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Security Protocol and Data Model (SPDM) Specification

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14 CONTENTS

15 1 Foreword

16 The *Platform Management Components Intercommunication (PMCI)* working group of the DMTF prepared the *Security Protocol and Data Model (SPDM) Specification* (DSP0274). DMTF is a not-for-profit association of industry members that promotes enterprise and systems management and interoperability. For information about the DMTF, see DMTF.

17 This version supersedes version 1.1 and its errata versions. For a list of the changes, see ANNEX E (informative) change log.

18 1.1 Acknowledgments

19 The DMTF acknowledges the following individuals for their contributions to this document:

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21 2 Introduction

22 The *Security Protocol and Data Model (SPDM) Specification* defines *messages*, data objects, and sequences for performing message exchanges between *devices* over a variety of transport and physical media. The description of message exchanges includes *authentication* and provisioning of hardware identities, measurement for firmware identities, session key exchange protocols to enable confidentiality with integrity protected data communication and other related capabilities. The SPDM enables efficient access to low-level security capabilities and operations. Other mechanisms, including non-PMCI- and DMTF-defined mechanisms, can use the SPDM.

23 2.1 Advice

24 The authors recommend readers visit tutorial and education materials under Platform Management Communications Infrastructure (PMCI) on DMTF website prior to or during the reading of this specification to help understand this specification.

25 2.2 Conventions

26 The following conventions apply to all SPDM specifications.

27 2.2.1 Document conventions

- Document titles appear in *italics*.
- The first occurrence of each important term appears in *italics* with a link to its definition.
- ABNF rules appear in a mono-spaced font.

28 2.2.2 Reserved and unassigned values

29 Unless otherwise specified, any reserved, unspecified, or unassigned values in enumerations or other numeric ranges are reserved for future definition by the DMTF.

30 Unless otherwise specified, field values marked as Reserved shall be written as zero (`0`), ignored when read, not modified and not interpreted as an error if not zero, and used in transcript hash calculations as is.

31 2.2.3 Byte ordering

32 Unless otherwise specified, for all SPDM specifications *byte* ordering of multi-byte numeric fields or multi-byte bit fields is "Little Endian" (that is, the lowest byte offset holds the least significant byte, and higher offsets hold the more significant bytes).

33 **2.2.3.1 Hash byte order**

34 For fields or values containing a digest or hash, SPDM preserves the byte order of the digest as the specification of a given hash algorithm defines. SPDM views these digests, simply, as a string of octets where the first byte is the left most byte of the digest, the second byte is the second leftmost byte, the third byte is the third leftmost byte and this pattern continues until the last byte of the digest. Thus, the byte order for SPDM digests or hashes is the first byte is placed at the lowest offset in the field or value, the second byte is placed at the second lowest offset, the third byte is placed at the third lowest offset in the field or value and this pattern continues until the last byte.

35 For example, in FIPS 180-4, a SHA 256 hash is the concatenation of eight 32-bit words where each word is in big endian order but the order of words do not have any endianness associated with it. SPDM simply views this 256-bit digest as a string of octets that is 32 bytes in size where the first byte is the value at H_0[31:24] of the final digest, the second byte is the value at H_0[23:16], the third byte is value at H_0[15:8], the forth byte is value at H_0[7:0], the fifth bytes is the value at H_1[31:24] and this pattern continues until the last byte, which is the value at H_7[7:0] where the FIPS 180-4 specification defines H_0, H_1, and H_7.

36 **2.2.3.2 Encoded ASN.1 byte order**

37 For fields or values containing DER, CER or BER encoded data, SPDM preserves the byte order as described in X.690 specification. SPDM views a DER, CER or BER encoded data as simply a string of octets where the first byte is the leftmost byte of Figure 1 or Figure 2 in the X.690 specification, the second byte is the second leftmost byte, the third byte is the third leftmost byte and this pattern continues until the last byte. The first byte is also called either the Identifier octet or the Leading identifier octet. The X.690 specification defines Figure 1, Figure 2, and identifier octets. When populating a DER, CER, or BER encoded data in SPDM fields, the first byte is placed in the lowest address, the second byte is placed in the second lowest offset, the third byte is placed in the third lowest offset in the field or value and this pattern continues until the last byte.

38 2.2.4 SPDM data types

39 Table 1 — SPDM data types lists the abbreviations and descriptions for common data types that SPDM message fields and data structure definitions use. These definitions follow DSP0240.

40 **Table 1 — SPDM data types**

Data type	Interpretation
`ver8`	Eight-bit encoding of the SPDM version number. Version encoding defines the encoding of the version number.
`bitfield8`	Byte with eight bit fields.
`bitfield16`	Two-byte word with 16-bit fields.

41 **2.2.5 Version encoding**

42 The `SPDMVersion` field represents the version of the specification through a combination of *Major* and *Minor* nibbles, encoded as follows:

Version	Matches	Incremented when
Major	Major version field in the `SPDMVersion` field in the SPDM message header.	Protocol modification breaks backward compatibility.
Minor	Minor version field in the `SPDMVersion` field in the SPDM message header.	Protocol modification maintains backward compatibility.

43 EXAMPLE:

44 Version 3.7 → `0x37`

45 Version 1.0 → `0x10`

46 Version 1.2 → `0x12`

47 An *endpoint* that supports Version 1.2 can interoperate with an older endpoint that supports Version 1.0 or other previous minor versions. Whether an endpoint supports inter-operation with previous minor versions of the SPDM specification is an implementation-specific decision.

48 An endpoint that supports Version 1.2 only and an endpoint that supports Version 3.7 only are not interoperable and shall not attempt to communicate beyond `GET_VERSION`.

49 This specification considers two minor versions to be interoperable when it is possible for an implementation that is conformant to a higher minor version number to also communicate with an implementation that is conformant to a lower minor version number with minimal differences in operation. In such a case, the following rules apply:

- Both endpoints shall use the same lower version number in the `SPDMVersion` field for all messages.
- Functionality shall be limited to what the lower minor version of the SPDM specification defines.
- Differences can exist in computations or other operations between the higher and lower minor versions of the SPDM specification. These differences are dependent on the value in the `SPDMVersion` field in the message.
- In a newer minor version of the SPDM specification, a given message can be longer, bit fields and enumerations can contain new values, and reserved fields can gain functionality. Existing numeric and bit fields retain their existing definitions.

50 For details on the version agreement process, see GET_VERSION request and VERSION response messages. The detailed version encoding that the `VERSION` response message returns contains an additional byte that indicates specification bug fixes or development versions. See Table 9 — Successful VERSION response message format.

51 ### 2.2.6 Notations

52 SPDM specifications use the following notations:

Notation	Description
`M:N`	In field descriptions, this notation typically represents a range of byte offsets starting from byte `M` and continuing to and including byte `N` (`M ≤ N`). The lowest offset is on the left. The highest offset is on the right.
`[4]`	Square brackets around a number typically indicate a bit offset. Bit offsets are zero-based values. That is, the least significant bit (`[LSb]`) offset = 0.
`[M:N]`	A range of bit offsets where M is greater than or equal to N. The most significant bit is on the left, and the least significant bit is on the right.
`1b`	A lowercase `b` after a number consisting of `0` s and `1` s indicates that the number is in binary format.
`0x12A`	Hexadecimal, indicated by the leading `0x` .
`N+`	Variable-length byte range that starts at byte offset N.
`{ Payload }`	Used mostly in figures, this notation indicates the payload specified in the enclosing curly brackets is encrypted and/or authenticated by the keys derived from one or more major secrets. The specific secret used is described throughout this specification. For example, `{ HEARTBEAT }` shows that the Heartbeat message is encrypted and/or authenticated by the keys derived from one or more major secrets.
`{ Payload }::[[`S_X`]]`	Used mostly in figures, this notation indicates the payload specified in the enclosing curly brackets is encrypted and/or authenticated by the keys derived from major Secret X. For example, `{ HEARTBEAT }::[[`S_2`]]` shows that the Heartbeat message is encrypted and/or authenticated by the keys derived from major secret S_2 .

53 ### 2.2.7 Text or string encoding

54 When a value is indicated as a text or string data type, the encoding for the text or string shall be an array of contiguous *bytes* whose values are ordered. The first byte of the array resides at the lowest offset and the last byte of the array is at the highest offset. The order of characters in the array shall be where the leftmost character of the string is placed at the first byte in the array, the second leftmost character is placed in the second byte and so on forth until the last character is placed in the last byte.

55 Each byte in the array shall be the numeric value that represents that character, as ASCII — ISO/IEC 646:1991 defines.

56 Table 2 — "spdm" encoding example shows an encoding example of the "spdm" string:

57 **Table 2 — "spdm" encoding example**

Offset	Character	Value
0	s	`0x73`
1	p	`0x70`
2	d	`0x64`
3	m	`0x6D`

58 2.2.8 Deprecated material

59 Deprecated material is not recommended for use in new development efforts. Existing and new implementations can use this material but they shall move to the favored approach as soon as possible. Implementations can implement any deprecated elements as required by this document to achieve backwards compatibility. Although implementations can use deprecated elements, they are directed to use the favored elements instead.

60 The following typographical convention indicates deprecated material:

---

61 DEPRECATED

62 Deprecated material appears here.

63 DEPRECATED

---

64 In places where this typographical convention cannot be used (for example, tables or figures), the "DEPRECATED" label is used alone.

65 3 Scope

66 This specification describes how to use messages, data objects, and sequences to exchange messages between two devices over a variety of transports and physical media. This specification contains the message exchanges, sequence diagrams, message formats, and other relevant semantics for such message exchanges, including authentication of hardware identities and firmware measurement.

67 Other specifications define the mapping of these messages to different transports and physical media. This specification provides information to enable security policy enforcement but does not specify individual policy decisions.

68 # 4 Normative references

69 The following documents are indispensable for the application of this specification. For dated or versioned references, only the edition cited, including any corrigenda or DMTF update versions, applies. For references without a date or version, the latest published edition of the referenced document (including any corrigenda or DMTF update versions) applies.

- *ISO/IEC Directives, Part 2, Principles and rules for the structure and drafting of ISO and IEC documents - 2018 (8th edition)*
- DMTF DSP0004, *Common Information Model (CIM) Metamodel*, https://www.dmtf.org/sites/default/files/standards/documents/DSP0004_3.0.1.pdf
- DMTF DSP0223, *Generic Operations*, https://www.dmtf.org/sites/default/files/standards/documents/DSP0223_1.0.1.pdf
- DMTF DSP0236, *MCTP Base Specification 1.3.0*, https://dmtf.org/sites/default/files/standards/documents/DSP0236_1.3.0.pdf
- DMTF DSP0239, *MCTP IDs and Codes 1.6.0*, https://www.dmtf.org/sites/default/files/standards/documents/DSP0239_1.6.0.pdf
- DMTF DSP0240, *Platform Level Data Model (PLDM) Base Specification*, https://www.dmtf.org/sites/default/files/standards/documents/DSP0240_1.0.0.pdf
- DMTF DSP0275, *Security Protocol and Data Model (SPDM) over MCTP Binding Specification*, https://www.dmtf.org/dsp/DSP0275
- DMTF DSP1001, *Management Profile Usage Guide*, https://www.dmtf.org/sites/default/files/standards/documents/DSP1001_1.2.0.pdf
- IETF TLS DTLS13-43, *The Datagram Transport Layer Security (DTLS) Protocol Version 1.3 draft-ietf-tls-dtls13-43*, 30 April 2021
- IETF RFC2986, *PKCS #10: Certification Request Syntax Specification*, November 2000
- IETF RFC4716, *The Secure Shell (SSH) Public Key File Format*, November 2006
- IETF RFC5234, *Augmented BNF for Syntax Specifications: ABNF*, January 2008
- IETF RFC5280, *Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile*, May 2008
- IETF RFC7250, *Using Raw Public Keys in Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS)*, June 2014
- IETF RFC7919, *Negotiated Finite Field Diffie-Hellman Ephemeral Parameters for Transport Layer Security (TLS)*, August 2016
- IETF RFC8032, *Edwards-Curve Digital Signature Algorithm (EdDSA)*, January 2017
- IETF RFC8446, *The Transport Layer Security (TLS) Protocol Version 1.3*, August 2018
- *USB Authentication Specification Rev 1.0 with ECN and Errata through January 7, 2019*
- *TCG Algorithm Registry, Family "2.0", Level 00 Revision 01.32*, June 25, 2020

- NIST Special Publication 800-38D, *Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC*, November 2007
- IETF RFC8439, *ChaCha20 and Poly1305 for IETF Protocols*, June 2018
- IETF RFC8998, *ShangMi (SM) Cipher Suites for TLS 1.3*, March 2021
- GB/T 32918.1-2016, *Information security technology—Public key cryptographic algorithm SM2 based on elliptic curves—Part 1: General*, August 2016
- GB/T 32918.2-2016, *Information security technology—Public key cryptographic algorithm SM2 based on elliptic curves—Part 2: Digital signature algorithm*, August 2016
- GB/T 32918.3-2016, *Information security technology—Public key cryptographic algorithm SM2 based on elliptic curves—Part 3: Key exchange protocol*, August 2016
- GB/T 32918.4-2016, *Information security technology—Public key cryptographic algorithm SM2 based on elliptic curves—Part 4: Public key encryption algorithm*, August 2016
- GB/T 32918.5-2016, *Information security technology—Public key cryptographic algorithm SM2 based on elliptic curves—Part 5: Parameter definition*, August 2016
- GB/T 32905-2016, *Information security technology—SM3 cryptographic hash algorithm*, August 2016
- GB/T 32907-2016, *Information security technology—SM4 block cipher algorithm*, August 2016
- **ASN.1 — ISO-822-1-4, DER — ISO-8825-1**
  - ITU-T X.680, X.681, X.682, X.683, X.690, 08/2015
- **X.509 — ISO-9594-8**
  - ITU-T X.509, 08/2015
- **ASCII — ISO/IEC 646:1991**, 09/1991
- **ECDSA**
  - Section 6, The Elliptic Curve Digital Signature Algorithm (ECDSA) in FIPS PUB 186-4 Digital Signature Standard (DSS)
  - Appendix D: Recommended Elliptic Curves for Federal Government Use in FIPS PUB 186-4 Digital Signature Standard (DSS)
- ANSI X9.62, 2005
- **SHA2-256**, **SHA2-384**, and **SHA2-512**
  - FIPS PUB 180-4 Secure Hash Standard (SHS)
- **SHA3-256**, **SHA3-384**, and **SHA3-512**
  - FIPS PUB 202 SHA-3 Standard: Permutation-Based Hash and Extendable-Output Functions

70 # 5 Terms and definitions

71 In this document, some terms have a specific meaning beyond the normal English meaning. This clause defines those terms.

72 The terms "shall" ("required"), "shall not", "should" ("recommended"), "should not" ("not recommended"), "may", "need not" ("not required"), "can" and "cannot" in this document are to be interpreted as described in ISO/IEC Directives, Part 2, Clause 7. The terms in parenthesis are alternatives for the preceding term, for use in exceptional cases when the preceding term cannot be used for linguistic reasons. Note that ISO/IEC Directives, Part 2, Clause 7 specifies additional alternatives. Occurrences of such additional alternatives shall be interpreted in their normal English meaning.

73 The terms "clause", "subclause", "paragraph", and "annex" in this document are to be interpreted as described in ISO/IEC Directives, Part 2, Clause 6.

74 The terms "normative" and "informative" in this document are to be interpreted as described in ISO/IEC Directives, Part 2, Clause 3. In this document, clauses, subclauses, or annexes labeled "(informative)" do not contain normative content. Notes and examples are always informative elements.

75 The terms that DSP0004, DSP0223, DSP0236, DSP0239, DSP0275, and DSP1001 define also apply to this document.

76 This specification uses these terms:

Term	Definition
alias certificate	Certificate that is dynamically generated by the *component* or component firmware.
application data	Data that is specific to the application and whose definition and format is outside the scope of this specification. Application data usually exist at the application layer, which is, in general, the layer above SPDM and the transport layer. Examples of data that could be application data include: messages carried as DMTF MCTP payloads; Internet traffic (PCIe transaction layer packets (TLPs)); camera images and video (MIPI CSI-2 packets); video display stream (MIPI DSI-2 packets) and touchscreen data (MIPI I3C Touch).
authentication initiator	Endpoint that initiates the authentication process by challenging another endpoint.
authentication	Process of determining whether an entity is who or what it claims to be.
byte	Eight-bit quantity. Also known as an *octet*.
certificate authority (CA)	Trusted entity that issues certificates.
certificate chain	Typically a series of two or more certificates. Each certificate is signed by the preceding certificate in the chain.

