**[MS-NLMP]:**

**NT LAN Manager (NTLM) Authentication Protocol**

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# Introduction

The NT LAN Manager (NTLM) Authentication Protocol is used for authentication between clients and servers.

These extensions provide additional capability for authorization information including group memberships, interactive logon information, and message integrity, as well as constrained delegation and encryption supported by [**Kerberos**](#gt_d6a282ce-b1da-41e1-b05a-22f777a5c1fe) principals.

Kerberos authentication [[MS-KILE]](%5BMS-KILE%5D.pdf#Section_2a32282edd484ad9a542609804b02cc9) replaces NTLM as the preferred authentication protocol.[<1>](#Appendix_A_1" \o "Product behavior note 1) However, NTLM can be used when the Kerberos Protocol Extensions (KILE) do not work, such as in the following scenarios.

* One of the machines is not Kerberos-capable.
* The server is not joined to a [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca).
* The KILE configuration is not set up correctly.
* The implementation chooses to directly use NLMP.

Sections 1.5, 1.8, 1.9, 2, and 3 of this specification are normative. All other sections and examples in this specification are informative.

## Glossary

This document uses the following terms:

**Active Directory**: The Windows implementation of a general-purpose directory service, which uses LDAP as its primary access protocol. [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90) stores information about a variety of objects in the network such as user accounts, computer accounts, groups, and all related credential information used by [**Kerberos**](#gt_d6a282ce-b1da-41e1-b05a-22f777a5c1fe) [[MS-KILE]](%5BMS-KILE%5D.pdf#Section_2a32282edd484ad9a542609804b02cc9). [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90) is either deployed as Active Directory Domain Services (AD DS) or Active Directory Lightweight Directory Services (AD LDS), which are both described in [[MS-ADOD]](%5BMS-ADOD%5D.pdf#Section_5ff67bf4c14548cb89cd4f5482d94664): Active Directory Protocols Overview.

**AV pair**: An attribute/value pair. The name of some attribute, along with its value. [**AV pairs**](#gt_5158aff7-f968-422b-a78f-6cbb653e7b2a) in NTLM have a structure specifying the encoding of the information stored in them.

**challenge**: A piece of data used to authenticate a user. Typically a challenge takes the form of a [**nonce**](#gt_001c0e40-0980-417d-853c-f7cb34ba6d3b).

**checksum**: A value that is the summation of a byte stream. By comparing the checksums computed from a data item at two different times, one can quickly assess whether the data items are identical.

**code page**: An ordered set of characters of a specific script in which a numerical index (code-point value) is associated with each character. Code pages are a means of providing support for character sets and keyboard layouts used in different countries. Devices such as the display and keyboard can be configured to use a specific code page and to switch from one code page (such as the United States) to another (such as Portugal) at the user's request.

**connection oriented NTLM**: A particular variant of NTLM designed to be used with connection oriented [**remote procedure call (RPC)**](#gt_8a7f6700-8311-45bc-af10-82e10accd331).

**cyclic redundancy check (CRC)**: An algorithm used to produce a [**checksum**](#gt_fa444149-ef93-4512-a278-2e756295630c) (a small, fixed number of bits) against a block of data, such as a packet of network traffic or a block of a computer file. The CRC is a broad class of functions used to detect errors after transmission or storage. A CRC is designed to catch random errors, as opposed to intentional errors. If errors might be introduced by a motivated and intelligent adversary, a cryptographic hash function should be used instead.

**directory**: The database that stores information about objects such as users, groups, computers, printers, and the directory service that makes this information available to users and applications.

**domain**: A set of users and computers sharing a common namespace and management infrastructure. At least one computer member of the set must act as a [**domain controller (DC)**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) and host a member list that identifies all members of the domain, as well as optionally hosting the [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90) service. The domain controller provides authentication of members, creating a unit of trust for its members. Each domain has an identifier that is shared among its members. For more information, see [[MS-AUTHSOD]](%5BMS-AUTHSOD%5D.pdf#Section_953d700a57cb4cf7b0c3a64f34581cc9) section 1.1.1.5 and [[MS-ADTS]](%5BMS-ADTS%5D.pdf#Section_d243592709994c628c6d13ba31a52e1a).

**domain controller (DC)**: The service, running on a server, that implements [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90), or the server hosting this service. The service hosts the data store for objects and interoperates with other [**DCs**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) to ensure that a local change to an object replicates correctly across all [**DCs**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd). When [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90) is operating as Active Directory Domain Services (AD DS), the [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) contains full NC replicas of the configuration naming context (config NC), schema naming context (schema NC), and one of the domain NCs in its [**forest**](#gt_fd104241-4fb3-457c-b2c4-e0c18bb20b62). If the AD DS [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) is a global catalog server (GC server), it contains partial NC replicas of the remaining domain NCs in its [**forest**](#gt_fd104241-4fb3-457c-b2c4-e0c18bb20b62). For more information, see [MS-AUTHSOD] section 1.1.1.5.2 and [MS-ADTS]. When [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90) is operating as Active Directory Lightweight Directory Services (AD LDS), several AD LDS [**DCs**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) can run on one server. When [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90) is operating as AD DS, only one AD DS [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) can run on one server. However, several AD LDS [**DCs**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) can coexist with one AD DS [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) on one server. The AD LDS [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) contains full NC replicas of the config NC and the schema NC in its [**forest**](#gt_fd104241-4fb3-457c-b2c4-e0c18bb20b62). The domain controller is the server side of Authentication Protocol Domain Support [[MS-APDS]](%5BMS-APDS%5D.pdf#Section_dd444344fd7e430eb3137e95ab9c338e).

**domain name**: A domain name or a NetBIOS name that identifies a [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca).

**forest**: One or more [**domains**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) that share a common schema and trust each other transitively. An organization can have multiple [**forests**](#gt_fd104241-4fb3-457c-b2c4-e0c18bb20b62). A [**forest**](#gt_fd104241-4fb3-457c-b2c4-e0c18bb20b62) establishes the security and administrative boundary for all the objects that reside within the [**domains**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) that belong to the [**forest**](#gt_fd104241-4fb3-457c-b2c4-e0c18bb20b62). In contrast, a [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) establishes the administrative boundary for managing objects, such as users, groups, and computers. In addition, each [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) has individual security policies and trust relationships with other [**domains**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca).

**fully qualified domain name (FQDN)**: In [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90), a fully qualified domain name (FQDN) that identifies a [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca).

**identify level token**: A security token resulting from authentication that represents the authenticated user but does not allow the [**service**](#gt_2dc07ca2-2b40-437e-a5ec-ed28ebfb116a) holding the token to impersonate that user to other resources.

**Kerberos**: An authentication system that enables two parties to exchange private information across an otherwise open network by assigning a unique [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) (called a ticket) to each user that logs on to the network and then embedding these tickets into messages sent by the users. For more information, see [MS-KILE].

**key**: In cryptography, a generic term used to refer to cryptographic data that is used to initialize a cryptographic algorithm. [**Keys**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) are also sometimes referred to as keying material.

**key exchange key**: The [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) used to protect the [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) that is generated by the client. The [**key exchange key**](#gt_5f9cd8ed-6284-46f0-aaf1-9e9f0f6a2db7) is derived from the [**response key**](#gt_0368db93-c0f9-4ea7-a30e-c04699c1f22d) during authentication.

**LMOWF**: The result generated by the [**LMOWF**](#gt_fd74ef50-cb97-4acd-b537-4941bdd9e064) function.

**LMOWF()**: A one-way function used to generate a [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) based on the user's password.

**Message Authentication Code (MAC)**: A message authenticator computed through the use of a symmetric key. A [**MAC**](#gt_3a669297-5242-417e-bff9-5828a186fcf8) algorithm accepts a secret key and a data buffer, and outputs a [**MAC**](#gt_3a669297-5242-417e-bff9-5828a186fcf8). The data and [**MAC**](#gt_3a669297-5242-417e-bff9-5828a186fcf8) can then be sent to another party, which can verify the integrity and authenticity of the data by using the same secret key and the same [**MAC**](#gt_3a669297-5242-417e-bff9-5828a186fcf8) algorithm.

**nonce**: A number that is used only once. This is typically implemented as a random number large enough that the probability of number reuse is extremely small. A nonce is used in authentication protocols to prevent replay attacks. For more information, see [[RFC2617]](https://go.microsoft.com/fwlink/?LinkId=90373).

**NTOWF**: A general-purpose function used in the context of an NTLM authentication protocol, as specified in [[MS-NLMP]](%5BMS-NLMP%5D.pdf#Section_b38c36ed28044868a9ff8dd3182128e4), which computes a one-way function of the user's password. The result generated by the NTOWF() function.

**NTOWF()**: A one-way function (similar to the [**LMOWF**](#gt_fd74ef50-cb97-4acd-b537-4941bdd9e064) function) used to generate a [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) based on the user's password.

**object identifier (OID)**: In the context of an object server, a 64-bit number that uniquely identifies an object.

**original equipment manufacturer (OEM) character set**: A character encoding used where the mappings between characters is dependent upon the [**code page**](#gt_210637d9-9634-4652-a935-ded3cd434f38) configured on the machine, typically by the manufacturer.

**remote procedure call (RPC)**: A communication protocol used primarily between client and server. The term has three definitions that are often used interchangeably: a runtime environment providing for communication facilities between computers (the RPC runtime); a set of request-and-response message exchanges between computers (the RPC exchange); and the single message from an RPC exchange (the RPC message). For more information, see [[C706]](https://go.microsoft.com/fwlink/?LinkId=89824).

**response key**: A [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) generated by a one-way function from the name of the user, the name of the user's domain, and the password. The function depends on which version of NTLM is being used. The [**response key**](#gt_0368db93-c0f9-4ea7-a30e-c04699c1f22d) is used to derive the [**key exchange key**](#gt_5f9cd8ed-6284-46f0-aaf1-9e9f0f6a2db7).

**Security Support Provider Interface (SSPI)**: An API that allows connected applications to call one of several security providers to establish authenticated connections and to exchange data securely over those connections. It is equivalent to Generic Security Services (GSS)-API, and the two are on-the-wire compatible.

**sequence number**: In the NTLM protocol, a sequence number can be explicitly provided by the application protocol, or generated by NTLM. If generated by NTLM, the sequence number is the count of each message sent, starting with 0.

**service**: A process or agent that is available on the network, offering resources or services for clients. Examples of services include file servers, web servers, and so on.

**session**: In [**Kerberos**](#gt_d6a282ce-b1da-41e1-b05a-22f777a5c1fe), an active communication channel established through [**Kerberos**](#gt_d6a282ce-b1da-41e1-b05a-22f777a5c1fe) that also has an associated cryptographic [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b), message counters, and other state.

**session key**: A relatively short-lived symmetric key (a cryptographic key negotiated by the client and the server based on a shared secret). A [**session key's**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) lifespan is bounded by the [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12) to which it is associated. A [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) has to be strong enough to withstand cryptanalysis for the lifespan of the [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12).

**session security**: The provision of message integrity and/or confidentiality through use of a [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d).

**Unicode**: A character encoding standard developed by the Unicode Consortium that represents almost all of the written languages of the world. The [**Unicode**](#gt_c305d0ab-8b94-461a-bd76-13b40cb8c4d8) standard [[UNICODE5.0.0/2007]](https://go.microsoft.com/fwlink/?LinkId=154659) provides three forms (UTF-8, UTF-16, and UTF-32) and seven schemes (UTF-8, UTF-16, UTF-16 BE, UTF-16 LE, UTF-32, UTF-32 LE, and UTF-32 BE).

**MAY, SHOULD, MUST, SHOULD NOT, MUST NOT:** These terms (in all caps) are used as defined in [[RFC2119]](https://go.microsoft.com/fwlink/?LinkId=90317). All statements of optional behavior use either MAY, SHOULD, or SHOULD NOT.

## References

Links to a document in the Microsoft Open Specifications library point to the correct section in the most recently published version of the referenced document. However, because individual documents in the library are not updated at the same time, the section numbers in the documents may not match. You can confirm the correct section numbering by checking the [Errata](https://go.microsoft.com/fwlink/?linkid=850906).

### 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.

[FIPS46-2] FIPS PUBS, "Data Encryption Standard (DES)", FIPS PUB 46-2, December 1993, [http://my.fit.edu/~gmarin/CSE5636/FIPS46-2DES.htm](https://go.microsoft.com/fwlink/?LinkId=89871)

[MS-APDS] Microsoft Corporation, "[Authentication Protocol Domain Support](%5BMS-APDS%5D.pdf#Section_dd444344fd7e430eb3137e95ab9c338e)".

[MS-DTYP] Microsoft Corporation, "[Windows Data Types](%5BMS-DTYP%5D.pdf#Section_cca2742956894a16b2b49325d93e4ba2)".

[MS-ERREF] Microsoft Corporation, "[Windows Error Codes](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90)".

[MS-RPCE] Microsoft Corporation, "[Remote Procedure Call Protocol Extensions](%5BMS-RPCE%5D.pdf#Section_290c38b192fe422991e64fc376610c15)".

[MS-SMB] Microsoft Corporation, "[Server Message Block (SMB) Protocol](%5BMS-SMB%5D.pdf#Section_f210069c70864dc2885e861d837df688)".

[MS-SPNG] Microsoft Corporation, "[Simple and Protected GSS-API Negotiation Mechanism (SPNEGO) Extension](%5BMS-SPNG%5D.pdf#Section_f377a379c24f4a0fa3eb0d835389e28a)".

[RFC1320] Rivest, R., "The MD4 Message-Digest Algorithm", RFC 1320, April 1992, [http://www.ietf.org/rfc/rfc1320.txt](https://go.microsoft.com/fwlink/?LinkId=90274)

[RFC1321] Rivest, R., "The MD5 Message-Digest Algorithm", RFC 1321, April 1992, [http://www.ietf.org/rfc/rfc1321.txt](https://go.microsoft.com/fwlink/?LinkId=90275)

[RFC2104] Krawczyk, H., Bellare, M., and Canetti, R., "HMAC: Keyed-Hashing for Message Authentication", RFC 2104, February 1997, [http://www.ietf.org/rfc/rfc2104.txt](https://go.microsoft.com/fwlink/?LinkId=90314)

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997, [http://www.rfc-editor.org/rfc/rfc2119.txt](https://go.microsoft.com/fwlink/?LinkId=90317)

[RFC2743] Linn, J., "Generic Security Service Application Program Interface Version 2, Update 1", RFC 2743, January 2000, [http://www.rfc-editor.org/rfc/rfc2743.txt](https://go.microsoft.com/fwlink/?LinkId=90378)

[RFC2744] Wray, J., "Generic Security Service API Version 2 : C-bindings", RFC 2744, January 2000, [http://www.ietf.org/rfc/rfc2744.txt](https://go.microsoft.com/fwlink/?LinkId=125716)

[RFC4121] Zhu, L., Jaganathan, K., and Hartman, S., "The Kerberos Version 5 Generic Security Service Application Program Interface (GSS-API) Mechanism: Version 2", RFC 4121, July 2005, [http://www.ietf.org/rfc/rfc4121.txt](https://go.microsoft.com/fwlink/?LinkId=90459)

[RFC4757] Jaganathan, K., Zhu, L., and Brezak, J., "The RC4-HMAC Kerberos Encryption Types Used by Microsoft Windows", RFC 4757, December 2006, [http://www.ietf.org/rfc/rfc4757.txt](https://go.microsoft.com/fwlink/?LinkId=90488)

### Informative References

[MS-AUTHSOD] Microsoft Corporation, "[Authentication Services Protocols Overview](%5BMS-AUTHSOD%5D.pdf#Section_953d700a57cb4cf7b0c3a64f34581cc9)".

[MS-GPOL] Microsoft Corporation, "[Group Policy: Core Protocol](%5BMS-GPOL%5D.pdf#Section_62d1292462524052996f161d2b9019f4)".

[MS-KILE] Microsoft Corporation, "[Kerberos Protocol Extensions](%5BMS-KILE%5D.pdf#Section_2a32282edd484ad9a542609804b02cc9)".

[MS-NTHT] Microsoft Corporation, "[NTLM Over HTTP Protocol](%5BMS-NTHT%5D.pdf#Section_f09cf6e1529e403ba8a57368ee096a6a)".

[MSDN-DecryptMsg] Microsoft Corporation, "DecryptMessage (General) function", [http://msdn.microsoft.com/en-us/library/aa375211.aspx](https://go.microsoft.com/fwlink/?LinkId=101488)

[MSDN-EncryptMsg] Microsoft Corporation, "EncryptMessage (General)", [http://msdn.microsoft.com/en-us/library/aa375378.aspx](https://go.microsoft.com/fwlink/?LinkId=94577)

## Overview

NT LAN Manager (NTLM) is the name of a family of security protocols. NTLM is used by application protocols to authenticate remote users and, optionally, to provide [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff) when requested by the application.

NTLM is a [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba)-response style authentication protocol. This means that to authenticate a user, the server sends a challenge to the client. The client then sends back a response that is a function of the challenge, the user's password, and possibly other information. Computing the correct response requires knowledge of the user's password. The server (or another party trusted by the server) can validate the response by consulting an account database to get the user's password and computing the proper response for that challenge.

The NTLM protocols are embedded protocols. Unlike stand-alone application protocols such as [[MS-SMB]](%5BMS-SMB%5D.pdf#Section_f210069c70864dc2885e861d837df688) or HTTP, NTLM messages are embedded in the packets of an application protocol that requires authentication of a user. The application protocol semantics determine how and when the NTLM messages are encoded, framed, and transported from the client to the server and vice versa. See section [4](#Section_5af9a2f8ebcd43a5817c62a0d0862ff6) for an example of how NTLM messages are embedded in the SMB Version 1.0 Protocol as specified in [MS-SMB]. The NTLM implementation also differs from normal protocol implementations, in that the best way to implement it is as a function library called by some other protocol implementation (the application protocol), rather than as a layer in a network protocol stack. For more information about GSS-API calls, see section [3.4.6](#Section_a06bfc2b30fc4483b876a9386f4808ed). The NTLM function library receives parameters from the application protocol caller and returns an authentication message that the caller places into fields of its own messages as it chooses. Nevertheless, if one looks at just the NTLM messages apart from the application protocol in which they are embedded, there is an NTLM protocol and that is what is specified by this document.

There are two major variants of the NTLM authentication protocol: the [**connection-oriented**](#gt_a102d214-1b25-4113-b95f-466986ddbade) variant and the connectionless variant. In the connectionless (datagram) variant:

* NTLM does not use the internal [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) maintained by the NTLM implementation. Instead, it uses a sequence number passed in by the protocol implementation in which NTLM is embedded.
* [**Keys**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) for session security are established at client initialization time (while in connection-oriented mode they are established only at the end of authentication exchange), and session security can be used as soon as the [**session keys**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) are established.
* It is not possible to send a NEGOTIATE message (see section [2.2.1.1](#Section_b34032e53aae4bc684c3c6d80eadf7f2)).

Each of these variants has three versions: LM, NTLMv1, and NTLMv2. The message flow for all three is the same; the only differences are the function used to compute various response fields from the challenge, and which response fields are set. [<2>](#Appendix_A_2" \o "Product behavior note 2)

In addition to authentication, the NTLM protocol optionally provides for session security—specifically message integrity and confidentiality through signing and sealing functions in NTLM.

### NTLM Authentication Call Flow

This section provides an overview of the end-to-end message flow when application protocols use NTLM to authenticate a user to a server.

The following diagram shows a typical connection-oriented message flow when an application uses NTLM. The message flow typically consists of a number of application messages, followed by NTLM authentication messages (which are embedded in the application protocol and transported by the application from the client to the server), and then additional application messages, as specified in the application protocol.



Figure 1: Typical NTLM authentication message flow

**Note**  In the preceding diagram, the embedding of NTLM messages in the application protocol is shown by placing the NTLM messages within [ ] brackets. NTLM messages for both connection-oriented and connectionless authentication are embedded in the application protocol as shown. Variations between the connection-oriented and connectionless NTLM protocol sequence are documented in sections [1.3.1.1](#Section_1fbf5c3b04c14591a4be9dc232c4744b) and [1.3.1.2](#Section_70752f07c1444777bc8dd02f61e45e84).

After an authenticated NTLM [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12) is established, the subsequent application messages can be protected with NTLM [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff). This is done by the application, which specifies what options (such as message integrity or confidentiality, as specified in the Abstract Data Model) it requires, before the NTLM authentication message sequence begins.[<3>](#Appendix_A_3" \o "Product behavior note 3)

Success and failure messages that are sent after the NTLM authentication message sequence are specific to the application protocol invoking NTLM authentication and are not part of the NTLM Authentication Protocol.

**Note**  In subsequent message flows, only the NTLM message flows are shown because they are the focus of this document. Keep in mind that the NTLM messages in this section are embedded in the application protocol and transported by that protocol.

An overview of the connection-oriented and connectionless variants of NTLM is provided in the following sections.

#### NTLM Connection-Oriented Call Flow

The following illustration shows a typical NTLM connection-oriented call flow when an application protocol creates an authenticated [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12). For detailed message specifications, see section [2](#Section_b1242a27d60e4c5c94b68626a7a2910f). The messages are processed (section [3](#Section_a25aef49de574c6e92f8ed0a711d3802)).



Figure 2: Connection-oriented NTLM message flow

1. Application-specific protocol messages are sent between client and server.
2. The NTLM protocol begins when the application requires an authenticated session. The client sends an NTLM NEGOTIATE\_MESSAGE message to the server. This message specifies the desired security features of the session.
3. The server sends an NTLM CHALLENGE\_MESSAGE message to the client. The message includes agreed upon security features, and a [**nonce**](#gt_001c0e40-0980-417d-853c-f7cb34ba6d3b) that the server generates.
4. The client sends an NTLM AUTHENTICATE\_MESSAGE message to the server. The message contains the name of a user and a response that proves that the client has the user's password. The server validates the response sent by the client. If the user name is for a local account, it can validate the response by using information in its local account database. If the user name is for a [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) account, it can validate the response by sending the user authentication information (the user name, the [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba) sent to the client, and the response received from the client) to a [**domain controller (DC)**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) that can validate the response. (Section 3.1 [[MS-APDS]](%5BMS-APDS%5D.pdf#Section_dd444344fd7e430eb3137e95ab9c338e)). The NTLM protocol completes.
5. If the challenge and the response prove that the client has the user's password, the authentication succeeds and the application protocol continues according to its specification. If the authentication fails, the server might send the status in an application protocol–specified way, or it might simply terminate the connection.

#### NTLM Connectionless (Datagram-Oriented) Call Flow

The following illustration shows a typical NTLM connectionless (datagram-oriented) call flow.



Figure 3: Connectionless NTLM message flow

Although it appears that the server is initiating the request, the client initiates the sequence by sending a message specified by the application protocol in use.

1. Application-specific protocol messages are sent between client and server.
2. The NTLM protocol begins when the application requires an authenticated session. The server sends the client an NTLM CHALLENGE\_MESSAGE message. The message includes an indication of the security features desired by the server, and a [**nonce**](#gt_001c0e40-0980-417d-853c-f7cb34ba6d3b) that the server generates.
3. The client sends an NTLM AUTHENTICATE\_MESSAGE message to the server. The message contains the name of a user and a response that proves that the client has the user's password. The server validates the response sent by the client. If the user name is for a local account, it can validate the response by using information in its local account database. If the user name is for a [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) account, it validates the response by sending the user authentication information (the user name, the [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba) sent to the client, and the response received from the client) to a [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) that can validate the response. (see [[MS-APDS]](%5BMS-APDS%5D.pdf#Section_dd444344fd7e430eb3137e95ab9c338e) section 3.1). The NTLM protocol completes.
4. If the challenge and the response prove that the client has the user's password, the authentication succeeds and the application protocol continues according to its specification. If the authentication fails, the server might send the status in an application protocol–specified way, or it might simply terminate the connection.

## Relationship to Other Protocols

Because NTLM is embedded in the application protocol, it does not have transport dependencies of its own.

NTLM is used for authentication by several application protocols, including server message block [[MS-SMB]](%5BMS-SMB%5D.pdf#Section_f210069c70864dc2885e861d837df688) (SMB), and [[MS-NTHT]](%5BMS-NTHT%5D.pdf#Section_f09cf6e1529e403ba8a57368ee096a6a) (HTTP). For an example of how NTLM is used in SMB, see section [4](#Section_5af9a2f8ebcd43a5817c62a0d0862ff6).

Other protocols invoke NTLM as a function library. The interface to that library is specified in GSS-API [[RFC2743]](https://go.microsoft.com/fwlink/?LinkId=90378). The NTLM implementation of GSS-API calls is specified in section [3.4.6](#Section_a06bfc2b30fc4483b876a9386f4808ed).[<4>](#Appendix_A_4" \o "Product behavior note 4)

## Prerequisites/Preconditions

To use NTLM or to use the NTLM security support provider (SSP), a client is required to have a shared secret with the server or domain controller (DC) when using a domain account.

## Applicability Statement

An implementer can use the NTLM Authentication Protocol to provide for client authentication (where the server verifies the client's identity) for applications. Because NTLM does not provide for server authentication, applications that use NTLM are susceptible to attacks from spoofed servers. Applications are therefore discouraged from using NTLM directly. If it is an option, authentication via KILE is preferred.[<5>](#Appendix_A_5" \o "Product behavior note 5)

## Versioning and Capability Negotiation

The NTLM authentication version is not negotiated by the protocol. It has to be configured on both the client and the server prior to authentication. The version is selected by the client, and requested during the protocol negotiation. If the server does not support the version selected by the client, authentication fails.

NTLM implements capability negotiation by using the flags described in section [2.2.2.5](#Section_99d90ff4957f4c8a80e45bfe5a9a9832). The protocol messages used for negotiation depend on the mode of NTLM being used:

* In connection-oriented NTLM, negotiation starts with a NEGOTIATE\_MESSAGE, carrying the client's preferences, and the server replies with NegotiateFlags in the subsequent CHALLENGE\_MESSAGE.
* In connectionless NTLM, the server starts the negotiation with the CHALLENGE\_MESSAGE and the client replies with NegotiateFlags in the subsequent AUTHENTICATE\_MESSAGE.

## Vendor-Extensible Fields

None.

## Standards Assignments

NTLM has been assigned the following [**object identifier (OID)**](#gt_aaaf2f1a-0b0a-487e-a0f0-c3510a6091b2): iso.org.dod.internet.private.enterprise.Microsoft.security.mechanisms.NTLM (1.3.6.1.4.1.311.2.2.10)

# Messages

## Transport

NTLM messages are passed between the client and server. The NTLM messages MUST be embedded within the application protocol that is using NTLM authentication. NTLM itself does not establish any transport connections.

## Message Syntax

The NTLM Authentication Protocol consists of three message types used during authentication and one message type used for message integrity after authentication has occurred.

The authentication messages:

* [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2) (2.2.1.1)
* [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) (2.2.1.2)
* [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) (2.2.1.3)

are variable-length messages containing a fixed-length header and a variable-sized message payload. The fixed-length header always starts as shown in the following table with a **Signature** and **MessageType** field.

Depending on the **MessageType** field, the message can have other message-dependent fixed-length fields. The fixed-length fields are then followed by a variable-length message payload.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Signature |
| ... |
| MessageType |
| MessageDependentFields (variable) |
| ... |
| payload (variable) |
| ... |

**Signature (8 bytes):** An 8-byte character array that MUST contain the ASCII string ('N', 'T', 'L', 'M', 'S', 'S', 'P', '\0').

**MessageType (4 bytes):** The **MessageType** field MUST take one of the values from the following list:

| Value | Meaning |
| --- | --- |
| NtLmNegotiate0x00000001 | The message is a NEGOTIATE\_MESSAGE. |
| NtLmChallenge0x00000002 | The message is a CHALLENGE\_MESSAGE. |
| NtLmAuthenticate0x00000003 | The message is an AUTHENTICATE\_MESSAGE. |

**MessageDependentFields (variable):** The NTLM message contents, as specified in section [2.2.1](#Section_760a9788bd324d9e87ad2aa5970786ac).

