Accounting for HTTP Messages

draft-cavage-http-signatures-08

Abstract

When communicating over the Internet using the HTTP protocol, it can be desirable for a server or client to authenticate the sender of a particular message. It can also be desirable to ensure that the message was not tampered with during transit. This document describes a way for servers and clients to simultaneously add authentication and message integrity to HTTP messages by using a digital signature.

Feedback

This specification is a joint work product of the W3C Digital Verification Community Group [1] and the W3C Credentials Community Group [2]. Feedback related to this specification should be sent to public-credentials@w3.org [3].

Status of This Memo

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1. Introduction

This protocol extension is intended to provide a simple and standard way for clients to sign HTTP messages.

HTTP Authentication [RFC2617] defines Basic and Digest authentication mechanisms, TLS 1.2 [RFC5246] defines cryptographically strong transport layer security, and OAuth 2.0 [RFC6749] provides a fully-specified alternative for authorization of web service requests. Each of these approaches are employed on the Internet today with varying degrees of protection. However, none of these schemes are designed to cryptographically sign the HTTP messages themselves, which is required in order to ensure end-to-end message integrity. An added benefit of signing the HTTP message for the purposes of end-to-end message integrity is that the client can be authenticated using the same mechanism without the need for multiple round-trips.

Several web service providers have invented their own schemes for signing HTTP messages, but to date, none have been standardized. While there are no techniques in this proposal that are novel beyond the previous art, it is useful to standardize a simple and cryptographically strong mechanism for digitally signing HTTP messages.

1.1. Using Signatures in HTTP Requests

It is common practice to protect sensitive website API functionality via authentication mechanisms. Often, the entity accessing these APIs is a piece of automated software outside of an interactive human session. While there are mechanisms like OAuth and API secrets that are used to grant API access, each have their weaknesses such as unnecessary complexity for particular use cases or the use of shared secrets which may not be acceptable to an implementer.

Digital signatures are widely used to provide authentication without the need for shared secrets. They also do not require a round-trip in order to authenticate the client. A server need only have a mapping between the key being used to sign the content and the authorized entity to verify that a message was signed by that entity.

This specification provides two mechanisms that can be used by a server to authenticate a client. The first is the ‘Signature’ HTTP Authentication Scheme, which may be used for interactive sessions.
The second is the Signature HTTP Header, which is typically used by automated software agents.

1.2. Using Signatures in HTTP Responses

For high security transactions, having an additional signature on the HTTP header allows a client to ensure that even if the transport channel has been compromised, that the content of the messages have not been compromised. This specification provides a HTTP Signature Header mechanism that can be used by a client to authenticate the sender of a message and ensure that particular headers have not been modified in transit.

2. The Components of a Signature

There are a number of components in a signature that are common between the ‘Signature’ HTTP Authentication Scheme and the ‘Signature’ HTTP Header. This section details the components of a digital signature.

2.1. Signature Parameters

The following section details the signature parameters.

2.1.1. keyId

REQUIRED. The 'keyId' field is an opaque string that the server can use to look up the component they need to validate the signature. It could be an SSH key fingerprint, a URL to machine-readable key data, an LDAP DN, etc. Management of keys and assignment of 'keyId' is out of scope for this document.

2.1.2. algorithm

REQUIRED. The 'algorithm' parameter is used to specify the digital signature algorithm to use when generating the signature. Valid values for this parameter can be found in the Signature Algorithms registry located at http://www.iana.org/assignments/signature-algorithms and MUST NOT be marked "deprecated".

2.1.3. headers

OPTIONAL. The 'headers' parameter is used to specify the list of HTTP headers included when generating the signature for the message. If specified, it should be a lowercased, quoted list of HTTP header fields, separated by a single space character. If not specified, implementations MUST operate as if the field were specified with a single value, the 'Date' header, in the list of HTTP headers. Note
that the list order is important, and MUST be specified in the order the HTTP header field-value pairs are concatenated together during signing.

2.1.4. signature

REQUIRED. The 'signature' parameter is a base 64 encoded digital signature, as described in RFC 4648 [RFC4648], Section 4. The client uses the 'algorithm' and 'headers' signature parameters to form a canonicalized 'signing string'. This 'signing string' is then signed with the key associated with 'keyId' and the algorithm corresponding to 'algorithm'. The 'signature' parameter is then set to the base 64 encoding of the signature.