Term	Definition
certificate	Digital form of identification that provides information about an entity and certifies ownership of a particular asymmetric key-pair.
component	Physical device, contained in a single package.
device certificate	Certificate that contains information that identifies the component. Can be a leaf certificate or an *intermediate certificate*.
device	Physical entity such as a network controller or a fan.
DMTF	Formerly known as the Distributed Management Task Force, the DMTF creates open manageability standards that span diverse emerging and traditional information technology (IT) infrastructures, including cloud, virtualization, network, servers, and storage. Member companies and alliance partners worldwide collaborate on standards to improve the interoperable management of IT.
encapsulated request	A request embedded into `ENCAPSULATED_REQUEST` or `ENCAPSULATED_RESPONSE_ACK` response message to allow the Responder to issue a request to a Requester. See GET_ENCAPSULATED_REQUEST request and ENCAPSULATED_REQUEST response messages.
endpoint	Logical entity that communicates with other endpoints over one or more transport protocol.
intermediate certificate	Certificate that is neither a root certificate nor a leaf certificate.
invasive debug mode	A device mode that enables debug access that might expose or allow modification of security critical firmware, hardware, or settings. Invasive debug mode might include access to the device TCB.
large SPDM message	An SPDM message that is greater than the `DataTransferSize` of the receiving SPDM endpoint.
large SPDM request message	A large SPDM message that is an SPDM request.
large SPDM response message	A large SPDM message that is an SPDM response.
leaf certificate	Last certificate in a certificate chain.
measurement	Representation of firmware/software or configuration data on an endpoint.
message	See SPDM message.
message body	Portion of an SPDM message that carries additional data.
message transcript	The concatenation of a sequence of messages in the order in which they are sent and received by an endpoint. The final message included in the message transcript may be truncated to allow inclusion of a signature in that message which is computed over the message transcript. If an endpoint is communicating with multiple peer endpoints concurrently, the message transcripts for the peers are accumulated separately and independently.
most significant byte (MSB)	Highest order *byte* in a number consisting of multiple bytes.

Term	Definition
Negotiated State	Set of parameters that represent the state of the communication between a corresponding pair of Requester and Responder at the successful completion of the `NEGOTIATE_ALGORITHMS` messages. These parameters may include values provided in `VERSION` , `CAPABILITIES` and `ALGORITHMS` messages. Additionally, they may include parameters associated with the transport layer. They may include other values deemed necessary by the Requester or Responder to continue or preserve communication with each other.
nibble	Computer term for a four-bit aggregation, or half of a byte.
non-invasive debug mode	A device mode that enables debug access that does not expose or allow modification of security critical firmware, hardware, or settings.
nonce	Number that is unpredictable to entities other than its generator. The probability of the same number occurring more than once is negligible. Nonce may be generated by combining a pseudo random number of at least 64 bits, optionally concatenated with a monotonic counter of size suitable for the application.
payload	Information-bearing fields of a message. These fields are separate from the transport fields and elements, such as address fields, framing bits, and checksums, that transport the message from one point to another. In some instances, a field can be both a payload field and a transport field.
physical transport binding	Specifications that define how a base messaging protocol is implemented on a particular physical transport type and medium, such as SMBus/I^2C or PCI Express™ Vendor Defined Messaging.
Platform Management Component Intercommunication (PMCI)	Working group under the DMTF that defines standardized communication protocols, low-level data models, and transport definitions that support communications with and between management controllers and management devices that form a platform management subsystem within a managed computer system.
record	A unit or chunk of data that is either encrypted and/or authenticated.
Requester	Original transmitter, or source, of an SPDM request message. It is also the ultimate receiver, or destination, of an SPDM response message. A Requester is the sender of the `GET_VERSION` request and remains the requester for the remainder of that connection.
Reset	This term is used to denote a Reset or restart of a device that runs the Requester or Responder code, that typically leads to loss of all volatile state on the device.
Responder	Ultimate receiver, or destination, of an SPDM request message. It is also the original transmitter, or source of an SPDM response message.
root certificate	First certificate in a certificate chain, which acts as the trust anchor, typically self-signed.
secure session	Provides either or both of encryption or message authentication for communicating data over a transport.
session keys	Any secrets, derived cryptographic keys, or any cryptographic information bound to a session.

Term	Definition
Session-Secrets-Exchange	This term denotes any SPDM request and their corresponding response that initiates a session and provides initial cryptographic exchange. Examples of such requests are `KEY_EXCHANGE` and `PSK_EXCHANGE` .
Session-Secrets-Finish	This term denotes any SPDM request and their corresponding response that finalizes a session setup and provides the final exchange of cryptographic or other information before application data can be securely transmitted. Examples of such requests are `FINISH` and `PSK_FINISH` .
SPDM message payload	Portion of the message body of an SPDM message. This portion of the message is separate from those fields and elements that identify the SPDM version, the SPDM request and response codes, and the two parameters.
SPDM message	Unit of communication in SPDM communications. See Generic SPDM message format.
SPDM request message	Message that is sent to an endpoint to request a specific SPDM operation. A corresponding SPDM response message acknowledges receipt of an SPDM request message.
SPDM response message	Message that is sent in response to a specific SPDM request message. This message includes a `Response Code` field that indicates whether the request completed normally.
Session-Secrets-Exchange	Any SPDM request and their corresponding response that initiates a session and provides initial cryptographic exchange. Examples of such requests are `KEY_EXCHANGE` and `PSK_EXCHANGE` .
trusted computing base (TCB)	Set of all hardware, firmware, and/or software components that are critical to its security, in the sense that bugs or vulnerabilities occurring inside the TCB might jeopardize the security properties of the entire system. By contrast, parts of a computer system outside the TCB shall not be able to misbehave in a way that would leak any more privileges than are granted to them in accordance to the security policy. Reference: https://en.wikipedia.org/wiki/Trusted_computing_base

77 # 6 Symbols and abbreviated terms

78 The abbreviations that DSP0004, DSP0223, and DSP1001 define apply to this document.

79 The following additional abbreviations are used in this document.

Abbreviation	Definition
AEAD	Authenticated Encryption with Associated Data
CA	*certificate authority*
DMTF	Formerly the *Distributed Management Task Force*
KDF	Key Derivation Function
MAC	Message Authentication Code
MSB	*most significant byte*
OID	Object identifier
PMCI	*Platform Management Component Intercommunication*
RMA	Return Merchandise Authorization
SPDM	Security Protocol and Data Model
TCB	*trusted computing base*
VCA	Version-Capabilities-Algorithms

80 7 SPDM message exchanges

81 The message exchanges that this specification defines are between two endpoints and are performed and exchanged through sending and receiving of *SPDM* messages that *SPDM messages* defines. The SPDM message exchanges are defined in a generic fashion that allows the messages to be communicated across different physical mediums and over different transport protocols.

82 The specification-defined message exchanges enable Requesters to:

- Discover and negotiate the security capabilities of a Responder.
- Authenticate or provision an identity of a Responder.
- Retrieve the measurements of a Responder.
- Securely establish cryptographic *session keys* to construct a secure communication channel for the transmission or reception of *application data*.

83 These message exchange capabilities are built on top of well-known and established security practices across the computing industry. The following clauses provide a brief overview of each message exchange capability. Some message exchange capabilities are based on the security model that the *USB Authentication Specification Rev 1.0 with ECN and Errata through January 7, 2019* defines.

84 7.1 Security capability discovery and negotiation

85 This specification defines a mechanism for a Requester to discover the security capabilities of a Responder. For example, an endpoint could support multiple cryptographic hash functions that this specification defines. Furthermore, the specification defines a mechanism for a Requester and Responder to select a common set of cryptographic algorithms to use for all subsequent message exchanges before another negotiation is initiated by the Requester, if an overlapping set of cryptographic algorithms exists that both endpoints support.

86 7.2 Identity authentication

87 In this specification, the authenticity of a Responder is determined by digital signatures using well-established techniques based on public key cryptography. A Responder proves its identity by generating digital signatures using a private key, and the signatures can be cryptographically verified by the Requester using the public key associated with that private key.

88 At a high-level, the authentication of the identity of a Responder involves these processes:

- Identity provisioning
- Runtime authentication

89 ## 7.2.1 Identity provisioning

90 Identity provisioning is the process that device vendors follow during or after hardware manufacturing to equip a device with a secure identifier. In the context of this specification, this secure identifier consists of an asymmetric key pair and, optionally, a device certificate (`DeviceCert`) to bind the key pair to a particular instance of a device and associate it with additional metadata. The specifics of key generation and provisioning are outside the scope of this specification, however, as the security of the SPDM protocol depends on device identities that cannot be easily modified, removed or copied, it is strongly recommended that identity keys are unique per device and generated using cryptographically-strong random seeds.

91 ### 7.2.1.1 Device certificate models

92 If trust in a device public key is established through certificates, typically the device certificate (`DeviceCert`) is part of a *certificate chain*. The certificate chain has a *root certificate* (`RootCert`) as its root and a *leaf certificate* as the last certificate in it. The `RootCert` is generated by a trusted root *certificate authority (CA)* and certifies the `DeviceCert` either directly or indirectly through a number of intermediate CAs. *Authentication initiators* use the `RootCert` to verify the validity of device certificate chains.

93 The certificate chain may be built according to one of two models, both of which are shown in the *Figure 1 — SPDM certificate chain models*. In one model, shown on the left in the following figure, the leaf certificate is a `DeviceCert` , which contains the public key that corresponds to the device private key. In the other model, shown on the right in the following figure, the leaf certificate is an alias certificate (`AliasCert`), in which case there may be one or more intermediate `AliasCert` certificates between the `DeviceCert` and the leaf `AliasCert` . In the `AliasCert` model, the device private key signs the next level `AliasCert` , and then the private key associated with the public key in each `AliasCert` signs the `AliasCert` below it. When the `AliasCert` model is in use, the Device Certificate is referred to as a Device Certificate CA, indicating that the certificate both contains device hardware identity information and functions as a certificate authority to sign an additional certificate.

94 A device that implements the `AliasCert` model might factor some mutable information, such as the measurement of a firmware image, into the derivation of the public/private key pairs for the intermediate and leaf alias certificates. Therefore, the asymmetric public/private key pairs for each `AliasCert` should be treated as mutable.

95 Through the certificate chain, the root CA indirectly endorses the device public key in the `DeviceCert` . When the `AliasCert` model is in use, the `AliasCert`s are endorsed by the device private key, meaning that the `AliasCert`s are also indirectly endorsed by the root CA.

96 The certificate chain should contain at least one certificate that includes hardware identity information, and the hardware identity information should be present in the device certificate, whether the `DeviceCert` or `AliasCert` model is in use. Though existing deployments cannot include the hardware identity information in a certificate, it is strongly recommended that new deployments include this information. The public/private key pair associated with a hardware identity certificate is constant on the instance of the device, regardless of version of firmware running on the device. The Hardware identity OID should be used to indicate hardware identity certificates.

97 When the `AliasCert` model is used, the device creates and endorses one or more certificates. The certificates from the root certificate to the device certificate are immutable, and can only be changed through the `SET_CERTIFICATE` command or an equivalent capability. The certificates below the device certificate can be created on the device and are mutable certificates in that they can change when the device state changes, such as a device *reset*. The Mutable certificate OID should be used to indicate mutable certificates.

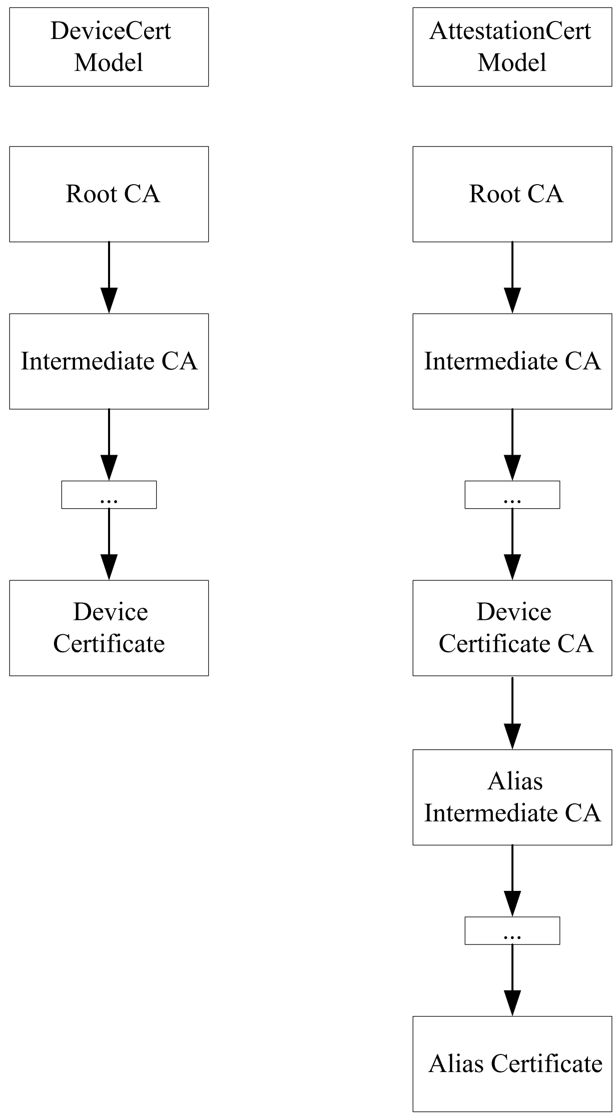
98 In addition, when the `AliasCert` model is used, one or more `AliasCert`s can contain firmware identity information. Other standards bodies might define the format of the firmware identity information. That definition is outside the scope of this specification.

99 Note that a signature algorithm used with a mutable alias certificate can insert random data during signing, which would cause the digest of the certificate chain to change each time it is regenerated. An implementer can use a mechanism that is outside the scope of this specification to ensure that such a signature does not change between reads of the certificate chain.

100 A Responder can use the `DeviceCert` model or the `AliasCert` model. A Requester should be capable of performing Runtime authentication on a certificate chain that conforms to either model.

101 Figure 1 — SPDM certificate chain models shows the SPDM certificate chain models:

102 **Figure 1 — SPDM certificate chain models**



103 ### 7.2.2 Raw public keys

104 Alternatively to certificate chains, the vendor can provision the raw public key of the Responder to the Requester in a trusted environment; for example, during the secure manufacturing process. In this case, trust of the public key of the Responder is established without the need for a certificate-based public key infrastructure.

105 The format of the provisioned public key is out of scope of this specification. Vendors can use proprietary formats or public key formats that other standards define, such as RFC7250 and RFC4716.

106 ### 7.2.3 Runtime authentication

107 Runtime authentication is the process by which an authentication initiator, or Requester, interacts with a Responder in a running system. The authentication initiator can retrieve the certificate chains from the Responder and send a unique challenge to the Responder. The Responder uses the private key associated with the leaf certificate to sign the challenge. The authentication initiator verifies the signature by using the public key associated with the leaf certificate of the Responder, and any intermediate public keys within the certificate chain by using the root certificate as the trusted anchor.

108 If the public key of the Responder was provisioned to the Requester in a trusted environment, the authentication initiator sends a unique challenge to the Responder. The Responder signs the challenge with the private key. The authentication initiator verifies the signature by using the public key of the Responder. The transport layer should handle device identification, which is outside the scope of this specification.

109 ## 7.3 Firmware and configuration measurement

110 A measurement is a representation of firmware/software or configuration data on an endpoint. A measurement is typically a cryptographic hash value of the data, or the raw data itself. The endpoint optionally binds a measurement with the endpoint identity through the use of digital signatures. This binding enables an authentication initiator to establish the identity and measurement of the firmware/software or configuration running on the endpoint.

111 ## 7.4 Secure sessions

112 Many devices exchange data with other devices that might require protection. In this specification, the device-specific data that is communicated is generically referred to as application data. The protocol of the application data usually exists at a higher layer and it is outside the scope of this specification. The protocol of the application data usually allows for encrypted and/or authenticated data transfer.

113 This specification provides a method to perform a cryptographic key exchange such that the protocol of the application data can use the exchanged keys to provide a secure channel of communication by using encryption and message authentication. This cryptographic key exchange provides either Responder-only authentication or mutual authentication, which can be considered equivalent to Runtime authentication. For more details, see the Session clause.

114 Finally, many SPDM requests and their corresponding responses can also be afforded the same protection. For more details, see Table 6 — SPDM request and response messages validity and the SPDM request and response code issuance allowance clause.

115 Figure 2 — SPDM messaging protocol flow gives a very high-level view of when the *secure session* actually starts.

116 ## 7.5 Mutual authentication overview

117 The ability for a Responder to verify the authenticity of the Requester is called mutual authentication. Several mechanisms in this specification are detailed to provide mutual authentication capabilities. The cryptographic means to verify the identity of the Requester is the same as verifying the identity of the Responder. The Identity provisioning clause discusses identity in regards to the Responder but the details also apply to the Requester.

