their operation. The information is presented in the following topics:

- Programming Model
- Distributed Systems Model
- How RPC Works
- Microsoft RPC Components
- Microsoft RPC Security Model

3.1.1.1.2 Programming Model

In the early days of computer programming, each program was written as a large monolithic chunk that was filled with goto statements. Each program had to manage its own input and output to different hardware devices. As the programming discipline matured, this monolithic code was organized into procedures, and the most commonly used procedures were packaged in libraries for sharing and reuse.

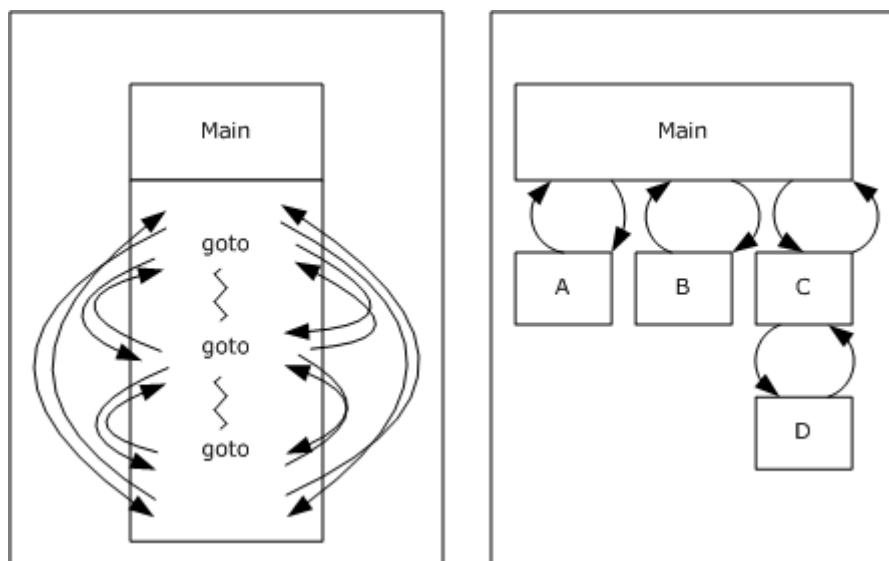


Figure 2: Monolithic vs. procedural implementation model.

In procedure-oriented programming languages, such as C, the main procedure relates to all other procedures as black boxes. For example, the main procedure cannot find out how procedures A, B, and X do their work. The main procedure only calls another procedure; it has no information about how that procedure is implemented.

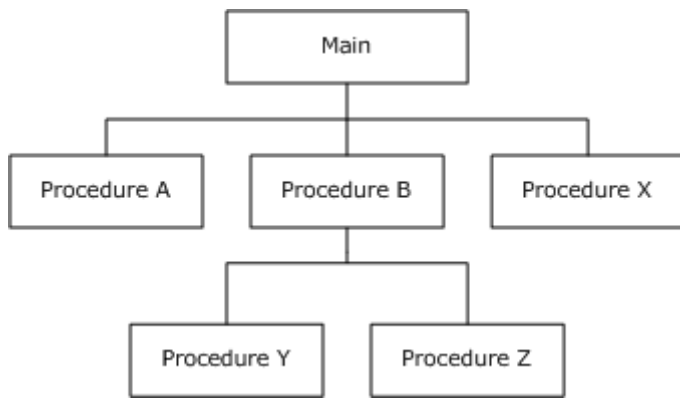


Figure 3: Procedure-oriented code implementation model.

Procedure-oriented programming languages provide simple mechanisms for specifying and writing procedures. For example, the ISO-standard C-function prototype is a construct that is used to specify the name of a procedure, the type of the result that it returns (if any), and the number, sequence, and type of its parameters. Using the function prototype is a formal way to specify an interface between procedures.

Microsoft RPC builds on this programming model by allowing procedures that are grouped together in interfaces to reside in different processes than the caller. Microsoft RPC also adds a more formal approach to procedure definition which allows the caller and the called procedure to adopt a contract for remotely exchanging data and invoking functionality. In the Microsoft RPC programming model, traditional function calls are supplemented with two additional elements:

- An .idl/.acf file that precisely describes the data exchange and parameter-passing mechanism between the caller and a called procedure.
- A set of runtime APIs that provide developers with granular control of the remote procedure call, which includes security aspects, managing state on the server, specifying which clients can communicate with the server, and so on.

3.1.1.1.3 Distributed Systems Model

Historically, having software run across multiple computers meant splitting the software into separate client and server components. In such systems, the client component handled the user interface and the server provided back-end processing, such as database access, printing, and so on.

As computers proliferated, dropped in cost, and became connected by ever higher bandwidth networks, splitting software systems into multiple components became more convenient, with each component running on a different computer and performing a specialized function. This approach simplified development, management, and administration, and often improved performance and robustness because failure in one computer did not necessarily disable the entire system.

In many cases, the system appeared to the client as an opaque cloud that performed the necessary operations, even though the distributed system was composed of individual nodes, as illustrated in the following figure.

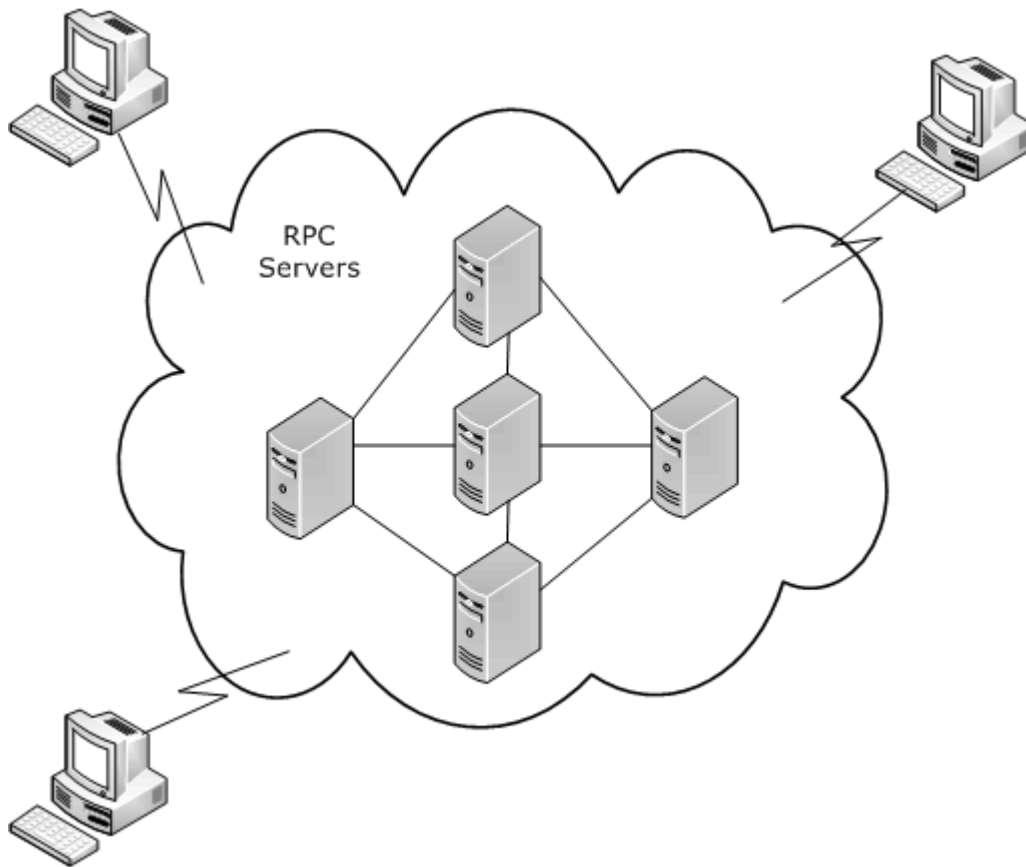


Figure 4: Distributed system paradigm.

The opacity of the cloud was maintained because computing operations were invoked on behalf of the client. As such, clients could locate a computer (a *node*) within the cloud and request a particular operation; in performing the operation, that computer could invoke functionality on other computers within the cloud without exposing the additional steps, or the computer on which they were carried out, to the client.

Using this paradigm, the mechanics of a distributed, cloud-like system can be broken down into many individual packet exchanges, or conversations between individual nodes.

Traditional client/server systems have two nodes with fixed roles and responsibilities. Modern distributed systems can have more than two nodes, and their roles are often dynamic. In one conversation, a node can be a client; while in another conversation, the node can be the server. In many cases, the ultimate consumer of the exposed functionality is a client with a user sitting at a keyboard and watching the output. In other cases, the distributed system functions unattended, while performing background operations.

The distributed system may not have dedicated clients and servers for each particular packet exchange, but it is important to remember that there is a caller (or initiator), often referred to as the client. There is also the recipient of the call (often referred to as the server). It is not necessary to have two-way packet exchanges in the request-reply format of a distributed system; often messages are sent only one way.

3.1.1.1.4 How RPC Works

The RPC tools make it appear to users that a client directly calls a procedure that is located in a remote server program. The client and server each have their own address spaces; that is, each has its own memory resource allocated to data that is used by the procedure. The following figure illustrates the RPC architecture.

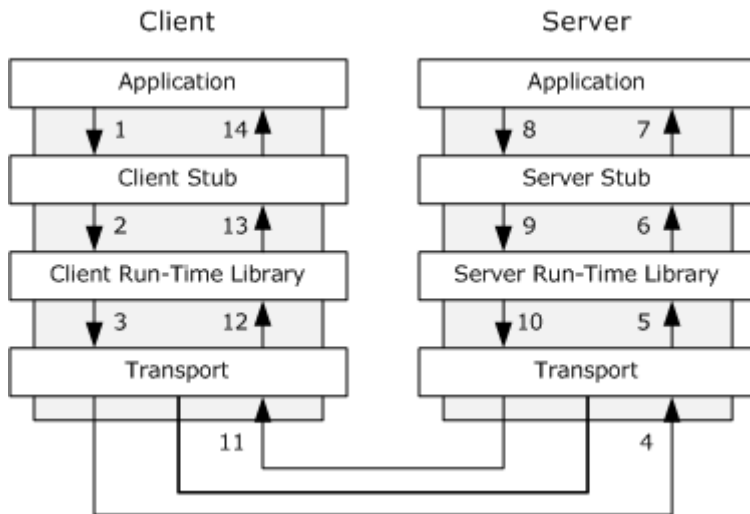


Figure 5: RPC architectural implementation model

As the illustration shows, the client application calls a local stub procedure instead of the actual code that implements the procedure. Stubs are compiled and linked with the client application. Instead of containing the actual code that implements the remote procedure, the client stub code:

- Retrieves the required parameters from the client address space.
- Translates the parameters, as needed, into a **Network Data Representation (NDR)** format for transmission over the network.
- Calls functions in the RPC client run-time library to send the request and its parameters to the server.

The server performs the following steps to call the remote procedure:

- The server RPC run-time library functions accept the request and call the server stub procedure.
- The server stub retrieves the parameters from the network buffer and converts them from the network transmission format to the format required by the server.
- The server stub calls the actual procedure on the server.

The remote procedure runs, possibly generating output parameters and a return value. When the remote procedure is complete, a similar sequence of steps returns the data to the client.

- The remote procedure returns its data to the server stub.
- The server stub converts output parameters to the format required for transmission over the network and returns them to the RPC run-time library functions.

- The server RPC run-time library functions transmit the data on the network to the client computer.

The client completes the process by accepting the data over the network and returning it to the calling function.

- The client RPC run-time library receives the remote-procedure return values and returns them to the client stub.
- The client stub converts the data from its NDR to the format used by the client computer. The stub writes data into the client memory and returns the result to the calling program on the client.
- The calling procedure continues as if the procedure had been called on the same computer.

For Windows, the run-time libraries are provided in two parts: an import library, which is linked with the application, and the RPC run-time library, which is implemented as a dynamic-link library (DLL).

The server application contains calls to the server run-time library functions, which register the server's interface and allow the server to accept remote procedure calls. The server application also contains the application-specific remote procedures that are called by the client applications.

3.1.1.1.5 Microsoft RPC Components

Microsoft RPC includes the following major components:

- The MIDL compiler.
- Run-time libraries and header files.
- The **name service provider** (sometimes referred to as the locator).
- The **endpoint mapper** (sometimes referred to as the port mapper).

In the RPC model, the **Interface Definition Language (IDL)** is used to formally specify an interface to the remote procedures. The Microsoft implementation of this language is called the Microsoft Interface Definition Language, or MIDL.

If an interface is created using the Microsoft development environment, it must be passed through the MIDL compiler. This compiler generates the stubs that translate local procedure calls into remote procedure calls.

Stubs are placeholder functions that make the calls to the run-time library functions; the run-time library functions manage the remote procedure call. The advantage of this approach is that the network becomes almost completely transparent to the distributed application. The client program calls what appear to be local procedures; the work of turning them into remote calls is done automatically.

All of the code that translates data, accesses the network, and retrieves results is generated by the MIDL compiler and is invisible to the application.

3.1.1.1.6 Microsoft RPC Security Model

The Microsoft RPC security model builds on the basic Windows security model. MSRPC is network protocol agnostic; the client and server have to agree on the adoption of a particular protocol. The available protocols are described in [\[MS-RPCE\]](#) section 2.1 Transport. MSRPC is also authentication agnostic. A client and server can select from a list of security providers, including SPNEGO, NTLM,

Kerberos, Netlogon, and No Authentication. The complete list of security providers is provided in [\[MS-RPCE\]](#) section 2.2.1.1.7 Security Providers. The required security provider is indicated by calling the RPC runtime routine [RpcServerRegisterAuthInfo](#) (this is the Microsoft implementation of the DCE function `rpc_server_register_auth_info`). In addition to the choice of security providers is the concept of the authentication level, which allows fine grain control over the level of protection. The possible authentication levels and their values are described in [\[MS-RPCE\]](#) section 2.2.1.1.8 Authentication Levels. A detailed example and explanation of a Remote Procedure Services server task can be found in the Authentication Services System Overview [\[MS-AUTHSO\]](#).

3.1.1.2 RPC over HTTP Protocol

The RPC over HTTP protocol [\[MS-RPCH\]](#) specifies the use of either HTTP [\[RFC2616\]](#) or HTTPS [\[RFC2818\]](#) as a transport for the Microsoft Remote Procedure Calls Extensions [\[MS-RPCE\]](#). In particular, it specifies provisions for using HTTP request/response streams as virtual channels, for encoding rules for transporting RPC **protocol data units (PDUs)** with HTTP requests and responses, and for roles for participants in the protocol.

3.1.1.2.1 Protocol Stack

The following figure illustrates the protocol stack that results from the combined roles and encoding rules for the RPC over HTTP protocol [\[MS-RPCH\]](#).

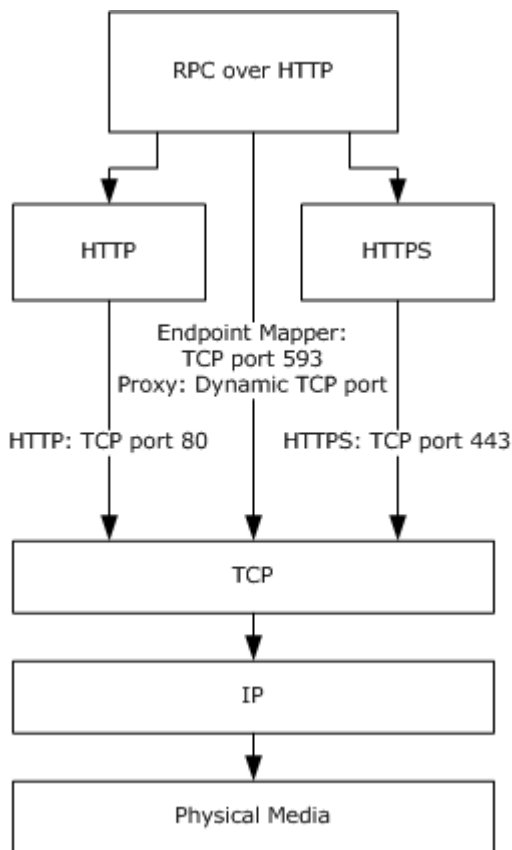


Figure 6: RPC over HTTP protocol stack.

As shown in the preceding figure, the RPC over HTTP protocol is layered directly over the HTTP and HTTPS protocols using their standard TCP port numbers.

The protocol stack for this section does not contain any other protocols.

3.1.1.2.2 Logical Dependencies

The RPC over HTTP protocol [\[MS-RPCH\]](#) is not logically dependent on any protocols other than HTTP, HTTPS, and TCP, which are its underlying transports.

3.1.1.3 Distributed Component Object Model

The Distributed Component Object Model (DCOM) Remote Protocol, as specified in [\[MS-DCOM\]](#), provides mechanisms for exposing application objects in distributed systems via remote procedure calls. It consists of a set of RPC interfaces that may be implemented over any RPC transport by using any RPC protocol sequence that is supported by the Remote Procedure Call Protocol Extensions, as specified in [\[MS-RPCE\]](#). This layering is illustrated in the following figure.

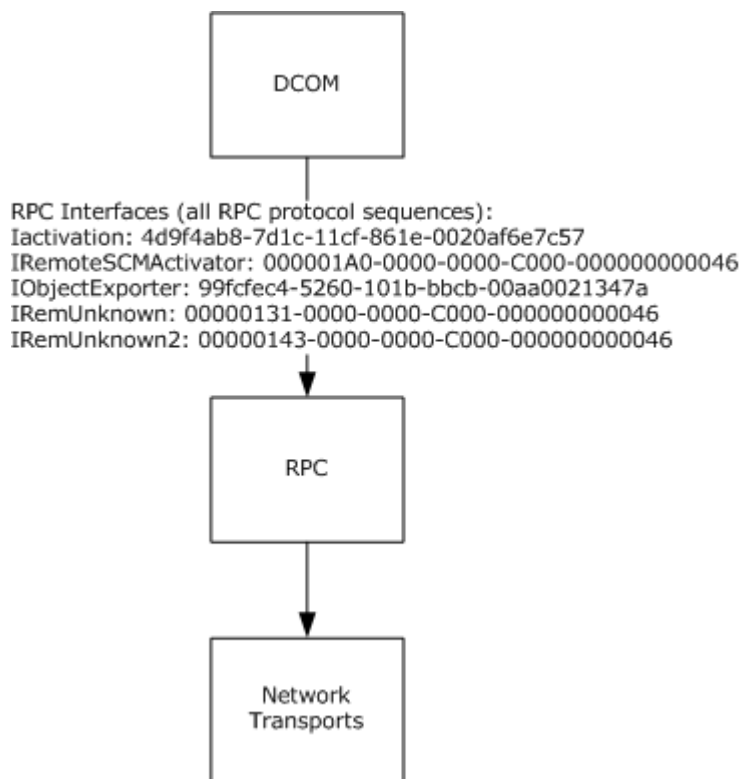


Figure 7: Remote Procedure Call Protocol Extensions stack layers.

The DCOM Remote Protocol, as specified in [\[MS-DCOM\]](#), is not logically dependent on any protocols other than the Remote Procedure Call Protocol Extensions.

3.1.1.4 Named Pipes

Many protocols layer on top of **named pipes**, either directly or indirectly, through the Remote Procedure Call Protocol Extensions, as specified in [\[MS-RPCE\]](#). The advantage of using named pipes

is that they insulate the higher-layer protocol from the chosen transport and they also offer the higher-layer protocol the authentication services of the CIFS/SMB/SMB2 connection.

A named pipe is a logical connection, similar to a Transmission Control Protocol (TCP) session, between the client and server that are involved in a CIFS/SMB/SMB2 connection. The name of the pipe serves as the **endpoint** for the communication, in the same manner as a port number serves as the endpoint for TCP sessions. This is called a named pipe endpoint. The **SMB Access Protocols** ([\[MS-CIFS\]](#), [\[MS-SMB\]](#), [\[MS-SMB2\]](#) supported by [\[MS-FSCC\]](#)) offer the named pipe construct.

A share is a local resource that is offered by an **SMB** server for access by SMB clients over the network. The protocol defines three types of shares: file (or disk) shares, which represent a directory tree and its included files; pipe shares, which expose access to named pipes; and print shares, which provide access to print resources on the server.

SMB clients access named pipe endpoints using the named pipe share named "IPC\$". The IPC\$ named pipe share allows only named pipe operations and Distributed File System (DFS) referral requests to itself. The data that is carried over IPC\$ is an implementation detail of SMB, as specified in [\[MS-CIFS\]](#). This implementation detail is transparent to the Remote Procedure Call Protocol Extensions, as specified in [\[MS-RPCE\]](#).

3.1.1.5 Obsolete - HTTP Retry With Extension

The HTTP protocol is an application level protocol for data retrieval and exchange across the internet, as specified in [\[RFC2616\]](#). An extension to this protocol was introduced in Windows; however the extension is considered obsolete and is described here for historical reference.

3.1.1.5.1 Extension Overview

"The HTTP Retry With" extension added the following to the base HTTP protocol:

- A mechanism for the server to indicate that a request for a **resource** should be retried.
- A mechanism for the client to indicate that a request is being retried.

The extension was applicable in scenarios where a server was required to gather extra information from a client to satisfy a request for a server resource.

3.1.1.5.2 Message Syntax

The following new status code was specified in the extension:

- The **449 Retry With** status code allowed the server to indicate that the request did not contain sufficient information and should be retried by the client.

The following new headers were specified:

- The **Ms-Echo-Request** header is a response header. It is returned by the server when replying to a request with the **449 Retry With** status code.
- The **Ms-Echo-Reply** header is a request header that is sent by the client when reissuing a request for a resource after receiving a **449 Retry With** status code for a previous request.

3.1.1.5.2.1 Retry With Status Code 449

The **449 Retry With** status code indicates that the request cannot be satisfied because insufficient information was provided by the client.

The extension status code is defined as follows (using the Augmented Backus-Naur Form (ABNF) Syntax, as specified in [\[RFC2616\]](#) section 2.1):

```
Status-code = "449"  
Reason-phrase = "Reply With"
```

3.1.1.5.2.2 Ms-Echo-Request Header

The **Ms-Echo-Request** header is a response header. It is returned by the server when replying to a request with the **449 Retry With** status code.

This new header is defined as follows (using the Augmented Backus-Naur Form (ABNF) Syntax, as specified in [\[RFC2616\]](#) section 2.1):

```
Ms-Echo-Request Header = "Ms-Echo-Request" ":" field-value
```

The **field-value** rule is specified in [\[RFC2616\]](#) section 4.2. The field value of the Ms-Echo-Request header is opaque. Its value MUST NOT be examined by the client, except as necessary to ensure validity with the client's implementation of the underlying HTTP protocol.

3.1.1.5.2.3 Ms-Echo-Reply Header

The **Ms-Echo-Reply** header is a request header sent by the client when reissuing a request for a resource after receiving a **449 Retry With** status code for a previous request.

This new header is defined as follows (using the Augmented Backus-Naur Form (ABNF) Syntax, as specified in [\[RFC2616\]](#) section 2.1):

```
Ms-Echo-Reply Header = "Ms-Echo-Reply" ":" field-value
```

The **field-value** rule is specified in [\[RFC2616\]](#) section 4.2. The field value of the Ms-Echo-Reply header is opaque. Its value MUST NOT be examined by the server, except as necessary to ensure validity with the server's implementation of the underlying HTTP protocol.

3.1.1.5.3 Message Processing Events and Sequencing Rules

A client that implements the HTTP 449 Retry With Protocol Extensions should behave as an HTTP client, as specified in [\[RFC2616\]](#), until it receives a response with the **449 Retry With** status code.

When a client that implements the HTTP 449 Retry With Protocol Extensions receives a 449 status code, the client processes the entity body of the response as normal, but preferably not display its contents to the user.

Once the entity body has been processed, the client shall repeat the request that generated the 449 status code to the server and it is required to include the **Ms-Echo-Reply** header with the new request.

If the client does not support the HTTP 449 Retry With Protocol Extensions, it is suggested that the client treat the 449 Retry With status code as an unrecognized status code, as specified in [\[RFC2616\]](#) section 6.1.1, and also treat the **Ms-Echo-Request** header as an unrecognized entity header and ignore it, as specified in [\[RFC2616\]](#) section 7.1.

3.1.1.5.4 Example - 449 Response and Echo Reply

The following example shows a server returning a 449 response status, along with a script to request that the browser set a cookie with the client's available screen dimensions. The client responds to the 449 response and echo request with an echo reply and the cookie generated as a result of executing the script.

Request:

```
GET /449/screen.449 HTTP/1.1
Host: localhost
Accept: */*
```

Response:

```
HTTP/1.1 449 Reply With
Content-Type: text/html
Ms-Echo-Request: token
Content-Length: 296

<html>
<head>
</head>
<body onload="createCookie();">
<script language="JavaScript">
<!--
function createCookie()
{
    strCookie = 'availWidth=' + screen.availWidth + '&availHeight=' + screen.availHeight;
    document.cookie = 'screen=' + strCookie;
}
--></script>
</body>
</html>
```

Echo Reply:

```
GET /449/screen.449 HTTP/1.1
Host: localhost
Accept:*/*
Ms-Echo-Reply: token
Cookie: screen=availWidth=800&availHeight=600
```

Final Response:

```
HTTP/1.1 200 OK
Content-Type: text/html
Content-Length: 125

<html>
<head>
</head>
<body>
Please adjust your screen resolution to 1600 x 1200 to enjoy this content.
</body>
```

</html>

3.1.1.6 Secure End-to-End IP Communication

This section describes secure end-to-end IP communications in Windows systems.

3.1.1.6.1 IPsec overview

Because IP network traffic can flow across a wide variety of networks, including networks populated or even controlled by hostile parties, end hosts communicating using IP are subject to a variety of threats. These include packet-tampering (modifying packets in transit so as to alter their effect on the receiver); packet inspection (reading confidential information from packets in transit); and identity spoofing (making packets appear to originate with a different sender, so as to alter their effect on the receiver).

To protect against these threats, IP communications can be secured in Windows using **Internet Protocol security (IPsec)** [RFC4301]. IPsec defines a set of authentication protocols and cryptographic packet transforms that, when used, can ensure that packets cannot be tampered with, that their origin is identifiable and verifiable, and that their contents cannot be determined by in-transit inspection. IPsec supports creating policies that control what traffic is allowed and how that traffic is to be protected. An example of such a policy that includes access control, privacy and authenticated: all hosts intra-communicating to other hosts in the organization must be authenticated within a particular Windows domain, and all related traffic between hosts should be private (encrypted) and protected against traffic spoofing (digitally signed).

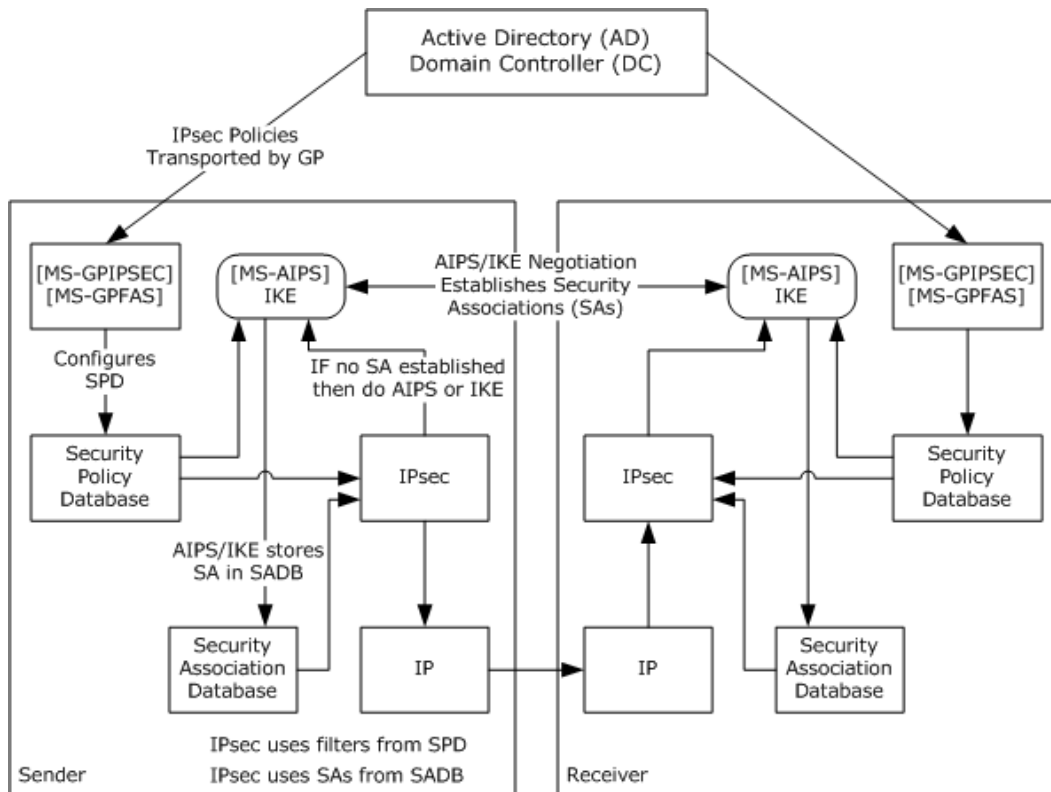


Figure 8: Windows IPsec Architecture

3.1.1.6.2 Security Associations

IPsec relies on the concept of a **security association (SA)**, which consists of a shared state (primarily cryptographic keys and parameters) maintained between two endpoints to secure traffic between them. SAs are established between two hosts using either **Internet Key Exchange (IKE)** ([\[RFC2409\]](#), [\[RFC4306\]](#)) or **Authenticated IP (AuthIP)** ([\[MS-AIPS\]](#)). These protocols handle the negotiation of the shared state that makes up the SA, as well as authenticating the two hosts to each other. Once an SA is established, IPsec-encapsulated IP traffic can pass between the two endpoints. Once an SA is established, a host sending an IPsec packet marks the packet with a Security Parameter Index (SPI) from the SA shared state, and performs the cryptographic and digital signing operations parameterized by the state in the SA ([\[RFC4301\]](#) section 5.1). The receiving host's IPsec layer uses the SPI and other packet information to find the SA's shared state values to check digital signatures and decrypt traffic as needed before passing the packet up to higher layer transports ([\[RFC4301\]](#) section 5.2).

Authentications between two IPsec hosts can be performed using three mechanisms:

- GSS-API-based authentication that can be performed by hosts that are Windows-domain-joined ([\[MS-AIPS\]](#) section 1.4). This form of authentication can support Kerberos-, NTLM- or TLS-based authentications. IKE has been extended ([\[MS-AIPS\]](#)) to use GSS-API. This extension includes the ability to authenticate users and machines.
- Certificate-based authentication.
- Shared key, a deprecated method that is implemented in conformance with the IPsec RFCs. Microsoft does not recommend the use of this mechanism.

On each host, the SA negotiation is controlled by a **security policy database (SPD)**. The SPD specifies how an IPsec-supporting network stack should process packets, based on criteria such as their source, destination, and encapsulated protocol. The packet-processing requirements determine what cryptographic encapsulation should be used on data packets, and hence how an SA should be negotiated for it to support the required encapsulation. An abstract data model for the IPsec **SPD** structure is detailed in [\[RFC4301\]](#) section 4.4.1. When an outbound data packet is sent to IPsec, IPsec uses the packet information such as source, destination IP addresses, transport protocol (e.g., TCP), and transport source and destination ports to match the filters in the SPD to determine whether the packet requires additional IPsec processing such as encryption and/or digital signing.

3.1.1.6.3 Security Policy Database Structure

In Windows, the IPsec SPD for every host can be remotely managed via Group Policy Objects ([\[MS-GPIPSEC\]](#), [\[MS-GPFAS\]](#)). The structure of the Windows IPsec SPD is derived from the one defined in [\[RFC4301\]](#). The SPD controls the packet processing rules for IPsec, and it also provides the parameters for IKE when it establishes SAs.

The Windows IPsec SPD, like its [\[RFC4301\]](#) counterpart, consists of a list of rules, similar in structure to firewall rules. Each rule specifies an action, namely **ALLOW** or **PROTECT**, to be applied to a class of IP packets defined by a set of filters (called "selectors" in [\[RFC4301\]](#)). **ALLOW** corresponds to the [\[RFC4301\]](#) **BYPASS** action; the packet is allowed to bypass IPsec processing. The result of SA authentications can be used to perform access control that result in **ALLOW** or **PROTECT** decisions by the IPsec layer. [\[RFC4301\]](#) also defines a **DISCARD** action, which causes the packet to be discarded; in Windows, this is considered a firewall policy, rather than an IPsec policy. The ways in which firewall and connection security (IPsec) interact in Windows is documented in [\[MS-FASP\]](#).

The **PROTECT** rules specify, for a particular class of packets defined by a set of filters, the cryptography policies for **main mode security association (MM SA)** and **quick mode security**

association (QM SA) negotiation, the authentication policy for main mode SA negotiation, and in the case of AuthIP, **extended mode (EM)** negotiation. Authentication policies specify such parameters as permitted authentication methods such as packet signing, certificate formats and certificate authorities. The cryptography policies specify such parameters as permitted cryptography algorithms, modes and key lengths. The cryptography policies for quick mode SAs also include policies for per-packet cryptographic protection, such as whether to use **Encapsulating Security Payload (ESP)** [RFC4303] or **authentication header (AH)** [RFC4302], and what algorithms, modes and key lengths to use.

3.1.1.6.4 IPsec Policy Specification Formats

The rules may be specified in either of two different formats, defined in [MS-GPIPSEC] and [MS-GPFAS]. In the [MS-GPIPSEC] format, policies consist of:

- An ISAKMP policy (see [MS-GPIPSEC] section 2.2.1.2), defining the cryptography and authentication policies for IKE **main mode (MM)** negotiations. (**AuthIP** policies are not supported in this format.)
- A set of **negotiation filter association (NFA)** policies (see [MS-GPIPSEC] section 2.2.1.3), each consisting of:
 - A set of filters defining a class of traffic to which the NFA policy applies (see [MS-GPIPSEC] section 2.2.1.5).
 - A negotiation policy (see [MS-GPIPSEC] section 2.2.1.4) defining a cryptography policy for IKE quick mode SA negotiation (including per-packet cryptographic protection).

The action implicitly associated with each such policy is PROTECT; the absence of such a policy for a class of traffic implicitly associates it with an ALLOW action.

In the [MS-GPFAS] format, policies (Connection Security Rules, see [MS-GPFAS] section 2.2.6) consist of:

- A collection of filters (see [MS-GPFAS] section 2.2.6.2) defining a class of traffic to which the policy is to be applied.
- An Action (see [MS-GPFAS] section 2.2.6.1), defined separately for inbound and outbound packets, and including, in the case of PROTECT, whether it is mandatory or optional (that is, whether, in the absence of a successful SA negotiation, the action should be ALLOW).
- A set of cryptography policies (see [MS-GPFAS] section 2.2.5) for quick mode SA negotiation and per-packet cryptographic protection.
- A set of authentication policies (see [MS-GPFAS] section 2.2.4) for AuthIP extended mode (EM) negotiation.
- A main mode (MM) rule (see [MS-GPFAS] section 2.2.7) specifying cryptography and authentication policies for main mode SA negotiation.

3.1.1.6.5 IPsec Encapsulations

Windows IPsec supports both:

- Transport Mode encapsulation that is used for end-to-end IPsec encapsulation between two hosts ([RFC4303] section 3.1.1).

- Tunnel Mode encapsulation that is used for an IPsec protected tunnel from a host **H** to a gateway **G** ([RFC4303] section 3.1.2). The IPsec tunnel carries an IP packet as its payload, where the packet is between **H** and a host **Hx**. Packets from **H** to **Hx** are put into the IPsec tunnel by **H** and sent to **G**. **G** terminates the IPsec tunnel, decapsulates the IP packet between **H** and **Hx**, and then forwards the packets on to **Hx**. IP packets from **Hx** to **H** can follow a reverse path if the route from **Hx** to **H** goes through **G**. If the packet hits **G**, then **G** can put the packet into the IPsec tunnel to **H**. At **G** the IP packet between **Hx** and **H** is taken out of the tunnel, and the packet is delivered **H**'s IP layer. Packets from Tunnel mode encapsulation can be used when a host is out on the public Internet and wishes to send traffic to hosts on a private network where a gateway **G** is deployed to protect and perform access control for hosts on the private network when communicating with hosts on the public Internet.

3.1.1.6.6 IP Over HTTP Proxy Traversal

Many private networks are protected by **HTTP proxies** and other firewalls that do not understand how to forward IPsec encapsulated packets. These gateways and proxies commonly understand how to forward **HTTP** traffic. The Windows networking stack can encapsulate and tunnel IP traffic in a **HTTPS** tunnel [MS-IPHTTPS], including end-to-end IPsec packets. IP over HTTPS tunnels are commonly used to connect a host behind a firewall or proxy to a corporate IP over HTTPS gateway that enables tunneled access from the host to hosts behind the gateway on a corporate network. Thus, a corporate network can deploy end-to-end IPsec security, and still have end-to-end IPsec connectivity even if some of the gateways in the network do not support forwarding of IPsec packets.

3.1.1.7 Windows Name Resolution

Name resolution is the function of taking a name and resolving that name to one or more IP addresses. Windows name resolution supports **Domain Name System (DNS)** resolution ([RFC1034], [RFC1035]), **NetBIOS** name resolution ([RFC1001], [RFC1002]), and Link Local Multicast Name Resolution (LLMNR) ([RFC4795]). Name resolution in Windows can resolve several name formats: **DNS FQDNs** and single label names. Single label names can be resolved as both a DNS name and a NetBIOS name. For a single label name to be resolved by DNS it must be converted to a FQDN by post-pending suffixes to the single label (for instance, "example" is converted to "example.contoso.com").

Name resolution can be done by using a variety of name resolution processes:

- The Domain Name System (DNS) ([RFC1034], [RFC1035]) is a distributed system of name resolvers. DNS names are fully qualified domain names (FQDNs) such as "www.contoso.com". The result of a DNS query can return a list of **IPv4** and **IPv6** addresses.
- The NetBIOS name resolution ([RFC1001], [RFC1002]) resolves a NetBIOS name to one or more IPv4 address. A NetBIOS name is a 16-byte string (see [MS-NBTE] section 2.2). An example of a process that uses a NetBIOS name is the File and Printer Sharing for Microsoft Networks service on a computer running Windows. When a Windows computer starts up, this File and Printer service registers a unique 16-byte NetBIOS name from the name of the computer. The exact NetBIOS name used by the service is the Windows Computer name padded out to 15 bytes plus a 16th byte of 0x20 representing that the name is related to the File and Printer service. A common NetBIOS name resolution is from the name of a Windows domain to a list of IP addresses for Domain Controllers. The NetBIOS name for a Windows domain is formed by padding the domain name to 15 bytes with blanks, and appending the byte 0x01 representing the Domain Controller service.
- The purpose of Link-Local Multicast Name Resolution (LLMNR) is to enable name resolution in scenarios in which conventional DNS name resolution is not possible (see [MS-LLMNRP]). LLMNR

supports all current and future DNS formats, types, and classes, while operating on a separate port from DNS, and with a distinct resolver cache. LLMNR only operates on the local link so it cannot be considered a substitute for DNS. Like DNS, LLMNR can resolve to IPv4 and IPv6 addresses.

3.1.1.7.1 DNS client configuration

This section describes the Domain Name System (DNS) parameter that the DNS client consumes. For information on the details of DNS support in Windows and DNS client configuration, see [\[MSFT-DNSCLIENT\]](#).

- **DNS server IP addresses:** The IP addresses of DNS servers to be queried during name resolution can be configured in three different locations.
 - **Per-interface DNS servers** are configured on each interface either statically or via **DHCP**. These DNS servers are only to be used for queries being issued on the interface that they are configured on. The order of the entries in the list is preserved as configured.
 - **Global DNS servers**[<1>](#) are configured either statically or via Group Policy. In the presence of the global DNS servers, per-interface DNS servers are not used. The order of the entries in the list is preserved as configured.
 - **Per-namespace DNS servers**[<2>](#) are configured in the **Name Resolution Policy Table (NRPT)** [\[MS-GPNRPT\]](#) and are only for queries that belong to the said namespace. The order of the list is preserved as configured.
- **DNS suffixes:** Suffixes can be configured in four different locations and are used for different purposes as described below:
 - **Global DNS suffix search list** can be configured statically or via Group Policy. Suffixes in the DNS suffix search list are added to non-FQDN names.
 - **Primary DNS suffix** can be configured statically, but is typically the same suffix as the Active Directory domain to which the client is joined. This suffix is added to non-FQDN names only in the absence of a global DNS suffix search list.
 - **Interface-specific suffixes** (also known as **connection-specific suffix**) can be configured statically or via DHCP. These suffixes are added to non-FQDN names only for queries on the specific interface in the absence of a global DNS suffix search list, and after the primary DNS suffix has been added.
 - **Suffixes in the Name Resolution Policy Table**[<3>](#) can be configured statically or via Group Policy. These suffixes are used as a reference to determine the special handling that a particular query may require.

3.1.1.7.2 Invocation of Name Resolution Protocols in Windows

Invocation of name resolution protocols in Windows is accomplished using well known standards-based API calls such as **gethostbyname()** and **getaddrinfo()** as specified in [\[POSIX\]](#). These methods retrieve information about hosts in a manner consistent with the [\[POSIX\]](#) definition. This information is considered to be stored in a database that can be accessed sequentially or randomly. Implementation of this database is (deliberately) unspecified in the [\[POSIX\]](#) standard. In Windows the API calls can invoke DNS, NetBIOS and LLMNR services in a single call, and return a list of IP addresses together with the type of those addresses (IPv4, IPv6). There are also extensions of these calls in Windows; for example, **GetAddrInfoEx()** provides protocol-independent name resolution with additional parameters to qualify which namespace providers use.

When a name-resolution API is invoked, if more than one namespace provider returns information then the method aggregates all responses. Name resolution can be by the Domain Name System (DNS), LLMNR, NetBIOS or a local host file.

The processing of a namespace provider in Windows is normally as follows (but is configurable):

- Winsock invokes the DNS Name Service Provider (NSP), which first initiates a DNS query.
- If the DNS query does not successfully resolve the name, the query fails over to the LLMNR protocol ([\[RFC4795\]](#)).[.<4>](#)
- If the LLMNR protocol does not successfully resolve the name, the query fails over to the NetBIOS protocol name resolution ([\[MS-NBTE\]](#) section 3.1.4.2).

3.1.1.7.3 Effective DNS suffix search list

- If a global suffix search list is configured on the host, then the global suffix search list is the effective suffix search list for all queries.
- If a global suffix search list is absent, then the effective suffix search list **for a given interface** is:
 - The host's primary DNS suffix.
 - The interface-specific suffix(es) on the interface.
 - Devolution performed on the primary DNS suffix.

3.1.1.7.4 DNS Devolution

DNS Devolution is a process that allows client computers that are members of a child namespace to access resources in the parent namespace without the need to explicitly provide the fully qualified domain name of the resource.

The DNS client creates new FQDNs by appending the single-label, unqualified domain name with the parent suffix of the primary DNS suffix name, and the parent of that suffix, and so on, stopping if the name is successfully resolved or at a level determined by the devolution level settings. Devolution works by removing the left-most label of the suffix and continuing to get the parent suffix.

Devolution level is the level at which devolution will terminate. The devolution level is determined as follows:

- If a value for the devolution level is explicitly configured, this value is used as the devolution level.[.<5>](#)
- The name of the forest root domain and the primary DNS suffix of the host are compared. If the number of labels in the forest root domain is 1, devolution is not performed.
- If the primary DNS suffix is a trailing subset of the forest root domain (if it ends with the forest root domain), the devolution level is set to the number of labels in the forest root domain.
- If the primary DNS suffix is not a trailing subset of the forest root domain, devolution is not performed.

For more information on DNS Devolution, see [\[MSFT-DNSDEVOLUTION\]](#).

3.1.1.7.5 Prior to a DNS query

The DNS client does the following before a query is issued:

- If the query name is a single-label name, the DNS client adds the first suffix from the effective suffix list to create a fully qualified domain name (FQDN).
- If the query is a multi-label name and the host is configured to append suffixes to multi-label queries, the DNS client first queries for the multi-label name without appending any suffixes. If this query fails, the DNS client adds the first suffix from the effective suffix list.

3.1.1.7.6 Name Resolution Policy Table (NRPT) processing and issuing DNS queries

Name Resolution Policy Table (NRPT) is a table of DNS suffixes, which map to a list of DNS servers that provide DNS service for that suffix. The client looks up the FQDN of the query against the suffixes configured in the NRPT. [<6>](#) If a matching entry is found and the NRPT specifies the DNS servers to query, the DNS client follows this process:

1. A DNS query is issued to the first DNS server on the list.
2. If a response is not received in 1 second, a DNS query is issued to the next DNS server on the list.
3. If a response is not received in another 1 second, a DNS query is issued to the next DNS server on the list.
4. If a response is not received in another 2 seconds, a DNS query is issued to all DNS servers on the list.
5. If a response is not received in another 4 seconds, a DNS query is issued to all DNS servers on the list.
6. If a response is not received in another 4 seconds, the query times out.

If a matching entry is not found in the NRPT, or if the entry in the NRPT does not specify the DNS servers to query, the DNS queries being issued to the interface DNS servers follows the following process:

1. A DNS query is first issued to the first DNS server in the list of DNS servers of the first network interface. The first interface is determined by a local windows binding order of network interfaces.
2. If a response is not received in 1 second, a DNS query is issued to the next most preferred DNS server on the best interface and the most preferred DNS server on all other interfaces.
3. If a response is not received in another 1 second to any of these queries, a DNS query is issued to the next most preferred server on all interfaces.
4. If a response is not received in another 2 seconds to any of these queries, a DNS query is sent to all DNS servers on all interfaces.
5. If a response is not received in another 4 seconds to any of these queries, a DNS query is sent to all DNS servers on all interfaces.
6. If a response is not received in another 4 seconds to any of these queries, the query times out.

If, a response is received at any step during the process of querying, one of the following actions is taken, depending on the response:

- If the response is a successful name resolution, the process is terminated and the response is returned.
- If the response is a NAME ERROR, then the next suffix in the effective suffix search list is appended and the name resolution process continues.

3.1.1.7.7 Returning DNS responses

After a name has been successfully resolved from the wire, DNS returns the response to the Windows name resolver. If the response is a list of IP addresses (obtained as a result of a DNS query type **A** or type **AAAA**), the IP addresses are returned in the order they are received.

The name resolver sorts the IP addresses returned as specified in [\[RFC3484\]](#).

3.1.1.7.8 DNS Dynamic Updates

Windows supports dynamic registration of a host's DNS address based on the Windows computer name and the suffixes that are configured for the system. Dynamic updates are performed as specified in [\[RFC2136\]](#). Dynamic updates happen in the following circumstances:

- An IP address is added, removed, or modified in the TCP/IP properties configuration for any one of the installed network connections (for example, an Ethernet NIC, a PPP dialup connection, or a WiFi adapter).
- An IP address lease changes or renews with the DHCP server any one of the installed network connections.
- The command "ipconfig /registerdns" is issued.
- The computer starts up (is turned off and then on, or restarts).
- A member server is promoted to being a domain controller.
- A Windows computer joined to a domain is running a client that is located outside the corporate firewall on the public Internet, and is connected to the corporate private network using [\[MS-IPHTTPS\]](#). In this case, dynamic update attempts are tried continuously until the update is successful. This is new behavior in Windows 7 operating system and is applicable only for those clients configured to use [MS-IPHTTPS] from outside the firewall.
- The **DnsModifyRecordsInSet()** API is called by an application and a specific name is provided that the client must register.