2.2. Ambiguous Parameters

If any of the parameters listed above are erroneously duplicated in the associated header field, then the last parameter defined MUST be used. Any parameter that is not recognized as a parameter, or is not well-formed, MUST be ignored.

2.3. Signature String Construction

In order to generate the string that is signed with a key, the client MUST use the values of each HTTP header field in the 'headers' Signature parameter, in the order they appear in the 'headers' Signature parameter. It is out of scope for this document to dictate what header fields an application will want to enforce, but implementers SHOULD at minimum include the request target and Date header fields.

To include the HTTP request target in the signature calculation, use the special '(request-target)' header field name.

1. If the header field name is '(request-target)' then generate the header field value by concatenating the lowercased :method, an ASCII space, and the :path pseudo-headers (as specified in HTTP/2, Section 8.1.2.3).

2. Create the header field string by concatenating the lowercased header field name followed with an ASCII colon ':', an ASCII space ' ', and the header field value. Leading and trailing optional whitespace (OWS) in the header field value MUST be omitted (as specified in RFC7230 [RFC7230], Section 3.2.4). If there are multiple instances of the same header field, all header field values associated with the header field MUST be concatenated, separated by a ASCII comma and an ASCII space ' , ', and used in the order in which they will appear in the
transmitted HTTP message. Any other modification to the header field value MUST NOT be made.

3. If value is not the last value then append an ASCII newline '\n'.

To illustrate the rules specified above, assume a 'headers' parameter list with the value of '(request-target) host date cache-control x-example' with the following HTTP request headers:

GET /foo HTTP/1.1
Host: example.org
Date: Tue, 07 Jun 2014 20:51:35 GMT
X-Example: Example header with some whitespace.
Cache-Control: max-age=60
Cache-Control: must-revalidate

For the HTTP request headers above, the corresponding signature string is:

(request-target): get /foo
host: example.org
date: Tue, 07 Jun 2014 20:51:35 GMT
cache-control: max-age=60, must-revalidate
x-example: Example header with some whitespace.

2.4. Creating a Signature

In order to create a signature, a client MUST:

1. Use the contents of the HTTP message, the 'headers' value, and the Signature String Construction algorithm to create the signature string.

2. The 'algorithm' and key associated with 'keyId' must then be used to generate a digital signature on the signature string.

3. The 'signature' is then generated by base 64 encoding the output of the digital signature algorithm.

For example, assume that the 'algorithm' value was "rsa-sha256". This would signal to the application that the data associated with 'keyId' is an RSA Private Key (as defined in RFC 3447 [RFC3447]), the signature string hashing function is SHA-256, and the signing algorithm is the one defined in RFC 3447 [RFC3447], Section Section 8.2.1 [8]. The result of the signature creation algorithm specified in RFC 3447 [RFC3447] should result in a binary
string, which is then base 64 encoded and placed into the `signature` value.

2.5. Verifying a Signature

In order to verify a signature, a server MUST:

1. Use the received HTTP message, the `headers` value, and the Signature String Construction algorithm to recreate the signature string.

2. The `algorithm`, `keyId`, and base 64 decoded `signature` listed in the signature parameters are then used to verify the authenticity of the digital signature.

For example, assume that the `algorithm` value was "rsa-sha256". This would signal to the application that the data associated with `keyId` is an RSA Public Key (as defined in RFC 3447 [RFC3447]), the signature string hashing function is SHA-256, and the `signature` verification algorithm to use to verify the signature is the one defined in RFC 3447 [RFC3447], Section 8.2.2 [9]. The result of the signature verification algorithm specified in RFC 3447 [RFC3447] should result in a successful verification unless the headers protected by the signature were tampered with in transit.

3. The 'Signature' HTTP Authentication Scheme

The "signature" authentication scheme is based on the model that the client must authenticate itself with a digital signature produced by either a private asymmetric key (e.g., RSA) or a shared symmetric key (e.g., HMAC). The scheme is parameterized enough such that it is not bound to any particular key type or signing algorithm. However, it does explicitly assume that clients can send an HTTP `Date` header.