**payload (variable):** The payload data contains a message-dependent number of individual payload messages. This payload data is referenced by byte offsets located in the **MessageDependentFields**.

The message integrity message, NTLMSSP\_MESSAGE\_SIGNATURE (section [2.2.2.9](#Section_b192b940a50843298513efb3342f2c85)) is fixed length and is appended to the calling application's messages. This message type is used only when an application has requested message integrity or confidentiality operations, based on the [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) negotiated during a successful authentication.

All multiple-byte values are encoded in little-endian byte order. Unless specified otherwise, 16-bit value fields are of type unsigned short, while 32-bit value fields are of type unsigned long.

All character string fields in NEGOTIATE\_MESSAGE contain characters in the [**OEM character set**](#gt_3240e34e-920e-40ac-a672-342ac34a5e22). As specified in section [2.2.2.5](#Section_99d90ff4957f4c8a80e45bfe5a9a9832), the client and server negotiate if they both support Unicode characters—in which case, all character string fields in the CHALLENGE\_MESSAGE and AUTHENTICATE\_MESSAGE contain RPC\_UNICODE\_STRING ([[MS-DTYP]](%5BMS-DTYP%5D.pdf#Section_cca2742956894a16b2b49325d93e4ba2) section 2.3.10) unless otherwise specified. Otherwise, the OEM character set is used. Agreement between client and server on the choice of OEM character set is not covered by the protocol and MUST occur out-of-band.

All Unicode strings are encoded with UTF-16 and the Byte Order Mark (BOM) is not sent over the wire. NLMP uses little-endian order unless otherwise specified.

### NTLM Messages

#### NEGOTIATE\_MESSAGE

The NEGOTIATE\_MESSAGE defines an NTLM Negotiate message that is sent from the client to the server. This message allows the client to specify its supported NTLM options to the server.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Signature |
| ... |
| MessageType |
| NegotiateFlags |
| DomainNameFields |
| ... |
| WorkstationFields |
| ... |
| Version |
| ... |
| Payload (variable) |
| ... |

**Signature (8 bytes):** An 8-byte character array that MUST contain the ASCII string ('N', 'T', 'L', 'M', 'S', 'S', 'P', '\0').

**MessageType (4 bytes):** A 32-bit unsigned integer that indicates the message type. This field MUST be set to 0x00000001.

**NegotiateFlags (4 bytes):** A [NEGOTIATE](#Section_99d90ff4957f4c8a80e45bfe5a9a9832) structure that contains a set of flags, as defined in section 2.2.2.5. The client sets flags to indicate options it supports.

**DomainNameFields (8 bytes):** A field containing **DomainName** information. The field diagram for **DomainNameFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| DomainNameLen | DomainNameMaxLen |
| DomainNameBufferOffset |

If the NTLMSSP\_NEGOTIATE\_OEM\_DOMAIN\_SUPPLIED flag is set in **NegotiateFlags**, indicating that a **DomainName** is supplied in **Payload**, the fields are set to the following values:

* **DomainNameLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of **DomainName** in **Payload**.
* **DomainNameMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of **DomainNameLen,** and MUST be ignored on receipt.
* **DomainNameBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the NEGOTIATE\_MESSAGE to **DomainName** in **Payload**.

Otherwise, if the NTLMSSP\_NEGOTIATE\_OEM\_DOMAIN\_SUPPLIED flag is not set in **NegotiateFlags**, indicating that a **DomainName** is not supplied in **Payload**, the fields take the following values, and MUST be ignored upon receipt.

* **DomainNameLen** and **DomainNameMaxLen** fields SHOULD be set to zero.
* **DomainNameBufferOffset** field SHOULD be set to the offset from the beginning of the NEGOTIATE\_MESSAGE to where the **DomainName** would be in **Payload** if it was present.

**WorkstationFields (8 bytes):** A field containing **WorkstationName** information**.** The field diagram for **WorkstationFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| WorkstationLen | WorkstationMaxLen |
| WorkstationBufferOffset |

If the NTLMSSP\_NEGOTIATE\_OEM\_WORKSTATION\_SUPPLIED flag is set in **NegotiateFlags**, indicating that a **WorkstationName** is supplied in **Payload**, the fields are set to the following values:

* **WorkstationLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of **WorkStationName** in **Payload**.
* **WorkstationMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of **WorkstationLen** and MUST be ignored on receipt.
* **WorkstationBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the NEGOTIATE\_MESSAGE to **WorkstationName** in **Payload**.

Otherwise, if the NTLMSSP\_NEGOTIATE\_OEM\_WORKSTATION\_SUPPLIED flag is not set in **NegotiateFlags**, indicating that a **WorkstationName** is not supplied in **Payload**, the fields take the following values, and MUST be ignored upon receipt.

* **WorkstationLen** and **WorkstationMaxLen** fields SHOULD be set to zero.
* **WorkstationBufferOffset** field SHOULD be set to the offset from the beginning of the NEGOTIATE\_MESSAGE to where the **WorkstationName** would be in **Payload** if it was present.

**Version (8 bytes):** A [VERSION](#Section_b1a6ceb2f8ad462bb5aff18527c48175) structure (as defined in section 2.2.2.10) that is populated only when the NTLMSSP\_NEGOTIATE\_VERSION flag is set in the **NegotiateFlags** field. This structure SHOULD[<6>](#Appendix_A_6" \o "Product behavior note 6) be used for debugging purposes only. In normal (nondebugging) protocol messages, it is ignored and does not affect the NTLM message processing.

**Payload (variable):** A byte-array that contains the data referred to by the **DomainNameBufferOffset** and **WorkstationBufferOffset** message fields. **Payload** data can be present in any order within the **Payload** field, with variable-length padding before or after the data. The data that can be present in the **Payload** field of this message, in no particular order, are:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| DomainName (variable) |
| ... |
| WorkstationName (variable) |
| ... |

**DomainName (variable):** If **DomainNameLen** does not equal 0x0000, **DomainName** MUST be a byte-array that contains the name of the client authentication [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) that MUST be encoded using the [**OEM character set**](#gt_3240e34e-920e-40ac-a672-342ac34a5e22). Otherwise, this data is not present.[<7>](#Appendix_A_7" \o "Product behavior note 7)

**WorkstationName (variable):** If **WorkstationLen** does not equal 0x0000, **WorkstationName** MUST be a byte array that contains the name of the client machine that MUST be encoded using the OEM character set. Otherwise, this data is not present.

#### CHALLENGE\_MESSAGE

The CHALLENGE\_MESSAGE defines an NTLM [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba) message that is sent from the server to the client. The CHALLENGE\_MESSAGE is used by the server to challenge the client to prove its identity. For connection-oriented requests, the CHALLENGE\_MESSAGE generated by the server is in response to the [NEGOTIATE\_MESSAGE (section 2.2.1.1)](#Section_b34032e53aae4bc684c3c6d80eadf7f2) from the client.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Signature |
| ... |
| MessageType |
| TargetNameFields |
| ... |
| NegotiateFlags |
| ServerChallenge |
| ... |
| Reserved |
| ... |
| TargetInfoFields |
| ... |
| Version |
| ... |
| Payload (variable) |
| ... |

**Signature (8 bytes):** An 8-byte character array that MUST contain the ASCII string ('N', 'T', 'L', 'M', 'S', 'S', 'P', '\0').

**MessageType (4 bytes):** A 32-bit unsigned integer that indicates the message type. This field MUST be set to 0x00000002.

**TargetNameFields (8 bytes):** A field containing **TargetName** information. The field diagram for **TargetNameFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| TargetNameLen | TargetNameMaxLen |
| TargetNameBufferOffset |

If the NTLMSSP\_REQUEST\_TARGET flag is set in **NegotiateFlags**, indicating that a **TargetName** is required, the fields are set to the following values:

* **TargetNameLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of **TargetName** in **Payload**.
* **TargetNameMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of **TargetNameLen** and MUST be ignored on receipt.
* **TargetNameBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the CHALLENGE\_MESSAGE to **TargetName** in **Payload**. If **TargetName** is a Unicode string, the values of **TargetNameBufferOffset** and **TargetNameLen** MUST be multiples of 2.

If the NTLMSSP\_REQUEST\_TARGET flag is not set in **NegotiateFlags**, indicating that a **TargetName** is not required, the fields take the following values, and MUST be ignored upon receipt.

* **TargetNameLen** and **TargetNameMaxLen** SHOULD be set to zero on transmission.
* **TargetNameBufferOffset** field SHOULD be set to the offset from the beginning of the CHALLENGE\_MESSAGE to where the **TargetName** would be in **Payload** if it were present.

**NegotiateFlags (4 bytes):** A [NEGOTIATE](#Section_99d90ff4957f4c8a80e45bfe5a9a9832) structure that contains a set of flags, as defined by section 2.2.2.5. The server sets flags to indicate options it supports or, if there has been a NEGOTIATE\_MESSAGE (section 2.2.1.1), the choices it has made from the options offered by the client.

**ServerChallenge (8 bytes):** A 64-bit value that contains the NTLM challenge. The challenge is a 64-bit [**nonce**](#gt_001c0e40-0980-417d-853c-f7cb34ba6d3b). The processing of the ServerChallenge is specified in sections [3.1.5](#Section_550de46c71e54f5e9dfd6e5ec6bcc454) and [3.2.5](#Section_a4689496ea884a50867da7330db4d935).

**Reserved (8 bytes):** An 8-byte array whose elements MUST be zero when sent and MUST be ignored on receipt.

**TargetInfoFields (8 bytes):** A field containing **TargetInfo** information. The field diagram for **TargetInfoFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| TargetInfoLen | TargetInfoMaxLen |
| TargetInfoBufferOffset |

If the NTLMSSP\_NEGOTIATE\_TARGET\_INFO flag is not clear in **NegotiateFlags**, indicating that **TargetInfo** is required, the fields SHOULD[<8>](#Appendix_A_8" \o "Product behavior note 8) be set to the following values:

* **TargetInfoLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of TargetInfo in Payload.
* **TargetInfoMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of TargetInfoLen and MUST be ignored on receipt.
* **TargetInfoBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the CHALLENGE\_MESSAGE to TargetInfo in Payload.

If the NTLMSSP\_NEGOTIATE\_TARGET\_INFO flag is clear in **NegotiateFlags**, indicating that **TargetInfo** is not required, the fields take the following values, and MUST be ignored upon receipt.

* **TargetInfoLen** and **TargetInfoMaxLen** SHOULD be set to zero on transmission.
* **TargetInfoBufferOffset** field SHOULD be set to the offset from the beginning of the CHALLENGE\_MESSAGE to where the **TargetInfo** would be in **Payload** if it were present.

**Version (8 bytes):** A [VERSION](#Section_b1a6ceb2f8ad462bb5aff18527c48175) structure (as defined in section 2.2.2.10) that SHOULD[<9>](#Appendix_A_9" \o "Product behavior note 9) be populated only when the NTLMSSP\_NEGOTIATE\_VERSION flag is set in the **NegotiateFlags** field. This structure is used for debugging purposes only. In normal (non-debugging) protocol messages, it is ignored and does not affect the NTLM message processing.

**Payload (variable):** A byte array that contains the data referred to by the **TargetNameBufferOffset** and **TargetInfoBufferOffset** message fields. Payload data can be present in any order within the **Payload** field, with variable-length padding before or after the data. The data that can be present in the **Payload** field of this message, in no particular order, are:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| TargetName (variable) |
| ... |
| TargetInfo (variable) |
| ... |

**TargetName (variable):** If **TargetNameLen** does not equal 0x0000, **TargetName** MUST be a byte array that contains the name of the server authentication realm, and MUST be expressed in the negotiated character set. A server that is a member of a [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) returns the domain of which it is a member, and a server that is not a member of a domain returns the server name.

**TargetInfo (variable):** If **TargetInfoLen** does not equal 0x0000, **TargetInfo** MUST be a byte array that contains a sequence of AV\_PAIR structures. The AV\_PAIR structure is defined in section [2.2.2.1](#Section_83f5e789660d478184915f8c6641f75e). The length of each AV\_PAIR is determined by its **AvLen** field (plus 4 bytes).

**Note**  An AV\_PAIR structure can start on any byte alignment and the sequence of AV\_PAIRs has no padding between structures.

The sequence MUST be terminated by an AV\_PAIR structure with an **AvId** field of MsvAvEOL. The total length of the **TargetInfo** byte array is the sum of the lengths, in bytes, of the AV\_PAIR structures it contains.

**Note**  If a **TargetInfo** AV\_PAIR Value is textual, it MUST be encoded in Unicode irrespective of what character set was negotiated (section 2.2.2.1).

#### AUTHENTICATE\_MESSAGE

The AUTHENTICATE\_MESSAGE defines an NTLM authenticate message that is sent from the client to the server after the [CHALLENGE\_MESSAGE (section 2.2.1.2)](#Section_801a468188094be9ab0d61dcfe762786) is processed by the client.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Signature |
| ... |
| MessageType |
| LmChallengeResponseFields |
| ... |
| NtChallengeResponseFields |
| ... |
| DomainNameFields |
| ... |
| UserNameFields |
| ... |
| WorkstationFields |
| ... |
| EncryptedRandomSessionKeyFields |
| ... |
| NegotiateFlags |
| Version |
| ... |
| MIC (16 bytes) |
| ... |
| ... |
| Payload (variable) |
| ... |

**Signature (8 bytes):** An 8-byte character array that MUST contain the ASCII string ('N', 'T', 'L', 'M', 'S', 'S', 'P', '\0').

**MessageType (4 bytes):** A 32-bit unsigned integer that indicates the message type. This field MUST be set to 0x00000003.

**LmChallengeResponseFields (8 bytes):** A field containing **LmChallengeResponse** information. The field diagram for **LmChallengeResponseFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| LmChallengeResponseLen | LmChallengeResponseMaxLen |
| LmChallengeResponseBufferOffset |

If the client chooses to send an **LmChallengeResponse** to the server, the fields are set to the following values:

* **LmChallengeResponseLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of LmChallengeResponse in Payload.
* **LmChallengeResponseMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of LmChallengeResponseLen and MUST be ignored on receipt.
* **LmChallengeResponseBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the AUTHENTICATE\_MESSAGE to LmChallengeResponse in Payload.

Otherwise, if the client chooses not to send an **LmChallengeResponse** to the server, the fields take the following values:

* **LmChallengeResponseLen** and **LmChallengeResponseMaxLen** MUST be set to zero on transmission.
* **LmChallengeResponseBufferOffset** field SHOULD be set to the offset from the beginning of the AUTHENTICATE\_MESSAGE to where the **LmChallengeResponse** would be in **Payload** if it was present.

**NtChallengeResponseFields (8 bytes):** A field containing **NtChallengeResponse** information. The field diagram for **NtChallengeResponseFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| NtChallengeResponseLen | NtChallengeResponseMaxLen |
| NtChallengeResponseBufferOffset |

If the client chooses to send an **NtChallengeResponse** to the server, the fields are set to the following values:

* **NtChallengeResponseLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of **NtChallengeResponse** in **Payload**.
* **NtChallengeResponseMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of **NtChallengeResponseLen** and MUST be ignored on receipt.
* **NtChallengeResponseBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the AUTHENTICATE\_MESSAGE to **NtChallengeResponse** in **Payload**.[<10>](#Appendix_A_10" \o "Product behavior note 10)

Otherwise, if the client chooses not to send an **NtChallengeResponse** to the server, the fields take the following values:

* **NtChallengeResponseLen**, and **NtChallengeResponseMaxLen** MUST be set to zero on transmission.
* **NtChallengeResponseBufferOffset** field SHOULD be set to the offset from the beginning of the AUTHENTICATE\_MESSAGE to where the **NtChallengeResponse** would be in **Payload** if it was present.

**DomainNameFields (8 bytes):** A field containing **DomainName** information. The field diagram for **DomainNameFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| DomainNameLen | DomainNameMaxLen |
| DomainNameBufferOffset |

If the client chooses to send a **DomainName** to the server, the fields are set to the following values:

* **DomainNameLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of **DomainName** in **Payload**.
* **DomainNameMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of **DomainNameLen** and MUST be ignored on receipt.
* **DomainNameBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the AUTHENTICATE\_MESSAGE to **DomainName** in **Payload**. If **DomainName** is a Unicode string, the values of **DomainNameBufferOffset** and **DomainNameLen** MUST be multiples of 2.

Otherwise, if the client chooses not to send a **DomainName** to the server, the fields take the following values:

* **DomainNameLen** and **DomainNameMaxLen** MUST be set to zero on transmission.
* **DomainNameBufferOffset** field SHOULD be set to the offset from the beginning of the AUTHENTICATE\_MESSAGE to where the **DomainName** would be in **Payload** if it was present.

**UserNameFields (8 bytes):** A field containing **UserName** information. The field diagram for the **UserNameFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| UserNameLen | UserNameMaxLen |
| UserNameBufferOffset |

If the client chooses to send a **UserName** to the server, the fields are set to the following values:

* **UserNameLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of **UserName** in **Payload**, not including a NULL terminator.
* **UserNameMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of **UserNameLen** and MUST be ignored on receipt.
* **UserNameBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the AUTHENTICATE\_MESSAGE to **UserName** in **Payload**. If the **UserName** to be sent contains a Unicode string, the values of **UserNameBufferOffset** and **UserNameLen** MUST be multiples of 2.

Otherwise, if the client chooses not to send a **UserName** to the server, the fields take the following values:

* **UserNameLen** and **UserNameMaxLen** MUST be set to zero on transmission.
* **UserNameBufferOffset** field SHOULD be set to the offset from the beginning of the AUTHENTICATE\_MESSAGE to where the **UserName** would be in **Payload** if it were present.

**WorkstationFields (8 bytes):** A field containing **Workstation** information. The field diagram for the **WorkstationFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| WorkstationLen | WorkstationMaxLen |
| WorkstationBufferOffset |

If the client chooses to send a **Workstation** to the server, the fields are set to the following values:

* **WorkstationLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of **Workstation** in **Payload**.
* **WorkstationMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of **WorkstationLen** and MUST be ignored on receipt.
* **WorkstationBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the AUTHENTICATE\_MESSAGE to **Workstation** in **Payload**. If **Workstation** contains a Unicode string, the values of **WorkstationBufferOffset** and **WorkstationLen** MUST be multiples of 2.

Othewise, if the client chooses not to send a **Workstation** to the server, the fields take the following values:

* **WorkstationLen** and **WorkstationMaxLen** MUST be set to zero on transmission.
* **WorkstationBufferOffset** field SHOULD be set to the offset from the beginning of the AUTHENTICATE\_MESSAGE to where the **Workstation** would be in **Payload** if it was present.

**EncryptedRandomSessionKeyFields (8 bytes):** A field containing **EncryptedRandomSessionKey** information. The field diagram for **EncryptedRandomSessionKeyFields** is as follows.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| EncryptedRandomSessionKeyLen | EncryptedRandomSessionKeyMaxLen |
| EncryptedRandomSessionKeyBufferOffset |

If the NTLMSSP\_NEGOTIATE\_KEY\_EXCH flag is set in **NegotiateFlags**, indicating that an **EncryptedRandomSessionKey** is supplied, the fields are set to the following values:

* **EncryptedRandomSessionKeyLen (2 bytes):** A 16-bit unsigned integer that defines the size, in bytes, of EncryptedRandomSessionKey in Payload.
* **EncryptedRandomSessionKeyMaxLen (2 bytes):** A 16-bit unsigned integer that SHOULD be set to the value of **EncryptedRandomSessionKeyLen** and MUST be ignored on receipt.
* **EncryptedRandomSessionKeyBufferOffset (4 bytes):** A 32-bit unsigned integer that defines the offset, in bytes, from the beginning of the AUTHENTICATE\_MESSAGE to **EncryptedRandomSessionKey** in **Payload**.

Otherwise, if the NTLMSSP\_NEGOTIATE\_KEY\_EXCH flag is not set in **NegotiateFlags**, indicating that an **EncryptedRandomSessionKey** is not supplied, the fields take the following values, and must be ignored upon receipt:

* **EncryptedRandomSessionKeyLen** and **EncryptedRandomSessionKeyMaxLen** SHOULD be set to zero on transmission.
* **EncryptedRandomSessionKeyBufferOffset** field SHOULD be set to the offset from the beginning of the AUTHENTICATE\_MESSAGE to where the **EncryptedRandomSessionKey** would be in **Payload** if it was present.

**NegotiateFlags (4 bytes):** In connectionless mode, a [NEGOTIATE](#Section_99d90ff4957f4c8a80e45bfe5a9a9832) structure that contains a set of flags (section 2.2.2.5) and represents the conclusion of negotiation—the choices the client has made from the options the server offered in the CHALLENGE\_MESSAGE. In connection-oriented mode, a NEGOTIATE structure that contains the set of bit flags (section 2.2.2.5) negotiated in the previous messages.

**Version (8 bytes):** A [VERSION](#Section_b1a6ceb2f8ad462bb5aff18527c48175) structure (section 2.2.2.10) that is populated only when the NTLMSSP\_NEGOTIATE\_VERSION flag is set in the **NegotiateFlags** field. This structure is used for debugging purposes only. In normal protocol messages, it is ignored and does not affect the NTLM message processing.[<11>](#Appendix_A_11" \o "Product behavior note 11)

**MIC (16 bytes):** The message integrity for the NTLM NEGOTIATE\_MESSAGE, CHALLENGE\_MESSAGE, and AUTHENTICATE\_MESSAGE.[<12>](#Appendix_A_12" \o "Product behavior note 12)

**Payload (variable):** A byte array that contains the data referred to by the **LmChallengeResponseBufferOffset**, **NtChallengeResponseBufferOffset**, **DomainNameBufferOffset**, **UserNameBufferOffset**, **WorkstationBufferOffset**, and **EncryptedRandomSessionKeyBufferOffset** message fields. Payload data can be present in any order within the **Payload** field, with variable-length padding before or after the data. The data that can be present in the **Payload** field of this message, in no particular order, are:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| LmChallengeResponse (variable) |
| ... |
| NtChallengeResponse (variable) |
| ... |
| DomainName (variable) |
| ... |
| UserName (variable) |
| ... |
| Workstation (variable) |
| ... |
| EncryptedRandomSessionKey (variable) |
| ... |

**LmChallengeResponse (variable):** An [LM\_RESPONSE](#Section_e3fee6d10d93402084abca4dc5405fc9) or [LMv2\_RESPONSE](#Section_8659238ff5a944ad8ee7f37d3a172e56) structure that contains the computed LM response to the [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba). If NTLM v2 authentication is configured, **LmChallengeResponse** MUST be an LMv2\_RESPONSE structure (section 2.2.2.4). Otherwise, it MUST be an LM\_RESPONSE structure (section 2.2.2.3).

**NtChallengeResponse (variable):** An [NTLM\_RESPONSE](#Section_b88739c6126649f79d22b13923bd8d66) or [NTLMv2\_RESPONSE](#Section_d43e22246fc3449d9f37b90b55a29c80) structure that contains the computed NT response to the challenge. If NTLM v2 authentication is configured, **NtChallengeResponse** MUST be an NTLMv2\_RESPONSE (section 2.2.2.8). Otherwise, it MUST be an NTLM\_RESPONSE structure (section 2.2.2.6).

**DomainName (variable):** The [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) or computer name hosting the user account. **DomainName** MUST be encoded in the negotiated character set.

**UserName (variable):** The name of the user to be authenticated. **UserName** MUST be encoded in the negotiated character set.

**Workstation (variable):** The name of the computer to which the user is logged on. **Workstation** MUST be encoded in the negotiated character set.

**EncryptedRandomSessionKey (variable):**  The client's encrypted random [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d). **EncryptedRandomSessionKey** and its usage are defined in sections [3.1.5](#Section_550de46c71e54f5e9dfd6e5ec6bcc454) and [3.2.5](#Section_a4689496ea884a50867da7330db4d935).

### NTLM Structures

#### AV\_PAIR

The AV\_PAIR structure defines an attribute/value pair. Sequences of AV\_PAIR structures are used in the [CHALLENGE\_MESSAGE (section 2.2.1.2)](#Section_801a468188094be9ab0d61dcfe762786) directly. They are also in the [AUTHENTICATE\_MESSAGE (section 2.2.1.3)](#Section_033d32cc88f944839bf2b273055038ce) via the [NTLMv2\_CLIENT\_CHALLENGE (section 2.2.2.7)](#Section_aee311d621a7447092a5c4ecb022a87b) structure.

Although the following figure suggests that the most significant bit (MSB) of **AvId** is aligned with the MSB of a 32-bit word, an AV\_PAIR can be aligned on any byte boundary and can be 4+N bytes long for arbitrary N (N = the contents of **AvLen**).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| AvId | AvLen |
| Value (variable) |
| ... |

**AvId (2 bytes):** A 16-bit unsigned integer that defines the information type in the **Value** field. The contents of this field MUST be a value from the following table. The corresponding **Value** field in this AV\_PAIR MUST contain the information specified in the description of that **AvId**.

| Value | Meaning |
| --- | --- |
| MsvAvEOL0x0000 | Indicates that this is the last AV\_PAIR in the list. **AvLen** MUST be 0. This type of information MUST be present in the [**AV pair**](#gt_5158aff7-f968-422b-a78f-6cbb653e7b2a) list. |
| MsvAvNbComputerName0x0001 | The server's NetBIOS computer name. The name MUST be in Unicode, and is not null-terminated. This type of information MUST be present in the AV\_pair list. |
| MsvAvNbDomainName0x0002 | The server's NetBIOS [**domain name**](#gt_45a1c9f1-0263-49a8-97c7-7aca1a99308c). The name MUST be in Unicode, and is not null-terminated. This type of information MUST be present in the AV\_pair list. |
| MsvAvDnsComputerName0x0003 | The [**fully qualified domain name (FQDN)**](#gt_1769aec9-237e-44ed-9014-1abb3ec6de6e) of the computer. The name MUST be in Unicode, and is not null-terminated. |
| MsvAvDnsDomainName0x0004 | The FQDN of the domain. The name MUST be in Unicode, and is not null-terminated. |
| MsvAvDnsTreeName0x0005 | The FQDN of the [**forest**](#gt_fd104241-4fb3-457c-b2c4-e0c18bb20b62). The name MUST be in Unicode, and is not null-terminated.[<13>](#Appendix_A_13" \o "Product behavior note 13) |
| MsvAvFlags0x0006 | A 32-bit value indicating server or client configuration.0x00000001: Indicates to the client that the account authentication is constrained.0x00000002: Indicates that the client is providing message integrity in the MIC field (section 2.2.1.3) in the AUTHENTICATE\_MESSAGE.[<14>](#Appendix_A_14" \o "Product behavior note 14)0x00000004: Indicates that the client is providing a target SPN generated from an untrusted source.[<15>](#Appendix_A_15" \o "Product behavior note 15) |
| MsvAvTimestamp0x0007 | A **FILETIME** structure ([[MS-DTYP]](%5BMS-DTYP%5D.pdf#Section_cca2742956894a16b2b49325d93e4ba2) section 2.3.3) in little-endian byte order that contains the server local time. This structure is always sent in the CHALLENGE\_MESSAGE.[<16>](#Appendix_A_16" \o "Product behavior note 16) |
| MsvAvSingleHost0x0008 | A [Single\_Host\_Data (section 2.2.2.2)](#Section_f221c061cc40447195dad2ff71c85c5b) structure. The **Value** field contains a platform-specific blob, as well as a **MachineID** created at computer startup to identify the calling machine.[<17>](#Appendix_A_17" \o "Product behavior note 17) |
| MsvAvTargetName0x0009 | The SPN of the target server. The name MUST be in Unicode and is not null-terminated.[<18>](#Appendix_A_18" \o "Product behavior note 18) |
| MsvAvChannelBindings0x000A | A channel bindings hash. The **Value** field contains an MD5 hash ([[RFC4121]](https://go.microsoft.com/fwlink/?LinkId=90459) section 4.1.1.2) of a gss\_channel\_bindings\_struct ([[RFC2744]](https://go.microsoft.com/fwlink/?LinkId=125716) section 3.11). An all-zero value of the hash is used to indicate absence of channel bindings.[<19>](#Appendix_A_19" \o "Product behavior note 19) |

**AvLen (2 bytes):** A 16-bit unsigned integer that defines the length, in bytes, of the **Value** field.

**Value (variable):** A variable-length byte-array that contains the value defined for this AV pair entry. The contents of this field depend on the type expressed in the **AvId** field. The available types and resulting format and contents of this field are specified in the table within the **AvId** field description in this topic.