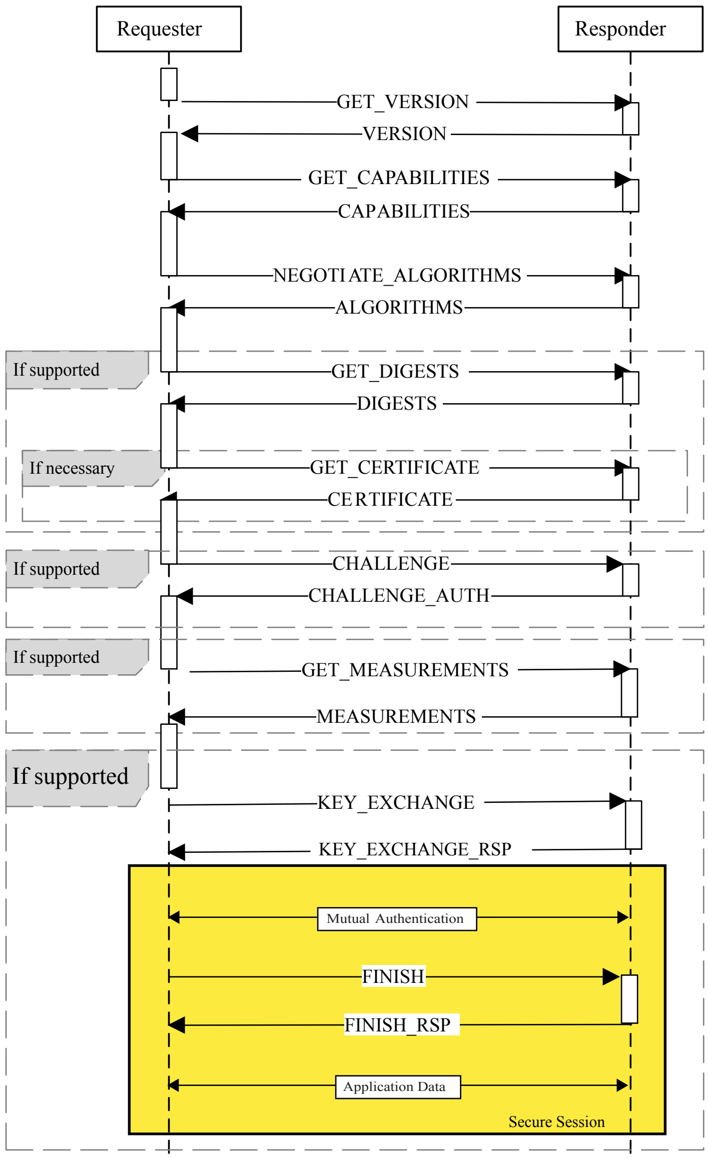
118 In general, when this specification states requirements or recommendations for Responders in the context of identity, those same rules also apply to Requesters in the context of mutual authentication. The various clauses in this specification provide more details.

119 8 SPDM messaging protocol

120 The SPDM messaging protocol defines a request-response messaging model between two endpoints to perform the message exchanges outlined in SPDM message exchanges. Each *SPDM request message* shall be responded to with an SPDM response message as this specification defines unless this specification states otherwise.

121 Figure 2 — SPDM messaging protocol flow depicts the high-level request-response flow diagram for SPDM. An endpoint that acts as the *Requester* sends an SPDM request message to another endpoint that acts as the *Responder*, and the Responder returns an SPDM response message to the Requester.

122 **Figure 2 — SPDM messaging protocol flow**



123 All SPDM request-response messages share a common data format, that consists of a four-*byte* message header and zero or more bytes message *payload* that is message-dependent. The following clauses describe the common message format and SPDM messages' details for each of the request and response messages.

124 The Requester shall issue `GET_VERSION` , `GET_CAPABILITIES` , and `NEGOTIATE_ALGORITHMS` request messages before issuing any other request messages. The responses to `GET_VERSION` , `GET_CAPABILITIES` , and `NEGOTIATE_ALGORITHMS` can be saved by the Requester so that after Reset the Requester can skip these requests.

125 8.1 SPDM connection model

126 In SPDM, communication between a pair of SPDM endpoints starts when one endpoint sends a `GET_VERSION` request to another SPDM endpoint. The SPDM endpoint that starts the communication is called the Requester. The endpoint receiving the `GET_VERSION` and providing the `VERSION` response is called a Responder. The communication between a pair of Requester and Responder is called a connection. One or more connections can exist between a Requester and Responder. Different connections might exist over the same transport or over different transports. When there are multiple connections over the same transport, the transport is responsible for providing mechanisms for SPDM endpoints to distinguish between one or more connections. When the transport does not provide such a mechanism, there shall be one connection between the Requester and Responder.

127 SPDM endpoints can be both a Requester and Responder. As a Requester, an SPDM endpoint can communicate with one or more Responders. Likewise, as a Responder, an SPDM endpoint can respond to multiple Requesters. The SPDM connection model considers each of these communications to be separate connections. For example, a pair of SPDM endpoints can be both Requester and Responder to each other. Thus, the SPDM connection model considers this to be two separate connections.

128 Within a connection, the Requester remains the Requester for the remainder of the connection. Likewise, the Responder remains the Responder for the remainder of the connection. However, under certain scenarios allowed by SPDM, a Responder can send a request to a Requester and likewise, a Requester might provide a response to a Responder. These cases are limited and this specification explicitly defines these cases. In such scenarios, when a Requester provides a response, the Requester shall abide by all requirements in this specification as if they are a Responder for that request. Similarly, when a Responder sends a request, the Responder SHALL abide by all requirements in this specification as if they are a Requester for that request.

129 Within a connection, the Requester can establish one or more secure sessions. These secure sessions are considered to be a part of the same connection. Secure sessions can terminate or additional sessions can be established at any time. A `GET_VERSION` can reset the connection and all context associated with that connection including, but not limited to, information such as session keys, session ID's. However, this is not considered a termination of the connection. A connection can terminate due to external events such as a device reset or an error handling strategy implemented on an SPDM endpoint but such scenarios are outside the scope of this specification. Connections can be terminated using mechanisms outside the scope of this specification.

130 8.2 SPDM bits-to-bytes mapping

131 All SPDM fields, regardless of size or endianness, map the highest numeric bits to the highest numerically assigned byte in monotonically decreasing order until the least numerically assigned byte of that field. The following two figures illustrate this mapping.

132 Figure 3 — One-byte field bit map shows the one-byte field bit map:

133 **Figure 3 — One-byte field bit map**

134 Example: A One-Byte Field

Byte 1							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

135 Figure 4 — Two-byte field bit map shows the two-byte field bit map:

136 **Figure 4 — Two-byte field bit map**

137 Example: A Two-Byte Field

Byte 3								Byte 2							
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

138 8.3 Generic SPDM message format

139 Table 3 — Generic SPDM message field definitions defines the fields that constitute a generic SPDM message, including the message header and payload:

140 **Table 3 — Generic SPDM message field definitions**

Byte offset	Bit offset	Size (bits)	Field	Description
0	[7:4]	4	SPDM Major Version	The major version of the SPDM Specification. An endpoint shall not communicate by using an incompatible SPDM version value. See Version encoding.
0	[3:0]	4	SPDM Minor Version	The minor version of the SPDM Specification. A specification with a given minor version extends a specification with a lower minor version as long as they share the major version. See Version encoding.
1	[7:0]	8	Request Response Code	The request message code or response code, which Table 4 — SPDM request codes and Table 5 — SPDM response codes enumerate. `0x00` through `0x7F` represent response codes and `0x80` through `0xFF` represent request codes. In request messages, this field is considered the request code. In response messages, this field is considered the response code.
2	[7:0]	8	Param1	The first one-byte parameter. The contents of the parameter is specific to the `Request Response Code` .

Byte offset	Bit offset	Size (bits)	Field	Description
3	[7:0]	8	Param2	The second one-byte parameter. The contents of the parameter is specific to the `Request Response Code`.
4	See the description.	Variable	*SPDM message payload*	Zero or more bytes that are specific to the `Request Response Code`.

141 ### 8.3.1 SPDM version

142 The `SPDMVersion` field, present as the first field in all SPDM messages, indicates the version of the SPDM specification that the format of an SPDM message adheres to. The format of this field shall be the same as byte 0 in Table 3 — Generic SPDM message field definitions. The value of this field shall be the same value as the version of this specification except for `GET_VERSION` and `VERSION` messages.

143 For example, if the version of this specification is 1.2, the value of `SPDMVersion` is `0x12`, which also corresponds to an `SPDM Major Version` of 1 and an `SPDM Minor Version` of 2. See Version encoding for more examples.

144 The version of this specification can be found on the title page or the header or footer of each page in this document.

145 The `SPDMVersion` for the version of this specification shall be `0x12`.

146 The `SPDMversionString` shall be a string formed by concatenating the major version, "." and minor version. For example, if the version of this specification is 1.2.3, then `SPDMversionString` is `"1.2"`.

147 ## 8.4 SPDM request codes

148 Table 4 — SPDM request codes defines the SPDM request codes. The **Implementation requirement** column indicates requirements on the Requester.

149 All SPDM-compatible implementations shall use SPDM request codes.

150 If an `ERROR` response is sent for unsupported request codes, the `ErrorCode` shall be `UnsupportedRequest`.

151 **Table 4 — SPDM request codes**

Request	Code value	Implementation requirement	Message format
GET_DIGESTS	0x81	Optional	Table 29 — GET_DIGESTS request message format

Request	Code value	Implementation requirement	Message format
GET_CERTIFICATE	0x82	Optional	Table 31 — GET_CERTIFICATE request message format
CHALLENGE	0x83	Optional	Table 35 — CHALLENGE request message format
GET_VERSION	0x84	Required	Table 8 — GET_VERSION request message format
CHUNK_SEND	0x85	Optional	Table 82 — CHUNK_SEND request format table
CHUNK_GET	0x86	Optional	Table 86 — CHUNK_GET request format
GET_MEASUREMENTS	0xE0	Optional	Table 40 — GET_MEASUREMENTS request message format
GET_CAPABILITIES	0xE1	Required	Table 11 — GET_CAPABILITIES request message format
NEGOTIATE_ALGORITHMS	0xE3	Required	Table 15 — NEGOTIATE_ALGORITHMS request message format
KEY_EXCHANGE	0xE4	Optional	Table 58 — KEY_EXCHANGE request message format
FINISH	0xE5	Optional	Table 61 — FINISH request message format
PSK_EXCHANGE	0xE6	Optional	Table 63 — PSK_EXCHANGE request message format
PSK_FINISH	0xE7	Optional	Table 65 — PSK_FINISH request message format
HEARTBEAT	0xE8	Optional	Table 67 — HEARTBEAT request message format
KEY_UPDATE	0xE9	Optional	Table 69 — KEY_UPDATE request message format
GET_ENCAPSULATED_REQUEST	0xEA	Optional	Table 72 — GET_ENCAPSULATED_REQUEST request message format
DELIVER_ENCAPSULATED_RESPONSE	0xEB	Optional	Table 74 — DELIVER_ENCAPSULATED_RESPONSE request message format
END_SESSION	0xEC	Optional	Table 76 — END_SESSION request message format
GET_CSR	0xED	Optional	Table 79 — GET_CSR request message format
SET_CERTIFICATE	0xEE	Optional	Table 81 — SET_CERTIFICATE request message format
VENDOR_DEFINED_REQUEST	0xFE	Optional	Table 57 — VENDOR_DEFINED_REQUEST request message format
RESPOND_IF_READY	0xFF	Required	Table 56 — RESPOND_IF_READY request message format
Reserved	All other values		SPDM implementations compatible with this version shall not use the reserved request codes.

152 ## 8.5 SPDM response codes

153 The `Request Response Code` field in the SPDM response message shall specify the appropriate response code for a request. All SPDM-compatible implementations shall use Table 5 — SPDM response codes.

154 On a successful completion of an SPDM operation, the specified response message shall be returned. Upon an unsuccessful completion of an SPDM operation, the `ERROR` response message should be returned.

155 Table 5 — SPDM response codes defines the response codes for SPDM. The **Implementation requirement** column indicates requirements on the Responder.

156 **Table 5 — SPDM response codes**

Response	Value	Implementation requirement	Message format
DIGESTS	0x01	Optional	Table 30 — Successful DIGESTS response message format
CERTIFICATE	0x02	Optional	Table 32 — Successful CERTIFICATE response message format
CHALLENGE_AUTH	0x03	Optional	Table 36 — Successful CHALLENGE_AUTH response message format
Version	0x04	Required	Table 9 — Successful VERSION response message format
CHUNK_SEND_ACK	0x05	Optional	Table 85 — CHUNK_SEND_ACK response message format
CHUNK_RESPONSE	0x06	Optional	Table 88 — CHUNK_RESPONSE response format
MEASUREMENTS	0x60	Optional	Table 43 — Successful MEASUREMENTS response message format
CAPABILITIES	0x61	Required	Table 12 — Successful CAPABILITIES response message format
ALGORITHMS	0x63	Required	Table 21 — Successful ALGORITHMS response message format
KEY_EXCHANGE_RSP	0x64	Optional	Table 60 — Successful KEY_EXCHANGE_RSP response message format
FINISH_RSP	0x65	Optional	Table 62 — Successful FINISH_RSP response message format
PSK_EXCHANGE_RSP	0x66	Optional	Table 64 — PSK_EXCHANGE_RSP response message format
PSK_FINISH_RSP	0x67	Optional	Table 66 — Successful PSK_FINISH_RSP response message format
HEARTBEAT_ACK	0x68	Optional	Table 68 — HEARTBEAT_ACK response message format

Response	Value	Implementation requirement	Message format
KEY_UPDATE_ACK	0x69	Optional	Table 70 — KEY_UPDATE_ACK response message format
ENCAPSULATED_REQUEST	0x6A	Optional	Table 73 — ENCAPSULATED_REQUEST response message format
ENCAPSULATED_RESPONSE_ACK	0x6B	Optional	Table 75 — ENCAPSULATED_RESPONSE_ACK response message format
END_SESSION_ACK	0x6C	Optional	Table 78 — END_SESSION_ACK response message format
CSR	0x6D	Optional	Table 80 — CSR response message format
SET_CERTIFICATE_RSP	0x6E	Optional	Table 82 — Successful SET_CERTIFICATE_RSP response message format
VENDOR_DEFINED_RESPONSE	0x7E	Optional	Table 57 — VENDOR_DEFINED_RESPONSE response message format
ERROR	0x7F	Required	Table 47 — ERROR response message format
Reserved	All other values		SPDM implementations compatible with this version shall not use the reserved response codes.

157 8.6 SPDM request and response code issuance allowance

158 Table 6 — SPDM request and response messages validity describes the conditions under which a request and response can be issued.

159 The **Session** column describes whether the respective request and response can be sent in a session. If the value is *"Allowed"*, the issuer of the request and response shall be able to send it in a secure session; thereby, affording them the protection of a secure session. If the **Session** column value is `Prohibited`, the issuer shall be prohibited from sending the respective request and response in a secure session.

160 The **Outside of a session** column indicates which requests and responses are allowed to be sent free and independent of a session; thereby lacking the protection of a secure session. An *"Allowed"* in this column indicates that the respective request and response shall be able to be sent outside the context of a secure session. Likewise, a *"Prohibited"* in this column shall prohibit the issuer from sending the respective request or response outside the context of a session.

161 A request and its corresponding response can have the `Allowed` value in both the **Session** and **Outside of a session** columns, in which case they can be sent and received in both scenarios but might have additional restrictions. For details, see the respective request and response clauses.

162 A request and its corresponding response that has `Allowed` value in the **Session** and `Prohibited` in the **Outside**

of a session columns are commands used by the session. These commands only operate on the session that they were sent under, which is outside of the SPDM specification. The session ID is implicit from the session used to transmit the commands.

163 Finally, the **Session phases** column describes which phases of a session the respective request and response shall be issued when they are allowed to be issued in a session.

164 For details, see the Session clause.

165 **Table 6 — SPDM request and response messages validity**

Request	Response	Session	Outside of a session	Session phases
GET_MEASUREMENTS	MEASUREMENTS	Allowed	Allowed	Application Phase
FINISH	FINISH_RSP	Allowed	Prohibited	Session Handshake
PSK_FINISH	PSK_FINISH_RSP	Allowed	Prohibited	Session Handshake
HEARTBEAT	HEARTBEAT_ACK	Allowed	Prohibited	Application Phase
KEY_UPDATE	KEY_UPDATE_ACK	Allowed	Prohibited	Application Phase
END_SESSION	END_SESSION_ACK	Allowed	Prohibited	Application Phase
Not Applicable	ERROR	Allowed	Allowed	All Phases
GET_ENCAPSULATED_REQUEST	ENCAPSULATED_REQUEST	Allowed	Allowed	All Phases
DELIVER_ENCAPSULATED_RESPONSE	ENCAPSULATED_RESPONSE_ACK	Allowed	Allowed	All Phases
VENDOR_DEFINED_REQUEST	VENDOR_DEFINED_RESPONSE	Allowed	Allowed	Application Phase
CHUNK_SEND	CHUNK_SEND_ACK	Allowed	Allowed	All Phases
CHUNK_GET	CHUNK_RESPONSE	Allowed	Allowed	All Phases
GET_CSR	CSR	Allowed	Allowed	All Phases
SET_CERTIFICATE	SET_CERTIFICATE_RSP	Allowed	Allowed	All Phases
All others	All others	Prohibited	Allowed	Not Applicable

166 For `ERROR` response in the session handshake or application phase of a session, the Requester is only allowed in certain situations to send the `ERROR` response.

167 ## 8.7 Concurrent SPDM message processing

168 This clause describes the specifications and requirements for handling concurrent overlapping SPDM request messages.

169 If an endpoint can act as both a Responder and Requester, it shall be able to send request messages and response messages independently.

170 ## 8.8 Requirements for Requesters

171 A Requester shall not have multiple outstanding requests to the same Responder, within a connection, with the following exceptions:

- As the GET_VERSION request and VERSION response messages clause describes, a Requester can issue a `GET_VERSION` to a Responder to reset the connection at any time, even if the Requester has existing outstanding requests to the same Responder.
- In large SPDM messages transfer mechanism, a single large SPDM request message and a single `CHUNK_SEND` request can be outstanding at the same time.

172 An outstanding request is a request where the request message has begun transmission, the corresponding response has not been fully received and the request is not a retry as described in Timing Requirements.