3.1. Authorization Header

The client is expected to send an Authorization header (as defined in RFC 7235 [RFC7235], Section 4.1 [10]) where the "auth-scheme" is "Signature" and the "auth-param" parameters meet the requirements listed in Section 2: The Components of a Signature.

The rest of this section uses the following HTTP request as an example.
POST /foo HTTP/1.1
Host: example.org
Date: Tue, 07 Jun 2014 20:51:35 GMT
Content-Type: application/json
Digest: SHA-256=X48E9qOokqqrvdts8n0JRJN30WDUoyWxBf7kbu9DBPE=
Content-Length: 18

{"hello": "world"}

Note that the use of the 'Digest' header field is per RFC 3230
[RFC3230], Section 4.3.2 and is included merely as a
demonstration of how an implementer could include information about
the body of the message in the signature. The following sections
also assume that the "rsa-key-1" keyId refers to a private key known
to the client and a public key known to the server. The "hmac-key-1"
keyId refers to key known to the client and server.

3.1.1. Initiating Signature Authorization

A server may notify a client when a protected resource could be
accessed by authenticating itself to the server. To initiate this
process, the server will request that the client authenticate itself
via a 401 response code. The server may optionally specify which
HTTP headers it expects to be signed by specifying the 'headers'
parameter in the WWW-Authenticate header. For example:

HTTP/1.1 401 Unauthorized
Date: Thu, 08 Jun 2014 18:32:30 GMT
Content-Length: 1234
Content-Type: text/html
WWW-Authenticate: Signature realm="Example",headers="(request-target) date"

...

3.1.2. RSA Example

The authorization header and signature would be generated as:

Authorization: Signature keyId="rsa-key-1",algorithm="rsa-sha256",
headers="(request-target) host date digest content-length",
signature="Base64(RSA-SHA256(signing string))"

The client would compose the signing string as:
(request-target): post /foo
host: example.org
date: Tue, 07 Jun 2014 20:51:35 GMT
digest: SHA-256=X48E9qO0kqqrVdts8n0JRJN3OWDuoyxWxBf7kbu9DBPE=
content-length: 18

Note that the ' \n ' symbols above are included to demonstrate where the new line character should be inserted. There is no new line on the final line of the signing string.

For an RSA-based signature, the authorization header and signature would then be generated as:

Authorization: Signature keyId="rsa-key-1",algorithm="rsa-sha256",
headers="(request-target) host date digest content-length",
signature="Base64(RSA-SHA256(signing string))"

3.1.3. HMAC Example

For an HMAC-based signature without a list of headers specified, the authorization header and signature would be generated as:

Authorization: Signature keyId="hmac-key-1",algorithm="hmac-sha256",
headers="(request-target) host date digest content-length",
signature="Base64(HMAC-SHA256(signing string))"

The only difference between the RSA Example and the HMAC Example is the signature algorithm that is used. The client would compose the signing string in the same way as the RSA Example above:

(request-target): post /foo
host: example.org
date: Tue, 07 Jun 2014 20:51:35 GMT
digest: SHA-256=X48E9qO0kqqrVdts8n0JRJN3OWDuoyxWxBf7kbu9DBPE=
content-length: 18

4. The 'Signature' HTTP Header

The "signature" HTTP Header is based on the model that the sender must authenticate itself with a digital signature produced by either a private asymmetric key (e.g., RSA) or a shared symmetric key (e.g., HMAC). The scheme is parameterized enough such that it is not bound to any particular key type or signing algorithm. However, it does explicitly assume that senders can send an HTTP 'Date' header.
4.1. Signature Header

The sender is expected to transmit a header (as defined in RFC 7230 [RFC7230], Section 3.2 [12]) where the "field-name" is "Signature", and the "field-value" contains one or more "auth-param"s (as defined in RFC 7235 [RFC7235], Section 4.1 [13]) where the "auth-param" parameters meet the requirements listed in Section 2: The Components of a Signature.

The rest of this section uses the following HTTP request as an example.