When AV pairs are specified, MsvAvEOL MUST be the last item specified. All other AV pairs, if present, can be specified in any order.

#### Single\_Host\_Data

The Single\_Host\_Data structure allows a client to send machine-specific information within an authentication exchange to services on the same machine. The client can produce additional information to be processed in an implementation-specific way when the client and server are on the same host. If the server and client platforms are different or if they are on different hosts, then the information MUST be ignored. Any fields after the **MachineID** field MUST be ignored on receipt.[<20>](#Appendix_A_20" \o "Product behavior note 20)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Size |
| Z4 |
| CustomData |
| ... |
| MachineID (32 bytes) |
| ... |
| ... |

**Size (4 bytes):** A 32-bit unsigned integer that defines the length, in bytes, of the **Value** field in the [AV\_PAIR (section 2.2.2.1)](#Section_83f5e789660d478184915f8c6641f75e) structure.

**Z4 (4 bytes):** A 32-bit integer value containing 0x00000000.

**CustomData (8 bytes):** An 8-byte platform-specific blob containing info only relevant when the client and the server are on the same host.[<21>](#Appendix_A_21" \o "Product behavior note 21)

**MachineID (32 bytes):** A 256-bit random number created at computer startup to identify the calling machine.[<22>](#Appendix_A_22" \o "Product behavior note 22)

#### LM\_RESPONSE

The LM\_RESPONSE structure defines the NTLM v1 authentication **LmChallengeResponse** in the [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce). This response is used only when NTLM v1 authentication is configured.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Response (24 bytes) |
| ... |
| ... |

**Response (24 bytes):** A 24-byte array of unsigned char that contains the client's **LmChallengeResponse** as defined in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5).

#### LMv2\_RESPONSE

The LMv2\_RESPONSE structure defines the NTLM v2 authentication **LmChallengeResponse** in the [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce). This response is used only when NTLM v2 authentication is configured.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Response (16 bytes) |
| ... |
| ... |
| ChallengeFromClient |
| ... |

**Response (16 bytes):** A 16-byte array of unsigned char that contains the client's LM [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba)-response. This is the portion of the **LmChallengeResponse** field to which the HMAC\_MD5 algorithm has been applied, as defined in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3). Specifically, **Response** corresponds to the result of applying the HMAC\_MD5 algorithm, using the key ResponseKeyLM, to a message consisting of the concatenation of the ResponseKeyLM, ServerChallenge and ClientChallenge.

**ChallengeFromClient (8 bytes):** An 8-byte array of unsigned char that contains the client's ClientChallenge (as defined in section 3.3.2). See section [3.1.5.1.2](#Section_c0250a97294040c782fb20d208c71e96) for details.

#### NEGOTIATE

During NTLM authentication, each of the following flags is a possible value of the **NegotiateFlags** field of the [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2), [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786), and [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce), unless otherwise noted. These flags define client or server NTLM capabilities supported by the sender.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| W | V | U | r1 | r2 | r3 | T | r4 | S | R | r5 | Q | P | r6 | O | N | M | r7 | L | K | J | r8 | H | r9 | G | F | E | D | r 1 0 | C | B | A |

**W (1 bit):** If set, requests 56-bit encryption. If the client sends NTLMSSP\_NEGOTIATE\_SEAL or NTLMSSP\_NEGOTIATE\_SIGN with NTLMSSP\_NEGOTIATE\_56 to the server in the NEGOTIATE\_MESSAGE, the server MUST return NTLMSSP\_NEGOTIATE\_56 to the client in the CHALLENGE\_MESSAGE. Otherwise it is ignored. If both NTLMSSP\_NEGOTIATE\_56 and NTLMSSP\_NEGOTIATE\_128 are requested and supported by the client and server, NTLMSSP\_NEGOTIATE\_56 and NTLMSSP\_NEGOTIATE\_128 will both be returned to the client. Clients and servers that set NTLMSSP\_NEGOTIATE\_SEAL SHOULD set NTLMSSP\_NEGOTIATE\_56 if it is supported. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_56**.

**V (1 bit):** If set, requests an explicit [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) exchange. This capability SHOULD be used because it improves security for message integrity or confidentiality. See sections [3.2.5.1.2](#Section_f9e6fbc4a9534f24b229ccdcc213b9ec), [3.2.5.2.1](#Section_b46d85da050d4f18a2e114863f587163), and [3.2.5.2.2](#Section_34a9417d7cc043b0b61c1f19740df66f) for details. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_KEY\_EXCH**.

**U (1 bit):** If set, requests 128-bit [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) negotiation. An alternate name for this field is NTLMSSP\_NEGOTIATE\_128. If the client sends NTLMSSP\_NEGOTIATE\_128 to the server in the NEGOTIATE\_MESSAGE, the server MUST return NTLMSSP\_NEGOTIATE\_128 to the client in the CHALLENGE\_MESSAGE only if the client sets NTLMSSP\_NEGOTIATE\_SEAL or NTLMSSP\_NEGOTIATE\_SIGN. Otherwise it is ignored. If both NTLMSSP\_NEGOTIATE\_56 and NTLMSSP\_NEGOTIATE\_128 are requested and supported by the client and server, NTLMSSP\_NEGOTIATE\_56 and NTLMSSP\_NEGOTIATE\_128 will both be returned to the client. Clients and servers that set NTLMSSP\_NEGOTIATE\_SEAL SHOULD set NTLMSSP\_NEGOTIATE\_128 if it is supported. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_128**.[<23>](#Appendix_A_23" \o "Product behavior note 23)

**r1 (1 bit):** This bit is unused and MUST be zero.

**r2 (1 bit):** This bit is unused and MUST be zero.

**r3 (1 bit):** This bit is unused and MUST be zero.

**T (1 bit):** If set, requests the protocol version number. The data corresponding to this flag is provided in the **Version** field of the NEGOTIATE\_MESSAGE, the CHALLENGE\_MESSAGE, and the AUTHENTICATE\_MESSAGE.[<24>](#Appendix_A_24" \o "Product behavior note 24) An alternate name for this field is **NTLMSSP\_NEGOTIATE\_VERSION**.

**r4 (1 bit):** This bit is unused and MUST be zero.

**S (1 bit):** If set, indicates that the **TargetInfo** fields in the CHALLENGE\_MESSAGE (section 2.2.1.2) are populated. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_TARGET\_INFO**.

**R (1 bit):** If set, requests the usage of the [**LMOWF**](#gt_fd74ef50-cb97-4acd-b537-4941bdd9e064). An alternate name for this field is **NTLMSSP\_REQUEST\_NON\_NT\_SESSION\_KEY**.

**r5 (1 bit):** This bit is unused and MUST be zero.

**Q (1 bit):** If set, requests an [**identify level token**](#gt_1834903a-31fb-43e9-a297-cacede73324e). An alternate name for this field is **NTLMSSP\_NEGOTIATE\_IDENTIFY**.

**P (1 bit):** If set, requests usage of the NTLM v2 [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff). NTLM v2 session security is a misnomer because it is not NTLM v2. It is NTLM v1 using the extended session security that is also in NTLM v2. NTLMSSP\_NEGOTIATE\_LM\_KEY and NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY are mutually exclusive. If both NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY and NTLMSSP\_NEGOTIATE\_LM\_KEY are requested, NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY alone MUST be returned to the client. NTLM v2 authentication session key generation MUST be supported by both the client and the [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) in order to be used, and extended session security signing and sealing requires support from the client and the server in order to be used.[<25>](#Appendix_A_25" \o "Product behavior note 25) An alternate name for this field is **NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY**.

**r6 (1 bit):** This bit is unused and MUST be zero.

**O (1 bit):** If set, **TargetName** MUST be a server name. The data corresponding to this flag is provided by the server in the **TargetName** field of the CHALLENGE\_MESSAGE. If this bit is set, then NTLMSSP\_TARGET\_TYPE\_DOMAIN MUST NOT be set. This flag MUST be ignored in the NEGOTIATE\_MESSAGE and the AUTHENTICATE\_MESSAGE. An alternate name for this field is **NTLMSSP\_TARGET\_TYPE\_SERVER**.

**N (1 bit):** If set, **TargetName** MUST be a [**domain name**](#gt_45a1c9f1-0263-49a8-97c7-7aca1a99308c). The data corresponding to this flag is provided by the server in the **TargetName** field of the CHALLENGE\_MESSAGE. If set, then NTLMSSP\_TARGET\_TYPE\_SERVER MUST NOT be set. This flag MUST be ignored in the NEGOTIATE\_MESSAGE and the AUTHENTICATE\_MESSAGE. An alternate name for this field is **NTLMSSP\_TARGET\_TYPE\_DOMAIN**.

**M (1 bit):** If set, a session key is generated regardless of the states of NTLMSSP\_NEGOTIATE\_SIGN and NTLMSSP\_NEGOTIATE\_SEAL. A session key MUST always exist to generate the MIC (section [3.1.5.1.2](#Section_c0250a97294040c782fb20d208c71e96)) in the authenticate message. NTLMSSP\_NEGOTIATE\_ALWAYS\_SIGN MUST be set in the NEGOTIATE\_MESSAGE to the server and the CHALLENGE\_MESSAGE to the client. NTLMSSP\_NEGOTIATE\_ALWAYS\_SIGN is overridden by NTLMSSP\_NEGOTIATE\_SIGN and NTLMSSP\_NEGOTIATE\_SEAL, if they are supported. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_ALWAYS\_SIGN**.

**r7 (1 bit):** This bit is unused and MUST be zero.

**L (1 bit):**  This flag indicates whether the **Workstation** field is present. If this flag is not set, the **Workstation** field MUST be ignored. If this flag is set, the length of the **Workstation** field specifies whether the workstation name is nonempty or not.[<26>](#Appendix_A_26" \o "Product behavior note 26) An alternate name for this field is **NTLMSSP\_NEGOTIATE\_OEM\_WORKSTATION\_SUPPLIED**.

**K (1 bit):** If set, the domain name is provided (section 2.2.1.1).[<27>](#Appendix_A_27" \o "Product behavior note 27) An alternate name for this field is **NTLMSSP\_NEGOTIATE\_OEM\_DOMAIN\_SUPPLIED**.

**J (1 bit):** If set, the connection SHOULD be anonymous.[<28>](#Appendix_A_28" \o "Product behavior note 28)

**r8 (1 bit):** This bit is unused and SHOULD be zero.[<29>](#Appendix_A_29" \o "Product behavior note 29)

**H (1 bit):** If set, requests usage of the NTLM v1 session security protocol. NTLMSSP\_NEGOTIATE\_NTLM MUST be set in the NEGOTIATE\_MESSAGE to the server and the CHALLENGE\_MESSAGE to the client. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_NTLM**.

**r9 (1 bit):** This bit is unused and MUST be zero.

**G (1 bit):** If set, requests LAN Manager (LM) session key computation. NTLMSSP\_NEGOTIATE\_LM\_KEY and NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY are mutually exclusive. If both NTLMSSP\_NEGOTIATE\_LM\_KEY and NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY are requested, NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY alone MUST be returned to the client. NTLM v2 authentication session key generation MUST be supported by both the client and the DC in order to be used, and extended session security signing and sealing requires support from the client and the server to be used. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_LM\_KEY**.

**F (1 bit):** If set, requests connectionless authentication. If NTLMSSP\_NEGOTIATE\_DATAGRAM is set, then NTLMSSP\_NEGOTIATE\_KEY\_EXCH MUST always be set in the AUTHENTICATE\_MESSAGE to the server and the CHALLENGE\_MESSAGE to the client. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_DATAGRAM**.

**E (1 bit):** If set, requests session key negotiation for message confidentiality. If the client sends NTLMSSP\_NEGOTIATE\_SEAL to the server in the NEGOTIATE\_MESSAGE, the server MUST return NTLMSSP\_NEGOTIATE\_SEAL to the client in the CHALLENGE\_MESSAGE. Clients and servers that set NTLMSSP\_NEGOTIATE\_SEAL SHOULD always set NTLMSSP\_NEGOTIATE\_56 and NTLMSSP\_NEGOTIATE\_128, if they are supported. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_SEAL**.

**D (1 bit):** If set, requests session key negotiation for message signatures. If the client sends NTLMSSP\_NEGOTIATE\_SIGN to the server in the NEGOTIATE\_MESSAGE, the server MUST return NTLMSSP\_NEGOTIATE\_SIGN to the client in the CHALLENGE\_MESSAGE. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_SIGN**.

**r10 (1 bit):** This bit is unused and MUST be zero.

**C (1 bit):** If set, a **TargetName** field of the **CHALLENGE\_MESSAGE** (section 2.2.1.2) MUST be supplied. An alternate name for this field is **NTLMSSP\_REQUEST\_TARGET**.

**B (1 bit):** If set, requests OEM character set encoding. An alternate name for this field is **NTLM\_NEGOTIATE\_OEM**. See bit A for details.

**A (1 bit):** If set, requests [**Unicode**](#gt_c305d0ab-8b94-461a-bd76-13b40cb8c4d8) character set encoding. An alternate name for this field is **NTLMSSP\_NEGOTIATE\_UNICODE**.

The A and B bits are evaluated together as follows:

* A==1: The choice of character set encoding MUST be Unicode.
* A==0 and B==1: The choice of character set encoding MUST be OEM.
* A==0 and B==0: The protocol MUST return SEC\_E\_INVALID\_TOKEN.

#### NTLM v1 Response: NTLM\_RESPONSE

The NTLM\_RESPONSE structure defines the NTLM v1 authentication **NtChallengeResponse** in the [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce). This response is only used when NTLM v1 authentication is configured.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Response (24 bytes) |
| ... |
| ... |

**Response (24 bytes):** A 24-byte array of unsigned char that contains the client's **NtChallengeResponse** (section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5)).

#### NTLM v2: NTLMv2\_CLIENT\_CHALLENGE

The NTLMv2\_CLIENT\_CHALLENGE structure defines the client [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba) in the [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce). This structure is used only when NTLM v2 authentication is configured and is transported in the [NTLMv2\_RESPONSE (section 2.2.2.8)](#Section_d43e22246fc3449d9f37b90b55a29c80) structure.[<30>](#Appendix_A_30" \o "Product behavior note 30)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| RespType | HiRespType | Reserved1 |
| Reserved2 |
| TimeStamp |
| ... |
| ChallengeFromClient |
| ... |
| Reserved3 |
| AvPairs (variable) |
| ... |

**RespType (1 byte):** An 8-bit unsigned char that contains the current version of the challenge response type. This field MUST be 0x01.

**HiRespType (1 byte):** An 8-bit unsigned char that contains the maximum supported version of the challenge response type. This field MUST be 0x01.

**Reserved1 (2 bytes):** A 16-bit unsigned integer that SHOULD be 0x0000 and MUST be ignored on receipt.

**Reserved2 (4 bytes):** A 32-bit unsigned integer that SHOULD be 0x00000000 and MUST be ignored on receipt.

**TimeStamp (8 bytes):** A 64-bit unsigned integer that contains the current system time, represented as the number of 100 nanosecond ticks elapsed since midnight of January 1, 1601 (UTC).

**ChallengeFromClient (8 bytes):** An 8-byte array of unsigned char that contains the client's ClientChallenge (as defined in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3)). See section [3.1.5.1.2](#Section_c0250a97294040c782fb20d208c71e96) for details.

**Reserved3 (4 bytes):** A 32-bit unsigned integer that SHOULD be 0x00000000 and MUST be ignored on receipt.

**AvPairs (variable):** A byte array that contains a sequence of [AV\_PAIR](#Section_83f5e789660d478184915f8c6641f75e) structures (section 2.2.2.1). The sequence contains the server-naming context and is terminated by an AV\_PAIR structure with an **AvId** field of MsvAvEOL.

#### NTLM2 V2 Response: NTLMv2\_RESPONSE

The NTLMv2\_RESPONSE structure defines the NTLMv2 authentication NtChallengeResponse in the [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce). This response is used only when NTLMv2 authentication is configured.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Response (16 bytes) |
| ... |
| ... |
| NTLMv2\_CLIENT\_CHALLENGE (variable) |
| ... |

**Response (16 bytes):** A 16-byte array of unsigned char that contains the client's **NTChallengeResponse** as defined in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3). Response corresponds to the NTProofStr variable from section 3.3.2.

**NTLMv2\_CLIENT\_CHALLENGE (variable):** A variable-length byte array, defined in section [2.2.2.7](#Section_aee311d621a7447092a5c4ecb022a87b), that contains the **ClientChallenge** as defined in section 3.3.2. ChallengeFromClient corresponds to the temp variable from section 3.3.2.

#### NTLMSSP\_MESSAGE\_SIGNATURE

The NTLMSSP\_MESSAGE\_SIGNATURE structure (section [3.4.4](#Section_bd5ae0a8a13146a8891b0dc2b9ca9bf7)), specifies the signature block used for application message integrity and confidentiality. This structure is then passed back to the application, which embeds it within the application protocol messages, along with the NTLM-encrypted or integrity-protected application message data.

This structure MUST take one of the two following forms, depending on whether the NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag is negotiated:

* [NTLMSSP\_MESSAGE\_SIGNATURE](#Section_83fbd0e78ab048738cbe795249b46b8a)
* [NTLMSSP\_MESSAGE\_SIGNATURE for Extended Session Security](#Section_2c3b4689d6f14dc685c90bf01ea34d9f)

##### NTLMSSP\_MESSAGE\_SIGNATURE

This version of the NTLMSSP\_MESSAGE\_SIGNATURE structure MUST be used when the NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag is not negotiated.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Version |
| RandomPad |
| Checksum |
| SeqNum |

**Version (4 bytes):** A 32-bit unsigned integer that contains the signature version. This field MUST be 0x00000001.

**RandomPad (4 bytes):** A 4-byte array that contains the random pad for the message.

**Checksum (4 bytes):** A 4-byte array that contains the [**checksum**](#gt_fa444149-ef93-4512-a278-2e756295630c) for the message.

**SeqNum (4 bytes):** A 32-bit unsigned integer that contains the NTLM [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) for this application message.

##### NTLMSSP\_MESSAGE\_SIGNATURE for Extended Session Security

This version of the NTLMSSP\_MESSAGE\_SIGNATURE structure MUST be used when the NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag is negotiated.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| Version |
| Checksum |
| ... |
| SeqNum |

**Version (4 bytes):**  A 32-bit unsigned integer that contains the signature version. This field MUST be 0x00000001.

**Checksum (8 bytes):**  An 8-byte array that contains the [**checksum**](#gt_fa444149-ef93-4512-a278-2e756295630c) for the message.

**SeqNum (4 bytes):**  A 32-bit unsigned integer that contains the NTLM [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) for this application message.

#### VERSION

The VERSION structure contains operating system version information that SHOULD[<31>](#Appendix_A_31" \o "Product behavior note 31) be ignored. This structure is used for debugging purposes only and its value does not affect NTLM message processing. It is populated in the [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2), [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786), and [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) messages only if NTLMSSP\_NEGOTIATE\_VERSION is negotiated.[<32>](#Appendix_A_32" \o "Product behavior note 32)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 30 | 1 |
| ProductMajorVersion | ProductMinorVersion | ProductBuild |
| Reserved | NTLMRevisionCurrent |

**ProductMajorVersion (1 byte):** An 8-bit unsigned integer that SHOULD[<33>](#Appendix_A_33" \o "Product behavior note 33) contain the major version number of the operating system in use.

**ProductMinorVersion (1 byte):** An 8-bit unsigned integer that SHOULD[<34>](#Appendix_A_34" \o "Product behavior note 34) contain the minor version number of the operating system in use.

**ProductBuild (2 bytes):** A 16-bit unsigned integer that contains the build number of the operating system in use. This field SHOULD be set to a 16-bit quantity that identifies the operating system build number.

**Reserved (3 bytes):** A 24-bit data area that SHOULD be set to zero and MUST be ignored by the recipient.

**NTLMRevisionCurrent (1 byte):** An 8-bit unsigned integer that contains a value indicating the current revision of the NTLMSSP in use. This field SHOULD contain the following value:

| Value | Meaning |
| --- | --- |
| NTLMSSP\_REVISION\_W2K30x0F | Version 15 of the NTLMSSP is in use. |

# Protocol Details

The following sections offer a detailed specification of the NTLM message computation:

* Sections [3.1.5](#Section_550de46c71e54f5e9dfd6e5ec6bcc454) and [3.2.5](#Section_a4689496ea884a50867da7330db4d935) specify how the client and server compute messages and respond to messages.
* Section [3.3](#Section_1b72429ad8b84a04bc821eedc980b87a) specifies how the response computation is calculated, depending on whether NTLM v1 or NTLM v2 is used. This includes the ComputeResponse function, as well as the [**NTOWF**](#gt_7a2805fa-1dcd-4b4e-a8e4-2a2bcc8651e9) and [**LMOWF**](#gt_fd74ef50-cb97-4acd-b537-4941bdd9e064) functions, which are used by the ComputeResponse function.
* Section [3.4](#Section_d1c86e81eb6647fd8a6f970050121347) specifies how message integrity and message confidentiality are provided, including a detailed specification of the algorithms used to calculate the signing and sealing [**keys**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b).

The Cryptographic Operations Reference in section [6](#Section_26c42637954946aebe2e90f6f1360193) defines the cryptographic primitives used in this section.

## Client Details

### Abstract Data Model

The following sections specify variables that are internal to the client and are maintained across the NTLM authentication sequence.

#### Variables Internal to the Protocol

**ClientConfigFlags**: The set of client configuration flags (section [2.2.2.5](#Section_99d90ff4957f4c8a80e45bfe5a9a9832)) that specify the full set of capabilities of the client.

**ExportedSessionKey**: A 128-bit (16-byte) [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) used to derive ClientSigningKey, ClientSealingKey, ServerSealingKey, and ServerSigningKey.

**NegFlg**: The set of configuration flags (section 2.2.2.5) that specifies the negotiated capabilities of the client and server for the current NTLM [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12).

**User**: A string that indicates the name of the user.

**UserDom**: A string that indicates the name of the user's [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca).

The following NTLM configuration variables are internal to the client and impact all authenticated sessions:

**NoLMResponseNTLMv1**: A Boolean setting that SHOULD[<35>](#Appendix_A_35" \o "Product behavior note 35) control using the NTLM response for the LM response to the server challenge when NTLMv1 authentication is used. The default value of this state variable is TRUE.

**ClientBlocked**: A Boolean setting that SHOULD[<36>](#Appendix_A_36" \o "Product behavior note 36) disable the client from sending NTLM authenticate messages, as defined in section [2.2.1.3](#Section_033d32cc88f944839bf2b273055038ce). The default value of this state variable is FALSE.

**ClientBlockExceptions**: A list of server names that SHOULD[<37>](#Appendix_A_37" \o "Product behavior note 37) use NTLM authentication. The default value of this state variable is NULL.

**ClientRequire128bitEncryption**: A Boolean setting that requires the client to use 128-bit encryption.[<38>](#Appendix_A_38" \o "Product behavior note 38)

The following variables are internal to the client and are maintained for the entire length of the authenticated session:

**MaxLifetime**: An integer that indicates the maximum lifetime for challenge/response pairs.[<39>](#Appendix_A_39" \o "Product behavior note 39)

**ClientSigningKey**: The signing [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) used by the client to sign messages and used by the server to verify signed client messages. It is generated after the client is authenticated by the server and is not passed over the wire.

**ClientSealingKey**: The sealing key used by the client to seal messages and used by the server to unseal client messages. It is generated after the client is authenticated by the server and is not passed over the wire.

**SeqNum**: A 4-byte [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) (section [3.4.4](#Section_bd5ae0a8a13146a8891b0dc2b9ca9bf7)).

**ServerSealingKey**: The sealing key used by the server to seal messages and used by the client to unseal server messages. It is generated after the client is authenticated by the server and is not passed over the wire.

**ServerSigningKey**: The signing key used by the server to sign messages and used by the client to verify signed server messages. It is generated after the client is authenticated by the server and is not passed over the wire.

#### Variables Exposed to the Application

The following parameters are provided by the application to the NTLM client. These logical parameters can influence various protocol-defined flags.[<40>](#Appendix_A_40" \o "Product behavior note 40)

**Note**  The following variables are logical, abstract parameters that an implementation MUST maintain and expose to provide the proper level of [**service**](#gt_2dc07ca2-2b40-437e-a5ec-ed28ebfb116a). How these variables are maintained and exposed is up to the implementation.

**Integrity:** A Boolean setting that indicates that the caller requests that messages be signed so that they cannot be tampered with while in transit. Setting this flag results in the NTLMSSP\_NEGOTIATE\_SIGN flag being set in the **NegotiateFlags** field of the NTLM NEGOTIATE\_MESSAGE.

**Replay Detect:** A Boolean setting that indicates that the caller requests that messages be signed so that they cannot be replayed. Setting this flag results in the NTLMSSP\_NEGOTIATE\_SIGN flag being set in the **NegotiateFlags** field of the NTLM NEGOTIATE\_MESSAGE.

**Sequence Detect:**  A Boolean setting that indicates that the caller requests that messages be signed so that they cannot be sent out of order. Setting this flag results in the NTLMSSP\_NEGOTIATE\_SIGN flag being set in the **NegotiateFlags** field of the NTLM NEGOTIATE\_MESSAGE.

**Confidentiality:** A Boolean setting that indicates that the caller requests that messages be encrypted so that they cannot be read while in transit. If the Confidentiality option is selected by the client, NTLM performs a bitwise OR operation with the following NTLM Negotiate Flags into the **ClientConfigFlags**. (The ClientConfigFlags indicate which features the client host supports.)

1. NTLMSSP\_NEGOTIATE\_SEAL
2. NTLMSSP\_NEGOTIATE\_KEY\_EXCH
3. NTLMSSP\_NEGOTIATE\_LM\_KEY
4. NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY

**Datagram:** A Boolean setting that indicates that the connectionless mode of NTLM is to be selected. If the Datagram option is selected by the client, then connectionless mode is used and NTLM performs a bitwise OR operation with the following NTLM Negotiate Flag into the **ClientConfigFlags**.

1. NTLMSSP\_NEGOTIATE\_DATAGRAM

**Identify:** A Boolean setting that indicates that the caller wants the server to know the identity of the caller, but that the server not be allowed to impersonate the caller to resources on that system. Setting this flag results in the NTLMSSP\_NEGOTIATE\_IDENTIFY flag being set. Indicates that the GSS\_C\_IDENTIFY\_FLAG flag was set in the GSS\_Init\_sec\_context call, as discussed in [[RFC4757]](https://go.microsoft.com/fwlink/?LinkId=90488) section 7.1, and results in the GSS\_C\_IDENTIFY\_FLAG flag set in the authenticator's **checksum** field ([RFC4757] section 7.1).

The following variables are used by applications for channel binding token support:

**ClientSuppliedTargetName**: Service principal name (SPN) of the service to which the client wishes to authenticate. This value is optional.[<41>](#Appendix_A_41" \o "Product behavior note 41)

**ClientChannelBindingsUnhashed**: An octet string provided by the application used for channel binding. This value is optional.[<42>](#Appendix_A_42" \o "Product behavior note 42)

**UnverifiedTargetName**: A Boolean setting that indicates that the caller generated the target's SPN from an untrusted source. This value is optional.[<43>](#Appendix_A_43" \o "Product behavior note 43)

### Timers

None.

### Initialization

None.