The following are the possible roles with respect to dynamic updates:

- The **A** and/or **AAAA** records for the host name appended with the primary DNS suffix are registered by the host.
- The **A** and/or **AAAA** records for the host name appended with connection specific suffixes may be registered by the DHCP server if configured, or by the host if not.
- The **PTR** records for the IPv4 and/or IPv6 addresses of the host are registered against the host name appended with the primary DNS suffix by the host.

- The **PTR** records for the IPv4 and/or IPv6 addresses of the host are registered against the host name appended with the connection specific DNS suffix by the DHCP server if configured, or by the host if not.

3.1.2 Identity and Security Concepts

This section provides an overview of foundational identity and security concepts in Windows. The concepts described in this section apply to Active Directory Domain Services (AD DS). [\[MS-ADTS\]](#) specifies in detail the differences between AD DS and AD LDS as appropriate.

3.1.2.1 Identity

The first security concept that is important to understand is identity. There are several types of identities in Windows, and they exist and are managed in several ways, which are detailed in the following sections. For example, identity can refer to the set of users on a single computer or to the identities that are available in a domain.

3.1.2.1.1 Security Principal

A security principal is a common concept in security; it is an actor in a security system and is often capable of initiating action. Typically, a security principal is associated with a human user of the computer system, but it can also be an autonomous program within the system, such as a logging daemon, system backup program, or something similar.

The security principal is an entity that can be authenticated. In Windows, a security principal is typically a user but can also be a computer or a service. A security principal is often referred to as an *account*.

Security principals receive permissions to access resources such as files and folders. User rights, such as interactive logons, are granted or denied to accounts directly or via membership in a group. The accumulation of these permissions and rights defines what security principals can and cannot do when working on the network.

3.1.2.1.2 Accounts

One of the most important aspects of any security principal is that it serves as a point of management between the system and the administrator. As such, it is required to have attributes that make it meaningful to the administrator or the user. The security principal (or account) has at least a name and an *identifier*.

The name is a simple textual name for the account, such as Rene Valdes, SYSTEM, or RedmondDc1\$. However, the name is an attribute of the account and can change over time. A common scenario is that the person to whom the account refers changes his or her name.

Also, the name is treated as *case-insensitive*. That is, "Rene Valdes", "RENE VALDES", "rene valdes", and "reNe ValDES" are all treated the same in Windows. Microsoft views case-sensitivity as an unnecessary burden on the administrator that can lead to mistakes.

The identifier, though also an attribute of the account, has to satisfy other attributes as well. Of particular importance are the uniqueness and persistence of the identifier and the issuer of the identifier. The persistence of the identifier is what provides the administrator with the capability to assign a resource to that account and not be surprised in the future by changes to the account.

Consider the case of Rene Valdes. The administrator may assign Rene Valdes access to a certain document at a point in time. If that Rene Valdes leaves the company and a new Rene Valdes is hired, the new Rene Valdes should not have access to the resources of the original Rene Valdes.

Conversely, if Rene Valdes changes her name to Rene Q. Valdes, she should not lose access to the resources previously granted to her.

Another important attribute is the issuer of the identifier. Identities have different values depending on the issuer. In the physical world, a store is generally willing to accept a driver's license as proof of identity, but the store is unwilling to accept a gymnasium membership card. In the Windows model, the issuer of an account is encoded with the identity so that any recipient can make a similar decision.

The identifier that Windows uses for accounts is called a **security identifier (SID)**.

Windows contains a number of built-in accounts:

- **User account:** Identifies users who belong to the domain by storing their names, their passwords, the groups to which they belong, the permissions that they have for accessing system resources, and other personal information.
- **Group account:** Identifies a specific group of users and is used to assign them permissions to objects and resources.
- **Computer account:** Identifies computers that belong to the domain. A computer account is commonly referred to as a "machine account".

Each built-in user, computer, or group account is a security principal.<7>

User and computer accounts can be added, disabled, reset, and deleted by using the Active Directory Users and Computers console. A computer account can also be created when a computer is joined to a domain.

3.1.2.1.2.1 User accounts

In the Active Directory directory service, each user account has a user logon name, a pre-Windows 2000 operating system user logon name (security accounts manager (SAM) account name), and a user principal name (UPN) suffix. The administrator enters the user logon name and selects the UPN suffix when creating the user account. Active Directory suggests a pre-Windows 2000 user logon name that uses the first 20 bytes of the user logon name. Administrators can change the pre-Windows 2000 logon name at any time.

In Active Directory, each user account has a UPN based on [RFC822](#). The UPN is composed of the user logon name and the UPN suffix joined by the "at" sign (@).

Note When creating a user account, it is not necessary to add the "at" sign (@) to the user logon name or to the UPN suffix. Active Directory automatically adds the "at" sign (@) when it creates the UPN. A UPN that contains more than one "at" sign (@) is invalid. User logon names do not end with a period or multiple periods.<8>

The second part of the UPN, the UPN suffix, can be the Domain Name System (DNS) domain name, the DNS name of any domain in the forest, or an alternative name that is created by an administrator and used just for logon purposes. This alternative UPN suffix is not required to be a valid DNS name.

In Active Directory, the default UPN suffix is the DNS name of the domain in which the user account is created. Using alternative domain names as the UPN suffix can simplify the names that are used to log on to another domain in the forest.

For example, if an organization uses a deep domain tree that is organized by department and region, domain names can become quite long. The default UPN for a user in that domain might be

sales.westcoast.contoso.com. The logon name for a user in that domain would be user@sales.westcoast.contoso.com. Creating a UPN suffix of "contoso" would allow that same user to log on by using the much simpler logon name of user@contoso.

3.1.2.1.2.2 Computer Accounts

Each computer account that is created in Active Directory has a relative distinguished name (RDN), a pre-Microsoft Windows 2000 computer name (SAM account name), a primary DNS suffix, a DNS host name, and a service principal name (SPN) in addition to the computer name. The administrator enters the computer name when creating the computer account. The computer account must include the dollar sign (\$) character at the end of the name (for example RedmondDc1\$).

When the domain functional level has been set to Windows Server 2003 operating system, a new **lastLogonTimestamp** attribute is used to track the last logon time of a user or computer account. This attribute is replicated in the domain and can provide important information regarding the history of a user or a computer.

Every Windows computer that joins a domain has a computer account. [<9>](#) Similar to user accounts, computer accounts provide a means for authenticating and auditing computer access to the network and to domain resources. Each computer account must be unique.

When the Netlogon service that runs on a client computer connects to the Netlogon service on a domain controller (DC) in order to authenticate a user, the Netlogon services challenge each other to determine whether they both have a valid computer account. This allows a secure communication channel to be established for logon purposes.

In order for a Windows computer to join a domain, the computer must have a computer account in Active Directory. [<10>](#)

The computer name (for example RedmondDc1\$) is used as the Lightweight Directory Access Protocol (LDAP) relative distinguished name (RDN). Active Directory suggests the pre-Windows 2000 name that uses the first 15 bytes of the RDN. The administrator can change the pre-Windows 2000 name at any time.

The DNS name for a host is called a full computer name and is a DNS fully qualified domain name (FQDN). The full computer name is a concatenation of the computer name (the first 15 bytes of the SAM account name of the computer account without the "\$" character) and the primary DNS suffix (the DNS domain name of the domain in which the computer account exists). It is listed on the Computer Name tab in the System Properties dialog box in Control Panel.

By default, the primary DNS suffix portion of the FQDN for a computer must be the same as the name of the Active Directory domain where the computer is located. To allow different primary DNS suffixes, a domain administrator may create a restricted list of allowed suffixes by creating the **msDS-AllowedDNSSuffixes** attribute in the domain object container. This attribute is created and managed by the domain administrator by using the Active Directory Service Interfaces (ADSI) [\[MSDN-ADSI\]](#) or LDAP (see [\[MS-ADTS\]](#) section 6.1.1.1.4).

The SPN is a multivalue attribute. It is usually built from the DNS name of the host. The SPN is used in the process of mutual authentication between the client and the server hosting a particular service. The client finds a computer account that is based on the SPN of the service to which it is trying to connect. The SPN can be modified by members of the Domain Admins group.

3.1.2.1.3 Security Identifiers (SIDs)

The security identifier (SID) is an account identifier. The SID is variable in length and encapsulates the hierarchical notion of issuer and identifier. It consists of a 6-byte *identifier authority* field that is

followed by one to fourteen 32-bit *subauthority* values and ends in a single 32-bit *relative identifier (RID)*. For example, a two-subauthority SID appears as shown in the following figure.

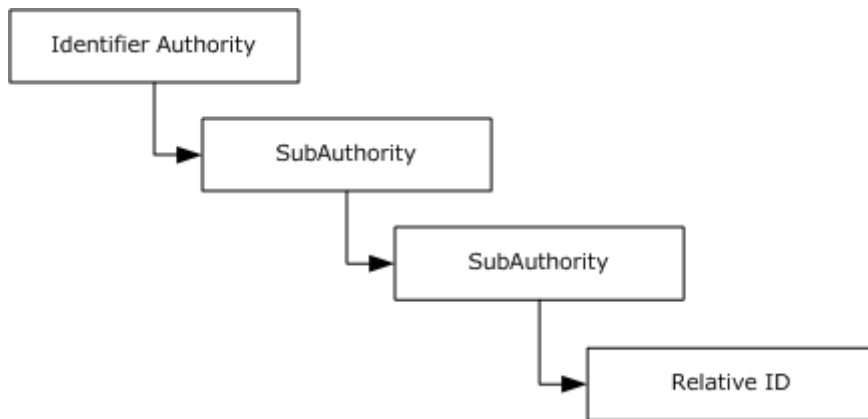


Figure 9: Windows security identifier with subauthorities.

When displayed textually, the accepted form is the following:

```
S-1-<identifier authority>-<sub1>-<sub2>-...-<subn>-<rid>
```

where *S* and *1* are literal strings, *identifier authority* is the 6-byte value, *sub1* through *subn* are the subauthority values, and *rid* is the RID.

The original definition of an SID called out each level of the hierarchy. Each layer included a new subauthority, and an enterprise could lay out arbitrarily complicated hierarchies of issuing authorities. Each layer could, in turn, create additional authorities beneath it. In reality, this system created a lot of overhead for setup and deployment and made the management model group even more complicated. The notion of arbitrary depth identities did not survive the early stages of Windows® development, however the structure was too deeply ingrained to be removed.

In practice, two SID patterns developed. For built-in, predefined identities, the hierarchy was compressed to a depth of two or three subauthorities. For real identities of other principals, the identifier authority was set to five, and the set of subauthorities was set to four.

Whenever a new issuing authority under Windows is created (for example, a new machine deployed or a domain created), it is assigned an SID with 5 (an arbitrary value) as the *identifier authority*. A fixed value of 21 is used as a unique value to root this set of subauthorities, and a 96-bit random number is created and parceled out to the three subauthorities with each subauthority that receives a 32-bit chunk. When the new issuing authority for which this SID was created is a domain, this SID is known as a "domain SID".

Windows allocates RIDs starting at 1,000; RIDs having a value less than 1,000 are considered reserved and are used for special accounts. For example, all Windows accounts with a RID of 500 are considered built-in Administrator accounts in their respective issuing authorities.

Thus, an SID that is associated with an account appears as depicted in the following figure.

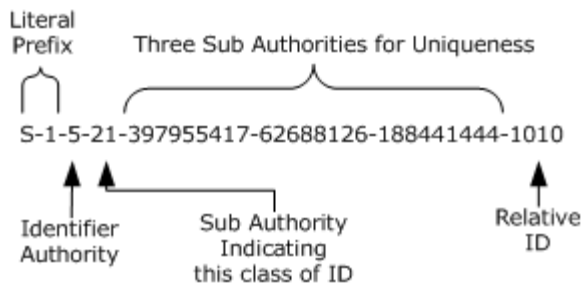


Figure 10: SID with account association.

For most uses, the SID can be treated as a single long identifier for an account. By the time a specific SID is associated with a resource or logged in a file, it is effectively just a single entity. For some cases, however, it should conceptually be treated as two values: a value that indicates the issuing authority and an identifier relative to that authority. Sending a series of SIDs, all from the same issuer, is one example: the list can easily be compressed to be the issuer portion and the list of IDs relative to that issuer.

It is the responsibility of the issuing authority to preserve the uniqueness of the SIDs, which implies that the issuer must not issue the same RID more than one time. A simple approach to this entails allocating RIDs sequentially. More complicated schemes are certainly possible. For example, Active Directory uses a multimaster approach that allocates RIDs in blocks. It is possible for an issuing authority to run out of RIDs; therefore, the issuing authority must be sure to handle this situation correctly. Typically, the authority must be retired.

Windows supports the concept of groups with much the same mechanisms as individual accounts. Each group has a name, just as the accounts have names. Each group also has an associated SID.

User accounts and groups share the same SID and namespaces. Users and groups cannot have the same name on a Windows-based system nor can the SID for a group and a user be the same.

For access control, Windows makes no distinction for whether an SID is assigned to a group or an account. Changing the name of a user, computer, or domain does not change the underlying SID for an account. Administrators cannot modify the SID for an account, and there is generally no need to know the SID that is assigned to a particular account. SIDs are primarily intended to be used internally by the operating system to ensure that accounts are uniquely identified in the system.

3.1.2.1.4 Groups

A group is a collection of user accounts, computer accounts, and other groups that can be managed as a single unit from a security perspective. Groups can either be based in Active Directory or be local to a particular computer.

Windows Server has several built-in accounts and security groups that are preconfigured with the appropriate rights and permissions to perform specific tasks. [11](#) Active Directory provides two types of administrative responsibility: service administrators are responsible for maintaining and delivering the directory service, including **domain controller (DC)** management and directory service configuration, whereas data administrators are responsible for maintaining the data that is stored in the directory service and on servers and workstations that are domain members.

It is important to understand which default accounts and groups are service administrators. Service administration accounts and groups have the most widespread power in the network environment and require the most protection.

3.1.2.1.4.1 Group Types

Starting with Windows 2000 operating system, Windows provides two types of groups:

- Security groups: These groups can contain members and can be granted permissions in order to control access to network resources. Security groups can contain users, other groups, and even computers.
- Distribution groups: These groups are used for nonsecurity functions, such as grouping users together to send email messages. Unlike security groups, these groups cannot be used to control access to network resources.

Windows NT Server operating system has only one type of group, which is equivalent to the security groups in Windows 2000 Server operating system, Windows Server 2003 operating system, Windows Server 2003 R2 operating system, Windows Server 2008 operating system, and Windows Server 2008 R2 operating system.

Starting with Windows 2000 Server, groups can be created by using the Active Directory Users and Computers console, and groups are stored as group objects in Active Directory. In Windows NT operating system, groups can be created by using User Manager for Domains, and groups are stored in the SAM database. Users can belong to multiple groups at the same time. A group does not actually contain its member user accounts, rather it is just a list of the user accounts.

3.1.2.1.4.2 Group Scope

The scope of a group can be local or global depending on the portion of the network for which the group can be granted rights and permissions. Beginning with Windows 2000 operating system, Windows provides three levels of scope for security groups:

- Universal groups: These groups can contain members for any domain and can be granted permissions to resources in any domain in a specific Active Directory forest. An Active Directory forest is a collection of one or more Active Directory domains that share a common logical structure, directory schema, and network configuration, as well as automatic two-way transitive **trust** relationships. Each forest is a single instance of the directory and defines a security boundary. Universal groups can contain user accounts, global groups, and universal groups from any domain in the current forest. An administrator can create a universal group only when the domain is in native mode and not in mixed mode, as defined in section [3.1.2.1.4.3](#).
- Global groups: These groups can contain members only from their own domain but can be granted permissions to resources in any trusting domain. When the domain is in native mode, global groups can contain user accounts and global groups from the same domain. When the domain is in mixed mode, these groups can contain only user accounts.
- Domain local groups: These groups can contain members from any trusted domain, but can be granted permissions only to resources in their own domain. Unlike Windows NT local groups, a domain local group can be granted permissions to resources on all servers (both the DCs and member servers) in its domain. When the domain is in mixed mode, domain local groups can contain user accounts and global groups from any trusted domain or forest. When the domain is in native mode, domain local groups can also contain domain local groups from their own domain and universal groups from any trusted domain.

Beginning with the Windows 2000 Server operating system, for all member servers and client computers, a fourth scope of group called a local group can exist only within the local security database of the computer where it is created. Local groups in Windows 2000 Server, Windows Server 2003 operating system, Windows Server 2003 R2 operating system, Windows Server 2008 operating system, Windows Server 2008 R2 operating system, Windows XP operating system,

Windows Vista operating system, Windows 7 operating system, and Windows Home Server server software are similar to local groups in Windows NT operating system. They can contain user accounts that are local to the computer and user accounts and global groups from their own domain. A local group can be granted permissions to resources only on the computer where the local group was created. The Local Users and Groups Microsoft Management Console (MMC) is used to create local groups on a computer.

Windows NT groups have only two levels of scope:

- **Global groups:** A global group can be granted permissions to resources in its own domain and to resources in trusting domains. A global group can contain user accounts only from its own domain. Global groups are created on Windows NT domain controllers (DC) and exist in the domain directory database.
- **Local groups:** A local group created with Windows NT Workstation operating system can be granted permissions only to resources on the computer where it was created. A local group created with Windows NT Server operating system DC can be granted permissions only to resources on the DCs of its own domain. A local group can contain user accounts and global groups both from its own domain and from trusted domains. Network administrators of enterprise-level Windows NT networks can use a resource-access strategy called AGLP (whereby accounts are organized by placing them in global groups, which are then placed in local groups that have appropriate Permissions and rights assigned to them) to plan and implement local groups in their network.

Beginning with Windows 2000 Server, the scope of a group can be changed. For example, global groups that are not members of other global groups can be converted to universal groups. Domain local groups that do not contain other domain local groups can be converted to universal groups.

3.1.2.1.4.3 Nested Groups

Windows supports the concept of nested groups, or the addition of groups to other groups. The use of nested groups can help reduce the number of permissions that are required to be individually assigned to users or groups.

The process of creating groups across domains involves the following steps:

1. The administrator in each domain creates global groups and adds user accounts that have the same resource requirements to the global groups.
2. A domain administrator creates a domain local group for each resource that exists within a domain, such as file shares or printers, and then adds the appropriate global groups from each domain to this domain local group.
3. A domain administrator assigns the appropriate permissions for the resources to the domain local group. Users in each global group receive the required permissions because their global group is a member of the domain local group.

If groups are effectively nested in a multidomain environment, then the network traffic between domains is reduced and the administration in a domain tree is simplified. A domain tree is a collection of domains that are grouped together in hierarchical structures so that they can be administered as single logical unit.

When a domain is added to the domain tree, it becomes a child of the tree root domain. The domain to which a child domain is attached is called the parent domain. A child domain can contain its own child domain. The name of a child domain is combined with the name of its parent to form its own

unique DNS name, such as Corp.mycompany.contoso. In this manner, a tree has a contiguous namespace.

The extent to which nesting can be used in a specific organization depends on which mode the domain controller (DC) was configured in the system. DCs can be configured in two modes: mixed mode or native mode.

- **Mixed mode:** A DC that is configured to support a mixed environment with Windows NT 4.0 operating system, Windows 2000 operating system, Windows Server 2003 operating system, Windows Server 2003 R2 operating system, and Windows Server 2008 operating system DCs in the same domain.
- **Native mode:** A DC that is configured to support only mixed Windows 2000 Server operating system, Windows Server 2003, Windows Server 2003 R2, and Windows Server 2008 environments.

In mixed mode, only one type of nesting is available; global groups can be members of domain local groups. Universal groups do not exist in mixed mode. In native mode, multiple levels of nesting are available. The nesting rules for group memberships for Windows 2000 are summarized in the following table.

Group scope	Can contain	Can be a member of
Domain local group	User accounts and universal and global groups from any trusted domain. Domain local groups from the same domain.	Domain local groups in the same domain.
Global group	User accounts and global groups from the same domain.	Universal and domain local groups in any domain. Global groups in the same domain.
Universal group	User accounts and universal and global groups from any domain.	Universal or domain local groups in any domain.

3.1.2.1.5 Account Domains

Accounts are always created relative to an issuing authority, which is responsible for allocating and assigning the security identifier (SID). In Windows, the issuing authority is referred to as a domain. Domains come in two varieties; local and remote.

3.1.2.1.5.1 Local Domains and Account Database

Every computer that runs Windows has a local domain; that is, it has an **account database** for accounts that are specific to that computer. Conceptually, this is an account database like any other with accounts, groups, security identifiers (SID), and so on. These are referred to as local accounts, local groups, and so on. Because computers typically do not trust each other for account information, these identities stay local to the computer on which they were created.

In Windows the Security Account Manager (SAM) Remote Protocol (Client-to-Server) specified in [\[MS-SAMR\]](#) exposes this account database, for both local and remote domains. [MS-SAMR] specifies the behavior for local and remote domains by having a common data model, the Active Directory data model, specified in [\[MS-ADTS\]](#).

In a domain controller (DC) configuration, the data manipulated by the server of this protocol is stored in Active Directory and is replicated by the replication protocol specified in [\[MS-DRSR\]](#), made available through the Lightweight Directory Access Protocol (LDAP) interface specified in [\[MS-ADTS\]](#)

section 3.1.1.3, and replicated by the NETLOGON replication interface specified in [\[MS-NRPC\]](#). The data manipulated by the server of this protocol is used as a security principal database for authentication protocols such as NTLM [\[MS-NLMP\]](#) and Kerberos [\[MS-KILE\]](#).

The abstract data model for the SAM Remote Protocol (Client-to-Server) that exposes the account database is described in [\[MS-SAMR\]](#) sections [3.1](#) and [3.2](#).

3.1.2.1.5.2 Remote Domains and Domain Controllers

With a remote domain, certain Windows-based servers can be configured to be domain controllers (DC). A DC is a server that has made its account database available to other machines in a controlled manner. Starting with Windows 2000 operating system, [<12>](#) DCs began supporting a database of more than just accounts, becoming a general-purpose directory. This is known as Active Directory.

Because the account database is typically distributed across multiple DCs, there can be a mix of different versions of the individual servers. Active Directory employs a *functional level*, which serves as a version level for the entire directory. The functional level is managed by the administrator and the system itself.

A domain has built-in groups, which are defined by Microsoft and created within the domain during installation. For example, built-in groups include the Domain Users, Domain Computers, and Domain Admins groups. By default, the Domain Users group includes all users who are defined in the domain.

A DC accepts authentication requests on behalf of the machines that have chosen to trust it.

A DC can have peers within the domain, which are other servers that also have been configured to host this account database. Any server participating in the domain as a DC may or may not allow changes; the configuration is a choice of the administrator. [<13>](#)

When a change is allowed, the servers replicate the change so that all DCs have the same information.

3.1.2.1.5.3 Domain Membership

Domain membership is the state of trusting a third party (the domain controller (DC)) for identity and authentication information. Any system can be part of a domain. Windows-based systems can easily be configured to be part of a domain and to trust the DC for many tasks. Also, certain configuration changes are made, such as accepting the domain as the authoritative source of time.

Windows-based systems can have local groups that include members from a domain. This allows the member system to manage its resources in the manner most relevant to it and not be completely dependent on the decisions of the domain administrator. A domain administrator can create a domain local group for each resource that exists within a domain, such as file shares or printers, and then add the appropriate global groups from each domain to this domain local group. The domain administrator then assigns the appropriate permissions for the resources to the domain local group.

Joining a domain can be summarized as establishing an account on the domain that represents the system joining the domain, and setting the password (or key) for the account on both the domain and the actual system. In Windows, this process is encapsulated in a domain join function (NetJoinDomain). Several tools, including WinBind, exist for non-Windows operating systems to join a Windows domain.

All Windows-based systems have a component that manages their relationship with their DC. This component, called Netlogon, maintains the keys that are necessary for ongoing authentication of the

member system to the DC. It also creates a general-purpose channel to the Netlogon instance on the DC. This general-purpose channel that Netlogon creates for authentication is not specific to any protocol and is available only to components involved in authentication.

This channel is used by various authentication protocol implementations to redirect an authentication request to (or augment their activities with) their instance on the DC.

3.1.2.1.5.4 Effect on Accounts

Windows domains have an effect on the way that accounts and groups work. Some of this is by convention, and some is by design.

By convention, when a Windows-based system is added to a domain, the domain administrators group is made a member of the local administrators group.

By design, groups have different scopes when domains are involved. Groups can be defined as globally known and therefore usable by other domains, or known only within the domain in which they are defined.

3.1.2.1.6 Globally Unique Identifiers (GUIDs)

In Windows programming and in Windows operating systems, a globally unique identifier (GUID), as specified in [\[RFC4122\]](#), is a 128-bit value that is a binary unique identifier (ID) for a specific entity. The term universally unique identifier (UUID) is sometimes used in Windows protocol specifications as a synonym for GUID.

3.1.2.1.6.1 Uniqueness

All GUIDs are assumed to be unique; however, it cannot be said that they **MUST** be unique because there is no mechanism to enforce that uniqueness. Some GUIDs are also unpredictable. [\[RFC4122\]](#) defines five versions of GUID, one of which, version 4, is unpredictable by design. Because a GUID includes a version number field, no GUID of one version could equal a GUID of a different version.

Sometimes GUIDs are generated at design time and remain constant throughout the life of a protocol, such as a GUID that identifies a remote procedure call (RPC) interface or one that identifies a particular Active Directory schema. Such GUID values, when used in a protocol, are typically listed in the protocol document. Other GUIDs are generated at runtime by the protocol implementation itself and are used to identify transitory things such as individual sessions, connections, transactions, and activities.

Some protocols use unpredictable GUIDs as self-authenticating identifiers or nonces. That is, the GUID value (for example, a GUID that represents a client ID) is kept secret by both parties to the protocol and is used as an identifier. However, because it is assumed to have significant entropy, it also serves as a high-entropy password. Alternatively, a random GUID can be used as a nonce, which is a number that is used only one time and is unpredictable by the attacker. A nonce is typically used for the purpose of preventing replay attacks.

3.1.2.1.6.2 Internal Structure

A GUID has substructure, which a GUID generator is required to be aware of. A protocol stack implementation that uses a GUID, unless the individual protocol specification explicitly states the contrary, **SHOULD** treat that GUID as an opaque single quantity to which only equality or inequality tests are applied. Such a protocol implementation **SHOULD NOT** make decisions based upon the substructure of the GUID.

[\[RFC4122\]](#) defines five versions of GUID and specifies how they are constructed. The known substructure is represented by the version and variant fields. The remaining fields (what the RFC refers to as time stamp and node) are what make the GUID unique.

In a version 1 GUID, these fields carry a value that is derived from the time and the computer's network node address, respectively. A side effect of a version 1 GUID is that it identifies the machine on which it was generated (barring replacement or transfer of its network interface card).

In a version 4 GUID, these fields have been replaced by random bits. In generating a version 4 GUID, an implementation SHOULD use a Federal Information Processing Standard (FIPS)-approved pseudo-random number generator (PRNG) (as specified in [\[FIPS140\]](#) or later), but any superior source of random bits (such as a true hardware PRNG) MAY be used instead. For more information about entropy sources, see [\[RFC4086\]](#). If a PRNG is used as the source of random bits, it takes a parameter called a seed. Although many experts in the field have studied, tested, and approved each FIPS-approved PRNG algorithm, no approved or nonapproved PRNG output is or can be more unique or less guessable than its seed. <14><15>

Any implementation of version 4 GUIDs MAY implement two types of GUID: one GUID for uniqueness only and another GUID for use as a nonce. These types are characterized as follows:

- **Uniqueness-only:** This GUID is not kept secret and it is not required to be unguessable. Therefore, the PRNG that is used to generate a version 4 GUID is required to be seeded only with values that have a high probability of being unique for that machine and that session. Typically, such a seed is formed by the cryptographic hash of uniqueness values, such as the CPU ID, MAC address, time of day, processor tick count, system process table, and system state.
- **Nonce or authenticator:** This GUID must be kept secret to preserve its security value. The PRNG that is used to generate a version 4 GUID for this purpose is required to be seeded with values that have a high probability, not only of being unique, but also of being unguessable by an attacker. Typically, such a seed is formed by the cryptographic hash of unguessable values of high entropy, such as the output of a hardware True Random Bit Generator, the system state readable in kernel mode, the history of system state over a long runtime, the accumulated entropy from earlier operation of the system (retained in a place that the attacker cannot access), the time of arrival of hardware interrupts, or the history of mouse positions as it moves.

A secret GUID that is suitable for a nonce is also suitable for uniqueness. Any system that generates cryptographic keys requires a source of true random or pseudo-random bits that are unguessable enough for building those keys. Therefore, it is common practice for an implementer to provide only one type of version 4 GUID, which is a type that is suitable for a nonce. It is also common practice to use cryptographic-quality random bits for generating that GUID, even when it is used only for uniqueness. <16>

3.1.2.1.6.3 Quality of Random Bits

Each use of a version 4 GUID has a measure of quality:

- **Uniqueness:** The probability that some other system will happen to generate the same GUID (without any conscious attempt by an attacker to create that collision).
- **Nonce:** The probability that some conscious attacker will be able to guess the generated GUID.

An ideal GUID that uses N bits of randomness collides with some chosen value by accident (violating uniqueness) with a probability proportional to 2^{-N} and is guessable by an attacker with work proportional to 2^N . This quality of randomness is measured by entropy. The ideal case is said to represent N bits of entropy.

If N allegedly random bits actually contain $M < N$ bits of entropy, the probability of accidental collision is proportional to 2^{-M} , and the work for an attacker is proportional to 2^M . This leads, in the case of GUIDs for uniqueness, to a higher-than-ideal probability of accidental collision. If such a collision occurs, the two different identified objects will have the same ID, which can lead to confusion. In the case of GUIDs for use as nonces, the lower work by the attacker might result in a successful replay attack.

Neither of these flaws, if one occurs, changes any protocol that uses such a GUID. It might change the security claims that such a protocol might make, but not the state machine, packet sequence, or packet contents of the protocol. The same applies to GUIDs that are used for uniqueness. If two GUIDs that were supposed to be different are the same, then the protocol implementation does not change, but the probability that a mistaken identity might occur increases.

Therefore, the implementer of a protocol is not required by the protocol specification to guarantee any quality of random bits. Nothing in the specification of any Microsoft Communications Protocol Program (MCP) protocol directs a conformant implementation to look for, much less detect, any use of low-quality random bits in GUID generation. This means that even a very low-entropy random bit stream can be used to generate GUIDs that will allow a protocol to interoperate and be indistinguishable from any other protocol implementation, no matter what the quality of random bits in the other implementation.

Of course, implementers who prefer to minimize the confusion that can result from nonunique GUIDs or the replay attacks that would result from guessable nonces are well advised to use the best-quality random bit sources that they can find.

3.1.2.2 Authentication

This section describes how identity is proven across a Windows network.

The purpose of authentication is for two communicating entities to establish the identity of one or both parties. It is presumed that the communication medium between the two entities is completely hostile, and that an attacker can inspect any message or tamper with any message. Tamper here means change, suppress, or replay. Protocols must be developed that allow the two entities to authenticate in such a challenging environment. The two entities usually consist of a client and a server.

Authentication can encompass several aspects. For example, authentication of the server may be sufficient. The use of Secure Sockets Layer (SSL) on the Internet is primarily centered on assuring the client of the identity of the server. For protected networks, client authentication may be sufficient because the valuable resource lives on a single server, and the server is required only to address the identity of the client.

On modern networks, however, proving the identity of both the client and the server is very important. Clients depend on the identity of a server to avoid divulging something important to a rogue server; servers must be assured of the identity of clients to avoid granting clients inappropriate access. This security concept is typically called mutual authentication.

Ultimately, authentication must be performed with cryptographic operations of a form, such as encryption or signatures. There are two main types of encryption: symmetric and asymmetric. Symmetric encryption uses the same key to encrypt and decrypt a message. Asymmetric encryption uses one key to encrypt and uses a different key to decrypt. These keys are linked by mathematical requirements. Signatures can be implemented in a number of ways through keyed hashes and encrypted hashes.

3.1.2.2.1 GSS Authentication Model

In the early 1990s, John Linn, then of Digital Equipment Corporation, proposed that applications not be tied to specific security protocols. This proposal was the genesis of the Generic Security Service Application Programming Interface (GSS-API). This concept has driven the model of most authentication protocols that are intended for use within an application protocol. This concept is generally referred to as GSS style or the GSS model. Note that there have been a number of channel-based protocols, such as Secure Sockets Layer (SSL), Transport Layer Security (TLS), and Secure Shell (SSH), which are intended to be below the application protocol layer.

This approach, however, has led to a simplified form of interaction between the application protocol and the authentication protocol. In this model, the application protocol is responsible for ferrying discrete, opaque packets that are produced by the authentication protocol. The application has no visibility into the contents of the message; its responsibility is merely to carry them. These messages, which GSS specifications refer to as tokens, implement the authentication process.

The application in this model first calls the authentication protocol on the client. The client portion of the authentication protocol creates a token and returns it to the calling application. The application then transmits that token to the server side of its connection, embedded within the application protocol. On the server side, the server application extracts the token and supplies it to the authentication protocol on the server side. The server-side authentication protocol can process the token and possibly generate a response or determine that the authentication is complete. If another token is generated, the application must carry it back to the client, where the process continues.

This exchange of security tokens continues until one or both sides determine that authentication is complete. If authentication fails, the application should drop the connection and indicate the error. If it succeeds, the application can then be assured of the identity of the participants, as far as the underlying protocol can accomplish.

When authentication is complete, session-specific security services can be available. The application can then invoke the authentication protocol to sign or encrypt the messages that are sent as part of the application protocol. These operations are done in much the same way, where the application can indicate what portion of the message is to be encrypted, and then must include a per-message security token. By signing or encrypting the messages, or both, the application can obtain privacy, resistance to tampering of messages, and detection of messages dropped, suppressed, or replayed.

3.1.2.2.2 History of the Windows Authentication Model

Microsoft Windows networking has its roots in the LAN Manager (LM) network product. LM was designed for a time when client authentication was sufficient for most needs, and when computational capacity was exceeded by the algorithms common at the time. For example, exhaustively searching Data Encryption Standard (DES) keys was unthinkable by any but the most dedicated government resources. LM authentication used a straightforward challenge-response style of authentication and was sufficient for many customers for many years.

When Microsoft decided to adopt the Kerberos protocol for Windows and move away from NT LAN Manager (NTLM), it required a substantial change for a number of protocols. This process is still going on today. Rather than repeat the process when circumstances required a new or additional security protocol, Microsoft chose to insert a protocol, in this case, Simple and Protected GSS-API Negotiation (SPNEGO), to allow security protocol selection and extension.

3.1.2.2.3 Authentication Protocols

Several protocols are available for authentication in Windows, each with different strengths and weaknesses, capabilities, and uses within the product.

3.1.2.2.3.1 Kerberos

In 1993, Microsoft began working toward adopting the **Kerberos** protocol. Kerberos support for mutual authentication, transitive trust among authorities, extensibility, public inspection and review, and performance and caching, all pointed to this protocol as the authentication protocol for enterprise deployment for the foreseeable future. Windows 2000 operating system shipped in 1999 with the Kerberos protocol natively supported.

For more information about the Kerberos protocol, see [\[MS-KILE\]](#), [\[MS-PKCA\]](#), and [\[MS-SFU\]](#).

3.1.2.2.3.2 NT LAN Manager (NTLM)

NT LAN Manager (NTLM) is an ongoing extension to the original LAN Manager (LM) authentication protocol. NTLM is conceptually straightforward and only performs client authentication. NTLM has undergone some revision (known as NTLMv2), which incorporates additional information into the computation of the response; however, it still follows the same general message flow.

NTLM can never provide mutual authentication in all situations; the client can never be assured of the identity of the server in a general manner. The only time that NTLM can provide mutual authentication is when the client knows, through out-of-band means, that the user name used for authentication exists only on the target server. This can constrain the authentication to, at a minimum, the extended set of trusted domains.

For more information about NTLM authentication, see [\[MS-NLMP\]](#).

3.1.2.2.3.3 Secure Sockets Layer (SSL) and Transport Layer Security (TLS)

SSL was introduced by Netscape to allow browsers to authenticate servers. SSL went through several revisions, culminating in adoption by the IETF and becoming the TLS protocol. For more information, see [\[RFC2246\]](#). Although SSL and TLS are used primarily for authenticating servers and creating a secure pipe between the client and the server, they do allow for client authentication. The client signs a challenge from the server with its private, asymmetric key, and sends both the signed data and the certificate to the server.

In Windows, the certificate is associated with an account in several ways, based on local policy and on the certificate fields of interest to the server or domain administrator. Ultimately, the SSL/TLS implementation on the server calls up to the DC through the Netlogon channel and asks the SSL instance on the DC to determine which account is associated with the certificate.

3.1.2.2.3.4 Simple and Protected GSS-API Negotiation Mechanism (SPNEGO)

SPNEGO is an authentication protocol that allows secure negotiation among other security protocols when the client and the server might support more than one protocol. SPNEGO uses a GSS-API authentication mechanism. GSS-API is a literal set of functions that include an API and a methodology for approaching authentication. As specified in [\[RFC2743\]](#), GSS-API and the individual **security protocols** that correspond to the GSS-API were developed to insulate **application protocols** from the specifics of security protocols as much as possible.

Windows uses SPNEGO instead of a specific protocol, to allow for simpler substitutions of additional security protocols. For more information, see [\[MS-SPNG\]](#).

3.1.2.3 Authorization

After an identity is suitably authenticated, the next step is to use the identity to authorize access to a resource. Windows has a very expressive authorization model available for applications and system components to use for making authorization decisions.

Windows was originally designed to meet the requirements of the C2 level of the Trusted Computer System Evaluation Criteria (TCSEC). The TCSEC program has since been supplanted by profiles written under the Common Criteria for Information Technology Security Evaluation, such as the Controlled Access Protection Profile.

The C2 requirements (and later the CAPP requirements) for authorization are centered upon *discretionary* access control. For discretionary access control, the owner of a particular resource (or a delegate of the owner) determines the level of access others should have, which is in contrast to mandatory access control schemes in which another party maintains control over the resource regardless of the expectations of the owner.

3.1.2.3.1 Resource Managers

Windows meets these requirements for discretionary access control by providing a single access evaluation routine that any number of **resource managers (RM)** can invoke. Many RMs—including the file system, registry, Active Directory, and operating system constructs such as processes—exist in a Windows-based system. Even though these RMs control very different objects, they share a common method for controlling access.

In the Windows authorization model, a RM is the code or component that implements one or more object types. The NTFS file system is a RM that implements files and directories; the Windows registry is a RM that implements keys. To participate in the authorization scheme, the RM is required to maintain a *security descriptor* with each object that is protected. The RM is required to maintain the storage for the security descriptor and is not required to understand the contents.

The Windows Security Overview also distinguishes between ordinary objects in the RM and containers exposed by the RM. In the file system example, files are objects and directories are containers. This distinction is important during the creation of new objects.

3.1.2.3.2 Security Descriptors

The security descriptor is a collection of four main elements. The **owner** field is a security identifier (SID) that specifies the owner of the resource. The **group** field specifies the group associated with the resource. The group field is not evaluated by Windows components, and it exists for POSIX compatibility. The **DACL** field specifies the discretionary access control list, and the **SACL** field specifies the system access control list (SACL).

When associated with a resource, the security descriptor is intended to be opaque. The resource manager (RM) should never be required to examine the contents of the security descriptor. However, the security descriptor fields can be used by the RM for other purposes. For example, in a billing scenario, the file system can implement a storage quota system by using the owner field in the security descriptor to determine the resources consumed with a specific user.

3.1.2.3.3 Discretionary Access Control Lists (DACLs) and Access Control Entries (ACEs)

Discretionary access control lists (DACLs, but often shortened to ACLs) form the primary means by which authorization is determined. An ACL is, conceptually, a list of **<account, access-rights>** pairs, although they are significantly richer than that.

Each pair in the ACL is termed an access control entry (ACE). Each ACE has additional modifiers that are used primarily during inheritance. There are also several different kinds of ACEs for representing both access to a single object (such as a file) and access to an object with multiple properties (such as an object in Active Directory).

The ACE contains the security identifier (SID) of the account to which the ACE pertains. The SID can be for a user or a group.

Windows supports both positive ACEs, which grant or allow access rights to a particular account, and negative ACEs, which deny access rights to a particular account. Supporting both positive and negative ACEs allows a resource owner to specify, for example, *grant read-access to group Y, except for user Z*.

DACLs can be configured at the discretion of any account that possesses the appropriate permissions to modify the configuration, including Take Ownership, Change Permissions, or Full Control permissions. DACLs consist of the following elements:

Header: Metadata pertaining to the ACEs associated with the DACL.

SID (user): The SID of the owner of the object.

SID (group): The SID of the built-in Administrators or Domain Admins group if the account that owns the object is a member of either of these groups.

Access control entry (ACE): A DACL can contain several ACEs. The following list identifies and describes these terms:

Explicit allow ACE: An ACE applied directly to the resource that grants access. An explicit allow will always override an inherited deny, but will always be overridden by explicit deny ACEs.

Explicit deny ACE: An ACE applied directly to the resource that denies access. An explicit deny will always override all other permissions.

Generic deny ACE: An ACE that denies access to an account or security group based on the user or group SID. A generic deny ACE can be inherited from the object's parent or assigned directly to the object. The generic deny ACE is specific to the object and child objects of the same class, based on the security settings defined in the object class in the schema.

Generic allow ACE: An ACE that allows access to an account or security group based on the user or group SID. A generic allow ACE can be inherited from the object's parent or assigned directly to the object. The generic allow ACE is specific to the object and child objects of the same class, based on the security settings defined in the object class in the schema.

Inherited deny ACE: An ACE inherited from the resource's parent object. An inherited deny ACE overrides an inherited allow permission, but is overridden by an explicit allow.

Inherited allow ACE: An ACE inherited from the resource's parent object.

Object-specific deny ACE: An ACE used within Active Directory that does one of the following:

- Denies access to a property on the Active Directory object.
- Denies access to a property set on the Active Directory object.

- Limits the ACE inheritance to a specified type of child object based on the SID(s) of the child or children.

The object-specific deny ACE can be inherited from the object's parent or assigned directly to the object. Also, the object-specific deny ACE applies to specific classes of child objects.

Object-specific allow ACEs: An ACE used within Active Directory that does one of the following:

- Allows access to a property on the Active Directory object.
- Allows access to a property set on the Active Directory object.
- Limits the ACE inheritance to a specified type of child object based on SID(s) of the child or children.

The object-specific allow ACE can be inherited from the object's parent or assigned directly to the object, and it applies to specific classes of child objects.

When access is requested to an Active Directory object, the Local Security Authority (LSA) compares the access token of the account that is requesting access to the object to the DACL. The security subsystem checks the object's DACL, looking for ACEs that apply to the user and group SIDs referenced in the user's access token. The security subsystem then steps through the DACL until it finds any ACEs that allow or deny access to the user or to one of the user's groups. The subsystem does this by first examining ACEs that have been explicitly assigned to the object and then examining ones that have been inherited by the object. The following illustration shows the evaluation process for an access token and a DACL when a request is evaluated.

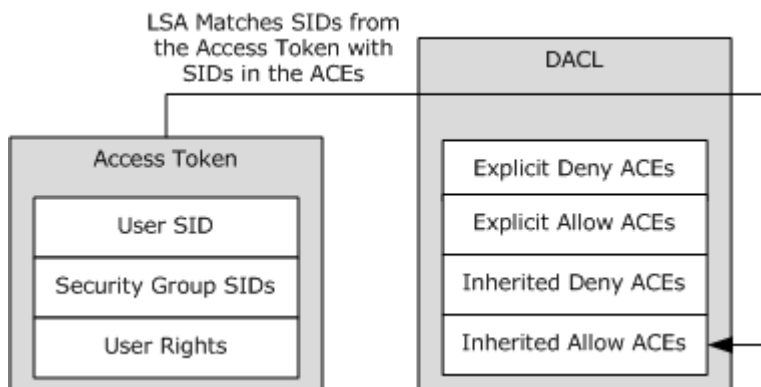


Figure 11: Evaluation process for access tokens against a DACL.

If an explicit deny is found, access is denied. Explicit deny ACEs are always applied, even if conflicting allow ACEs exist. Explicit allow ACEs are examined, as are inherited deny and allow ACEs. The ACEs that apply to the user are accumulated. Inherited deny ACEs overrule inherited allow ACEs but are overruled themselves by explicit allow permissions. If none of the user SIDs or group SIDs in the access token match the DACL, the user is denied access implicitly.

In Windows, a security principal's level of access to files and folders is determined by NTFS file system and share permissions. These permissions are discretionary, that is anyone with ownership of a file or folder, Change permissions, or Full Control permissions can assign access control at their discretion. When Windows is first installed, Windows assigns default permission structures to

operating system files and folders when it is newly installed, but a user might be required to alter these permissions to meet specific security requirements.

When a user attempts to access a file or folder on an NTFS partition, the user's access token is compared with the DACL of the file or folder. If no ACEs correspond to a SID in the user's access token, the user is implicitly denied access to the resource. If ACEs correspond to the user's access token, the ACEs are applied in the following order:

1. Explicit deny
2. Explicit allow
3. Inherited deny
4. Inherited allow

ACEs that apply to the user are cumulative, which means that the user will receive the sum of the ACEs that apply to his or her user account and groups of which the user is a member. For example, if an ACL contains two allow ACEs that apply to the user, one for Read access and the other for Write access, the user will receive Read and Write access.

3.1.2.3.4 Access Rights

Different resource managers (RM) and resource types have varying access rights. For example, files could have read and write access while processes could have entirely different rights, such as terminate. However, all RMs use the same formats for encoding access rights in the ACEs by allowing the RMs to define their own specific access rights.

Windows accomplishes the encoding of access rights in the ACEs by partitioning the access rights space. All access rights are encoded into a single, 32-bit value in the ACE. The most significant 16 bits are considered standard access rights and are common across all RMs. These rights include Delete access, Generic-Read access, and other similar rights. These rights are either expected of all RMs (such as Delete) or are used in a way that allows programs to work with multiple RMs in a similar manner.

The least significant 16 bits are termed object-specific and are meaningful only to the RM that defines them. As a result, the file system may specify that bit 1 indicates the capability to read the file and that bit 2 indicates the capability to write the file, whereas the registry may define bit 1 to be "enumerate subkeys" and bit 2 to be "read a key's value".

3.1.2.3.5 Authorization

Windows uses a single method in the system for determining access so that the results are always predictable and consistent. The authorization process is as follows:

To determine access, the calling resource manager (RM) supplies the security descriptor (which contains the ACL) with the identity of the user and all of the groups of which the user is a member, as well as the access requested by the user. The following example can be used to illustrate the authorization process:

```
Security Descriptor: Owner: U1, DACL: <<U2, Read>, <G1, Read>,
                  <G2, Write>>
Identity: <U1, G2>
Access Request: Write
```

In this example, the security descriptor has an ACL that grants U2 Read access, G1 Read access, and G2 Write access. The identity of the user making the request is U1, and that user is a member of the group G2 as well. The request is for Write access.