173 If the Requester has sent a request to a Responder and wants to send a subsequent request to the same Responder, then the Requester shall wait to send the subsequent request until after the Requester completes one of the following actions:

- Receives the response from the Responder for the outstanding request.
- Times out waiting for a response.
- Receives an indication, from the transport layer, that transmission of the request message failed.
- The Requester encounters an internal error or Reset.

174 A Requester might send simultaneous request messages to different Responders.

175 ## 8.9 Requirements for Responders

176 A Responder is not required to process more than one request message at a time, even across connections, with the following exceptions:

- As the GET_VERSION request and VERSION response messages clause describes, a Requester can issue a `GET_VERSION` to a Responder to reset a connection at any time, even if the Requester has existing outstanding requests to the same Responder.

- In the large SPDM messages transfer mechanism, a single large SPDM request message and a single `CHUNK_SEND` request can be outstanding at the same time.
- Retries can be issued multiple times to the same Responder, as Timing requirements defines.

177 A Responder that is not ready to accept a new request message or process more than one outstanding request at a time from the same Requester shall either respond with an `ERROR` response message with `ErrorCode=Busy` or silently discard the request message.

178 If a Responder is working on a request message from a Requester, the Responder can respond with `ErrorCode=Busy`.

179 If a Responder enables simultaneous communications with multiple Requesters, the Responder is expected to distinguish the Requesters by using mechanisms that are outside the scope of this specification.

180 # 9 Timing requirements

181 Table 7 — Timing specification for SPDM messages shows the timing specifications for Requesters and Responders.

182 If the Requester does not receive a response within **T1** or **T2** time accordingly, the Requester can retry a request message. A retry of a request message shall be a complete re-transmission of the original SPDM request message.

183 The Responder shall not retry SPDM response messages. It is understood that the transport protocol(s) can retry but that is outside of the SPDM specification.

184 ## 9.1 Timing measurements

185 A Requester shall measure timing parameters, applicable to it, from the end of a successful transmission of an SPDM request to the beginning of the reception of the corresponding SPDM response. A Responder shall measure timing parameters, applicable to it, from the end of the reception of the SPDM request to the beginning of transmission of the response.

186 ## 9.2 Timing specification table

187 The **Ownership** column in Table 7 — Timing specification for SPDM messages specifies whether the timing parameter applies to the Responder or Requester. For *encapsulated requests*, the Requester shall comply with the timing parameters where the **Ownership** indicates a Responder.

188 **Table 7 — Timing specification for SPDM messages**

Timing parameter	Ownership	Value	Units	Description
RTT	Requester	See the description.	μs	Worst case round-trip transport timing. The maximum value shall be the worst case total time for the complete transmission and delivery of an SPDM message round trip at the transport layer(s). The actual value for this parameter is transport- or media-specific. Both the actual value and how an endpoint obtains this value are outside the scope of this specification.

Timing parameter	Ownership	Value	Units	Description
ST1	Responder	100,000	μs	Shall be the maximum amount of time the Responder has to provide a response to requests that do not require cryptographic processing, such as the `GET_CAPABILITIES`, `GET_VERSION`, or `NEGOTIATE_ALGORITHMS` request message. See Table 11 — GET_CAPABILITIES request message format, Table 8 — GET_VERSION request message format, and Table 15 — NEGOTIATE_ALGORITHMS request message format.
T1	Requester	`RTT` + `ST1`	μs	Shall be the minimum amount of time the Requester shall wait before issuing a retry for requests that do not require cryptographic processing. For details, see the `ST1` timing parameter.
CT	Requester and Responder	$2^{CTExponent}$	μs	CTExponent is reported in the `GET_CAPABILITIES` request message and `CAPABILITIES` response message. This timing parameter shall be the maximum amount of time the endpoint has to provide any response requiring cryptographic processing, such as the `GET_MEASUREMENTS` or `CHALLENGE` request messages. See Table 11 — GET_CAPABILITIES request message format, Table 12 — Successful CAPABILITIES response message format, Table 40 — GET_MEASUREMENTS request message format, and Table 35 — CHALLENGE request message format.
T2	Requester	`RTT` + `CT`	μs	Shall be the minimum amount of time the Requester shall wait before issuing a retry for requests that require cryptographic processing. For details, see the `CT` timing parameter.
RDT	Responder	$2^{RDTExponent}$	μs	Recommended delay, in microseconds that the Responder needs to complete the requested cryptographic operation. When the Responder cannot complete cryptographic processing response within the `CT` time, it shall provide `RDTExponent` as part of the `ERROR` response as Table 47 — ERROR response message format shows. See Table 49 — ResponseNotReady extended error data for the `RDTExponent` value. For details, see `ErrorCode=ResponseNotReady` in Table 49 — ResponseNotReady extended error data.

Timing parameter	Ownership	Value	Units	Description
WT	Requester	RDT	μs	Amount of time that the Requester should wait before issuing the `RESPOND_IF_READY` request message as Table 55 — RESPOND_IF_READY request message format shows. The Requester shall measure this time parameter from the reception of the `ERROR` response to the transmission of `RESPOND_IF_READY` request. The Requester can take into account the transmission time of the `ERROR` from the Responder to Requester when calculating `WT` . For details, see the `RDT` timing parameter.
WT_{Max}	Requester	(RDT*RDTM)-RTT	μs	Maximum wait time the Requester has to issue the `RESPOND_IF_READY` request message, as Table 55 — RESPOND_IF_READY request message format shows, unless the Requester issued a successful `RESPOND_IF_READY` request message, as Table 55 — RESPOND_IF_READY request message format shows, earlier. After this time the Responder is allowed to drop the response. The Requester shall take into account the transmission time of the `ERROR` response, as Table 47 — ERROR response message format shows, from the Responder to Requester when calculating `WT Max` . The `RDTM` value appears in Table 49 — ResponseNotReady extended error data. The Responder should ensure that `WT Max` does not result in less than `WT` in determination of `RDTM` . See `ErrorCode=ResponseNotReady` in Table 49 — ResponseNotReady extended error data.
HeartbeatPeriod	Requester and Responder	Variable	s	See the HEARTBEAT request and HEARTBEAT_ACK response clause.

189 # 10 SPDM messages

190 SPDM messages can be divided into the following categories, supporting different aspects of security exchanges between a Requester and Responder:

- Capability discovery and negotiation
- Responder identity authentication
- Measurement
- Key agreement for secure channel establishment

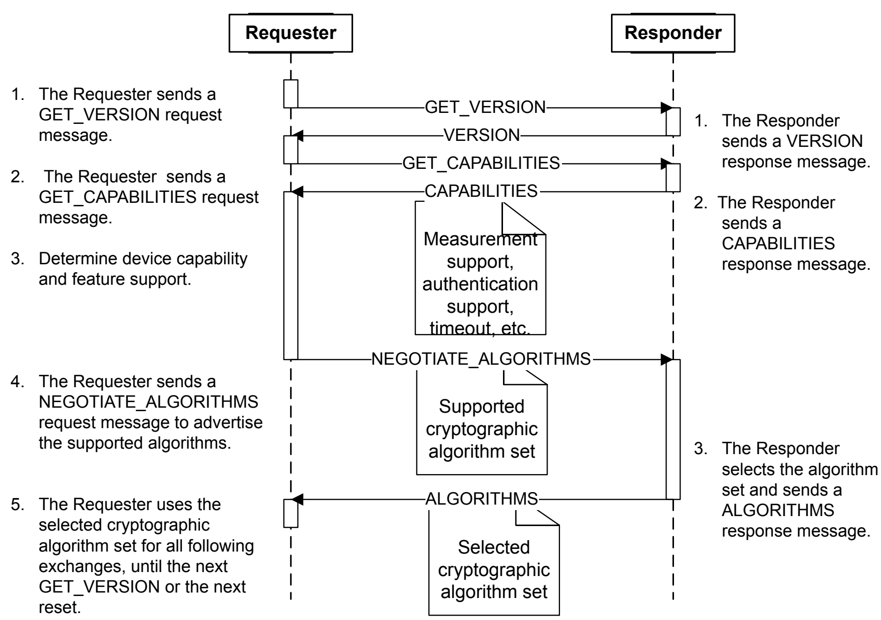
191 ## 10.1 Capability discovery and negotiation

192 All Requesters and Responders shall support `GET_VERSION`, `GET_CAPABILITIES`, and `NEGOTIATE_ALGORITHMS`.

193 Figure 5 — Capability discovery and negotiation flow shows the high-level request-response flow and sequence for the capability discovery and negotiation:

194 **Figure 5 — Capability discovery and negotiation flow**

195



196 10.1.1 Negotiated state preamble

197 The `VCA` *(Version-Capabilities-Algorithms)* refers to the concatenation of messages `GET_VERSION`, `VERSION`, `GET_CAPABILITIES`, `CAPABILITIES`, `NEGOTIATE_ALGORITHMS`, and `ALGORITHMS` last exchanged between the Requester and the Responder.

198 If the Responder supports caching the negotiated state (`CACHE_CAP=1`), the Requester might not issue `GET_VERSION`, `GET_CAPABILITIES`, and `NEGOTIATE_ALGORITHMS`. In this case, the Requester and the Responder shall store the most recent `VCA` as part of the Negotiated State.

199 If the two endpoints support session key establishment with the PSK (Pre-Shared Key) option, then Negotiated State is not applicable and `VCA` is not stored.

200 10.2 GET_VERSION request and VERSION response messages

201 This request message shall retrieve the SPDM version of an endpoint. Table 8 — GET_VERSION request message format shows the `GET_VERSION` request message format and Table 9 — Successful VERSION response message format shows the `VERSION` response message format.

202 In all future SPDM versions, the `GET_VERSION` and `VERSION` response messages will be backward compatible with all earlier versions.

203 The Requester shall begin the discovery process by sending a `GET_VERSION` request message with the value of the `SPDMVersion` field set to `0x10`. All Responders shall always support the `GET_VERSION` request message with major version `0x1` and provide a `VERSION` response containing all supported versions, as Table 8 — GET_VERSION request message format describes.

204 The Requester shall consult the `VERSION` response to select a common supported version, which should be the latest supported common version. The Requester shall use the selected version in all future communication of other requests. A Requester shall not issue other requests until it receives a successful `VERSION` response and identifies a common version that both sides support. A Responder shall not respond to the `GET_VERSION` request message with `ErrorCode=ResponseNotReady`. The selected version shall be the version in the `SPDMVersion` field of the Request (other than `GET_VERSION`) immediately following the `GET_VERSION` request. If the Requester uses a different version than the selected version in other Requests, the Responder should return an `ERROR` message with `ErrorCode = VersionMismatch` or the Responder can silently discard the Request.

205 A Requester can issue a `GET_VERSION` request message to a Responder at any time, which is as an exception to Requirements for Requesters to allow for scenarios where a Requester shall restart the protocol due to an internal error or Reset.

206 After receiving a valid `GET_VERSION` request, the Responder shall cancel all previous requests from the same Requester. All active sessions between the Requester and the Responder are terminated and information (such as

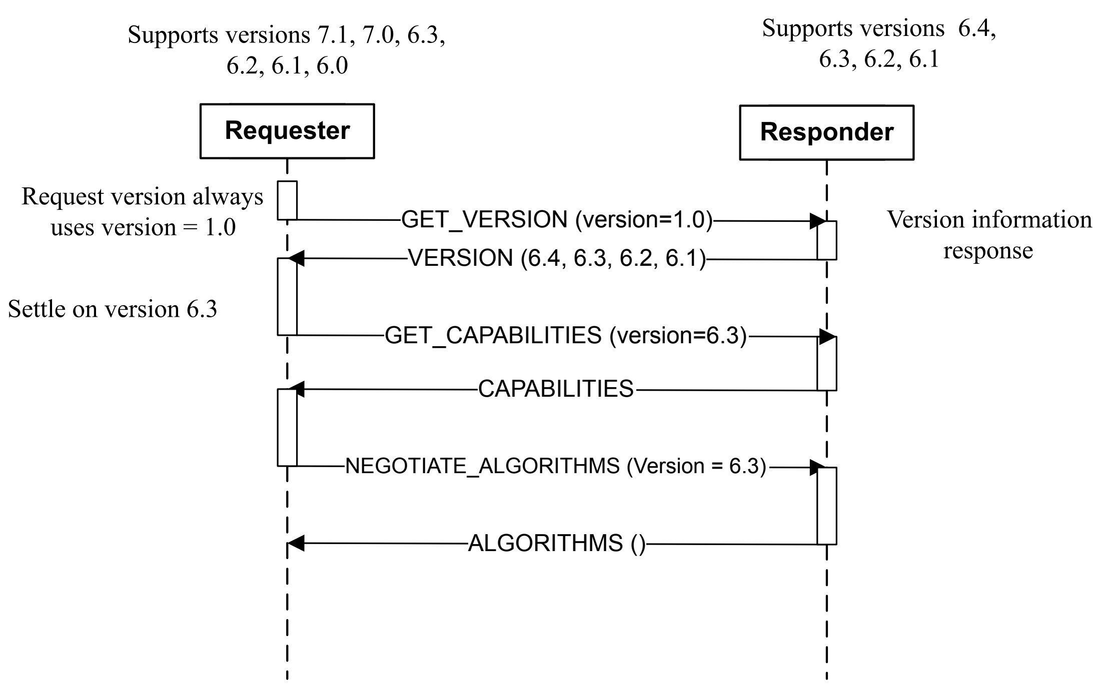
session keys, session IDs) for those sessions should not be used anymore. Additionally, this message shall clear the previously *Negotiated State*, if any, in both the Requester and its corresponding Responder. An invalid `GET_VERSION` request that results in the Responder returning an error to the Requester shall not affect the session state. The `ERROR` message resulting from an invalid `GET_VERSION` request shall have the value of the `SPDMVersion` field set to `0x10`.

207 After sending the `VERSION` response for a `GET_VERSION` request, if the Responder completes a runtime code or configuration change for its hardware or firmware measurement and the change has taken effect, then the Responder shall silently discard any request received outside of a session, or respond with `ErrorCode=RequestResynch` to any request received outside of a session, until a `GET_VERSION` request is received. For requests received within a session, the Responder shall follow the selected session policy that the Requester selects in Table 59 — Session Policy at the time of session establishment.

208 Figure 6 — Discovering the common major version shows the process:

209 **Figure 6 — Discovering the common major version**

210



211 Table 8 — GET_VERSION request message format shows the `GET_VERSION` request message format:

212 **Table 8 — GET_VERSION request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be `0x10` (V1.0).
1	RequestResponseCode	1	`0x84` = `GET_VERSION`. See Table 4 — SPDM request codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.

213 Table 9 — Successful VERSION response message format shows the successful `VERSION` response message format:

214 **Table 9 — Successful VERSION response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be `0x10` (V1.0).
1	RequestResponseCode	1	`0x04` = `VERSION`. See Table 5 — SPDM response codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.
4	Reserved	1	Reserved.
5	VersionNumberEntryCount	1	Number of version entries present in this table (=n).
6	VersionNumberEntry1:n	2*n	16-bit version entry. See Table 10 — VersionNumberEntry definition.

215 Table 10 — VersionNumberEntry definition shows the `VersionNumberEntry` definition:

216 **Table 10 — VersionNumberEntry definition**

Bit offset	Field	Description
[15:12]	MajorVersion	Version of the specification with changes that are incompatible with one or more functions in earlier major versions of the specification.
[11:8]	MinorVersion	Version of the specification with changes that are compatible with functions in earlier minor versions of this major version specification.
[7:4]	UpdateVersionNumber	Version of the specification with editorial updates but no functionality additions or changes. Informational; possible errata fixes. Ignore when checking versions for interoperability.

Bit offset	Field	Description
[3:0]	Alpha	Pre-release work-in-progress version of the specification. Backward compatible with earlier minor versions of this major version specification. However, because the `Alpha` value represents an in-development version of the specification, versions that share the same major and minor version numbers but have different `Alpha` versions might not be fully interoperable. Released versions shall have an `Alpha` value of zero (`0`).

217 10.3 GET_CAPABILITIES request and CAPABILITIES response messages

218 This request message shall retrieve the SPDM capabilities of an endpoint.

219 Table 11 — GET_CAPABILITIES request message format shows the `GET_CAPABILITIES` request message format.

220 Table 12 — Successful CAPABILITIES response message format shows the `CAPABILITIES` response message format.

221 Table 13 — Flag fields definitions for the Requester shows the flag fields definitions for the Requester.

222 Likewise, Table 14 — Flag fields definitions for the Responder shows the flag fields definitions for the Responder.

223 A Responder shall not respond to `GET_CAPABILITIES` request message with `ErrorCode=ResponseNotReady` .

224 To properly support transferring of SPDM messages, the Requester and Responder shall indicate two buffer sizes:

- One for receiving a single SPDM message called `DataTransferSize` .
- One for indicating their maximum internal buffer size for processing a single SPDM message called `MaxSPDMmsgSize` .