POST /foo HTTP/1.1
Host: example.org
Date: Tue, 07 Jun 2014 20:51:35 GMT
Content-Type: application/json
Digest: SHA-256=X48E9qOokqqrvdts8nOJRJN3OWDUoyWxBf7kbu9DBPE=
Content-Length: 18

{"hello": "world"}

The following sections assume that the "rsa-key-1" keyId refers to a private key known to the client and a public key known to the server. The "hmac-key-1" keyId refers to key known to the client and server.

4.1.1. RSA Example

The signature header and signature would be generated as:

Signature: keyId="rsa-key-1",algorithm="rsa-sha256",
headers="(request-target) host date digest content-length",
signature="Base64(RSA-SHA256(signing string))"

The client would compose the signing string as:

(request-target): post /foo
host: example.org
date: Tue, 07 Jun 2014 20:51:35 GMT
digest: SHA-256=X48E9qOokqqrvdts8nOJRJN3OWDUoyWxBf7kbu9DBPE=
content-length: 18

Note that the ‘\n’ symbols above are included to demonstrate where the new line character should be inserted. There is no new line on the final line of the signing string.

For an RSA-based signature, the authorization header and signature would then be generated as:

POST /foo HTTP/1.1
Host: example.org
Date: Tue, 07 Jun 2014 20:51:35 GMT
Content-Type: application/json
Digest: SHA-256=X48E9qOokqqrvdts8nOJRJN3OWDUoyWxBf7kbu9DBPE=
Content-Length: 18

{"hello": "world"}
Signature: keyId="rsa-key-1",algorithm="rsa-sha256",
headers="(request-target) host date digest content-length",
signature="Base64(RSA-SHA256(signing string))"

4.1.2. HMAC Example

For an HMAC-based signature without a list of headers specified, the
authorization header and signature would be generated as:

Signature: keyId="hmac-key-1",algorithm="hmac-sha256",
headers="(request-target) host date digest content-length",
signature="Base64(HMAC-SHA256(signing string))"

The only difference between the RSA Example and the HMAC Example is
the signature algorithm that is used. The client would compose the
signing string in the same way as the RSA Example above:

(request-target): post /foo
host: example.org
date: Tue, 07 Jun 2014 20:51:35 GMT
digest: SHA-256=X48E9qOokqqr6ts8nOJRJN3OWDUoyWxBf7kbu9DBPE=
content-length: 18

5. References

5.1. Normative References

[I-D.ietf-jose-json-web-algorithms]
Jones, M., "JSON Web Algorithms (JWA)", draft-ietf-jose-
json-web-algorithms-20 (work in progress), January 2014.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
Requirement Levels", BCP 14, RFC 2119,
DOI 10.17487/RFC2119, March 1997,

[RFC4648] Josefsson, S., "The Base16, Base32, and Base64 Data
Encodings", RFC 4648, DOI 10.17487/RFC4648, October 2006,

"DomainKeys Identified Mail (DKIM) Signatures", STD 76,
RFC 6376, DOI 10.17487/RFC6376, September 2011,


5.2. Informative References


5.3. URIs

[1] https://w3c-dvcm.github.io/


[3] mailto:public-credentials@w3.org


Appendix A. Security Considerations

There are a number of security considerations to take into account when implementing or utilizing this specification. A thorough security analysis of this protocol, including its strengths and weaknesses, can be found in Security Considerations for HTTP Signatures [14].

Appendix B. Extensions

This specification was designed to be simple, modular, and extensible. There are a number of other specifications that build on this one. For example, the HTTP Signature Nonces [15] specification details how to use HTTP Signatures over a non-secured channel like HTTP and the HTTP Signature Trailers [16] specification explains how to apply HTTP Signatures to streaming content. Developers that desire more functionality than this specification provides are urged to ensure that an extension specification doesn’t already exist before implementing a proprietary extension.
If extensions to this specification are made by adding new Signature Parameters, those extension parameters MUST be registered in the Signature Authentication Scheme Registry. The registry will be created and maintained at (the suggested URI) http://www.iana.org/assignments/http-auth-scheme-signature [17]. An example entry in this registry is included below:

Signature Parameter: nonce
Reference to specification: [HTTP_AUTH_SIGNATURE_NONCE], Section XYZ.
Notes (optional): The HTTP Signature Nonces specification details how to use HTTP Signatures over a unsecured channel like HTTP.