When processing this request, Windows iterates through the entries in the ACL, testing against the identity. If the identity in the ACE matches one of the identities of the user, the ACE is examined further. In this example, the first two ACEs do not match any identity, and so they are skipped. The third ACE applies (G2 matches), and then the granted access rights are compared against the access request. They match, and the user is therefore granted access.

As noted earlier, multiple access rights are encoded together, and therefore the access request could be for both Read access and Write access. In the preceding example, access would be denied because G2 was granted only Write access.

All the requested rights do not have to be granted by a single ACE. Consider the following example:

```
Security Descriptor: Owner:U1, DACL:<<U2,Read>,<G1,Read>,<G2,Write>>
Identity:<U1,G1,G2>
Access Request: Read,Write
```

For this example, the processing would be as follows:

The first ACE does not match, and so it is skipped. The second ACE does match and is therefore examined further. The granted access is removed from the access request, which, in this case, is Read. There are still values remaining in the access request, and therefore processing continues. The third ACE matches (on G2) and grants Write access. The granted access, Write, is removed from the access request, but there are no remaining access requests. The access is granted, and processing stops.

3.1.2.3.6 Inheritance

The Windows authorization model supports a concept of inheritance by which new objects can inherit one or more ACEs from their parent container. In practice, this allows an administrator to establish default security on, for example, a directory, and all new files that are created in that directory receive a preset ACL. The owner of the file can still override the ACL and establish its own. However, if nothing is done (through the premise of discretionary access control), the default is set by the administrator.

One attribute that can be applied to ACEs is the **Object-Inherit** flag. This flag indicates that when a new object is created, the ACE should be carried forward to the security descriptor of the new object. An additional flag, **Container-Inherit**, indicates that new containers that are created under this container should receive this ACE. For the file system, this allows different default ACLs for directories as opposed to files.

3.1.2.3.7 System Access Control Lists

A system access control list (SACL) enables administrators to log attempts to access a secured object. Like a DACL, an SACL is a list of ACEs. Each ACE specifies the types of access attempts made by a specified account, which cause the system to generate a record in the security event log. An ACE in an SACL can generate audit records when an access attempt fails, when it succeeds, or both.

3.1.2.3.8 Windows Integrity Mechanism

Beginning with Windows Vista operating system, the Windows integrity mechanism extends the security architecture by defining a new access control entry (ACE) type to represent an **integrity**

level in an object's security descriptor (see [\[MS-DTYP\]](#) section 2.4.6). Windows restricts access rights depending on whether the subject's integrity level is equal to, higher than, or lower than the object's integrity level. The integrity level of an object is stored as a mandatory label ACE which distinguishes it from the discretionary ACEs governing access to the object. <17>

The ACE represents the object integrity level. An integrity level is also assigned to the security access token when the access token is initialized. The integrity level in the access token represents a subject integrity level. The integrity level in the access token is compared against the integrity level in the security descriptor when the security reference monitor performs an access check. See [\[MS-DTYP\]](#) section 2.5.3.2 for an example of access-check algorithm pseudocode. The security subsystem implements the integrity level as a mandatory label to distinguish it from the discretionary access (under user control) that DACLs provide. See [\[MSDN-WIMD\]](#) for a discussion of Windows integrity mechanism design.

3.1.2.4 Impersonation and Delegation

In distributed systems, it is typical for a server to accomplish tasks on behalf of a client. The functionality of a server performing a task using the security context of a client to access the server's local resources is called **impersonation**.

The functionality of a server performing a task using the security context of a client to access another server's resources (remote resources) is called **delegation**.

In a Windows environment, delegation is only supported through RPC protocols when Kerberos authentication is used.

3.1.2.4.1 RPC Impersonation

Through impersonation, a thread runs in a security context that is different from the context of the process that owns the thread. When a server thread runs in the security context of the client, it uses an access token that represents the client credentials in order to obtain access to the objects to which the client has access. This provides the ability for a thread to run by using different security information from the process that owns the thread. Typically, a thread in a server application impersonates a client. This impersonation allows the server thread to act for that client in order to access objects on the server or validate access to the client objects.

The following figure shows the impersonation process. A client makes a request to server A. If server A must query server B to complete the request, server A impersonates the client security context and makes the request to server B for the client. Server B uses the security context of the original client, instead of the security identity for server A, to determine whether to complete the task.

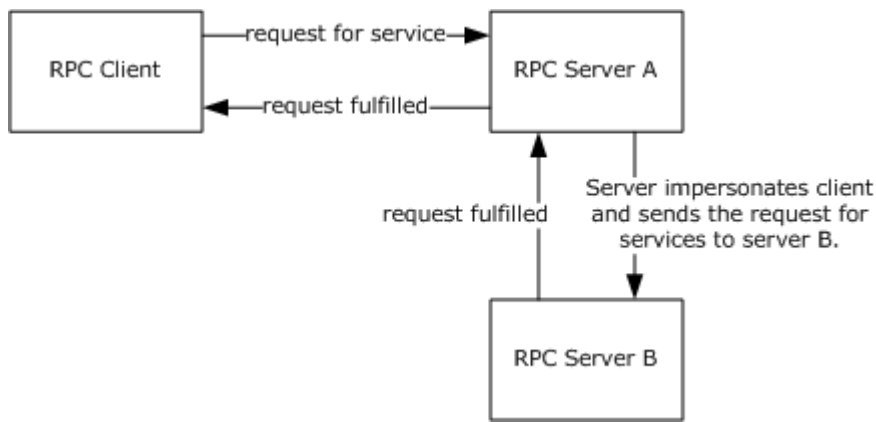


Figure 12: Impersonation process.

When delegation is used, a server that is impersonating a client can call another server and can make network calls by using the credentials of the client. From the perspective of the second server, requests that come from the first server are indistinguishable from requests that come from the client. Not all security providers support delegation. Windows provides only one security provider that supports delegation: the Kerberos protocol.

Delegation must be implemented with caution due to the privileges that the client gives to the server during a remote procedure call (RPC). To address this, the Kerberos protocol allows calls that use the impersonation level of delegation only if mutual authentication is requested. Domain administrators can limit the computers to which calls with delegation impersonation level are made to prevent unsuspecting clients from making calls to servers that can abuse their credentials.

Calls that use **ncalrpc** [\[MSDN-NCALRPC\]](#) are an exception to the delegation rule. When these calls are made, the server gets delegation rights, even if an impersonation level of impersonate is specified. That is, a server can call other servers on behalf of the client. This works for one remote call only. For example, if client A calls local server LB using **ncalrpc**, local server LB can impersonate and call remote server RB. Remote server RB can act for client A, but only on the remote computer on which remote server RB is running. Local server LB cannot make another network call to remote computer C unless LB specifies an impersonation level of delegate when it calls RB.

A primary use of impersonation is to perform access checks against the client identity. Using the client identity for access checks can cause access to be either restricted or expanded, depending on what the client has permission to do. For example, a **file server** might have files that contain confidential information and each of these files is protected by an ACL. To help prevent a client from obtaining unauthorized access to information in these files, the server can impersonate the client before accessing the files.

3.1.2.4.2 SMB Impersonation

The CIFS/SMB/SMB2 protocols also have support for clients to request impersonation on file creation requests, but in reality the impersonation implementation in the CIFS/SMB/SMB2 protocols is entirely superficial. The protocols do allow for the transport of an impersonation level, but although the requested impersonation level carried by the SMB protocols is checked by the server for validity, it is not acted on by any component of the SMBprocessing path.

Therefore for the SMB family, impersonation can be described as having no meaning.

An added confusion arises because the basic principle of an SMB server operation is sometimes referred to as "impersonating" clients. The reason for this is that for each create or open operation, the SMB server passes the session's authenticated security context to the object store for the purposes of authorizing the access to the file for the specified "Desired Access". Because the SMB server is a privileged entity, it is said to be "impersonating" the remote client. However, the remote client does not direct this process, and cannot request any other impersonation service. Subsequent operations involving the previously issued handle do not require further authorization, as the checks were performed at the time of initial access.

There is a small number of other SMB operations that perform authorization decisions based on the authenticated Security Context, such as **TreeConnect**, SMB2's **ABDE (Access-Based Directory Enumeration)** and **quota info**. None of these operations provide an impersonation level, bearing out the vestigial nature of the one carried out by SMB open and create.

3.1.2.4.3 Cloaking

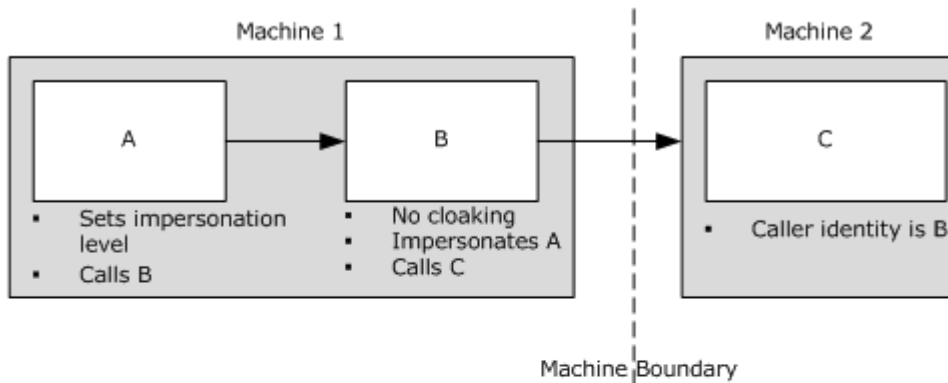
There are two important security considerations for using [impersonation](#) and delegation:

- What should the server be allowed to do when acting for the client?
- What identity is presented by the server when it calls other servers for a client?

In Windows, the Component Object Model (COM) provides the functionality that is explained here. The client can set an [impersonation level](#) that determines the extent to which the server can act as the client. If the client grants enough authority to the server, the server can impersonate (pretend to be) the client. When the server impersonates the client, it is given access to only those objects or resources for which the client has permission to use. The server, acting as a client, can also enable [cloaking](#) in order to mask its own identity and project the client identity in calls to other COM components.

The following figure illustrates impersonation without and with cloaking. A and B represent two processes running on machine 1, and C represents a process that is running on machine 2. Process A calls B, and B calls C. Client A sets the impersonation level. B sets the cloaking capability. If A sets an impersonation level that permits impersonation, B can impersonate A when calling C on A's behalf. The identity that is presented to process C is either A's identity or B's identity, depending on whether cloaking was enabled by B. If cloaking is enabled, the identity that is presented to process C is A. If cloaking is not enabled, B's identity is presented to C.

A) Impersonation without cloaking



B) Impersonation with cloaking

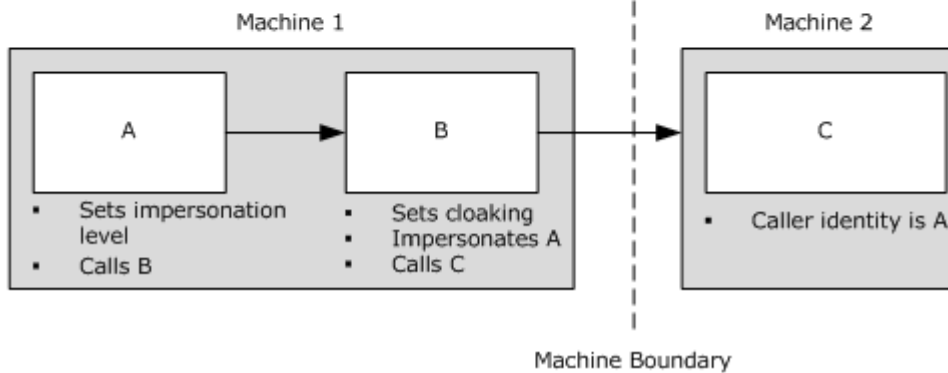


Figure 13: Impersonation without and with cloaking.

3.1.2.4.4 Impersonation Tokens

Access tokens are objects that describe the security context of a process or a thread. They provide information that includes the identity of a user account and a subset of the privileges that are available to the user account. Every process has a *primary* access token that describes the security context of the user account that is associated with the process.

By default, the system uses the primary token when a thread of the process interacts with a securable object. However, when a thread impersonates a client, the impersonating thread has both a primary access token and an impersonation token. The impersonation token represents the security context of the client.

Authentication protocols ([\[MS-KILE\]](#) and [\[MS-APDS\]](#)) which transport authorization data based on security identifiers (SIDs) populate the User SID and Security Group SIDs in the impersonation token. By default, all fields of the token are NULL and the token is not valid until populated by these protocols.

The authentication protocols query the local account database for the built-in and local group membership by passing the User SID and Security Group SIDs to GatherGroupMembershipForSystem (section [3.1.2.4.4.1](#)) and then updates the impersonation token. Finally, the authentication protocols can use AddPrivilegesToToken (section [3.1.2.4.4.2](#)) to populate the privileges of the impersonation token.

If an authentication takes place across a network then the impersonation token is populated with the NETWORK group SID ([\[MS-DTYP\]](#) section 2.4.2.4, Well-Known SID Structures).

This access token is the one that is used for access checks during impersonation. When impersonation is complete, the thread reverts to using only the primary access token.

3.1.2.4.4.1 GatherGroupMembershipForSystem

The **GatherGroupMembershipForSystem** function accepts an array of SIDs and invokes **GatherLocalGroupMembership** which in turns invokes **GatherLocalGroupMembershipFromLocalDomain** for the local account domain and again for the built-in domain.

An array of SIDs is returned that includes all input SIDs and the SIDs for all local groups of which the input SIDs are members.

```
GatherGroupMembershipForSystem( InitialMembership, FinalMembership )
--
-- On entry   InitialMembership is a non-empty array of SIDs
--
-- On exit    FinalMembership is a array of SIDs
--
CALL GatherLocalGroupMembership ( InitialMembership, FinalMembership )
END_SUBROUTINE
```

The *InitialMembership* and *FinalMembership* parameters are arrays of SIDs. This method is called by authentication protocols during the process of authentication (see [\[MS-KILE\]](#) section 3.4.5.3: Processing Authorization Data, and [\[MS-APDS\]](#) section 3.1.5: Processing Events and Sequencing Rules).

```
GatherLocalGroupMembership( InitialMembership, FinalMembership )
--
-- On entry
--   InitialMembership is a non-empty set of SIDs
--
-- On exit
--   FinalMembership is a set of SIDs
--
    GatherLocalGroupMembershipFromLocalDomain( InitialMembership,
                                                LocalDomainSid,
                                                FinalMembership )
    GatherLocalGroupMembershipFromLocalDomain( FinalMembership,
                                                BuiltinDomainSid,
                                                FinalMembership )
END_SUBROUTINE
```

```
GatherLocalGroupMembershipFromLocalDomain( InitialMembership,
                                            LimitingDomain,
                                            FinalMembership )
--
-- On entry
--   InitialMembership is an array of SIDs
--   LimitingDomain is a domain SID
--
-- On exit
```

```

--      FinalMembership is an array of SIDs including any SID from InitialMembership
--      plus all SIDs of groups of which SIDs in InitialMembership are members.
--
Domain d is the domain in Local Domains with objectSid equal LimitingDomain
AdditionalMembership is a set of sids initially empty

Set FinalMembership equal to InitialMembership

FOR EACH GROUP g in d DO
  FOR EACH SID m in g.members DO
    FOR EACH SID s in InitialMembership DO
      if m equals s
        Set AdditionalMembership equal to the union of
          AdditionalMembership and g.objectSid
      END IF
    END FOR
  END FOR
END FOR

Set FinalMembership equal to the union of
  InitialMembership and AdditionalMembership
END_SUBROUTINE

```

3.1.2.4.4.2 AddPrivilegesToToken

The **AddPrivilegesToToken** function returns a token with privileges based on the local **PrivilegeMapping** array (see [5.1](#)) using the SID in the token passed to the function.

```

AddPrivilegesToToken( Token )
-- On entry
-- Token is an authorization context containing all sids that represent the security
principal

FOR EACH SID s in Token DO
  FOR EACH MAPPING mapping in PrivilegeMapping DO
    IF mapping.SID equals s
      Token.Privileges is a union of Token.Privileges and mapping.Privileges
    END IF
  END FOR
END FOR
END-SUBROUTINE

```

3.1.2.4.5 Impersonation Levels

Windows provides various degrees of impersonation through impersonation levels, which indicate how much authority is given to the server when it is impersonating the client.

Currently, four impersonation levels are available: anonymous, identify, impersonate, and delegate. [<18>](#) The following list briefly identifies and describes each impersonation level:

- **Anonymous level (RPC_C_IMP_LEVEL_ANONYMOUS):** The client is anonymous to the server. The server process can impersonate the client, but the impersonation token does not contain any information about the client. This level is supported only over the local interprocess communication transport. All other transports silently promote this level to identify.

- **Identify level (RPC_C_IMP_LEVEL_IDENTIFY):** The system default level. The server can obtain the identity of the client, and impersonate the client in order to do ACL checks.
- **Impersonate level (RPC_C_IMP_LEVEL_IMPERSONATE):** The server can impersonate the security context of the client while acting for the client. The server can access local resources as the client. If the server is local, it can access network resources as the client. If the server is remote, it can access only resources that are on the same machine as the server.
- **Delegate level (RPC_C_IMP_LEVEL_DELEGATE):** The most powerful impersonation level. When this level is selected, the server (whether local or remote) can impersonate the security context of the client while acting on behalf of the client. During impersonation, the client credentials (both local and network) can be passed to any number of machines. <19>

For impersonation to work at the delegate level, the following requirements must be met:

- The client must set the impersonation level to `RPC_C_IMP_LEVEL_DELEGATE`.
- The client account must not have the `ADS_UF_NOT_DELEGATED` bit set on the `userAccountControl` attribute ([MS-ADTS] section 2.2.15) in Active Directory.
- The server account must have the `ADS_UF_TRUSTED_FOR_DELEGATION` bit set on the `userAccountControl` attribute ([MS-ADTS] section 2.2.15) in Active Directory.
- The computers that host the client, the server, and any "downstream" servers must all support and use Kerberos.

By choosing the impersonation level, the client tells the server how far it can go in impersonating the client. The client sets the impersonation level either process-wide or through the proxy it uses to communicate with the server.

A request for Delegation may succeed or fail. If the request fails, then the default level is used, which is Impersonate.

3.1.2.4.6 Setting the Impersonation Level

There are two ways to set the impersonation level:

- The client can set the impersonation level processwide through a call to [CoInitializeSecurity](#).
- The client can set proxy-level security on an interface of a remote object through a call to [IClientSecurity::SetBlanket](#) (or the helper function [CoSetProxyBlanket](#)).

The impersonation level is set by passing an appropriate `RPC_C_IMP_LEVEL_xxx` value to [CoInitializeSecurity](#) or [CoSetProxyBlanket](#) through the `dwImpLevel` parameter.

Different authentication services support delegate-level impersonation to a different extent. For example, NTLMSSP in Windows 2000 operating system supports cross-thread and cross-process delegate-level impersonation, but not cross-machine impersonation. However, the Kerberos protocol (implemented by Windows 2000) supports delegate-level impersonation across machine boundaries, whereas SChannel does not support any impersonation at the delegate level. If there is a proxy at the impersonate level and the implementer wants to set the impersonation level to delegate, [IClientSecurity::SetBlanket](#) SHOULD be called by using the default constants for every parameter except the impersonation level. COM chooses NTLM locally and the Kerberos protocol remotely (when the Kerberos protocol is supported).

3.1.2.4.7 Windows API Impersonation Functions

The Windows API provides the following functions to begin an impersonation:

- A Dynamic Data Exchange (DDE) server application can call the [DdeImpersonateClient](#) function to impersonate a client.
- A named pipe server can call the [ImpersonateNamedPipeClient](#) function.
- The [ImpersonateLoggedOnUser](#) function can be called to impersonate the security context of an [access token](#) for a logged-on user.
- The [ImpersonateSelf](#) function enables a thread to generate a copy of its own access token. This is useful when an application is required to change the security context of a single thread. For example, sometimes only one thread of a process is required to enable a [privilege](#).
- The [SetThreadToken](#) function can be called to prompt the target thread to run in the security context of a specified [impersonation token](#).
- An remote procedure call (RPC) server application can call the [RpcImpersonateClient](#) function to impersonate a client.
- A [security package](#) or application server can call the [ImpersonateSecurityContext](#) function to impersonate a client.

For most of these impersonations, the impersonating thread can revert to its own security context by calling the [RevertToSelf](#) function. The exception is the RPC impersonation, in which the RPC server application calls [RpcRevertToSelf](#) or [RpcRevertToSelfEx](#) to revert to its own security context.

For more information about the Windows API impersonation functions, visit the [MSDN home page](#).

3.1.3 File, Print, and Fax Concepts

Fax Services, Print Services, and File Access Services all require foundational knowledge of:

- SMTP: The Simple Mail Transfer Protocol, as defined in [\[RFC821\]](#)
- TIFF: Tagged Image File Format, as defined in [\[RFC3302\]](#)
- EMFPLUS: Enhanced Metafile Format Plus Extensions, as defined in [\[MS-EMFPLUS\]](#)
- Object Stores (NTFS, FAT, FAT32)
- Accessing a File Share through NFS Access Protocols or SMB Access Protocols

The following concepts are important for understanding the usage of the File Access System and the Print Services System, as described in [\[MS-FSSO\]](#) and [\[MS-PSSO\]](#), respectively:

- Group Policy
- Active Directory
- Windows® BranchCache™

The following section compares and contrasts concepts that are common to the File, Print, and Fax protocols.

3.1.3.1 File Access Services and Print Services Commonalities

The Print Services System and File Access Services are related as a result of a mutual dependency: the Print Services System uses the SMB Services component within the File Access Services System, and the SMB Services component uses the Print Services System.

The Print Services System uses the SMB Services component within the File Access Services System for the following tasks:

- When the **print client** copies printer driver files and printer driver packages from **print server** by calling local APIs of the SMB Services component, which remotely uses the SMB protocol family.
- In certain configurations and scenarios, when the print client sends print jobs to print server by calling local APIs of the SMB Services component, which remotely uses the SMB protocol family.
- In certain configurations and scenarios, when the print client monitors **print queue** and job status on the print server by calling local APIs of the SMB Services component, which remotely uses the protocol described in [\[MS-RAP\]](#).

The SMB Services component within the File Access Services System uses the Print Services System for the following tasks:

- To route print jobs received via the SMB protocol family to a local API of the **print spooler** running on the same server.
- To route print queue and job status monitoring requests received via the protocol described in [\[MS-RAP\]](#) to a local API of the print spooler running on the same server.

These mutual dependencies require that the subsystems that support the Print Services System and File Access Services are installed together on clients and servers.

3.1.3.1.1 Remote File Systems

Remote file systems enable an application that runs on a local computer to access files stored on a remote computer. See *[Rifkin1986]* for a discussion on providing transparent access to remote files. The remote file access takes place using some form of local area network (LAN), wide area network (WAN), point-to-point link, or other communication mechanism. These file systems are often referred to as network file systems or distributed file systems. Windows includes support for several remote file systems, including systems based on the following protocols:

- CIFS / SMB / SMB2 Family
- Network File System (NFS) [\[RFC1813\]](#)
- WebDAV
- NetWare Core Protocol (NCP) [\[NCP\]](#)
- IBM mainframe VSAM and AS/400 file access

The support for remote file systems in Windows is based on installable drivers and therefore may be extended. The support of remote file systems requires three components:

- Software installed on the client to use a transport protocol.
- A transport protocol used for communication, and a network connection.

- Software installed on the server to use a transport protocol.

The software component of a remote file system on a client computer is referred to in Windows as a network redirector, as it is responsible for redirecting requests for file operations from local client applications to a remote server where the requests are processed. The network redirector receives responses from the remote server that are then returned to the local application. The local application may be unaware that remote file I/O rather than local file I/O has occurred. Hence the network redirector software creates the appearance on the client system that remote files and resources are the same as local files and resources and allows them to be used and manipulated in the same way. In Windows it is possible to have multiple redirectors installed at any given time. The Windows Driver Kit (WDK) [\[MSDN-WinDriverKit\]](#) gives details for developing providers, which are essentially device drivers.

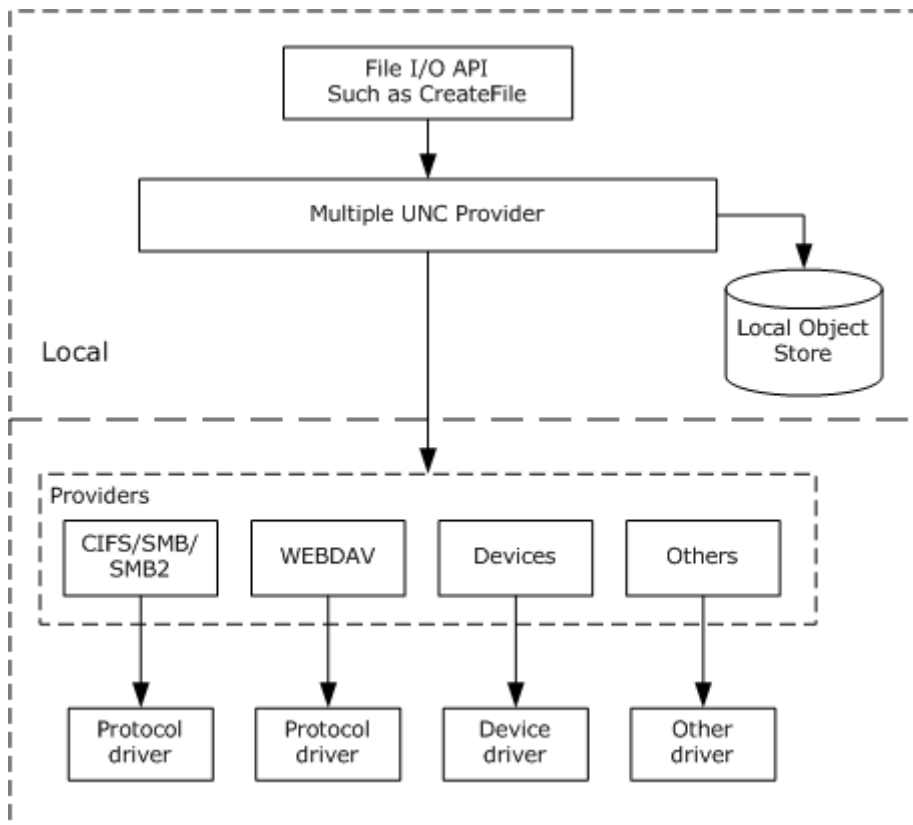


Figure 14: The Windows File Provider Architecture

The **Multiple UNC Provider** component of Windows is a **Universal Naming Convention (UNC)** resource locator responsible for determining the correct provider for UNC connections. By using the Multiple UNC Provider to find the provider for a UNC connection, Windows can simultaneously have multiple network redirectors installed that support various formats of UNC names.

With multiple redirectors that can all support UNC names, there is the potential that more than one provider could service a UNC name, therefore an arbitrator is needed. Windows inspects an application's UNC requests, determines which of the currently installed providers, if any, can service the UNC name, and routes the application request to that provider.

Provider selection is invoked as part of all UNC name based I/O requests. When Windows receives a UNC request, it accesses all of the installed providers in order to determine what provider, or

providers, can accept the request. Further details on the process are available in [WININTERNALS] chapter 13.

Once the initial routing is determined, no further interaction from provider selection is required and the application accesses the file via the provider as it would any file-based service, whether local or remote.

3.1.3.2 Network Printing and Internet Printing

The Print Services System provides support for a print client that is sending print jobs to a printer that is using a private network, as well as to a printer using the internet. Network printing and internet printing use different protocols that provide different capabilities:

- **Network printing:** A print client within a private network can send a print job to a printer attached to a print server within the same network. When printing within a private network, the authentication of a print client's right to use the print server is included, which supports a level of security that allows print clients to use RPC-based printing protocols to communicate with a print server, such as RPRN (RPC/named SMB pipes), PAR (RPC/TCP), and PAN (RPC/TCP).
- **Internet printing:** A print client can send a print job across the internet to a printer attached to a print server connected to the internet. The print server may be within a private network that is connected to the internet by a server providing a **firewall**. The process of printing across the internet typically involves sending a print job or a print driver file across a firewall that prohibits the use of RPC-based protocols for security reasons. Consequently, the Print Services System supports alternate protocols based on HTTP/HTTPS for sending a print job to the print server (standard IPP), and for downloading a printer driver file from the print server (WPRN). The Print Services System also supports internet printing using the standard LPD/LPR protocol.

3.1.3.3 Fax Services and Print Services Distinctions

The protocol described [MS-FAX] enables communication between a client system and a FAX Server. Use of the FAX protocol is completely distinct from use of the printing-related protocols described in the Print Services System documented in [MS-PSSO], though both are RPC-based. Although a single shared fax driver appears locally in the user interface on a client system (enumerated as a 'printer' driver), no [MS-PSSO] protocols are used to interact with that driver or to support any FAX use cases. The fax printer driver uses only the [MS-FAX] protocol to transfer faxes from the client system to a FAX Server, without relying on any member protocol of the Print Services System.

The primary component described by the Print Services System is a print spooler, which is responsible for receiving the print output of an application, buffering it, and sending the print data to a shared print queue managed by the print spooler. Print queues are associated with printer drivers that support the creation of application print output and the translation of **metafiles**, which allows applications to obtain metrics and status information about printers. The Windows implementations of the print client and print server roles are provided by the print spooler component. Each Windows system runs a print spooler. Therefore, each Windows computer can act as a print client or a print server.

The primary components described by the Fax Services are client-based components for composing fax documents, which includes the ability to select and edit fax cover pages, server-based components for queuing, routing, transmitting, and archiving fax documents, as well as a fax console used to configure the Fax Server using protocol methods described in [MS-FAX]. The fax functionality embodied in the shared fax driver on a client wrap the **fax job** in an RPC-based wrapper and then forward the job, using RPC interfaces, to the RPC Interface Module of the Fax Server, and then to the outgoing **fax queue**.

The fax queues on a Fax Server, as described in [MS-FAX], provide different capabilities than the print queues described in [MS-PSSO], although both are called "queues". A Fax Server has a single outgoing queue of faxes awaiting transmission. The Fax Server's outbound routing module dynamically determines, based on rules installed by default or configured from the fax console, which fax device or device group to use to transmit each fax job stored in the single outgoing queue. A print server described in [MS-PSSO] has multiple print queues associated with multiple devices. The client of the print server chooses a single print queue to be used for any particular print job.

A Fax Server also has a single incoming queue that holds received faxes that have not yet been delivered to their final destinations. The Fax Server uses inbound fax routing extensions to process received faxes and deliver them to their destinations. Of three standard fax routing extensions, one extension delivers a fax to a printer, and does so by making local API calls to the Print Services.

Fax queues use only the .TIFF data format to store sent and received fax jobs, however fax queues also use a variety of queue data formats (.FQP, .FQE, .FQR, .FQT) defined by Fax Services to support routing and transmission of fax jobs. To print an inbound fax, the Fax Services use local print spooler API calls and printer drivers to send the fax to a print queue in a manner identical to that of other printing applications. The .TIFF data format is converted locally to a print system-specific data format.

3.1.4 Systems Management Concepts

3.1.4.1 Managed Host

The Windows Management System provides management of individual computers, called managed hosts, and also provides management of individual objects on those hosts. The Windows Protocols System provides not only the ability to monitor host functions and health, but also to modify the behavior of certain of those functions through the Windows Management System and the Group Policy System.

3.1.4.2 Managed Object

A managed object is a hardware or software component of a managed host. The Windows Protocols System provides not only the ability to monitor the behavior and history of an object, but also to modify certain behaviors of the object through the Windows Management System and the Group Policy System.

3.1.4.3 Group Policy

Group Policy is an infrastructure used to deliver and apply one or more desired configurations or policy settings to a set of targeted users and computers within an Active Directory environment. This infrastructure consists of a Group Policy engine and multiple client-side extensions (CSEs) responsible for writing specific policy settings on target client computers.

Group Policy settings are contained in Group Policy Objects (GPOs), which live in the domain and can be linked to Active Directory sites, domains, or organizational units (OUs) containers. The settings within GPOs are then evaluated by the affected targets through Active Directory.

Group Policy is one of a group of systems management technologies that provides users with consistent access to their applications, application settings, roaming user profiles, and user data, from any managed computer -- even when they are disconnected from the network.

Core Group Policy or the Group Policy engine is the framework that handles common functionalities across Administrative Template settings and other client-side extensions.

3.1.5 Application Services Concepts

For implementations that use the Transaction Processing System and/or the Message Queuing System, the following background knowledge, as described in [GRAY], is required:

- ACID transactions
- Transaction processing concepts
- Concept of **transaction managers**, applications, and resource managers in transaction processing
- Two-Phase Commit protocol
- Transaction trees, root transaction manager, superior and subordinate participants
- Transaction marshalling, transaction pull and push propagation, and transaction recovery

Additionally, an understanding of the following concepts is required, as described in [MS-TPSO] sections [3.1.3](#), [3.1.4](#), and [3.1.5](#):

- Phase Zero
- Single-Phase Commit
- System Base and System External protocols

3.1.6 Web Services Concepts

Several Windows Protocols Systems protocols, such as those specified in [MS-RMPR], [MS-WUSP], and [MS-WSMAN], are implemented as Web Services protocols using SOAP and Web Services Description Language (WSDL). Other protocols in the Windows Protocols System, such as the one specified in [MS-LWSSP], are extensions or profiles of SOAP and Web Services protocols, such as [WSTrust1.3].

For more information on Web Services, see the [W3C] web site.

The following table lists the documents that describe the Microsoft Web Services protocols and their associated System Documents, where applicable.

Documents describing Microsoft Web Services protocols and associated System Documents.

Document short name	System document	Protocol name
[MS-ADCAP]	None	Active Directory Web Services: Custom Action Protocol Specification
[MS-ADDM]	None	Active Directory Web Services: Data Model and Common Elements
[MS-BPDP]	None	Background Intelligent Transfer Service (BITS) Peer-Caching: Peer Discovery Protocol Specification
[MS-DPWSSN]	None	Devices Profile for Web Services (DPWS): Size Negotiation Extension
[MS-DSML]	None	Directory Services Markup Language (DSML) 2.0 Protocol Extensions

Document short name	System document	Protocol name
[MS-LWSSP]	None	Lightweight Web Services Security Profile
[MS-MWBE]	None	Microsoft Web Browser Federated Sign-on Protocol Extensions
[MS-MWBF]	None	Microsoft Web Browser Federated Sign-on Protocol Specification
[MS-WSDS]	[MS-ADSO]	WS-Enumeration: Directory Services Protocol Extensions
[MS-WSMAN]	[MS-WMSO]	Web Services Management Protocol Extensions for Windows Server 2003
[MS-WSMV]	[MS-WMSO]	Web Services Management Protocol Extensions for Windows Vista
[MS-WSPELD]	[MS-ADSO]	WS-Transfer and WS-Enumeration Protocol Extension for Lightweight Directory Access Protocol v3 Controls Specification
[MS-WSTEP]	[MS-CAESO]	WS-Trust X.509v3 Token Enrollment Extensions
[MS-WSTIM]	None	WS-Transfer: Identity Management Operations for Directory Access Extensions
[MS-WSRVCAT]	[MS-TPSO]	WS-AtomicTransaction (WS-AT) Version 1.0 Protocol Extensions
[MS-XOPP]	None	XML-binary Optimized Packaging (XOP) Profile

3.1.7 Digital Rights Management and Rights Management Services

Two unrelated protocols in Windows share the terms "rights management" in their titles:

- Windows Media Digital Rights Management (WMDRM): License Protocol specified in [\[MS-DRM\]](#). This protocol is commonly referred to as WMDRM License protocol.
- Rights Management Services (RMS): Client-to-Server Protocol specified in [\[MS-RMPR\]](#). This protocol is commonly referred to as RMS Client-to-Server protocol.

WMDRM License protocol provides secure distribution, promotion, and sale of digital media content. This protocol is used to acquire licenses specifically for Windows Media content protected using Digital Rights Management Version 1, Digital Rights Management Version 7, or Digital Rights Management Version 11 technologies. In order to implement this protocol, the following data must be licensed from Microsoft for the license acquisition server prior to implementing any of these protocols:

- Private server cryptographic key (KS_{priv}).
- Server certificate chain (CS).

For every license server that implements this protocol, the implementer must generate the unique key pair, Server public/private key pair (KL), as specified in [\[MS-DRM\] \(section 1.5\)](#). The client applications that acquire licenses from the license server use the following keys and **certificates** as specified in [\[MS-DRM\] \(section 1.5\)](#):

- Private client cryptographic key (KC_{priv}).
- Public server cryptographic key (KS_{pub}).

- Client application certificate (CA) (leaf certificate only).
- Client machine certificate (CM).
- Public key representing the root certification authority (CA) key used to sign the root certificate in CS (KI_{pub}).

In contrast, the RMS Client-to-Server protocol is a **SOAP**-based protocol that uses HTTP 1.1, as specified in [\[RFC2616\]](#), as its transport. A system (RMS system) that implements this protocol enables end users to create and access protected information from the RMS system. The RMS Client-to-Server protocol is used for obtaining and issuing certificates and licenses through content encryption and fine-grained **policy** definition and enforcement. This protocol is used for restricting information access to only authorized users who are using trusted applications. Content protected with Windows RMS technologies (RMS-protected content) is encrypted and contains an associated usage policy, which defines the restrictions each user has when using the content. Usage policies work by assigning rights to users or groups of users. RMS defines and recognizes several rights by default. Such as permission to read, copy, print, save, forward, and edit. Applications can also add custom rights.

The RMS Client-to-Server Protocol uses the SOAP messaging protocol, as specified in [\[SOAP1.2-1/2003\]](#), for formatting requests and responses. It transmits these messages using the HTTP and/or HTTPS protocols. SOAP is considered the wire format used for messaging, and HTTP and HTTPS are the underlying transport protocols. The content files are downloaded using HTTP.

The RMS Client-to-Server Protocol user certification endpoint uses authentication to determine the requesting user's identity.

For user authentication of requests to the licensing or user certification endpoints, the RMS Client-to-Server Protocol can use the Microsoft Web Browser Federated Sign-On Protocol, as specified in [\[MS-MWBF\]](#).

The RMS Client-to-Server Protocol is composed of Web services using SOAP over HTTP or HTTPS, for communication.

A system that implements RMS, as specified in [\[MS-RMSO\]](#), has three major entities: the creator, the consumer, and the server. The creator builds content and chooses an access policy for that content. When the RMS creator protects the content it is encrypted using a randomly generated content key. Both this key and the access policy are bound to the content in the form of a publishing license.

The consumer, upon receiving the document from the creator and opening it, supplies the server with the publishing license and the consumer's identity. If the consumer is allowed access, according to the access policy in the license, the server issues the consumer a use license that specifies the access policy for the consumer and binds the content decryption key to the consumer's identity.

A client can play the role of a creator, a consumer, or both, depending on the type of implementation. The client is responsible for requesting certificates, licenses, and policies from the server. It is also responsible for enforcing authorization policies as they apply to protected information and encrypting or decrypting content as appropriate.

The server role in an RMS implementation is responsible for issuing certifications, keys, and authorization policies, and for signing these issued certificates and policies with keys it holds in escrow. It is also responsible for evaluating and issuing authorization policies based on identity credentials the client provides in protocol requests.

3.2 System Purposes

Microsoft Communications Protocol-based systems provide services based on Microsoft protocols (including extensions to industry-standard or other published protocols) and in conjunction with publicly available standards-based protocols, such as TCP/IP, HTTP, HTTPS, SMTP, and FTP. These systems are not oriented toward server-to-server protocols, nor are they oriented toward client-to-device protocols. They do not include any printer protocols or printer-specific commands or content. They are also not oriented towards communication solely within a single computer that is not using a network.

Systems that use Microsoft Communications Protocols provide server software that interoperates with Windows desktop operating systems to provide the following services to clients:

- **Authentication Services:** Services that provide account authentication, authorization, access control, policy enforcement, data-packets usage accounting, and data-packet auditing services between a client and a server.
- **Collaboration Services:** Services that provide audio and/or video conferencing, instant messaging, white boarding, application sharing, and similar services.
- **File Services:** Services that communicate data packets from data stored on storage media that is located on other network-attached computers.
- **Network Access Protection Services:** Services that communicate client health status information, digital certificate requests, and digital certificate issuance or refusal data packets between a client and server to accomplish system health evaluation goals and to aid in ensuring the health and protection of networked systems.
- **Multiplayer Games Services:** Services that transfer multiplayer game data is over the network.
- **Proxy/Firewall/NAT Services:** Services that examine and reject or forward data packets based on predefined permissions.
- **Systems Management Services:** Services that provide remote systems management functionality.
- **Virtual Private Network Services:** Services that provide functionality for communication between a VPN server and a VPN client, which includes the following data communication:
 - Authentication, policy, authorization, and connection data packets as part of a private network connection.
 - Secure and private network data packets encoded for IPsec network address translator traversal.
- **Windows Update Services:** Services that communicate software update information, software update metadata, and XPRESS compression data between a Windows Server Update Services (WSUS) implementation and a Windows Client configured to communicate with the Windows Update Services (WUS).
- **Certificate Services:** Services that provide X.509 certificate requests, renewal, key archival, certificate issuance, and lifecycle-management services.
- **Digital Rights Management Services:** Services that access and generate **license** requests relating to digital rights management.
- **General Services** include the following:

- **Transaction Processing Services** used to communicate with a transaction manager to perform distributed transaction coordination to drive the transaction life cycle.
- **Message Queuing Services** that enable reliable and secure asynchronous messaging between applications over a variety of deployment topologies.
- **Networking and transports** provide a general-purpose set of protocols that are not mapped to a specific service.
- **Media Streaming Services:** Services that communicate data packets that originate from downloadable and streaming audio, visual, and other multimedia data files.
- **Print and Fax Services:** Services that manage the interaction between file/print and fax servers and clients, which include authentication to the print/fax server, notification of print/fax status, and management of remote print jobs.
- **Rights Management Services:** Services that provide support for information protection through content encryption and fine-grained policy definition and enforcement thus, which enables the end users to create and consume protected information.
- **Terminal Services:** Services that communicate remote graphical desktop interaction and display data packets and sound, file redirection, and print redirection data packets from applications accessed by authorized clients to a **terminal server**.
- **Web Services:** Services that manage and communicate with servers that provide Internet services to:
 - Communicate with remote services.
 - Provide remote services that can be accessed by existing clients.
 - Provide management interfaces (for both content and administrative data) for the documented services.

3.3 System Use Cases

This section lists the set of use cases that span the functionality of the Windows Protocols System. The following tables summarize the use cases described in the System Documents.

3.3.1 Networking and Transport Protocols Use Cases

[MS-NAPSO]: Network Access Protection System Overview.

Use case	Description
Create SoH - client user (Triggered by client user)	The goal of this use case is to create the statement of health (SoH) when the client user triggers a new SoH transaction.
Create SoH - client user (Triggered by PEP)	The goal of this use case is to create the SoH for the client user when PEP triggers a new SoH transaction.
Create SoH - client user (Triggered by Group Policy)	The goal of this use case is to create the SoH for the client user when a change of the Group Policy on the computer triggers a new SoH transaction.
Create SoH - client user	The goal of this use case is to create the SoH for the client user when a

Use case	Description
(Triggered by Network Status)	change in the network connectivity status of the client Computer triggers a new SoH transaction.
Send SoH via HTTP/S Channel - client user	The goal of this use case is to send the SoH for the client user via an HTTP/S Channel.
Send SoH via PEAP Channel - client user	The goal of this use case is to send the SoH for the client user via a PEAP Channel.
Send SoH via DHCP Channel - client user	The goal of this use case is to send the SoH for the client user via a DHCP Channel.
Receive State of Health via RADIUS Channel	The goal of this use case is to receive the SoH on the NAP health policy server via RADIUS Channel.
Evaluate Health - PEP	The goal of this use case is to evaluate health using the received SoH.
Create SoHR - PEP	The goal of this use case is to create a statement of health response (SoHR) after the evaluation of health on the PDP.
Send SoHR via RADIUS Channel - PDP	The goal of this use case is to send the SoHR and enforcement decision from the PDP to PEP via a RADIUS Channel.
Restrict Network Access of the NAP client Using the DHCP Channel - PDP	The goal of this use case is to restrict the network access of a NAP client using DHCP enforcement or DHCP PEP based on the response from the server.
Restrict Network Access of the NAP client Using the HTTP/S Channel	The goal of this use case is to restrict network access of the client using the HTTP/S channel or an HTTP/S-based PEP based on the response from the server.
Restrict Network Access of the NAP client Using the PEAP Channel	The goal of this use case is to restrict network access of the client using the PEAP channel or a PEAP-based PEP based on the response from the NAP health policy server.
Provide Full Network Access of the NAP client Using the DHCP Channel	The goal of this use case is to provide full network access for a client using the DHCP channel or a DHCP-based PEP based on the response from the NAP health policy server.
Provide Full Network Access of the NAP client Using the HTTP/S Channel	The goal of this use case is to provide full network access for a client using the HTTP/S channel or a HTTP/S-based PEP based on the response from the server.
Provide Full Network Access of the NAP client Using the PEAP Channel	The goal of this use case is to provide full network access for a client using a PEAP-based PEP based on the response from the NAP health policy server.
Receive SoHR via HTTP/S Channel - PDP	The goal of this use case is to receive SoHR messages on the NAP client via an HTTP/S Channel.
Receive SoHR via PEAP Channel - client user	The goal of this use case is to receive SoHR messages on the NAP client via a PEAP Channel.
Receive SoHR via DHCP Channel - client user	The goal of this use case is to receive SoHR messages on the NAP client via a DHCP Channel.
Process SoHR - client user	The goal of this use case is to process the SoHR for the client user so that the system state of the client Computer is updated and automatic

Use case	Description
	remediation can be triggered if the client Computer is unhealthy.
Manual Remediation of the NAP client - PDP	The goal of this use case is to manually remediate the client based on the response from the server (SoHR). The exact method of remediation depends on the specifics of the SHA/SHV, but this document uses the WSHA/WSHV, as described in [MS-WSH] , as an example.
Automatic Remediation of the NAP client - PDP	The goal of this use case is to automatically remediate the client based on the response from the PDP (the SoHR). The exact method of remediation depends on the specifics of the SHA/SHV, but this document uses the WSHA/WSHV, as described in [MS-WSH] , as an example.

3.3.2 Identity and Security Protocols Use Cases

[MS-ADSO]: Active Directory System Overview.

Use case group	Use cases
Object Management	Create Directory Object in Application NC – Client Application Search for Directory Object – Client Application Modify Directory Object – Client Application Delete Directory Object – Client Application Create Organizational Unit – Client Application
Identity Lifecycle Management	Create a New Account – Client Application Reset an existing account's password – Client Application Change an existing account's password – Client Application Query an account's group membership – Client Application Delete an account – Client Application Create a security group – Client Application Update group member list – Client Application Query members of a group – Client Application
Schema Management	Add a new class to the schema - Client Application Add a new attribute to the schema - Client Application Add an attribute to a class - Client Application
Name Translation	Convert a SID to/from a human-readable format – Client Application

[MS-AUTHSO]: Windows Authentication Services System Overview.