225 Both the Requester and Responder shall support a minimum buffer size to successfully transfer SPDM messages. The minimum size, referred to as `MinDataTransferSize` , shall be the size, in bytes, of the SPDM message with the largest size in this list:

- `GET_VERSION`
- `GET_CAPABILITIES`
- `CAPABILITIES`
- `CHUNK_SEND` using the size of the SPDM Header for the size of the `SPDMchunk` field.
- `CHUNK_SEND_ACK` using the maximum size of `ERROR` message for the size of the `ResponseToLargeRequest` field.
- `CHUNK_GET`

- `CHUNK_RESPONSE` using the size of SPDM Header for the size of the `SPDMchunk` field.
- `ERROR` using the maximum size for the ExtendedErrorData

226 The calculation of `MinDataTransferSize` shall assume all fields are present. For this version of the specification, the `MinDataTransferSize` shall be 42.

227 **GET_CAPABILITIES request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xE1` = `GET_CAPABILITIES`. See Table 4 — SPDM request codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.
4	Reserved	1	Reserved.
5	CTExponent	1	Shall be exponent of base 2, which is used to calculate `CT`. See Table 7 — Timing specification for SPDM messages. The equation for `CT` shall be $2^{CTExponent}$ microseconds (μs). For example, if `CTExponent` is `10`, `CT` is 2^{10} `=1024 µs`.
6	Reserved	2	Reserved.
8	Flags	4	See Table 13 — Flag fields definitions for the Requester.
12	DataTransferSize	4	This field shall indicate the maximum buffer size, in bytes, of the Requester for receiving a single SPDM message. The value of this field shall be equal to or greater than `MinDataTransferSize`. The `DataTransferSize` shall exclude transport headers, encryption headers, and MAC.
16	MaxSPDMmsgSize	4	This field shall indicate the maximum size, in bytes, of the internal buffer of a Requester for processing a single Large SPDM message. This field shall be greater than or equal to `DataTransferSize`.

228 **Successful CAPABILITIES response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.

Byte offset	Field	Size (bytes)	Description
1	RequestResponseCode	1	`0x61` = `CAPABILITIES` . See Table 5 — SPDM response codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.
4	Reserved	1	Reserved.
5	CTExponent	1	Shall be the exponent of base 2, which used to calculate `CT` . See Table 7 — Timing specification for SPDM messages. The equation for `CT` shall be $2^{\text{CTExponent}}$ microseconds (μs). For example, if `CTExponent` is `10` , `CT` is 2^{10} `=1024 μs` .
6	Reserved	2	Reserved.
8	Flags	4	See Table 14 — Flag fields definitions for the Responder.
12	DataTransferSize	4	This field shall indicate the maximum buffer size, in bytes, of the Responder for receiving a single SPDM message. The value of this field shall be equal to or greater than `MinDataTransferSize` . The `DataTransferSize` shall exclude transport headers, encryption headers, and MAC.
16	MaxSPDMmsgSize	4	This field shall indicate the maximum size, in bytes, of the internal buffer of a Responder for processing a single Large SPDM message. This field shall be greater than or equal to `DataTransferSize` .

229 As described in other parts of this specification, a Requester or Responder can reverse roles or be both roles for certain SPDM messages and flows. Thus, in general, an SPDM endpoint cannot send an SPDM message that exceeds the `MaxSPDMmsgSize` of the receiving SPDM endpoint. Specifically, a requesting SPDM endpoint shall not send a request that exceeds the size of the receiving SPDM endpoint. Likewise, a responding SPDM endpoint shall not send a response that exceeds the size of `MaxSPDMmsgSize` of the requesting SPDM endpoint. If the size of a response message exceeds the size of the `MaxSPDMmsgSize` of the requesting SPDM endpoint, the responding SPDM endpoint shall respond with `ErrorCode == ResponseTooLarge` or silently discard the request. Likewise, if the size of a request message exceeds the size of the `MaxSPDMmsgSize` of the responding SPDM endpoint, the responding SPDM endpoint shall respond with `ErrorCode=RequestTooLarge` or silently discard the request. Additionally, an SPDM endpoint should provide graceful error handling (for example, buffer overflow/underflow protection) in the event they receive an SPDM messages that exceed their `MaxSPDMmsgSize` .

230 Table 13 — Flag fields definitions for the Requester shows the flag fields definitions for the Requester.

231 Unless otherwise stated, if a Requester indicates support of a capability associated with an SPDM request or response message, it means the Requester can receive the corresponding request and produce a successful response. In other words, the Requester is acting as a Responder to that SPDM request associated with that

capability. For example, if a Requester sets `CERT_CAP` bit to `1`, the Requester can receive a `GET_CERTIFICATE` request and send back a successful `CERTIFICATE` response message.

232 **Table 13 — Flag fields definitions for the Requester**

Byte offset	Bit offset	Field	Description
0	0	Reserved	Reserved.
0	1	CERT_CAP	If set, Requester supports `DIGESTS` and `CERTIFICATE` response messages.
0	2	CHAL_CAP	If set, Requester supports `CHALLENGE_AUTH` response message.
0	[5:3]	Reserved	Reserved.
0	6	ENCRYPT_CAP	If set, Requester supports message encryption in a secure session. If set, when the Requester chooses to start a secure session, the Requester shall send one of the Session-Secrets-Exchange request messages supported by the Responder.
0	7	MAC_CAP	If set, Requester supports message authentication in a secure session. If set, when the Requester chooses to start a secure session, the Requester shall send one of the Session-Secrets-Exchange request messages supported by the Responder.
1	0	MUT_AUTH_CAP	If set, Requester supports mutual authentication. If set, Requester supports sending `GET_ENCAPSULATED_REQUEST` and `DELIVER_ENCAPSULATED_RESPONSE` requests and receiving `ENCAPSULATED_REQUEST` and `ENCAPSULATED_RESPONSE_ACK` response.
1	1	KEY_EX_CAP	If set, Requester supports `KEY_EXCHANGE` messages. If set, `ENCRYPT_CAP` or `MAC_CAP` shall be set.
1	[3:2]	PSK_CAP	Pre-shared key capabilities of the Requester. • `00b`. Requester does not support pre-shared key capabilities. • `01b`. Requester supports pre-shared key • `10b` and `11b`. Reserved. If supported, `ENCRYPT_CAP` or `MAC_CAP` shall be set.
1	4	ENCAP_CAP	**DEPRECATED:** If set, Requester supports `GET_ENCAPSULATED_REQUEST`, `ENCAPSULATED_REQUEST`, `DELIVER_ENCAPSULATED_RESPONSE`, and `ENCAPSULATED_RESPONSE_ACK` messages. Additionally, the transport may require the Requester to support these messages. `ENCAP_CAP` is deprecated because Basic mutual authentication is deprecated.
1	5	HBEAT_CAP	If set, Requester supports `HEARTBEAT` messages.
1	6	KEY_UPD_CAP	If set, Requester supports `KEY_UPDATE` messages.

Byte offset	Bit offset	Field	Description
1	7	HANDSHAKE_IN_THE_CLEAR_CAP	If set, the Requester can support a Responder that can only send and receive all SPDM messages exchanged during the Session Handshake Phase in the clear (such as without encryption and message authentication). Application data is encrypted and/or authenticated using the negotiated cryptographic algorithms as normal. Setting this bit leads to changes in the contents of certain SPDM messages, discussed in other parts of this specification. If this bit is cleared, the Requester signals that it requires encryption and/or message authentication of SPDM messages exchanged during the Session Handshake Phase. If the Requester does not support encryption and message authentication, then this bit shall be zero.
2	0	PUB_KEY_ID_CAP	If set, the public key of the Requester was provisioned to the Responder. The transport layer is responsible for identifying the Responder. In this case, the `CERT_CAP` of the Requester shall be `0` .
2	1	CHUNK_CAP	If set, Requester supports Large SPDM message transfer mechanism messages.
2	[7:2]	Reserved	Reserved.
3	[7:0]	Reserved	Reserved.

233 Table 14 — Flag fields definitions for the Responder shows the flag fields definitions for the Responder.

234 Unless otherwise stated, if a Responder indicates support of a capability associated with an SPDM request or response message, it means the Responder can receive the corresponding request and produce a successful response. For example, if a Responder sets `CERT_CAP` bit to `1` , the Responder can receive a `GET_CERTIFICATE` request and send back a successful `CERTIFICATE` response message.

235 **Table 14 — Flag fields definitions for the Responder**

Byte offset	Bit offset	Field	Description
0	0	CACHE_CAP	If set, the Responder supports the ability to cache the *Negotiated State* across a Reset. This allows the Requester to skip reissuing the `GET_VERSION` , `GET_CAPABILITIES` and `NEGOTIATE_ALGORITHMS` requests after a Reset. The Responder shall cache the selected cryptographic algorithms as one of the parameters of the Negotiated State. If the Requester chooses to skip issuing these requests after the Reset, the Requester shall also cache the same selected cryptographic algorithms.

Byte offset	Bit offset	Field	Description
0	1	CERT_CAP	If set, Responder supports `DIGESTS` and `CERTIFICATE` response messages.
0	2	CHAL_CAP	If set, Responder supports `CHALLENGE_AUTH` response message.
0	[4:3]	MEAS_CAP	`MEASUREMENTS` response capabilities of the Responder. • `00b` . The Responder does not support `MEASUREMENTS` response capabilities. • `01b` . The Responder supports `MEASUREMENTS` response but cannot perform signature generation. • `10b` . The Responder supports `MEASUREMENTS` response and can generate signatures. • `11b` . Reserved. Note that, apart from affecting `MEASUREMENTS` , this capability also affects Param2 of `CHALLENGE` , Param1 of `KEY_EXCHANGE` , Param1 of `PSK_EXCHANGE` , MeasurementSummaryHash field of `KEY_EXCHANGE_RSP` , `CHALLENGE_AUTH` , `PSK_EXCHANGE_RSP` . See the respective request and response clauses for further details.
0	5	MEAS_FRESH_CAP	`0` . As part of `MEASUREMENTS` response message, the Responder may return `MEASUREMENTS` that were computed during the last Responder's Reset. • `1` . The Responder supports recomputing all `MEASUREMENTS` without requiring a Reset, and shall always return fresh `MEASUREMENTS` as part of `MEASUREMENTS` response message.
0	6	ENCRYPT_CAP	If set, Responder supports message encryption in a secure session. If set, `PSK_CAP` or `KEY_EX_CAP` shall be set accordingly to indicate support.
0	7	MAC_CAP	If set, Responder supports message authentication in a secure session. If set, `PSK_CAP` or `KEY_EX_CAP` shall be set accordingly to indicate support.
1	0	MUT_AUTH_CAP	If set, Responder supports mutual authentication. If set, Responder supports sending `ENCAPSULATED_REQUEST` and `ENCAPSULATED_RESPONSE_ACK` responses and receiving `GET_ENCAPSULATED_REQUEST` and `DELIVER_ENCAPSULATED_RESPONSE` requests.
1	1	KEY_EX_CAP	If set, Responder supports `KEY_EXCHANGE` messages. If set, `ENCRYPT_CAP` or `MAC_CAP` shall be set.
1	[3:2]	PSK_CAP	`Pre-Shared Key` capabilities of the Responder. • `00b` . Responder does not support `Pre-Shared Key` capabilities. • `01b` . Responder supports `Pre-Shared Key` but does not provide ResponderContext for session key derivation. • `10b` . Responder supports `Pre-Shared Key` and provides ResponderContext for session key derivation. • `11b` . Reserved. If supported, `ENCRYPT_CAP` or `MAC_CAP` shall be set.

Byte offset	Bit offset	Field	Description
1	4	ENCAP_CAP	**DEPRECATED:** If set, Responder supports `GET_ENCAPSULATED_REQUEST` , `ENCAPSULATED_REQUEST` , `DELIVER_ENCAPSULATED_RESPONSE` , and `ENCAPSULATED_RESPONSE_ACK` messages. Additionally, the transport may require the Responder to support these messages. `ENCAP_CAP` is deprecated because Basic mutual authentication is deprecated.
1	5	HBEAT_CAP	If set, Responder supports `HEARTBEAT` messages.
1	6	KEY_UPD_CAP	If set, Responder supports `KEY_UPDATE` messages.
1	7	HANDSHAKE_IN_THE_CLEAR_CAP	If set, the Responder can only send and receive messages without encryption and message authentication during the Session Handshake Phase. If set, `KEY_EX_CAP` shall also be set. Setting this bit leads to changes in the contents of certain SPDM messages, discussed in other parts of this specification. If the Responder does not support encryption and message authentication, then this bit shall be zero.
2	0	PUB_KEY_ID_CAP	If set, the public key of the Responder was provisioned to the Requester. The transport layer is responsible for identifying the Requester. In this case, `CERT_CAP` and `ALIAS_CERT_CAP` of the Responder shall both be `0` .
2	1	CHUNK_CAP	If set, Responder supports Large SPDM message transfer mechanism messages.
2	2	ALIAS_CERT_CAP	If set, the Responder uses the `AliasCert` model. See Identity provisioning for details.
2	[7:3]	Reserved	Reserved.
3	[7:0]	Reserved	Reserved.

236 In the case where an SPDM implementation incorrectly returns an illegal combination of capability flags, as these are defined by this specification (for example `ENCRYPT_CAP` is set but both `KEY_EX_CAP` and `PSK_CAP` are cleared), the following guidance is provided: If a Responder detects an illegal capability flag combination reported by the Requester, it shall issue an `ERROR` message and should set the `ErrorCode` = `InvalidRequest` . If a Requester detects an illegal capability flag combination reported by the Responder it should retry once by issuing `GET_VERSION` and `GET_CAPABILITIES` . If the illegal combination is returned again it should cease communicating with this particular Responder over SPDM and log an error in an implementation-specific manner to assist with identifying the problem.

237 10.4 NEGOTIATE_ALGORITHMS request and ALGORITHMS response messages

238 This request message shall negotiate cryptographic algorithms. A Requester shall not issue a `NEGOTIATE_ALGORITHMS` request message until it receives a successful `CAPABILITIES` response message.

239 After a Requester issues a NEGOTIATE_ALGORITHMS request, it shall not issue any other SPDM requests, with the exception of `GET_VERSION`, until it receives a successful `ALGORITHMS` response message.

240 A Responder shall not respond to `NEGOTIATE_ALGORITHMS` request message with `ErrorCode=ResponseNotReady`.

241 Table 15 — NEGOTIATE_ALGORITHMS request message format shows the `NEGOTIATE_ALGORITHMS` request message format.

242 **Table 15 — NEGOTIATE_ALGORITHMS request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xE3` = `NEGOTIATE_ALGORITHMS`. See Table 4 — SPDM request codes.
2	Param1	1	Number of algorithms structure tables in this request using ReqAlgStruct
3	Param2	1	Reserved.
4	Length	2	Length of the entire request message, in bytes. Length shall be less than or equal to 128 bytes.
6	MeasurementSpecification	1	Bit mask. The `MeasurementSpecification` field in Table 44 — Measurement block format defines the values in this field. The Requester can set more than one bit to indicate multiple measurement specification support.
7	OtherParamsSupport	1	Selection Bit mask. Bits [3:0] - See Opaque Data Format Support and Selection Table Bits [7:4] - Reserved.

Byte offset	Field	Size (bytes)	Description
8	BaseAsymAlgo	4	Bit mask listing Requester-supported SPDM-enumerated asymmetric key signature algorithms for the purpose of signature verification. If the capabilities do not support this algorithm, this value is not used and shall be set to zero. Let `SigLen` be the size of the signature in bytes. If the size of a signature component is less than specified size, then `0x00` octets are padded to the left of the most significant byte. • Byte 0 Bit 0. TPM_ALG_RSASSA_2048 where `SigLen` =256. • Byte 0 Bit 1. TPM_ALG_RSAPSS_2048 where `SigLen` =256. • Byte 0 Bit 2. TPM_ALG_RSASSA_3072 where `SigLen` =384. • Byte 0 Bit 3. TPM_ALG_RSAPSS_3072 where `SigLen` =384. • Byte 0 Bit 4. TPM_ALG_ECDSA_ECC_NIST_P256 where `SigLen` =64 (32-byte r followed by 32-byte s). • Byte 0 Bit 5. TPM_ALG_RSASSA_4096 where `SigLen` =512. • Byte 0 Bit 6. TPM_ALG_RSAPSS_4096 where `SigLen` =512. • Byte 0 Bit 7. TPM_ALG_ECDSA_ECC_NIST_P384 where `SigLen` =96 (48-byte r followed by 48-byte s). • Byte 1 Bit 0. TPM_ALG_ECDSA_ECC_NIST_P521 where `SigLen` =132 (66-byte r followed by 66-byte s). • Byte 1 Bit 1. TPM_ALG_SM2_ECC_SM2_P256 where `SigLen` =64 (32-byte r followed by 32-byte s). • Byte 1 Bit 2. EdDSA ed25519 where `SigLen` =64 (32-byte R followed by 32-byte S). • Byte 1 Bit 3. EdDSA ed448 where `SigLen` =114 (57-byte R followed by 57-byte S). • All other values reserved.
12	BaseHashAlgo	4	Bit mask listing Requester-supported SPDM-enumerated cryptographic hashing algorithms. If the capabilities do not support this algorithm, this value is not used and shall be set to zero. • Byte 0 Bit 0. TPM_ALG_SHA_256 • Byte 0 Bit 1. TPM_ALG_SHA_384 • Byte 0 Bit 2. TPM_ALG_SHA_512 • Byte 0 Bit 3. TPM_ALG_SHA3_256 • Byte 0 Bit 4. TPM_ALG_SHA3_384 • Byte 0 Bit 5. TPM_ALG_SHA3_512 • Byte 0 Bit 6. TPM_ALG_SM3_256 • All other values reserved.
16	Reserved	12	Reserved.
28	ExtAsymCount	1	Number of Requester-supported extended asymmetric key signature algorithms (=A) for the purpose of signature verification. `A` + `E` + `ExtAlgCount2` + `ExtAlgCount3` + `ExtAlgCount4` + `ExtAlgCount5` shall be less than or equal to 20. If the capabilities do not support this algorithm, this value is not used and shall be set to zero.