Appendix C. Test Values

The following test data uses the following RSA 2048-bit keys, which we will refer to as ‘keyId=Test’ in the following samples:

-----BEGIN PUBLIC KEY-----
MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQDCFENGw33yGihy92pDjZQh10C36rPJj+CvfsSC8+q28hxA161QFNd13wuCTUcgQqD2qsBe/2hFyc2DCJJg0h1L6z8+6Z4UMR7EopfdUE9hf3m.hs+FU45uBJeDK1HSFHD8bHKD6kv8FPGfJTotc+2xJjW0Yi+1hqplfIekaxsyQIDAQAB
-----END PUBLIC KEY-----

-----BEGIN RSA PRIVATE KEY-----
MIICXgIBAAKBgQDCFENGw33yGihy92pDjZQh10C36rPJj+CvfsSC8+q28hxA161QFNUd13wuCTUcgQqD2qsBe/2hFyc2DCJJg0h1L6z8+6Z4UMR7EopfdUE9hf3m.hs+FUR45uBJeDK1HSFHD8bHKD6kv8FPGfJTotc+2xJjW0Yi+1hqplfIekaxsyQIDAQABAoGBAJR82kCUvx5kvzv+utd17TSMnordTIITvoXXJGXK7Z2Z+UuvMNUcdN2Qfc4sB1aQWvLw1cSkt5DsKZ8UEtpYFy8pFYnnD2dDYaew9+xEpubyeW2oH4Zx71wQBTOKkwXRa/pzdpiciuRRjkl6vE6Y7EBBs/g?uanVpGibOVAEsqH1AkEA7DkJyVH28WDUgflNqvnZfnJ6C7TnICe3jGJsz277z12mBMHFDONMLUrXR/Zm3pR5m0tCmBq5a5RK95u412j1dIPwIBANJT3v8pnkth48bQo/fke16kEyyboRtA5/uuHUKZ6FQ70UKG0gcmsJlu0dct56hIlvIsL0QZJgQOMEOw+r+wKSMCQPCC4kXJEHsAve77oP66LG/I1En7kpyUXRNvFsE0czpJJBV/a1FuFJxuRK191jhjC68sA7NsKMcg5OXbS15jJ36xaKeaEAgiTr7aFOYFwGgQAqKWNKLvysGkBzATeLBacPHQlZI1PfndtvAcypAZ50RKmW6aFKaqQfOKCXvWoUIVknQJAx1gySFci/2ueK1IE1QqIiLSZ8V8O1pFLRnb1pxIZ7UiyQXnTAEFYM560y1JzyUpOb1V4cScGd365tiSMvxLOvTa==
-----END RSA PRIVATE KEY-----

All examples use this request:
POST /foo?param=value&pet=dog HTTP/1.1  
Host: example.com  
Date: Thu, 05 Jan 2014 21:31:40 GMT  
Content-Type: application/json  
Digest: SHA-256=X48E9qOokqqrvt8s8n0JRN30DUoyWxBf7ku9DBPE=  
Content-Length: 18  
{"hello": "world"}

C.1. Default Test

If a list of headers is not included, the date is the only header that is signed by default. The string to sign would be:

date: Thu, 05 Jan 2014 21:31:40 GMT

The Authorization header would be:

Authorization: Signature keyId="Test",algorithm="rsa-sha256",  
signature="jKyvPcx04Jbm074y4mByyBy7cZfN14OW9H9pFQlG7N4YcJPteKTu4MW  
CLyk+gIр0wDqgtLWf9NLPpMAMimdfsH7FSWGfbMFSrsVTHNTk0rk3usrFnt1ldx  
sM4j10kYJCKTGI/UWkqixwNiKgcdlEDrTcUhhFs0Io8Vhddm2TZ8w="

The Signature header would be:

Signature: keyId="Test",algorithm="rsa-sha256",  
signature="jKyvPcx04Jbm074y4mByyBy7cZfN14OW9H9pFQlG7N4YcJPteKTu4MW  
CLyk+gIр0wDqgtLWf9NLPpMAMimdfsH7FSWGfbMFSrsVTHNTk0rk3usrFnt1ldx  
sM4j10kYJCKTGI/UWkqixwNiKgcdlEDrTcUhhFs0Io8Vhddm2TZ8w="