Use case	Description
Interactive Domain Logon - User	The user is required to access local and network resources that are authorized to the user.
HTTP Access Authentication - Server	The user requires authentication to access protected resources on an HTTP server.
SMB Access Authentication - Server	The user is required to access protected resources on an SMB server.

Use case	Description
Remote Procedure Services - RPC Server	The user is required to execute a procedure on an RPC server.

[MS-CAESO]: Certificate Autoenrollment System Overview.

Use case	Description
Automatically Enroll and Renew Certificates - Server Administrator	The goal of this use case is to automatically enroll and renew certificates for a computer based on the administrator-defined CEPs.

[MS-CASO]: Certification Authority System Overview.

Use case	Description
Enroll for a Certificate - End Entity	The goal of this use case is for the End Entity to be issued a certificate.
Edit CA Configuration Settings - CA Administrator	The goal of this use case is for the certification authority (CA) Administrator to be able to define and edit various configuration settings on the CA that affect behavior and policy around the issuance of certificates.
Revoke a Certificate - CA Administrator	The goal of this use case is to revoke a previously issued certificate and to publish a list of revoked certificates.
Recover Archived Certificate and Key - CA Administrator	The goal of this use case is to recover a certificate and its private key that have been archived within the CA database.

[MS-DISO]: Domain Interactions System Overview.

Use case	Description
Locating a Domain Controller - Domain Client	This is the first step when a client attempts to join a domain or to remove itself from the domain. The client must either have the name of the domain controller (DC), or else know that one is available to be located. The client can be a workstation or a server. On success, the name of the DC is returned to the client.
Joining a Domain using Predefined Account - Domain Client	This case assumes that the DC has been located. The client establishes membership in the domain and then consumes resources that are offered by domain member servers. If the client is also a server, then the client publishes necessary information about itself so that the other clients in the domain can consume the resources that the initial client is offering.
Joining a Domain by Creating an Account via SAM - Domain Client	This case assumes that the DC has been located. The client establishes membership in the domain and then consumes resources that are offered by domain member servers. If the client is also a server, then the client publishes necessary information about itself so that the other clients in the domain can consume the resources that the initial client is offering.
Joining a Domain by Creating an Account via LDAP - Domain Client	This case assumes that the DC has been located. The client establishes membership in the domain and then consumes resources that are offered by domain member servers. If the client is also a server, then the client publishes necessary information about itself so that the other clients in the domain can consume the resources that the initial client is offering.

Use case	Description
Removing a Domain Member - Domain Client	This case assumes that the DC has been located. The client will update its information in the machine object to inform the member servers that it is removing itself. The client then logs off and disconnects from the domain.

3.3.3 File, Print, and Fax Protocols Use Cases

[MS-FSSO]: File Access Services System Overview.

Use case	Description
Create Share SMB - Admin Tool	The goal of this use case is to create a share for access via SMB Access Protocols.
Configure Share Directory - Admin Tool	The goal of this use case is to configure file server share directory quota and a file screen.
Create DFS Standalone Namespace - Admin Tool	The goal of this use case is to create a standalone DFS namespace for access via SMB Access Protocols, with [MS-DFSC] extensions.
Create DFS Domain Namespace - Admin Tool	The goal of this use case is to create a domain DFS namespace for access via SMB Access Protocols with [MS-DFSC] extensions.
Create DFS Link - Admin Tool	The goal of this use case is to create a DFS link for access via SMB Access Protocols with [MS-DFSC] extensions.
List Computers - Application	The goal of this use case is to list computers in a workgroup or domain in order to discover computers that may provide file service.
List Shares SMB - Application	The goal of this use case is to list shares on a file server that are accessible via SMB Access Protocols.
List Shares NFS - Application	The goal of this use case is to list shares on a file server that are accessible via NFS Access Protocols.
List Files SMB - Application	The goal of this use case is to list files in a network share directory that are accessible via SMB Access Protocols.
List Files NFS - Application	The goal of this use case is to list files in a network share directory that are accessible via NFS Access Protocols.
Open File SMB - Application	The goal of this use case is to open or create a file in a directory located in an SMB file share, or optionally through an [MS-DFSC] mediated namespace.
Open File NFS - Application	The goal of this use case is to open or create a file in an NFS network share directory.
Perform File Operation SMB - Application	The goal of this use case is to perform a file operation (such as Read, Write, or Delete) on a file in an SMB share directory.
Perform File Operation NFS - Application	The goal of this use case is to perform a file operation (such as Read, Write, or Delete) on a file in an NFS network share directory.
Act on Directory Change Notification SMB - Application	The goal of this use case is to act on a directory change notification that was previously requested by the Application.

[MS-PSSO]: Print Services System Overview.

Use case	Description
Provision a Print Queue - Administrative Client	The goal of this use case is to make a Print Queue available on a print server, which subsequently allows a User to select the Print Queue, and which establishes all attributes and components necessary to make the Print Queue discoverable and accessible to a print client.
Locate and Establish a Connection to a Print Queue in a Domain Environment - print client	The goal of this use case is to make a connection to a shared Print Queue in a domain environment so that documents can be printed by the User.
Locate and Establish a Connection to a Print Queue in a Workgroup Environment - print client	The goal of this use case is to make a connection to a shared Print Queue in a workgroup environment so that documents can be printed by the User.
Locate and Establish a Connection to a Print Queue from an Internet Client using IPP; Download a Printer Driver Using [MS-WPRN] - print client	The goal of this use case is to make a connection to a shared Print Queue from an Internet client so that documents can be printed by the User.
Set Permissions for a Print Queue - Administrative Client	The goal of this use case is to set permissions for a Print Queue, such as the priority of the Print Queue and the times it is available for shared use, as well as who may access it.
Submit a Print Job - print client	The goal of this use case is to print a document.
Manage Print Jobs - print client	The goal of this use case is for a User to manage his or her own submitted print jobs, which includes the ability to pause them, resume them, cancel them, change their priority, change their order in the queue, or restart them.

3.3.4 Systems Management Protocols Use Cases

[MS-GPSO]: Group Policy System Overview.

Use case	Description
Apply Group Policy - GP Client	The goal of the use case is to retrieve policy content from the GP server and to apply it on the GP client.
Administer Policy - Admin Tool	The goal of the use case is to create, update, and delete Group Policy content.

[MS-WMSO]: Windows Management System Overview.

Use case	Description
Create a CIM Instance - Windows Management Client	The goal of this use case is to use the client to create a new CIM object in the CIM repository. The newly-created object will have attributes populated as specified by the client.
Invoke a Method on a CIM Instance - Windows Management Client	The goal of this use case is to invoke a method on a managed object.

Use case	Description
Set Properties of an Instance - Windows Management Client	The goal of this use case is to set one or more properties of an existing CIM instance.
Query Properties of a CIM Instance - Windows Management Client	The goal of this use case is to retrieve the values of some set of properties of a CIM instance.
Monitor Events from WMS - Windows Management Client	The goal of this use case is to submit a query to WMS to notify the submitter when conditions given in the query are met.
Delete CIM Object - Windows Management Client	The goal of this use case is to use the client to delete an existing CIM object in the CIM repository.
Attempt Delete on CIM Object - Windows Management Client	The goal of this use case is to illustrate the failure of a requested CIM object deletion.

3.3.5 Application Services Use Cases

[MS-MQSO]: Message Queuing System Overview.

Use case	Description
Create or Modify Queue - Application	This use case is initiated by an application to create a queue or modify the properties of a queue.
Query Queue Information - Application	This use case is initiated by an application to query configuration and runtime information about the Message Queuing System.
Send Message to Queue - Application	This use case places a message in a queue.
Send Message in Transaction - Application	This use case places a message in a queue under the context of an atomic transaction.
Transfer Message - Application	This use case transfers a message from one queue manager to another.
Receive a Message from a Queue - Application	This use case receives a message from a queue.
Receive a Message in Transaction - Application	This use case receives a message from a queue under the context of an atomic transaction.

[MS-TPSO]: Transaction Processing Services System Overview.

Use case	Description
Create a Transaction - Application	The goal of the use case is to start a new transaction with a transaction manager in the system.
Create a Transaction - External Application	This use case is the same use case as Create a Transaction - Application, with External Application as the direct actor.
Do Transacted Work - Application	The goal of the use case is to perform a set of operations within an atomic transaction.

Use case	Description
Do Transacted Work - External Application	This use case is the same use case as Do Transacted Work - Application, with External Application as the direct actor.
Do Remote Transacted Work with Pull Propagation - Application	The goal of the use case is to perform a set of operations in an atomic transaction on a remote resource, where the remote resource has a separate transaction manager. The transaction information is communicated to the remote transaction manager by using pull propagation.
Do Remote Transacted Work with Pull Propagation - External Application	This use case is the same use case as Do Remote Transacted Work with Pull Propagation - Application, with External Application as the direct actor.
Do Remote Transacted Work with Push Propagation - External Application	The goal of the use case is to perform a set of operations in an atomic transaction on a remote resource, where the remote resource has a separate transaction manager. The transaction information is communicated to the remote transaction manager by using push propagation.
Pull Transaction - Transaction Manager	The goal of the use case is to pull the information about a transaction from a remote transaction manager.
Pull Transaction - External Transaction Manager	This use case is the same use case as Pull Transaction - Transaction Manager, with External Transaction Manager as the direct actor.
Push Transaction - Transaction Manager	The goal of the use case is to push the information about a transaction to a remote transaction manager.
Enlist in a Transaction - Resource Manager	The goal of the use case is to enlist a resource manager in a particular transaction. When it is enlisted, the resource manager will be able to participate in the coordination of the transaction.
Enlist in a Transaction - External Resource Manager	This use case is the same use case as Enlist in a Transaction - Resource Manager, with External Resource Manager as the direct actor.
Complete a Transaction - Application	The goal of the use case is to complete a transaction with an abort or a commit outcome.
Complete a Transaction - External Application	This use case is the same use case as Complete a Transaction - Application, with External Application as the direct actor.
Drive Completion of a Transaction - Transaction Manager	The goal of the use case is to inform the transaction participants of the outcome of the transaction and driving a consistent outcome.
Do Transaction Recovery - Resource Manager	The goal of the use case is to discover the outcome of transactions.
Do Transaction Recovery - External Resource Manager	This use case is the same use case as Do Transaction Recovery - Resource Manager, with External Resource Manager as the direct actor.
Do Transaction Recovery - Transaction Manager	This use case is the same use case as Do Transaction Recovery - Resource Manager, with Transaction Manager as the direct actor.
Do Transaction Recovery - External Transaction Manager	This use case is the same use case as Do Transaction Recovery - Resource Manager, with External Transaction Manager as the direct actor.

Use case	Description
Manage Transaction Managers - Management Tool	The goal of the use case is to monitor and administer a transaction manager in the system.
Manage Transactions - Management Tool	The goal of the use case is to monitor and administer a transaction manager in the system.

3.3.6 General Use Cases

The following tables summarize the use cases for the protocols that support collaboration, media services, protected content, remote desktop services (terminal services), and update services functionality.

[\[MS-CSSO\]](#): Collaboration Services System Overview.

Use case	Description
Collaboration Client Registration - Client	The goal of this use case is to allow a Collaboration Client to publish its name and IP address in an ILS Server in order to allow a second Collaboration Client to look up the IP address of the first Collaboration Client.
Collaboration Client Query - Client	The goal of this use case is to query an ILS Server for a list of registered Collaboration Clients in order to select one for which to receive its location information.

[\[MS-MGSO\]](#): DirectPlay System Overview.

Use case	Description
Host a DirectPlay Game - Host Entity	The goal of the use case is to host a DirectPlay game session.
Join a DirectPlay Game - Client Entity	The goal of the use case is to join a DirectPlay game.

[\[MS-MSSO\]](#): Media Streaming Server System Overview.

Use case	Description
Publish Content to Media Server - Encoder	The goal of this use case is to create content for broadcast through the Media Streaming Server System.
Publish Secure Content to Media Server - DRM Packager	The goal of this use case is to provide protected content to the Media Server for streaming.
Stream Content from Media Server - Media Player	The goal of this use case is to stream media files and streams from Media Servers.
Request License from License Server - Media Player	The goal of this use case is to provide and enable playback for DRM protected media streams.
Log Statistics to Servers - Media Player	The goal of this use case is to obtain statistics for the Media Streaming Server System experience.

[\[MS-RMSO\]](#): Rights Management Services System Overview.

Use case	Description
Enroll RMS Server - RMS Server	The goal of this use case is to enroll the server with the Microsoft Cloud Service so that clients trust the server and send it requests.
Bootstrap RMS Client - RMS Client Application	The goal of this use case is to prepare an RMS Client Application to participate in the RMS System.
Acquire Templates - RMS Client Application	The goal of this use case is to retrieve the rights policy templates published by the RMS Server for use in publishing protected content.
Publish Protected Content Online - RMS Client Application	The goal of this use case is to publish protected content through direct communication with the RMS Server.
Publish Protected Content Offline - RMS Client Application	The goal of this use case is to protect content without making calls to an RMS Server.
Consume Protected Content - RMS Client Application	The goal of this use case is to remove protection from and consume content protected by RMS.

[\[MS-TSSO\]](#): Terminal Services System Overview.

Use case	Description
Establish a Connection to a TS Server in an Intranet Environment - RDP Client	The goal of this use case is for an RDP Client to establish a connection with a TS Server.
Establish a Connection to a VM Host in an Intranet Environment - RDP Client	The goal of this use case is for an RDP Client to establish a connection with a VM Host.
Establish a Connection Using a TS Gateway - RDP Client	The goal of this use case is for an RDP Client to establish a connection with a TS Server.
Establish a Connection to a TS Server in a TS Server Farm - RDP Client	The goal of this use case is for an RDP Client to establish a connection to a TS Server within a server farm.
Access Local Drives on an RDP Client - Remote Application	The goal of this use case is for the Remote Application to access local drives on the RDP Client.
Redirect Clipboard Data from a Remote Application - RDP Client	The goal of this use case is to use the local Clipboard of the RDP Client to perform Clipboard operations on a Remote Application running on a TS Server.
Use Printer on an RDP Client - Remote Application	The goal of this use case is for the Remote Application to send a print job to a printer on the RDP Client, which prints the job.
Redirect Smart Card Data from an RDP Client - Remote Application	The goal of this use case is for the Remote Application to access a smart card on the RDP Client.
Access Plug and Play Device on an RDP Client - Remote Application	The goal of this use case is for the Remote Application to access a Plug and Play device on the RDP Client.
Present Content from a TS Server on an RDP Client - Media Player	The goal of this use case is to present content streamed from the Media Player running on the TS Server to the RDP Client.
Access Audio Device on an RDP Client - Remote Application	The goal of this use case is for the Remote Application to access an audio device on the RDP Client.

Use case	Description
Log Off from a Remote Session - RDP Client	The User of the RDP Client logs off from a TS Server, which causes the user session on the TS Server to be closed.
Disconnect from a Remote Session- RDP Client	The RDP Client disconnects from a TS Server, but the user session remains in a suspended mode for possible later use.

[\[MS-WSUSO\]](#): **Windows Server Update Services System Overview.**

Use case	Description
Configure Update Server - WSUS Administrator	The goal of this use case is to configure the update server according to the deployment requirements.
Manage Computer Groups - WSUS Administrator	The goal of this use case is to create computer target groups and establish membership of computers managed by the update server within those target groups.
Approve Update - WSUS Administrator	The goal of this use case is to approve an update to a target group for either installation or uninstallation. This is the primary use case that enables the system purpose of controlling update delivery.
Monitor Update Installation - WSUS Administrator	The goal of this use case is to generate update installation and applicability reports. The type of reports that are generated is determined by how the system is implemented.
Synchronize Server - WSUS Administrator	The goal of this use case is to synchronize a downstream server (DSS) in an update server hierarchy with updates and approvals from an upstream server (USS) .
Configure Update Client - Computer User	The goal of this use case is to assign user-specified values to configuration settings that control the client's behavior.
Start Update Scan - Computer User	The goal of this use case is to discover changes in the set of updates available to the client computer and their deployments since the last time the use case was executed. Additionally, update metadata is retrieved from the update server for new updates.
Install Updates - Computer User	The goal of this use case is to carry out the directive the WSUS Administrator specified for each update that is applicable to the client computer. These directives include Install and Uninstall. An update installation can also entail a download of update files.

4 System Context

This section describes the relationship between this system and its environment.

4.1 System Environment

The individual system documents describe the relationship between each protocol system that is part of the Windows Protocols System and its environment. This section provides some additional information that applies to the environment of all Windows Protocols systems.

The Windows Protocols System environment is a distributed computing environment that is based on a client-server framework called the Distributed Computing Environment (DCE), which was specified by an industry consortium in the early 1990s. Typically, implementations of DCE are divided into administrative units called "cells" with the following core services available to all clients and servers that participate in a given cell:

- Authentication Service
- Distributed Directory Services
- Distributed Time Services (DTS)
- remote procedure call (RPC)
- Threads Service

The Windows NT operating system is based on the DCE framework. In Windows, the term "domain" corresponds to the term "cell", and the DCE core services are still pervasive in Windows today.

Computers that are members of a domain (domain members) include the following key services:

- An Authentication Service based on Kerberos [\[MS-KILE\]](#) and [\[MS-AUTHSO\]](#)
- A Distributed Directory Service based on Active Directory [\[MS-ADTS\]](#) and [\[MS-DISO\]](#)
- Remote Procedure Call [\[MS-RPCE\]](#)
- Time Services [\[MS-W32T\]](#)

In a Windows environment, there is no requirement to add threads as a separate service because the operating systems provide this service. There are also additional services such as the **Distributed File System (DFS)**, which is intended to support user functionality. This framework has been extended and improved upon over time. For example, HTTP-based distributed computing is now commonly used, and SOAP-based protocols are often used instead of the traditional RPC. Despite these changes, the core DCE model remains.

The Windows environment has many optional features. A naming service, for example, is highly desirable but not essential. IPv6 is also desirable, but not essential. The minimum environment required for hosts is IPv4 connectivity. More complex, secure, and robust configurations have additional requirements, such as naming services and time services.

Many of the Windows protocols require a durable storage system to maintain the state of the directory and to meet the transactional guarantees specified in [\[MS-ADTS\]](#) section 3.1.1.5.1.4. This storage system SHOULD provide a means of securing the contents of the storage system from unauthorized access.

Many protocols also require a networking system that clients can use to send requests to the directory server and to receive a response. This networking system MUST support the TCP, UDP, and Server Message Block (SMB) transports. This networking system MUST also supply access to the Domain Name System (DNS). DNS can be used by clients of the Active Directory System in order to locate directory servers using the algorithms described in [\[MS-ADTS\]](#) section 6.3.

Several Windows protocols are RPC-based and depend on the availability of an RPC runtime that implements an RPC mechanism, as described in [\[MS-RPCE\]](#).

The environment for Fax Services, the Print Services System, and the File Access Services System protocols exist within Windows as sets of drivers and services. This functionality is consumed by other Windows Protocol System services and applications. Users are not expected to interact directly with these services, but rather indirectly through text or graphical **shells**, applications, and higher level Windows APIs.

4.2 System Assumptions and Preconditions

The following preconditions apply to all Windows protocol systems, and these systems assume that the preconditions are established and verified outside of the system before the system is started:

- A network that provides a viable transport for communications between the directory server and its clients MUST be available. As specified in the previous section, this network MUST supply access to DNS.
- The transport protocol for that network MUST be available and configured (for example, the TCP transport must be configured with a valid IP address).
- A security infrastructure that supports identity, authentication, and authorization is in place.
- Most of the protocols from the Windows Protocol System can be implemented with a client computer that is either joined to a domain or is a standalone computer. For protocol implementations that require or use the services provisioned by a DC, or consume the authentication services documented in [\[MS-AUTHSO\]](#), the following preconditions apply:
 - A computer in the domain is required to be promoted and configured as the primary DC for that domain to support the domain and authentication services documented in [\[MS-DISO\]](#) and [\[MS-AUTHSO\]](#).
 - The user account for all domain clients is required to be created and provisioned on the DC by the domain administrator.
 - Domain clients have successfully joined the domain that provisions domain services for them.

The following systems assume the client computer is joined to a domain:

- Authentication Services System [\[MS-AUTHSO\]](#)
- Certificate Autoenrollment System [\[MS-CAESO\]](#)
- Domain Interactions System [\[MS-DISO\]](#)
- File Access Services System [\[MS-FSSO\]](#)
- Group Policy System [\[MS-GPSO\]](#)
- Message Queuing System [\[MS-MQSO\]](#)
- Network Access Protection System [\[MS-NAPSO\]](#)

- Print Services System [\[MS-PSSO\]](#)
- Rights Management Services System [\[MS-RMSO\]](#)
- Terminal Services System [\[MS-TSSO\]](#)
- Windows Management System [\[MS-WMSO\]](#)

As part of the Windows startup procedure for the domain clients, the following preconditions apply:

- Successful connection to network and startup of networking stacks.
- Network discovery of site and DC.
- Establishment of a secure channel with DC.
- Download of Group Policy settings.
- Client certificate autoenrollment.
- Time synchronization.
- Dynamic DNS update.

The following systems require that the Authentication Services System [MS-AUTHSO] is available:

- File Access Services System [MS-FSSO]
- Print Services System [MS-PSSO]

The following systems require that the Active Directory System [\[MS-ADSO\]](#) is available:

- Certificate Autoenrollment System [\[MS-CASO\]](#)
- File Access Services System [MS-FSSO]
- Message Queuing System [MS-MQSO]
- Print Services System [MS-PSSO]

The following systems assume that there is durable storage to store system state:

- Active Directory System [MS-ADSO]
- Print Services System [MS-PSSO]
- Rights Management Services System [MS-RMSO]
- Transaction Processing Services System [\[MS-TPSO\]](#)
- Windows Server Update Services System [\[MS-WSUSO\]](#)

For protocols of the Windows Protocols System that use either HTTP [\[RFC2616\]](#) or HTTPS [\[RFC2818\]](#) as a transport, the HTTP server has to be configured and the HTTP service should be started so that the HTTP server can respond to HTTP requests from the client.

For protocols that use SMB as a transport or depend on SMB for file access, the SMB service must be properly configured and started.

For protocols that use RPC as a transport, the RPC service on both the client and server computers must be properly configured and started.

For protocols that depend on DCOM as a transport or to authenticate its clients, the **DCOMLAUNCH** service should be started.

4.3 System Relationships

This section describes the relationships across the system and external components, system dependencies, and other systems influenced by the system.

4.3.1 Black Box Relationship Diagrams

The individual system documents describe the black box relationships for each Windows Protocols System. This section provides two additional black box relationship diagrams that provide a composite view of the black box diagrams for protocols and systems in the File, Print, and Fax protocols group and the Systems Management protocols group.

4.3.1.1 Black Box Relationship for the File, Print, and Fax Protocols

The following black box diagram of the File Access Services System and the Print Services System illustrates interfacing external system and service components.

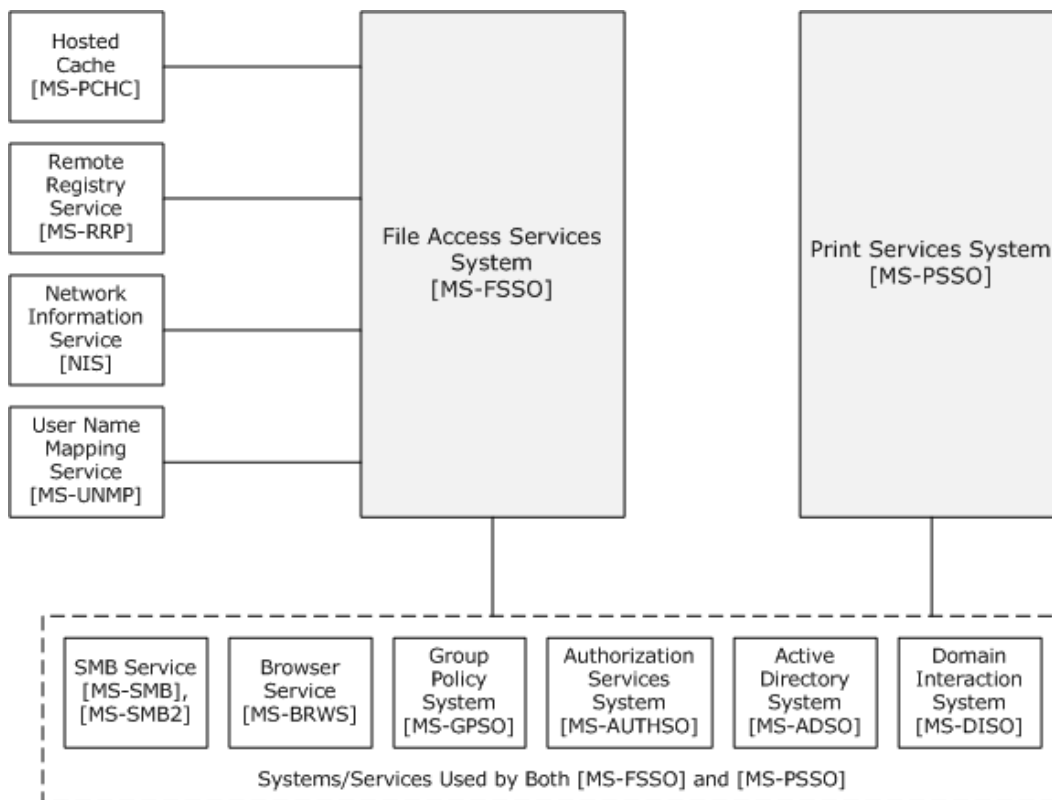


Figure 15: Black box for File Access Services System and Print Services System.

The following components are shared by both systems:

- Active Directory System [\[MS-ADSO\]](#), which supports the publishing of shared print resources.
- Authorization Services System [\[MS-AUTHSO\]](#), which supports domain-based security.
- Browser Service [\[MS-BRWS\]](#), which supports the publication of shared print resources in workgroup environments.
- Domain Interaction System [\[MS-DISO\]](#), which supports domain-based security.
- Group Policy System [\[MS-GPSO\]](#), which supports the pushing of preconfigured connections between print servers and print clients.
- SMB Service, which supports print functionality using the SMB Protocol Family, including [\[MS-SMB\]](#), [\[MS-SMB2\]](#), and [\[MS-CIFS\]](#).

In addition, there is a mutual dependency between the Print Services System and the File Access Services System, as described in section [3.1.4.1](#).

The following system and service components interface to the File Access Services System, where each is used as described in [\[MS-FSSO\]](#):

- Hosted Cache [\[MS-PCHC\]](#)
- Network Information Service [\[NIS\]](#)
- Remote Registry Service [\[MS-RRP\]](#)
- User Name Mapping Service [\[MS-UNMP\]](#)

The Black Box diagram of the [\[MS-FAX\]](#) Facilities below illustrates interfacing external systems. All of these systems are accessed with local API calls on client and server computers that implement [\[MS-FAX\]](#) support, not with system protocols defined by the external systems.

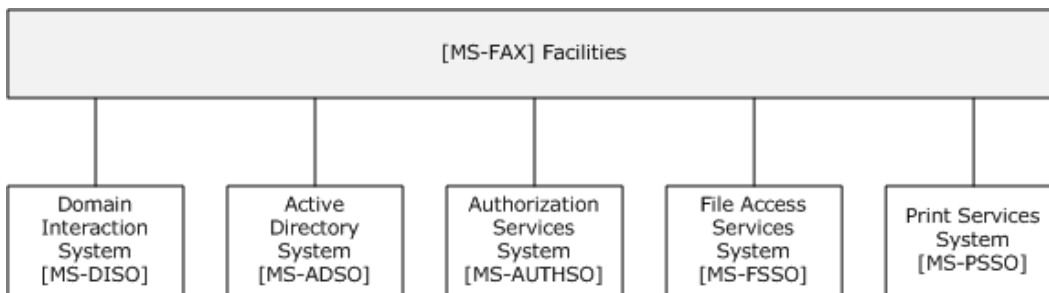


Figure 16: Black Box for [\[MS-FAX\]](#) Facilities.

Of the supporting systems, the Print Services System is the most directly used by [\[MS-FAX\]](#) facilities: the print spooler is used to enumerate available Fax Queues to which a client can connect, and to enable a client to connect to a Fax Queue.

4.3.1.2 Black Box Relationship for the Systems Management Protocols

This diagram shows, at a high level, the interaction between components of the Windows Management Capabilities. The Group Policy System and the Windows Management System, together, provide complete monitoring and control of every hardware and software resource in the managed system. The Group Policy System is used to control access permissions to resources and their management metadata. The Windows Management System provides access to the resources

and their management metadata, if the entity requesting access has the proper access permissions. The Group Policy System allows system administrators to collect multiple users or system resources into one named security principal in order to make system administration much easier. For more details on the capabilities of the Windows Management System, see [\[MS-WMSO\]](#). For more details on the capabilities of the Group Policy System, see [\[MS-GPSO\]](#).

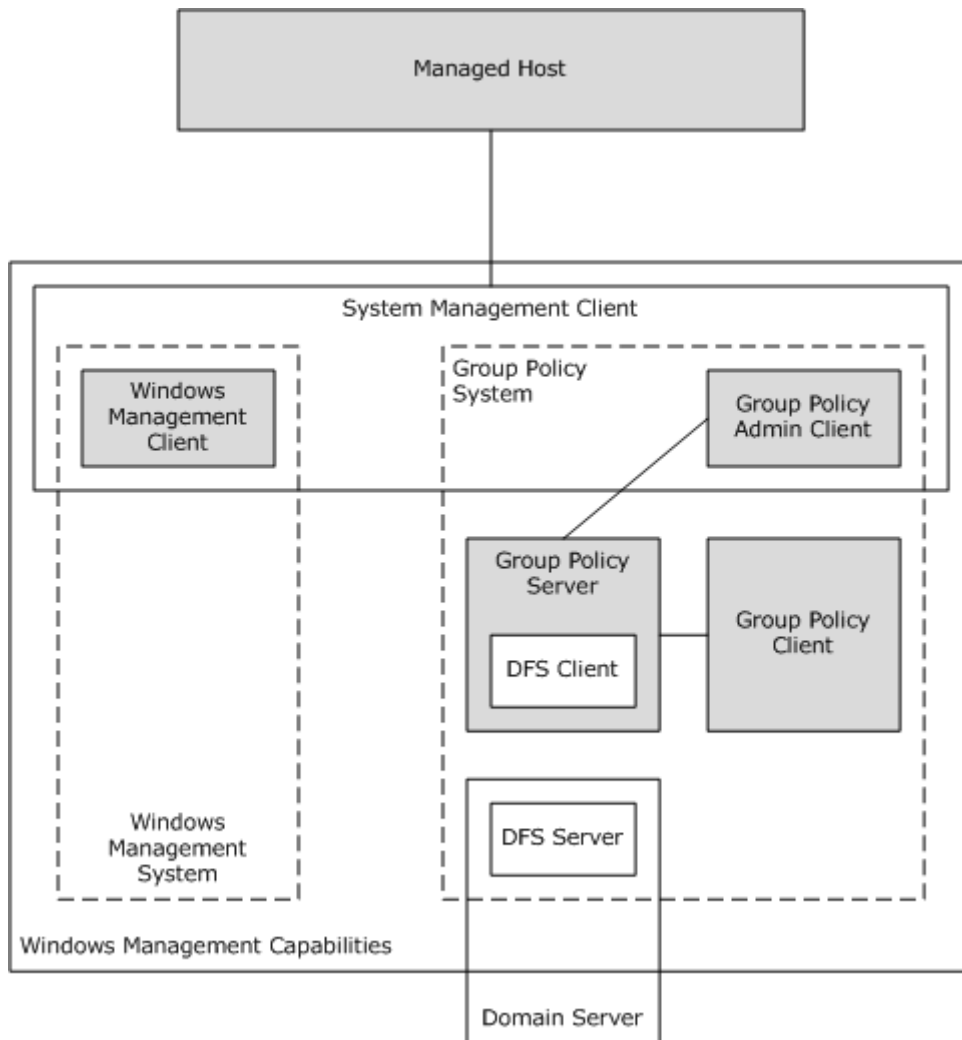


Figure 17: Windows Management Capabilities black box diagram.

4.3.2 System Dependencies

The individual system documents describe system dependencies for each Windows protocols system. There are no additional Windows-wide system dependencies.

4.3.3 System Influences

The individual system documents describe system influences for each Windows Protocols System. There are no additional Windows-wide system influences.

4.4 System Applicability

This system is applicable for client-to-server usage. This system does not describe server-to-server usage, such as usage within an enterprise.

The Technical Documents (TDs) for the protocols describe the applicability of the individual protocols (see section 1.6, "Applicability Statement", in each TD) and Protocol Family System Overviews (PFSOs) give the applicability of the protocol family, as described in the following sections.

4.5 System Versioning and Capability Negotiation

The TD for each protocol describes the available vendor-extensible fields (see section 1.7, "Versioning and Capability Negotiation", in each TD). Protocol Family System Overviews provide the vendor-extensible fields of their protocol family (see section 4.5 in each PFSD). The available versions of the system will be based on the collected versions and capabilities that are negotiated with and among the individual protocols.

There is no versioning or capability negotiation at the level of the entire Windows Protocols System. There are standard bundles of versions and capabilities with implementation-specific releases.

4.6 System Vendor-Extensible Fields

The TD for each protocol describes the available vendor-extensible fields (see section 1.8, "Vendor-Extensible fields", in each TD). Protocol Family System Overviews give the vendor-extensible fields of their protocol family, as described in this section.

Certain vendor-extensible fields are shared across multiple TDs. If a value is defined for one protocol, then a different meaning should not be associated with the same value in another protocol.

The most common vendor-extensible fields include the following:

- **HRESULTS:** Vendors can choose their own values, as long as the **C** bit (0x20000000) is set, which indicates that it is a customer code. For more details, see [\[MS-ERREF\]](#). The structures documented in [\[MS-ERREF\]](#) have no vendor-extensible fields.
- **Win32 Error Codes:** Vendors should reuse values that have indicated meanings. Choosing any other value runs the risk of a collision in the future. For more details, see [\[MS-ERREF\]](#).
- **NTSTATUS:** Vendors can choose their own values for this field, as long as the **C** bit (0x20000000) is set, which indicates that it is a customer code. For more details, see [\[MS-ERREF\]](#).
- **SOAP Fault and SOAP Fault Codes:** SOAP Fault detail elements can be vendor selected when the content of the SOAP Fault Detail element does not affect interoperability of the protocol. SOAP Fault Codes can be vendor selected when the choice of the SOAP Fault Code does not affect interoperability of the protocol. For more details about SOAP Fault, see [\[SOAP1.1\]](#) section 4.4. For more details about SOAP Fault Codes, see [\[SOAP1.2-1/2007\]](#) section 5.4.
- Vendor extensibility in an XML Schema is indicated by `##OTHER` or `##ANY` for XML attributes or elements in their own namespace.
- Vendor-defined objects should be unique across all of the protocols that use the object. Vendors extend the directory by adding objects, which include **schema objects**, as specified in [\[MS-ADTS\]](#), to control the vendor objects.

LDAP is not extensible by Active Directory applications. Applications extend the directory by adding objects, which includes schema objects to control the application objects.

5 System Architecture

This section describes the basic structure of the system and the interrelationships among its parts, consumers, and dependencies.

5.1 Abstract Data Model

The abstract data model for the Windows Protocols System can be found in the Abstract Data Model sections of the Systems Documents that are listed in the Normative Reference section of this document. Two Systems Documents have elements in their abstract data models that are not used in any other Windows Protocols System. These documents are "Multiplayer Games System Overview" [\[MS-MGSO\]](#) and "Media Streaming Server System" [\[MS-MSSO\]](#). In both of these documents, the user identities are not tied to a specific domain.

The following Windows Protocols System abstract data model elements are common across the Windows Protocol Family Systems and Defined Task Systems:

- User Identity, detailed in [\[MS-ADSO\]](#).
 - Name - (maps to Active Directory common name (cn) attribute) defined in [\[MS-ADSO\]](#).
- User Credentials, detailed in [\[MS-AUTHSO\]](#).
 - UserClientMachineServiceTicket - The Kerberos service ticket for the member machine.
 - UserTGT - The Kerberos ticket-granting ticket (TGT) for user logon.
 - UserGroupPolicy - Group Policy to be applied to the user during logon.
 - UserDFSRef - DFS referral information for the user.
- Group Policy elements detailed, in [\[MS-GPSO\]](#) section 5.3.1.

5.2 White Box Relationships

The individual system documents describe the white box relationships for each Windows protocols system. This section provides two additional white box relationship diagrams that provide a composite view of the black-box diagrams for protocols and systems in the File, Print, and Fax protocols group and the Systems Management protocols group.

5.2.1 File, Print, and Fax Protocols

The diagram in this section shows how system components can be distributed across multiple computers. The diagram illustrates the communications that occur between the File Access System and the Print Services System, as well as the communications to external systems ([\[MS-ADSO\]](#), [\[MS-AUTHSO\]](#), [\[MS-DISO\]](#), and [\[MS-GPSO\]](#)), where dotted lines indicate local calls and solid lines indicate protocol-based communications. The diagram also shows internal communications that use protocol-based communications between clients and servers that implement these two systems, and communications that use local API calls within a client and a server that implement both systems.

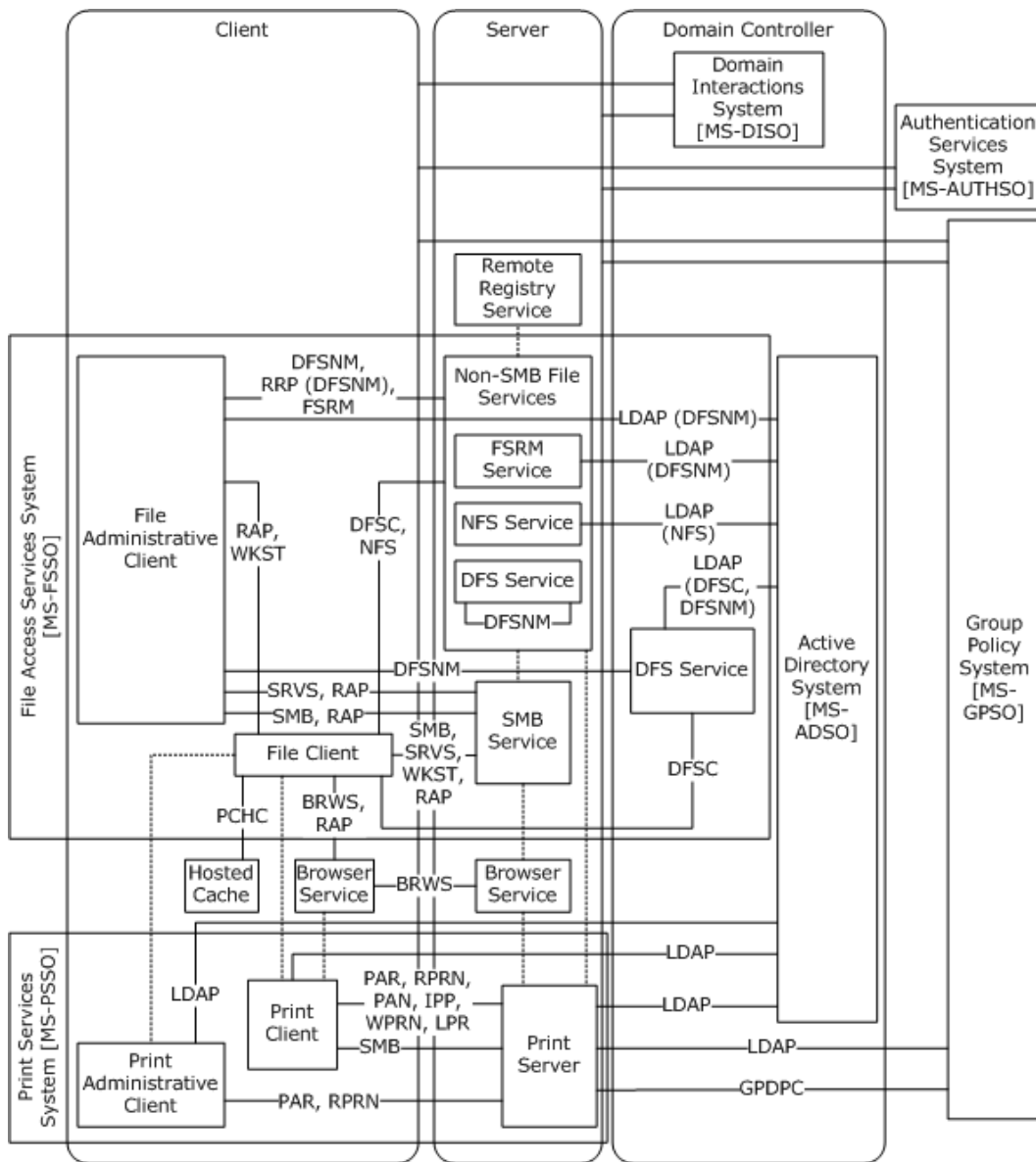


Figure 18: White Box showing File Access Services System and Print Services System interactions.

The White Box diagram for [\[MS-FAX\]](#) facilities shows the use of the [\[MS-FAX\]](#) protocol between the client and Fax server, where dotted lines indicate local calls and solid lines indicate protocol-based communications. It also shows the component interactions between the components of [\[MS-FAX\]](#) facilities and their use of local calls to perform fax-related functions, and the external systems that support the fax clients and fax servers ([\[MS-ADSO\]](#), [\[MS-AUTHSO\]](#), and [\[MS-DISO\]](#)and).

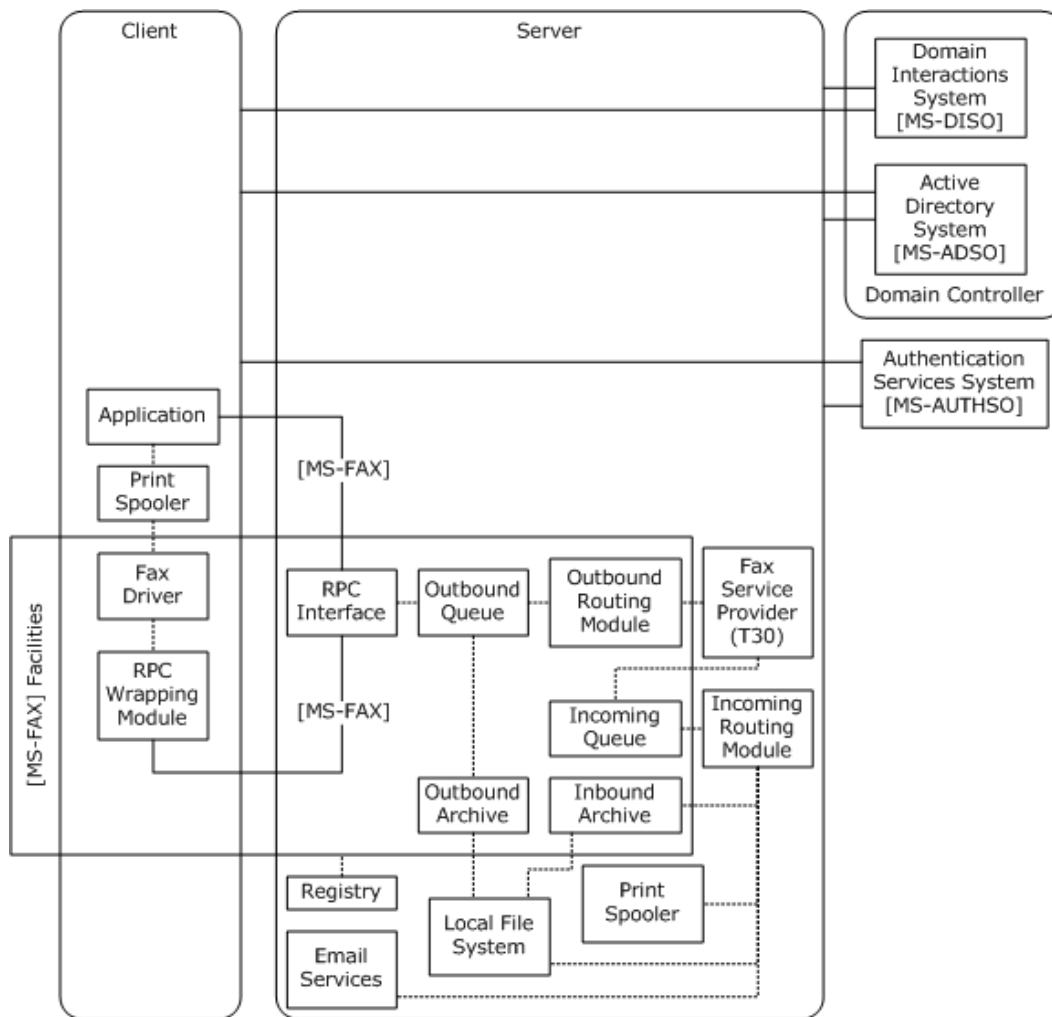


Figure 19: White Box showing [MS-FAX] facilities.

5.2.1.1 Protocol Layering for File, Print, and Fax

The protocol layering diagram in this section shows the mutual use of various protocols to perform File-related, Print-related, and Fax-related functions.

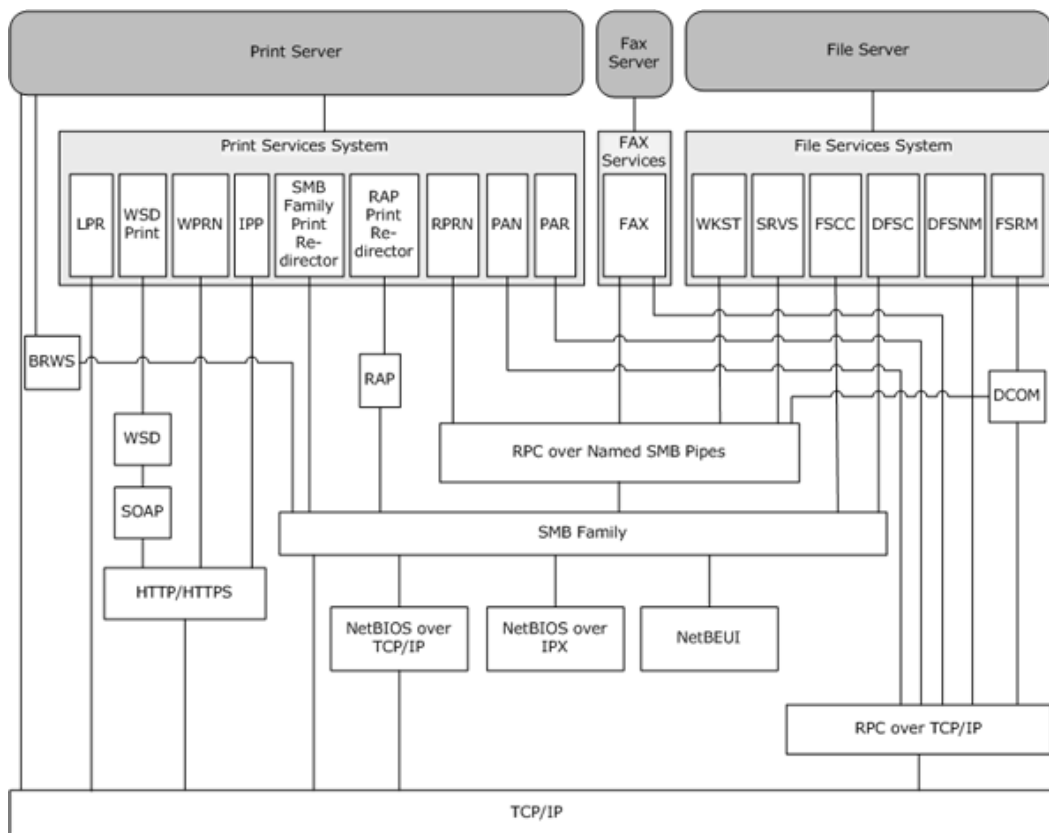


Figure 20: Protocol Layering diagram.