### Higher-Layer Triggered Events

The application SHOULD[<44>](#Appendix_A_44" \o "Product behavior note 44) initiate NTLM authentication through the [**Security Support Provider Interface (SSPI)**](#gt_fb216516-748b-4873-8bdd-64c5f4da9920). NTLM does not support token framing as defined in [[RFC2743]](https://go.microsoft.com/fwlink/?LinkId=90378) section 3.1.

* GSS\_Init\_sec\_context

The client application calls GSS\_Init\_sec\_context() to establish a security context with the server application.

If the ClientBlocked == TRUE and targ\_name ([RFC2743] section 2.2.1) does not equal any of the **ClientBlockExceptions** server names, then the NTLM client MUST return STATUS\_NOT\_SUPPORTED ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.3.1) to the client application.[<45>](#Appendix_A_45" \o "Product behavior note 45)

NTLM has no requirements on which flags are used and will simply honor what was requested by the application or protocol. For an example of such a protocol specification, see [[MS-RPCE]](%5BMS-RPCE%5D.pdf#Section_290c38b192fe422991e64fc376610c15) section 3.3.1.5.2.2. The application will send the NEGOTIATE\_MESSAGE (section [2.2.1.1](#Section_b34032e53aae4bc684c3c6d80eadf7f2)) to the server application.

When the client application receives the CHALLENGE\_MESSAGE (section [2.2.1.2](#Section_801a468188094be9ab0d61dcfe762786)) from the server application, the client application will call GSS\_Init\_sec\_context() with the CHALLENGE\_MESSAGE as input. The client application will send the AUTHENTICATE\_MESSAGE (section [2.2.1.3](#Section_033d32cc88f944839bf2b273055038ce)) to the server application.

* GSS\_Wrap

Once the security context is established, the client application can call GSS\_WrapEx() (section [3.4.6](#Section_a06bfc2b30fc4483b876a9386f4808ed)) to encrypt messages.

* GSS\_Unwrap

Once the security context is established, the client application can call GSS\_UnwrapEx() (section [3.4.7](#Section_e1d497b0f5704c369c17bd6f3db53eba)) to decrypt messages that were encrypted by GSS\_WrapEx.

* GSS\_GetMIC

Once the security context is established, the client application can call GSS\_GetMICEx() (section [3.4.8](#Section_369a319eac794828a036e9c6c3eec1f2)) to sign messages, producing an NTLMSSP\_MESSAGE\_SIGNATURE structure (section [2.2.2.9](#Section_b192b940a50843298513efb3342f2c85)).

* GSS\_VerifyMIC

Once the security context is established, the client application can call GSS\_VerifyMICEx() (section [3.4.9](#Section_02b712fdd7aa4ab5a2673943bddc3ab5)) to verify a signature produced by GSS\_GetMICEx().

### Message Processing Events and Sequencing Rules

This section specifies how the client processes and returns messages. As discussed earlier, the message transport is provided by the application that is using NTLM.

#### Connection-Oriented

Message processing on the client takes place in the following two cases:

* When the application initiates authentication and the client then sends a [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2).
* When the client receives a [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) from the server and then sends back an [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce).

These two cases are described in the following sections.

When encryption is desired, the stream cipher RC4 is used. The [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) for RC4 is established at the start of the [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12) for an instance of RC4 dedicated to that session. RC4 then continues to generate key stream in order over all messages of the session, without rekeying.

The pseudocode RC4(handle, message) is defined as the bytes of the message XORed with bytes of the RC4 key stream, using the current state of the session's RC4 internal key state. When the session is torn down, the key structure is destroyed.

The pseudocode RC4K(key,message) is defined as a one-time instance of RC4 whose key is initialized to key, after which RC4 is applied to the message. On completion of this operation, the internal key state is destroyed.

##### Client Initiates the NEGOTIATE\_MESSAGE

When the client application initiates the exchange through [**SSPI**](#gt_fb216516-748b-4873-8bdd-64c5f4da9920), the NTLM client sends the [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2) to the server, which is embedded in an application protocol message, and encoded according to that application protocol.

If ClientBlocked == TRUE and targ\_name ([[RFC2743]](https://go.microsoft.com/fwlink/?LinkId=90378) section 2.2.1) does not equal any of the **ClientBlockExceptions** server names, then the NTLM client MUST return STATUS\_NOT\_SUPPORTED ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.3.1) to the client application.[<46>](#Appendix_A_46" \o "Product behavior note 46)

The client prepares a NEGOTIATE\_MESSAGE and sets the following fields:

* The **Signature** field is set to the string, "NTLMSSP".
* The **MessageType** field is set to NtLmNegotiate.

The client sets the following configuration flags in the **NegotiateFlags** field of the NEGOTIATE\_MESSAGE:

* NTLMSSP\_REQUEST\_TARGET
* NTLMSSP\_NEGOTIATE\_NTLM
* NTLMSSP\_NEGOTIATE\_ALWAYS\_SIGN
* NTLMSSP\_NEGOTIATE\_UNICODE

If LM authentication is not being used, then the client sets the following configuration flag in the **NegotiateFlags** field of the NEGOTIATE\_MESSAGE:

* NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY

In addition, the client sets the flags specified by the application in the **NegotiateFlags** field in addition to the initialized flags.

If the NTLMSSP\_NEGOTIATE\_VERSION flag is set by the client application, the **Version** field MUST be set to the current version (section [2.2.2.10](#Section_b1a6ceb2f8ad462bb5aff18527c48175)), the **DomainName** field MUST be set to a zero-length string, and the **Workstation** field MUST be set to a zero-length string.

##### Client Receives a CHALLENGE\_MESSAGE from the Server

When the client receives a [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) from the server, it MUST determine if the features selected by the server are strong enough for the client authentication policy. If not, the client MUST return an error to the calling application. Otherwise, the client responds with an [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) message.

If ClientRequire128bitEncryption == TRUE, then if 128-bit encryption is not negotiated, then the client MUST return SEC\_E\_UNSUPPORTED\_FUNCTION ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.1.1) to the application.

The client processes the CHALLENGE\_MESSAGE and constructs an AUTHENTICATE\_MESSAGE per the following pseudo code where all strings are encoded as RPC\_UNICODE\_STRING ([[MS-DTYP]](%5BMS-DTYP%5D.pdf#Section_cca2742956894a16b2b49325d93e4ba2) section 2.3.10):

1. -- Input:
2. -- ClientConfigFlags, User, and UserDom - Defined in section 3.1.1.
3. -- NbMachineName - The NETBIOS machine name of the server.
4. -- An NTLM NEGOTIATE\_MESSAGE whose fields are defined in
5. section 2.2.1.1.
6. -- An NTLM CHALLENGE\_MESSAGE whose message fields are defined in
7. section 2.2.1.2.
8. -- An NTLM AUTHENTICATE\_MESSAGE whose message fields are
9. defined in section 2.2.1.3 with MIC field set to 0.
10. -- OPTIONAL ClientSuppliedTargetName - Defined in section 3.1.1.2
11. -- OPTIONAL ClientChannelBindingUnhashed - Defined in section 3.1.1.2
12. --
13. -- Output:
14. -- ClientHandle - The handle to a key state structure corresponding
15. -- to the current state of the ClientSealingKey
16. -- ServerHandle - The handle to a key state structure corresponding
17. -- to the current state of the ServerSealingKey
18. -- An NTLM AUTHENTICATE\_MESSAGE whose message fields are defined in
19. section 2.2.1.3.
20. --
21. -- The following NTLM keys generated by the client are defined in
22. section 3.1.1:
23. -- ExportedSessionKey, ClientSigningKey, ClientSealingKey,
24. ServerSigningKey, and ServerSealingKey.
25. -- Temporary variables that do not pass over the wire are defined
26. below:
27. -- KeyExchangeKey, ResponseKeyNT, ResponseKeyLM, SessionBaseKey -
28. Temporary variables used to store 128-bit keys.
29. -- Time - Temporary variable used to hold the 64-bit time.
30. -- MIC - message integrity for the NTLM NEGOTIATE\_MESSAGE,
31. CHALLENGE\_MESSAGE and AUTHENTICATE\_MESSAGE
32. --
33. -- Functions used:
34. -- NTOWFv1, LMOWFv1, NTOWFv2, LMOWFv2, ComputeResponse - Defined in
35. section 3.3
36. -- KXKEY, SIGNKEY, SEALKEY - Defined in sections 3.4.5, 3.4.6,
37. and 3.4.7
38. -- Currenttime, NIL, NONCE - Defined in section 6.

Fields MUST be set as follows:

* **ChallengeFromClient** to an 8-byte [**nonce**](#gt_001c0e40-0980-417d-853c-f7cb34ba6d3b).
* **UserName** to User.
* **DomainName** to UserDom.
* **Signature** to the string "NTLMSSP".
* **MessageType** to NtLmAuthenticate.

If the NTLMSSP\_NEGOTIATE\_VERSION flag is set by the client application, the **Version** field MUST be set to the current version (section [2.2.2.10](#Section_b1a6ceb2f8ad462bb5aff18527c48175)), and the **Workstation** field MUST be set to NbMachineName.

If NTLM v2 authentication is used, the client SHOULD send the timestamp in the CHALLENGE\_MESSAGE.[<47>](#Appendix_A_47" \o "Product behavior note 47)

1. If there exists a CHALLENGE\_MESSAGE.TargetInfo.AvId ==
2. MsvAvTimestamp
3. Set Time to CHALLENGE\_MESSAGE.TargetInfo.Value of that AVPair
4. Else
5. Set Time to Currenttime
6. Endif

If NTLM v2 authentication is used and the CHALLENGE\_MESSAGE does not contain both MsvAvNbComputerName and MsvAvNbDomainName AVPairs and either Integrity is TRUE or Confidentiality is TRUE, then return STATUS\_LOGON\_FAILURE ([MS-ERREF] section 2.3.1).

If NTLM v2 authentication is used and the CHALLENGE\_MESSAGE **TargetInfo** field (section 2.2.1.2) has an MsvAvTimestamp present, the client SHOULD NOT send the LmChallengeResponse and SHOULD send Z(24) instead.[<48>](#Appendix_A_48" \o "Product behavior note 48)

Response keys are computed using the ComputeResponse() function, as specified in section [3.3](#Section_1b72429ad8b84a04bc821eedc980b87a).

1. Set AUTHENTICATE\_MESSAGE.NtChallengeResponse,
2. AUTHENTICATE\_MESSAGE.LmChallengeResponse, SessionBaseKey to
3. ComputeResponse(CHALLENGE\_MESSAGE.NegotiateFlags, ResponseKeyNT,
4. ResponseKeyLM, CHALLENGE\_MESSAGE.ServerChallenge,
5. ChallengeFromClient, Time,
6. CHALLENGE\_MESSAGE.TargetInfo)
7. Set KeyExchangeKey to KXKEY(SessionBaseKey, LmChallengeResponse,
8. CHALLENGE\_MESSAGE.ServerChallenge)
9. If (NTLMSSP\_NEGOTIATE\_KEY\_EXCH bit is set in
10. CHALLENGE\_MESSAGE.NegotiateFlags )
11. Set ExportedSessionKey to NONCE(16)
12. Set AUTHENTICATE\_MESSAGE.EncryptedRandomSessionKey to
13. RC4K(KeyExchangeKey, ExportedSessionKey)
14. Else
15. Set ExportedSessionKey to KeyExchangeKey
16. Set AUTHENTICATE\_MESSAGE.EncryptedRandomSessionKey to NIL
17. Endif
18. Set ClientSigningKey to SIGNKEY(NegFlg, ExportedSessionKey, "Client")
19. Set ServerSigningKey to SIGNKEY(NegFlg, ExportedSessionKey, "Server")
20. Set ClientSealingKey to SEALKEY(NegFlg, ExportedSessionKey, "Client")
21. Set ServerSealingKey to SEALKEY(NegFlg, ExportedSessionKey, "Server")
22. RC4Init(ClientHandle, ClientSealingKey)
23. RC4Init(ServerHandle, ServerSealingKey)
24. Set MIC to HMAC\_MD5(ExportedSessionKey, ConcatenationOf(
25. NEGOTIATE\_MESSAGE, CHALLENGE\_MESSAGE, AUTHENTICATE\_MESSAGE))
26. Set AUTHENTICATE\_MESSAGE.MIC to MIC

If the CHALLENGE\_MESSAGE **TargetInfo** field (section 2.2.1.2) has an MsvAvTimestamp present, the client SHOULD provide a MIC:[<49>](#Appendix_A_49" \o "Product behavior note 49)

* If there is an [AV\_PAIR](#Section_83f5e789660d478184915f8c6641f75e) structure (section 2.2.2.1) with the **AvId** field set to MsvAvFlags,
	+ then in the **Value** field, set bit 0x2 to 1.
	+ else add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvFlags and the **Value** field bit 0x2 to 1.
* Populate the **MIC** field with the MIC.

The client SHOULD send the channel binding AV\_PAIR [<50>](#Appendix_A_50" \o "Product behavior note 50):

* If the CHALLENGE\_MESSAGE contains a **TargetInfo** field (section 2.2.1.2)
	+ If the ClientChannelBindingsUnhashed (section [3.1.1.2](#Section_a4a41f0dca2744bfad1d6f8c3a3796f2)) is not NULL
		- Add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvChannelBindings and the **Value** field to MD5\_HASH(ClientChannelBindingsUnhashed).
		- Else add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvChannelBindings and the **Value** field to Z(16).
	+ If ClientSuppliedTargetName (section 3.1.1.2) is not NULL
		- Add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvTargetName and the **Value** field to ClientSuppliedTargetName without terminating NULL. If UnverifiedTargetName (section 3.1.1.2) is TRUE, then in **AvId** field = MsvAvFlags set 0x00000004 bit.[<51>](#Appendix_A_51" \o "Product behavior note 51)
		- Else add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvTargetName and the **Value** field to an empty string without terminating NULL.

When this process is complete, the client MUST send the AUTHENTICATE\_MESSAGE to the server, embedded in an application protocol message, and encoded as specified by that application protocol.

#### Connectionless

The client action for connectionless NTLM authentication is similar to that of connection-oriented authentication (section [3.1.5.1](#Section_1f18ef3b7d624e1aa8a76bc0607fad70)). However, the first message sent in connectionless authentication is the [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) from the server to the client; there is no client-initiated [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2) as in the connection-oriented authentication.

The message processing for connectionless NTLM authentication[<52>](#Appendix_A_52" \o "Product behavior note 52) is as specified in the following sections.

##### Client Receives a CHALLENGE\_MESSAGE

When the client receives a [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786), it MUST produce a [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba) response and an encrypted [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d). The client MUST send the negotiated features (flags), the user name, the user's [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca), the client part of the challenge, the challenge response, and the encrypted session key to the server. This message is sent to the server as an [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce).

If the ClientBlocked == TRUE and targ\_name ([[RFC2743]](https://go.microsoft.com/fwlink/?LinkId=90378) section 2.2.1) does not equal any of the **ClientBlockExceptions** server names, then the NTLM client MUST return STATUS\_NOT\_SUPPORTED ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.3.1) to the client application.[<53>](#Appendix_A_53" \o "Product behavior note 53)

If NTLM v2 authentication is used and the CHALLENGE\_MESSAGE contains a **TargetInfo** field, the client SHOULD NOT send the **LmChallengeResponse** field and SHOULD set the **LmChallengeResponseLen** and **LmChallengeResponseMaxLen** fields in the AUTHENTICATE\_MESSAGE to zero.[<54>](#Appendix_A_54" \o "Product behavior note 54)

If NTLM v2 authentication is used, the client SHOULD send the timestamp in the AUTHENTICATE\_MESSAGE.[<55>](#Appendix_A_55" \o "Product behavior note 55)

1. If there exists a CHALLENGE\_MESSAGE.TargetInfo.AvId ==
2. MsvAvTimestamp
3. Set Time to CHALLENGE\_MESSAGE.TargetInfo.Value of the AVPair
4. ELSE
5. Set Time to Currenttime
6. Endif

If the CHALLENGE\_MESSAGE **TargetInfo** field (section 2.2.1.2) has an MsvAvTimestamp present, the client SHOULD provide a MIC[<56>](#Appendix_A_56" \o "Product behavior note 56):

* If there is an [AV\_PAIR](#Section_83f5e789660d478184915f8c6641f75e) structure (section 2.2.2.1) with the **AvId** field set to MsvAvFlags,
	+ then in the **Value** field, set bit 0x2 to 1.
	+ else add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvFlags and the Value field bit 0x2 to 1.
* Populate the **MIC** field with the MIC, where
1. Set MIC to HMAC\_MD5(ExportedSessionKey, ConcatenationOf(
2. CHALLENGE\_MESSAGE, AUTHENTICATE\_MESSAGE))

The client SHOULD send the channel binding AV\_PAIR [<57>](#Appendix_A_57" \o "Product behavior note 57):

* If the CHALLENGE\_MESSAGE contains a **TargetInfo** field (section 2.2.1.2)
	+ If the ClientChannelBindingsUnhashed (section [3.1.1.2](#Section_a4a41f0dca2744bfad1d6f8c3a3796f2)) is not NULL
		- Add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvChannelBindings and the **Value** field to MD5\_HASH(ClientChannelBindingsUnhashed).
		- Else add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvChannelBindings and the **Value** field to Z(16).
	+ If ClientSuppliedTargetName (section 3.1.1.2) is not NULL
		- Add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvTargetName and the **Value** field to ClientSuppliedTargetName without terminating NULL. If UnverifiedTargetName (section 3.1.1.2) is TRUE, then in **AvId** field = MsvAvFlags set 0x00000004 bit.[<58>](#Appendix_A_58" \o "Product behavior note 58)
		- Else add an AV\_PAIR structure (section 2.2.2.1) and set the **AvId** field to MsvAvTargetName and the **Value** field to an empty string without terminating NULL.

When this process is complete, the client MUST send the AUTHENTICATE\_MESSAGE to the server, embedded in an application protocol message, and encoded as specified by that application protocol.

### Timer Events

None.

### Other Local Events

None.

## Server Details

### Abstract Data Model

The following sections specify variables that are internal to the server and are maintained across the NTLM authentication sequence.

#### Variables Internal to the Protocol

The server maintains all of the variables that the client does (section [3.1.1.1](#Section_f711d05939834b9dafbbff2f8c97ffbf)) except the **ClientConfigFlags**.

Additionally, the server maintains the following:

**CfgFlg**: The set of server configuration flags (section [2.2.2.5](#Section_99d90ff4957f4c8a80e45bfe5a9a9832)) that specify the full set of capabilities of the server.

**DnsDomainName**: A string that indicates the [**fully qualified domain name (FQDN)**](#gt_1769aec9-237e-44ed-9014-1abb3ec6de6e) of the server's [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca).

**DnsForestName**: A string that indicates the FQDN of the server's [**forest**](#gt_fd104241-4fb3-457c-b2c4-e0c18bb20b62). The DnsForestName is NULL on machines that are not domain joined.

**DnsMachineName**: A string that indicates the FQDN of the server.

**NbDomainName**: A string that indicates the NetBIOS name of the server's domain.

**NbMachineName**: A string that indicates the NetBIOS machine name of the server.

The following NTLM server configuration variables are internal to the client and impact all authenticated sessions:

**ServerBlock**: A Boolean setting that disables the server from generating challenges and responding to NEGOTIATE\_MESSAGE messages.[<59>](#Appendix_A_59" \o "Product behavior note 59)

**ServerRequire128bitEncryption**: A Boolean setting that requires the server to use 128-bit encryption.[<60>](#Appendix_A_60" \o "Product behavior note 60)

#### Variables Exposed to the Application

The server also maintains the ClientSuppliedTargetName variable (section [3.1.1.2](#Section_a4a41f0dca2744bfad1d6f8c3a3796f2)).

The following parameters are provided by the application to the NTLM server:

**Datagram:** A Boolean setting which indicates that the connectionless mode of NTLM is to be used. If the Datagram option is selected by the server, connectionless mode is used, and NTLM performs a bitwise OR operation with the following NTLM Negotiate bit flags into the CfgFlg internal variable:

* NTLMSSP\_NEGOTIATE\_DATAGRAM.

**ServerChannelBindingsUnhashed**: An octet string provided by the application used for channel binding. This value is optional. [<61>](#Appendix_A_61" \o "Product behavior note 61)

**ApplicationRequiresCBT**: A Boolean setting which indicates the application requires channel binding. [<62>](#Appendix_A_62" \o "Product behavior note 62)

### Timers

None.

### Initialization

The [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) is set to zero.

### Higher-Layer Triggered Events

The application server initiates NTLM authentication through the [**SSPI**](#gt_fb216516-748b-4873-8bdd-64c5f4da9920).

* GSS\_Accept\_sec\_context

The server application calls GSS\_Accept\_sec\_context() to establish a security context with the client. NTLM has no requirements on which flags are used and will simply honor what was requested by the application or protocol. For an example of such a protocol specification, see [[MS-RPCE]](%5BMS-RPCE%5D.pdf#Section_290c38b192fe422991e64fc376610c15) section 3.3.1.5.2.2. The server application will send the CHALLENGE\_MESSAGE (section [2.2.1.2](#Section_801a468188094be9ab0d61dcfe762786)) to the client application.

* GSS\_Wrap

After the security context is established, the server application can call GSS\_WrapEx() (section [3.4.6](#Section_a06bfc2b30fc4483b876a9386f4808ed)) to encrypt messages.

* GSS\_Unwrap

Once the security context is established, the server application can call GSS\_UnwrapEx() (section [3.4.7](#Section_e1d497b0f5704c369c17bd6f3db53eba)) to decrypt messages that were encrypted by GSS\_WrapEx.

* GSS\_GetMIC

Once the security context is established, the server application can call GSS\_GetMICEx() (section [3.4.8](#Section_369a319eac794828a036e9c6c3eec1f2)) to sign messages, producing an NTLMSSP\_MESSAGE\_SIGNATURE structure whose fields are defined in section [2.2.2.9](#Section_b192b940a50843298513efb3342f2c85).

* GSS\_VerifyMIC

Once the security context is established, the server application can call GSS\_VerifyMICEx() (section [3.4.9](#Section_02b712fdd7aa4ab5a2673943bddc3ab5)) to verify a signature produced by GSS\_GetMICEx().

### Message Processing Events and Sequencing Rules

The server-side processing of messages can happen in response to two different messages from the client:

* The server receives a [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2) from the client (the server responds with a [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786)).
* The server receives an [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) from the client (the server verifies the client's authentication information that is embedded in the message).

#### Connection-Oriented

Message processing on the server takes place in the following two cases:

* Upon receipt of the embedded [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2), the server extracts and decodes the NEGOTIATE\_MESSAGE.
* Upon receipt of the embedded [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce), the server extracts and decodes the AUTHENTICATE\_MESSAGE.

These two cases are described in the following sections.

##### Server Receives a NEGOTIATE\_MESSAGE from the Client

Upon receipt of the embedded [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2), the server MUST extract and decode the NEGOTIATE\_MESSAGE.

If **ServerBlock** == TRUE, then the server MUST return STATUS\_NOT\_SUPPORTED ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.3.1).[<63>](#Appendix_A_63" \o "Product behavior note 63)

If the security features selected by the client are not strong enough for the server security policy, the server MUST return an error to the calling application. Otherwise, the server MUST respond with a [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) message. This includes the negotiated features and a 64-bit (8-byte) [**nonce**](#gt_001c0e40-0980-417d-853c-f7cb34ba6d3b) value for the ServerChallenge value. The nonce is a pseudo-random number generated by the server and intended for one-time use. The flags returned as part of the CHALLENGE\_MESSAGE in this step indicate which variant the server wants to use and whether the server's [**domain name**](#gt_45a1c9f1-0263-49a8-97c7-7aca1a99308c) or machine name are present in the **TargetName** field.

If ServerRequire128bitEncryption == TRUE, then if 128-bit encryption is not negotiated then the server MUST return SEC\_E\_UNSUPPORTED\_FUNCTION ([MS-ERREF] section 2.1.1) to the application.

The server processes the NEGOTIATE\_MESSAGE and constructs a CHALLENGE\_MESSAGE per the following pseudocode where all strings are encoded as RPC\_UNICODE\_STRING ([[MS-DTYP]](%5BMS-DTYP%5D.pdf#Section_cca2742956894a16b2b49325d93e4ba2) section 2.3.10).

1. -- Input:
2. -- CfgFlg - Defined in section 3.2.1.
3. -- An NTLM NEGOTIATE\_MESSAGE whose message fields are defined in
4. section 2.2.1.1.
5. --
6. -- Output:
7. -- An NTLM CHALLENGE\_MESSAGE whose message fields are defined in
8. section 2.2.1.2.
9. --
10. -- Functions used:
11. -- AddAVPair(), NIL, NONCE - Defined in section 6.

The server SHOULD return only the capabilities it supports. For example, if a newer client requests capability X and the server only supports capabilities A-U, inclusive, then the server does not return capability X. The CHALLENGE\_MESSAGE **NegotiateFlags** field SHOULD[<64>](#Appendix_A_64" \o "Product behavior note 64) be set to the following:

* All the flags set in CfgFlg (section [3.2.1.1](#Section_d28ae9a9d70a49d59fa5394056e17343))
* The supported flags requested in the NEGOTIATE\_MESSAGE.NegotiateFlags field
* NTLMSSP\_REQUEST\_TARGET
* NTLMSSP\_NEGOTIATE\_NTLM
* NTLMSSP\_NEGOTIATE\_ALWAYS\_SIGN

The **Signature** field MUST be set to the string, "NTLMSSP". The **MessageType** field MUST be set to 0x00000002, indicating a message type of NtLmChallenge. The **ServerChallenge** field MUST be set to an 8-byte nonce.

If the NTLMSSP\_NEGOTIATE\_VERSION flag is set, the **Version** field MUST be set to the current version (section [2.2.2.10](#Section_b1a6ceb2f8ad462bb5aff18527c48175)).

1. If (NTLMSSP\_NEGOTIATE\_UNICODE is set in NEGOTIATE.NegotiateFlags)
2. Set the NTLMSSP\_NEGOTIATE\_UNICODE flag in
3. CHALLENGE\_MESSAGE.NegotiateFlags
4. ElseIf (NTLMSSP\_NEGOTIATE\_OEM flag is set in NEGOTIATE.NegotiateFlag)
5. Set the NTLMSSP\_NEGOTIATE\_OEM flag in
6. CHALLENGE\_MESSAGE.NegotiateFlags
7. EndIf
8. If (NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag
9. is set in NEGOTIATE.NegotiateFlags)
10. Set the NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag in
11. CHALLENGE\_MESSAGE.NegotiateFlags
12. ElseIf (NTLMSSP\_NEGOTIATE\_LM\_KEY flag is set in NEGOTIATE.NegotiateFlag)
13. Set the NTLMSSP\_NEGOTIATE\_LM\_KEY flag in
14. CHALLENGE\_MESSAGE.NegotiateFlags
15. EndIf
16. If (Server is domain joined)
17. Set CHALLENGE\_MESSAGE.TargetName to NbDomainName
18. Set the NTLMSSP\_TARGET\_TYPE\_DOMAIN flag in
19. CHALLENGE\_MESSAGE.NegotiateFlags
20. Else
21. Set CHALLENGE\_MESSAGE.TargetName to NbMachineName
22. Set the NTLMSSP\_TARGET\_TYPE\_SERVER flag in
23. CHALLENGE\_MESSAGE.NegotiateFlags
24. EndIf
25. Set the NTLMSSP\_NEGOTIATE\_TARGET\_INFO and NTLMSSP\_REQUEST\_TARGET flags in
26. CHALLENGE\_MESSAGE.NegotiateFlags
27. If (NbMachineName is not NIL)
28. AddAvPair(TargetInfo, MsvAvNbComputerName, NbMachineName)
29. EndIf
30. If (NbDomainName is not NIL)
31. AddAvPair(TargetInfo, MsvAvNbDomainName, NbDomainName)
32. EndIf
33. If (DnsMachineName is not NIL)
34. AddAvPair(TargetInfo, MsvAvDnsComputerName, DnsMachineName)
35. EndIf
36. If (DnsDomainName is not NIL)
37. AddAvPair(TargetInfo, MsvAvDnsDomainName, DnsDomainName)
38. EndIf
39. If (DnsForestName is not NIL)
40. AddAvPair(TargetInfo, MsvAvDnsTreeName, DnsForestName)
41. EndIf
42. AddAvPair(TargetInfo, MsvAvEOL, NIL)

When this process is complete, the server MUST send the CHALLENGE\_MESSAGE to the client, embedded in an application protocol message, and encoded according to that application protocol.