C.2. Basic Test

The minimum recommended data to sign is the (request-target), host,  
and date. In this case, the string to sign would be:

(request-target): post /foo?param=value&pet=dog  
host: example.com  
date: Thu, 05 Jan 2014 21:31:40 GMT

The Authorization header would be:

Authorization: Signature keyId="Test",algorithm="rsa-sha256",  
headers="(request-target) host date", signature="HUxc9BS3P/kPhSM  
mJo+0pQ4lsC007vkv6bUm4Qhnx+B1Eo4Mq5/6Ky1ET72ZpMUS80Xvjl0Pjxzx  
feTQj4DiKbArwJAb4HX3qX6obQTa00/gPDx1MepD2JtTw33yNnm/0xV7fQvuILN  
/ys+378Ysi082+4xBQFwvhNVsOvSvGv4="
C.3. All Headers Test

A strong signature including all of the headers and a digest of the body of the HTTP request would result in the following signing string:

(request-target): post /foo?param=value&pet=dog
host: example.com
date: Thu, 05 Jan 2014 21:31:40 GMT
content-type: application/json
digest: SHA-256=X48E9qOokqqrvtss8nOJRNJ3OWDUowXxWb7kbu9DBPE=
content-length: 18

The Authorization header would be:

Authorization: Signature keyId="Test",algorithm="rsa-sha256",
headers="(request-target) host date content-type digest content-length",
signature="Ef7MlxLxBovhlii3AlyjBoWALg4TN3tibLj7uuNB3CROat/9Kae
Q4hW2NiJ+pZ6HQEOx9yZAYyi+7cmIkmJszJC5ut5kQLAwuX+Ms/mUFvpK1So9StS
2bMXDBNjOh4Au774GFj4gwjS+3NhFeosyr/MuN6HsEnkv6zdGF2i0=

The Signature header would be:

Signature: keyId="Test",algorithm="rsa-sha256",
headers="(request-target) host date content-type digest content-length",
signature="Ef7MlxLxBovhlii3AlyjBoWALg4TN3tibLj7uuNB3CROat/9Kae
Q4hW2NiJ+pZ6HQEOx9yZAYyi+7cmIkmJszJC5ut5kQLAwuX+Ms/mUFvpK1So9StS
2bMXDBNjOh4Au774GFj4gwjS+3NhFeosyr/MuN6HsEnkv6zdGF2i0=

Appendix D. Acknowledgements

The editor would like to thank the following individuals for feedback on and implementations of the specification (in alphabetical order):

Appendix E. IANA Considerations

E.1. Signature Authentication Scheme

The following entry should be added to the Authentication Scheme Registry located at http://www.iana.org/assignments/http-authschemes
[18]

Authentication Scheme Name: Signature
Reference: [RFC_THIS_DOCUMENT], Section 2.
Notes (optional): The Signature scheme is designed for clients to authenticate themselves with a server.

E.2. Signature Algorithm Registry

The following initial entries should be added to the Signature Algorithm Registry to be created and maintained at (the suggested URI) http://www.iana.org/assignments/signature-algorithms [19]:

Editor’s note: The references in this section are problematic as many of the specifications that they refer to are too implementation specific, rather than just pointing to the proper signature and hashing specifications. A better approach might be just specifying the signature and hashing function specifications, leaving implementers to connect the dots (which are not that hard to connect).

Algorithm Name: rsa-sha1
Reference: RFC 6376 [RFC6376], Section 3.3.1
Status: deprecated

Algorithm Name: rsa-sha256
Reference: RFC 6376 [RFC6376], Section 3.3.2
Status: active

Algorithm Name: hmac-sha256
Reference: HS256 in JOSE JSON Web Algorithms [I-D.ietf-jose-json-web-algorithms], Section 3.2
Status: active

Algorithm Name: ecdsa-sha256
Reference: ES256 in JOSE JSON Web Algorithms [I-D.ietf-jose-json-web-algorithms], Section 3.4
Status: active

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