The Print Services System includes protocol stacks that support HTTP/HTTPS for internet printing scenarios, as well as RPC-based protocols for network printing.

The [\[MS-FAX\]](#) protocol uses RPC/SMB named pipes to send fax data to the server, and RPC/TCP/IP to send fax-related events to the client.

The File Access Services System uses the protocol layering noted in the diagram, as well as NFS-related protocols not shown here, but illustrated in detail in [\[MS-FSSO\]](#) section 5.2.

5.2.2 System Management Protocols

There are two major components of the Systems Management Protocols: the Windows Management System, as discussed in [\[MS-WMSO\]](#), and the Group Policy System, as discussed in [\[MS-GPSO\]](#). The following diagrams show the relationships between the two systems.

5.2.2.1 The Windows Protocols System Management System

The Windows Protocols System Management System provides management capabilities over large and widely distributed sets of computers.

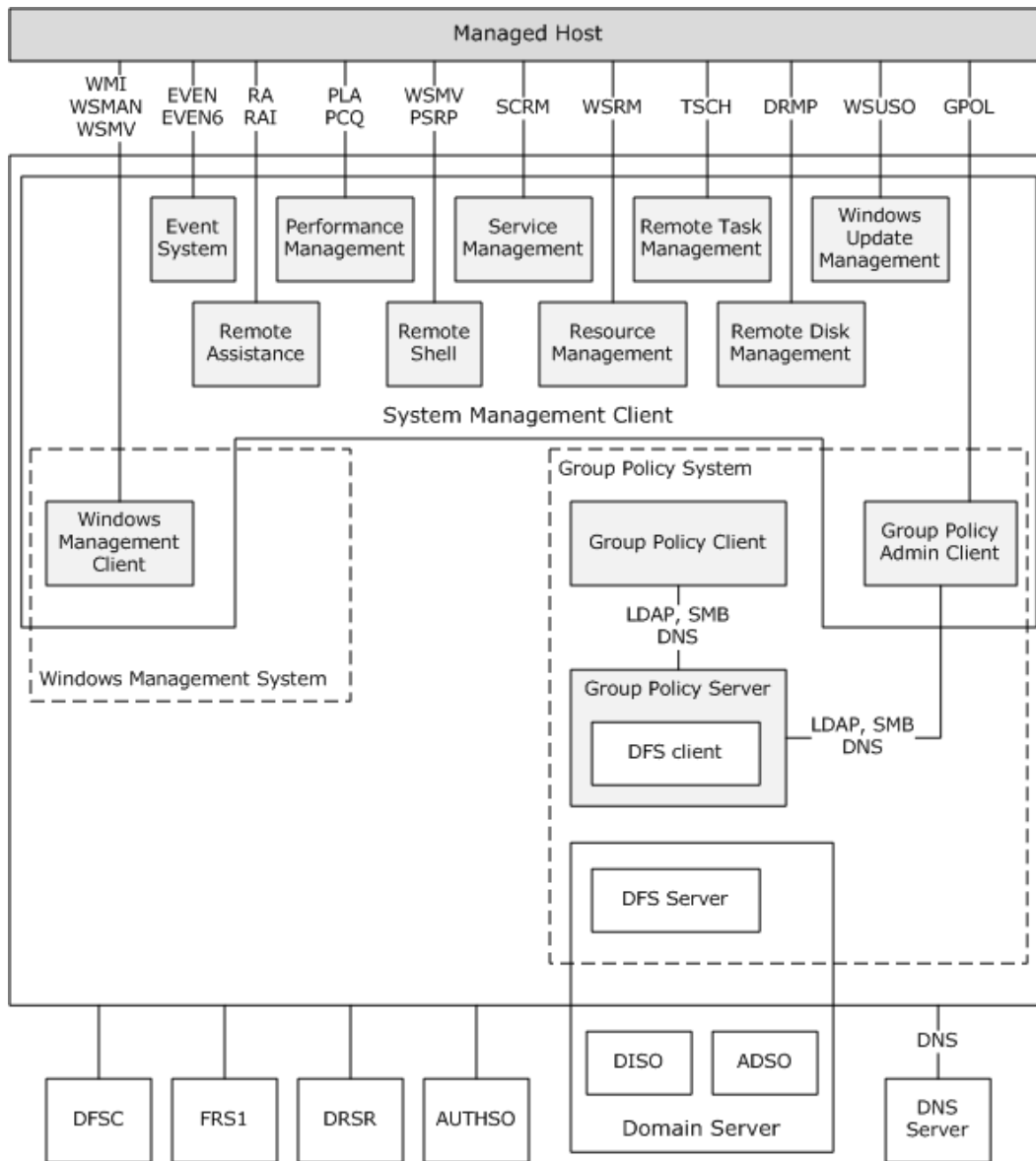


Figure 21: WMSO GPSO Interrelations White Box Diagram.

The Windows Management System components shown in the previous figure are covered in more detail in [\[MS-WMSO\]](#). The Group Policy System components shown in the previous figure are covered in more detail in [\[MS-GPSO\]](#). Components that are not discussed in either of these documents are detailed as follows.

System Management Client

- In addition to the Group Policy Admin Client and the Windows Management Client, the System Management Client allows access to and modification of other Windows management components.

- The Event System allows access to the event logs maintained by the system. An expanded white box diagram that details the event system and its protocols is shown in section [5.2.2.2](#).
- Remote Assistance allows an administrator to share the **desktop** view of a remote computer.
- Performance Management allows for the examination of performance logs maintained by the system.
- Remote Shell capabilities allow an administrator to open a shell on a remote computer. The PowerShell protocol can be utilized for a Remote Shell scenario. For details, see [\[MS-PSRP\]](#).
- Service Management allows for the remote administration of Windows Services.
- Resource Management allows for the management of machine resources, such as processor allocation, memory allocation, and so on.
- Remote Task Management allows for the scheduling of tasks to be run on remote computers.
- Remote Disk Management allows for the management of disk resources, such as volume names and sizes on remote computers.
- Windows Update Management allows for the configuration of the Windows Update feature, which determines when and which Windows Updates are downloaded and installed on the local computer.

Domain Server

The Domain server provides domain membership and management capabilities for Windows domains.

Supporting Systems

- AUTHSO: The system described in [\[MS-AUTHSO\]](#) handles user credentials, authentication, and authorization to system resources.
- DFSC: The Distributed File System (DFS): Referral Protocol allows file system clients to resolve names from a namespace that is distributed across many servers and geographies into local names on specific file servers.
- DNS Server: The DNS server provides resolution for Internet domain names.
- DRSR: The Directory Replication Service (DRS) Remote Protocol allows Active Directory entries to be replicated to local servers, for enhanced access speeds.
- FRS1: The File Replication Service protocol allows files to be replicated to remote locations while retaining the same UNC.

5.2.2.2 The EventLog system

The EventLog system is the only complex system component shown in the previous diagram for which there is not an associated System Document. The following diagram shows the internal white box architecture for the EventLog system.

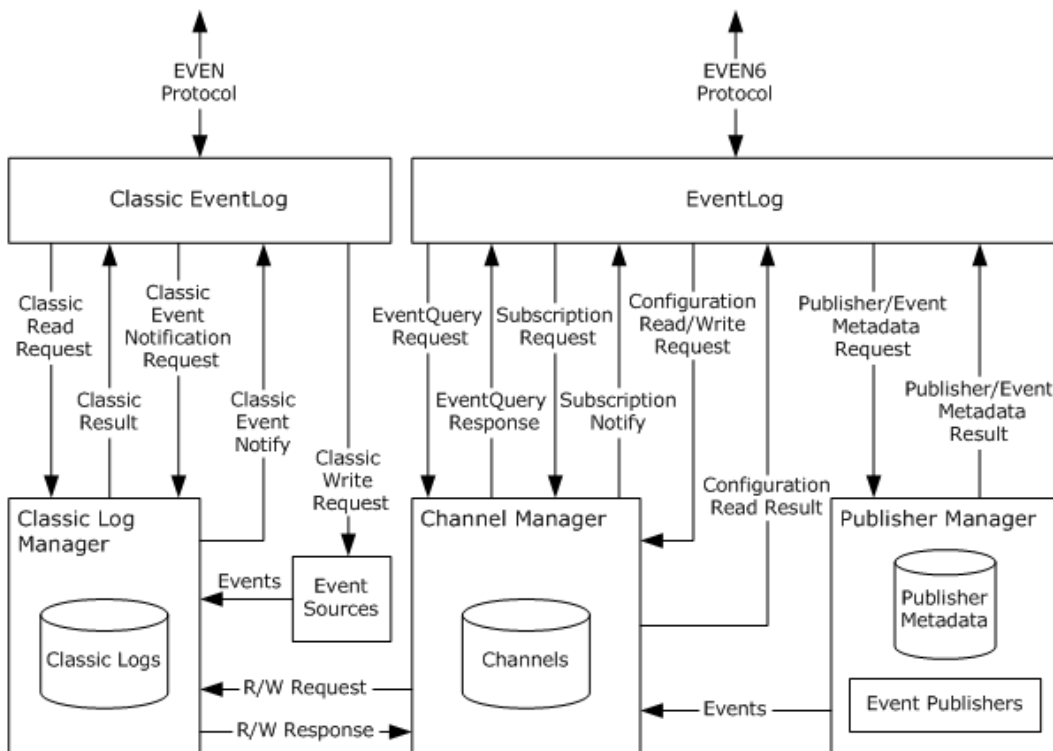


Figure 22: EventLog System white box relationships.

The EVEN protocol and the EVEN6 protocol provide access to EventLog data, although the protocols access different sets of data. The data available through the EVEN protocol is a strict subset of the data available through the EVEN6 protocol. As shown in the diagram, the Publisher Manager used in EVEN6 provides Publisher Metadata that is not available through EVEN. In addition, the EVEN protocol allows events to be written to the Classic Log Manager, but EVEN6 does not provide a write capability to the System Management Client. For more details on the EVEN and EVEN6 protocols and accessible data, see [\[MS-EVEN\]](#) and [\[MS-EVEN6\]](#).

6 System Details

This section provides a summary of the examples that are covered in detail in each of the System Overview documents. It also includes general information that applies to all System Overview documents about communication details, transport requirements, timers, non-timer events, initialization and reinitialization procedures, and status and error returns.

6.1 Architectural Details

6.1.1 System Document Examples

This section lists the examples (also referred to as scenarios) from each System Document and provides a short description of each example.

6.1.1.1 Networking and Transports Protocols

[MS-NAPSO]: Network Access Protection System Overview.

Example	Description
Network Access Protection (NAP) client Creating a Statement of Health (SoH)	This example illustrates a NAP client that creates an SoH. The client utilizes several SHA, NAP Agent, and EC functions to accomplish the request.
NAP client Sending a SoH	This example illustrates a NAP client that sends an SoH. The client utilizes several NAP Agent and EC functions to accomplish the request.
PDP (NAP health policy server) Receiving an SoH.	This example illustrates a PDP that receives an SoH. The PDP utilizes several Policy Engine, NAP Validator, and SHV functions to accomplish the request.
PDP (NAP health policy server) Evaluating Health	This example illustrates a PDP that evaluates health. The PDP utilizes several Policy Engine, NAP Validator, and SHV functions to accomplish the request.
PDP (NAP health policy server) Creating a Statement of Health Response (SoHR)	This example illustrates a PDP that creates an SoHR. The PDP utilizes several Policy Engine, NAP Validator, and SHV functions to accomplish the request.
PDP (NAP health policy server) Sending an SoHR.	This example illustrates a PDP that sends an SoHR. The PDP utilizes several Policy Engine, NAP Validator, and SHV functions to accomplish the request.
PDP (NAP health policy server) Enforcing Network Restrictions	This example illustrates a PDP that enforces network restrictions on a client. The PDP utilizes PEP and the NAP client functions to accomplish the request.
NAP client Receiving an SoHR	This example illustrates a NAP client that receives an SoHR. The client utilizes several NAP Agent, SHA, and EC functions to accomplish the request.
NAP client Processing an SoHR	This example illustrates a NAP client that processes an SoHR. The client utilizes several NAP Agent, SHA, and EC functions to accomplish the request.
NAP client remediating Itself	This example illustrates a NAP client that remediates itself. The

Example	Description
	client utilizes several NAP Agent, SHA, and EC functions to accomplish the request.

6.1.1.2 Identity and Security Protocols

[MS-ADSO]: Active Directory System Overview.

Example	Description
Provision a User Account Using the LDAP Protocol	In this scenario, an administrator provisions a user account using the LDAP protocol. To perform this task, an Administrator runs a Client Application from a client computer, targeting a directory server in the Active Directory System. The Client Application creates a user account and sets its user properties using the LDAP protocol, and sets the user account's password using the Kerberos protocol.
Provision a User Account using the SAMR Protocol	A common administrative task is to provision an account for a new user. As shown in the previous section, this can be done using LDAP. Another way of accomplishing this is to use the SAMR protocol to communicate with the Active Directory System. Regardless of which protocol is chosen, the end state is the same: a new user object is created in the directory tree. To perform this task, an administrator runs a Client Application using the SAMR protocol from a client computer targeting a directory server in the Active Directory System.
Change a User Account's Password	In this scenario, a User changes the password on their account by using the SAMR protocol. To perform this task, a User runs a Client Application from a client computer, targeting a directory server in the Active Directory System. The Client Application changes the account's password using the SAMR protocol.
Determine the Group Membership of a User	In this scenario, an Administrator determines the group membership of a user by querying the directory using the SAMR protocol. To perform this task, an Administrator runs a Client Application from a client computer, targeting a directory server in the Active Directory System. The Client Application queries the user's group membership using the SAMR protocol.
Delete a User Account	In this scenario, an Administrator deletes a user account. This includes directory objects of class user as well as those of classes derived from user. One way this can be accomplished is by using the LDAP protocol. To perform this task, an Administrator runs a Client Application from a client computer and targets a directory server in the Active Directory System. The Client Application deletes the user by using the LDAP protocol.
Obtain a List of User Accounts Using the Web Services Protocols	One way to obtain a list of users in the Active Directory System is to query the directory using the Web Services protocols, specifically, WS-Enumeration. A client application can create a query with a supplied filter to locate accounts based on specific criteria, similar to an LDAP search operation. To perform this task the client application sends a query to the directory service using the Web Services protocols. This scenario uses the WS-Enumeration protocol to communicate with the directory service.
Obtain a List of User Accounts Using the LDAP Protocol	Obtaining a list of user accounts in the Active Directory System can be achieved by querying the directory using the LDAP protocol. A client can create a query with a supplied filter to locate accounts based on specific criteria. To perform this task, a user runs a Client Application from a client

Example	Description
	computer that sends a query targeting a directory server in the Active Directory System.
Manage Groups and Their Memberships	This section discusses the process of creating groups, adding members to that group, and querying its membership. This process is illustrated by the state transitions of the directory client and the message flow between client and server.
Delete a Group	In this scenario, a user deletes a security group which is transformed into a Tombstone, [MS-ADTS] section 3.1.1.5.5.1.1. One way this can be accomplished is by using the LDAP protocol. To perform this task, a user runs a client application from a client computer, targeting a directory server in the Active Directory System and deletes a security group.
Extend the Schema to Support an Application by Adding a New Class	In this scenario, an Administrator extends the schema by adding a class required by an application. This is accomplished using the LDAP protocol. To perform this task, an Administrator runs a Client Application from a client computer targeting a Directory Server which is the Schema Master FSMO role in the Active Directory System. The Client Application adds a class and sets its properties using the LDAP protocol.
Extend the Schema to Support an Application by Adding a New Attribute	In this scenario, an Administrator extends the schema by adding an attribute required by an application. This is accomplished using the LDAP protocol. To perform this task, an Administrator runs a Client Application from a client computer targeting a Directory Server which is the Schema Master FSMO role in the Active Directory System. The Client Application adds an attribute and sets its properties using the LDAP protocol.
Extend the Schema to Support an Application by Adding an Attribute to a Class	In this scenario, an Administrator extends the schema by adding an attribute already present in the schema to a class that is also already present in the schema. This is accomplished using the LDAP protocol. To perform this task, an Administrator runs a Client Application from a client computer targeting a Directory Server which is the Schema Master FSMO role in the Active Directory System. The Client Application adds an attribute to a class using the LDAP protocol.
Partition Directory Data with Organizational Units	In this scenario, a user partitions the directory data using organizational units. This can be accomplished using the LDAP protocol. To perform this task, a user runs a client application from a client computer targeting a directory server in the Active Directory System. The client application creates an organizational unit to represent an organization's department and existing directory objects are moved under the new departmental organizational unit.
Store Application Data in the Directory	Developers can create directory-enabled applications that store data in the Active Directory System. To store application data, a user runs the client application from a client computer, targeting a directory server in the Active Directory System. The Client Application creates the directory object in the application NC using the LDAP protocol.
Manage Access Control on Directory Objects	In this scenario, an administrator reads and modifies the access control settings of a directory object. This permits the administrator to control who has access to that object, and what type of access they have.
Raise the Domain Functional Level	In this scenario, an administrator modifies the ms-DS-Behavior-Version attribute ([MS-ADA2] section 2.246 and [MS-ADTS] section 3.1.1.5.3.1.1.5) using the LDAP protocol, to an incremental value. To perform this task, an administrator runs a client application from a client computer, targeting a directory server in the Active Directory System and raises the domain

Example	Description
	functional level ([MS-ADTS] section 6.1.4.4).

[MS-AUTHSO]: Windows Authentication Services System Overview.

Example	Description
Interactive Domain Logon	Interactive logon can be performed in a number of ways. This example shows the password-based Kerberos exchanges.
HTTP Web Access Authentication	This example provides the steps that the server undertakes for HTTP Web Access Authentication. The example details the protocol traffic between the HTTP client, HTTP server, and domain controller when the HTTP client uses NTLM authentication.
File System Services - SMB Server	This example describes the steps that the server undertakes to provide support for authentication of SMB file system services.
Remote Procedure Services - RPC Server	This example describes the steps that the server undertakes to provide authentication for RPC system services.

[MS-CAESO]: Certificate Autoenrollment System Overview.

Example	Description
Computer Certificate Autoenrollment	This example shows how to enroll certificates automatically and renew them as they get close to their expiration, based on a machine-readable CEP.

[MS-CASO]: Certification Authority System Overview.

Example	Description
Enrollment from a Standalone CA (Basic Enrollment)	The simplest case of certificate enrollment is basic enrollment. In this example, the caller creates a PKCS#10 request by populating its fields as the caller chooses. The caller then uses an implementation that has a WCCE client component to submit the request to the WCCE server (CA).
Enrollment from an Enterprise CA (Template Based Enrollment)	This example builds on the example Enrollment from a Standalone CA (Basic Enrollment) by introducing an enterprise CA.
Enrollment with CA Administrator Approval	This example builds on the example Enrollment from an Enterprise CA (Template Based Enrollment) by introducing a CA Administrator who modifies and approves the certificate request before the certificate is issued.
Enroll on Behalf of Request and Renewal	This example builds on the example Enrollment from an Enterprise CA (Template Based Enrollment) by introducing a cosigner for the certificate request.
Private Key Archival and Recovery	This example builds on the example Enrollment from an Enterprise CA (Template Based Enrollment) by introducing private key archival and recovery.
Certificate Revocation	This example builds on the example Enrollment from an Enterprise CA (Template Based Enrollment) by adding the process of revoking a previously issued certificate.

Example	Description
Certificate Denied by Policy Algorithm	This example builds on the example Enrollment from an Enterprise CA (Template Based Enrollment), however, in this scenario, the caller requests a certificate based on a template for which it does not have permission to enroll. In this case the CA's policy algorithm denies the request after it examines the permissions applied to the template.
Certificate Denied Due to Out-of-Sync Certificate Templates	This example builds on the example Enrollment from an Enterprise CA (Template Based Enrollment) and illustrates a situation where two Active Directory servers are out of sync, which results in a version mismatch between the certificate templates used by client and server.

[MS-DISO]: Domain Interactions System Overview.

Example	Description
Locating a Domain Controller	This example shows the pattern for locating a domain controller based on the domain name that is provided, Flat NetBIOS names, as well as the fully qualified Domain Name System (DNS) names preferred for domains that use Active Directory, are valid.
Joining a Domain with a Predefined Account	This example illustrates the process by which a computer joins a domain using an account that is already configured within the domain.
Joining a Domain by Creating an Account via SAM	This is an example of a more secure variant for joining a domain that involves establishing the account on the domain controller via the SAM RPC interface and creating a new, random password for the domain client and the account in the domain.
Joining a Domain by Creating an Account via LDAP	This example illustrates the process by which a computer joins a domain after creating an account within the domain. This example creates the account via LDAP rather than using the SAM RPC interface.
Unjoining a Domain Member	This example illustrates the process by which a client is removed from the domain. The client must first be confirmed as part of the domain, then update information on the machine object so that accompanying domain servers will detect that the client is being removed.

6.1.1.3 File, Print, and Fax Protocols

[MS-FSSO]: File Access Services System Overview.

Example	Description
Configure a File Service	Configure File Service is illustrative of typical Admin interaction with the File Access Services System as the Admin provisions remotely accessible storage on a given file server.
Find a File in a Workgroup	Find File in Workgroup is illustrative of typical User interaction with the File Access Services System as a User locates a file server and a share on it, obtains a directory listing, and then opens a file.
Find a File in a Domain	Find File in Domain is illustrative of typical User interaction with the File Access Services System as the User locates a file within a DFS namespace and then opens the file.

Example	Description
Two Applications Communicate using a Shared File	The sequence described in this example allows two applications, one using the NFS File Access Protocol and another using the SMB File Access Protocol, to share a file on a remote file server.

[MS-PSSO]: Print Services System Overview.

Example	Description
Discover and Utilize a Print Queue in a Domain	In this example, a print client locates a Print Queue in a domain, establishes a connection to the Print Queue, downloads a print driver, registers for notifications of printing status, submits a print job, receives notifications, and then unregisters for notifications and disconnects from the Print Queue. The LDAP protocol is used to discover the available shared Print Queues, after which the protocol described in [MS-RPRN] as well as the SMB family protocols are used for subsequent operations.
Discover and Utilize a Print Queue in a Workgroup	In this example, a print client running Windows XP and located in a workgroup locates a shared Print Queue on another computer in the workgroup, establishes a connection to the Print Queue and registers for notifications, submits a print job to the Print Queue and receives notifications, and unregisters for notifications and disconnects from the Print Queue.
Locate Print Queue in a Domain and Establish a Connection, then Submit a Print Job to a Manual Duplex Printer Using [MS-RPRN] and [MS-PAR] and Enable Unidirectional IHV-defined Communication Between print client and print server Using [MS-PAN]	In this example, a print client locates a Print Queue in a domain, establishes a connection to the Print Queue, downloads a print driver, enables OEM-defined communications between the print client and print server, submits a print job, and receives notifications.
Enumerate Print Jobs from All Users, Then Cancel Several Print Jobs	In this example, an administrator with appropriate privileges using an Administrative print client views and overrides print jobs submitted to a shared Print Queue by other users.
Provision a Print Queue Using [MS-RPRN] from an Administrative Client, then Delete the Same Print Queue Using [MS-PAR] from a Different Administrative Client	In this example, two Administrative print clients are involved in managing Print Queues: the first client provisions a Print Queue using the protocol described in [MS-RPRN] and the second client subsequently deletes the same Print Queue using the protocol described in [MS-PAR] .
Send a Print Job to an SMB Share	In this example, a user performs commands from the command line by sending a print job to an SMB share by using the command "copy /b file \\server\printer" at the command line. The print client subsequently uses the SMB protocol family to copy the file to the specified SMB print share of the print server.

6.1.1.4 Systems Management Protocols

[MS-GPSO]: Group Policy System Overview.

Example	Description
Populating Administrative Tools with Configuration Data	This example demonstrates the process that occurs when the Group Policy administrative tools load and retrieve the appropriate data from the stores that contain policy data.
Authoring a New Policy	This example describes the message flow during the action of authoring a new policy.
Administrative Tool Cannot Connect to a Domain Controller	When the Admin tool launches, it attempts to contact a domain controller (DC). That DC can be any available Read/Write DC in the domain to be managed. If a DC cannot be reached, the Admin tool generates an error message that states that the directory cannot be located.
Querying Active Directory for Scope of Management (SOM) and Version Information	In this example, a GP Client queries a GP Server for Scope of Management (SOM) and version information.
Client Applying Policy	The Client's interaction with the GP Server in policy application exhibits a pull application in which the Client polls a GP server to check for new user GPOs.
Client Cannot Connect to a Domain Controller When Applying Policy	When the Client reapplies policy, it attempts to contact a domain controller (DC). That DC can be any available readable DC in the domain. If a DC cannot be reached, the Client generates an error message to the event log that states that the directory cannot be located.

[MS-WMSO]: Windows Management System Overview.

Example	Description
Single Request/Response Operations	A majority of the operations that are carried out within the WMS System are comprised of a single request and response. This example illustrates the communication flow of these simple operations.
Enumerations	When enumerating a set of managed objects, the result set may be too large to fit in a single response message. Therefore, enumerations consist of more than a single request/response pair. This example illustrates the communication flow of an enumeration operation.
Event Subscriptions	When subscribing for the delivery of events in the WMS System, there are three general message-flows that cover the different scenarios: pull subscriptions, push subscriptions, and publisher-initiated subscriptions. This example illustrates the communication flow of subscription and event delivery with these three scenarios.

6.1.1.5 Application Services

[MS-MQSO]: Message Queuing System Overview.

Example	Description
Disconnected Data Entry	An application that requires exactly-once delivery guarantee to transfer business messages asynchronously between machines.
Web Order Entry	An application that requires independent scaling out of the front-end application servers and the back-end processing servers.

Example	Description
Modify a Public Queue	A management application that requires the ability to administer Message Queuing operations locally and remotely.
Creating and Monitoring a Remote Private Queue	A management application that requires the ability to configure and monitor queues locally and remotely.
Branch Office Order Processing	An application that requires asynchronous and efficient message transfer functionality in a complex network topology.
Business-to-Business Messaging Across Firewall	An application that requires message communication between two or more business units across organizational network boundaries.
Server Farm	An application that requires scaled-out processing of messages that are asynchronously and reliably transferred from multiple application machines to a central intermediary server.
Stock Ticker	An application that requires the broadcasting of messages from a central machine to multiple recipient machines.
Business-to-Business Messaging Across Heterogeneous Systems	An application that requires asynchronous message communication between two or more business units when at least one business unit has a different message queuing system other than the Message Queuing (MSMQ) System.

[MS-TPSO]: Transaction Processing Services System Overview.

Example	Description
Basic Transaction Life Cycle	This example shows how transaction life-cycle roles interact with each other in the life time of the transaction.
Two-Phase Commit	This example is the continuation of the example Basic Transaction Life Cycle and shows how transaction life-cycle roles interact with each other during the Two-Phase Commit protocol.
Transaction Is Aborted	This example is the continuation of the example Basic Transaction Life Cycle and shows how transaction life-cycle roles interact with each other during the Two-Phase Commit protocol when one of the participants aborts the transaction.
Connection to Resource Manager Breaks Down	This example is the continuation of the example Basic Transaction Life Cycle and shows how transaction life-cycle roles interact with each other during the Two-Phase Commit protocol when connection to a resource manager breaks down, and shows how the resource manager drives recovery afterwards.
Transaction Manager Recovers after a Connection Failure	This example is the continuation of the example Basic Transaction Life Cycle and shows how transaction life-cycle roles interact with each other during the Two-Phase Commit protocol where connection to a subordinate transaction manager breaks down, and how the transaction manager drives recovery afterwards.
Distributed Transaction Coordination with External Components - Distributed Transaction Coordination with External Components Precursory	This example shows the message exchanges that occur at the initialization time of the participants.

Example	Description
Message Exchanges	
Distributed Transaction Coordination with External Components - Application-Driven Transactional Message Exchanges	This example shows the message exchanges that occur when an application creates a transaction and other participants enlist in the transaction.
Distributed Transaction Coordination with External Components - Two-Phase Commit Transactional Message Exchanges	This example shows the message exchanges that occur when an application requests its Transaction Manager to drive the transaction to a conclusion by using the Two-Phase Commit protocol.

6.1.1.6 General Protocols

The following tables summarize the examples for the protocols that support collaboration, media services, protected content, remote desktop services (terminal services), and update services functionality.

[MS-CSSO] Collaboration Services System Overview.

Example	Description
Collaboration Client Sending Registration Information to an ILS Server	The Collaboration Client does not automatically discover the ILS Server. The location of the ILS Server is entered manually by the user within the Collaboration Client application. This example illustrates Collaboration Client that sends registration information to an ILS Server. The client utilizes several LDAP operations in order to accomplish the request
Collaboration Client Retrieving Registration Information	This example illustrates Collaboration Client that retrieves registration information that other Collaboration Clients have placed on the ILS Server. The client will utilize several LDAP functions in order to accomplish the requests.

[MS-MGSO]: Multiplayer Games System Overview.

Example	Description
Discovering, Joining, and Leaving a Local Area Network DirectPlay 8 Game Session	This scenario provides a conceptual overview of the process of discovering an existing DirectPlay 8 session on a Local Area Network.
Joining a DirectPlay 8 Host and Existing Peer With Network Address Translation Extensions	This scenario provides a conceptual overview of a nascent peer joining a previously established DirectPlay 8 game session with a host and existing peer.

[MS-MSSO]: Media Streaming Server System Overview.

Example	Description
Encoder Push to Media Server	A key scenario is getting content from the server and onto the media server. One way the MSS System enables the encoder to get content onto the media server is through a push.
Media Server Pull from	In addition to the push model, the MSS System also supports a pull model for getting content from an encoder. The example illustrates the communication flow between the

Example	Description
Encoder	encoder and the server during a pull mode.
Multicast Playback	A key scenario for the MSS System is playing back multimedia content. The architectural details of this protocol are not expanded by the MSS System.
Unicast Playback	This example illustrates the communication flow between the Player Application and the server. The process for streaming multicast is broken down into four major areas: discovery, configuring the ports, stream selection, and playback.
Packet-Pair Bandwidth Estimation	This example illustrates packet-pair bandwidth estimation communication flow. To estimate bandwidth, the media server sends two or more consecutive packets of highly entropic data, and the client estimates the bandwidth by measuring the difference between the times that it receives the packets.
Advanced Fast Start/Fast Start	Fast Start and Advanced Fast Start work together to optimize the playback experience for the end user. This example shows the communication between a media player client, an origin server, and distribution server while taking into account the Advanced Fast Start and Fast Start headers.
Logging	Logging is a process that allows the media player to submit information and statistics to a media server or a web server. This example shows the logging communication between a Media Player Application, the Media Player Client Role, a media server Server Role, and a web server.
Integrating DRM	Digital Rights Management (DRM) integration happens entirely outside of the MSS System. This example shows the logging communication between a Media Player Application, the Encoder Application, the DRM Packager, the DRM Server, the MSS Server, and the MSS Client.

[MS-RMSO]: Rights Management Services System Overview.

Example	Description
Protecting Content Using Offline Publishing	This example illustrates the typical steps that can be completed for a user and computer that has not used RMS in the past to bootstrap the client, acquire a Client Licensor Certificate (CLC), acquire templates and, finally, publish the content offline.
Protecting Content Using Online Publishing	In online publishing, the client computer is not required to be activated and the client user is not required to be bootstrapped. This example describes a typical scenario using online publishing, assuming rights policy templates are used in the publishing process.
Consuming Protected Content	This example illustrates the typical steps performed to consume content, while assuming the computer and user have not used RMS in the past.

[MS-TSSO]: Terminal Services System Overview.

Example	Description
Connecting from an RDP Client to a TS Server	This example illustrates the RDP Client state model for a basic connection scenario. In this scenario, an RDP client connects to a TS Server in an intranet environment where no gateway is used.
Connecting from an RDP Client to a TS Server	This example illustrates the communication messages within the Terminal Services System for establishing a connection between an RDP Client and

Example	Description
through a TS Gateway	TS Server using a TS Gateway.
Establishing a Dynamic Virtual Channel for Plug and Play Device Redirection	One common scenario for using a dynamic virtual channel involves redirecting data from a Plug and Play device that is connected to an RDP Client after a user session has been established. This example illustrates the sequence that establishes the dynamic virtual channel.
Redirecting Clipboard Data	A Static Virtual Channel is used to redirect Clipboard data. This example illustrates how a Clipboard channel is initialized and subsequently used to transfer data.
Disconnection Sequence	This example illustrates two ways that an RDP Client may leave a connection with a TS Server: The RDP Client is disconnected from a TS Server due to network or other reasons, and the user of the RDP Client logs off from the TS Server.

[MS-WSUSO]: Windows Server Update Services System Overview.

Example	Description
Update Synchronization to DSS	This example describes the scenario where a downstream server (DSS) is configured to synchronize with an upstream server (USS), and the synchronization is triggered using the server management tool or triggered on a schedule from the DSS.
Initial Approval Sync to Replica DSS	When the DSS is configured as a replica of the USS, it synchronizes target groups and update approvals that are also from the USS, in addition to updates. This example describes the message exchanges required to accomplish this synchronization when a DSS communicates with a USS.
Initial Update Sync to Update Client	The goal of this example is for a particular Update Client to synchronize update metadata and deployments from a particular Update Server for the first time. In this case, the Update Client has no cached data from previous synchronizations with the Update Server.
Differential Update Sync to Update Client	The goal of this example is for a particular Update Client to synchronize update metadata and deployments from a particular Update Server after having already synchronized at a previous point in time. In this case, the Update Client has cached data from previous synchronizations with the Update Server, which it uses to optimize the synchronization.
Rollup of Reporting Data to USS	In this example, the goal of the scenario is for the DSS to send update installation and applicability information about the clients and descendent DSSs to the USS.
Update Client is Pointed to a New Update Server	In this example, the goal of the scenario is for a particular Update Client to synchronize update metadata and deployments from a different Update Server than it used for its previous synchronization.

6.2 Communication Details

In the Communication Details section of many System Overview documents, the system does not define additional communication details beyond those described in the specifications of the protocols supported by the system. The following documents fall into this category: [\[MS-MSSO\]](#), [\[MS-PSSO\]](#), [\[MS-RMSO\]](#), [\[MS-TPSO\]](#), [\[MS-TSSO\]](#), [\[MS-WMSO\]](#), and [\[MS-WSUSO\]](#).

For the rest of the System Overview documents, the Communication Details are as follows.

- [\[MS-ADSO\]](#)

Some of the protocols in the Active Directory System can operate on more than one transport. The constraints are as follows:

- The Active Directory System supports both TCP and UDP transports for LDAP versions 2 and 3, however TCP is the preferred transport.
- For SAMR, all opnums are exposed over both the Server Message Block (SMB) and TCP transports, except that SamrValidatePassword (opnum 67) is only exposed via the TCP transport. Clients MUST use the TCP transport when performing this operation.
- For LSAT, clients MUST choose which transport to use (either SMB or TCP) based on the opnum of the request that they are sending to the server.

The system does not define additional communication details beyond those described in the specifications of the protocols supported by the system.

- [\[MS-CASO\]](#)

The system components communicate through the shared elements that are listed in the Abstract Data Model section in [\[MS-CASO\]](#) (section [6.1](#)).

All messages and their processing rules are documented in the protocol specifications for the protocols that this system implements, as specified in [\[MS-CASO\]](#) section 2.2.

- [\[MS-FSSO\]](#)

For protocol layering, each protocol may be transported by a number of lower-layer protocols, and the lower-layer protocol connection must be established before the given protocol connection can be established. This system does not define additional communication details beyond those described in the specifications of the protocols supported by the system.

- [\[MS-GPSO\]](#)

The two communication process flows of interest are the interactions between the Group Policy Client and the Group Policy server and the interaction between the Administrative tool and the Group Policy Server, described as follows:

- Protocol communication between a Group Policy Client and Group Policy Server ([\[MS-GPSO\]](#) section 6.2.1): Communication between the GP Client and the GP Server uses core protocols to transport GP-specific information. Protocol communication to and from the Administrative Tool and Group Policy Server ([\[MS-GPSO\]](#) section 6.2.2): Group Policy is managed with an administrative tool that uses the same protocols and, in several instances, the same protocol sequence methods that the GP Client itself uses.

- [\[MS-MGSO\]](#)

The DirectPlay System is capable of using multiple underlying transports, such as UDP/TCP, IPX, or serial connections. However, firewall and Network Address Translation issues only apply to UDP/TCP (IP-based) transports, therefore the [\[MC-DPLNAT\]](#) extensions are not relevant to other transports.

- [\[MS-MQSO\]](#)

The communications within the Message Queuing System and between the system and external entities are described in [MS-MQSO] sections [5.4.1](#) and [5.4.2](#), respectively. The system does not define additional communication details beyond those described in the specifications of the protocols supported by the system.

6.3 Transport Requirements

In this section of many System Overview documents, the system does not define a transport or define any transport requirements beyond those described in the specifications of the member protocols. The following documents fall into this category: [\[MS-FSSO\]](#), [\[MS-MSSO\]](#), [\[MS-RMSO\]](#), [\[MS-TPSO\]](#), [\[MS-WMSO\]](#), and [\[MS-WSUSO\]](#).

For the rest of the System Overview documents, the Transport Requirements are as follows.

- [\[MS-ADSO\]](#)

Clients communicate with the directory service using RPC-based, block-structured, and SOAP protocols. The Web Services protocols use SOAP 1.2 [\[SOAP1.2-1/2003\]](#) as the message format over the "net.tcp" transport defined in [\[MC-NMF\]](#). WS-Addressing is bound to SOAP 1.2 as described in [\[WSASB\]](#).

- [\[MS-CASO\]](#)

The system-specific transport requirements are defined in [\[MS-CSRA\]](#) section 2.1, [\[MS-ICPR\]](#) section 2.1, and [\[MS-WCCE\]](#) section 2.1.

- [\[MS-GPSO\]](#)

The GP Client uses SMB and LDAP for transmitting Group Policy settings, and for transmitting instructions between the GP Client and the GP Server. The GP Client uses DC Locator/DNS for finding the GP Server; Kerberos and SPNEGO for authenticating the computer-for-computer policy application; and, SPNEGO for user-policy application.

- [\[MS-MGSO\]](#)

In the DirectPlay 4 System protocols, normal [\[MC-DPL4CS\]](#) operations and application-specified payloads are transported using [MC-DPL4CS] message types. When the application has enabled voice functionality, it uses an API provided by the voice protocol implementation to invoke its functionality.

- [\[MS-MQSO\]](#)

The following transports are used within the Message Queuing system, as well as with external entities:

- Transports Used Within the System ([\[MS-MQSO\]](#) section 6.3.1): The MQQB protocol is used to transfer a message from an outgoing queue to a destination queue with a range of delivery assurances. This block protocol uses either TCP/IP or SPX/IPX as the underlying data transport. The SRMP protocol is also used to transfer messages from an outgoing queue to a destination queue with a range of delivery assurances.
- Transports Used Between the Systems ([\[MS-MQSO\]](#) section 6.3.2): Applications communicate with the queue manager over several RPC-based and DCOM-based protocols. Applications and queue managers interact with the Directory Service through LDAP.

- [\[MS-PSSO\]](#)

The Print Services System uses transports as described in the component protocol documentation. There is no system-wide transport security. Each component protocol specifies its own transport security.

- [\[MS-TSSO\]](#)

RDP Client to TS Server communication requires Transmission Control Protocol (TCP) transport over either an IPV4 or IPV6 network.

6.4 Timers

In this section of many System Overview documents, the system has no timer events or does not define any timer requirements beyond those described in the specifications of the member protocols. These documents fall into this category: [\[MS-ADSO\]](#), [\[MS-CASO\]](#), [\[MS-MSSO\]](#), [\[MS-PSSO\]](#), [\[MS-RMSO\]](#), [\[MS-TPSO\]](#), and [\[MS-WMSO\]](#). In the case of [\[MS-TPSO\]](#), an implementation of the system is required to provide the timers described in the specifications of the protocols supported by the system.

For the rest of the System Overview documents, the System Timers are described as follows.

- [\[MS-FSSO\]](#)

The timers for this system are as follows:

- SMB Oplock Break Response Wait Timer ([\[MS-FSSO\]](#) section 6.4.2).
- SMB Scavenger Thread Timer ([\[MS-FSSO\]](#) section 6.4.3).
- SMB Session Auto-Disconnect Timer ([\[MS-FSSO\]](#) section 6.4.1).

- [\[MS-GPSO\]](#)

For Group Policy, the client SHOULD have the Periodic Refresh timer. This timer SHOULD be triggered periodically to check for updated policy for the computer or for each user interactively logged on to the computer. The frequency of this timer is implementation specific, as described in [\[MS-GPSO\]](#).

- [\[MS-MGSO\]](#)

The DirectPlay System timers are confined to affecting only the associated Member Protocol in which they are documented. However, because of the largely vertical relationship among Member Protocols, a timer may cause a lower-layer protocol to transition to a state that appears as an external non-timer event to a higher layer.

- [\[MS-MQSO\]](#)

The timers of the Message Queuing System are described in the specifications of the protocols supported by the system. The following timers are important to the state of the overall system, and the Message Queuing System is required to maintain them:

- Directory Service Synchronization Timers ([\[MS-MQSO\]](#) section 6.4.1): The synchronization timers in this section are enabled only if the Message Queuing System is operating in Directory-Integrated with Routing mode.
- Message Timers ([\[MS-MQSO\]](#) section 6.4.2): The message timers are described in [\[MS-MQDMPR\]](#) section 3.1.2.4, and the associated timer events are described in [\[MC-MQAC\]](#) section 3.1.6.1.1.

- Security Timers ([\[MS-MQSO\]](#) section 6.4.3): This section discusses the following security timers:
 - Certificate Data Cache Validity Timer: This timer regulates the amount of time that a queue manager that operates in Directory-Integrated mode waits before it invalidates the internal certificate data cache.
 - Queue Manager Public Key Cache Validity Timer: This timer regulates the amount of time that the queue manager waits before invalidating the cache.
- [\[MS-TSSO\]](#)

The Session Disconnect timer is the primary timer that is used by the TS Server to disconnect an idle session. The TS Server disconnects the session on a timeout event by initiating a protocol disconnect event.
- [\[MS-WSUSO\]](#)

An update server SHOULD use a timer to trigger periodic synchronization with its upstream server (USS). The frequency of the timer is implementation-specific. Similarly, an update client SHOULD use a timer to trigger periodic reporting to its update server. The frequency of the timer is implementation-specific. The periodic reporting of the update client to its update server impacts the update server's USS.

6.5 Non-Timer Events

In this section of many System Overview documents, the system does not have any non-timer events or it does not define any non-timer events beyond those described in the specifications of the member protocols. The following documents fall into this category: [\[MS-FSSO\]](#), [\[MS-MQSO\]](#), [\[MS-MSSO\]](#), [\[MS-RMSO\]](#), [\[MS-WMSO\]](#), and [\[MS-WSUSO\]](#).

For the rest of the System Overview documents, the non-timer events are described as follows.

- [\[MS-ADSO\]](#)

There is one non-timer event, Host Name Change, in the Active Directory System (beyond those non-timer events specified in the underlying protocol documents).
- [\[MS-CASO\]](#)

The system-specific events are defined in [\[MS-CSRA\]](#) section 3.1.4, [\[MS-ICPR\]](#) section 3.2.4, and [\[MS-WCCE\]](#) section 3.2.1.4.

A system that implements the enterprise CA mode SHOULD register for the asynchronous change notifications to the certificate template objects in Active Directory. See [\[MS-WCCE\]](#) section 6.5.
- [\[MS-GPSO\]](#)

On the client, policy application in computer policy mode SHOULD be invoked at the time that the computer boots or connects to a new network and MAY be invoked at other times. Policy application in user policy mode are be invoked at the time a user logs in or connects to a new network and MAY be invoked at other times.
- [\[MS-MGSO\]](#)

Because of the largely vertical nature of the DirectPlay System's relationships among Member Protocols, many external events apply equally to each protocol. Because each DirectPlay System

Member Protocol encapsulates the state of those below it, the state of the system as a whole is effectively the same as the state of the highest-level protocol.

- [\[MS-PSSO\]](#)

In the event of a system shutdown, the Print Services System MUST close all open handles to remote objects and unregister endpoints. When a local Plug and Play event occurs or when new printer hardware is detected on a local port of a computer acting as print server, the Print Services System automatically locates a matching driver for the detected printer and installs a Print Queue. The created Print Queue can optionally be set up as a shared Print Queue (per policy setting).

- [\[MS-TPSO\]](#)

This section describes one local event, which is when a connection is disconnected ([\[MS-TPSO\]](#) section 6.5.1.1), and one external event ([\[MS-TPSO\]](#) section 6.5.1.2.1), which is system recovery.

- [\[MS-TSSO\]](#)

The Terminal Services System depends on platform facilities for creating a remote session for the remote user. As such, there are several error events possible during this operation that arise from several subsystems such as authentication, authorization, group policy, and licensing.

6.6 Initialization and Reinitialization Procedures

In this section of many System Overview documents, there are no system initialization or reinitialization requirements beyond what is described in the individual protocol Technical Documents. The following documents fall into this category: [\[MS-FSSO\]](#), [\[MS-MQSO\]](#), [\[MS-MSSO\]](#), [\[MS-RMSO\]](#), [\[MS-TPSO\]](#), and [\[MS-WMSO\]](#).

For the rest of the System Overview documents, the system initialization and reinitialization requirements are described as follows.

- [\[MS-ADSO\]](#)

The Active Directory System does not contain a requirement to reinitialize the protocols, nor does it contain specific procedures for reinitializing the protocols.

- [\[MS-CASO\]](#)

The initialization processes are defined in [\[MS-CSRA\]](#) section 3.1.3, [\[MS-ICPR\]](#) section 3.2.3, and [\[MS-WCCE\]](#) sections [3.2.1.3](#) and [3.2.2.3](#).

- [\[MS-GPSO\]](#)

During initialization, the Group Policy client SHOULD register for computer boot and user logon notification. As part of re-initialization, the Group Policy client SHOULD recreate the operational state pertaining to the machine and every logged-on user.

- [\[MS-MGSO\]](#)

Initialization and reinitialization of the DirectPlay System is controlled by the application. An application should be designed to use either DirectPlay 4 or DirectPlay 8. The protocols to be used should be initialized together, at the same time, since higher layers depend on lower ones, and all share similar lifetimes.

- [\[MS-PSSO\]](#)

Initialization occurs at system startup, which will start the print spooler service. Reinitialization occurs up to two times only upon abnormal termination of the print spooler service.

- [\[MS-TSSO\]](#)

The initialization of the RDP Client, TS Server, and TS Gateway are described in this section of [\[MS-TSSO\]](#). Other components of the Terminal Services System are initialized as described in the component protocol documentation. Virtual channels, including dynamic virtual channels (DVC), are initialized as a part of the connection sequence between the RDP Client and the TS Server.