##### Server Receives an AUTHENTICATE\_MESSAGE from the Client

Upon receipt of the embedded [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce), the server MUST extract and decode the AUTHENTICATE\_MESSAGE.

If **ServerBlock** is set to TRUE then the server MUST return STATUS\_NOT\_SUPPORTED ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.3.1).[<65>](#Appendix_A_65" \o "Product behavior note 65)

If the user name and response are empty, the server authenticates the client as the ANONYMOUS user (see [[MS-DTYP]](%5BMS-DTYP%5D.pdf#Section_cca2742956894a16b2b49325d93e4ba2) section 2.4.2.4). Regardless of whether or not the client is an ANONYMOUS user, if the security features selected by the client are not strong enough for the server security policy, the server MUST return an error to the calling application. Otherwise, the server obtains the [**response key**](#gt_0368db93-c0f9-4ea7-a30e-c04699c1f22d) by looking up the user name in a database. With the NT and LM responses [**keys**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) and the client [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba), the server computes the expected response. If the expected response matches the actual response, then the server MUST generate [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12), signing, and sealing keys; otherwise, it MUST deny the client access.

NTLM servers SHOULD support NTLM clients which incorrectly use NIL for the UserDom for calculating ResponseKeyNT and ResponseKeyLM.

The keys MUST be computed with the following algorithm where all strings are encoded as RPC\_UNICODE\_STRING ([MS-DTYP] section 2.3.10).

1. -- Input:
2. -- CHALLENGE\_MESSAGE.ServerChallenge - The ServerChallenge field
3. from the server CHALLENGE\_MESSAGE in section 3.2.5.1.1
4. -- NegFlg - Defined in section 3.1.1.
5. -- ServerName - The NETBIOS or the DNS name of the server.
6. -- An NTLM NEGOTIATE\_MESSAGE whose message fields are defined
7. in section 2.2.1.1.
8. -- An NTLM AUTHENTICATE\_MESSAGE whose message fields are defined
9. in section 2.2.1.3.
10. --- An NTLM AUTHENTICATE\_MESSAGE whose message fields are
11. defined in section 2.2.1.3 with the MIC field set to 0.
12. -- OPTIONAL ServerChannelBindingsUnhashed - Defined in
13. section 3.2.1.2
14. ---- Output:      Result of authentication
15. -- ClientHandle - The handle to a key state structure corresponding
16. -- to the current state of the ClientSealingKey
17. -- ServerHandle - The handle to a key state structure corresponding
18. -- to the current state of the ServerSealingKey
19. -- The following NTLM keys generated by the server are defined in
20. section 3.1.1:
21. -- ExportedSessionKey, ClientSigningKey, ClientSealingKey,
22. ServerSigningKey, and ServerSealingKey.
23. ---- Temporary variables that do not pass over the wire are defined
24. below:
25. -- KeyExchangeKey, ResponseKeyNT, ResponseKeyLM, SessionBaseKey
26. - Temporary variables used to store 128-bit keys.
27. -- MIC - message integrity for the NTLM NEGOTIATE\_MESSAGE,
28. CHALLENGE\_MESSAGE and AUTHENTICATE\_MESSAGE
29. -- MessageMIC - Temporary variable used to hold the original value of
30. the MIC field to compare the computed value.
31. -- Time - Temporary variable used to hold the 64-bit current time from the
32. NTLMv2\_CLIENT\_CHALLENGE.Timestamp, in the format of a
33. FILETIME as defined in [MS-DTYP] section 2.3.1.
34. -- ChallengeFromClient – Temporary variable to hold the client's 8-byte
35. challenge, if used.
36. -- ExpectedNtChallengeResponse
37. - Temporary variable to hold results
38. returned from ComputeResponse.
39. -- ExpectedLmChallengeResponse
40. - Temporary variable to hold results
41. returned from ComputeResponse.
42. -- NullSession – Temporary variable to denote whether client has
43. explicitly requested to be anonymously authenticated.
44. ---- Functions used:
45. -- ComputeResponse
46. - Defined in section 3.3
47. -- KXKEY, SIGNKEY, SEALKEY
48. - Defined in sections 3.4.5, 3.4.6, and 3.4.7
49. -- GetVersion(), NIL - Defined in section 6
50. Set NullSession to FALSE
51. Set GuestSession to FALSE
52. If (AUTHENTICATE\_MESSAGE.UserNameLen == 0 AND
53. AUTHENTICATE\_MESSAGE.NtChallengeResponse.Length == 0 AND
54. (AUTHENTICATE\_MESSAGE.LmChallengeResponse == Z(1)
55. OR
56. AUTHENTICATE\_MESSAGE.LmChallengeResponse.Length == 0))
57. -- Special case: client requested anonymous authentication
58. Set NullSession to TRUE
59. Else
60. Retrieve the ResponseKeyNT and ResponseKeyLM from the local user
61. account database using the UserName and DomainName specified in the
62. AUTHENTICATE\_MESSAGE.
63. If AUTHENTICATE\_MESSAGE.NtChallengeResponseFields.NtChallengeResponseLen > 0x0018
64. Set ChallengeFromClient to NTLMv2\_RESPONSE.NTLMv2\_CLIENT\_CHALLENGE.ChallengeFromClient
65. ElseIf NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY is set in NegFlg
66. Set ChallengeFromClient to LM\_RESPONSE.Response[0..7]
67. Else
68. Set ChallengeFromClient to NIL
69. EndIf
70. Set ExpectedNtChallengeResponse, ExpectedLmChallengeResponse,
71. SessionBaseKey to ComputeResponse(NegFlg, ResponseKeyNT,
72. ResponseKeyLM, CHALLENGE\_MESSAGE.ServerChallenge,
73. ChallengeFromClient, Time, ServerName)
74. Set KeyExchangeKey to KXKEY(SessionBaseKey,
75. AUTHENTICATE\_MESSAGE.LmChallengeResponse, CHALLENGE\_MESSAGE.ServerChallenge)
76. If (AUTHENTICATE\_MESSAGE.NtChallengeResponse !=
77. ExpectedNtChallengeResponse)
78. If (AUTHENTICATE\_MESSAGE.LmChallengeResponse !=
79. ExpectedLmChallengeResponse)
80. Retry using NIL for the domain name: Retrieve the ResponseKeyNT
81. and ResponseKeyLM from the local user account database using
82. the UserName specified in the AUTHENTICATE\_MESSAGE and
83. NIL for the DomainName.
84. Set ExpectedNtChallengeResponse, ExpectedLmChallengeResponse,
85. SessionBaseKey to ComputeResponse(NegFlg, ResponseKeyNT,
86. ResponseKeyLM, CHALLENGE\_MESSAGE.ServerChallenge,
87. ChallengeFromClient, Time, ServerName)
88. Set KeyExchangeKey to KXKEY(SessionBaseKey,
89. AUTHENTICATE\_MESSAGE.LmChallengeResponse,
90. CHALLENGE\_MESSAGE.ServerChallenge)
91. If (AUTHENTICATE\_MESSAGE.NtChallengeResponse !=
92. ExpectedNtChallengeResponse)
93. If (AUTHENTICATE\_MESSAGE.LmChallengeResponse !=
94. ExpectedLmChallengeResponse)
95. If (Guest user is not disabled AND Guest user has no password set AND
 UserName does not exist in user account database)
96. --Special case: User can be logged in as Guest user
97. Set GuestSession to TRUE
98. Else
99. Return INVALID message error
100. EndIf
101. EndIf
102. EndIf
103. EndIf
104. EndIf
105. EndIf
106. Set MessageMIC to AUTHENTICATE\_MESSAGE.MIC
107. Set AUTHENTICATE\_MESSAGE.MIC to Z(16)
108. If (NTLMSSP\_NEGOTIATE\_KEY\_EXCH flag is set in NegFlg
109. AND (NTLMSSP\_NEGOTIATE\_SIGN OR NTLMSSP\_NEGOTIATE\_SEAL are set in NegFlg) )
110. Set ExportedSessionKey to RC4K(KeyExchangeKey,
111. AUTHENTICATE\_MESSAGE.EncryptedRandomSessionKey)
112. Else
113. Set ExportedSessionKey to KeyExchangeKey
114. EndIf
115. Set MIC to HMAC\_MD5(ExportedSessionKey, ConcatenationOf(
116. NEGOTIATE\_MESSAGE, CHALLENGE\_MESSAGE,
117. AUTHENTICATE\_MESSAGE))
118. Set ClientSigningKey to SIGNKEY(NegFlg, ExportedSessionKey , "Client")
119. Set ServerSigningKey to SIGNKEY(NegFlg, ExportedSessionKey , "Server")
120. Set ClientSealingKey to SEALKEY(NegFlg, ExportedSessionKey , "Client")
121. Set ServerSealingKey to SEALKEY(NegFlg, ExportedSessionKey , "Server")
122. RC4Init(ClientHandle, ClientSealingKey)
123. RC4Init(ServerHandle, ServerSealingKey)

If NullSession is TRUE, the server authenticates the client as the ANONYMOUS user account (see [MS-DTYP] section 2.4.2.4).

If NullSession is TRUE, a SessionBaseKey with all-zeroes, Z(16), is used.

If GuestSession is TRUE, the server authenticates the client as the Guest user account (see [MS-DTYP] section 2.4.2.4).

If GuestSession is TRUE, a SessionBaseKey with all-zeroes, Z(16), is used.

If NTLM v2 authentication is used and channel binding is provided by the application, then the server MUST verify the channel binding:[<66>](#Appendix_A_66" \o "Product behavior note 66)

* If ServerChannelBindingsUnhashed (section [3.2.1.2](#Section_42fc475e4e8b471c8e55266f29a6619f)) is not NULL
	+ If the AUTHENTICATE\_MESSAGE contains a nonzero MsvAvChannelBindings AV\_PAIR
		- If MD5\_HASH(ServerChannelBindingsUnhashed) != MsvAvChannelBindings.AvPair.Value)
			* The server MUST return GSS\_S\_BAD\_BINDINGS
		- Else the server MUST return GSS\_S\_BAD\_BINDINGS
	+ Else If ApplicationRequiresCBT (section 3.2.1.2) == TRUE
		- If the AUTHENTICATE\_MESSAGE does not contain a nonzero MsvAvChannelBindings AV\_PAIR
			* The server MUST return GSS\_S\_BAD\_BINDINGS
* If the AUTHENTICATE\_MESSAGE contains an MsvAvTargetName
	+ If MsvAvFlags bit 0x00000004 is set, the server MUST set ClientSuppliedTargetName (section [3.1.1.2](#Section_a4a41f0dca2744bfad1d6f8c3a3796f2)) to NULL.[<67>](#Appendix_A_67" \o "Product behavior note 67)
	+ AvID == MsvAvTargetName
	+ Value == ClientSuppliedTargetName

If the AUTHENTICATE\_MESSAGE indicates the presence of a **MIC** field,[<68>](#Appendix_A_68" \o "Product behavior note 68) then the MIC value computed earlier MUST be compared to MessageMIC, and if the two MIC values are not equal, then an authentication failure MUST be returned. An AUTHENTICATE\_MESSAGE indicates the presence of a **MIC** field if the **TargetInfo** field has an AV\_PAIR structure whose two fields:

* AvId == MsvAvFlags
* Value bit 0x2 == 1

If NTLM v2 authentication is used and the AUTHENTICATE\_MESSAGE.NtChallengeResponse.TimeStamp (section [2.2.2.7](#Section_aee311d621a7447092a5c4ecb022a87b)) is more than **MaxLifetime** (section [3.1.1.1](#Section_f711d05939834b9dafbbff2f8c97ffbf)) difference from the server time, then the server SHOULD return a failure.[<69>](#Appendix_A_69" \o "Product behavior note 69)

Both the client and the server now have the session, signing, and sealing keys. When the client runs an integrity check on the next message from the server, it detects that the server has determined (either directly or indirectly) the user password.

**Note** User names MUST be case-insensitive. For additional information about the case sensitivity of user names, see [[MS-AUTHSOD]](%5BMS-AUTHSOD%5D.pdf#Section_953d700a57cb4cf7b0c3a64f34581cc9) section 1.1.1.2.

#### Connectionless NTLM

The server action for connectionless NTLM authentication is similar to that of connection-oriented authentication (section [3.1.5.1](#Section_1f18ef3b7d624e1aa8a76bc0607fad70)). However, the first message sent in connectionless authentication is the CHALLENGE\_MESSAGE from the server to the client; there is no client-initiated NEGOTIATE\_MESSAGE as in the connection-oriented authentication.

The message processing for connectionless NTLM authentication[<70>](#Appendix_A_70" \o "Product behavior note 70) is as specified in the following sections.

##### Server Sends the Client an Initial CHALLENGE\_MESSAGE

The server MUST send a set of supported features and a random [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) to use as part of the [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba). This key is in the form of a 64-bit (8-byte) [**nonce**](#gt_001c0e40-0980-417d-853c-f7cb34ba6d3b) value for the ServerChallenge value. The nonce is a pseudo-random number generated by the server and intended for one-time use. The connectionless variant always uses key exchange, so the NTLMSSP\_NEGOTIATE\_KEY\_EXCH flag MUST be set in the required flags mask. The client SHOULD determine the set of supported features and whether those meet minimum security requirements. This message is sent to the client as a [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786).

##### Server Response Checking

If **ServerBlock** == TRUE, then the server MUST return STATUS\_NOT\_SUPPORTED ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.3.1). [<71>](#Appendix_A_71" \o "Product behavior note 71)

If ServerRequire128bitEncryption == TRUE, then if 128-bit encryption is not negotiated then the server MUST return SEC\_E\_UNSUPPORTED\_FUNCTION ([MS-ERREF] section 2.1.1) to the application. [<72>](#Appendix_A_72" \o "Product behavior note 72)

The client MUST compute the expected [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) for signing and encryption, which it sends to the server in the AUTHENTICATE\_MESSAGE (section [3.1.5.2.1](#Section_8bbf686d06d145119502b0c071f9d6d7)). Using this [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) from the AUTHENTICATE\_MESSAGE, the server MUST check the signature and/or decrypt the protocol response, and compute a response. The response MUST be signed and/or encrypted and sent to the client.

1. Set MIC to HMAC\_MD5(ResponseKeyNT, ConcatenationOf(
2. CHALLENGE\_MESSAGE, AUTHENTICATE\_MESSAGE))

If the [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) indicates the presence of a **MIC** field,[<73>](#Appendix_A_73" \o "Product behavior note 73) then the MIC value computed earlier MUST be compared to the MIC field in the message, and if the two MIC values are not equal, then an authentication failure MUST be returned. An AUTHENTICATE\_MESSAGE indicates the presence of a **MIC** field if the **TargetInfo** field has an AV\_PAIR structure whose two fields:

* AvId == MsvAvFlags
* Value bit 0x2 == 1
1. If (NTLMSSP\_NEGOTIATE\_KEY\_EXCH flag is set in NegFlg
2. AND (NTLMSSP\_NEGOTIATE\_SIGN OR NTLMSSP\_NEGOTIATE\_SEAL are set in NegFlg) )
3. Set ExportedSessionKey to RC4K(KeyExchangeKey,
4. AUTHENTICATE\_MESSAGE.EncryptedRandomSessionKey)
5. Set MIC to HMAC\_MD5(ExportedSessionKey, ConcatenationOf(
6. NEGOTIATE\_MESSAGE, CHALLENGE\_MESSAGE,
7. AUTHENTICATE\_MESSAGE))
8. Else
9. Set MIC to HMAC\_MD5(KeyExchangeKey, ConcatenationOf(
10. NEGOTIATE\_MESSAGE, CHALLENGE\_MESSAGE,
11. AUTHENTICATE\_MESSAGE))
12. Endif

If NTLM v2 authentication is used and the AUTHENTICATE\_MESSAGE.NtChallengeResponse.TimeStamp (section [2.2.2.7](#Section_aee311d621a7447092a5c4ecb022a87b)) is more than **MaxLifetime** (section [3.1.1.1](#Section_f711d05939834b9dafbbff2f8c97ffbf)) difference from the server time, then the server SHOULD return a failure.[<74>](#Appendix_A_74" \o "Product behavior note 74)

If NTLM v2 authentication is used and channel binding is provided by the application, then the server MUST verify the channel binding[<75>](#Appendix_A_75" \o "Product behavior note 75):

* If ServerChannelBindingsUnhashed (section [3.2.1.2](#Section_42fc475e4e8b471c8e55266f29a6619f)) is not NULL
	+ If the AUTHENTICATE\_MESSAGE contains a nonzero MsvAvChannelBindings AV\_PAIR
		- If MD5\_HASH(ServerChannelBindingsUnhashed) != MsvAvChannelBindings.AvPair.Value)
			* The server MUST return GSS\_S\_BAD\_BINDINGS
		- Else the server MUST return GSS\_S\_BAD\_BINDINGS
	+ Else If ApplicationRequiresCBT (section 3.2.1.2) == TRUE
		- If the AUTHENTICATE\_MESSAGE does not contain a nonzero MsvAvChannelBindings AV\_PAIR
			* The server MUST return GSS\_S\_BAD\_BINDINGS
* If the AUTHENTICATE\_MESSAGE contains a MsvAvTargetName
	+ If MsvAvFlags bit 0x00000004 is set, the server MUST set ClientSuppliedTargetName (section [3.1.1.2](#Section_a4a41f0dca2744bfad1d6f8c3a3796f2)) to NULL.[<76>](#Appendix_A_76" \o "Product behavior note 76)
	+ AvID == MsvAvTargetName
	+ Value == ClientSuppliedTargetName

### Timer Events

None.

### Other Local Events

None.

## NTLM v1 and NTLM v2 Messages

This section provides further details about how the client and server compute the responses depending on whether NTLM v1 or NTLM v2 is used. It also includes details about the [**NTOWF**](#gt_7a2805fa-1dcd-4b4e-a8e4-2a2bcc8651e9) and [**LMOWF**](#gt_fd74ef50-cb97-4acd-b537-4941bdd9e064) functions whose output is subsequently used to compute the response.

### NTLM v1 Authentication

The following pseudocode defines the details of the algorithms used to calculate the [**keys**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) used in NTLM v1 authentication.

**Note**  The LM and NTLM authentication versions are not negotiated by the protocol. It MUST be configured on both the client and the server prior to authentication. The [**NTOWF**](#gt_7a2805fa-1dcd-4b4e-a8e4-2a2bcc8651e9) v1 function defined in this section is NTLM version-dependent and is used only by NTLM v1. The [**LMOWF**](#gt_fd74ef50-cb97-4acd-b537-4941bdd9e064) v1 function defined in this section is also version-dependent and is used only by LM and NTLM v1.

The NT and LM [**response keys**](#gt_0368db93-c0f9-4ea7-a30e-c04699c1f22d) MUST be encoded using the following specific one-way functions where all strings are encoded as RPC\_UNICODE\_STRING ([[MS-DTYP]](%5BMS-DTYP%5D.pdf#Section_cca2742956894a16b2b49325d93e4ba2) section 2.3.10).

Explanation of message fields and variables:

**ClientChallenge**: The 8-byte challenge message generated by the client.

**LmChallengeResponse**: The LM response to the server challenge. This field is computed by the client.

**NegFlg, User, UserDom**: Defined in section 3.3.1.

**NTChallengeResponse**: The NT response to the server challenge. This field is computed by the client.

**Passwd**: Password of the user. If the password is longer than 14 characters, the LMOWF v1 cannot be computed. For LMOWF v1, if the password is shorter than 14 characters, it is padded by appending zeroes.

**ResponseKeyNT**: Temporary variable to hold the results of calling NTOWF().

**ResponseKeyLM**: Temporary variable to hold the results of calling LMGETKEY.

**CHALLENGE\_MESSAGE.ServerChallenge**: The 8-byte challenge message generated by the server.

1. --
2. -- Functions Used:
3. -- Z(M)- Defined in section 6.
4. Define NTOWFv1(Passwd, User, UserDom) as MD4(UNICODE(Passwd))
5. EndDefine
6. Define LMOWFv1(Passwd, User, UserDom) as
7. ConcatenationOf( DES( UpperCase( Passwd)[0..6],"KGS!@#$%"),
8. DES( UpperCase( Passwd)[7..13],"KGS!@#$%"))
9. EndDefine
10. Set ResponseKeyNT to NTOWFv1(Passwd, User, UserDom)
11. Set ResponseKeyLM to LMOWFv1( Passwd, User, UserDom )
12. Define ComputeResponse(NegFlg, ResponseKeyNT, ResponseKeyLM,
13. CHALLENGE\_MESSAGE.ServerChallenge, ClientChallenge, Time, ServerName)
14. As
15. If (User is set to "" AND Passwd is set to "")
16. -- Special case for anonymous authentication
17. Set NtChallengeResponseLen to 0
18. Set NtChallengeResponseMaxLen to 0
19. Set NtChallengeResponseBufferOffset to 0
20. Set LmChallengeResponse to Z(1)
21. ElseIf
22. If (NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag is set in NegFlg)
23. Set NtChallengeResponse to DESL(ResponseKeyNT,
24. MD5(ConcatenationOf(CHALLENGE\_MESSAGE.ServerChallenge,
25. ClientChallenge))[0..7])
26. Set LmChallengeResponse to ConcatenationOf{ClientChallenge,
27. Z(16)}
28. Else
29. Set NtChallengeResponse to DESL(ResponseKeyNT,
30. CHALLENGE\_MESSAGE.ServerChallenge)
31. If (NoLMResponseNTLMv1 is TRUE)
32. Set LmChallengeResponse to NtChallengeResponse
33. Else
34. Set LmChallengeResponse to DESL(ResponseKeyLM,
35. CHALLENGE\_MESSAGE.ServerChallenge)
36. EndIf
37. EndIf
38. EndIf
39. Set SessionBaseKey to MD4(NTOWF)

On the server, if the user account to be authenticated is hosted in [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90), the [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba)-response pair MUST be sent to the [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) to verify ([[MS-APDS]](%5BMS-APDS%5D.pdf#Section_dd444344fd7e430eb3137e95ab9c338e) section 3.1.5).

The DC calculates the expected value of the response using the NTOWF v1 and/or LMOWF v1, and matches it against the response provided. If the response values match, it MUST send back the SessionBaseKey; otherwise, it MUST return an error to the calling application. The server MUST return an error to the calling application if the DC returns an error. If the DC returns STATUS\_NTLM\_BLOCKED, then the server MUST return STATUS\_NOT\_SUPPORTED ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.3.1).

If the user account to be authenticated is hosted locally on the server, the server calculates the expected value of the response using the NTOWF v1 and/or LMOWF v1 stored locally, and matches it against the response provided. If the response values match, it MUST calculate KeyExchangeKey; otherwise, it MUST return an error to the calling application.[<77>](#Appendix_A_77" \o "Product behavior note 77)

### NTLM v2 Authentication

The following pseudocode defines the details of the algorithms used to calculate the [**keys**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) used in NTLM v2 authentication.

**Note**  The NTLM authentication version is not negotiated by the protocol. It MUST be configured on both the client and the server prior to authentication. The [**NTOWF**](#gt_7a2805fa-1dcd-4b4e-a8e4-2a2bcc8651e9) v2 and [**LMOWF**](#gt_fd74ef50-cb97-4acd-b537-4941bdd9e064) v2 functions defined in this section are NTLM version-dependent and are used only by NTLM v2.

NTLM clients SHOULD use **UserDom** for calculating ResponseKeyNT and ResponseKeyLM.

The NT and LM [**response keys**](#gt_0368db93-c0f9-4ea7-a30e-c04699c1f22d) MUST be encoded using the following specific one-way functions where all strings are encoded as RPC\_UNICODE\_STRING ([[MS-DTYP]](%5BMS-DTYP%5D.pdf#Section_cca2742956894a16b2b49325d93e4ba2) section 2.3.10).

Explanation of message fields and variables:

**NegFlg, User, UserDom:** Defined in section [3.1.1](#Section_168f2c513ac74dffada7ba7cdba28ca3).

**Passwd**: Password of the user.

**LmChallengeResponse**: The LM response to the server challenge. Computed by the client.

**NTChallengeResponse**: The NT response to the server challenge. Computed by the client.

**ClientChallenge**: The 8-byte challenge message generated by the client.

**CHALLENGE\_MESSAGE.ServerChallenge**: The 8-byte challenge message generated by the server.

**ResponseKeyNT**: Temporary variable to hold the results of calling NTOWF().

**ResponseKeyLM**: Temporary variable to hold the results of calling LMGETKEY.

**ServerName:** The NtChallengeResponseFields.NTLMv2\_RESPONSE.NTLMv2\_CLIENT\_CHALLENGE.AvPairs field structure of the AUTHENTICATE\_MESSAGE payload.

**KeyExchangeKey**: Temporary variable to hold the results of calling KXKEY.

**HiResponserversion**: The 1-byte highest response version understood by the client. Currently set to 1.

**Responserversion**: The 1-byte response version. Currently set to 1.

**Time**: The 8-byte little-endian time in GMT.

Functions Used:

**Z(M)**: Defined in section [6](#Section_26c42637954946aebe2e90f6f1360193).

1. Define NTOWFv2(Passwd, User, UserDom) as HMAC\_MD5(
2. MD4(UNICODE(Passwd)), UNICODE(ConcatenationOf( Uppercase(User),
3. UserDom ) ) )
4. EndDefine
5. Define LMOWFv2(Passwd, User, UserDom) as NTOWFv2(Passwd, User,
6. UserDom)
7. EndDefine
8. Set ResponseKeyNT to NTOWFv2(Passwd, User, UserDom)
9. Set ResponseKeyLM to LMOWFv2(Passwd, User, UserDom)
10. Define ComputeResponse(NegFlg, ResponseKeyNT, ResponseKeyLM,
11. CHALLENGE\_MESSAGE.ServerChallenge, ClientChallenge, Time, ServerName)
12. As
13. If (User is set to "" && Passwd is set to "")
14. -- Special case for anonymous authentication
15. Set NtChallengeResponseLen to 0
16. Set NtChallengeResponseMaxLen to 0
17. Set NtChallengeResponseBufferOffset to 0
18. Set LmChallengeResponse to Z(1)
19. Else
20. Set temp to ConcatenationOf(Responserversion, HiResponserversion,
21. Z(6), Time, ClientChallenge, Z(4), ServerName, Z(4))
22. Set NTProofStr to HMAC\_MD5(ResponseKeyNT,
23. ConcatenationOf(CHALLENGE\_MESSAGE.ServerChallenge,temp))
24. Set NtChallengeResponse to ConcatenationOf(NTProofStr, temp)
25. Set LmChallengeResponse to ConcatenationOf(HMAC\_MD5(ResponseKeyLM,
26. ConcatenationOf(CHALLENGE\_MESSAGE.ServerChallenge, ClientChallenge)),
27. ClientChallenge )
28. EndIf
29. Set SessionBaseKey to HMAC\_MD5(ResponseKeyNT, NTProofStr)
30. EndDefine

On the server, if the user account to be authenticated is hosted in [**Active Directory**](#gt_e467d927-17bf-49c9-98d1-96ddf61ddd90), the challenge-response pair SHOULD be sent to the [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) to verify ([[MS-APDS]](%5BMS-APDS%5D.pdf#Section_dd444344fd7e430eb3137e95ab9c338e)).