Byte offset	Field	Size (bytes)	Description
29	ExtHashCount	1	Number of Requester-supported extended hashing algorithms (=E). `A` + `E` + `ExtAlgCount2` + `ExtAlgCount3` + `ExtAlgCount4` + `ExtAlgCount5` shall be less than or equal to 20. If the capabilities do not support this algorithm, this value is not used and shall be set to zero.
30	Reserved	2	Reserved.
32	ExtAsym	4 * `A`	List of Requester-supported extended asymmetric key signature algorithms for the purpose of signature verification. Table 27 — Extended Algorithm field format describes the format of this field.
32 + 4 * `A`	ExtHash	4 * `E`	List of the extended hashing algorithms supported by Requester. Table 27 — Extended Algorithm field format describes the format of this field.
32 + 4 * `A` + 4 * `E`	ReqAlgStruct	`AlgStructSize`	See the `AlgStructure` request field.

243 `AlgStructSize` is the sum of the size of the following algorithm structure tables. The algorithm structure table shall be present only if the Requester supports that `AlgType`. `AlgType` shall monotonically increase for subsequent entries.

244 Table 16 — Algorithm request structure shows the Algorithm request structure:

245 **Table 16 — Algorithm request structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	Type of algorithm. • 0 and 1. Reserved. • 2. DHE. • 3. `AEADCipherSuite`. • 4. `ReqBaseAsymAlg`. • 5. `KeySchedule`. • All other values reserved.
1	AlgCount	1	Requester supported fixed algorithms. • Bit [7:4]. Number of bytes required to describe Requester supported SPDM-enumerated fixed algorithms (= `FixedAlgCount`). `FixedAlgCount` + 2 shall be a multiple of 4. • Bit [3:0]. Number of Requester-supported extended algorithms (= `ExtAlgCount`).

Byte offset	Field	Size (bytes)	Description
2	AlgSupported	`FixedAlgCount`	Bit mask listing Requester-supported SPDM-enumerated algorithms.
2 + FixedAlgCount	AlgExternal	4* `ExtAlgCount`	List of Requester-supported extended algorithms. Table 27 — Extended Algorithm field format describes the format of this field.

246 The following tables describe the Algorithm request structure mapped to their respective type:

- Table 17 — DHE structure
- Table 18 — AEAD structure
- Table 19 — ReqBaseAsymAlg structure
- Table 20 — KeySchedule structure
- Table 21 — Successful ALGORITHMS response message format
- Table 22 — Response AlgStructure field format

247 **Table 17 — DHE structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	`0x02` = `DHE`
1	AlgCount	1	• Bit [7:4]. 2. • Bit [3:0]. Number of Requester-supported extended DHE groups (= `ExtAlgCount2`).
2	AlgSupported	2	Bit mask listing Requester-supported SPDM-enumerated Diffie-Hellman Ephemeral (DHE) groups. Values in parentheses specify the size of the corresponding public values associated with each group. • Byte 0 Bit 0. ffdhe2048 (D = 256). • Byte 0 Bit 1. ffdhe3072 (D = 384). • Byte 0 Bit 2. ffdhe4096 (D = 512). • Byte 0 Bit 3. secp256r1 (D = 64, C = 32). • Byte 0 Bit 4. secp384r1 (D = 96, C = 48). • Byte 0 Bit 5. secp521r1 (D = 132, C = 66). • Byte 0 Bit 6. SM2_P256 (Part 3 and Part 5 of GB/T 32918 specification) (D = 64, C = 32). • All other values reserved.
4	AlgExternal	4* `ExtAlgCount2`	List of Requester-supported extended DHE groups. Table 27 — Extended Algorithm field format describes the format of this field.

248 **Table 18 — AEAD structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	`0x03` = `AEAD`
1	AlgCount	1	• Bit [7:4]. 2. • Bit [3:0]. Number of Requester supported extended *AEAD* algorithms (= `ExtAlgCount3`).
2	AlgSupported	2	Bit mask listing Requester-supported SPDM-enumerated AEAD algorithms. • Byte 0 Bit 0. AES-128-GCM. 128-bit key; 96-bit IV (initialization vector); tag size is specified by transport layer. • Byte 0 Bit 1. AES-256-GCM. 256-bit key; 96-bit IV; tag size is specified by transport layer. • Byte 0 Bit 2. CHACHA20_POLY1305. 256-bit key; 96-bit IV; 128-bit tag. • Byte 0 Bit 3. AEAD_SM4_GCM. 128-bit key; 96-bit IV; tag size is specified by transport layer. • All other values reserved.
4	AlgExternal	4* `ExtAlgCount3`	List of Requester-supported extended AEAD algorithms. Table 27 — Extended Algorithm field format describes the format of this field.

249 **Table 19 — ReqBaseAsymAlg structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	`0x04` = `ReqBaseAsymAlg`
1	AlgCount	1	• Bit [7:4]. 2. • Bit [3:0]. Number of Requester supported extended asymmetric key signature algorithms for the purpose of signature generation (= `ExtAlgCount4`).

Byte offset	Field	Size (bytes)	Description
2	AlgSupported	2	Bit mask listing Requester-supported SPDM-enumerated asymmetric key signature algorithms for the purpose of signature generation. • Byte 0 Bit 0. TPM_ALG_RSASSA_2048. • Byte 0 Bit 1. TPM_ALG_RSAPSS_2048. • Byte 0 Bit 2. TPM_ALG_RSASSA_3072. • Byte 0 Bit 3. TPM_ALG_RSAPSS_3072. • Byte 0 Bit 4. TPM_ALG_ECDSA_ECC_NIST_P256. • Byte 0 Bit 5. TPM_ALG_RSASSA_4096. • Byte 0 Bit 6. TPM_ALG_RSAPSS_4096. • Byte 0 Bit 7. TPM_ALG_ECDSA_ECC_NIST_P384. • Byte 1 Bit 0. TPM_ALG_ECDSA_ECC_NIST_P521. • Byte 1 Bit 1. TPM_ALG_SM2_ECC_SM2_P256. • Byte 1 Bit 2. EdDSA ed25519. • Byte 1 Bit 3. EdDSA ed448. • All other values reserved.
4	AlgExternal	4* `ExtAlgCount4`	List of Requester-supported extended asymmetric key signature algorithms for the purpose of signature generation. Table 27 — Extended Algorithm field format describes the format of this field.

250 **Table 20 — KeySchedule structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	`0x05` = `KeySchedule`
1	AlgCount	1	• Bit [7:4]. 2. • Bit [3:0]. Number of Requester supported extended key schedule algorithms (= `ExtAlgCount5`).
2	AlgSupported	2	Bit mask listing Requester-supported SPDM-enumerated Key Schedule algorithms. • Byte 0 Bit 0. SPDM Key Schedule. • All other values reserved.
4	AlgExternal	4* `ExtAlgCount5`	List of Requester-supported extended key schedule algorithms. Table 27 — Extended Algorithm field format describes the format of this field.

251 **Table 21 — Successful ALGORITHMS response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x63` = `ALGORITHMS` . See Table 5 — SPDM response codes.
2	Param1	1	Number of algorithms structure tables in this request using RespAlgStruct
3	Param2	1	Reserved.
4	Length	2	Length of the response message, in bytes.
6	MeasurementSpecificationSel	1	Bit mask. The Responder shall select one of the measurement specifications supported by the Requester. Thus, no more than one bit shall be set. The `MeasurementSpecification` field of Table 44 — Measurement block format defines the values in this field.
7	OtherParamsSelection	1	Selected Parameter Bit Mask. • Bit [3:0]. See Opaque Data Format Support and Selection Table. • Bit [7:4]. Reserved.
8	MeasurementHashAlgo	4	Bit mask indicating the SPDM-enumerated hashing algorithms used for measurements. • Byte 0 Bit 0. Raw Bit Stream Only. • Byte 0 Bit 1. TPM_ALG_SHA_256. • Byte 0 Bit 2. TPM_ALG_SHA_384. • Byte 0 Bit 3. TPM_ALG_SHA_512. • Byte 0 Bit 4. TPM_ALG_SHA3_256. • Byte 0 Bit 5. TPM_ALG_SHA3_384. • Byte 0 Bit 6. TPM_ALG_SHA3_512. • Byte 0 Bit 7. TPM_ALG_SM3_256. • If the Responder supports `GET_MEASUREMENTS` , exactly one bit in this bit field shall be set. Otherwise, the Responder shall set this field to `0` . • All other values reserved. A Responder shall only select bit 0 if the Responder supports raw bit streams as the only form of measurement; otherwise, it shall select one of the other bits.
12	BaseAsymSel	4	Bit mask indicating the SPDM-enumerated asymmetric key signature algorithm selected for the purpose of signature generation. If the capabilities do not support this algorithm, this value is not used and shall be set to zero. The Responder shall set no more than one bit.
16	BaseHashSel	4	Bit mask indicating the SPDM-enumerated hashing algorithm selected. If the capabilities do not support this algorithm, this value is not used and shall be set to zero. The Responder shall set no more than one bit.
20	Reserved	12	Reserved.

Byte offset	Field	Size (bytes)	Description
32	ExtAsymSelCount	1	Number of extended asymmetric key signature algorithms selected for the purpose of signature generation. Shall be either `0` or `1` (=A'). If the capabilities do not support this algorithm, this value is not used and shall be set to zero.
33	ExtHashSelCount	1	The number of extended hashing algorithms selected. Shall be either `0` or `1` (=E'). If the capabilities do not support this algorithm, this value is not used and shall be set to zero.
34	Reserved	2	Reserved.
36	ExtAsymSel	4 * `A'`	The extended asymmetric key signature algorithm selected for the purpose of signature generation. The Responder shall use this asymmetric signature algorithm for all subsequent applicable response messages to the Requester. The Extended algorithm field format table describes the format of this field.
36 + 4 * `A'`	ExtHashSel	4 * `E'`	Extended hashing algorithm selected. The Responder shall use this hashing algorithm during all subsequent response messages to the Requester. The Requester shall use this hashing algorithm during all subsequent applicable request messages to the Responder. The Extended algorithm field format table describes the format of this field.
36 + 4 * `A'` + 4 * `E'`	RespAlgStruct	`AlgStructSize`	See Table 22 — Response AlgStructure field format.

252 `AlgStructSize` is the sum of the size of all Algorithm structure tables, as the following tables show. The algorithm structure table need be present only if the Responder supports that `AlgType`. `AlgType` shall monotonically increase for subsequent entries.

253 **Table 22 — Response AlgStructure field format**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	Type of algorithm. • 0x00 and 0x01. Reserved. • 0x02. DHE. • 0x03. `AEADCipherSuite`. • 0x04. `ReqBaseAsymAlg`. • 0x05. `KeySchedule`. • All other values reserved.

Byte offset	Field	Size (bytes)	Description
1	AlgCount	1	Bit mask listing Responder supported fixed algorithm requested by the Requester. • Bit [7:4]. Number of bytes required to describe Requester-supported SPDM-enumerated fixed algorithms (= `FixedAlgCount`). `FixedAlgCount` + 2 shall be a multiple of 4. • Bit [3:0]. Number of Requester-supported, Responder-selected, extended algorithms (= `ExtAlgCount`'). This value shall be either 0 or 1.
2	AlgSupported	`FixedAlgCount`	Bit mask for indicating a Requester-supported, Responder-selected, SPDM-enumerated algorithm. Responder shall set at most one bit to 1.
2 + `FixedAlgCount`	AlgExternal	4* `ExtAlgCount'`	If present: a Requester-supported, Responder-selected, extended algorithm. Responder shall select at most one external algorithm. Table 27 — Extended Algorithm field format describes the format of this field.

254 The following tables describe each individual type and their associated fixed fields:

- Table 23 — DHE structure
- Table 24 — AEAD structure
- Table 25 — ReqBaseAsymAlg structure
- Table 26 — KeySchedule structure
- Table 27 — Extended Algorithm field format

255 **Table 23 — DHE structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	`0x02` = `DHE`
1	AlgCount	1	• Bit [7:4]. 2. • Bit [3:0]. Number of Requester-supported, Responder-selected, extended DHE groups (= `ExtAlgCount2'`). This value shall be either 0 or 1.

Byte offset	Field	Size (bytes)	Description
2	AlgSupported	2	Bit mask for indicating a Requester-supported, Responder-selected, SPDM-enumerated DHE group. Values in parentheses specify the size of the corresponding public values associated with each group. • Byte 0 Bit 0. ffdhe2048 (D = 256). • Byte 0 Bit 1. ffdhe3072 (D = 384). • Byte 0 Bit 2. ffdhe4096 (D = 512). • Byte 0 Bit 3. secp256r1 (D = 64, C = 32) • Byte 0 Bit 4. secp384r1 (D = 96, C = 48). • Byte 0 Bit 5. secp521r1 (D = 132, C = 66). • Byte 0 Bit 6. SM2_P256 (Part 3 and Part 5 of GB/T 32918) (D = 64, C = 32). • All other values reserved.
4	AlgExternal	4* `ExtAlgCount2'`	If present: a Requester-supported, Responder-selected, extended DHE algorithm. Table 27 — Extended Algorithm field format describes the format of this field.

256 **Table 24 — AEAD structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	`0x03` = `AEAD`
1	AlgCount	1	• Bit [7:4]. 2. • Bit [3:0]. Number of Requester-supported, Responder-selected, extended AEAD algorithms (= `ExtAlgCount3'`). This value shall be either 0 or 1.
2	AlgSupported	2	Bit mask for indicating a Requester-supported, Responder-selected, SPDM-enumerated AEAD algorithm. • Byte 0 Bit 0. AES-128-GCM. • Byte 0 Bit 1. AES-256-GCM. • Byte 0 Bit 2. CHACHA20_POLY1305. • Byte 0 Bit 3. AEAD_SM4_GCM. • All other values reserved.
4	AlgExternal	4* `ExtAlgCount3'`	If present: a Requester-supported, Responder-selected, extended AEAD algorithm. Table 27 — Extended Algorithm field format describes the format of this field.

257 **Table 25 — ReqBaseAsymAlg structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	`0x04` = `ReqBaseAsymAlg`
1	AlgCount	1	• Bit [7:4]. 2. • Bit [3:0]. Number of Requester-supported, Responder-selected, extended asymmetric key signature algorithms (= `ExtAlgCount4'`) for the purpose of signature verification. This value shall be either 0 or 1.
2	AlgSupported	2	Bit mask for indicating a Requester-supported, Responder-selected, SPDM-enumerated asymmetric key signature algorithm for the purpose of signature verification. • Byte 0 Bit 0. TPM_ALG_RSASSA_2048. • Byte 0 Bit 1. TPM_ALG_RSAPSS_2048. • Byte 0 Bit 2. TPM_ALG_RSASSA_3072. • Byte 0 Bit 3. TPM_ALG_RSAPSS_3072. • Byte 0 Bit 4. TPM_ALG_ECDSA_ECC_NIST_P256. • Byte 0 Bit 5. TPM_ALG_RSASSA_4096. • Byte 0 Bit 6. TPM_ALG_RSAPSS_4096. • Byte 0 Bit 7. TPM_ALG_ECDSA_ECC_NIST_P384. • Byte 1 Bit 0. TPM_ALG_ECDSA_ECC_NIST_P521. • Byte 1 Bit 1. TPM_ALG_SM2_ECC_SM2_P256. • Byte 1 Bit 2. EdDSA ed25519. • Byte 1 Bit 3 EdDSA ed448. • All other values reserved.
4	AlgExternal	4* `ExtAlgCount4'`	If present: a Requester-supported, Responder-selected extended asymmetric key signature algorithm for the purpose of signature verification. Table 27 — Extended Algorithm field format describes the format of this field.

258 **Table 26 — KeySchedule structure**

Byte offset	Field	Size (bytes)	Description
0	AlgType	1	`0x05` = `KeySchedule`
1	AlgCount	1	• Bit [7:4]. 2. • Bit [3:0]. Number of Requester-supported, Responder-selected, extended key schedule algorithms (= `ExtAlgCount5'`). This value shall be either 0 or 1.

Byte offset	Field	Size (bytes)	Description
2	AlgSupported	2	Bit mask for indicating a Requester-supported, Responder-selected, SPDM-enumerated key schedule algorithm. • Byte 0 Bit 0. SPDM key schedule. • All other values are reserved.
4	AlgExternal	4* `ExtAlgCount5'`	If present: a Requester-supported, Responder-selected, extended key schedule algorithm. Table 27 — Extended Algorithm field format describes the format of this field.

259 **Table 27 — Extended Algorithm field format**

Byte offset	Field	Size (bytes)	Description
0	Registry ID	1	Shall represent the registry or standards body. The **ID** column in Table 50 — Registry or standards body ID describes the value of this field.
1	Reserved	1	Reserved.
2	Algorithm ID	2	Shall indicate the desired algorithm. The registry or standards body owns the value of this field. See Table 50 — Registry or standards body ID.