- [\[MS-WSUSO\]](#)

Initialization of the system entails the following:

- Update servers generate a globally unique identifier to identify themselves to other update servers.
- Update clients generate a globally unique identifier to identify themselves to update servers.
- Update servers are initialized with the location (for example, DNS name and port) of their upstream server (USS).
- Update clients are initialized with the location (for example, DNS name and port) of their update server.

An update server or update client can be individually reinitialized without reinitializing the entire system.

6.7 Status and Error Returns

In this section of many System Overview documents, the system does not define any error handling requirements beyond those described in the specifications of the member protocols. The following documents fall into this category: [\[MS-FSSO\]](#), [\[MS-GPSO\]](#), [\[MS-MGSO\]](#), [\[MS-MQSO\]](#), [\[MS-MSSO\]](#), [\[MS-PSSO\]](#), [\[MS-RMSO\]](#), [\[MS-TPSO\]](#), [\[MS-TSSO\]](#), [\[MS-WMSO\]](#), and [\[MS-WSUSO\]](#).

For the rest of the System Overview documents, the error-handling requirements are as follows.

- [\[MS-ADSO\]](#)

The Active Directory System does not define any error handling requirements beyond those described in the Technical Documents of the protocols supported by the system, and does not have a dedicated configuration or administration protocol. It is configured using the same protocols that are otherwise used by applications for interacting with the system.

This document also adds a section on System Management Details ([\[MS-ADSO\]](#) section 6.8).

- [\[MS-CASO\]](#)

The error handling requirements are defined in [\[MS-CSRA\]](#) section 2.2.5 and [\[MS-WCCE\]](#) section 2.2.4.

7 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:

- Windows NT operating system
- Windows 2000 operating system
- Windows Millennium Edition operating system
- Windows XP operating system
- Windows XP operating system Service Pack 1 (SP1)
- Windows XP operating system Service Pack 2 (SP2)
- Windows XP operating system Service Pack 3 (SP3)
- Windows Server 2003 operating system
- Windows Server 2003 operating system with Service Pack 1 (SP1)
- Windows Server 2003 operating system with Service Pack 2 (SP2)
- Windows Server 2003 R2 operating system
- Windows Vista operating system
- Windows Vista operating system with Service Pack 1 (SP1)
- Windows Server 2008 operating system
- Windows 7 operating system
- Windows Server 2008 R2 operating system
- Windows Home Server server software
- Windows Home Server 2011 server software

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 3.1.1.7.1:](#) Supported in Windows 2000 Server, Windows 2000, Windows Server 2003, and Windows XP.

[<2> Section 3.1.1.7.1:](#) Supported in Windows Server 2008 R2 and Windows 7.

[<3> Section 3.1.1.7.1:](#) Supported in Windows Server 2008 R2 and Windows 7.

[<4> Section 3.1.1.7.2:](#) Supported in Windows Server 2008, Windows Vista, Windows Server 2008 R2 and Windows 7.

[<5> Section 3.1.1.7.4:](#) The devolution level in Windows is configured in the following registry locations:

- HKEY_LOCAL_MACHINE \ SYSTEM \ CurrentControlSet \ Services \ Dnscache \ Parameters \ DomainNameDevolutionLevel (if configured by the local system administrator).
- **HKEY_LOCAL_MACHINE \ SYSTEM \ CurrentControlSet \ Policies \ Microsoft \ Windows NT \ DNSClient \ DomainNameDevolutionLevel** (if configured through Group Policy).

[<6> Section 3.1.1.7.6:](#) Supported in Windows Server 2008 R2 and Windows 7.

[<7> Section 3.1.2.1.2:](#) In Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Server 2003 R2, Windows Vista, Windows Server 2008, and Windows Server 2008 R2, the built-in administrator account is enabled by default. In Windows 7, the built-in administrator account is supported but disabled by default.

[<8> Section 3.1.2.1.2.1:](#) Windows Server 2003, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2 domains do not allow the use of a period (.) or multiple periods at the end of a user logon name. The use of a period at the end of a user logon name, as long as the user logon name does not consist solely of period characters, is allowed in the following domains: Windows NT 3.1, Windows NT 3.5, Windows NT 3.51, and Windows NT 4.0.

[<9> Section 3.1.2.1.2.2:](#) Domain join is supported in Windows NT 3.1, Windows NT 3.5, Windows NT 3.51, Windows NT 4.0, Windows 2000, Windows XP, Windows Server 2003, Windows Server 2003 R2, Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2.

[<10> Section 3.1.2.1.2.2:](#) Active Directory is supported in Windows 2000, Windows Server 2003, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2.

[<11> Section 3.1.2.1.4:](#) Supported in Windows Server 2003, Windows Server 2003 R2, Windows Server 2008 and Windows Server 2008 R2.

[<12> Section 3.1.2.1.5.2:](#) The applicable servers are: Windows 2000 Server, Windows Server 2003, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2.

[<13> Section 3.1.2.1.5.2:](#) Windows NT 4.0 domains have one domain controller (DC) that accepts changes, and all other DCs are read-only. Windows 2000 servers and Windows Server 2003 servers cannot be configured this way. Active Directory DCs that do not accept changes are a new feature for Windows Server 2008

[<14> Section 3.1.2.1.6.2:](#) Windows 98, Windows 2000, Windows 2000 Server, Windows Millennium Edition, Windows XP, Windows XP SP1, Windows XP SP2, Windows XP SP3, Windows Vista, Windows Server 2003, Windows Server 2003 with SP1, Windows Server 2003 SP2, Windows Server 2003 with SP3, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2 use algorithms that are compliant with the FIPS 140-2 standard. Windows Vista SP1 uses a new algorithm that is compliant with the NIST SP 800-90 standard. The random number generation in all versions of Windows prior to Windows Vista SP1 is consistent with FIPS 186-2 Change Notice 1.

[<15> Section 3.1.2.1.6.2:](#) Windows uses the cryptographic PRNG from the Cryptographic API (CAPI) and the Cryptographic API Next Generation (CNG) for generation of Version 4 GUIDs.

[<16> Section 3.1.2.1.6.2:](#) For reasons of increased privacy protection for our customers, Microsoft systems, beginning with Windows 2000, prefer to generate version 4 GUIDs in which the 122 bits of nonformat information are random. Although only a small minority of version 4 GUIDs require

cryptographic randomness, the random bits for all version 4 GUIDs built in Windows are obtained via the Windows CryptGenRandom cryptographic API or the equivalent, which is the same source that is used for the generation of cryptographic keys. This source is FIPS 140-certified in various versions of Windows, as documented at [\[MSFIP140CryptCerts\]](#).

[<17> Section 3.1.2.3.8:](#) There are four primary integrity levels in Windows Vista with four corresponding values. A lower value indicates a lower integrity level or a lower level of trustworthiness. These values are defined in the header file, winnt.h. See [\[MS-DTYP\]](#) section 2.4.4.13 for the integrity levels and their corresponding values.

[<18> Section 3.1.2.4.5:](#) Prior to Windows 2000, the only supported impersonation levels were identify and impersonate. Windows 2000 adds support for delegate-level impersonation. The anonymous level is not supported remotely.

[<19> Section 3.1.2.4.5:](#) This level is supported beginning with Windows 2000.

8 Appendix B: Protocols Affected by Group Policy

Implementations of the Windows Protocols System, as listed in the following table, can be affected by Group Policy. Some of these protocols have one or more properties that can be configured by Group Policy. See [Appendix D](#) for a list of the ADM and ADMX files that shipped in Windows operating systems, and where to find them on the download center.

Protocol name	TD short name
Active Directory Web Services Custom Action Protocol Specification	[MS-ADCAP]
Authentication Protocol Domain Support Specification	[MS-APDS]
Background Intelligent Transfer Service (BITS) Peer-Caching Peer Authentication Protocol Specification	[MS-BPAU]
Corporate Error Reporting Version 1.0 Protocol Specification	[MS-CER]
Component Object Model Plus (COM+) Protocol Specification	[MS-COM]
Distributed Component Object Model (DCOM) Remote Protocol Specification	[MS-DCOM]
Distributed File System (DFS) Referral Protocol Specification	[MS-DFSC]
Distributed Link Tracking Workstation Protocol Specification	[MS-DLTW]
Digital Rights Management License Acquisition Data Structure	[MS-DRM]
Directory Replication Service (DRS) Remote Protocol	[MS-DRSR]
Firewall and Advanced Security Protocol Specification	[MS-FASP]
File System Control Codes	[MS-FSCC]
File Server Resource Manager Protocol Specification	[MS-FSRM]
Health Certificate Enrollment Protocol Specification	[MS-HCEP]
Internet Information Services (IIS) IMSAdminBaseW Remote Protocol Specification	[MS-IMSA]
IP over HTTPS (IP-HTTPS) Tunneling Protocol Specification	[MS-IPHTTPS]
Internet Information Services (IIS) Inetinfo Remote Protocol Specification	[MS-IRP]
Kerberos Protocol Extensions	[MS-KILE]
Link Layer Topology Discovery (LLTD) Protocol Specification	[MS-LLTD]
Microsoft Media Server (MMS) Protocol Specification	[MS-MMSP]
Message Queuing (MSMQ) Directory Service Protocol Specification	[MS-MQDS]
Message Queuing (MSMQ) Queue Manager Remote Read Protocol Specification	[MS-MQRR]
Microsoft Web Browser Federated Sign-On Protocol Extensions	[MS-MWBE]
Microsoft Web Browser Federated Sign-On Protocol Specification	[MS-MWBF]

Protocol name	TD short name
NT LAN Manager (NTLM) Authentication Protocol Specification	[MS-NLMP]
Protected Extensible Authentication Protocol (PEAP) Specification	[MS-PEAP]
Peer Name Resolution Protocol (PNRP) Version 4.0 Specification	[MS-PNRP]
Remote Assistance Protocol Specification	[MS-RA]
Remote Administration Protocol Specification	[MS-RAP]
Remote Certificate Mapping Protocol Specification	[MS-RCMP]
Remote Desktop Protocol Basic Connectivity and Graphics Remoting Specification	[MS-RDPBCGR]
Remote Desktop Protocol Composited Remoting V2 Specification	[MS-RDPCR2]
Remote Desktop Protocol Audio Output Virtual Channel Extension	[MS-RDPEA]
Remote Desktop Protocol Graphics Device Interface (GDI) Acceleration Extensions	[MS-RDPEGDI]
Rights Management Services (RMS) Client-to-Server Protocol Specification	[MS-RMPR]
Remote Procedure Call Protocol Extensions	[MS-RPCE]
Remote Procedure Call over HTTP Protocol Specification	[MS-RPCH]
Remote Procedure Call Location Services Extensions	[MS-RPCL]
Print System Remote Protocol Specification	[MS-RPRN]
Routing and Remote Access Server (RRAS) Management Protocol Specification	[MS-RRASM]
Removable Storage Manager (RSM) Remote Protocol Specification	[MS-RSMP]
Remote Shutdown Protocol Specification	[MS-RSP]
Security Account Manager (SAM) Remote Protocol Specification (Client-to-Server)	[MS-SAMR]
Kerberos Protocol Extensions Service for User and Constrained Delegation Protocol Specification	[MS-SFU]
Server Message Block (SMB) Protocol Specification	[MS-SMB]
Server Message Block (SMB) Version 2 Protocol Specification	[MS-SMB2]
Secure Socket Tunneling Protocol (SSTP) Specification	[MS-SSTP]
Transport Layer Security (TLS) Profile	[MS-TLSP]
Terminal Services Terminal Server Runtime Interface Protocol Specification	[MS-TSTS]
W32Time Remote Protocol Specification	[MS-W32T]
Windows Client Certificate Enrollment Protocol Specification	[MS-WCCE]
Web Distributed Authoring and Versioning (WebDAV) Protocol Client Extensions	[MS-WDV]

Protocol name	TD short name
Web Distributed Authoring and Versioning (WebDAV) Protocol Microsoft Extensions	[MS-WDVME]
Workstation Service Remote Protocol Specification	[MS-WKST]
Web Point-and-Print Protocol Specification	[MS-WPRN]
Web Services Management Protocol Extensions for Windows Server 2003	[MS-WSMAN]
Web Services Management Protocol Extensions for Windows Vista	[MS-WSMV]
Windows System Resource Manager (WSRM) Protocol Specification	[MS-WSRM]
Windows Update Services Client-Server Protocol Specification	[MS-WUSP]

9 Appendix C: Standards and Other Specifications Implemented in Windows

9.1 Standards Implemented

Windows implements the following standards:

6to4 Protocol: This protocol standard is an optional interim mechanism for IPv6 sites to communicate with each other over the IPv4 network without explicit tunnel setup. It also allows IPv6 sites to communicate with native IPv6 domains via relay routers across an IPv4 network. The protocol additionally provides an interim, globally unique IPv6 address prefix to any site with at least one globally unique IPv4 address.

1394 Serial Bus Protocol 2 (SPB2): This protocol standard is used to encapsulate small computer system interface (SCSI) requests over an IEEE 1394 bus. It provides support for IEEE 1394 printers, CD-ROM, DVD, scanner, and storage devices.

Address Resolution Protocol (ARP): ARP is used to dynamically map an IP address of an onlink node to its 48 bit Ethernet address. ARP is also used to detect duplicate IP addresses within a network.

ANSI Terminal Emulation: ANSI describes the control characters (or escape sequences) transmitted over the wire from a computer to a dumb terminal, or terminal emulator, that control the positioning and color of characters on the terminal/emulator screen. The supported character set (defined originally in ANSI X3.64-1979 and superseded by ECMA-48) is described in [\[ECMA-048\]](#).

ANSI Terminal Emulation: Wide Character Extension (ANSIW): ANSIW is derived from ANSI (see the ANSI Terminal Emulation protocol entry) and describes the control characters (or escape sequences) transmitted over the wire from a computer to a dumb terminal, or terminal emulator, that control the positioning and color of characters on the terminal/emulator screen. ANSIW supports wide (double byte ASCII characters) in addition to single byte ASCII characters. The supported character set (defined originally in ANSI X3.64-1979 and superseded by ECMA-48) is described in [\[ECMA-048\]](#).

ANSI X3T12: ANSI X3T12 (FDDI) is a protocol standard that enables the transfer of information and control between a pair of data link layer service access points on an FDDI Network. Windows includes third party drivers that implement the protocol for communication with their devices. These drivers are in the form for Network Interface Cards. There are no online copies. The ANSI specification can be obtained from: ANSI standards (published FDDI standards) American National Standards Institute, Attention: Sales Dept., 1430 Broadway, New York, NY 10018, USA.

AT Attachment 8 - ATA/ATAPI Command Set (ATA8-ACS): This standard specifies the AT Attachment command set between host systems and storage devices. It provides a common command set for systems manufacturers, system integrators, software suppliers, and suppliers of intelligent storage devices. It includes the PACKET feature set implemented by devices commonly known as ATAPI devices. This standard maintains a high degree of compatibility with the AT Attachment Interface with Packet Interface - 7 (ATA/ATAPI-7) volume 1, INCITS 397-2004, and, while providing additional functions, is not intended to require changes to devices or software that comply with previous T13 standards.

Serial ATA Revision 2.6: This protocol standard defines a high-speed serialized ATA data link interface (specifying Phy, Link, Transport, and Application layers). The serialized interface uses the command set from the ATA/ATAPI-6 standard, augmented with Native Command Queuing commands optimized for the serialized interface. The serialized ATA interface is defined in a

register-compatible manner with parallel ATA to enable backward compatibility with parallel ATA drivers.

AT command (ITU-T v.250) Protocol: The AT modem command set is used to enable an entity (for example an operating system) to talk to a modem device in a standard way. The AT command set, for example, specifies which string should be sent to the modem to tell the device to prepare for dialing a number, open a line, dial, negotiate baud rate (speed), etc. This protocol is strictly for communication between a host and a device, in this case a modem.

ATAPI: ATAPI is a local hardware interface for communication with storage devices (hard disks). ATAPI stands for Advanced Technology Attachment Packet Interface.

ATM User-Network Interface (UNI) Protocol: The Asynchronous Transfer Mode (ATM) User-Network Interface (UNI) protocol standard specifies the interfaces to be used between ATM user devices (for example, a system running Windows) and ATM network equipment (for example, an ATM switch) for the purposes of setting up end-to-end connections between ATM user devices. For more information on ATM, see: [\[BroadbandForum\]](#).

Atom Publishing Protocol: The Atom Publishing Protocol (AtomPub) standard is an application-level protocol for publishing and editing web resources. The protocol is based on HTTP transfer of Atom-formatted representations. The Atom format is documented in the Atom Syndication Format. A number of Windows Live services follow this protocol, such as Windows Live Photos.

Atom Syndication Format 1.0: Atom is an XML-based file format that describes lists of related information known as "feeds". Feeds are composed of a number of items, known as "entries", each with an extensible set of attached metadata. For example, each entry has a title. The primary use case that Atom addresses is the syndication of web content such as weblogs and news headlines to websites as well as directly to user agents.

Basic Profile Version 1.0: The WS-I Basic Profile 1.0 consists of a set of non-proprietary Web services specifications, along with clarifications and amendments to those specifications, which promote interoperability.

Basic Profile Version 1.1: The WS-I Basic Profile 1.1 consists of a set of non-proprietary Web services specifications, along with clarifications, refinements, interpretations, and amplifications of those specifications, which promote interoperability.

Basic Security Profile: Core and SAML: This profile restricts usage of WS-Security and the Security Assertion Markup Language (SAML) standards in SOAP Web services in order to aid interoperability.

Bluetooth: The Bluetooth® protocol standard is a low bandwidth serial bus protocol for connecting wireless devices to computers.

Bluetooth Advanced Audio Distribution Profile (A2DP): The Bluetooth® Advanced Audio Distribution Profile (A2DP) defines the protocols and procedures that realize distribution of audio content of high-quality in mono or stereo on asynchronous connection-oriented (ACL) channels. The A2DP profile relies on the transport service capability provided by the Audio/Video Distribution Transport Protocol (AVDTP). The A2DP requirements are expressed in terms of end-user services, and by defining the features and procedures that are required for interoperability between Bluetooth devices in the audio distribution usage model.

Bluetooth Audio/Video Remote Control Profile (AVRCP): This profile defines the requirements for Bluetooth® devices that are necessary for the support of the Audio/Video Remote Control usage case. The requirements are expressed in terms of end-user services, and by defining the features and procedures that are required for interoperability between Bluetooth devices in the Audio/Video Remote Control usage case. This profile specifies the scope of the Audio/Video Control (AV/C) Digital

Interface Command Set (AV/C command set, which is defined by the 1394 Trade Association) to be applied, and it realizes simple implementation and easy operability. This profile adopts the AV/C device model and command format for control messages, and those messages are transported by the Audio/Video Control Transport Protocol (AVCTP). In this profile, the controller translates the detected user action to the A/V control signal, and then transmits it to a remote Bluetooth device. The functions available for a conventional infrared remote controller can be realized in this profile. The remote control described in this profile is designed specifically to A/V control. Other remote control solutions using Bluetooth wireless technology may be applied for general Bluetooth devices including A/V devices.

Bluetooth Hands-free Profile (HFP): The Hands-free Profile defines the minimum set of functions for which an audio gateway can be used in conjunction with a hands-free device (for example, one that is installed in the car or represented by a wearable device such as a headset), with a Bluetooth® Link providing a wireless means for both remote control of the audio gateway by the hands-free device and voice connections between the audio gateway and the hands-free device.

Bluetooth Hardcopy Cable Replacement Profile: The Bluetooth® Hardcopy Cable Replacement Profile (HCRP) protocol standard is a protocol for printing to Bluetooth printers.

Bluetooth Headset Profile (HSP): The Bluetooth® headset profile defines the protocols and procedures that are required to be used by devices implementing the usage model called 'Ultimate Headset'. The most common examples of such devices are headsets, personal computers, and cellular phones. For this model, Windows is acting as the audio gateway, and communicates with the Bluetooth profile exposed by the Bluetooth device using the headset profile protocol.

Bluetooth Object Push Profile Version 1.0: Bluetooth® Object Push Profile (OPP) provides wireless connections by enabling systems to perform object exchange (OBEX) functions. This feature is only client-client, since Bluetooth® support is not in the Windows Server family of operating systems (2000, 2003, or Vista Server).

Bluetooth Personal Area Network User (PANU) Profile: Bluetooth® Personal Area Network (PAN) provides wireless connections by enabling links between mobile computers, mobile phones, portable handheld devices, and the Internet. This is a complete implementation of the PANU (PAN User) profile role, as specified in the Bluetooth PAN specification by the Bluetooth SIG.

Bluetooth Serial Port Profile - (Bluetooth RFCOMM): The RFCOMM protocol standard emulates the serial cable line settings and status of an RS-232 serial port and is used for providing serial data transfer. RFCOMM connects to the lower layers of the Bluetooth® protocol stack through the L2CAP layer. By providing serial-port emulation, RFCOMM supports legacy serial-port applications, while also supporting the OBEX protocol, among others. RFCOMM is a subset of the ETSI TS 07.10 standard, along with some Bluetooth-specific adaptations.

Cascading Style Sheets (CSS), Level 1: This data structure specifies level 1 of the Cascading Style Sheet mechanism (CSS1). CSS1 is a simple style sheet mechanism that allows authors and readers to attach style (for example, fonts, colors and spacing) to HTML documents. The CSS1 language is human readable and writable, and expresses style in common desktop publishing terminology.

Cascading Style Sheets (CSS) 2.1: Cascading Style Sheets, level 2 revision 1 (CSS 2.1) is a style sheet language that allows authors and users to attach style (for example, fonts and spacing) to structured documents (for example, HTML documents and XML applications). By separating the presentation style of documents from the content of documents, CSS 2.1 simplifies web authoring and site maintenance. This entry is intended to cover CSS 2.0 as well as CSS 2.1.

Character Generator Protocol: The Character Generator Protocol standard is a debugging and measurement tool. A character generator service sends data without regard to the input.

Common NNTP Extensions: Extensions, including authentication, for NNTP. NNTP Server does not ship in Windows Vista operating system client or Windows Server 2008 operating system.

Cross Domain Request (XDR) Protocol: This protocol standard allows a client-side object, for example, an AJAX object, to make requests to a server outside of the domain where it was downloaded. The client-side object will add a request header along with the request to a server from another domain. The server can return a response header with the response body to allow the response to be surfaced on a client-side object. If the response header is missing, the client-side object will discard the response as if an error occurred. The request header and response header provide an explicit opt-in mechanism for the client and server to communicate across the domain. This protocol standard is new for Windows 7 operating system, but will ship down-level as part of IE8 deployment.

Daytime Protocol standard: The Daytime Protocol standard is a debugging and measurement tool. A daytime service sends the current date and time as a character string without regard to the input.

Devices Profile for Web Services (DPWS): The Web services architecture includes a suite of specifications that define rich functions and that may be composed to meet varied service requirements. In order to promote both interoperability between resource-constrained Web service implementations and interoperability with more flexible client implementations, this profile identifies a core set of Web service specifications in the following areas:

- Sending secure messages to and from a Web service.
- Dynamically discovering a Web service.
- Describing a Web service.
- Subscribing to, and receiving events from, a Web service.

In each of these areas, this profile defines minimal implementation requirements for compliant Web service implementations.

DCE 1.1: Remote Procedure Call: This protocol standard defines wire format, behavior, and portable APIs for the execution of cooperating components by using a remote procedure call model. The Windows implementation is described in section [3.1.1.1](#), "Remote Procedure Call Model", in this document.

DHCP Options and BOOTP Vendor Extensions: The Dynamic Host Configuration Protocol (DHCP) standard provides a framework for passing configuration information to hosts on a TCP/IP network. Configuration parameters and other control information are carried in tagged data items that are stored in the 'options' field of the DHCP message. The data items themselves are also called "options".

Differentiated Services (DIFFSERV): IETF RFC 2474 defines the Differentiated Services (DS) field, which supersedes the IPv4 TOS field [\[RFC791\]](#) and the IPv6 Traffic Class field. The DS field can have a value from 0-63 (inclusive) for marking the priority of an IP datagram; this value is called a Differentiated Services Code Point (DSCP) value.

Digest Access Authentication: The Digest authentication mechanism [\[RFC2617\]](#) [\[RFC2831\]](#) performs authentication between a client and a server based on a user name and a password. Digest can authenticate the client to the server, and optionally the server to a client. The latter case is termed mutual authentication. Digest was originally specified as a native authentication method for HTTP/1.1, in [\[RFC2616\]](#), to serve as an improvement on HTTP's Basic Authentication. Digest's popularity grew, and it was covered as a SASL [\[RFC2222\]](#) mechanism by the specification in [\[RFC2831\]](#). Once made into a SASL mechanism, Digest became available for other protocols, such

as LDAP [\[RFC2251\]](#). The standard implemented in Windows includes both digest and basic authentication.

Digital Living Network Alliance (DLNA) Home Networked Device Interoperability

Guidelines: The DLNA Networked Device Interoperability Guidelines provide vendors with the information required to build interoperable networked platforms and devices for the digital home. They specify the necessary standards and technologies that enable products to be built for networked entertainment-centric usages, which allow for the seamless sharing of music, photos, and videos. As much as possible, the DLNA Guidelines refer to standards from established, open-industry standards organizations, such as the UPnP™ Implementers Corporation (UIC) and the Wi-Fi™ Alliance. The DLNA Guidelines govern the design, compliance testing, and certification of new digital devices that are authorized to use the DLNA CERTIFIED™ logo and trademark. These Guidelines add additional restrictions and mandate the use of specific codecs to a number of standard protocols.

Note An implementation of this protocol will be included in Windows 7 Home Server.

Directory Services Markup Language 2.0: Directory Services Markup Language 2.0 defines methods for expressing directory queries and updates (and the results of these operations) by using the SOAP protocol. It also provides a syntax for representing directory information as an XML document.

Discard Protocol standard: The Discard Protocol standard is a debugging and measurement tool. A discard service throws away any data that it receives.

Domain Name System (DNS) Protocol standard: The Domain Name System (DNS) is a client/server protocol standard used for name resolution, and for querying and updating name records. It includes the response to queries per the IETF standard DNS query protocol and the acceptance of updates per the IETF standard DNS dynamic update protocol.

Domain Name System (DNS) Resource Record (RR) for Encoding Dynamic Host

Configuration Protocol (DHCP) Information (DHCID RR): The Domain Name System's database is a collection of Resource Records. Each Resource Record specifies information about a particular object. This protocol stores client identifiers in DNS to unambiguously associate domain names with DHCP clients, using a Dynamic Host Configuration ID (DHCID) RR. It defines mechanisms to update the FQDN records and it minimizes chances of new clients registering themselves with DNS by using hostnames that have been assigned to other servers.

Domain Name System Security Extensions (DNSSEC): Domain Name System Security Extensions (DNSSEC) are extensions to the Domain Name System (DNS) that provide data integrity and authentication to security aware resolvers or applications through the use of cryptographic digital signatures.

Dynamic Configuration of IPv4 Link-Local Addresses: To participate in wide-area IP networking, a host needs to be configured with IP addresses for its interfaces either manually by the user or automatically from a source on the network such as a Dynamic Host Configuration Protocol (DHCP) server. Unfortunately, such address configuration information may not always be available. It is therefore beneficial for a host to be able to depend on a useful subset of IP networking functions when no address configuration is available. [\[RFC3927\]](#) describes how a host may automatically configure an interface with an IPv4 address within the 169.254/16 prefix that is valid for communication with other devices connected to the same physical (or logical) link.

Dynamic Host Configuration Protocol (DHCP): The Dynamic Host Configuration Protocol (DHCP) standard provides a framework for passing configuration information to hosts on a TCP/IP network. DHCP is based on the Bootstrap Protocol (BOOTP), and adds the capability of automatic allocation of

reusable network addresses and additional configuration options. Some aspects of this protocol standard (including the DHCP relay agent) are not implemented in client SKUs.

Dynamic Host Configuration Protocol for IPv6 (DHCPv6): The Dynamic Host Configuration Protocol for IPv6 (DHCPv6) standard enables DHCP servers to pass configuration parameters, such as IPv6 network addresses, to IPv6 nodes. It offers the capability of automatic allocation of reusable network addresses and additional configuration flexibility.

Dynamic Host Configuration Protocol for IPv6 (DHCPv6) Client Fully Qualified Domain Name (FQDN) Option: This protocol standard specifies a new Dynamic Host Configuration Protocol for IPv6 (DHCPv6) option that can be used to exchange information about a DHCPv6 client's Fully Qualified Domain Name (FQDN) and about the responsibility for updating DNS resource records (RRs) related to the client's address assignments.

Echo Protocol: The Echo Protocol standard is a debugging and measurement tool. An echo service sends any data it receives back to the originating source. The data may be sent over either TCP or UDP.

Extensible Authentication Protocol (EAP) Message Digest Algorithm 5: The Extensible Authentication (EAP) standard is an authentication framework that supports multiple authentication methods. EAP typically runs directly over data link layers such as Point-to-Point Protocol (PPP) or IEEE 802, without requiring IP. EAP Message Digest Algorithm 5 (EAP-MD5) is an EAP method that supports MD5-Challenge authentication. The MD5-Challenge method is analogous to the PPP CHAP protocol, defined in [\[RFC1994\]](#), with MD5 as the specified algorithm.

Extensible Authentication Protocol Transport Level Security (EAP-TLS): The Extensible Authentication Protocol (EAP) standard is an authentication framework which supports multiple authentication methods. EAP typically runs directly over data link layers such as Point-to-Point Protocol (PPP) or IEEE 802, without requiring IP. EAP Transport Layer Security (EAP-TLS) is an EAP method that supports mutual certificate-based authentication, based on TLS, as specified in [\[RFC2246\]](#).

Extensible Authentication Protocol (EAP): The Extensible Authentication Protocol (EAP) standard is an authentication framework that supports multiple authentication methods. EAP typically runs directly over data link layers, such as Point-to-Point Protocol (PPP) or IEEE 802, without requiring IP. EAP provides its own support for duplicate elimination and retransmission, but is reliant on lower-layer ordering guarantees. Fragmentation is not supported within EAP itself; however, individual EAP methods may support this.

eXtensible Markup Language (XML): eXtensible Markup Language (XML) is a standard for formatting streams of data. XML is stored within files and is used for some protocols as the descriptive language for the payload.

File Transfer Protocol (FTP): The File Transfer Protocol (FTP) standard is used to transfer files between two remote computers. FTP allows a remote computer to execute data transfer functions and file transfer functions on a remote host.

File Transfer Protocol (FTP) Extensions: These extensions to the File Transfer Protocol (FTP) enable support for FTP over Transport Layer Security (TLS), internationalization, and the ability to specify a virtual host.

FTP extensions for IPv6 and NATs: The FTP extensions for IPv6 and NATs allow the FTP protocol to work over IPv6 and future network protocols. As it stands, without the extensions, FTP would not support IPv6 addresses.

General Event Notification Architecture (GENA): This specification provides for the ability to send and receive notifications using HTTP over TCP/IP and administratively scoped unreliable

multicast UDP. Provisions are made for the use of intermediary arbiters, called subscription arbiters, which handle routing notifications to their intended destination.

Generic Security Services for Remote Procedure Call (RPCSEC_GSS): Generic Security Services for Remote Procedure Call (RPCSEC_GSS) is an Open Network Computing / Remote Procedure Call (ONC/RPC) that allows RPC protocols to access the Generic Security Services Application Programming Interface (GSS_API).

H.245 Protocol: H.245 specifies syntax and semantics of terminal information messages, as well as procedures to use them for in-band negotiation at the start of or during communication. The messages include receiving and transmitting capabilities, as well as mode preference from the receiving end, logical channel signaling, and Control and Indication. Acknowledged signaling procedures are specified to ensure reliable audiovisual and data communication.

H.323 Protocol: The H.323 protocol standard describes protocols and packets between terminals and other entities that provide multimedia communications services over Packet Based Networks (PBN), which may not provide a guaranteed Quality of Service. H.323 entities may provide real-time audio, video, and/or data communications. It is a protocol for establishing audio/video sessions and packet payloads that are sent and received during a session. Support for audio is mandatory, while data and video are optional, but if supported, the ability to use a specified common mode of operation is required, so that all terminals supporting that media type can interwork. The packet based network over which H.323 entities communicate may be a point-to-point connection, a single network segment, or an internetwork having multiple segments with complex topologies. H.323 entities may be used in point-to-point, multipoint, or broadcast (as described in Recommendation H.322) configurations.

High-Definition Multimedia Interface Audio Protocol: High-Definition Multimedia Interface (HDMI) is used to stream audio and video over a single cable from a source product (for example, a PC or DVD player) to a connected device (for example, a TV or Audio/Video receiver). HDMI enables a source to query the connected device for its capabilities and send up to 8-channel, 192 kHz uncompressed audio, in addition to compressed audio formats. Windows uses HDMI in order to retrieve the audio capabilities of the connected device and stream audio to that device.

Host Name Data Structure: [\[RFC952\]](#), as updated by [\[RFC1123\]](#), defines the syntax of a Host Name, which can be carried in various protocols, such as DNS. [\[RFC2181\]](#) defines the behavior of DNS, which deals with generic DNS names (of which host names are just one type).

HTTP Authentication: Basic and Digest Access Authentication Protocol standard: The HTTP Authentication: Basic and Digest protocol standard verifies that both parties of a communication know a shared secret. This standard is commonly used to authenticate clients that use browsers and it corresponds to the digest authentication implemented by digest.dll. Digest.dll no longer ships in Windows. It was removed for Windows Vista and replaced with wdigest.dll. Basic authentication is implemented directly in WinInet and WinHTTP.

Human Interface Device Profile: The Bluetooth® Human Interface Devices (HID) protocol standard defines a set of services that can be used between a host capable of supporting HID devices and a BT-HID device. Examples of this type of host are the mouse and the keyboard.

Hypertext Markup Language (HTML) 4.01: This specification defines the HyperText Markup Language (HTML), which is the publishing language of the World Wide Web. This specification defines HTML 4.01, which is a subversion of HTML 4. In addition to the text, multimedia, and hyperlink features of the previous versions of HTML (HTML 3.2 [\[HTML32\]](#) and HTML 2.0 [\[RFC1866\]](#)), HTML 4 supports more multimedia options, scripting languages, style sheets, better printing facilities, and documents that are more accessible to users with disabilities. HTML 4 also aims towards the internationalization of documents, with the goal of making the web worldwide. This entry is intended to cover HTML 4.0 as well as HTML 4.01.

Hypertext Markup Language (HTML) 3.2: The HyperText Markup Language (HTML) is a simple markup language used to create hypertext documents that are portable from one platform to another. HTML documents are SGML documents with generic semantics that are appropriate for representing information from a wide range of applications. This specification defines HTML version 3.2. HTML 3.2 aims to capture the recommended practice as of early 1996 and replaced HTML 2.0 [[RFC1866](#)].

Hypertext Transfer Protocol (HTTP): HTTP is an application-level, request/response protocol standard built on top of the TCP protocol. The protocol is standardized and maintained by the IETF and is currently at version 1.1.

ICMP Router Discovery Protocol: The ICMP Router Discovery Messages protocol standard specifies an extension of the Internet Control Message Protocol (ICMP) to enable hosts attached to multicast or broadcast networks to discover the IP addresses of their neighboring routers. The client role is implemented by the TCP/IP stack, and the server role is implemented by RRAS prior to Vista, and by the TCP/IP stack in Vista.

IEC 61883: The IEC 61883 protocol standard uses the IEEE 1394 standard to specify a digital interface for electronic audio/video equipment.

IEEE 1394: IEEE 1394 multimedia connection enables simple, low-cost, high-bandwidth isochronous (real-time) data interfacing between computers, peripherals, and consumer electronics products such as camcorders, VCRs, printers, PCs, TVs, and digital cameras.

IEEE 802.11-2007 Protocol: This protocol standard is an implementation the Institute of Electrical and Electronic Engineers (IEEE) 802.11 wireless Local Area Network (LAN) specification. The protocol is used to provide a layer 2 connection between PCs, devices, and other networks using unlicensed RF spectrum through a defined Media Access Control (MAC) and Physical layer (PHY). The protocol includes a client/server function as well as a peer to peer function.

Note Client acting as a server and server acting as a server are only implemented in Windows 7 and Windows Server 2008 R2 operating system.

IEEE 802.1x-2004 (802.1x): This supplement to ISO/IEC 15802-3:1998 (IEEE Std 802.1D-1998) defines the changes necessary to the operation of a MAC Bridge in order to provide switch/bridge port-based network access control capability. For information on integrity checks and key encryption calculations for 802.1x, see the radius extensions RFC [[RFC3580](#)]. Windows implements the client role only.

IEEE 802.2 (Logical Link Control): A set of procedures that are defined for the transfer of information and control between any pair of data link layer service access points on a Local Area Network (LAN). These procedures are independent of the type of medium access method used in a particular LAN. Windows includes third party drivers that implement the protocol for communication with their devices. These drivers are in the form of drivers for Network Interface Cards. The IEEE 802.2 specification can be obtained from [[IEEE802.2-1998](#)].

IEEE 802.5: 802.5 (Token ring) is a protocol data link layer protocol standard that enables the transfer of information and control between a pair of access points on a 802.5 Local Area Network (LAN). Down level Windows (pre Windows Vista) includes third party drivers that implement the protocol for communication with their devices. These drivers are in the form of drivers for Network Interface Cards. The IEEE 802.5 specification can be obtained from [[IEEE802.5-1998](#)].

Information Card Data Structure: Information Card is an XML document that contains data that describes the relationship between a Security Token Service (STS) and the issuer of the STS. This data includes, but is not limited to, the logical identifier for the issuer, token issuance endpoints of

the STS, token types and claims supported by the STS, and the descriptor for the authenticating credential.

Information Refresh Time Option for Dynamic Host Configuration Protocol for IPv6

(DHCPv6): The Information Refresh Time Option for Dynamic Host Configuration Protocol for IPv6 standard implements a Dynamic Host Configuration Protocol for IPv6 (DHCPv6) option that specifies an upper bound for how long a client should wait before refreshing information that is retrieved from DHCPv6. It is used with stateless DHCPv6 because there are no addresses or other entities with lifetimes that can tell the client when to contact the DHCPv6 server to refresh its configuration.

Integrated Services Digital Network (ISDN): The Integrated Services Digital Network (ISDN), as specified in ITU-T I.430 and ITU-T I.431, is a set of physical layer protocols for establishing and breaking circuit switched connections between the ISDN modem and the Internet Service Provider's telecommunication network. ISDN is designed to allow digital transmission of voice and data over ordinary telephone copper wires, which results in better quality and higher speeds than that available with the PSTN system. Windows includes third party drivers which implement the ISDN set of protocols for communication with the telecommunications network. These are in the form of drivers for Connection oriented Network Interface Cards.

Interface - Parallel (IEEE 1284): A signaling method for asynchronous, fully interlocked, bidirectional parallel communications between hosts and printers or other peripherals is defined. A format for a peripheral identification string and a method of returning this string to the host outside of the bi-directional data stream is also specified. Specifications for Interface - Parallel (IEEE 1284) are maintained by the Institute of Electrical and Electronics Engineers, Inc., (IEEE). For information on Interface - Parallel (IEEE 1284) see [\[IEEE1284\]](#).

Internet Control Message Protocol (ICMP): ICMP is used by Internet nodes and routers to signal error conditions, as well as for network diagnostics. ICMP is an integral part of the Internet Protocol Version 4 (IPv4).

Internet Control Message Protocol for IPv6 (ICMPv6): The Internet Protocol, version 6 (IPv6) standard is a new version of IP. ICMPv6 is the IPv6 equivalent of the Internet Control Message Protocol (ICMP) as defined for IPv4 [\[RFC792\]](#). The protocol is used to provide control notifications about network events. This standard also covers IPv6 neighbor and router discovery, which are implemented on top of ICMPv6 and are extensions to them (for example, default router selection).

Internet Gopher Protocol: The Internet Gopher protocol standard is designed for distributed document search and retrieval via TCP port 70.

Internet Group Management Protocol MIB (IGMP MIB): This module exposes counters and data for tracking multicast sessions, which use the Simple Network Management Protocol (SNMP). The IGMP MIB information is used by both the agent that exposes the MIB information, and by the MIB browser that renders it. The IGMP MIB information ships on all client operating systems as part of the browser component. The agent component shipped on Windows 2000 operating system and Windows XP operating system. It was removed from Windows Vista.

Internet Group Management Protocol Version 1 (IGMPv1): The Internet Group Management Protocol (IGMP) standard is used by IP hosts to report their host group memberships to any immediately-neighbor multicast routers. It is also used by routers to query hosts for their membership in multicast groups. IGMP is an integral part of IP. It is required to be implemented by all Internet nodes.

Note This standard is documented in [\[RFC1112\]](#), "Host Extensions for IP Multicasting". IGMP is specified in Appendix I of [\[RFC1112\]](#). [\[RFC1112\]](#) also deals with the data communication of IP multicasting, in addition to the membership query and reporting capability.

Internet Group Management Protocol Version 2 (IGMPv2): IGMPv2 is used by IP hosts to report their multicast group memberships to multicast routers. IGMPv2 allows group membership termination to be quickly reported to the routing protocol, which is important for high-bandwidth multicast groups and/or subnets with highly volatile group membership.

Note Clients do listen to traffic from other clients for the purpose of suppressing their own messages.

Internet Group Management Protocol Version 3 (IGMPv3): IGMP is the protocol standard used by IPv4 systems to report their IP multicast group memberships to neighboring multicast routers. Version 3 of IGMP adds support for "source filtering", which is the ability for a system to report interest in receiving packets only from specific source addresses, or from all but specific source addresses that are sent to a particular multicast address. This information may be used by multicast routing protocols to avoid delivering multicast packets from specific sources to networks where there are no interested receivers.

Internet Information Services (IIS) HTTP Protocol: The Hypertext Transfer Protocol (HTTP) standard is an application-level protocol standard for distributed, collaborative, hypermedia information systems. It is a generic, stateless, protocol which can be used for many tasks beyond its use for hypertext, such as for name servers and distributed object management systems, through extension of its request methods, error codes and headers. A feature of HTTP is the capacity to type and negotiate data representation, which allows systems to be built independently of the data being transferred.

Internet Key Exchange (IKE): The Internet Key Exchange protocols are used to negotiate IPsec settings and cryptographic keys in order to protect IP traffic from modification and information disclosure (IPsec is a suite of protocols that protect network communication at the IP layer - Layer 3 in the OSI model. The main protocols for the application of security to IP packets are the AH and ESP protocols. AH and ESP, in turn, can use different encryption and hashing algorithms that constitute a transformation protocol). [\[RFC3947\]](#) was first shipped on Windows XP.

Internet Key Exchange Version 2 (IKEv2) Protocol: The Internet Key Exchange Version 2 (IKEv2) protocol standard is used to negotiate IP Security (IPsec) settings and cryptographic keys in order to protect Internet Protocol (IP) traffic from modification and information disclosure. The IKEv2 protocol includes the mobility and multihoming extension to Internet Key Exchange Version 2 (MOBIKE). MOBIKE allows the IP addresses associated with Internet Key Exchange Version 2 (IKEv2) Protocol and tunnel mode IP Security Associations (SAs) to change.

Internet Message Access Protocol - Version 4: IMAP4 is a protocol standard for retrieving email messages from a server. The client side ships as part of Outlook Express and the server side is part of Exchange Server.

Internet Printing Protocol: The Internet Printing Protocol (IPP) is a standard, application-level protocol standard that can be used for distributed printing using Internet tools and technologies. IPP uses a simplified model that consists of abstract objects, their attributes, and their operation.

Internet Protocol over Asynchronous Transfer Mode (IPoATM) Protocol: The IP over ATM protocol standard defines procedures to resolve IP addresses to ATM addresses, and to carry IP datagrams within ATM Adaptation Layer 5 (AAL5) data units within ATM Virtual Circuits (VCs) and thus provide IP connectivity over an ATM network. Third-party vendors provide device drivers that transmit and receive AAL5 data units through ATM Network Interface Cards. An ATM ARP server is the only server role that is implemented. ATMUNI switch role is not implemented.

Internet Protocol Security (IPsec & IKE): Cryptographic Algorithms: The IPsec protocol suite is defined by a set of IETF standards that track RFC documents. IPsec protects network communication at the IP layer - Layer 3 in the OSI model. The main protocols for the application of

security to IP packets are the Authentication Header (AH) and Encapsulated Security Payload (ESP) protocols. AH and ESP, in turn, can use different encryption and hashing algorithms that constitute a payload transform. The Microsoft implementation of IPsec supports Advanced Encryption Standard (AES) Galois counter mode Message Authentication Code (GMAC) and AES Cipher Block Chaining Counter Mode (CCM) for use with AH and ESP.

Internet Protocol Security (IPsec) Protocol: The (IETF standard) IPsec protocols that are used to protect IP traffic from modification and information disclosure. IPsec is a suite of protocols that protect network communication at the IP layer - Layer 3 in the OSI model. The main protocols for the application of security to IP packets are the Authentication Header (AH) and Encapsulation Security Protocol (ESP) protocols. AH and ESP, in turn, can use different encryption and hashing algorithms that constitute a transformation protocol.

Internet Protocol Version 4 (IPv4): The Internet Protocol standard is designed for use in interconnected systems of packet-switched computer communication networks. The Internet Protocol provides for the transmission of blocks of data called datagrams from sources to destinations, where sources and destinations are hosts identified by fixed length addresses. The Internet Protocol also provides for fragmentation and reassembly of long datagrams, if necessary, for transmission through "small packet" networks. The IP extensions for IP packet multicasting are described in [\[RFC1112\]](#).

Internet Protocol Version 6 (IPv6): The IPv6 protocol standard is used by nodes to communicate with other nodes across a network, independent of the types of physical links present in the network. IPv6 is the successor to IPv4 ([\[RFC7911\]](#)). The Internet Protocol (IP) is a data-oriented protocol used for communicating data across a packet-switched internetwork. IP is a network-layer protocol in the internet protocol suite and is encapsulated in a data link layer protocol (for example, Ethernet). As a lower-layer protocol, IP provides the service of communicable unique global addressing amongst computers. This implies that the data link layer is not required to provide this service. This form also equally applies to ICMPv6 and IPv6 stateless address auto configuration ([\[RFC2463\]](#), [\[RFC2462\]](#)). The Microsoft IPv6 implementation also supports the host part of the router alert option RFC ([\[RFC2711\]](#)).

Internet SCSI (iSCSI) Protocol: The iSCSI protocol standard transports the SCSI storage protocol (T10 SPC-2 or greater) over TCP/IP. The protocol enables access from a computer to SCSI devices, such as disks, tapes, changers, and CD ROMs. It defines the rules and processes for device discovery, authentication, and data transfer. The protocol also provides support for a session (nexus) to implement fault tolerant access to disks across the network.

Internet Storage Name Service (iSNS): The Internet Storage Name Service (iSNS) Protocol standard is used for interaction between iSNS servers and iSNS clients, and facilitates automated discovery, management, and configuration of iSCSI and Fibre Channel devices (using iFCP gateways) on a TCP/IP network. iSNS provides intelligent storage discovery and management services comparable to those found in Fibre Channel networks, which allows a commodity IP network to function in a capacity similar to that of a storage area network. iSNS facilitates a seamless integration of IP and Fibre Channel networks due to its ability to emulate Fibre Channel fabric services and to manage both iSCSI and Fibre Channel devices. iSNS thereby provides value in any storage network comprised of iSCSI devices, Fibre Channel devices (using iFCP gateways), or any combination thereof.