The DC calculates the expected value of the response using the [**NTOWF v2**](#gt_5ea644f7-7dc8-4f0c-94c7-7c2c086cd753) and/or [**LMOWF v2**](#gt_7e5a734b-a121-43e9-81a4-4b59a21c3ade), and matches it against the response provided. If the response values match, it MUST send back the SessionBaseKey; otherwise, it MUST return an error to the calling application. The server MUST return an error to the calling application if the DC returns an error. If the DC returns STATUS\_NTLM\_BLOCKED then the server MUST return STATUS\_NOT\_SUPPORTED ([[MS-ERREF]](%5BMS-ERREF%5D.pdf#Section_1bc92ddfb79e413cbbaa99a5281a6c90) section 2.3.1).

If the user account to be authenticated is hosted locally on the server, the server calculates the expected NTOWF v2 and/or LMOWF v2 value of the response using the NTOWF and/or LMOWF stored locally, and matches it against the response provided. If the response values match, it MUST calculate KeyExchangeKey; otherwise, it MUST return an error to the calling application.[<78>](#Appendix_A_78" \o "Product behavior note 78)

## Session Security Details

If it is negotiated, [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff) provides message integrity (signing) and message confidentiality (sealing). When NTLM v2 authentication is not negotiated, only one [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) is used for sealing. As a result, operations are performed in a half-duplex mode: the client sends a message and then waits for a server response. For information on how key exchange, signing, and sealing keys are generated, see [KXKEY](#Section_d86303b5b29e4fb9b11977579c761370), [SIGNKEY](#Section_524cdccb563e479392b07bc321fce096), and [SEALKEY](#Section_bf39181de95d40d7a740ab4ec3dc363d).

In connection-oriented mode, messages are assumed to be received in the order sent. The application or communications protocol is expected to guarantee this property. As a result, the client and server sealing keys are computed only once per [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12).

For the case of Guest user login, there is no session security.

**Note**  In connectionless mode, messages can arrive out of order. Because of this, the sealing key MUST be reset for every message. Rekeying with the same sealing key for multiple messages would not maintain message security. Therefore, a per-message sealing key, SealingKey', is computed as the MD5 hash of the original sealing key and the message [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3). The resulting SealingKey' value is used to reinitialize the key state structure prior to invoking the following SIGN, SEAL, and MAC algorithms. To compute the SealingKey' and initialize the key state structure identified by the Handle parameter, use the following:

1. SealingKey' = MD5(ConcatenationOf(SealingKey, SequenceNumber))
2. RC4Init(Handle, SealingKey')

### Abstract Data Model

NTLM session security is provided through the [**SSPI**](#gt_fb216516-748b-4873-8bdd-64c5f4da9920). Variables are maintained per security context.

The following variables are maintained across the NTLM authentication sequence:

* ClientHandle (Public): The handle to a key state structure corresponding to the current state of the ClientSealingKey.
* ServerHandle (Public): The handle to a key state structure corresponding to the current state of the ServerSealingKey.

The following define the [**services**](#gt_2dc07ca2-2b40-437e-a5ec-ed28ebfb116a) provided by the NTLM SSP.

**Note**  The following variables are logical, abstract parameters that an implementation has to maintain and expose to provide the proper level of service. How these variables are maintained and exposed is up to the implementation.

* Integrity: Indicates that the caller wishes to construct signed messages so that they cannot be tampered with while in transit. If the client requests integrity, then the server MUST respond with integrity if supported or MUST NOT respond with integrity if not supported.
* Sequence Detect: Indicates that the caller wishes to construct signed messages such that out-of-order sequences can be detected. For more details, see section [3.4.2](#Section_131b00627958460ebca5c7a9f9086652).
* Confidentiality: Indicates that the caller wishes to encrypt messages such that they cannot be read while in transit. If the client requests confidentiality, then the server MUST respond with confidentiality if supported or MUST NOT respond with confidentiality if not supported.
* MessageBlockSize: An integer that indicates the minimum size of the input\_message for GSS\_WrapEx (section [3.4.6](#Section_a06bfc2b30fc4483b876a9386f4808ed)). The size of the input\_message MUST be a multiple of this value. This value MUST be 1.

 Usage of integrity and confidentiality is the responsibility of the application:

* If confidentiality is established, then the application MUST call GSS\_Wrap() to invoke confidentiality with the NTLM SSP. For more details, see section [3.4.3](#Section_115f9c7dbc304262ae96254555c14ea6), Message Confidentiality.
* If integrity is established, then the application MUST call GSS\_GetMIC() to invoke integrity with the NTLM SSP. For more details, see section 3.4.2.

### Message Integrity

The function to sign a message MUST be calculated as follows:

1. -- Input:
2. -- SigningKey - The key used to sign the message.
3. -- Message - The message being sent between the client and server.
4. -- SeqNum - Defined in section 3.1.1.
5. -- Handle - The handle to a key state structure corresponding to
6. -- the current state of the SealingKey
7. --
8. -- Output:      Signed message
9. -- Functions used:
10. -- ConcatenationOf() - Defined in Section 6.
11. -- MAC() - Defined in sections 3.4.4.1 and 3.4.4.2.
12. Define SIGN(Handle, SigningKey, SeqNum, Message) as
13. ConcatenationOf(Message, MAC(Handle, SigningKey, SeqNum, Message))
14. EndDefine

The format of the message integrity data that is appended to each message for signing and sealing purposes is defined by the NTLMSSP\_MESSAGE\_SIGNATURE structure (section [2.2.2.9](#Section_b192b940a50843298513efb3342f2c85)).

**Note**  If the client is sending the message, the signing [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) is the one that the client calculated. If the server is sending the message, the signing key is the one that the server calculated. The same is true for the sealing key. The [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) can be explicitly provided by the application protocol or by the NTLM security [**service**](#gt_2dc07ca2-2b40-437e-a5ec-ed28ebfb116a) provider. If the latter is chosen, the sequence number is initialized to zero and then incremented by one for each message sent.

On receipt, the [**message authentication code (MAC)**](#gt_3a669297-5242-417e-bff9-5828a186fcf8) value is computed and compared with the received value. If they differ, the message MUST be discarded (section [3.4.4](#Section_bd5ae0a8a13146a8891b0dc2b9ca9bf7)).

### Message Confidentiality

Message confidentiality, if it is negotiated, also implies message integrity. If message confidentiality is negotiated, a sealed (and implicitly signed) message is sent instead of a signed or unsigned message. The function that seals a message using the signing [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b), sealing key, and message [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) is as follows.

1. -- Input:
2. -- SigningKey - The key used to sign the message.
3. -- Message - The message to be sealed, as provided to the application.
4. -- NegFlg, SeqNum - Defined in section 3.1.1.
5. -- Handle - The handle to a key state structure corresponding to the
6. -- current state of the SealingKey
7. --
8. -- Output:
9. -- Sealed message – The encrypted message
10. -- Signature – The checksum of the Sealed message
11. --
12. -- Functions used:
13. -- RC4() - Defined in Section 6 and 3.1.
14. -- MAC() - Defined in Section 3.4.4.1 and 3.4.4.2.
15. Define SEAL(Handle, SigningKey, SeqNum, Message) as
16. Set Sealed message to RC4(Handle, Message)
17. Set Signature to MAC(Handle, SigningKey, SeqNum, Message)
18. EndDefine

Message confidentiality is available in connectionless mode only if the client configures extended [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff).

### Message Signature Functions

In the case of connectionless NTLM authentication, the *SeqNum* parameter SHOULD be specified by the application and the RC4 stream MUST be reinitialized before each message (see section [3.4](#Section_d1c86e81eb6647fd8a6f970050121347)).

In the case of connection-oriented authentication, the *SeqNum* parameter MUST start at 0 and is incremented by one for each message sent. The receiver expects the first received message to have *SeqNum* equal to 0, and to be one greater for each subsequent message received. If a received message does not contain the expected *SeqNum*, an error MUST be returned to the receiving application, and *SeqNum* is not incremented.

#### Without Extended Session Security

When Extended Session Security (NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY) is not negotiated and session security (NTLMSSP\_NEGOTIATE\_SIGN or NTLMSSP\_NEGOTIATE\_SEAL) is negotiated, the message signature for NTLM without extended session security is a 16-byte value that contains the following components, as described by the NTLMSSP\_MESSAGE\_SIGNATURE structure:

* A 4-byte version-number value that is set to 1.
* A 4-byte random pad.
* The 4-bytes of the message's CRC32.
* The 4-byte [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) (SeqNum).

If message integrity is negotiated, the message signature is calculated as follows:

1. -- Input:
2. -- SigningKey - The key used to sign the message.
3. -- SealingKey - The key used to seal the message or checksum.
4. -- RandomPad - A random number provided by the client. Typically 0.
5. -- Message - The message being sent between the client and server.
6. -- SeqNum - Defined in section 3.1.1.
7. -- Handle - The handle to a key state structure corresponding to the
8. -- current state of the SealingKey
9. --
10. -- Output:
11. -- An NTLMSSP\_MESSAGE\_SIGNATURE structure whose fields are defined
12. in section 2.2.2.9.
13. -- SeqNum - Defined in section 3.1.1.
14. --
15. -- Functions used:
16. -- ConcatenationOf() - Defined in Section 6.
17. -- RC4() - Defined in Section 6.
18. -- CRC32() - Defined in Section 6.
19. Define MAC(Handle, SigningKey, SeqNum, Message) as
20. Set NTLMSSP\_MESSAGE\_SIGNATURE.Version to 0x00000001
21. Set NTLMSSP\_MESSAGE\_SIGNATURE.Checksum to CRC32(Message)
22. Set NTLMSSP\_MESSAGE\_SIGNATURE.RandomPad RC4(Handle, RandomPad)
23. Set NTLMSSP\_MESSAGE\_SIGNATURE.Checksum to RC4(Handle,
24. NTLMSSP\_MESSAGE\_SIGNATURE.Checksum)
25. Set NTLMSSP\_MESSAGE\_SIGNATURE.SeqNum to RC4(Handle, 0x00000000)
26. If (connection oriented)
27. Set NTLMSSP\_MESSAGE\_SIGNATURE.SeqNum to
28. NTLMSSP\_MESSAGE\_SIGNATURE.SeqNum XOR SeqNum
29. Set SeqNum to SeqNum + 1
30. Else
31. Set NTLMSSP\_MESSAGE\_SIGNATURE.SeqNum to
32. NTLMSSP\_MESSAGE\_SIGNATURE.SeqNum XOR
33. (application supplied SeqNum)
34. Endif
35. Set NTLMSSP\_MESSAGE\_SIGNATURE.RandomPad to 0
36. EndDefine

#### With Extended Session Security

When Extended Session Security (NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY) is negotiated and session security (NTLMSSP\_NEGOTIATE\_SIGN or NTLMSSP\_NEGOTIATE\_SEAL) is negotiated, the message signature for NTLM with extended session security is a 16-byte value that contains the following components, as described by the NTLMSSP\_MESSAGE\_SIGNATURE structure:

* A 4-byte version-number value that is set to 1.
* The first eight bytes of the message's HMAC\_MD5.
* The 4-byte [**sequence number**](#gt_9c2d7dfc-4958-48b1-bbab-f23e97e71ff3) (*SeqNum*).

If message integrity is negotiated, the message signature is calculated as follows:

1. -- Input:
2. -- SigningKey - The key used to sign the message.
3. -- SealingKey - The key used to seal the message or checksum.
4. -- Message - The message being sent between the client and server.
5. -- SeqNum - Defined in section 3.1.1.
6. -- Handle - The handle to a key state structure corresponding to the
7. -- current state of the SealingKey
8. --
9. -- Output:
10. -- An NTLMSSP\_MESSAGE\_SIGNATURE structure whose fields are defined
11. in section 2.2.2.9.
12. -- SeqNum - Defined in section 3.1.1.
13. --
14. -- Functions used:
15. -- ConcatenationOf() - Defined in Section 6.
16. -- RC4() - Defined in Section 6.
17. -- HMAC\_MD5() - Defined in Section 6.
18. Define MAC(Handle, SigningKey, SeqNum, Message) as
19. Set NTLMSSP\_MESSAGE\_SIGNATURE.Version to 0x00000001
20. Set NTLMSSP\_MESSAGE\_SIGNATURE.Checksum to
21. HMAC\_MD5(SigningKey,
22. ConcatenationOf(SeqNum, Message))[0..7]
23. Set NTLMSSP\_MESSAGE\_SIGNATURE.SeqNum to SeqNum
24. Set SeqNum to SeqNum + 1
25. EndDefine

If a [**key exchange key**](#gt_5f9cd8ed-6284-46f0-aaf1-9e9f0f6a2db7) is negotiated, the message signature for the NTLM security [**service**](#gt_2dc07ca2-2b40-437e-a5ec-ed28ebfb116a) provider is the same as in the preceding description, except the 8 bytes of the HMAC\_MD5 are encrypted with RC4, as follows:

1. Define MAC(Handle, SigningKey, SeqNum, Message) as
2. Set NTLMSSP\_MESSAGE\_SIGNATURE.Version to 0x00000001
3. Set NTLMSSP\_MESSAGE\_SIGNATURE.Checksum to RC4(Handle,
4. HMAC\_MD5(SigningKey, ConcatenationOf(SeqNum, Message))[0..7])
5. Set NTLMSSP\_MESSAGE\_SIGNATURE.SeqNum to SeqNum
6. Set SeqNum to SeqNum + 1
7. EndDefine

### KXKEY, SIGNKEY, and SEALKEY

This topic specifies how [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) exchange ([KXKEY](#Section_d86303b5b29e4fb9b11977579c761370)), signing ([SIGNKEY](#Section_524cdccb563e479392b07bc321fce096)), and sealing ([SEALKEY](#Section_bf39181de95d40d7a740ab4ec3dc363d)) keys are generated.

#### KXKEY

If NTLM v1 is used and extended [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff) is not negotiated, the 128-bit [**key exchange key**](#gt_5f9cd8ed-6284-46f0-aaf1-9e9f0f6a2db7) value is calculated as follows:

1. -- Input:
2. -- SessionBaseKey - A session key calculated from the user's
3. password.
4. -- LmChallengeResponse - The LM response to the server challenge.
5. Computed by the client.
6. -- NegFlg - Defined in section 3.1.1.
7. --
8. -- Output:
9. -- KeyExchangeKey - The Key Exchange Key.
10. --
11. -- Functions used:
12. -- ConcatenationOf() - Defined in Section 6.
13. -- DES() - Defined in Section 6.
14. Define KXKEY(SessionBaseKey, LmChallengeResponse, ServerChallenge) as
15. If ( NTLMSSP\_NEGOTIATE\_LMKEY flag is set in NegFlg)
16. Set KeyExchangeKey to ConcatenationOf(DES(LMOWF[0..6],
17. LmChallengeResponse[0..7]),
18. DES(ConcatenationOf(LMOWF[7], 0xBDBDBDBDBDBD),
19. LmChallengeResponse[0..7]))
20. Else
21. If ( NTLMSSP\_REQUEST\_NON\_NT\_SESSION\_KEY flag is set in NegFlg)
22. Set KeyExchangeKey to ConcatenationOf(LMOWF[0..7], Z(8)),
23. Else
24. Set KeyExchangeKey to SessionBaseKey
25. Endif
26. Endif
27. EndDefine

If NTLM v1 is used and extended session security is negotiated, the key exchange key value is calculated as follows:

1. -- Input:
2. -- SessionBaseKey - A session key calculated from the user's
3. password.
4. -- ServerChallenge - The 8-byte challenge message
5. generated by the server.
6. -- LmChallengeResponse - The LM response to the server challenge.
7. Computed by the client.
8. --
9. -- Output:
10. -- KeyExchangeKey - The Key Exchange Key.
11. --
12. -- Functions used:
13. -- ConcatenationOf() - Defined in Section 6.
14. -- HMAC\_MD5() - Defined in Section 6.
15. Define KXKEY(SessionBaseKey, LmChallengeResponse, ServerChallenge) as
16. Set KeyExchangeKey to HMAC\_MD5(SessionBaseKey, ConcatenationOf(ServerChallenge, LmChallengeResponse [0..7]))
17. EndDefine

If NTLM v2 is used, KeyExchangeKey MUST be set to the given 128-bit SessionBaseKey value.

#### SIGNKEY

If extended [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff) is not negotiated (section [2.2.2.5](#Section_99d90ff4957f4c8a80e45bfe5a9a9832)), then no signing [**keys**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) are available and message signing is not supported.

If extended session security is negotiated, the signing key is a 128-bit value that is calculated as follows from the random [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) and the null-terminated ASCII constants shown.

Input:

* ExportedSessionKey: A randomly generated session key.
* NegFlg: Defined in section [3.1.1](#Section_168f2c513ac74dffada7ba7cdba28ca3).
* Mode: An enum that defines the local machine performing the computation. Mode always takes the value "Client" or "Server".

Output:

* SignKey - The key used for signing messages.

Functions used:

* ConcatenationOf(), MD5(), NIL - Defined in section [6](#Section_26c42637954946aebe2e90f6f1360193).
1. Define SIGNKEY(NegFlg, ExportedSessionKey, Mode) as
2. If (NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag is set in NegFlg)
3. If (Mode equals "Client")
4. Set SignKey to MD5(ConcatenationOf(ExportedSessionKey,
5. "session key to client-to-server signing key magic
6. constant"))
7. Else
8. Set SignKey to MD5(ConcatenationOf(ExportedSessionKey,
9. "session key to server-to-client signing key magic
10. constant"))
11. Endif
12. Else
13. Set SignKey to NIL
14. Endif
15. EndDefine

#### SEALKEY

The sealing [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) function produces an encryption key from the random [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) and the null-terminated ASCII constants shown.

* If extended [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff) is negotiated, the sealing key has either 40, 56, or 128 bits of entropy stored in a 128-bit value.
* If extended session security is not negotiated, the sealing key has either 40 or 56 bits of entropy stored in a 64-bit value.

**Note**  The MD5 hashes completely overwrite and fill the 64-bit or 128-bit value.

Input:

* ExportedSessionKey - A randomly generated session key.
* NegFlg - Defined in section [3.1.1](#Section_168f2c513ac74dffada7ba7cdba28ca3).
* Mode - An enum that defines the local machine performingthe computation.Mode always takes the value "Client" or "Server".

Output:

* SealKey - The key used for sealing messages.

Functions used:

* ConcatenationOf(), MD5() - Defined in section [6](#Section_26c42637954946aebe2e90f6f1360193).
1. Define SEALKEY(NegFlg, ExportedSessionKey, Mode) as
2. If (NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag is set in NegFlg)
3. If ( NTLMSSP\_NEGOTIATE\_128 is set in NegFlg)
4. Set SealKey to ExportedSessionKey
5. ElseIf ( NTLMSSP\_NEGOTIATE\_56 flag is set in NegFlg)
6. Set SealKey to ExportedSessionKey[0..6]
7. Else
8. Set SealKey to ExportedSessionKey[0..4]
9. Endif
10. If (Mode equals "Client")
11. Set SealKey to MD5(ConcatenationOf(SealKey, "session key to
12. client-to-server sealing key magic constant"))
13. Else
14. Set SealKey to MD5(ConcatenationOf(SealKey, "session key to
15. server-to-client sealing key magic constant"))
16. Endif
17. ElseIf ( (NTLMSSP\_NEGOTIATE\_LM\_KEY is set in NegFlg) or
18. ( (NTLMSSP\_NEGOTIATE\_DATAGRAM is set in NegFlg)
19. and (NTLMRevisionCurrent >= NTLMSSP\_REVISION\_W2K3) ) )
20. If (NTLMSSP\_NEGOTIATE\_56 flag is set in NegFlg)
21. Set SealKey to ConcatenationOf(ExportedSessionKey[0..6], 0xA0)
22. Else
23. Set SealKey to ConcatenationOf(ExportedSessionKey[0..4], 0xE5,
24. 0x38, 0xB0)
25. EndIf
26. Else
27. Set SealKey to ExportedSessionKey
28. Endif
29. EndDefine

### GSS\_WrapEx() Call

This call is an extension to **GSS\_Wrap** [[RFC2743]](https://go.microsoft.com/fwlink/?LinkId=90378) that passes multiple buffers.[<79>](#Appendix_A_79" \o "Product behavior note 79)

Inputs:

* context\_handle CONTEXT HANDLE
* qop\_req INTEGER, -- 0 specifies default QOP
* input\_message ORDERED LIST of:
	+ conf\_req\_flag BOOLEAN
	+ sign BOOLEAN
	+ data OCTET STRING

Outputs:

* major\_status INTEGER
* minor\_status INTEGER
* output\_message ORDERED LIST (in same order as input\_message) of:
	+ conf\_state BOOLEAN
	+ signed BOOLEAN
	+ data OCTET STRING
* signature OCTET STRING

This call is identical to **GSS\_Wrap**, except that it supports multiple input buffers.

The input data can be a list of security buffers.

Input data buffers for which conf\_req\_flag==TRUE are encrypted (section [3.4.3](#Section_115f9c7dbc304262ae96254555c14ea6), Message Confidentiality) in output\_message.

For NTLMv1, input data buffers for which sign==TRUE are included in the message signature. For NTLMv2, all input data buffers are included in the message signature (section [3.4.6.1](#Section_51454920cce44605b5cd22a6cf121ba7)).

#### Signature Creation for GSS\_WrapEx()

Section [3.4.2](#Section_131b00627958460ebca5c7a9f9086652) describes the algorithm used by GSS\_WrapEx() to create the signature. The signature contains the NTLMSSP\_MESSAGE\_SIGNATURE structure (section [2.2.2.9](#Section_b192b940a50843298513efb3342f2c85)).

The [**checksum**](#gt_fa444149-ef93-4512-a278-2e756295630c) is computed over the concatenated input buffers using only the input data buffers where sign==TRUE for NTLMv1 and all of the input data buffers for NTLMv2, including the cleartext data buffers.

### GSS\_UnwrapEx() Call

This call is an extension to **GSS\_Unwrap** [[RFC2743]](https://go.microsoft.com/fwlink/?LinkId=90378) that passes multiple buffers.[<80>](#Appendix_A_80" \o "Product behavior note 80)

Inputs:

* context\_handle CONTEXT HANDLE
* input\_message ORDERED LIST of:
	+ conf\_state BOOLEAN
	+ signed BOOLEAN
	+ data OCTET STRING
* signature OCTET STRING

Outputs:

* qop\_req INTEGER, -- 0 specifies default QOP
* major\_status INTEGER
* minor\_status INTEGER
* output\_message ORDERED LIST (in same order as input\_message) of:
	+ conf\_state BOOLEAN
	+ data OCTET STRING

This call is identical to **GSS\_Unwrap**, except that it supports multiple input buffers. Input data buffers having conf\_state==TRUE are decrypted in the output\_message.

#### Signature Creation for GSS\_UnwrapEx()

For NTLMv1, all input data buffers where signed==TRUE are concatenated together and the signature is verified against the resulting concatenated buffer. For NTLMv2, the signature is verified for all of the input data buffers.

### GSS\_GetMICEx() Call

Inputs:

* context\_handle CONTEXT HANDLE
* qop\_req INTEGER, -- 0 specifies default QOP
* message ORDERED LIST of:
	+ sign BOOLEAN
	+ data OCTET STRING

Outputs:

* major\_status INTEGER
* minor\_status INTEGER
* message ORDERED LIST of:
	+ signed BOOLEAN
	+ data OCTET STRING
* per\_msg\_token OCTET STRING

This call is identical to GSS\_GetMIC(), except that it supports multiple input buffers.

#### Signature Creation for GSS\_GetMICEx()

Section [3.4.2](#Section_131b00627958460ebca5c7a9f9086652) describes the algorithm used by GSS\_GetMICEx() to create the signature. The per\_msg\_token contains the NTLMSSP\_MESSAGE\_SIGNATURE structure (section [2.2.2.9](#Section_b192b940a50843298513efb3342f2c85)).

The [**checksum**](#gt_fa444149-ef93-4512-a278-2e756295630c) is computed over the concatenated input buffers using only the input data buffers where sign==TRUE for NTLMv1 and all of the input data buffers including the buffers where sign==FALSE for NTLMv2.

### GSS\_VerifyMICEx() Call

Inputs:

* context\_handle CONTEXT HANDLE
* message ORDERED LIST of:
	+ signed BOOLEAN
	+ data OCTET STRING
* per\_msg\_token OCTET STRING

Outputs:

* qop\_state INTEGER
* major\_status INTEGER
* minor\_status INTEGER

This call is identical to GSS\_VerifyMIC(), except that it supports multiple input buffers.

#### Signature Creation for GSS\_VerifyMICEx()

For NTLMv1, all input data buffers where signed==TRUE are concatenated together and the signature is verified against the resulting concatenated buffer. For NTLMv2, the signature is verified for all of the input data buffers including the buffers where signed==FALSE.

Section [3.4.2](#Section_131b00627958460ebca5c7a9f9086652) describes the algorithm used by GSS\_VerifyMICEx() to create the signature to verify against. The per\_msg\_token contains the NTLMSSP\_MESSAGE\_SIGNATURE structure (section [2.2.2.9](#Section_b192b940a50843298513efb3342f2c85)).

# Protocol Examples

## NTLM Over Server Message Block (SMB)

NTLM over a Server Message Block (SMB) transport is a common use of NTLM authentication and encryption. Although KILE is the preferred authentication method of an SMB session as described in section [1](#Section_a4f28e013df14fd180b2df1fbc183f21), when a client attempts to authenticate to an SMB server using the KILE protocol and fails, it can attempt to authenticate with NTLM.

The following is an example protocol flow of NTLM and Simple and Protected Generic Security [**Service**](#gt_2dc07ca2-2b40-437e-a5ec-ed28ebfb116a) Application Program Interface Negotiation Mechanism (SPNEGO) ([[MS-SPNG]](%5BMS-SPNG%5D.pdf#Section_f377a379c24f4a0fa3eb0d835389e28a)) authentication of an SMB [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12).

**Note**  The NTLM messages are embedded in the SMB messages. For details about how SMB embeds NTLM messages, see [[MS-SMB]](%5BMS-SMB%5D.pdf#Section_f210069c70864dc2885e861d837df688) section 4.1.



Figure 4: Message sequence to authenticate an SMB session

**Steps 1 and 2:** The SMB protocol negotiates protocol-specific options using the SMB\_COM\_NEGOTIATE request and response messages.

**Step 3:** The client sends an SMB\_COM\_SESSION\_SETUP\_ANDX request message. Assuming that NTLM authentication is negotiated, within this message an NTLM [NEGOTIATE\_MESSAGE](#Section_b34032e53aae4bc684c3c6d80eadf7f2) is embedded.

**Step 4:** The server responds with an SMB\_COM\_SESSION\_SETUP\_ANDX response message within which an NTLM [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) is embedded. The message includes an 8-byte random number, called a "[**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba)", that the server generates and sends in the **ServerChallenge** field of the message.

**Step 5:** The client extracts the **ServerChallenge** field from the NTLM CHALLENGE\_MESSAGE and sends an NTLM [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) to the server (embedded in an SMB\_COM\_SESSION\_SETUP\_ANDX request message).

If the challenge and the response prove that the client knows the user's password, the authentication succeeds and the client's security context is now established on the server.

**Step 6:** The server sends a success message embedded in an SMB\_COM\_SESSION\_SETUP\_ANDX response message.

## Cryptographic Values for Validation

The topics in this section contain Byte Array values which can be used when validating NTLM cryptographic implementations.

### Common Values

These values are used in multiple examples.

User:

1. 0000000: 55 00 73 00 65 00 72 00 U.s.e.r.
2. 0000000: 55 00 53 00 45 00 52 00 U.S.E.R.
3. 0000000: 55 73 65 72 User

UserDom:

1. 0000000: 44 00 6f 00 6d 00 61 00 69 00 6e 00 D.o.m.a.i.n.

Passwd:

1. 0000000: 50 00 61 00 73 00 73 00 77 00 6f 00 72 00 64 00 P.a.s.s.w.o.r.d.
2. 0000000: 50 41 53 53 57 4f 52 44 00 00 00 00 00 00 PASSWORD......

Server Name:

1. 00000000: 53 00 65 00 72 00 76 00 65 00 72 00 S.e.r.v.e.r.