260 **Opaque Data Format Support and Selection Table**

261 The Opaque Data Format Selection Table shows the bit definition for the format of the Opaque data fields. A Requester may set more than one bit in the table to indicate each supported format. A Responder shall select no more than one of the bits supported by the Requester in this table. If the Requester or the Responder does not set a bit, then all `OpaqueData` fields in this specification shall be absent by setting the respective `OpaqueDataLen` field to a value of zero.

Bit offset	Field	Description
0	OpaqueDataFmt0	If set, this bit shall indicate that the format for all `OpaqueData` fields in this specification is defined by the device vendor or other standards body.
1	OpaqueDataFmt1	If set, this bit shall indicate that the format for all `OpaqueData` fields in this specification is defined by the General opaque data format.
[3:2]	Reserved	Reserved.

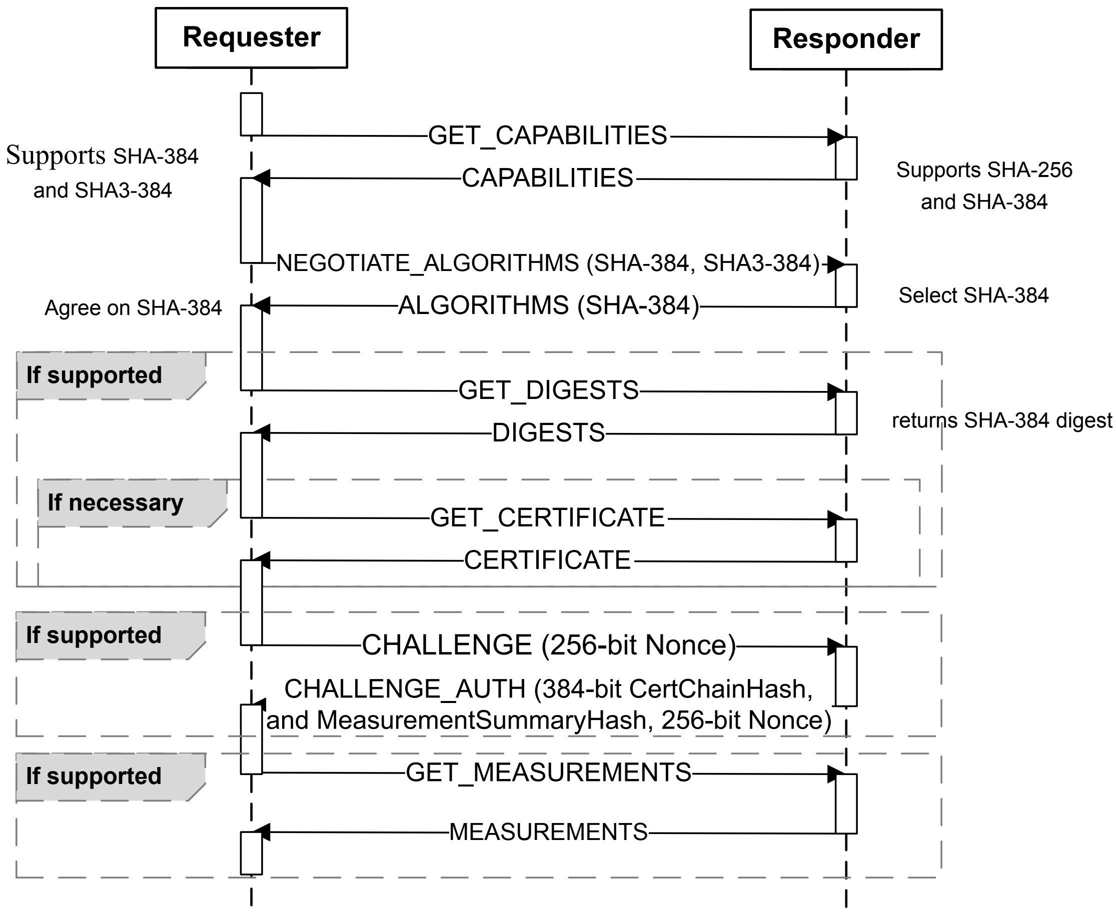
262 For each algorithm type, a Responder shall not select both an SPDM-enumerated algorithm and an extended algorithm.

263 Figure 4 — Hashing algorithm selection: Example 1 illustrates how two endpoints negotiate a base hashing algorithm.

264 In Figure 7 — Hashing algorithm selection: Example 1, endpoint A issues `NEGOTIATE_ALGORITHMS` request message and endpoint B selects an algorithm of which both endpoints are capable.

265 **Figure 7 — Hashing algorithm selection: Example 1**

266



267 The SPDM protocol accounts for the possibility that both endpoints can issue `NEGOTIATE_ALGORITHMS` request messages independently of each other. In this case, the endpoint A Requester and endpoint B Responder

communication pair might select a different algorithm compared to the endpoint B Requester and endpoint A Responder communication pair.

268 10.4.1 Connection Behavior after VCA

269 With the successful completion of the `ALGORITHMS` message, all of the parameters of the SPDM connection have been determined. Thus, all SPDM message exchanges after the VCA messages shall comply with the selected parameters in `ALGORITHMS`, with the exception of `GET_VERSION` and `VERSION` messages, or unless otherwise stated in this specification. To explain this behavior, suppose a Responder supports both RSA and ECDSA asymmetric algorithms. For an SPDM connection, the Responder selects the `TPM_ALG_RSASSA_2048` asymmetric algorithm in `BaseAsymSel` and the `TPM_ALG_SHA_256` hash algorithm in `BaseHashSel`. If the Requester on that same connection issues a `GET_DIGESTS`, the Responder returns `TPM_ALG_SHA_256` digests only for those populated slots that can provide a `TPM_ALG_RSASSA_2048` signature for a `CHALLENGE_AUTH` response. The Responder would violate this requirement if the Responder returns one or more digests of populated slots that perform ECDSA signatures or uses a different hash algorithm.

270 Unless otherwise stated in this specification and with the exception of `GET_VERSION`, if a Requester issues a request that violates one or more of the negotiated or selected parameters of a given connection, the Responder shall either silently discard the request or return an `ERROR` message with an appropriate error code.

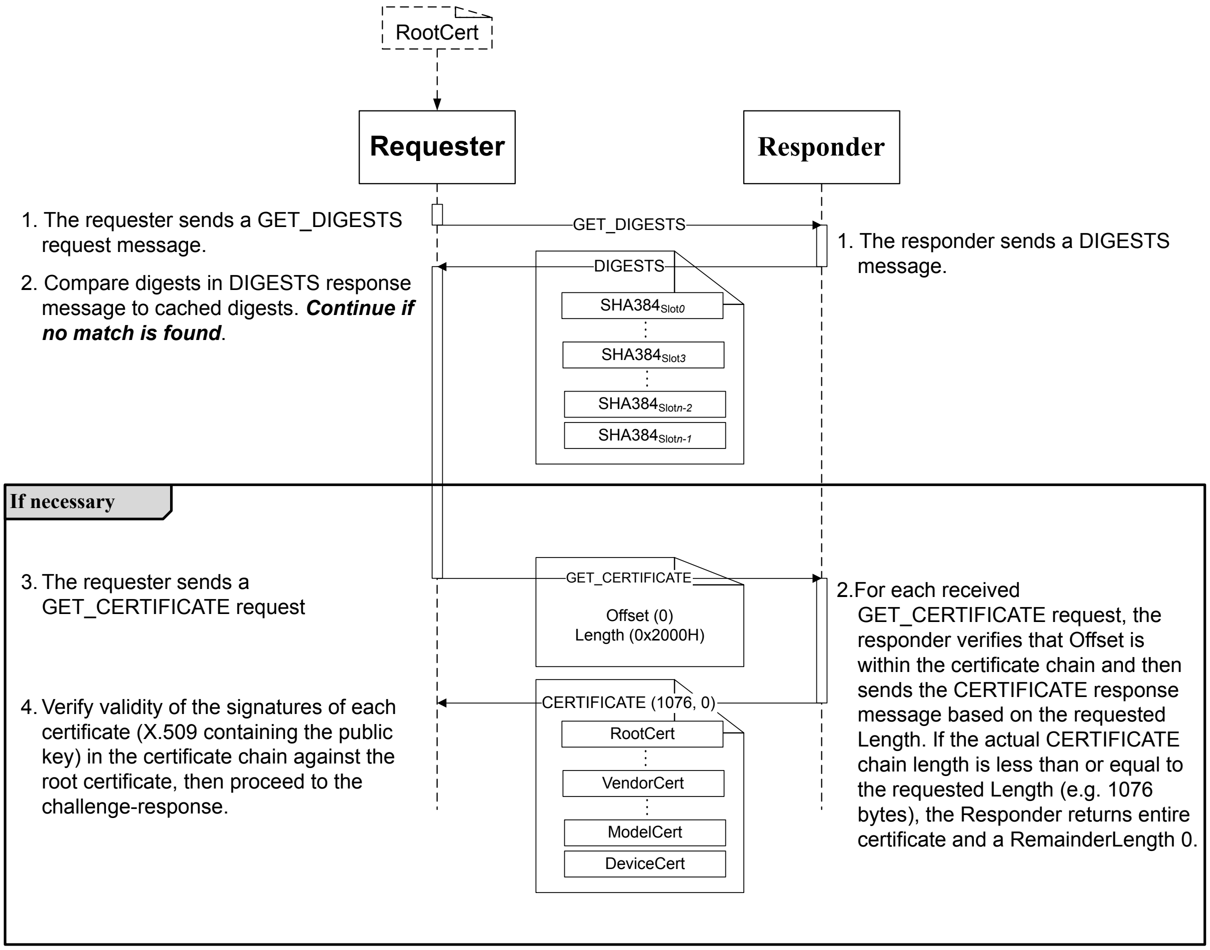
271 10.5 Responder identity authentication

272 This clause describes request messages and response messages associated with the identity of the Responder authentication operations. The `GET_DIGESTS` and `GET_CERTIFICATE` messages shall be supported by a Responder that returns `CERT_CAP`=1 in the `CAPABILITIES` response message. The `CHALLENGE` message that this clause defines shall be supported by a Responder that returns `CHAL_CAP`=1 in the `CAPABILITIES` response message. The `GET_DIGESTS` and `GET_CERTIFICATE` messages are not applicable if the public key of the Responder was provisioned to the Requester in a trusted environment.

273 Figure 8 — Responder authentication: Example certificate retrieval flow shows the high-level request-response message flow and sequence for *certificate* retrieval.

274 **Figure 8 — Responder authentication: Example certificate retrieval flow**

275



276 The `GET_DIGESTS` request message and `DIGESTS` response message can optimize the amount of data required to be transferred from the Responder to the Requester, due to the potentially large size of a certificate chain. The cryptographic hash values of each of the certificate chains stored on an endpoint is returned with the `DIGESTS` response message, such that the Requester can cache the previously retrieved certificate chain hash values to detect any change to the certificate chains stored on the device before issuing the `GET_CERTIFICATE` request message.

277 For the runtime challenge-response flow, the signature field in the `CHALLENGE_AUTH` response message payload shall be signed by using the private key associated with the leaf certificate over the hash of the message transcript. See Table 38 — Request ordering and message transcript computation rules for M1/M2.

278 This ensures cryptographic binding between a specific request message from a specific Requester and a specific response message from a specific Responder and enables the Requester to detect the presence of an active adversary attempting to downgrade cryptographic algorithms or SPDM versions.

279 Furthermore, a Requester-generated *nonce* protects the challenge-response from replay attacks, whereas a

Responder-generated nonce prevents the Responder from signing over arbitrary data that the Requester dictates. The message transcript generation for the signature computation is restarted with the latest `GET_VERSION` request received.

280 10.6 Requester identity authentication

281 If a Requester supports mutual authentication, it shall comply with all requirements placed on a Responder as specified in Responder identity authentication.

282 If a Responder supports mutual authentication, it shall comply with all requirements placed on a Requester as specified in Responder identity authentication. These two statements essentially describe a role reversal.

283 10.6.1 Certificates and certificate chains

284 Each SPDM endpoint that supports identity authentication using certificates shall carry at least one *complete* certificate chain. A certificate chain contains an ordered list of certificates, presented as the binary (byte) concatenation of the fields that Table 28 — Certificate chain format shows. In the context of this specification, a complete certificate chain is one where: (i) the first certificate is either signed by a Root Certificate (a certificate that specifies a trust anchor) or is a Root Certificate itself, (ii) each subsequent certificate is signed by the preceding certificate, and (iii) the final certificate contains the public key used to authenticate the SPDM endpoint. The final certificate is called the *leaf certificate*.

285 The SPDM endpoint shall contain a single public-private key pair per supported algorithm for its leaf certificate, regardless of how many certificate chains are stored on the device. The Responder selects a single asymmetric key signature algorithm per Requester.

286 Certificate chains are stored in logical locations called *slots*. Each slot shall either be empty or contain one complete certificate chain. A device shall not contain more than eight slots. Slots are numbered zero through seven inclusively. Slot 0 is populated by default. If a device uses the `DeviceCert` model (`ALIAS_CERT_CAP=0b` in `CAPABILITIES` response), then the certificate chain in every populated slot shall use `DeviceCert` s. If a device uses the `AliasCert` model (`ALIAS_CERT_CAP=1b` in `CAPABILITIES` response), then the certificate chain in every populated slot shall use `AliasCert` s. Additional slots may be populated through the supply chain such as by a platform integrator or by an end user such as the IT administrator. A slot mask identifies the certificate chains from the eight slots.

287 Each certificate in a chain shall be in ASN.1 DER-encoded X.509 v3 format. The ASN.1 DER encoding of each individual certificate can be analyzed to determine its length.

288 To allow for flexibility in supporting multiple certification models, the minimum number of certificates within a chain compliant with this specification shall be one, in which case the single certificate shall be the `DeviceCert` leaf certificate.

289 Table 28 — Certificate chain format describes the certificate chain format:

290 **Table 28 — Certificate chain format**

Byte offset	Field	Size (bytes)	Description
0	Length	2	Total length of the certificate chain, in bytes, including all fields in this table. This field is little endian.
2	Reserved	2	Reserved.
4	RootHash	H	Digest of the Root Certificate. Note that Root Certificate is ASN.1 DER-encoded for this digest. This field shall be in Hash byte order. `H` is the output size, in bytes, of the hash algorithm selected by the most recent `ALGORITHMS` response.
4 + H	Certificates	`Length` - (4 + H)	A complete certificate chain, consisting of one or more ASN.1 DER-encoded X.509 v3 certificates. This field shall be in Encoded ASN.1 byte order.

291 10.7 GET_DIGESTS request and DIGESTS response messages

292 This request message shall retrieve the certificate chain digests.

293 Table 29 — GET_DIGESTS request message format shows the `GET_DIGESTS` request message format.

294 The digests in Table 30 — Successful DIGESTS response message format shall be computed over the certificate chain as Table 28 — Certificate chain format shows.

295 **Table 29 — GET_DIGESTS request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x81` = `GET_DIGESTS`. See Table 4 — SPDM request codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.

296 **Table 30 — Successful DIGESTS response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x01` = `DIGESTS`. See Table 5 — SPDM response codes.

Byte offset	Field	Size (bytes)	Description
2	Param1	1	Reserved.
3	Param2	1	Slot mask. The bit in position K of this byte shall be set to 1b if and only if slot number K contains a certificate chain for the protocol version in the SPDMVersion field. (Bit 0 is the least significant bit of the byte.) The number of digests returned shall be equal to the number of bits set in this byte. The digests shall be returned in order of increasing slot number.
4	Digest[0]	H	Digest of the first certificate chain. This field shall be in Hash byte order.
...	...	...	...
4 + (H * (n -1))	Digest[n-1]	H	Digest of the last (n^{th}) certificate chain. This field shall be in Hash byte order.

297 10.8 GET_CERTIFICATE request and CERTIFICATE response messages

298 This request message shall retrieve the certificate chain from the specified slot number.

299 Table 31 — GET_CERTIFICATE request message format shows the `GET_CERTIFICATE` request message format.

300 Table 32 — Successful CERTIFICATE response message format shows the `CERTIFICATE` response message format.

301 The Requester should, at a minimum, save the public key of the leaf certificate and associate it with each of the digests returned by `DIGESTS` message response. The Requester sends one or more `GET_CERTIFICATE` requests to retrieve the certificate chain of the Responder.

302 **Table 31 — GET_CERTIFICATE request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x82` = `GET_CERTIFICATE`. See Table 4 — SPDM request codes.
2	Param1	1	Bit [7:4]. Reserved. Bit [3:0]. `SlotID`. Slot number of the Responder certificate chain to read. The value in this field shall be between 0 and 7 inclusive.
3	Param2	1	Reserved.

Byte offset	Field	Size (bytes)	Description
4	Offset	2	Offset in bytes from the start of the certificate chain to where the read request message begins. The Responder should send its certificate chain starting from this offset. For the first `GET_CERTIFICATE` request, the Requester shall set this field to 0. For non-first requests, `Offset` is the sum of `PortionLength` values in all previous GET_CERTIFICATE responses.
6	Length	2	Length of certificate chain data, in bytes, to be returned in the corresponding response. `Length` is an unsigned 16-bit integer. This value is the smaller of the following values: Capacity of the internal buffer of the Requester for receiving the certificate chain of the Responder. The `RemainderLength` of the preceding `GET_CERTIFICATE` response. For the first `GET_CERTIFICATE` request, the Requester should use the capacity of the receiving buffer of the Requester. If `Offset=0` and `Length=0xFFFF`, the Requester is requesting the entire chain.