Internet X.509 Public Key Infrastructure Time-Stamp Protocol: This protocol standard is a transport-agnostic Cryptographic Message Syntax (CMS)-based request-reply protocol for requesting and receiving a cryptographically signed time stamp token in response to the provision of a cryptographic hash. This time stamp is used as evidence that the hashed object existed prior to the time given in the time stamp.

Intra-Site Automatic Tunnel Addressing Protocol (ISATAP): The Intra-Site Automatic Tunnel Addressing Protocol (ISATAP) standard provides IPv6 connectivity across an IPv4 intranet. ISATAP views the IPv4 network as a link layer for IPv6 and views other nodes on the network as potential IPv6 hosts/routers. ISATAP supports an automatic tunneling abstraction similar to the Non-Broadcast Multiple Access (NBMA) model.

IP Forwarding Table MIB: This MIB module defines settings for managing routes in an IP network.

IP Version 6 over PPP: This protocol standard defines a method for transmission of IP Version 6 packets over PPP links. It also specifies the method of forming IPv6 link-local addresses on PPP links.

IP-in-IP Tunneling: This is a connectionless protocol standard used for point-to-point tunnels between routers in order to construct overlay networks. Support for this was added to RRAS in Windows 2000 Server and was then removed from subsequent releases.

IPv4 Address Conflict Detection: When two hosts on the same link attempt to use the same IPv4 address at the same time (except in rare special cases where this has been arranged by prior coordination), problems ensue for one or both hosts. [\[RFC5227\]](#) describes (i) a simple precaution that a host can take in advance to help prevent this misconfiguration from happening, and (ii) if this misconfiguration does occur, a simple mechanism by which a host can passively detect, after the fact, that it has happened, so that the host or administrator may respond to rectify the problem.

IPv4 Multicast Routing MIB: This MIB module provides the ability to read counters related to the IPv4 Multicast Routing protocol standard using SNMP.

IPv4 over High Performance Serial Bus (IEEE 1394) Protocol: This protocol standard specifies how to use a High Performance Serial Bus (IEEE 1394) for the transport of Internet Protocol Version 4 (IPv4) datagrams. This standard includes not only packet formats and encapsulation methods for datagrams, but also an address resolution protocol (1394 ARP) and a multicast channel allocation protocol (MCAP) that permits management of Serial Bus resources when used by IP multicast groups. This protocol is no longer supported as of Windows Vista.

IPv6 MIB: This MIB module specifies configuration settings for the IPv6 protocol.

IPv6 over IPv4 (6over4) Protocol: 6over4, also known as IPv4 multicast tunneling, is a host-to-host, host-to-router, and router-to-host automatic tunneling technology that is used to provide unicast and multicast IPv6 connectivity between IPv6 nodes across an IPv4 intranet.

IPv6-in-IPv4 Configured Tunnels: IPv6-in-IPv4 Configured Tunnels, as defined in [\[RFC2893\]](#), are point-to-point tunnels that are made by encapsulating IPv6 packets within IPv4 headers to carry them over IPv4 routing infrastructures. Windows supports the ability to manually configure such IPv6 tunnels via netsh.

IrDA Infrared Transfer Picture (IrTranP) Protocol: IrTranP is an image transfer protocol standard over the Infrared link for digital cameras. IrTranP includes a binary file transfer protocol and a simple command-execute protocol to transfer a Uni Picture Format (UPF). IrTranP is a higher-layer protocol that sits on top of Ir-Tiny-TP, Ir-LMP, and Ir-LAP, which collectively constitute the Infrared communications stack.

IrDA Tiny Transport Protocol (Tiny TP): The Tiny TP protocol standard provides independently flow controlled transport connections over the IrLMP (Infrared Link Management Protocol). In other words, IrTinyTP abstracts the lower layers of the Infrared stack (IrLMP and IrLAP - Link Access Protocol) from upper-layer protocols by means of providing abstracted methods to utilize the Infrared stack. The abstract methods are 'transport connections' that represent one flow of data from (or to) an application or application-layer protocol. The IrTinyTP protocol is part of the 'core'

Infrared protocols that are implemented in Windows as part of the native support in Windows for Infrared.

JavaScript Object Notation Protocol: JSON is a data interchange format based on the EcmaScript programming language. Our usage in ASP.NET is similar to the use of XML between a web client and server for the transmission of data. For more information about JSON, see [\[RFC4627\]](#).

Kerberos Network Authentication Service (V5): The Kerberos authentication protocol standard allows a user to log in to a network service: the KDC (key distribution center / Kerberos domain controller). Once a user is authenticated to the KDC, a session key is generated that is used by the user's machine for subsequent authentications to any computer or service in the same Kerberos domain or any other Kerberos domain that cooperates with ("shares trust with") the user's domain. When used for network authentication, the protocol is 3-way, which allows client-to-client authentication that is intermediated by the KDC server. This allowance implies that there are two different kinds of "server" role. In the entries in this form, we assume that only the KDC implements the "key server role", while any computer can implement the "app server role".

Kermit File Transfer Protocol: Kermit is a file transfer protocol standard developed by Columbia University beginning in 1981. The Kermit site may be found at [\[KermitProject\]](#). The protocol is documented in the book: Kermit: A File Transfer Protocol by Frank Da Cruz, Digital Press 1987, ISBN 0932376886.

LAN Emulation over ATM (LANE) Protocol: This protocol standard supports the emulation of an IEEE 802.3 (Ethernet) or IEEE 802.5 (Token Ring) Local Area Network over an underlying Asynchronous Transfer Mode (ATM) network, for the purposes of operating protocols such as IP and/or IPX over such a network. The protocol includes services for configuring end-nodes (hosts), which map between Ethernet/Token Ring addresses and ATM addresses, and for the transport of unicast, broadcast and multicast Ethernet/Token Ring frames. This transport provides Ethernet to ATM address resolution and Ethernet frame encapsulation and transport over ATM. The server role is an ATM switch. Communication between Windows client and server products always goes through an ATM switch.

Lightweight Directory Access Protocol (LDAP): This is a directory access protocol standard that provides for the ability to create, read, update, and delete entries in a directory service, such as Microsoft Active Directory. Each entry is an object identified by a unique name, which contains one or more attributes. Each of the attributes can have one or more values. Although the title does not specify, this protocol is LDAP V2.

Lightweight Directory Access Protocol (LDAP) Version 3: This is a directory access protocol standard that provides the ability to create, read, update, and delete entries in a directory service such as Microsoft Active Directory. This protocol standard builds upon LDAP V2 as its foundation, but adds greater extensibility via the LDAP extended control and LDAP extended operation mechanisms, as well as by refining and expanding upon other concepts that were initially introduced in LDAP v2. This is the preferred version of LDAP to use for accessing Active Directory. The following Active Directory MMC snap-ins make use of the LDAP V3 protocol standard: dsa.msc, dssite.msc, domain.msc, schmgmt.msc, adsiedit.msc, gpedit.msc, certmgr.msc, rsop.msc. The schmgmt.msc snap-in is not accessible by default, but must be enabled by registering schmmgmt.dll as documented in "Install the Active Directory Schema Snap-In" [\[MSFT-IADSSNPIN\]](#). Tri-state filter evaluation was not implemented in Win2k RTM; therefore, Win2K only implements the client role.

Lightweight Online Certificate Status Protocol (OCSP): This protocol standard, specified in [\[RFC5019\]](#) as "The Lightweight Online Certificate Status Protocol (OCSP) Profile for High Volume Environments", provides revocation information for x.509 certificates. It allows applications to query the current status of a certificate without downloading a certificate revocation list (CRL), which can be large in size. [\[RFC5019\]](#) is a profile of the Online Certificate Status Protocol (OCSP), as specified in [\[RFC2560\]](#).

Line Printer Daemon Protocol: The Line Printer Daemon (LPD) protocol standard communicates between line printer daemons (clients and servers). The Berkeley versions of the Unix operating system provide line printer spooling with a collection of programs: lpr (assign to queue), lpq (display the print queue), lprm (remove from print queue), and lpc (control the print queue). These programs interact with an autonomous process called the line printer daemon.

Management Information Base for Network Management of TCP/IP-based internets (MIB-II): This MIB module defines settings for the Internet Protocol Version 4 (IPv4).

Media Transfer Protocol (MTP): Media Transfer Protocol, or MTP, is a protocol standard that is designed for content exchange with, and command and control of, transient storage devices. The primary purpose of this protocol standard is to facilitate communication between media devices that have transient connectivity and significant storage capacity, which includes the exchange of binary objects and the enumeration of the contents of that connected device. The secondary purpose of this protocol standard is to enable command and control of the connected device, which includes the remote invocation of device functionality, monitoring of device-initiated events, and the reading and setting of device properties. A server in MTP serves the role of initiating the connection and sending the commands. A server in MTP is the MTP Initiator. A client is an MTP responder.

Microsoft Point-to-Point Compression (MPPC) Protocol: The Point-to-Point Protocol (PPP) provides a standard method for transporting multi-protocol datagrams over point-to-point links. The PPP Compression Control Protocol provides a method to negotiate and utilize compression protocols over PPP encapsulated links. The Microsoft Point-to-Point Compression (MPPC) protocol describes a method for compressing PPP encapsulated packets.

Microsoft Point-To-Point Encryption (MPPE) Protocol: The Point-to-Point Protocol (PPP) standard provides a standard method for transporting multi-protocol datagrams over point-to-point links. The PPP Compression Control Protocol provides a method to negotiate and utilize compression protocols over PPP encapsulated links. The Microsoft Point-To-Point Encryption (MPPE) Protocol describes a means for enhancing the confidentiality of PPP-encapsulated packets through encryption.

Microsoft PPP CHAP Extensions: This protocol standard describes the Microsoft PPP CHAP dialect [\[MS-CHAP\]](#), which extends the user authentication functionality provided on Windows networks to remote workstations. [MS-CHAP] is closely derived from the PPP Challenge Handshake Authentication Protocol, described in [\[RFC1994\]](#).

Microsoft PPP CHAP Extensions, Version 2: This protocol standard defines version 2 of the Microsoft PPP CHAP dialect [MS-CHAP-V2]. [MS-CHAP-V2] is similar to, but not compatible with, [MS-CHAP] version 1. In particular, some protocol fields have been deleted or reused with different semantics. In addition, [MS-CHAP-V2] provides for mutual authentication between the client and the server.

Minitel Terminal Emulation: Minitel was developed to work with dumb terminals attached to servers on an X.25 network via the V.23 modem protocol, as described in: International Telecommunication Union, "600/1200-baud modem standardized for use in the general switched telephone network", ITU-T Recommendation V.23, November 1988.

Moving Picture Experts Group (MPEG) Stream Encoding Protocol: The Moving Picture Experts Group (MPEG) Stream Encoding Protocol standard is used to encode and to stream broadcast audio/video content and related data from a device or service. Windows contains multimedia components for supporting the client side of the mpeg-2 transport stream (TS) and Packetized Elementary Stream (PES) stream protocols. This protocol is used in the Windows client and by Media Center in the Windows 7 Entertainment Server SKUs.

Multicast Address Dynamic Client Allocation Protocol (MADCAP): The Multicast Address Dynamic Client Allocation Protocol (MADCAP) standard allows hosts to request multicast address allocation services from multicast address allocation servers.

Multicast Listener Discovery Version 1 (MLDv1): This protocol standard is used by an IPv6 router to discover the presence of multicast listeners (that is, nodes wishing to receive multicast packets) on its directly-attached links, and to discover specifically which multicast addresses are of interest to those neighboring nodes. MLD is derived from version 2 of IPv4's Internet Group Management Protocol, IGMPv2. Note that clients do listen to traffic from other clients for the purpose of suppressing their own messages.

Multicast Listener Discovery Version 2 (MLDv2): This protocol standard specifies Version 2 of the Multicast Listener Discovery Protocol (MLDv2). MLD is used by an IPv6 router to discover the presence of multicast listeners on directly attached links, and to discover which multicast addresses are of interest to those neighboring nodes. MLDv2 is designed to be interoperable with MLDv1. MLDv2 adds the ability for a node to report interest in listening to packets with a particular multicast address only from specific source addresses or from all sources except for specific source addresses.

Multipurpose Internet Mail Extensions (MIME): MIME is short for Multipurpose Internet Mail Extensions, a specification for formatting non-ASCII messages so that they can be sent over the Internet. The implementation of the parser for this file format ships as part of Outlook Express.

NetBIOS over TCP (NetBT) Protocol: The NETBT protocol standard supports NetBIOS services in a TCP/IP environment.

Network File System (NFS) Protocol: Network File System (NFS) version 2 and 3 is a protocol standard originally developed by Sun Microsystems in 1984, defined in [\[RFC1094\]](#) (version 2) and [\[RFC1813\]](#) (version 3) as a Distributed File System (DFS) that allows a computer to access files over a network as easily as if the files were on its local disks. It is built upon two other standards - XDR [\[RFC1014\]](#) and Sun RPC [\[RFC1057\]](#). Embedded within [\[RFC1813\]](#) Appendix II is the Lock Manager Protocol, which often is thought of as a separate protocol, and is also supported. This protocol standard originally shipped in Microsoft Windows Services for Unix, and was later integrated in the client with Windows Vista and into the server with Windows Server 2003 operating system, Windows Server 2003 R2 operating system, Windows Server 2008 operating system, and Windows Server 2008 R2 operating system (NFS client-on-client SKUs, NFS client- and server-on-server SKUs).

Network News Transfer Protocol: This protocol allows for the exchange of messages in a public forum across the internet. The NNTP Server does not ship in Windows Vistaclient or Windows Server 2008.

Network Time Protocol (Version 3): Specification, Implementation and Analysis: The Network Time Protocol (NTP) provides the mechanisms to synchronize time and coordinate time distribution in a large, diverse internet, while operating at rates from mundane to lightwave. It uses a returnable-time design in which a distributed subnet of time servers that operate in a self-organizing, hierarchical-master-slave configuration synchronize local clocks within the subnet and to national time standards via wire or radio. The servers can also redistribute reference time via local routing algorithms and time daemons.

ONC Remote Procedure Call (RPC) Protocol: ONC RPC and XDR specify message communication and data transfer between different computer architectures using a remote procedure call style of data transfer. They are the required basis for the Network File System protocol. This protocol originally shipped in Services-for-Unix, and was later integrated in the client with Windows Vista and into the server with Windows Server 2003, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2 (ONC RPC client-on-client SKUs, ONC RPC client- and server-on-server SKUs).

Online Certificate Status Protocol (OCSP): This protocol standard, specified in [RFC2560](#) as "X.509 Internet Public Key Infrastructure Online Certificate Status Protocol - OCSP", provides revocation information for X.509 certificates. It allows applications to query the current status of a certificate without downloading a certificate revocation list (CRL), which can be large in size.

Open Font Format - Font File Format: This OpenType Font File Format details the format of OpenType fonts, the TrueType and CFF outline formats, and the TrueType hinting language. The specification has been developed jointly by Adobe® Systems Incorporated and Microsoft. Because OpenType is an extension of TrueType, portions of the specification are also developed jointly by Adobe, Microsoft, and Apple®. OpenType version 1.4 has been contributed to ISO and became the foundation for the development of the ISO/IEC 14496-22 "Open Font Format" standard. The standard was published in 2007, and is now freely available for download from ITTF website. OpenType version 1.5 was recently published and reflects updates to OpenType implemented within Windows Vista, as well as to fonts issued by Adobe. OpenType 1.6 is in development and will contain enhancements for future operating systems. Updates to the specification have been submitted for inclusion in ISO/IEC 14496-22, the "Open Font Format". These changes are reflected in the Committee Draft of the second edition of the ISO/IEC 14496-22.

OpenSearch Version 1.1 File Formats: The OpenSearch Version 1.1 file formats are a collection of simple formats for the sharing of search results over Hypertext Transfer Protocol. The OpenSearch description document format defines the URL format used to query a search engine. OpenSearch also defines additional elements to include in RSS or Atom result formats to help clients consume a search server's results.

OpenSearch Version 1.1 Protocol: The OpenSearch protocol standard defines the way in which a search query URL should be formed by the search client for sending to a search server, and how the client should interpret specific parameters returned in the resulting response sent back from the server.

OSPF Version 2: OSPF version 2 is a link-state routing protocol. It is designed to be run internal to a single Autonomous System. Each OSPF router maintains an identical database that describes the Autonomous System's topology. From this database, a routing table is calculated by constructing a shortest-path tree. OSPF recalculates routes quickly in the face of topological changes by utilizing a minimum of routing protocol traffic. OSPF provides support for equal-cost multipath. An area routing capability is provided, which enables an additional level of routing protection and a reduction in routing protocol traffic. In addition, all OSPF routing protocol exchanges are authenticated.

Part 12: ISO Base Media File Format (MPEG-4 Part 12): ISO/IEC 14496-12:2005: This specification designates the structure and uses of the ISO base media file format. The identical text is published as ISO/IEC 15444-12:2005. This file format is used to contain time-based media, such as video and audio. The storage of particular coding schemes is defined in specifications that derive from and reference ISO/IEC 14496-12:2005 and ISO/IEC 15444-12:2005, such as the MPEG-4 file format, specified in ISO/IEC 14496-14, or the Motion JPEG file format, specified in ISO/IEC 15444-3. This file format is designed to contain timed media information for a presentation in a flexible, extensible format that facilitates interchange, management, editing and presentation of the media. This presentation may be "local" to the system containing the presentation, or it may be streamed via a network or other stream delivery mechanism. The file format is designed to be independent of any particular network protocol, while enabling efficient support for network protocols in general. The file structure is object-oriented; a file can be easily decomposed into constituent objects, and the structure of the objects can be inferred directly from their type. This technically identical text is published as ISO/IEC 14496-12:2005 for MPEG-4, and as ISO/IEC 15444-12:2005 for JPEG 2000. This version adds various new tools, which includes those for content protection, better support of metadata, and better support for advanced coding. This file format currently ships Out of Band with Windows Server 2008 supplemental EULA. This is available on Windows Server 2008 and Windows

Server 2008 R2. This file format can be used with a client that is shipped in Microsoft Expression Encoder. The client is shipped along with the source as a template.

Password Authentication Protocol (PAP): The Point-to-Point Protocol (PPP) standard provides a standard method of encapsulating Network Layer protocol information over point-to-point links. PPP also defines an extensible Link Control Protocol, which allows negotiation of an Authentication Protocol for authenticating its peer before allowing Network Layer protocols to transmit over the link. The Password Authentication Protocol is one of two protocols for authentication defined in [\[RFC1334\]](#). It passes the user name and password in plaintext to the server.

Picture Transfer Protocol (PTP): The primary purpose of Picture Transfer Protocol (PTP) is to provide a common protocol for any device, including digital photography devices, to exchange images with a DSPD, either by retrieving images from a digital camera or by sending images to or from a digital camera. Secondary purposes of the protocol include a mechanism for devices to control digital cameras (for example, a PC can request that a digital camera change its shutter duration setting and capture a new picture), and the ability to transfer auxiliary information, such as non-image data files and associated information, for example a digital print order file (DPOF). A server is defined as a PTP Initiator by the PTP Specification. A client is defined as a PTP Responder by the PTP Specification.

Point to Point Protocol (PPP): The Point-to-Point Protocol (PPP) standard provides a standard method for transporting multi-protocol datagrams over point-to-point links. PPP is comprised of three main components:

- A method for encapsulating multi-protocol datagrams.
- A Link Control Protocol (LCP) for establishing, configuring, and testing the data-link connection.
- A family of Network Control Protocols (NCPs) for establishing and configuring different network-layer protocols.

Point-to-Point Protocol over ATM Adaptation Layer 5 (PPPoA): The Point-to-Point Protocol (PPP) standard provides a standard method for transporting multi-protocol datagrams over point-to-point links. This protocol describes the use of ATM Adaptation Layer 5 (AAL5) for framing Point-to-Point Protocol (PPP) encapsulated packets. PPPoA is used by a Windows client to connect to the Internet over an Asynchronous Digital Subscriber Line (ADSL) link.

Point-to-Point Protocol over Ethernet (PPPoE): The Point-to-Point Protocol (PPP) standard provides a standard method for transporting multi-protocol datagrams over point-to-point links. This protocol describes how to build PPP sessions and encapsulate PPP packets over Ethernet. PPPoE is used by a Windows client that is accessing the Internet over an Asynchronous Digital Subscriber Line (ADSL) link.

Portmap and RPCBind Protocol: Portmap and RPCBind are built on top of ONC RPC and enable discovery of ONC RPC-based services. By using the Portmap protocol standard, client computers can discover the services, such as NFS, that are available on a server computer and their corresponding networking transports and IP ports. This protocol standard originally shipped in Services-for-Unix, and was later integrated in the client with Windows Vista and into the server with Windows Server 2003, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2 (The client ships on client SKUs, the client and server on server SKUs).

Post Office Protocol - Version 3: The Post Office Protocol, version 3 (POP3), standard permits a workstation to dynamically access a mail drop on a server host. The POP3 protocol is used to allow a workstation to retrieve mail that the server is holding for it. The server side component will not ship with Windows 7 (it only shipped on Windows Server 2003 and Windows Server 2003 R2). Only the client side code will be present.

PPP AppleTalk Control Protocol (ATCP): The Point-to-Point Protocol (PPP) standard provides a standard method of encapsulating Network Layer protocol information over point-to-point links. PPP also defines an extensible Link Control Protocol, and proposes a family of Network Control Protocols (NCPs) for establishing and configuring different network-layer protocols. This extension defines the NCP for establishing and configuring the AppleTalk Protocol over PPP.

PPP Bandwidth Allocation Protocol (BAP) / PPP Bandwidth Allocation Control Protocol (BACP): BAP provides a method to manage the dynamic bandwidth allocation of implementations that support the PPP multilink protocol. BAP can be used to manage the number of links in a multilink bundle. BAP defines datagrams to co-ordinate the addition and removal of individual links in a multilink bundle, as well as the specification of which peer is responsible for which decisions with regard to managing bandwidth during a multilink connection.

PPP Challenge Handshake Authentication Protocol (CHAP): The Challenge Handshake Authentication Protocol (CHAP) standard defines a method for authentication using PPP, which uses a random challenge with a cryptographically hashed Response that depends on the Challenge and a secret key.

PPP Compression Control Protocol (CCP): The PPP Compression Control Protocol (CCP) standard configures, enables, and disables data compression algorithms on both ends of the point-to-point link.

PPP Internet Protocol Control Protocol (IPCP): The Point-to-Point Protocol (PPP) standard provides a standard method of encapsulating Network Layer protocol information over point-to-point links. PPP also defines an extensible Link Control Protocol, and proposes a family of Network Control Protocols (NCPs) for establishing and configuring different network-layer protocols. This protocol standard defines the NCP for establishing and configuring the Internet Protocol over PPP, and a method to negotiate and use Van Jacobson TCP/IP header compression with PPP. In addition, IPCP Extensions extend the NCP for establishing and configuring the Internet Protocol over PPP, which defines the negotiation of primary and secondary Domain Name System (DNS) and NetBIOS Name Server (NBNS) addresses.

PPP Internetwork Packet Exchange Control Protocol (IPXCP): The Point-to-Point Protocol (PPP) standard provides a method for the transmission of multi-protocol datagrams over point-to-point links. PPP defines an extensible Link Control Protocol, and proposes a family of Network Control Protocols for the establishment and configuration of different network-layer protocols. The IPX protocol was originally used in Novell's NetWare products, and was supported briefly by other vendors. This protocol defines a Network Control Protocol for the establishment and configuration of the IPX protocol over PPP.

PPP Multilink Protocol (MP): This protocol standard defines a method for splitting, recombining, and sequencing datagrams across multiple logical data links. This work was originally motivated by the desire to exploit multiple bearer channels in ISDN, but is equally applicable to any situation in which multiple PPP links connect two systems, including asynchronous links. This linking is accomplished by means of new PPP options and this protocol.

PPP NetBIOS Frames Control Protocol (NBFCP): The Point-to-Point Protocol (PPP) standard provides a standard method for transporting multi-protocol datagrams over point-to-point links. PPP defines an extensible Link Control Protocol, and proposes a family of Network Control Protocols for establishing and configuring different network-layer protocols. The NBF protocol was originally called the NetBEUI protocol. NBFCP defines a Network Control Protocol for establishing and configuring the NBF protocol over PPP.

Pragmatic General Multicast (PGM) Protocol: The PGM Protocol standard is a reliable multicast transport protocol for applications that require ordered or unordered, duplicate-free, multicast data delivery from multiple sources to multiple receivers.

Printer MIB: This MIB module is used for management of printed document production and management of printer settings. Some OIDs defined by the Printer MIB are used to query printers for status and configuration.

Protocol Modifications for the DNS Security Extensions: The Domain Name System Security Extensions (DNSSEC) is a suite of extensions to the Domain Name System (DNS) protocol designed to provide origin authority of DNS data, data integrity, and authenticated denial of existence.

Public Key Cryptography for Initial Authentication in Kerberos (PKINIT): The Public Key Cryptography for Initial Authentication in Kerberos (PKINIT) protocol extensions enable the use of public key cryptography in the initial authentication exchange of the Kerberos protocol (Authentication Service (AS) exchange) [\[MS-KILE\]](#). In the initial authentication exchange, Kerberos uses passwords shared between the client and the Key Distribution Center(KDC) to derive a key (AS-REP key) that is used to encrypt the Kerberos Ticket-Granting Ticket (TGT) and Ticket Granting Service (TGS) requests [\[RFC4120\]](#). By using this scheme, the Kerberos protocol encryption strength is tied to the strength of the passwords used, and it affects the security of subsequent protocol requests.

Quote of the Day Protocol: The Quote Of The Day (QOTD) service is an Internet protocol standard defined in [\[RFC865\]](#). It is intended for testing and measurement purposes. A host connects to a server that supports the QOTD protocol on either TCP or UDP port 17. The server then returns a short arbitrary message. This message was traditionally a random selection from a list of notable quotes.

Really Simple Syndication (RSS) 2.0: Really Simple Syndication (RSS) is an XML based file format that describes lists of related information known as feeds. An RSS document contains a <channel> element, with the information about the channel (metadata) and its content.

Real-Time Streaming Protocol (RTSP): The Real Time Streaming Protocol, or RTSP, is an application-level protocol standard for control over the delivery of data with real-time properties. RTSP provides an extensible framework to enable controlled, on-demand delivery of real-time data, such as audio and video. Sources of data can include both live data feeds and stored clips. This protocol is intended to control multiple data delivery sessions, to provide a means for choosing delivery channels such as UDP, multicast UDP and TCP, and to provide a means for choosing delivery mechanisms based upon RTP [\[RFC1889\]](#).

Note An implementation of this protocol is included in Windows 7 Home Server.

Remote Access Dial In User Service (RADIUS) Accounting Server MIB (ACCSERV.MIB): The Remote Access Dial In User Service (RADIUS) Protocol standard defined in [\[RFC2865\]](#) provides Authentication, Authorization, and Accounting (AAA) of endpoints in scenarios such as wireless networking, dial-up networking, and virtual private networking (VPN). These settings instrument RADIUS accounting server functions, which enables IP-based management stations to manage RADIUS accounting servers.

Remote Access Dial In User Service (RADIUS) Authentication Server MIB (AUTHSERV.MIB): The Remote Access Dial In User Service (RADIUS) Protocol standard, defined in [\[RFC2865\]](#), provides Authentication, Authorization, and Accounting (AAA) of endpoints in scenarios such as wireless networking, dial-up networking, and virtual private networking (VPN). These settings instrument RADIUS authentication server functions, which enables IP-based management stations to manage RADIUS authentication servers.

Remote Access Dial In User Service (RADIUS) IPv6: The Remote Access Dial In User Service (RADIUS) Protocol standard defined in [\[RFC2865\]](#) provides Authentication, Authorization, and Accounting (AAA) of endpoints in scenarios such as wireless networking, dial-up networking, and

virtual private networking (VPN). This protocol supports the operation of RADIUS over IPv6 and defines the RADIUS attributes used to support IPv6 network access.

Remote Authentication Dial-In User Service: The Remote Authentication Dial-In User Service (RADIUS) protocol is commonly used to provide centralized authentication, authorization, and accounting for dial-up, virtual private network, and, more recently, wireless network access.

Resource ReSerVation Protocol (RSVP): The resource reservation setup (RSVP) protocol standard is designed for an integrated services (IntServ) network. RSVP provides receiver-initiated setup of resource reservations for multicast or unicast data flows. RSVP requires signaling cooperation from network elements (for example, layer-3 routers). There are three roles in RSVP: the requestor of the reservation, the responding end point, and intermediate routers. The behaviors of the two end points are implemented and the router behavior is not implemented.

RIP Version 2 MIB: This MIB can be used to read counters related to the Routing Information Protocol version 2 (RIPv2), using SNMP on the RRAS server.

Rlogin Protocol: The rlogin facility provides a remote-echoed, locally flow-controlled virtual terminal with proper flushing of output. It is widely used between Unix hosts because it provides transport of more of the Unix terminal environment semantics than does the Telnet protocol, and because on many Unix hosts it can be configured to not require user entry of passwords when connections originate from trusted hosts. This protocol standard requires the use of TCP and uses port 513.

Routing Information Protocol (RIP 1.0, 2.0): The Routing Information Protocol standard is intended to do the following things:

- Define a protocol and algorithms that are used for routing.
- Specify improvements in the algorithms that will improve stability of the routes in large networks.
- Suggest some optional features to allow greater configurability and control.

RIP Version 2 specifies an extension of the Routing Information Protocol (RIP), as defined in [\[RFC1058\]](#), [\[RFC1723\]](#), and [\[RFC2453\]](#), to expand the amount of useful information carried in RIP messages and to add a measure of security.

RS-232 Serial Protocol: The original RS-232-C standard defined the electrical characteristics of a serial communications link, including signal voltages, signal timings, and header pin mapping. Characters sent across the link are bracketed during transport by start and stop bits that allow the receiver to stay in synchrony with the sender. In current usage, the term "RS-232" is often used to mean "ASCII (or ANSI) serial protocol", and it no longer indicates specific voltage levels. For a serial link, care should be taken that the signal voltages at the two ends of the link are compatible. For example, a PC COM port operating at a nominal 12 volts is incompatible with the serial connector of a microprocessor platform operating at 3 volts. For ANSI terminal emulation, see the "ANSI Terminal Emulation" standard described previously in this section.

SCSI Medium Changer Commands: This standard defines the SCSI commands and model for independent media changer devices and attached media changer that are functions integrated into other SCSI devices.

SCSI Multimedia Command Set: The SCSI Multimedia Command Set protocol standard allows communication with optical devices (for example, CD and DVD).

SCSI Primary Commands: The SCSI (Small Computer System Interface) Primary Commands defines the basic set of mandatory commands used with SCSI peripherals, such as hard drives, tape

drives, and scanners. These commands are used to drive device (storage, printer, scanner, and optical) operation. Examples of the commands are Read, Write, and Inquiry. Windows Server can virtualize storage devices and hence can act as a server role of the protocol.

SCSI Stream Commands: This standard specifies functional requirements for SCSI-3 Stream Commands (SSC). SSC permits SCSI streaming devices, such as tape and printer devices, to attach to computers and provides the definitions for their use.

Secure Digital Card Protocol: The Secure Digital (SD) Card protocol standard is used to support small form factor removable storage devices, like SD flash cards. The SD Card protocol enables communication between PC and locally attached storage cards over SD hardware bus within the PC. It enables discovery and mounting of SD card devices as removable file system volumes.

Security Assertion Markup Language (SAML) V1.1: The Security Assertion Markup Language (SAML) defines the syntax and processing semantics of assertions made about a subject by an issuer of assertions. SAML defines an XML data structure that may be used to describe attributes about a subject, such as a user. The data structure is usually signed by its issuer and serves as a security token.

Security Assertion Markup Language (SAML) v2.0: The Security Assertion Markup Language (SAML) V2.0 defines the protocols for the exchange of assertions made about a subject by an issuer of assertions, as well as the syntax and processing semantics of those assertions. SAML V2.0 defines an HTTP based block protocol for send assertions between servers using a web browser intermediary. SAML V2.0 defines an XML data structure for assertions that may be used to describe attributes about a subject, such as a user. The data structure is usually signed by its issuer and serves as a security token. This protocol will ship as an out of band (OOB) Windows Targeted Release (WTR) for Windows Server 2003, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2. This protocol is a server-SKU-to-server-SKU exchange using any arbitrary web browser as an intermediary. Client SKUs are not checked because, even though this protocol can be relayed through a client web browser, there is no code for this protocol in the web browser.

Serial Line Internet Protocol (SLIP): Serial Line IP is a protocol standard used for point-to-point serial connections running TCP/IP. It defines a standard encapsulation for IP packets over serial lines. This protocol standard is no longer in use and has been deprecated in Windows Vista and Windows Server 2008.

Session Description Protocol (SDP): Session directories assist the advertisement of conference sessions and communicate the relevant conference setup information to prospective participants. SDP is designed to convey this information to recipients. SDP is purely a format for session description -- it does not define or require a transport protocol.

Session Initiation Protocol (SIP): Session Initiation Protocol (SIP) standard is an application-layer control (signaling) protocol for creating, modifying, and terminating sessions with one or more participants. It is defined in [\[RFC2543\]](#) and later [\[RFC3261\]](#). The Real-Time Communications (RTC) API in Windows XP implemented [\[RFC2543\]](#). Windows Messenger uses the RTC API to use SIP to set up audio and video chat sessions with each other. A client is an MTP responder.

Simple and Protected Generic Security Service Application Program Interface Negotiation Mechanism (SPNEGO): The Simple and Protected GSS-API Negotiation Mechanism (SPNEGO) is used to select among possible authentication protocols. SPNEGO provides a framework for two parties engaged in authentication to select from a set of possible authentication mechanisms, in a fashion that preserves the opaque nature of the Security Protocols to the Application Protocol that uses SPNEGO. SPNEGO was first defined as [\[RFC2478\]](#). This RFC has since been supplanted by [\[RFC4178\]](#).

Simple Mail Transfer Protocol: A self-contained specification of the basic protocol standard for the Internet electronic mail transport. The SMTP server does not ship in Windows Vista but does ship in Windows Server 2008. Exchange 2007 ships a SMTP stack as well.

Simple Network Management Protocol (SNMP): The Simple Network Management Protocol (SNMP v2) standard conveys management information between agents and management stations. Operations of the protocol are carried out under an administrative framework that defines authentication, authorization, and access control. Management Information Base (MIB) specifications define specific values and variables that may be transferred between the SNMP agent and SNMP manager. MIBs that are included are SNMP framework MIB, SMI MIB, and host resource MIB. A zip file of Windows MIB files "Microsoft SNMP (Management Information Base) Files", is available at [\[MSFT-Windows-MIBs\]](#).

Simple Network Time Protocol (SNTP): The Simple Network Time Protocol (SNTP) standard is an adaptation of the Network Time Protocol (NTP) used to synchronize computer clocks on the Internet. SNTP can be used when the ultimate performance of the full NTP implementation described in [\[RFC1305\]](#) is not required or justified.

Simple Object Access Protocol (SOAP) 1.1: SOAP is a lightweight protocol standard for the exchange of information in a decentralized, distributed environment. It is an XML-based protocol that consists of three parts: an envelope that defines a framework for describing what is in a message and how to process it, a set of encoding rules for expressing instances of application-defined datatypes, and a convention for representing remote procedure calls and responses. SOAP can potentially be used in combination with a variety of other protocols; however, the only bindings defined in this document describe how to use SOAP in combination with HTTP and HTTP Extension Framework.

Simple Service Discovery Protocol (SSDP): The Simple Service Discovery Protocol (SSDP) standard provides a mechanism whereby network clients, with little or no static configuration, can discover network services. SSDP accomplishes this by providing for multicast discovery support as well as server-based notification and discovery routing.

Smart Card CCID version 1.1: This protocol standard is used for communication with USB-CCID-compliant smart card readers by the computer system. This protocol specifies the commands that are supported by smart card readers to facilitate the reading of smart cards.

Smart Card ICCD version 1.0: This protocol standard is used for communication with USB-ICCD-compliant smart cards by the computer system. This protocol specifies the commands that are supported by integrated smart card and reader devices.

SMTP Service Extension for Authentication: This protocol standard defines an SMTP service extension whereby an SMTP client may indicate an authentication mechanism to the server, perform an authentication protocol exchange, and, optionally, negotiate a security layer for subsequent protocol interactions.

SMTP Service Extension for Remote Message Queue Starting: This protocol standard defines an extension to the SMTP service whereby an SMTP client and server may interact to give the server an opportunity to start the processing of its queues for messages to go to a given host. This extension is meant to be used in startup conditions as well as for mail nodes that have transient connections to their service providers.

SMTP Service Extension for Secure SMTP over Transport Layer Security: This protocol standard is an extension to the SMTP (Simple Mail Transfer Protocol) service that allows an SMTP server and client to use TLS (Transport Layer Security) to provide private, authenticated communication over the Internet. This protocol gives SMTP agents the ability to protect some or all of their communications from eavesdroppers and attackers.

SOAP 1.1 Binding for MTOM 1.0: This specification details modifications to the SOAP Message Transmission Optimization Mechanism (MTOM) and XML-binary Optimized Packaging (XOP) specs necessary to successfully use these technologies with SOAP 1.1. The result is a MIME Multipart/Related XOP package: one body part, the root, which contains an XML 1.0 representation of the modified SOAP 1.1 envelope, with an additional part used to contain the binary representation of each element that was optimized. The Windows SDK includes sample code to use this data structure.

SOAP Message Transmission Optimization Mechanism (MTOM): SOAP Message Transmission Optimization Mechanism (MTOM) is a SOAP message encoding mechanism designed to optimize the transmission of base64 encoded data. The protocol specifies how SOAP envelopes are serialized using XML-binary Optimized Protocol (XOP) packaging encapsulated in a Multipart/Related MIME type and carried over HTTP. The Windows SDK includes samples to invoke this protocol.

SOAP Message Transmission Optimization Mechanism (MTOM) Policy Assertion: This document defines a WS-Policy policy assertion for specifying that the SOAP Message Transmission Optimization Feature (MTOM) encoding mechanism is to be used. The policy assertion is scoped to the endpoint and specifies that all messages sent to and received from the endpoint must be optimized using MTOM. The Windows SDK includes samples to use this data structure.

SOAP Version 1.2: SOAP Version 1.2 is a lightweight protocol standard intended for exchanging structured information in a decentralized, distributed environment. It uses XML technologies to define an extensible messaging framework that provides a message construct that can be exchanged over a variety of underlying protocols. SOAP 1.2 has a number of changes in syntax and provides additional (or clarified) semantics from those described in SOAP 1.1. The SOAP 1.2 specifications have been provided in two parts: SOAP Version 1.2 Part1: Messaging Framework ([\[SOAP1.2-1/2007\]](#)) provides an abstract Infoset-based definition of the SOAP message structure, a processing model, and an underlying protocol binding framework, while SOAP Version 1.2 Part2: Adjuncts ([\[SOAP1.2-2/2007\]](#)) provides serialization rules for conveying the infoset, as well as a particular HTTP binding.

SOAP-over-UDP: This protocol standard defines a one-way message-exchange pattern, a request-response message-exchange pattern, and a multicast transmission message-exchange pattern for SOAP envelopes carried in user datagrams. The Windows implementation of this profile is exercised by Windows Web Services API. There is no native usage of this implementation in Windows 7. In non-native usage, it is possible to implement both client and server roles on both Windows client and server SKUs.

Sockets Direct Protocol (SDP): The Sockets Direct Protocol (SDP) is a protocol standard originally defined by the Software Working Group (SWG) of the InfiniBand Trade Association (IBTA). It defines a standard wire protocol to support stream sockets (SOCK_STREAM) networking over InfiniBand. SDP utilizes various InfiniBand features (such as remote DMA (RDMA)), memory windows, solicited events, etc.) for high-performance zero-copy data transfers. SDP has been adapted to work over RDMA fabrics built on top of TCP/IP-based networks by the RDMA Consortium.

Spanning Tree Protocol (STP): The network bridge functionality uses the IEEE spanning tree algorithm (STA) to establish a loop-free forwarding topology when used to interconnect two or more network interfaces. PCs and devices that support the spanning tree algorithm transmit and receive Ethernet frames, as defined in IEEE 802.1D-1998 to determine the presence of other bridges on the network. The network bridge functionality and STA are included in most OS SKUs, but are not enabled by default.

Standard Protocol for Authentication in Host Attachments of Transient Storage Devices: The IEEE 1667 specification defines a standard protocol for the secure authentication and creation of trust between a secure host and a directly attached Transient Storage Device (TSD), such as a USB flash drive, portable hard drive, or cellular phone. The protocol has only an indirect relationship with

data integrity/security, and does not directly address issues of authorization and enforcement. The protocol also does not address devices that are attached using a network connection. However, a device that uses a point-to-point wireless connection, such as WUSB, may comply with this protocol.

Standard Protocol for Authentication in Host Attachments of Transient Storage Devices

v1.1: This protocol standard consists of extensions to the IEEE 1667 1.0 specification that are being proposed for a 1.1 revision, and additional extensions proposed by the working group. The additional functionality includes the password silo and updates to the authentication silo.

Subnet Bandwidth Manager (SBM) Protocol: The Subnet Bandwidth Manager (SBM) protocol standard is a signaling protocol for RSVP-based admission control over IEEE 802-style networks. SBM provides a method for mapping an Internet-level setup protocol, such as RSVP, onto IEEE 802 networks.

T.120: The T.120 protocol standard provides a means of telecommunicating all forms of Data/Telematic media between two or more multimedia terminals, and of managing such communication. The T.120 standards define the data conferencing portion of a multimedia teleconference. The recommendations specify how to efficiently and reliably distribute files and graphical information over a network. T.120 also has provision for the management of real-time (conversational) speech and video whose information signals are transmitted on channels separate from those that are carrying the T.120 protocol. The T.120 protocol can handle one or more simultaneous "conferences"; any terminal may participate in more than one of these conferences, if authorized to do so; the convener of any one conference may control the participation in that conference and the information which flows in that conference. T.120 does not inherently impose constraints on the configuration of the physical connections between terminals: they may be all connected to one star-point, or connected one to two others in a chain, or a chain of star-points, and so on. Constraints may be imposed upon T.120 by the type of network in use for a specific conference. No constraint is placed on the volume of information transmitted within the various media; the T.120 protocol has the capacity to organize appropriate capacity, within the constraints imposed by the type of network and connections established thereon, and by taking heed of the priorities that may be set from the applications above the T.120 protocol.

T.123 Protocol: T.123 specifies an additional transport layer that allows computer networks that are not connection-oriented to be made functionally connection oriented. The T.123 protocol standard is a mandatory provision of the t.120 stack. MCS (Multipoint Communication Service) expects its underlying Transport to provide reliable point-to-point sequenced data delivery of its PDUs, and to segment that data if necessary. T.123 is designed to provide open and easily extended network support for both standardized and non-standardized protocols. The basic T.123 presents a uniform OSI Transport interface and services (X.214/224) to the MCS layer above it. Connection-oriented profiles are provided for switched telecom and packet switched networks.

T.124 Protocol: The T.124 standard defines the document-conferencing and application-sharing (sometimes called data-conferencing) portion of a multimedia teleconference. The recommendations specify how to efficiently and reliably distribute files and graphical information over a network. It encompasses Generic Conference Control (GCC) functions, such as conference establishment and termination, management of the roster of nodes participating in a conference, management of the roster of Application Protocol Entities and Application Capabilities within a conference, registry services for use by Application Protocol Entities, coordination of conference conductorship, and other miscellaneous functions.

T.126 Protocol: The T.126 standard defines a protocol that supports the management of common multi-layer visual spaces, and the multipoint exchange of graphical information directed to these spaces, which includes images, pointers, and filled and unfilled parametric drawing elements (points, lines, polygons, and ellipses). In addition, keyboard and pointing device exchanges are specified to support basic user interaction. Protocol elements for creating and referencing archived visual spaces are defined to allow pre-stored or pre-distributed graphical materials to be referenced.

This protocol uses services provided by Recommendations T.122 (MCS) and T.124 (GCC), and complies with the guidelines specified in Recommendation T.121 (GAT).

T.127 Protocol: The T.127 standard defines a protocol that supports the interchange of binary file data within an interactive conferencing or group working environment, where the T.120 suite of standards is in use. It provides mechanisms to support simultaneous distribution of multiple files, selective distribution of files to a subset of participants, and retrieval of files from remote sites. T.127 uses a control/data channel architecture to facilitate simultaneous transfer of one or more binary files. It enables files to be broadcast to all participants within a conference, or to be directed selectively to a subset of sites as a private file transfer. No restrictions are placed on the type of data being transmitted. Two types of channels are used within T.127: control channels and data channels. Control channels are used to manage all aspects of the file transfer (offering files, requesting files), whereas data channels are used exclusively for the transfer of file data. Only one file can be transmitted on each data channel at a time, but additional data channels can be used to allow for the distribution of multiple files simultaneously. The number of data channels in use at any given time depends on the number of concurrent file transfers in progress.

T.128 Protocol: The T.128 standard defines a protocol that supports multipoint application sharing. The T.128 protocol supports multipoint computer application sharing by allowing a view onto a computer application that is executing at one site to be advertised within a session to other sites. Each site can, under specified conditions, take control of the shared computer application by sending remote keyboard and pointing device information. This style of application sharing does not require and does not make provision for the synchronization of multiple instances of the same computer application running at multiple sites. Instead, it enables remote viewing and control of a single application instance to provide the illusion that the application is running locally.

TCP Extensions for High Performance: These extensions define TCP options for scaled windows and timestamps in order to extend the domain of TCP's application to match increasing network capability. The extensions are designed to provide compatible interworking with TCP implementations that do not have the extensions. The timestamps are used for two distinct mechanisms: RTTM (Round Trip Time Measurement) and PAWS (Protect Against Wrapped Sequences).

Telnet Protocol standard: The Telnet protocol defines a standard method for interfacing terminal devices and terminal-oriented processes.

Teredo Protocol: The Teredo protocol standard enables computers located behind a Network Access Translation (NAT) to obtain an IPv6 address, which can then be used by IPv6-enabled applications (for example, peer-to-peer applications) in the same manner as any other IPv6 address. This capability allows applications to work across NATs without requiring any changes to be NAT-aware or even Teredo-aware. That is, Teredo sits "below" IPv6 and provides a link (like Ethernet does) that supports basic IPv6 Internet connectivity. The protocol includes signaling messages, which flow between two Teredo clients, as well as between Teredo clients and Teredo servers. It also includes a data channel that can flow between Teredo clients or between a Teredo client and Teredo relay. All Windows SKUs include Teredo client and relay functionality. Microsoft hosts a Teredo server as a service, and this functionality is now in Windows Server 2008 R2.

Timed Interactive Multimedia Extensions for HTML: Timed Interactive Multimedia Extensions for HTML (HTML+TIME) is a protocol that extends Synchronized Multimedia Integration Language (SMIL) into the web browser. It is defined in [\[NOTE-HTML+TIME\]](#) and described in [\[MSDN-HTML+TIME\]](#). The protocol adds timing and media synchronization support to HTML pages using a few Extensible Markup Language (XML)-based elements and attributes to add images, video, and sounds to an HTML page and synchronize them with HTML text elements over a specified amount of time.