Workstation Name:

1. 0000000: 43 00 4f 00 4d 00 50 00 55 00 54 00 45 00 52 00 C.O.M.P.U.T.E.R.

RandomSessionKey:

1. 0000000: 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 55 UUUUUUUUUUUUUUUU

Time:

1. 0000000: 00 00 00 00 00 00 00 00 ........

ClientChallenge:

1. 0000000: aa aa aa aa aa aa aa aa ........

ServerChallenge:

1. 0000000: 01 23 45 67 89 ab cd ef .#Eg..&#x2550;.

### NTLM v1 Authentication

The following calculations are used in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5).

The Challenge Flags used in the following NTLM v1 examples are:

* NTLMSSP\_NEGOTIATE\_KEY\_EXCH
* NTLMSSP\_NEGOTIATE\_56
* NTLMSSP\_NEGOTIATE\_128
* NTLMSSP\_NEGOTIATE\_VERSION
* NTLMSSP\_TARGET\_TYPE\_SERVER
* NTLMSSP\_NEGOTIATE\_ALWAYS\_SIGN
* NTLMSSP\_NEGOTIATE\_NTLM
* NTLMSSP\_NEGOTIATE\_SEAL
* NTLMSSP\_NEGOTIATE\_SIGN
* NTLM\_NEGOTIATE\_OEM
* NTLMSSP\_NEGOTIATE\_UNICODE
1. 0000000: 33 82 02 e2 3...

#### Calculations

##### LMOWFv1()

The LMOWFv1() is defined in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5).

1. DES( UpperCase( Passwd)[0..6],"KGS!@#$%"):
2. 0000000: e5 2c ac 67 41 9a 9a 22 .,.gA.."
3. DES( UpperCase( Passwd)[7..13],"KGS!@#$%"):
4. 0000000: 4a 3b 10 8f 3f a6 cb 6d J;..?..m

When calculating the LMOWFv1 using the values above, then LMOWFv1("Password", "User", "Domain") is:

1. 0000000: e5 2c ac 67 41 9a 9a 22 4a 3b 10 8f 3f a6 cb 6d ...gA.."J;..?..m

##### NTOWFv1()

The NTOWFv1() is defined in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5). When calculating the NTOWFv1 using the values above, then NTOWFv1("Password", "User", "Domain") is:

1. 0000000: a4 f4 9c 40 65 10 bd ca b6 82 4e e7 c3 0f d8 52 ...@e.....N....R

##### Session Base Key and Key Exchange Key

The SessionBaseKey is specified in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5).

1. 0000000: d8 72 62 b0 cd e4 b1 cb 74 99 be cc cd f1 07 84 .rb.&#x2550;...t...&#x2550;...

#### Results

##### NTLMv1 Response

The NTChallengeResponse is specified in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5). With NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY not set, using the values above, the result is:

1. 0000000: 67 c4 30 11 f3 02 98 a2 ad 35 ec e6 4f 16 33 1c g&#x2500;0......5..O.3.
2. 0000010: 44 bd be d9 27 84 1f 94 D...'...

##### LMv1 Response

The LmChallengeResponse is specified in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5). With the NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY flag not set and with the NoLMResponseNTLMv1 flag not set, using the values above, the result is:

1. 0000000: 98 de f7 b8 7f 88 aa 5d af e2 df 77 96 88 a1 72 .......].......r
2. 0000010: de f1 1c 7d 5c cd ef 13 ...}\&#x2550;..

If the NTLMSSP\_NEGOTIATE\_LM\_KEY flag is set then the KeyExchangeKey is:

1. 0000000: b0 9e 37 9f 7f be cb 1e af 0a fd cb 03 83 c8 a0 ..7.............

##### Encrypted Session Key

RC4 encryption of the RandomSessionKey with the KeyExchangeKey:

1. 0000000: 51 88 22 b1 b3 f3 50 c8 95 86 82 ec bb 3e 3c b7 Q."...P......&gt;&lt;.

NTLMSSP\_REQUEST\_NON\_NT\_SESSION\_KEY is set:

1. 0000000: 74 52 ca 55 c2 25 a1 ca 04 b4 8f ae 32 cf 56 fc tR.U........2.V.

NTLMSSP\_NEGOTIATE\_LM\_KEY is set:

1. 0000000: 4c d7 bb 57 d6 97 ef 9b 54 9f 02 b8 f9 b3 78 64 L..W....T.....xd

#### Messages

The [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) (section 2.2.1.2):

1. 0000000: 4e 54 4c 4d 53 53 50 00 02 00 00 00 0c 00 0c 00 NTLMSSP·········
2. 0000010: 38 00 00 00 33 82 02 e2 01 23 45 67 89 ab cd ef 8···3.·.·#Eg..═.
3. 0000020: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ················
4. 0000030: 06 00 70 17 00 00 00 0f 53 00 65 00 72 00 76 00 ··p·····S·e·r·v·
5. 0000040: 65 00 72 00 e·r·

The [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) (section 2.2.1.3):

1. 0000000: 4e 54 4c 4d 53 53 50 00 03 00 00 00 18 00 18 00 NTLMSSP·········
2. 0000010: 6c 00 00 00 18 00 18 00 84 00 00 00 0c 00 0c 00 l·······.·······
3. 0000020: 48 00 00 00 08 00 08 00 54 00 00 00 10 00 10 00 H·······T·······
4. 0000030: 5c 00 00 00 10 00 10 00 9c 00 00 00 35 82 80 e2 \·······.···5...
5. 0000040: 05 01 28 0a 00 00 00 0f 44 00 6f 00 6d 00 61 00 ··(·····D·o·m·a·
6. 0000050: 69 00 6e 00 55 00 73 00 65 00 72 00 43 00 4f 00 i·n·U·s·e·r·C·O·
7. 0000060: 4d 00 50 00 55 00 54 00 45 00 52 00 98 de f7 b8 M·P·U·T·E·R·....
8. 0000070: 7f 88 aa 5d af e2 df 77 96 88 a1 72 de f1 1c 7d ...]...w...r..·}
9. 0000080: 5c cd ef 13 67 c4 30 11 f3 02 98 a2 ad 35 ec e6 \═.·g─0·.·...5..
10. 0000090: 4f 16 33 1c 44 bd be d9 27 84 1f 94 51 88 22 b1 O·3·D...'...Q.".
11. 00000A0: b3 f3 50 c8 95 86 82 ec bb 3e 3c b7 ..P......><.

#### GSS\_WrapEx Examples

The GSS\_WrapEx() is specified in section [3.4.6](#Section_a06bfc2b30fc4483b876a9386f4808ed). The following data is part of the security context state for the NTLM Session.

SeqNum for the message:

1. 0000000: 00 00 00 00 ••••

RandomPad(4):

1. 0000000: 00 00 00 00 ••••

Plaintext data where conf\_req\_flag == TRUE and sign == TRUE:

1. 0000000: 50 00 6c 00 61 00 69 00 6e 00 74 00 65 00 78 00 P·l·a·i·n·t·e·x·
2. 0000010: 74 00 t·

The output message data and signature is created using SEAL() specified in section [3.4.3](#Section_115f9c7dbc304262ae96254555c14ea6). Output\_message will contain conf\_state == TRUE, signed == TRUE and data:

Data:

1. 0000000: 56 fe 04 d8 61 f9 31 9a f0 d7 23 8a 2e 3b 4d 45 V.•.a∙1...#è.;ME
2. 0000010: 7f b8 ⌂╕

Checksum: CRC32(Message):

1. 0000000: 7d 84 aa 93 }...

RandomPad: RC4(Handle, RandomPad):

1. 0000000: 45 c8 44 e5 E.D.

Checksum: RC4(Handle, NTLMSSP\_MESSAGE\_SIGNATURE.Checksum):

1. 0000000: 09 dc d1 df ·...

SeqNum: RC4(Handle, 0x00000000):

1. 0000000: 2e 45 9d 36 .E.6

SeqNum: XOR:

1. 0000000: 2e 45 9d 36 .E.6

Assembled Signature:

1. 0000000: 01 00 00 00 45 c8 44 e5 09 dc d1 df 2e 45 9d 36 ····E╚Dσ·▄╤▀.E¥6

### NTLM v1 with Client Challenge

The following calculations are used in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5). This example uses weaker key strengths than advised. Using stronger key strengths with NTLM v1 with client challenge results in the same GSS\_WrapEx outputs with NTLMv2.

The Challenge Flags used in the following NTLM v1 examples are:

* NTLMSSP\_NEGOTIATE\_56
* NTLMSSP\_NEGOTIATE\_VERSION
* NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY
* NTLMSSP\_TARGET\_TYPE\_SERVER
* NTLMSSP\_NEGOTIATE\_ALWAYS\_SIGN
* NTLMSSP\_NEGOTIATE\_NTLM
* NTLMSSP\_NEGOTIATE\_SEAL
* NTLMSSP\_NEGOTIATE\_SIGN
* NTLM\_NEGOTIATE\_OEM
* NTLMSSP\_NEGOTIATE\_UNICODE
1. 0000000: 33 82 0a 82 3...

#### Calculations

##### NTOWFv1()

The NTOWFv1() is defined in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5). When calculating the NTOWFv1 using the values above, then NTOWFv1("Password", "User", "Domain") is:

1. 0000000: a4 f4 9c 40 65 10 bd ca b6 82 4e e7 c3 0f d8 52 ...@e.....N....R

##### Session Base Key

The SessionBaseKey is specified in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5):

1. 0000000: d8 72 62 b0 cd e4 b1 cb 74 99 be cc cd f1 07 84 .rb.═...t...═.•.

##### Key Exchange Key

The KeyExchangeKey is specified in section [3.4.5.1](#Section_d86303b5b29e4fb9b11977579c761370). Using the values above, the result is:

1. 0000000: eb 93 42 9a 8b d9 52 f8 b8 9c 55 b8 7f 47 5e dc ..B...R...U..G..

#### Results

##### LMv1 Response

The LmChallengeResponse is specified in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5). Using the previous values, the result is:

1. 0000000: aa aa aa aa aa aa aa aa 00 00 00 00 00 00 00 00 ................
2. 0000010: 00 00 00 00 00 00 00 00 ........

##### NTLMv1 Response

The NTChallengeResponse is specified in section [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5). Using the values above, the result is:

1. 0000000: 75 37 f8 03 ae 36 71 28 ca 45 82 04 bd e7 ca f8 u7...6q(.E......
2. 0000010: 1e 97 ed 26 83 26 72 32 .... r2

#### Messages

The [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) (section 2.2.1.2):

1. 0000000: 4e 54 4c 4d 53 53 50 00 02 00 00 00 0c 00 0c 00 NTLMSSP·········
2. 0000010: 38 00 00 00 33 82 0a 82 01 23 45 67 89 ab cd ef 8···3.·.·#Eg..═.
3. 0000020: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ················
4. 0000030: 06 00 70 17 00 00 00 0f 53 00 65 00 72 00 76 00 ··p·····S·e·r·v·
5. 0000040: 65 00 72 00 e·r·

The [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) (section 2.2.1.3):

1. 0000000: 4e 54 4c 4d 53 53 50 00 03 00 00 00 18 00 18 00 NTLMSSP·········
2. 0000010: 6c 00 00 00 18 00 18 00 84 00 00 00 0c 00 0c 00 l·······.·······
3. 0000020: 48 00 00 00 08 00 08 00 54 00 00 00 10 00 10 00 H·······T·······
4. 0000030: 5c 00 00 00 00 00 00 00 9c 00 00 00 35 82 08 82 \·······.···5.·.
5. 0000040: 05 01 28 0a 00 00 00 0f 44 00 6f 00 6d 00 61 00 ··(·····D·o·m·a·
6. 0000050: 69 00 6e 00 55 00 73 00 65 00 72 00 43 00 4f 00 i·n·U·s·e·r·C·O·
7. 0000060: 4d 00 50 00 55 00 54 00 45 00 52 00 aa aa aa aa M·P·U·T·E·R·....
8. 0000070: aa aa aa aa 00 00 00 00 00 00 00 00 00 00 00 00 ....············
9. 0000080: 00 00 00 00 75 37 f8 03 ae 36 71 28 ca 45 82 04 ····u7.·.6q(.E.·
10. 0000090: bd e7 ca f8 1e 97 ed 26 83 26 72 32 ....·ù.&.&r2

#### GSS\_WrapEx Examples

The GSS\_WrapEx() is specified in section [3.4.6](#Section_a06bfc2b30fc4483b876a9386f4808ed). The following data is part of the security context state for the NTLM Session.

SeqNum for the message:

1. 0000000: 00 00 00 00 ••••

Plaintext data where conf\_req\_flag == TRUE and sign == TRUE:

1. 0000000: 50 00 6c 00 61 00 69 00 6e 00 74 00 65 00 78 00 P·l·a·i·n·t·e·x·
2. 0000010: 74 00 t·

The sealkey is created using SEALKEY() (section [3.4.5.3](#Section_bf39181de95d40d7a740ab4ec3dc363d)):

Cut [**key exchange key**](#gt_5f9cd8ed-6284-46f0-aaf1-9e9f0f6a2db7) to 56 bits:

1. 0000000: eb 93 42 9a 8b d9 52 ..B...R

MD5(ConcatenationOf(SealKey, "session key to client-to-server sealing key magic constant")):

1. 0000000: 04 dd 7f 01 4d 85 04 d2 65 a2 5c c8 6a 3a 7c 06 •..•M.•.e.\.j:.•

The signkey is created using SIGNKEY() (section [3.4.5.2](#Section_524cdccb563e479392b07bc321fce096)):

MD5(ConcatenationOf(RandomSessionKey, "session key to client-to-server signing key magic constant")):

1. 0000000: 60 e7 99 be 5c 72 fc 92 92 2a e8 eb e9 61 fb 8d `...\r...\*...a..

The output message data and signature is created using SEAL() specified in section [3.4.3](#Section_115f9c7dbc304262ae96254555c14ea6). Output\_message will contain conf\_state == TRUE, signed == TRUE and data:

Data:

1. 0000000: a0 23 72 f6 53 02 73 f3 aa 1e b9 01 90 ce 52 00 .#r.S•s..•.•..R•
2. 0000010: c9 9d ╔¥

Checksum: HMAC\_MD5(SigningKey, ConcatenationOf(SeqNum, Message))[0..7]:

1. 0000000: ff 2a eb 52 f6 81 79 3a \*.R..y:•

Signature:

1. 0000000: 01 00 00 00 ff 2a eb 52 f6 81 79 3a 00 00 00 00 •••• \*.R..y:••••

### NTLMv2 Authentication

The following calculations are used in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3).

The Challenge Flags used in the following NTLM v2 examples are:

* NTLMSSP\_NEGOTIATE\_KEY\_EXCH
* NTLMSSP\_NEGOTIATE\_56
* NTLMSSP\_NEGOTIATE\_128
* NTLMSSP\_NEGOTIATE\_VERSION
* NTLMSSP\_NEGOTIATE\_TARGET\_INFO
* NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY
* NTLMSSP\_TARGET\_TYPE\_SERVER
* NTLMSSP\_NEGOTIATE\_ALWAYS\_SIGN
* NTLMSSP\_NEGOTIATE\_NTLM
* NTLMSSP\_NEGOTIATE\_SEAL
* NTLMSSP\_NEGOTIATE\_SIGN
* NTLM\_NEGOTIATE\_OEM
* NTLMSSP\_NEGOTIATE\_UNICODE
1. 0000000: 33 82 8a e2 3...

AV Pair 1 - NetBIOS Server name:

1. 00000000: 53 00 65 00 72 00 76 00 65 00 72 00 S.e.r.v.e.r.

AV Pair 2 - NetBIOS Domain name:

1. 00000000: 44 00 6f 00 6d 00 61 00 69 00 6e 00 D.o.m.a.i.n.

#### Calculations

##### NTOWFv2() and LMOWFv2()

The LMOWFv2() and The NTOWFv2() are defined in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3). When calculating the LMOWFv2 or NTOWFv2, using the values above, then NTOWFv2("Password", "User", "Domain") is:

1. 0000000: 0c 86 8a 40 3b fd 7a 93 a3 00 1e f2 2e f0 2e 3f ...@;..........?

##### Session Base Key

The SessionBaseKey is specified in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3). Using the values above:

1. 0000000: 8d e4 0c ca db c1 4a 82 f1 5c b0 ad 0d e9 5c a3 ......J..\....\.

##### temp

temp is specified in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3). Using the values above:

1. 01 01 00 00 00 00 00 00 00 00 00 00 δ∩j•••••••••••••
2. 00000A0: 00 00 00 00 aa aa aa aa aa aa aa aa 00 00 00 00 ••••¬¬¬¬¬¬¬¬••••
3. 00000B0: 02 00 0c 00 44 00 6f 00 6d 00 61 00 69 00 6e 00 ••••D•o•m•a•i•n•
4. 00000C0: 01 00 0c 00 53 00 65 00 72 00 76 00 65 00 72 00 ••••S•e•r•v•e•r•
5. 00000D0: 00 00 00 00 00 00 00 00

#### Results

##### LMv2 Response

The LmChallengeResponse is specified in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3). Using the values above:

1. 0000000: 86 c3 50 97 ac 9c ec 10 25 54 76 4a 57 cc cc 19 ..P.....%TvJW...
2. 0000010: aa aa aa aa aa aa aa aa ........

##### NTLMv2 Response

The NTChallengeResponse is specified in section [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3). Using the values above, the response (section [2.2.2.8](#Section_D43E22246FC3449D9F37B90B55A29C80)) is:

1. 0000000: 68 cd 0a b8 51 e5 1c 96 aa bc 92 7b eb ef 6a 1c h&#x2550;..Q......{..j.

##### Encrypted Session Key

RC4 encryption of the RandomSessionKey with the KeyExchangeKey:

1. 0000000: c5 da d2 54 4f c9 79 90 94 ce 1c e9 0b c9 d0 3e ...TO.y........&gt;

#### Messages

The [CHALLENGE\_MESSAGE](#Section_801a468188094be9ab0d61dcfe762786) (section 2.2.1.2):

1. 0000000: 4e 54 4c 4d 53 53 50 00 02 00 00 00 0c 00 0c 00 NTLMSSP•••••••••
2. 0000010: 38 00 00 00 33 82 8a e2 01 23 45 67 89 ab cd ef 8•••3...•#Eg..═.
3. 0000020: 00 00 00 00 00 00 00 00 24 00 24 00 44 00 00 00 ••••••••$•$•D•••
4. 0000030: 06 00 70 17 00 00 00 0f 53 00 65 00 72 00 76 00 ••p•••••S•e•r•v•
5. 0000040: 65 00 72 00 02 00 0c 00 44 00 6f 00 6d 00 61 00 e•r•••••D•o•m•a•
6. 0000050: 69 00 6e 00 01 00 0c 00 53 00 65 00 72 00 76 00 i•n•••••S•e•r•v•
7. 0000060: 65 00 72 00 00 00 00 00 e•r•••••

The [AUTHENTICATE\_MESSAGE](#Section_033d32cc88f944839bf2b273055038ce) (section 2.2.1.3):

1. 0000000: 4e 54 4c 4d 53 53 50 00 03 00 00 00 18 00 18 00 NTLMSSP·········
2. 0000010: 6c 00 00 00 54 00 54 00 84 00 00 00 0c 00 0c 00 l···T·T·ä·······
3. 0000020: 48 00 00 00 08 00 08 00 54 00 00 00 10 00 10 00 H·······T·······
4. 0000030: 5c 00 00 00 10 00 10 00 d8 00 00 00 35 82 88 e2 \·······.···5...
5. 0000040: 05 01 28 0a 00 00 00 0f 44 00 6f 00 6d 00 61 00 ··(·····D·o·m·a·
6. 0000050: 69 00 6e 00 55 00 73 00 65 00 72 00 43 00 4f 00 i·n·U·s·e·r·C·O·
7. 0000060: 4d 00 50 00 55 00 54 00 45 00 52 00 86 c3 50 97 M·P·U·T·E·R·..P.
8. 0000070: ac 9c ec 10 25 54 76 4a 57 cc cc 19 aa aa aa aa ...·%TvJW..·....
9. 0000080: aa aa aa aa 68 cd 0a b8 51 e5 1c 96 aa bc 92 7b ....h═·.Q.·....{
10. 0000090: eb ef 6a 1c 01 01 00 00 00 00 00 00 00 00 00 00 δ∩j·············
11. 00000A0: 00 00 00 00 aa aa aa aa aa aa aa aa 00 00 00 00 ····¬¬¬¬¬¬¬¬····
12. 00000B0: 02 00 0c 00 44 00 6f 00 6d 00 61 00 69 00 6e 00 ····D·o·m·a·i·n·
13. 00000C0: 01 00 0c 00 53 00 65 00 72 00 76 00 65 00 72 00 ····S·e·r·v·e·r·
14. 00000D0: 00 00 00 00 00 00 00 00 c5 da d2 54 4f c9 79 90 ········...TO.y.
15. 00000E0: 94 ce 1c e9 0b c9 d0 3e ..·..·..>

#### GSS\_WrapEx Examples

The GSS\_WrapEx() is specified in section [3.4.6](#Section_a06bfc2b30fc4483b876a9386f4808ed). The following data is part of the security context state for the NTLM Session.

SeqNum for the message:

1. 0000000: 00 00 00 00 ••••

Plaintext data where conf\_req\_flag == TRUE and sign == TRUE:

1. 0000000: 50 00 6c 00 61 00 69 00 6e 00 74 00 65 00 78 00 P•l•a•i•n•t•e•x•
2. 0000010: 74 00 t•

The sealkey is created using SEALKEY() (section [3.4.5.3](#Section_bf39181de95d40d7a740ab4ec3dc363d)):

MD5(ConcatenationOf(RandomSessionKey, "session key to client-to-server sealing key magic constant")):

1. 0000000: 59 f6 00 97 3c c4 96 0a 25 48 0a 7c 19 6e 4c 58 Y.•.<─.•%H•.•nLX

The signkey is created using SIGNKEY() (section [3.4.5.2](#Section_524cdccb563e479392b07bc321fce096)):

MD5(ConcatenationOf(RandomSessionKey, "session key to client-to-server signing key magic constant")):

1. 0000000: 47 88 dc 86 1b 47 82 f3 5d 43 fd 98 fe 1a 2d 39 G...•G..]C...•-9

The output message data and signature is created using SEAL() specified in section [3.4.3](#Section_115f9c7dbc304262ae96254555c14ea6). Output\_message will contain conf\_state == TRUE, signed == TRUE and data:

Data:

1. 0000000: 54 e5 01 65 bf 19 36 dc 99 60 20 c1 81 1b 0f 06 T.•e.•6..`...•••
2. 0000010: fb 5f √\_

Checksum: HMAC\_MD5(SigningKey, ConcatenationOf(SeqNum, Message))[0..7]:

1. 0000000: 70 35 28 51 f2 56 43 09 p5(Q.VC•

Checksum: RC4(Checksum above):

1. 0000000: 7f b3 8e c5 c5 5d 49 76 .....]Iv

Signature:

1. 0000000: 01 00 00 00 7f b3 8e c5 c5 5d 49 76 00 00 00 00 ••••.....]Iv••••

# Security

## Security Considerations for Implementers

NTLM does not support any recent cryptographic methods, such as AES or SHA-256. It uses [**cyclic redundancy check (CRC)**](#gt_9cb45a36-92bb-4c14-b2fd-2ad7e2979bfd) or message digest algorithms ([[RFC1321]](https://go.microsoft.com/fwlink/?LinkId=90275)) for integrity, and it uses RC4 for encryption. Deriving a [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) from a password is as specified in [[RFC1320]](https://go.microsoft.com/fwlink/?LinkId=90274) and [[FIPS46-2]](https://go.microsoft.com/fwlink/?LinkId=89871). Therefore, applications are generally advised not to use NTLM.[<81>](#Appendix_A_81" \o "Product behavior note 81)

The NTLM server does not require the NTLM client to send the MIC, but sending the MIC when the timestamp is present greatly increases security. Although implementations of NLMP will work without support for MIC, they will be vulnerable to message tampering.

The use of NullSession results in a SessionBaseKey with all zeroes, which does not provide security. Therefore, applications are generally advised not to use NullSession.

The Guest user account is disabled by default in Windows for security reasons. If the Guest user account is enabled, it is strongly recommended to set a password so that logon failures do not result in Guest logins (section [3.2.5.1.2](#Section_f9e6fbc4a9534f24b229ccdcc213b9ec) ).

When the Guest user account has been assigned a password and is used explicitly to log in by using username Guest and by providing the assigned password, login processing happens just like a regular user. This is not recommended, as the Guest user would be handled like a regular user, which it is not an intended or desired result.

## Index of Security Parameters

| Security parameter | Section |
| --- | --- |
| MD4/MD5 usage in NTLM v1  | [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5) |
| MD4/MD5 usage in NTLM v2 | [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3) |
| MD5/RC4 usage during [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff) | [3.4](#Section_d1c86e81eb6647fd8a6f970050121347) |

# Appendix A: Cryptographic Operations Reference

In the algorithms provided in this documentation, pseudocode is provided to illustrate the process used to compute [**keys**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) and perform other cryptographic operations prior to protocol exchange. The following table defines the general purpose functions and operations used in this pseudocode.

|  Functions | Description  | Section |
| --- | --- | --- |
| AddAVPair(T, Id, Value) | An auxiliary function that is used to manage [**AV pairs**](#gt_5158aff7-f968-422b-a78f-6cbb653e7b2a) in NTLM messages. It is defined as follows.1. AddAvPair(T, Id, Value) {
2. STRING T
3. USHORT Id
4. STRING Value
5. T = ConcatenationOf(T, Id)
6. T = ConcatenationOf(T, Length(Value))
7. T = ConcatenationOf(T, Value)
8. }
 | [3.2.5.1.1](#Section_81d15e3e3ac341f0920d846149f3a814) |
| ComputeResponse(...) | A function that computes the NT response, LM responses, and [**key exchange key**](#gt_5f9cd8ed-6284-46f0-aaf1-9e9f0f6a2db7) from the [**response keys**](#gt_0368db93-c0f9-4ea7-a30e-c04699c1f22d) and [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba).  | [3.1.5.1.2](#Section_c0250a97294040c782fb20d208c71e96), [3.2.5.1.2](#Section_f9e6fbc4a9534f24b229ccdcc213b9ec), [3.3.1](#Section_464551a89fc4428eb3d3bc5bfb2e73a5), [3.3.2](#Section_5e55093891d4459fb67d75d70009e3f3) |
| ConcatenationOf(string1, string2, ... stringN) | Indicates the left-to-right concatenation of the string parameters, from the first string to the *Nn*th. Any numbers are converted to strings and all numeric conversions to strings retain all digits, even nonsignificant ones. The result is a string. For example, ConcatenationOf(0x00122, "XYZ", "Client") results in the string "00122XYZClient." | 3.3.1, 3.3.2, [3.4.2](#Section_131b00627958460ebca5c7a9f9086652), [3.4.3](#Section_115f9c7dbc304262ae96254555c14ea6), [3.4.4](#Section_bd5ae0a8a13146a8891b0dc2b9ca9bf7), [3.4.5.1](#Section_d86303b5b29e4fb9b11977579c761370), [3.4.5.2](#Section_524cdccb563e479392b07bc321fce096), [3.4.5.3](#Section_bf39181de95d40d7a740ab4ec3dc363d) |
| CRC32(M) | Indicates a 32-bit [**CRC**](#gt_9cb45a36-92bb-4c14-b2fd-2ad7e2979bfd) calculated over M. | 3.4.3, 3.4.4 |
| DES(K, D) | Indicates the encryption of an 8-byte data item D with the 7-byte key K using the Data Encryption Standard (DES) algorithm in Electronic Codebook (ECB) mode. The result is 8 bytes in length ([[FIPS46-2]](https://go.microsoft.com/fwlink/?LinkId=89871)). | 3.3.1, 3.4.5.1 |
| DESL(K, D) | Indicates the encryption of an 8-byte data item D with the 16-byte key K using the Data Encryption Standard Long (DESL) algorithm. The result is 24 bytes in length. DESL(K, D) is computed as follows.1. ConcatenationOf( DES(K[0..6], D), \
2. DES(K[7..13], D), DES( \
3. ConcatenationOf(K[14..15], Z(5)), D));

**Note**  K[] implies a key represented as a character array. | 3.3.1 |
| GetVersion() | An auxiliary function that returns an operating system version-specific value (section [2.2.2.8](#Section_d43e22246fc3449d9f37b90b55a29c80)). | [3.1.5.1.1](#Section_b535636e49c443af8685801cc381882f), 3.1.5.1.2, 3.2.5.1.1, 3.2.5.1.2 |
| LMGETKEY(U, D) | Retrieve the user's LM response key from the server database ([**directory**](#gt_49ce3946-04d2-4cc9-9350-ebcd952b9ab9) or local database). | 3.2.5.1.2 |
| NTGETKEY(U, D) | Retrieve the user's NT response key from the server database. | 3.2.5.1.2 |
| HMAC(K, M) | Indicates the encryption of data item M with the key K using the HMAC algorithm ([[RFC2104]](https://go.microsoft.com/fwlink/?LinkId=90314)). | 3.3.2, 3.4.4 |
| HMAC\_MD5(K, M) | Indicates the computation of a 16-byte HMAC-keyed MD5 message digest of the byte string M using the key K. | 3.3.2, 3.4.4 |
| KXKEY(K, LM, SC) | Produces a key exchange key from the session base key, LM response and server challenge as defined in the sections KXKEY, SIGNKEY, and SEALKEY. | 3.1.5.1.2, 3.2.5.1.2, 3.4.5.1 |
| [**LMOWF**](#gt_fd74ef50-cb97-4acd-b537-4941bdd9e064) | Computes a one-way function of the user's password to use as the response key. NTLM v1 and NTLM v2 define separate LMOWF functions in the NTLM v1 authentication and NTLM v2 authentication sections, respectively. | 3.1.5.1.2, 3.3.1, 3.3.2 |
| MD4(M) | Indicates the computation of an MD4 message digest of the null-terminated byte string M ([[RFC1320]](https://go.microsoft.com/fwlink/?LinkId=90274)). | 3.3.1, 3.3.2 |
| MD5(M) | Indicates the computation of an MD5 message digest of the null-terminated byte string M ([[RFC1321]](https://go.microsoft.com/fwlink/?LinkId=90275)). | 3.3.1, 3.3.2, 3.4.4, 3.4.5.2, 3.4.5.3 |
| MD5\_HASH(M) | Indicates the computation of an MD5 message digest of a binary blob ([[RFC4121]](https://go.microsoft.com/fwlink/?LinkId=90459) section 4.1.1.2). |  |
| NIL | A zero-length string. | 3.1.5.1.1, 3.1.5.1.2, 3.2.5.1.1, [3.2.5.2.2](#Section_34a9417d7cc043b0b61c1f19740df66f), 3.4.5.2 |
| NONCE(N) | Indicates the computation of an *N*-byte cryptographic-strength random number. **Note**  The NTLM Authentication Protocol does not define the statistical properties of the random number generator. It is left to the discretion of the implementation to define the strength requirements of the NONCE(N) operation. | 3.1.5.1.2, 3.2.5.1.1, 3.4.3 |
| [**NTOWF**](#gt_7a2805fa-1dcd-4b4e-a8e4-2a2bcc8651e9) | Computes a one-way function of the user's password to use as the response key. NTLM v1 and NTLM v2 define separate NTOWF functions in the NTLM v1 authentication and NTLM v2 authentication sections, respectively. | 3.1.5.1.2, 3.3.1, 3.3.2 |
| RC4(H, D) | The RC4 Encryption Algorithm. To obtain this stream cipher that is licensed by RSA Data Security, Inc., contact this company.Indicates the encryption of data item D with the current [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12) or message key state, using the RC4 algorithm. H is the handle to a key state structure initialized by RC4INIT. | 3.4.3, 3.4.4 |
| RC4K(K,D) | Indicates the encryption of data item D with the key K using the RC4 algorithm.**Note**  The key sizes for RC4 encryption in NTLM are defined in sections KXKEY, SIGNKEY, and SEALKEY, where they are created. | 3.1.5.1.2, 3.4.4 |
| RC4Init(H, K) | Initialization of the RC4 key and handle to a key state structure for the session. | 3.1.5.1.2, 3.2.5.1.2 |
| SEALKEY(F, K, string1) | Produces an encryption key from the [**session key**](#gt_4f67a585-fb00-4166-93e8-cf4abca8226d) as defined in sections KXKEY, SIGNKEY, and SEALKEY. | 3.1.5.1.2, 3.4.5.3 |
| SIGNKEY(flag, K, string1) | Produces a signing key from the session key as defined in sections KXKEY, SIGNKEY, and SEALKEY. | 3.1.5.1.2, 3.4.5.2 |
| Currenttime | Indicates the retrieval of the current time as a 64-bit value, represented as the number of 100-nanosecond ticks elapsed since midnight of January 1st, 1601 (UTC). | 3.1.5.1.2 |
| UNICODE(string) | Indicates the 2-byte little-endian byte order encoding of the Unicode UTF-16 representation of string. The Byte Order Mark (BOM) is not sent over the wire. | 3.3.1, 3.3.2 |
| UpperCase(string) | Indicates the uppercase representation of string. | 3.3.1, 3.3.2 |
| Z(N) | Indicates the creation of a byte array of length *N*. Each byte in the array is initialized to the value zero. | 3.3.1, 3.3.2 |

# Appendix B: Product Behavior

The information in this specification is applicable to the following Microsoft products or supplemental software. References to product versions include updates to those products.

* Windows NT operating system
* Windows 2000 operating system
* Windows XP operating system
* Windows Server 2003 operating system
* Windows Vista operating system
* Windows Server 2008 operating system
* Windows 7 operating system
* Windows Server 2008 R2 operating system
* Windows 8 operating system
* Windows Server 2012 operating system
* Windows 8.1 operating system
* Windows Server 2012 R2 operating system
* Windows 10 operating system
* Windows Server 2016 operating system
* Windows Server operating system
* Windows Server 2019 operating system

Exceptions, if any, are noted in this section. If an update version, service pack or Knowledge Base (KB) number appears with a product name, the behavior changed in that update. The new behavior also applies to subsequent updates unless otherwise specified. If a product edition appears with the product version, behavior is different in that product edition.

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

[<1> Section 1](#Appendix_A_Target_1): Except in Windows NT.

[<2> Section 1.3](#Appendix_A_Target_2): Only Windows NT clients initiate requests for the LM version of the protocol. All applicable Windows Server releases accept it if properly configured.

[<3> Section 1.3.1](#Appendix_A_Target_3): It is possible, with a Windows connectionless NTLM, for messages protected by NTLM [**session security**](#gt_a765e666-9942-484e-9447-941b79f806ff) to precede the completion of the established NTLM [**session**](#gt_0cd96b80-a737-4f06-bca4-cf9efb449d12), but such message orderings do not occur in practice.

[<4> Section 1.4](#Appendix_A_Target_4): When authenticating a [**domain**](#gt_b0276eb2-4e65-4cf1-a718-e0920a614aca) account with NTLM, Windows uses Netlogon ([[MS-APDS]](%5BMS-APDS%5D.pdf#Section_dd444344fd7e430eb3137e95ab9c338e)) to have the [**DC**](#gt_76a05049-3531-4abd-aec8-30e19954b4bd) take the [**challenge**](#gt_55106c8d-117e-42c2-bc43-40f5d47913ba) and the client's response, and validate the user authentication against the DC's user database.

[<5> Section 1.6](#Appendix_A_Target_5): Windows applications that use Negotiate ([[MS-SPNG]](%5BMS-SPNG%5D.pdf#Section_f377a379c24f4a0fa3eb0d835389e28a)) can authenticate via NTLM if [**Kerberos**](#gt_d6a282ce-b1da-41e1-b05a-22f777a5c1fe) is not available. Authenticating via NTLM would occur if either the client or server are down-level (running Windows NT 4.0 operating system or earlier) systems, if the server is not joined to a domain, if the application is using a [**remote procedure call (RPC)**](#gt_8a7f6700-8311-45bc-af10-82e10accd331) interface that uses NTLM directly, or if the administrator has not configured Kerberos properly. An implementer who wants to support these scenarios in which Kerberos does not work would need to implement NTLM.

[<6> Section 2.2.1.1](#Appendix_A_Target_6): The **Version** field is NOT sent or accessed by Windows NT or Windows 2000. Windows NT and Windows 2000 assume that the **Payload** field started immediately after **WorkstationBufferOffset**. Since all references into the **Payload** field are by offset from the start of the message (not from the start of the **Payload** field), Windows NT and Windows 2000 can correctly interpret messages with **Version** fields.

[<7> Section 2.2.1.1](#Appendix_A_Target_7): In Windows, the [**code page**](#gt_210637d9-9634-4652-a935-ded3cd434f38) mapping the [**OEM character set**](#gt_3240e34e-920e-40ac-a672-342ac34a5e22) to Unicode is configurable via HKEY\_LOCAL\_MACHINE\System\CurrentControlSet\control\Nls\Codepage\OEMCP, which is a **DWORD** that contains the assigned number of the code page.

[<8> Section 2.2.1.2](#Appendix_A_Target_8): Except in Windows NT, Windows 2000, Windows XP, and Windows Server 2003, the **TargetInfo** field is always sent.

[<9> Section 2.2.1.2](#Appendix_A_Target_9): The **Version** field is not sent or accessed by Windows NT or Windows 2000. Windows NT and Windows 2000 assume that the **Payload** field started immediately after **TargetInfoBufferOffset**. Since all references into the **Payload** field are by offset from the start of the message (not from the start of the **Payload** field), Windows NT and Windows 2000 can correctly interpret messages with **Version** fields.

[<10> Section 2.2.1.3](#Appendix_A_Target_10): Although the protocol allows authentication to succeed if the client provides either **LmChallengeResponse** or **NtChallengeResponse**, Windows provides both.

[<11> Section 2.2.1.3](#Appendix_A_Target_11): The **Version** field is NOT sent or consumed by Windows NT or Windows 2000. Windows NT and Windows 2000 assume that the **Payload** field started immediately after **NegotiateFlags**. Since all references into the **Payload** field are by offset from the start of the message (not from the start of the **Payload** field), Windows NT and Windows 2000 can correctly interpret messages constructed with **Version** fields.

[<12> Section 2.2.1.3](#Appendix_A_Target_12): The **MIC** field is omitted in Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<13> Section 2.2.2.1](#Appendix_A_Target_13): **MsvAvDnsTreeName** AV\_PAIR type is not supported in Windows NT and Windows 2000.

[<14> Section 2.2.2.1](#Appendix_A_Target_14): **MsvAvFlags** AV\_PAIR type is not supported in Windows NT and Windows 2000.

[<15> Section 2.2.2.1](#Appendix_A_Target_15): Not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7 or Windows Server 2008 R2.

[<16> Section 2.2.2.1](#Appendix_A_Target_16): **MsvAvTimestamp** AV\_PAIR type is not supported in Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<17> Section 2.2.2.1](#Appendix_A_Target_17): **MsvAvSingleHost** AV\_PAIR type is not supported in Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<18> Section 2.2.2.1](#Appendix_A_Target_18): **MsvAvTargetName** AV\_PAIR type is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, or Windows Server 2008.

[<19> Section 2.2.2.1](#Appendix_A_Target_19): **MsvAvChannelBindings** AV\_PAIR type is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, or Windows Server 2008.

[<20> Section 2.2.2.2](#Appendix_A_Target_20): Windows does not process this field when sent on the wire.

[<21> Section 2.2.2.2](#Appendix_A_Target_21): Windows NT, Windows 2000, Windows XP, Windows Server 2003, and Windows Vista do not create or send the **CustomData** field. The **CustomData** field is not processed when sent on the wire.

[<22> Section 2.2.2.2](#Appendix_A_Target_22): Windows NT, Windows 2000, Windows XP, Windows Server 2003, and Windows Vista do not create or send the **MachineID**. The **MachineID** is not processed when sent on the wire.

[<23> Section 2.2.2.5](#Appendix_A_Target_23): Except in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008, only 128-bit session key negotiation is supported by default; therefore this bit is always set.

[<24> Section 2.2.2.5](#Appendix_A_Target_24): The NTLMSSP\_NEGOTIATE\_VERSION flag is not supported in Windows NT and Windows 2000. This flag is used for debug purposes only.

[<25> Section 2.2.2.5](#Appendix_A_Target_25): The **NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY** is not set in the NEGOTIATE\_MESSAGE to the server and the CHALLENGE\_MESSAGE to the client in Windows NT Server 4.0 operating system Service Pack 3 (SP3).

[<26> Section 2.2.2.5](#Appendix_A_Target_26): The **NTLMSSP\_NEGOTIATE\_OEM\_WORKSTATION\_SUPPLIED** flag is not supported in Windows NT and Windows 2000.

[<27> Section 2.2.2.5](#Appendix_A_Target_27): The **NTLMSSP\_NEGOTIATE\_OEM\_DOMAIN\_SUPPLIED** flag is not supported in Windows NT and Windows 2000.

[<28> Section 2.2.2.5](#Appendix_A_Target_28): Windows sends this bit for anonymous connections, but a Windows-based NTLM server does not use this bit when establishing the session.

[<29> Section 2.2.2.5](#Appendix_A_Target_29): Windows NTLM clients can set this bit. No applicable Windows Server releases support it, so this bit is never used.

[<30> Section 2.2.2.7](#Appendix_A_Target_30): In some situations, Microsoft Windows adds bytes to the end of the variable-length section. These bytes are considered to be part of the **NTLMv2\_CLIENT\_CHALLENGE** structure, but have no defined contents.

[<31> Section 2.2.2.10](#Appendix_A_Target_31): NTLMSSP\_NEGOTIATE\_VERSION cannot be negotiated in Windows NT, Windows 2000, and Windows XP operating system Service Pack 1 (SP1).

[<32> Section 2.2.2.10](#Appendix_A_Target_32): The following table lists the Windows values of the **ProductMajorVersion** and **ProductMinorVersion** fields for each applicable product.

| Product | ProductMajorVersion | ProductMinorVersion |
| --- | --- | --- |
| Windows XP operating system Service Pack 2 (SP2) | WINDOWS\_MAJOR\_VERSION\_5 | WINDOWS\_MINOR\_VERSION\_1 |
| Windows Server 2003 | WINDOWS\_MAJOR\_VERSION\_5 | WINDOWS\_MINOR\_VERSION\_2 |
| Windows Vista | WINDOWS\_MAJOR\_VERSION\_6 | WINDOWS\_MINOR\_VERSION\_0 |
| Windows Server 2008 | WINDOWS\_MAJOR\_VERSION\_6 | WINDOWS\_MINOR\_VERSION\_0 |
| Windows 7 | WINDOWS\_MAJOR\_VERSION\_6 | WINDOWS\_MINOR\_VERSION\_1 |
| Windows Server 2008 R2 | WINDOWS\_MAJOR\_VERSION\_6 | WINDOWS\_MINOR\_VERSION\_1 |
| Windows 8 | WINDOWS\_MAJOR\_VERSION\_6 | WINDOWS\_MINOR\_VERSION\_2 |
| Windows Server 2012 operating system | WINDOWS\_MAJOR\_VERSION\_6 | WINDOWS\_MINOR\_VERSION\_2 |
| Windows 8.1 | WINDOWS\_MAJOR\_VERSION\_6 | WINDOWS\_MINOR\_VERSION\_3 |
| Windows Server 2012 R2 | WINDOWS\_MAJOR\_VERSION\_6 | WINDOWS\_MINOR\_VERSION\_3 |
| Windows 10 | WINDOWS\_MAJOR\_VERSION\_10 | WINDOWS\_MINOR\_VERSION\_0 |
| Windows Server 2016 Windows Server operating systemWindows Server 2019  | WINDOWS\_MAJOR\_VERSION\_10 | WINDOWS\_MINOR\_VERSION\_0 |

[<33> Section 2.2.2.10](#Appendix_A_Target_33): In Windows, this field contains one of the following values:

| Value | Meaning |
| --- | --- |
| WINDOWS\_MAJOR\_VERSION\_50x05 | The major version of the Windows operating system is 0x05. |
| WINDOWS\_MAJOR\_VERSION\_60x06 | The major version of the Windows operating system is 0x06. |
| WINDOWS\_MAJOR\_VERSION\_100x0A | The major version of the Windows operating system is 0x0A. |

[<34> Section 2.2.2.10](#Appendix_A_Target_34): In Windows, this field contains one of the following values:

| Value | Meaning |
| --- | --- |
| WINDOWS\_MINOR\_VERSION\_00x00 | The minor version of the Windows operating system is 0x00. |
| WINDOWS\_MINOR\_VERSION\_10x01 | The minor version of the Windows operating system is 0x01. |
| WINDOWS\_MINOR\_VERSION\_20x02 | The minor version of the Windows operating system is 0x02. |
| WINDOWS\_MINOR\_VERSION\_30x03 | The minor version of the Windows operating system is 0x03. |

[<35> Section 3.1.1.1](#Appendix_A_Target_35): Windows NT Server 4.0 SP3 does not support providing NTLM instead of LM responses.

[<36> Section 3.1.1.1](#Appendix_A_Target_36): **ClientBlocked** is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<37> Section 3.1.1.1](#Appendix_A_Target_37): **ClientBlockExceptions** is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<38> Section 3.1.1.1](#Appendix_A_Target_38): Except in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008, which set this variable to FALSE, Windows sets this variable to TRUE.

[<39> Section 3.1.1.1](#Appendix_A_Target_39): In Windows NT 4.0 and Windows 2000, the maximum lifetime for the challenge is 30 minutes. In Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2, the maximum lifetime is 36 hours.

[<40> Section 3.1.1.2](#Appendix_A_Target_40): Windows exposes these logical parameters to applications through the [**SSPI**](#gt_fb216516-748b-4873-8bdd-64c5f4da9920) interface.

[<41> Section 3.1.1.2](#Appendix_A_Target_41): **ClientSuppliedTargetName** is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<42> Section 3.1.1.2](#Appendix_A_Target_42): **ClientChannelBindingsUnhashed** is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<43> Section 3.1.1.2](#Appendix_A_Target_43): Not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7 or Windows Server 2008 R2.

[<44> Section 3.1.4](#Appendix_A_Target_44): Security Support Provider Interface (SSPI) is the Windows implementation of GSS API [[RFC2743]](https://go.microsoft.com/fwlink/?LinkId=90378).

[<45> Section 3.1.4](#Appendix_A_Target_45): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<46> Section 3.1.5.1.1](#Appendix_A_Target_46): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<47> Section 3.1.5.1.2](#Appendix_A_Target_47): Not supported by Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<48> Section 3.1.5.1.2](#Appendix_A_Target_48): This functionality is not supported in Windows NT and Windows 2000.

[<49> Section 3.1.5.1.2](#Appendix_A_Target_49): Not supported in Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<50> Section 3.1.5.1.2](#Appendix_A_Target_50): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<51> Section 3.1.5.1.2](#Appendix_A_Target_51): Not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7 or Windows Server 2008 R2.

[<52> Section 3.1.5.2](#Appendix_A_Target_52): Connectionless NTLM is supported only in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<53> Section 3.1.5.2.1](#Appendix_A_Target_53): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<54> Section 3.1.5.2.1](#Appendix_A_Target_54): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<55> Section 3.1.5.2.1](#Appendix_A_Target_55): Not supported by Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<56> Section 3.1.5.2.1](#Appendix_A_Target_56): Not supported in Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<57> Section 3.1.5.2.1](#Appendix_A_Target_57): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<58> Section 3.1.5.2.1](#Appendix_A_Target_58): Not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7 or Windows Server 2008 R2.

[<59> Section 3.2.1.1](#Appendix_A_Target_59): The default value of this state variable is FALSE. **ServerBlock** is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista or Windows Server 2008.

[<60> Section 3.2.1.1](#Appendix_A_Target_60): Except in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008, which set this variable to FALSE, Windows sets this value to TRUE.

[<61> Section 3.2.1.2](#Appendix_A_Target_61): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<62> Section 3.2.1.2](#Appendix_A_Target_62): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<63> Section 3.2.5.1.1](#Appendix_A_Target_63): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<64> Section 3.2.5.1.1](#Appendix_A_Target_64): Windows NT will set NTLMSSP\_NEGOTIATE\_TARGET\_INFO only if NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY is set. Windows 2000, Windows XP, and Windows Server 2003 will set NTLMSSP\_NEGOTIATE\_TARGET\_INFO only if NTLMSSP\_NEGOTIATE\_EXTENDED\_SESSIONSECURITY or NTLMSSP\_REQUEST\_TARGET is set.

[<65> Section 3.2.5.1.2](#Appendix_A_Target_65): **ServerBlock** is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<66> Section 3.2.5.1.2](#Appendix_A_Target_66): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<67> Section 3.2.5.1.2](#Appendix_A_Target_67): Not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7 or Windows Server 2008 R2.

[<68> Section 3.2.5.1.2](#Appendix_A_Target_68): MIC fields are not supported in Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<69> Section 3.2.5.1.2](#Appendix_A_Target_69): Supported by Windows NT 4.0, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2.

[<70> Section 3.2.5.2](#Appendix_A_Target_70): Connectionless NTLM is supported only in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<71> Section 3.2.5.2.2](#Appendix_A_Target_71): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<72> Section 3.2.5.2.2](#Appendix_A_Target_72): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<73> Section 3.2.5.2.2](#Appendix_A_Target_73): Not supported in Windows NT, Windows 2000, Windows XP, and Windows Server 2003.

[<74> Section 3.2.5.2.2](#Appendix_A_Target_74): Supported by Windows NT 4.0, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7, and Windows Server 2008 R2.

[<75> Section 3.2.5.2.2](#Appendix_A_Target_75): This functionality is not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, and Windows Server 2008.

[<76> Section 3.2.5.2.2](#Appendix_A_Target_76): Not supported in Windows NT, Windows 2000, Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7 or Windows Server 2008 R2.

[<77> Section 3.3.1](#Appendix_A_Target_77): If the client sends a domain that is unknown to the server, the server tries to perform the authentication against the local database.

[<78> Section 3.3.2](#Appendix_A_Target_78): If the client sends a domain that is unknown to the server, the server tries to perform the authentication against the local database.

[<79> Section 3.4.6](#Appendix_A_Target_79): The Windows implementation of **GSS\_WrapEx()** is called **EncryptMessage()**. For more information, see [[MSDN-EncryptMsg]](https://go.microsoft.com/fwlink/?LinkId=94577).

[<80> Section 3.4.7](#Appendix_A_Target_80): The Windows implementation of **GSS\_WrapEx()** is called **DecryptMessage()**. For more information, see [[MSDN-DecryptMsg]](https://go.microsoft.com/fwlink/?LinkId=101488).

[<81> Section 5.1](#Appendix_A_Target_81): NTLM domain considerations are as follows:

Microsoft DCs determine the minimum security requirements for NTLM authentication between a Windows client and the local Windows domain. Based on the minimum security settings in place, the DC can either allow or refuse the use of LM, NTLM, or NTLM v2 authentication, and servers can force the use of extended session security on all messages between the client and server. In a Windows domain, the DC controls domain level security settings through the use of Group Policy ([[MS-GPOL]](%5BMS-GPOL%5D.pdf#Section_62d1292462524052996f161d2b9019f4)), which replicates security policies to clients and servers throughout the local domain.

Domain-level security policies dictated by Group Policy have to be supported on the local system for authentication to take place. During NTLM authentication, clients and servers exchange NTLM capability flags that specify what levels of security they are able to support. If either the client or server's level of security support is less than the security policies of the domain, the authentication attempt is refused by the computer with the higher level of minimum security requirements. This is important for interdomain authentication where differing security policies might be enforced on either domain, and the client or server might not be able to support the security policies of the other's domain.

NTLM security levels are as follows:

The security policies exchanged by the server and client can be set independently of the DC minimum security requirements dictated by Group Policy. Higher local security policies can be exchanged by a client and server in a domain with low minimum security requirements in connection-oriented authentication during the capability flags exchange. However, during connectionless (datagram-oriented) authentication, it is not possible to exchange higher local security policies because they are strictly enforced by Group Policy. Local security policies that are set independently of the DC are subordinate to domain-level security policies for clients authenticating to a server on the local domain; therefore, it is not possible to use local-system policies that are less secure than domain-level policies.

Stand-alone servers that do not have a DC to authenticate clients set their own minimum security requirements.

NTLM security levels determine the minimum security settings allowed on a client, server, or DC to authenticate in an NTLM domain. The security levels cannot be modified in Windows NT 4.0 operating system Service Pack 3 (SP3) by setting this registry [**key**](#gt_718bfd46-3cd2-45e8-befa-55f5c9f3be7b) to one of the following security level values.

1. HKEY\_LOCAL\_MACHINE\System\CurrentControlSet\Control\Lsa\
2. LMCompatibilityLevel

Security-level descriptions:

**0:** Server sends LM and NTLM response and never uses extended session security. Clients use LM and NTLM authentication, and never use extended session security. DCs accept LM, NTLM, and NTLM v2 authentication.

**1:** Servers use NTLM v2 session security if it is negotiated. Clients use LM and NTLM authentication and use extended session security if the server supports it. DCs accept LM, NTLM, and NTLM v2 authentication.

**2:** Server sends NTLM response only. Clients use only NTLM authentication and use extended session security if the server supports it. DCs accept LM, NTLM, and NTLM v2 authentication.

**3:** Server sends NTLM v2 response only. Clients use NTLM v2 authentication and use extended session security if the server supports it. DCs accept LM, NTLM, and NTLM v2 authentication.

**4:** DCs refuse LM responses. Clients use NTLM authentication and use extended session security if the server supports it. DCs refuse LM authentication but accept NTLM and NTLM v2 authentication.

**5:** DCs refuse LM and NTLM responses, and accept only NTLM v2. Clients use NTLM v2 authentication and use extended session security if the server supports it. DCs refuse NTLM and LM authentication, and accept only NTLM v2 authentication.

# Change Tracking

This section identifies changes that were made to this document since the last release. Changes are classified as Major, Minor, or None.

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

* A document revision that incorporates changes to interoperability requirements.
* A document revision that captures changes to protocol functionality.

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

The revision class **None** means that no new technical changes were introduced. Minor editorial and formatting changes may have been made, but the relevant technical content is identical to the last released version.

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

| Section | Description | Revision class |
| --- | --- | --- |
| [2.2.2.5](#Section_99d90ff4957f4c8a80e45bfe5a9a9832) NEGOTIATE | 10035 : Revised description of M bit. | Major |
| [3.2.5.1.2](#Section_f9e6fbc4a9534f24b229ccdcc213b9ec) Server Receives an AUTHENTICATE\_MESSAGE from the Client | 10037 : Clarified GuestSession and Guest user account behaviors. | Major |
| [3.4](#Section_d1c86e81eb6647fd8a6f970050121347) Session Security Details | 10037 : Clarified default status of Guest session security. | Major |
| [4.2.2](#Section_2624850f36e9403ca8321d9c7243acc2) NTLM v1 Authentication | 9267 : Changed NTML NTLMSSP\_NEGOTIATE\_NTLM to NTLMSSP\_NEGOTIATE\_NTLM. | Major |
| [4.2.3](#Section_62b3a4218a57477882df9064a282f207) NTLM v1 with Client Challenge | 9267 : Changed NTML NTLMSSP\_NEGOTIATE\_NTLM to NTLMSSP\_NEGOTIATE\_NTLM. | Major |
| [4.2.4](#Section_125f7a94933e4023a146a449e49bf774) NTLMv2 Authentication | 9267 : Changed NTML NTLMSSP\_NEGOTIATE\_NTLM to NTLMSSP\_NEGOTIATE\_NTLM. | Major |
| [5.1](#Section_1e8466084c5f41f484541b91af8a755b) Security Considerations for Implementers | 10037 : Clarified default status of Guest account and password. | Major |

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