Transaction Internet Protocol: The Transaction Internet Protocol (TIP) standard requires a reliable ordered stream transport with low connection setup costs. In an Internet (IP) environment, TIP operates over TCP, optionally using TLS to provide a secured and authenticated connection, and optionally using a protocol to multiplex light-weight connections over the same TCP or TLS connection.

Transmission Control Protocol (TCP): The Transmission Control Protocol (TCP) standard is one of the core protocols of the Internet protocol suite. Using TCP, applications on networked hosts can create connections to one another, over which they can exchange data in packets. The protocol guarantees reliable and in-order delivery of data from sender to receiver. TCP also distinguishes data for multiple connections by concurrent applications (for example, web server and email server) running on the same host. TCP is used by many of the most popular application protocols and resulting applications on the Internet, including the World Wide Web and email.

Transport Protocol Class 4 (TP4): Transport Protocol Class 4 (TP4) is an OSI (Open Systems Interconnect) connection-oriented protocol standard used with a Connectionless Network Protocol (CLNP). The protocol defines the interactions between peer transport entities through the exchange of transport protocol data units, and it specifies mechanisms for negotiating the class of procedures to be used by the transport entities that are setting up a connection, and the structure and encoding of the transport protocol data units.

Trivial File Transfer Protocol (TFTP): Trivial File Transfer Protocol (TFTP) is a simple protocol standard that transfers files and can only read or write files (or email messages) to or from a remote server.

TTY Terminal Emulation: The TTY Emulation protocol standard mimics the character set and control characters used by a Teletype-33 (TTY) serial terminal. The character set is US-ASCII and the control characters include a number of escape sequences. An escape sequence is one or more US-ASCII characters that are preceded by the escape character, ESC (0x1B).

Universal Description Discovery and Integration (UDDI) Version 2.04 Protocol: Universal Description, Discovery and Integration, or UDDI, is the name of a group of web-based registries that expose information about a business or other entity and its technical interfaces (or APIs). These registries are run by multiple Operator Sites, and can be used by anyone who wants to make information available about one or more businesses or entities, as well as anyone that wants to find that information. By accessing any of the public UDDI Operator Sites, anyone can search for information about Web services that are made available by or on behalf of a business. The benefit of having access to this information is the ability to provide a mechanism that allows others to discover what technical programming interfaces are provided for interacting with a business for such purposes as electronic commerce, etc. The benefit to the individual business is increased exposure in an electronic commerce-enabled world. The information that can be registered by a business includes several kinds of simple data that help others to determine the answers to the questions "who, what, where, and how". Simple information about a business includes information such as name, business identifiers (D&B D-U-N-S Number®, etc.), and contact information. The process of answering the question "Who?" and "What?" involves providing classification information that includes industry codes and product classifications, as well as descriptive information about the services made available by the business. Answering the question "Where?" involves registering information about the URL or email address (or other address) through which each type of service is accessed. Finally, the question "How?" is answered by registering references to information about interfaces and other properties of a given service. These service properties describe how a particular software package or technical interface functions. These references are called tModels in the UDDI documentation. The server role was shipped in Windows Server 2003 and Windows Server 2008 but is no longer implemented in server SKUs in Windows 7. However the UDDI SDK that implements the protocol on the client side will continue to ship in the Windows 7 SDK. Any application using UDDI

SDK to talk to a UDDI registry for service metadata is a UDDI client. Currently there is no client code shipping with Windows 7.

Universal Plug and Play (UPnP) AVTransport Protocol: The Universal Plug and Play (UPnP) AVTransport Protocol standard is used by clients to control the streaming of audio/video (AV) content from a server. Media Center uses this protocol, as a client, with broadcast tuner devices that support either the Digital Receiver Interface Transceiver (DRIT) or Protected Broadcast Driver Architecture (PBDA) over IP protocol to initiate and control streaming aspects of the tuned broadcast AV stream from the tuner. This protocol is used in the Windows 7 client and by Media Center in the Windows 7 Entertainment server SKUs.

Universal Plug and Play (UPnP) Connection Manager Protocol: The Universal Plug and Play (UPnP) Connection Manager Protocol standard is used by clients to negotiate streaming connections to a server. Media Center uses this protocol as a client with broadcast tuner devices that support either the Digital Receiver Interface Transceiver (DRIT) or Protected Broadcast Driver Architecture (PBDA) over IP protocol to create a Universal Plug and Play (UPnP) AVTransport connection. This protocol is used in the Windows 7 client and by Media Center in the Windows 7 Entertainment server SKUs.

Universal Serial Bus (USB) Mass Storage Protocol: The USB Mass Storage Class Control/Bulk/Interrupt (CBI) Transport Specification is approved for use only with full speed floppy disk drives. CBI shall not be used in high-speed capable devices, or in devices other than floppy disk drives.

Universal Serial Bus (USB) Protocol: The Universal Serial Bus (USB) Core protocol standard is an external bus architecture for connecting USB-capable peripheral devices to a host computer. The USB Core is maintained by the USB Implementers Forum. For information on Interface - USB Core, see [\[USB\]](#).

UPnP IGD v1.0 Device Control Protocol: This is a protocol for communication between a client on a private IP network and a server that performs Network Address Translation (NAT) between the private IP network & public IP networks (such as the Internet). It provides a way for the client to request TCP/UDP port openings through the NAT router. This protocol standard is implemented in the Windows client SKUs and the Windows component of the Small Business Server SKU.

UPnP: Device & Service Templates: This template describes two XML documents that are defined by the UPnP forum to describe devices and services. The UPnP Device Template is a template that lists the device type, the required embedded devices (if any), and the required services. The UPnP Service Template is a template that lists the action names, the parameters for those actions, the state variables, and the properties of those state variables.

USB HID: This specification describes the Human Interface Device (HID) class for use with Universal Serial Bus (USB). Concepts from the USB Specification are used, but not explained, in this document. The HID class consists primarily of devices that are used by humans to control the operation of computer systems. Typical examples of HID class devices include:

- Keyboards and pointing devices, for example, standard mouse devices, trackballs, and joysticks.
- Front-panel controls, for example, knobs, switches, buttons, and sliders.
- Controls that might be found on devices such as telephones, VCR remote controls, games or simulation devices, for example, data gloves, throttles, steering wheels, and rudder pedals.
- Devices that may not require human interaction but provide data in a similar format to HID class devices, for example, bar-code readers, thermometers, or voltmeters.

Many typical HID class devices include indicators, specialized displays, audio feedback, and force or tactile feedback. Therefore, the HID class definition includes support for various types of output directed to the end user.

USB Mass Storage Protocol: The USB Mass Storage Protocol standard, also called RBC (Reduced Block Command) is a block storage protocol, which represents a subset of the SCSI (Small Computer System Interface) protocol. This protocol is used to support externally or internally connected mass storage devices, like flash disks or external hard drives, and is designed and used on the USB bus.

USB Modem: This specification provides information to guide implementers in the usage of the USB logical structures for communication devices. This information applies to manufacturers of communication devices and system software developers.

User Datagram Protocol (UDP): This User Datagram Protocol (UDP) standard is defined to make available a datagram mode of packet-switched computer communication in the environment of an interconnected set of computer networks. This protocol assumes that the Internet Protocol (IP) is used as the underlying protocol. This protocol provides a procedure for application programs to send messages to other programs with a minimum of protocol mechanism. This protocol is transaction oriented, and delivery and duplicate protection are not guaranteed. Applications that require ordered reliable delivery of streams of data should use the Transmission Control Protocol (TCP).

UTF-8 Encoding: The Unicode Standard and ISO/IEC 10646 define a large character set called the Universal Character Set (UCS), which encompasses most of the world's writing systems. UTF-8 is one of several character encoding forms defined by Unicode (and ISO/IEC 10646). UTF-8 is a variable-length encoding scheme in which each single UCS character is represented by a sequence of one or more octets (bytes). UTF-8 uses all bits of an octet, but has the quality of reserving the full US-ASCII range: US-ASCII characters are encoded in one octet and have the normal US-ASCII value, and any octet with such a value can only stand for a US-ASCII character. The current IETF RFC that describes UTF-8, [\[RFC3629\]](#), clearly states that the Unicode Standard is the authoritative source for the definition of this encoding. Note that the XML 1.0 specification requires all XML processors to accept XML encoded in UTF-8. Any XML-based protocol or format should be presumed to accept UTF-8 unless that protocol or format specification contains a statement to the contrary.

Viewdata Terminal Emulation: The Viewdata Terminal Emulation protocol standard mimics the character set and control characters used by a Viewdata serial terminal. The character set is US-ASCII and the control characters include a number of escape sequences. An escape sequence is one or more US-ASCII characters that are preceded by the escape character, ESC (0x1B). This is typically used via a V.23-compliant modem over PSTN. The back-end device could be a mainframe.

VML (Vector Markup Language): VML is an application of Extensible Markup Language (XML) 1.0 that defines a format for the encoding of vector information, together with additional markup to describe how that information may be displayed and edited.

VT100 Terminal Emulation: The VT100 Terminal Emulation protocol standard mimics the character set and control characters used by a family of Digital Equipment Corporation serial terminals. In the original hardware terminal, the character set is US-ASCII and the control characters include a number of escape sequences. An escape sequence is one or more US-ASCII characters that are preceded by the US-ASCII escape character, ESC (0x1B).

VT100 Terminal Emulation: Japanese Extensions (VT100J): The VT100J character set option supports the use of ASCII Double Byte Character Set (DBCS) characters in the transmitted data stream. DBCS provides support for extended language alphabets and for some East Asian language alphabets, including Chinese, Japanese, and Korean. DBCS uses the numbers 0-128 to represent the US-ASCII character set. Some numbers greater than 128 function as lead-byte characters, which are indicators that the following value is a character from a non-Latin character set. In DBCS, ASCII

characters are only 1 byte in length, whereas Japanese, Korean, and other East Asian characters are 2 bytes in length. For more information on DBCS, contact the ANSI standards organization.

VT52 Terminal Emulation: The VT52 Terminal Emulation protocol standard mimics the character set and control characters used by a family of Digital Equipment Corporation serial terminals. In the original VT52 terminal, the character set is US-ASCII, and the control characters include a number of escape sequences. An escape sequence is one or more US-ASCII characters that are preceded by the US-ASCII escape character, ESC (0x1B).

Web Distributed Authoring and Versioning (WebDAV) Protocol: WebDAV defines HTTP protocol extensions that enable users to collaboratively edit and manage files on remote web servers. It provides functionality to create, change, and move documents on a remote server (typically a web server or "web share"). WebDAV supports file locking and storage of meta-data properties such as creation date, author, and modified date. The Windows implementation of the client side of this protocol conforms to the [\[RFC2518\]](#). The server portion conforms to only portions of [\[RFC2518\]](#).

Web Services Addressing 1.0 - Core: This standard provides transport-neutral mechanisms to address Web services and messages. It defines a set of abstract properties and an XML information set [\[XML-INFOSET\]](#) representation thereof to reference Web services and to facilitate end-to-end addressing of endpoints in messages. This protocol enables messaging systems to support message transmission through networks that include processing nodes, such as endpoint managers, firewalls, and gateways in a transport-neutral manner. The version of the standard implemented in Windows is the recommendation of the W3C Web Services Addressing Working Group, and is titled "Web Services Addressing 1.0 – Core", published on May 9, 2006.

Web Services Addressing 1.0 - SOAP Binding: Web Services Addressing provides transport-neutral mechanisms to address Web services and messages. Web Services Addressing 1.0 - SOAP Binding defines the binding of the abstract properties defined in Web Services Addressing 1.0 - Core to SOAP Messages.

Web Services Addressing 1.0 - WSDL Binding: Web Services Addressing provides transport-neutral mechanisms to address Web services and messages. Web Services Addressing 1.0 - WSDL Binding defines how the abstract properties defined in Web Services Addressing 1.0 - Core are described using WSDL. The classes of products for which this specification is designed to be relevant include WSDL and WS-Addressing EPR consumers. The Windows SDK includes samples to exercise this protocol.

Web Services Description Language 1.1: Web Services Description Language (WSDL) is an XML format for describing network services as a set of endpoints that operate on messages containing either document-oriented or procedure-oriented information. As communications protocols and message formats are standardized in the web community, it becomes increasingly possible and important to be able to describe the communications in some structured way. WSDL addresses this requirement by defining an XML grammar for describing network services as collections of communication endpoints capable of exchanging messages. WSDL service definitions provide documentation for distributed systems and serve as a recipe for the automation of the details involved in applications communication.

Web Services Enumeration (WS-Enumeration): WS-Enumeration is a general SOAP-based protocol standard for enumerating a sequence of XML elements that is suitable for traversing logs, message queues, or other linear information models.

Wi-Fi Protected Access (WPA): WPA provides data protection and network access control for 802.11 wireless networks. Note that this specification allows an ad hoc mode in which a client can communicate directly with another client in the absence of the server role. In Windows Vista, this mode is not supported, and in Windows XP, this mode is not supported by any known drivers.

Wi-Fi Multimedia (WMM): WMM adds prioritized capabilities to Wi-Fi networks and optimizes their performance when multiple concurring applications, each with different latency and throughput requirements, compete for network resources. The specification also includes provisions for power save operations.

Wi-Fi Protected Setup (WPS) Protocol: The Wi-Fi Protected Setup Protocol standard provides wireless settings (for example, SSID and Network Key) to an 802.11 Access Point, and provides a configuration service to other 802.11 devices to supply settings for joining the wireless network.

WS-Addressing: WS-Addressing provides transport-neutral mechanisms to address Web services and messages. Specifically, this specification defines XML elements to identify Web service endpoints and to secure end-to-end endpoint identification in messages. This specification enables messaging systems to support message transmission through networks that include processing nodes, such as endpoint managers, firewalls, and gateways in a transport-neutral manner.

WS-Addressing Policy Assertion: This data structure defines a WS-Addressing policy assertion for specifying that messages sent to and received from an endpoint must use the WS-Addressing protocol. The Windows SDK includes samples that use this data structure.

WS-AtomicTransaction Version 1.0 Protocol: This protocol standard provides the definition of the atomic transaction coordination type that is to be used with the extensible coordination framework described in the WS-Coordination specification. The specification defines three specific agreement coordination protocols for the atomic transaction coordination type: completion, volatile two-phase commit, and durable two-phase commit. Developers can use any or all of these protocols when building applications that require consistent agreement on the outcome of short-lived distributed activities that have the all-or-nothing property.

WS-Coordination Version 1.0 Protocol: This protocol standard provides support for a general coordination context. This context is required to propagate an activity to other services and to register for coordination protocols. The framework enables existing transaction processing, workflow, and other systems for coordination to hide their proprietary protocols and to operate in a heterogeneous environment. Additionally, this specification describes a definition of the structure of context and the requirements for propagating context between cooperating services.

WS-Discovery: The WS-Discovery protocol standard defines a flexible way to discover Web services and Web services-based devices. It enables services to advertise themselves when they join and announce their departure from the network as they remove themselves from a network. Additionally, it allows clients to query the network for a specific or a broad range of Web services and Web services-based devices. The protocol allows for flexibility by granting the following:

- Clients can query a network for specific services.
- Clients can query a network for any service that matches a stated criteria.
- Services can respond to queries directly to the client.
- Services can announce their presence on a network.

WS-Discovery: Managed Mode Profile: WS-Discovery v1.1 CD1 Managed Mode allows cross subnet discovery of Web services endpoints, which permits roaming clients and devices to locate services not in their immediate topological presence. The Committee Draft 1 of WS-Discovery v1.1 specification is published by the OASIS WS-Device and Discovery Technical Committee. Windows implements the Managed Mode section of WS-Discovery v1.1 CD1. Windows additionally uses the Ad-hoc section of WS-Discovery v1.0 to locate proxies that implement WS-Discovery v1.1 CD1 Managed Mode. For more information, see [\[DvcProfileWSvcs1.1\]](#).

WS-Eventing: This specification describes a protocol standard for one Web service to register interest (for example, subscribe) with another Web service in order to receive notification messages about events. This protocol defines mechanisms to register, revoke, renew, and inquire status of subscriptions.

WS-Federation: This specification defines extensions to WS-Trust and new mechanisms to facilitate the federation of credentials between security realms for Web services, including usage from web browsers. These extensions include federation metadata documents and discovery, indicating/selecting federations, reference tokens for low-bandwidth, and pseudonym management and usage. The client for the specified protocol is a web browser, therefore Windows client ships the client role; however, there is no knowledge of the protocol-specific semantics in the Windows client SKU.

WS-I Basic Profile Version 1.1: This document specifies interoperability guidance for a core set of standard Web services specifications, such as HTTP, SOAP, WSDL, and UDDI, along with interoperability-promoting clarifications and amendments to those specifications. The Windows SDK includes samples that invoke this protocol.

WS-I Simple SOAP Binding 1.0: The Simple SOAP Binding Profile consists of those Basic Profile 1.0 requirements related to the serialization of the envelope and its representation in the message, which incorporates any errata to date.

WS-Management: Web Services: Management is a DMTF standard for the management of hardware and software resources in a network. The standard specifies a core set of Web services and usage requirements in order to expose a common set of operations that are central to all systems management. This comprises of the abilities to:

- DISCOVER the presence of management resources and navigate between them.
- GET, PUT, CREATE, RENAME, and DELETE individual management resources, such as settings and dynamic values.
- ENUMERATE the contents of containers and collections, such as large tables and logs.
- SUBSCRIBE to events emitted by managed resources.
- EXECUTE specific management methods with strongly typed input and output parameters.

WS-MetadataExchange: This protocol standard defines how metadata can be treated as WS-Transfer resources for retrieval purposes, how metadata can be embedded in Web service endpoint references, and how Web service endpoints can optionally support a request-response interaction for the retrieval of metadata.

WS-Policy: The Web Services Policy Framework (WS-Policy) provides a general purpose model and corresponding syntax to describe the policies of a Web service. WS-Policy defines a set of data structure elements that can be used and extended by other Web services specifications in order to describe a broad range of service requirements and capabilities.

WS-PolicyAttachment: This data structure defines two general-purpose mechanisms to associate policies with the subjects to which they apply; the policies may be defined as part of existing WS-Policy metadata about the subject, or the policies may be defined independently and associated through an external binding to the subject.

WS-ReliableMessaging Protocol: This protocol standard allows messages to be delivered reliably between distributed applications in the presence of software component, system, or network failures. The protocol is described in a transport-independent manner that allows it to be

implemented using different network technologies. To support interoperable Web services, a SOAP binding is defined. The Windows SDK includes samples that invoke this protocol.

WS-ReliableMessagingPolicy: This data structure describes a WS-Policy assertion that can be used to specify policy parameters for WS-ReliableMessaging (WS-RM). Policy parameters include InactivityTimeout, BaseRetransmissionInterval, AcknowledgementInterval, and ExponentialBackoff. The Windows SDK includes samples that use this data structure.

WS-SecureConversation: This specification defines extensions to WS-Trust to establish, renew, amend, and close Web service security contexts. Specifically, this protocol uses the mechanisms of WS-Trust to establish end-to-end security contexts by creating a new security token (representing the context) which can then be used to secure messages with WS-Security.

WS-Security: This specification describes how to secure Web services messages independent of transport, and how to pass different credential types within messages. Specifically this specification describes how to sign or encrypt portions of the message for one or more recipients, and how to attach credentials (security tokens). The associated token profiles (Username, X.509, Security Assertion Markup Language (SAML), Rights Expression Language (REL), and Kerberos) detail specific usages of those token types with WS-Security.

WS-SecurityPolicy: This specification defines extensions to WS-Policy to allow specification of security communication requirements for a Web service. This information is used to determine if a requester can communicate with a recipient (that is, if it has compatible options).

WS-Transfer: This specification defines a mechanism for creating, reading, updating, and deleting XML-based representations of data using the Web service infrastructure. Other than requiring the data to be serialized as XML, there are no other constraints on the data that is created, read, updated, or deleted. The .NET Framework implements the client role of the protocol. The server role of the protocol is implemented by an out of band (OOB) Windows targeted release (WTR), which ships for Windows Server 2003, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2.

WS-Trust: This specification defines a Web services protocol standard for obtaining, issuing, renewing, canceling, and verifying security tokens and credentials. This protocol allows for a requester to provide a set of credentials and options (such as, expiry and usage domains) in order to obtain new credentials. The verification aspect allows the provided credentials to be verified based on service trust policies.

X.224 Protocol: X.224 defines a procedure and protocol standard that will allow the transport connections for a T.120 conference to negotiate the availability of extended transport services. These services may include the use of security protocols, transport protocols, levels of reliability for data transfer, and support for address aliases. This negotiation is designed to provide backward compatibility with T.123 transport stacks that only support baseline transport connections. In addition to security and reliability services, this annex specifies a method for using an alias address list to establish extended transport connections. These aliases can be used for a variety of purposes, including proxy, gateway, and call redirection services for T.120 communications.

XML namespaces: eXtensible Markup Language (XML) namespaces provide a simple method to qualify element and attribute names that are used in Extensible Markup Language documents by associating them with namespaces identified by URI references.

XML Schema Definition (XSD): eXtensible Markup Language (XML) Schema specifies the XML Schema definition language, which offers facilities for describing the structure and constraining the contents of XML 1.0 documents, including those which exploit the XML Namespace facility. The schema language, which is represented in XML 1.0 and uses namespaces, substantially reconstructs and considerably extends the capabilities found in XML 1.0 document type definitions (DTDs).

XML-binary Optimized Packaging (XOP): This data structure defines the XML-binary Optimized Packaging (XOP) convention (see [\[XML-XOP\]](#)), which is a means of more efficiently serializing XML Infosets (see [\[XML-INFOSET\]](#)) that contain certain types of content. An XOP package is created by placing a serialization of the XML Infoset inside of an extensible packaging format (such as MIME Multipart/Related, see [\[RFC2387\]](#)). Then, selected portions of its content that are base64-encoded binary data are extracted and re-encoded (that is, the data is decoded from base64) and placed into the package. The locations of those selected portions are marked in the XML with a special element that links to the packaged data using URIs. The Windows SDK includes samples that use this data structure.

XML-Encryption Syntax and Processing: This document specifies a process for encrypting data and representing the result in XML. The data may be arbitrary data (including an XML document), an XML element, or XML element content. The result of encrypting the data is an XML Encryption EncryptedData element that contains (via one of its children's content) or identifies (via a URI reference) the cipher data. The .NET Framework receives and emits the data structure. The data structure is received and emitted by an out of band (OOB) Windows targeted release (WTR) that ships for Windows Server 2003, Windows Server 2003 R2, Windows Server 2008, and Windows Server 2008 R2. This data structure is used in the Security Assertion Markup Language (SAML) V2.0 protocol, the WS-Federation: Browser Extensions Version 2 protocol, and the WS-Trust protocol.

XML-Signature Syntax and Processing: This specification specifies Extensible Markup Language (XML) digital signature validation rules and syntax. XML Signatures provide integrity, message authentication, and/or signer authentication services for data of any type, whether it is located within the XML that includes the signature, or elsewhere. The roles specified in this form refer to creators (client) and validators (server) of the data structure.

XModem File Transfer Protocol: The Xmodem File Transfer protocol standard provides simple serial file transfer between a server and client across a point-to-point link using fixed-length packets. Each server packet contains 128 bytes of file data, and is individually acknowledged by the receiving client. Only one file can be sent per transmission, and the transmission must be restarted from the beginning if it fails.

XModem File Transfer Protocol: 1K Extension: The 1K extension to the Xmodem File Transfer protocol standard allows larger data blocks (1024 bytes of file data). The server uses an alternate start of header (SOH) character (0x02) to mark the start of a 1K Xmodem packet.

YModem File Transfer Protocol: The Ymodem File Transfer protocol standard provides simple serial file transfer between a server and client across a point-to-point link by using fixed-length packets. Each server packet contains either 128 bytes (the start of header character (SOH) = 0x01) or 1024 bytes (SOH = 0x02) of file data, and is individually acknowledged by the receiving client. Multiple files can be sent per transmission, and the transmission must be restarted from the beginning if it fails. Packet formats are similar to those for the HyperTerminal Xmodem File Transfer protocol.

YModem File Transfer Protocol: G Extension: The Ymodem-G File Transfer extension of the Ymodem File Transfer protocol standard can be requested by the client by polling the server with an ASCII G character instead of the ASCII C character used for the Ymodem File Transfer protocol. For the Ymodem-G File Transfer extension, the server sends data packets but does not wait for a client acknowledgement (ACK) for each individual packet. The server expects a client ACK in response to the end-of-transmission (EOT) character. If the receiver detects an error in a packet, it aborts the entire transmission by sending a cancel sequence that consists of multiple (typically 10) CAN line control characters (0x18).

ZModem File Transfer Protocol: The Zmodem File Transfer protocol standard provides a simple means of point-to-point serial file transfer. The session initialization dialog includes attributes that allow an interrupted file transfer to be resumed. Multiple files may be transferred per session. File

data is transmitted in 1024-byte data blocks. Data packets are strung together and acknowledged, only once, at end-of-file. Error detection supports checksum error checking. An interrupted file transfer can be restarted from the point of interruption.

ZModem File Transfer Protocol: Crash Recovery Extension: The Zmodem with Crash Recovery protocol standard provides a simple means of point-to-point serial file transfer. The session initialization dialog includes attributes that allow an interrupted file transfer to be resumed. Multiple files may be transferred per session. File data is transmitted in 1024-byte data blocks. Data packets are strung together and acknowledged only once, at end-of-file. Error detection supports CRC error checking.

9.2 Standards Extended

The table below lists protocol documents for the standards extended by Windows:

Protocol Document	Standards Extended
[MS-ODATA]: Open Data Protocol (OData) Specification	[RFC5023]
[MC-FPSEWM]: FrontPage Server Extensions: Website Management Specification	[RFC2616] and [RFC2854]
[MC-NBFSE]: .NET Binary Format: SOAP Extension	[SOAP1.1]
[MS-DHCPE]: Dynamic Host Configuration Protocol (DHCP) Extensions	[RFC2131]
[MS-DHCPN]: Dynamic Host Configuration Protocol (DHCP) Extensions for Network Access Protection (NAP)	[RFC2131]
[MS-DLNHND]: Digital Living Network Alliance (DLNA) Networked Device Interoperability Guidelines: Microsoft Extensions	[DLNA]
[MS-DPSP]: Digest Protocol Extensions	[RFC2617] and [RFC2831]
[MS-DPWSSN]: Devices Profile for Web Services (DPWS): Size Negotiation Extension	[DPWS]
[MS-DSML]: Directory Services Markup Language (DSML) 2.0 Protocol Extensions	[DSML2]
[MS-DTCLU]: MSDTC Connection Manager: OleTx Transaction Protocol Logical Unit Mainframe Extension	[LU62Peer]
[MS-FPSE]: FrontPage Server Extensions Remote Protocol Specification	[RFC2616] and [RFC2854]
[MS-GSSA]: Generic Security Service Algorithm for Secret Key Transaction Authentication for DNS (GSS-TSIG) Protocol Extension	[RFC3645]
[MS-H245]: H.245 Protocol: Microsoft Extensions	[H245-v3]
[MS-H26XPF]: Real-Time Transport Protocol (RTP/RTCP): H.261 and H.263 Video Streams Extensions	[RFC2032] and [RFC2190]
[MS-HNDS]: Host Name Data Structure Extension	[RFC1123]
[MS-IKEE]: Internet Key Exchange Protocol Extensions	[RFC2407], [RFC2408], [RFC2409], [RFC3947], and

Protocol Document	Standards Extended
	[RFC4306]
[MS-KILE] : Kerberos Protocol Extensions	[RFC4120]
[MS-L2TPIE] : Layer 2 Tunneling Protocol (L2TP) IPsec Extensions	[RFC2401]
[MS-MWBE] : Microsoft Web Browser Federated Sign-On Protocol Extensions	[WSFedPRP]
[MS-NBTE] : NetBIOS over TCP (NetBT) Extensions	[RFC1001] and [RFC1002]
[MS-NNTP] : NT LAN Manager (NTLM) Authentication: Network News Transfer Protocol (NNTP) Extension	[RFC977]
[MS-OCSP] : Online Certificate Status Protocol (OCSP) Extensions	[RFC5019]
[MS-PCCRTP] : Peer Content Caching and Retrieval: HTTP Extensions	[RFC2616]
[MS-POP3] : NT LAN Manager (NTLM) Authentication: Post Office Protocol - Version 3 (POP3) Extension	[RFC1939]
[MS-RPCE] : Remote Procedure Call Protocol Extensions	[C706]
[MS-RPCL] : Remote Procedure Call Location Services Extensions	[C706]
[MS-RTPDT] : Real-Time Transport Protocol (RTP/RTCP): DTMF Digits, Telephony Tones and Telephony Signals Data Extensions	[RFC4733]
[MS-RTPME] : Real-Time Transport Protocol (RTP/RTCP): Microsoft Extensions	[RFC3550]
[MS-RTPRAD] : Real-Time Transport Protocol (RTP/RTCP): Redundant Audio Data Extensions	[RFC2198]
[MS-RTSP] : Real-Time Streaming Protocol (RTSP) Windows Media Extensions	[RFC2326]
[MS-SDP] : Session Description Protocol (SDP) Extensions	[RFC4566]
[MS-SFU] : Kerberos Protocol Extensions: Service for User and Constrained Delegation Protocol Specification	[RFC4120]
[MS-SIP] : Session Initiation Protocol Extensions	[RFC3261] , [RFC3262] , [RFC3263] , and [RFC3863]
[MS-SMTP] : NT LAN Manager (NTLM) Authentication: Simple Mail Transfer Protocol (SMTP) Extension	[RFC2821]
[MS-SNTP] : Network Time Protocol (NTP) Authentication Extensions	[RFC1305] and [RFC2030]
[MS-SPNG] : Simple and Protected Generic Security Service Application Program Interface Negotiation Mechanism (SPNEGO) Protocol Extensions	[RFC4178]
[MS-SSDP] : SSDP: Networked Home Entertainment Devices (NHED) Extensions	[UPNPARCH1]
[MS-TIPP] : Transaction Internet Protocol (TIP) Extensions	[RFC2371]

Protocol Document	Standards Extended
[MS-UPMC]: UPnP Device and Service Templates: Media Property and Compatibility Extensions	[UPnP]
[MS-V4OF]: IPv4 Over IEEE 1394 Protocol Extensions	[RFC2734]
[MS-WDV]: Web Distributed Authoring and Versioning (WebDAV) Protocol: Client Extensions	[RFC4918]
[MS-WDVME]: Web Distributed Authoring and Versioning (WebDAV) Protocol: Microsoft Extensions	[RFC2518]
[MS-WDVSE]: Web Distributed Authoring and Versioning (WebDAV) Protocol: Server Extensions	[RFC4918] and [RFC2068]
[MS-WSDS]: WS-Enumeration: Directory Services Protocol Extensions	[WSENUM]
[MS-WSMAN]: Web Services Management Protocol Extensions for Windows Server 2003	[DMTF-DSP0227] and [DMTF-DSP0230]
[MS-WSMV]: Web Services Management Protocol Extensions for Windows Vista	[DMTF-DSP0226], [DMTF-DSP0227], and [DMTF-DSP0230]
[MS-WSPELD]: WS-Transfer and WS-Enumeration Protocol Extension for Lightweight Directory Access Protocol v3 Controls Specification	[WSENUM] and [WXFR]
[MS-WSTEP]: WS-Trust X.509v3 Token Enrollment Extensions	[WSTrust1.3]
[MS-WSTIM]: WS-Transfer: Identity Management Operations for Directory Access Extensions	[WXFR]

9.3 Other Specifications Implemented in Windows

Public Key Cryptography Based User-to-User Authentication (PKU2U) Protocol: The Public Key Cryptography Based User to User Authentication Protocol ([PKU2U-DRAFT]) standard provides security services in peer-to-peer networking environments without requiring a Kerberos **Key Distribution Center (KDC)**. A binding of this protocol for the Generic Security Service Application Program Interface (GSS-API) is provided.

10 Appendix D: ADM and ADMX Files

Administrative template files (ADM files) facilitate the management of registry-based policy. An ADM file is used to describe both the user interface presented to the Group Policy administrator and the registry keys that should be updated on target machines. An ADM file is a text file with a specific syntax which describes both the interface and the registry values which will be changed if the policy is enabled or disabled. The format of ADM files is specified in [MSDN-ADM_FORMAT].

By default, two ADM files are loaded when a new Group Policy Object is created; one for the user and one for the computer. These two ADM files are named **Inetres.adm** (Internet Explorer Settings) and **System.adm** (Windows operating system component settings).

The Policy settings that can be configured by ADM files are limited to the following registry locations:

- **HKLM\Software\Policies** (computer settings, the preferred location)
- **HKLM\Software\Microsoft\Windows\CurrentVersion\Policies** (computer settings, an alternative location)
- **HKCU\Software\Policies** (user settings, the preferred location)
- **HKCU\Software\Microsoft\Windows\CurrentVersion\Policies** (user settings, an alternative location)

The ADM templates are included in Windows and are located in the **%SystemRoot%\Inf** folder.

The ADM files that shipped in the following list of Windows operating systems are available in the download center:

- Windows 2000 operating system (at [\[GPADM\]](#))
- Windows XP operating system (at [\[GPADM\]](#))
- Windows XP operating system Service Pack 1 (SP1) (at [\[GPADM\]](#))
- Windows XP operating system Service Pack 2 (SP2) (at [\[GPADM\]](#))
- Windows XP operating system Service Pack 3 (SP3) (at [\[GPADM\]](#))
- Windows Server 2003 operating system (at [\[GPADM\]](#))
- Windows Server 2003 operating system with Service Pack 1 (SP1) (at [\[GPADM\]](#))
- Windows Server 2003 operating system with Service Pack 2 (SP2) (at [\[GPADM\]](#))
- Windows Server 2003 operating system with Service Pack 3 (SP3) (at [\[GPADM\]](#))
- Windows Server 2003 R2 operating system (at [\[GPADM\]](#))

The following table lists the ADM files, which are categorized by the version of the Windows operating system in which they were first shipped.

ADM File Name	Windows Version
conf.adm	Windows Server 2003 with SP1

ADM File Name	Windows Version
inetres.adm	Windows Server 2003 with SP1
system.adm	Windows Server 2003 with SP1
wmplayer.adm	Windows Server 2003 with SP1
wuau.adm	Windows Server 2003 with SP1

For details on administrative templates, go to [\[MSDN-ADMNTMPFF\]](#).

There are two ways to determine the purpose of a group policy setting, either from downloadable spread sheets at [\[GPADM\]](#) (Group Policy Settings Reference for Windows and Windows Server) or from the online search tool available at [\[MSDN-GPS-APP\]](#). The spreadsheets provide details for each Group Policy setting, including its name, whether the setting applies to individual users or the machine as a whole, its meaning, its registry location, to which product it applies, and whether the setting requires a reboot or logon/logoff before it becomes effective.

In Windows Vista operating system and later, registry-based policy settings are obtained from an XML-based administrative template ADMX file. An ADMX file is defined as a set of one language neutral file (**.adm**x) and associated ADMX language resource files (**.adml**). The syntax of ADMX files is defined by the ADMX schema ([\[MSDN-ADMX-Schema\]](#)).

The ADMX files that shipped in the following list of Windows operating systems are available in the download center:

- Windows Vista (at [\[MSDN-ADMX-VISTA\]](#))
- Windows Vista operating system with Service Pack 1 (SP1) (at [\[MSDN-ADMX-VISTA\]](#))
- Windows Vista operating system with Service Pack 2 (SP2) (at [\[MSDN-ADMX-VISTA\]](#))
- Windows Server 2008 operating system (at [\[MSDN-ADMX-2008\]](#))
- Windows Server 2008 R2 operating system (at [\[MSDN-ADMX-WIN7\]](#))
- Windows 7 operating system (at [\[MSDN-ADMX-WIN7\]](#))

11 Appendix E: NTFS Alternate Streams

11.1 NTFS Streams

All files on an **NTFS** volume consist of at least one stream - the main stream – this is the normal, viewable file that data is stored in. The full name of a stream is of the form below.

<filename>:<stream name>:<stream type>

The default data stream has no name. That is, the fully qualified name for the default stream for a file called "sample.txt" is "sample.txt::\$DATA" since "sample.txt" is the name of the file and "\$DATA" is the stream type.

A user can create a named stream in a file and "\$DATA" as a legal name. That means that for this stream the full name is sample.txt::\$DATA:\$DATA. If the user had created a named stream of name "bar", its full name would be sample.txt:bar::\$DATA. Any legal characters for a file name are legal for the stream name (including spaces). For more information of the naming format for streams, see [\[MS-FSCC\]](#). For more information of the attributes of a stream, see [\[MS-FSA\]](#).

In the case of directories, there is no default data stream but there is a default directory stream. Directories are the stream type \$INDEX_ALLOCATION. The default stream name for the type \$INDEX_ALLOCATION (a directory stream) is \$I30. (This contrasts with the default stream name for a \$DATA stream which has an empty stream name.) The following are equivalent:

Dir C:\Users

Dir C:\Users:\$I30:\$INDEX_ALLOCATION

Dir C:\Users::\$INDEX_ALLOCATION

Although directories do not have a default data stream, they can have named data streams. These alternate data streams are not normally visible but can be observed from a command line using the /R option of the DIR command.

11.2 NTFS Attribute Types

On a NTFS volume, each unit of information associated with a file including its name, its owner, its timestamp, its contents, and so on, is implemented as a file attribute. A file's data is an attribute; the "Data Attribute" known as \$DATA. A number of attributes exist on a NTFS volume. The attribute names used by NTFS are listed in the table below.

Attribute Name	Description
\$ATTRIBUTE_LIST	Lists the location of all attribute records that do not fit in the MFT record
\$BITMAP	Attribute for Bitmaps
\$DATA	Contains default file data
\$EA	Extended attribute index
\$EA_INFORMATION	Extended attribute information
\$FILE_NAME	File name
\$INDEX_ALLOCATION	The type name for a Directory Stream. A string for the attribute code for

Attribute Name	Description
	index allocation
\$INDEX_ROOT	Used to support folders and other indexes
\$LOGGED_UTILITY_STREAM	Use by the encrypting file system
\$OBJECT_ID	Unique GUID for every MFT record
\$PROPERTY_SET	Obsolete
\$REPARSE_POINT	Used for volume mount points
\$SECURITY_DESCRIPTOR	Security descriptor stores ACL and SIDs
\$STANDARD_INFORMATION	Standard information such as file times and quota data
\$SYMBOLIC_LINK	Obsolete
\$TXF_DATA	Transactional NTFS data
\$VOLUME_INFORMATION	Version and state of the volume
\$VOLUME_NAME	Name of the volume
\$VOLUME_VERSION	Obsolete. Volume version

A comprehensive discussion and explanation on attributes is available in [WININTERNALS] chapter 12 and [\[MSFT-NTFSWorks\]](#).

11.3 NTFS Reserved File Names

NTFS uses a number of names as part of the file system internals. The names used by NTFS within the root directory are listed in the following table:

Filename	Description
\\$Mft	Master File Table (MFT) - an index of every file
\\$MftMirr	A backup copy of the first 4 records of the MFT
\\$LogFile	Transactional logging file
\\$Volume	Serial number, creation time, dirty flag
\\$AttrDef	Attribute definitions
\\$Bitmap	Contains volume's cluster map (in-use vs. free)
\\$Boot	Boot record of the volume
\\$BadClus	Lists bad clusters on the volume
\\$Secure	Security descriptors used by the volume
\\$UpCase	Table of uppercase characters used for collating
\\$Extend	A directory

An additional set of names are found in the system directory as follows:

Filename	Description
\\$Extend\\$Config	Use for NTFS repair activity
\\$Extend\\$Delete	Delete file name
\\$Extend\\$ObjId	Unique Ids given to every file
\\$Extend\\$Quota	Quota information
\\$Extend\\$Repair	Repair name
\\$Extend\\$Repair.log	Repair log name
\\$Extend\\$Reparse	Reparse point information
\\$Extend\\$RmMetadata	Transactional NTFS resource manager metadata name
\\$Extend\\$Tops	Transactional NTFS Old Page Stream, used to store data that has been overwritten inside a currently active transaction
\\$Extend\\$Txf	Transactional NTFS
\\$Extend\\$TxflLog	Transactional NTFS log

11.4 NTFS Stream Names

NTFS by convention uses names starting with '\$' for internal metadata files and streams on those internal metadata files. There is no mechanism to stop applications from using names of this form; therefore, it is recommended that names of this form not be used internally by an object store for a server environment except when emulating NTFS metadata streams such as "\$Extend\$Quota:\$Q:\$INDEX_ALLOCATION" or "\$Extend\$Reparse:\$R:\$INDEX_ALLOCATION".

Stream Names currently used by NTFS are as follows:

NTFS Internal Stream Names	Example
\$I30	Default name for directory streams C:\Users:\$I30:\$INDEX_ALLOCATION
\$O	\\$Extend\\$ObjId:\$O:\$INDEX_ALLOCATION
\$Q	\\$Extend\\$Quota:\$Q:\$INDEX_ALLOCATION
\$R	\\$Extend\\$Reparse:\$R:\$INDEX_ALLOCATION
\$J	\\$Extend\\$UsnJrnl:\$J:\$DATA
\$MAX	\\$Extend\\$UsnJrnl:\$MAX:\$DATA
\$SDH	\\$Secure:\$SDH:\$INDEX_ALLOCATION
\$SII\\$Secure:\$SII:\$INDEX_ALLOCATION	\\$Secure:\$SII:\$INDEX_ALLOCATION

11.5 NTFS Stream Types

Names currently used are as follows:

NTFS Stream Types
\$DATA
\$INDEX_ALLOCATION
\$BITMAP

11.6 Known Alternate Stream Names

Selection of an alternate stream name is in principle identical to selection of a filename. An application may need to check whether a name is in use prior to attempting to use a name. When an application has successfully avoided a file name conflict, it has complete control over any stream names that it may wish to use. It is advisable to use textual GUID (**GUIDString**) as stream names in order to avoid conflicts. Injection of streams into files that an application does not completely own has the potential to cause unpredictable behavior and may be flagged by virus scanning software.

11.6.1 Zone.Identifier Stream Name

Windows Internet Explorer uses the stream name Zone.Identifier for storage of **URL** security zones.

The fully qualified form is sample.txt: Zone.Identifier:\$DATA

The stream is a simple text stream of the form:

```
[ZoneTransfer]
```

```
ZoneId=3
```

[\[MSDN-SECZONES\]](#) gives an explanation of security zones.

11.6.2 Outlook Express Properties Stream Name

Outlook Express uses the stream name OECustomProperty for storage of custom properties related to email files.

The fully qualified form is sample.eml:OECustomProperty:\$DATA

11.6.3 Document Properties Stream Name

Property sets, when applied to files, use a number of different stream names. The initial character is Unicode U+2663, known as (BLACK CLUB).

The names "♣ BnhqIkugBim0elg1M1pt2tjdZe", "♣ SummaryInformation" and the GUID {4c8cc155-6c1e-11d1-8e41-00c04fb9386d} are used.

The fully qualified names would be as follows:

```
sample.doc:♣ BnhqIkugBim0elg1M1pt2tjdZe:$DATA
```

```
sample.doc:♣ SummaryInformation:$DATA
```

```
sample.gif:{4c8cc155-6c1e-11d1-8e41-00c04fb9386d}:$DATA
```

11.6.4 Encryptable Thumbnails Stream Name

Windows Shell uses the stream name "encryptable" to store attributes relating to thumbnails in the thumbnails database.

The fully qualified name would be as follows:

Thumbs.db:encryptable:\$DATA

11.6.5 Internet Explorer Favicon Stream Name

Windows Internet Explorer uses the stream name "favicon" for storing favorite ICONs for web pages.

The fully qualified name would be as follows:

Pages.url:favicon:\$DATA

11.6.6 Macintosh Supported Stream Names

Two stream names exist for compatibility with Macintosh operating system property lists. These names are "AFP_AfpInfo" and "AFP_Resource".

The fully qualified name would be as follows:

Sample.txt:AFP_AfpInfo:\$DATA

Sample.txt:AFP_Resource:\$DATA

11.6.7 XPRESS Stream Name

The stream name "{59828bbb-3f72-4c1b-a420-b51ad66eb5d3}.XPRESS" is used during remote differential compression.

The fully qualified name would be as follows:

Sample.bin: {59828bbb-3f72-4c1b-a420-b51ad66eb5d3}.XPRESS:\$DATA

12 Change Tracking

No table of changes is available. The document is either new or has had no changes since its last release.

13 Index

A

[Abstract data model](#) 104
[Applicability](#) 103
Architecture
 [details](#) 111
 [overview](#) 104
[Assumptions](#) 98

C

[Capability negotiation](#) 103
[Change tracking](#) 177
[Communications](#) 121

D

[Data model - abstract](#) 104
[Digital rights management](#) 83

E

[Environment - overview](#) 97
[Error returns](#) 127
Examples
 [application services](#) 117
 [fax](#) 115
 [file](#) 115
 [general](#) 119
 [identity and security](#) 112
 [networking and transports](#) 111
 [overview](#) 111
 [print](#) 115
 [systems management](#) 116

F

[Fields - vendor-extensible](#) 103
[Foundation](#) 31

G

[Glossary](#) 9
[Group Policy](#) 131

I

[Informative references](#) 19
[Initialization](#) 126
[Introduction](#) 8

L

[List of member protocols](#) 26

M

[Member protocols](#) 26

N

[Networking and transport concepts](#) 31
[Non-timer events](#) 125
[Normative references](#) 13

O

[Overview](#) 25

P

[Preconditions](#) 98
Prerequisites
 background knowledge and system-specific concepts
 [application services](#) 82
 [authentication](#) 62
 [authorization](#) 65
 [fax](#) 77
 [file](#) 77
 [identity](#) 51
 [impersonation](#) 70
 networking and transport concepts
 [Distributed Component Object Model \(DCOM\)](#) 39
 [named pipes](#) 39
 [overview](#) 31
 [Remote Procedure Calls - overview](#) 32
 [RPC over HTTP](#) 38
 [overview](#) 31
 [print](#) 77
 [system management](#) 81
 [web services](#) 82
 [overview](#) 31
 [system purposes](#) 85
 [system use cases](#) 86
[Product behavior](#) 128
[Protocols affected by Group Policy](#) 131

R

References
 [informative](#) 19
 [normative](#) 13
 [overview](#) 13
[Reinitialization](#) 126
Relationships
 [black box](#) 100
 [overview](#) 100
 [system dependencies](#) 102
 [white box](#) 104
[Required information](#) 31
[Returns - status and error](#) 127
[Rights management services](#) 83

S

[Standards - Windows](#) 134
[Standards assignments](#) 30
[Status returns](#) 127
[System details](#) 111
[System influences](#) 102
[System purposes](#) 85
[System summary](#) 25
[System-environment relationship](#) 97

T

[Timers](#) 124
[Tracking changes](#) 177
[Transport requirements](#) 123

U

Use cases
[application services](#) 92
[fax](#) 90
[file](#) 90
[general](#) 94
[identity and security](#) 88
[networking](#) 86
[print](#) 90
[systems management](#) 91

V

[Vendor-extensible fields](#) 103
[Versioning](#) 103

W

White box relationships
[fax](#) 104
[file](#) 104
[overview](#) 104
[print](#) 104
[system management](#) 107