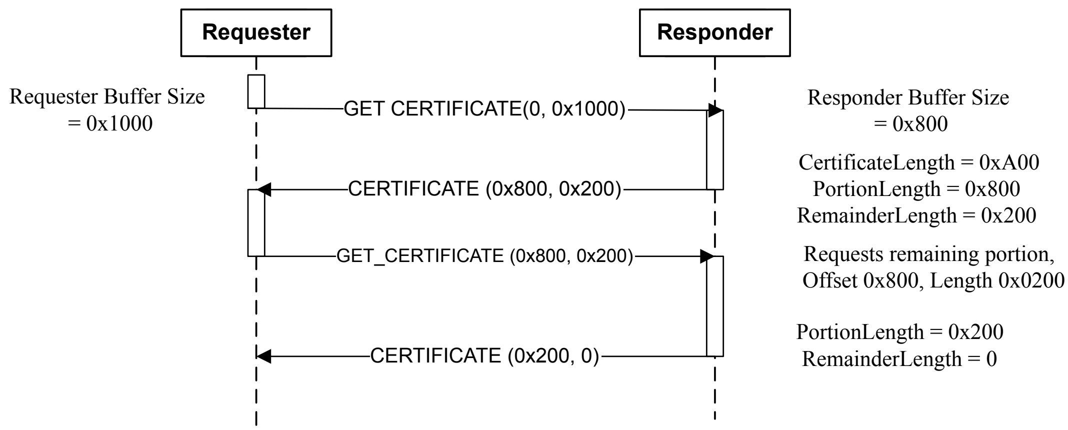
303 **Table 32 — Successful CERTIFICATE response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x02` = `CERTIFICATE`. See Table 5 — SPDM response codes.
2	Param1	1	Bit [7:4]. Reserved. Bit [3:0]. `SlotID`. Slot number of the certificate chain returned.
3	Param2	1	Reserved.
4	PortionLength	2	Number of bytes of this portion of certificate chain. This should be less than or equal to `Length` received as part of the request. For example, the Responder might set this field to a value less than `Length` received as part of the request due to limitations on the internal buffer of the Responder.
6	RemainderLength	2	Number of bytes of the certificate chain that have not been sent yet, after the current response. For the last response, this field shall be 0 as an indication to the Requester that the entire certificate chain has been sent.
8	CertChain	`PortionLength`	Requested contents of target certificate chain, as described in Certificates and certificate chains.

304 Figure 9 — Responder cannot return full length data flow shows the high-level request-response message flow for Responder response when it cannot return the entire data requested by the Requester in the first response.

305 **Figure 9 — Responder cannot return full length data flow**

306



307 Endpoints that support the large SPDM message transfer mechanism message set, shall use the large SPDM message transfer mechanism messages to manage the transfer of the requested certificate chain. Specifically:

- The Requester shall set `Offset` to `0` and `Length` to `0xFFFF` in the `GET_CERTIFICATE` request.
- The Responder shall set `PortionLength` equal to the size of the complete certificate chain stored in the requested slot, `RemainderLength` to `0` and store the contents of the complete certificate chain in `CertChain` in the `CERTIFICATE` response. The Responder shall then fragment and serve this response message in chunks, as per the clauses presented in `CHUNK_GET` request and `CHUNK_RESPONSE` response message.

308 10.8.1 Mutual authentication requirements for GET_CERTIFICATE and CERTIFICATE messages

309 If the Requester supports mutual authentication, the requirements placed on the Responder in GET_CERTIFICATE request and CERTIFICATE response messages clause shall also apply to the Requester. If the Responder supports mutual authentication, the requirements placed on the Requester in GET_CERTIFICATE request and CERTIFICATE response messages clause shall also apply to the Responder. These two statements essentially describe a role reversal.

310 10.8.2 SPDM certificate requirements and recommendations

311 This specification defines a number of X.509 v3 required and optional fields for compliant SPDM certificates. Unless stated otherwise, the following clauses apply to those certificates in the chain that are specific to a device instance,

that is, the leaf certificate in the `DeviceCert` model or the `DeviceCert` , all intermediate `AliasCert` s and the leaf certificate in the `AliasCert` model. See identity provisioning.

312 In addition, the `Subject Alternative Name` certificate extension `otherName` field is recommended for providing device information. See the Definition of otherName using the DMTF OID.

313 **Table 33 — Required fields**

Field	Description
Version	Version of the encoded certificate shall be present and shall be `3` (encoded as value `2`).
Serial Number	CA-assigned serial number shall be present with a positive integer value.
Signature Algorithm	`Signature` algorithm that CA uses shall be present.
Issuer	CA distinguished name shall be specified.
Subject Name	Subject name shall be present and shall represent the distinguished name associated with the leaf certificate.
Validity	See Certificate validity details, and RFC5280.
Subject Public Key Info	Device public key and the algorithm shall be present.
Key Usage	Shall be present and key usage bit for digital signature shall be set.

314 **Table 34 — Optional fields**

Field	Description
Basic Constraints	If present, the CA value shall be `FALSE` in the leaf certificate.
Subject Alternative Name otherName	In some cases, it might be desirable to provide device specific information as part of the leaf certificate. DMTF chose the `otherName` field with a specific format to represent the device information. The use of the `otherName` field also provides flexibility for other alliances to provide device specific information as part of the leaf certificate. See the Definition of otherName using the DMTF OID. Note that `otherName` field formats specified by other standards are permissible in the certificate.
Extended Key Usage (EKU)	If present in a certificate, the Extended Key Usage extension indicates one or more purposes for which the public key should be used. See Extended Key Usage authentication OIDs and Identity provisioning.

315 **Certificate validity details**

316 As per RFC5280, the certificate validity period is the time interval during which the CA warrants that it will maintain information about the status of the certificate. The field is represented as an ASN.1-encoded SEQUENCE of two

dates: the date when the certificate validity period begins (`notBefore`) and the date when the certificate validity period ends (`notAfter`).

317 For a leaf certificate whose chain is stored in Slot 0, the `notBefore` date should be the date of certificate creation, and the `notAfter` date should be set to GeneralizedTime value `99991231235959Z` . In general, immutable leaf certificates' `notAfter` dates should be set appropriately to ensure that the leaf certificate will not expire during the practical lifetime of the device.

318 For leaf certificates whose chains are stored in Slots 1-7, the `notBefore` date should be the date of certificate creation. The `notAfter` date can be set according to end user requirements, including values that will cause certificate expiration and necessitate certificate renewal, and thus device re-certification, during the lifetime of the device.

319 Definition of otherName using the DMTF OID shows the definition of otherName using the DMTF OID:

320 **Definition of otherName using the DMTF OID**

```
id-DMTF OBJECT IDENTIFIER ::= { 1 3 6 1 4 1 412 }

id-DMTF-spdm OBJECT IDENTIFIER ::= { id-DMTF 274 }

DMTFOtherName ::= SEQUENCE {
    type-id   DMTF-oid
    value [0] EXPLICIT ub-DMTF-device-info
}
-- OID for DMTF device info --
id-DMTF-device-info  OBJECT IDENTIFIER ::= { 1 3 6 1 4 1 412 1 }
DMTF-oid                               ::= OBJECT IDENTIFIER (id-DMTF-device-info)

-- All printable characters except ":" --
DMTF-device-string                     ::= UTF8String (ALL EXCEPT ":")

-- Device Manufacturer --
DMTF-manufacturer                      ::= DMTF-device-string

-- Device Product --
DMTF-product                           ::= DMTF-device-string

-- Device Serial Number --
DMTF-serialNumber                      ::= DMTF-device-string

-- Device information string  --
ub-DMTF-device-info                    ::= UTF8String({DMTF-manufacturer":"DMTF-product":"DMTF-serialNumber})
```

321 The Leaf certificate example shows an example leaf certificate.

322 **10.8.2.1 Extended Key Usage authentication OIDs**

323 The following Extended Key Usage purposes are defined for SPDM certificate authentication:

- SPDM Responder Authentication { id-DMTF-spdm 3 }: The presence of this OID shall indicate that a leaf certificate can be used for Responder authentication purposes.
- SPDM Requester Authentication { id-DMTF-spdm 4 }: The presence of this OID shall indicate that a leaf certificate can be used for Requester authentication purposes.

324 The presence of both OIDs shall indicate that the leaf certificate can be used for both Requester and Responder authentication purposes. If present, these OIDs shall appear in the leaf certificate.

325 A Responder device that supports mutual authentication should include the `SPDM Responder Authentication` OID in the Extended Key Usage field of its leaf certificate. A Requester device that supports mutual authentication should include the `SPDM Requester Authentication` OID in the Extended Key Usage field of its leaf certificate. Note that alternate OIDs specified by other standards are permissible in the certificate.

326 **10.8.2.2 SPDM Non-Critical Certificate Extension OID**

327 The `id-DMTF-spdm-extension` OID is a container of non-critical SPDM OIDs and their corresponding values. The OID value for `id-DMTF-spdm-extension` shall be { id-DMTF-spdm 6 }. Furthermore, this OID is a Certificate Extension as defined in RFC5280 and its encoding shall follow the `Extension` syntax also defined in RFC5280. The `Extension` syntax defines three parameters: `extnID`, `critical` and `extnValue`. The values of these three parameters for `id-DMTF-spdm-extension` shall be the DER encoding of the ASN.1 value as the DMTF SPDM Extension Format defines.

328 **Definition of DMTF SPDM Extension Format**

```
id-DMTF-spdm-extension Extension ::=
{
    extnID       { id-DMTF-spdm 6 }
    critical     FALSE
    extnValue    id-spdm-cert-oids
}

id-spdm-cert-oids ::= SEQUENCE SIZE (1..MAX) OF id-spdm-cert-oid

id-spdm-cert-oid ::=  SEQUENCE
{
    spdmOID              OBJECT IDENTIFIER
    spdmOIDdefinition    OCTET STRING OPTIONAL
}
```

329 The `spdmOID` field shall contain an OID defined in this specification. Only designated OIDs, permitted by this

specification, shall be allowed in `spdmOID`. The `spdmOIDdefinition` field shall be a DER encoding of the ASN.1 value of the definition indicated by `spdmOID`.

330 These clauses describe the definitions and formats of the SPDM OIDs contained in `id-DMTF-spdm-extension`. If present, these OIDs shall only be contained in `id-DMTF-spdm-extension`.

331 10.8.2.2.1 Hardware identity OID

332 The `id-DMTF-hardware-identity` OID is defined to help identify the hardware identity certificate in a chain regardless of the certificate chain model used (`DeviceCert` or `AliasCert`). If the `AliasCert` model is used, this OID shall not be present in any alias certificates in the chain. The `id-DMTF-hardware-identity` OID shall have a format as Hardware identity OID format defines.

333 **Hardware identity OID format**

```
id-DMTF-hardware-identity id-spdm-cert-oid :: = {
    spdmOID           { id-DMTF-spdm 2 }
    spdmOIDdefinition ABSENT
}
```

334 10.8.2.2.2 Mutable certificate OID

335 Mutable certificates may include the `id-DMTF-mutable-certificate` OID to identify them as mutable. If used, this OID shall be present in all mutable certificates in the chain. The `id-DMTF-mutable-certificate` OID shall have a format as Mutable certificate OID format defines.

336 **Mutable certificate OID format**

```
id-DMTF-mutable-certificate id-spdm-cert-oid ::= {
    spdmOID           { id-DMTF-spdm 5 }
    spdmOIDdefinition ABSENT
}
```

337 10.9 CHALLENGE request and CHALLENGE_AUTH response messages

338 This request message shall authenticate a Responder through the challenge-response protocol.

339 Table 35 — CHALLENGE request message format shows the `CHALLENGE` request message format.

340 Table 36 — Successful CHALLENGE_AUTH response message format shows the `CHALLENGE_AUTH` response message format.

341 Table 37 — Table 37 — CHALLENGE_AUTH response attribute shows the `CHALLENGE_AUTH` response attribute.

342 **Table 35 — CHALLENGE request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x83` = `CHALLENGE` . See Table 4 — SPDM request codes.
2	Param1	1	`SlotID` . Slot number of the Responder certificate chain that shall be used for authentication. It shall be `0xFF` if the public key of the Responder was provisioned to the Requester in a trusted environment, otherwise the value in this field shall be between 0 and 7 inclusive.
3	Param2	1	Type of measurement summary hash requested: • `0x0` . No measurement summary hash requested. • `0x1` . *TCB* measurements only. • `0xFF` . All measurements. • All other values reserved. If a Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response), the Requester shall set this value to `0x0` .
4	Nonce	32	The Requester should choose a random value.

343 **Table 36 — Successful CHALLENGE_AUTH response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x03` = `CHALLENGE_AUTH` . See Table 5 — SPDM response codes.
2	Param1	1	Response Attribute Field. See Table 37 — CHALLENGE_AUTH response attribute.
3	Param2	1	Slot mask. The bit in position K of this byte shall be set to `1b` if and only if slot number K contains a certificate chain for the protocol version in the `SPDMVersion` field. Bit 0 is the least significant bit of the byte. This field is reserved if the public key of the Responder was provisioned to the Requester in a trusted environment.

Byte offset	Field	Size (bytes)	Description
4	CertChainHash	H	Hash of the certificate chain, as Table 28 — Certificate chain format describes or public key (if the public key of the Responder was provisioned to the Requester in a trusted environment) used for authentication. The Requester can use this value to check that the certificate chain or public key matches the one requested. This field shall be in Hash byte order.
4 + H	Nonce	32	Responder-selected random value.
36 + H	MeasurementSummaryHash	H	If the Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response) or requested `Param2` = `0x0` , this field shall be absent. If the requested `Param2` = `0x1` , this field shall be the combined hash of measurements of all measurable components considered to be in the TCB required to generate this response, computed as `hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ...))` where `MeasurementBlock[x]` denotes a measurement of an element in the TCB. Measurements are concatenated in ascending order based on their measurement index as Table 44 — Measurement block format describes. When the requested `Param2` = `0x1` and there are no measurable components in the TCB required to generate this response, this field shall be `0` . If requested `Param2` = `0xFF` , this field shall be computed as `hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ..., MeasurementBlock[n]))` of all supported measurement blocks available in the measurement index range from `0x01` to `0xFE` , concatenated in ascending index order. Indices with no associated measurements shall not be included in the hash calculation. See the Measurement index assignments clause. If the Responder supports both raw bit stream and digest representations for a given measurement index, then the Responder shall use the digest form. This field shall be in Hash byte order.
36 + 2H	OpaqueDataLength	2	Size of the `OpaqueData` field that follows in bytes. The value should not be greater than 1024 bytes. Shall be `0` if no `OpaqueData` is provided.

Byte offset	Field	Size (bytes)	Description
38 + 2H	OpaqueData	`OpaqueDataLength`	The Responder can include Responder-specific information and/or information that its transport defines. If present, this field shall conform to the selected opaque data format in `OtherParamsSelection` .
38 + 2H + OpaqueDataLength	Signature	`SigLen`	`SigLen` is the size of the asymmetric-signing algorithm output that the Responder selected through the last `ALGORITHMS` response message to the Requester. The CHALLENGE_AUTH signature generation and CHALLENGE_AUTH signature verification clauses, respectively, define the signature generation and verification processes.

344 **Table 37 — CHALLENGE_AUTH response attribute**

Bit offset	Field	Description
[3:0]	SlotID	Shall contain the `SlotID` in the `Param1` field of the corresponding `CHALLENGE` request. If the Responder's public key was provisioned to the Requester previously, this field shall be `0xF` . The Requester can use this value to check that the certificate matched what was requested.
[6:4]	Reserved	Reserved.
7	**DEPRECATED:** BasicMutAuthReq	**DEPRECATED:** When mutual authentication is supported by both Responder and Requester, the Responder shall set this bit to indicate the Responder wants to authenticate the identity of the Requester using the basic mutual authentication flow. The Requester shall not set this bit in a basic mutual authentication flow. See Basic mutual authentication flow. If mutual authentication is not supported, this bit shall be zero; otherwise, it should be considered an error.

345
10.9.1 CHALLENGE_AUTH signature generation

346 To complete the `CHALLENGE_AUTH` signature generation process, the Responder shall complete these steps:

347 1. The Responder shall construct M1 and the Requester shall construct M2 message transcripts. For Responder authentication, see the Request ordering and message transcript computation rules for M1/M2 table. For Requester authentication in the mutual authentication scenario, see the Mutual authentication message transcript clause.

348 where:

349 `Concatenate()` is the standard concatenation function that is performed only after a successful completion response on the entire request and response contents.

350 ◦ If a response contains `ErrorCode=ResponseNotReady` :

351 Concatenation function is performed on the contents of both the original request and the successful response received during `RESPOND_IF_READY`. Neither the error response (`ResponseNotReady`) nor the RESPOND_IF_READY request shall be included in M1/M2.

352 ◦ If a response contains an `ErrorCode` other than `ResponseNotReady` :

353 No concatenation function is performed on the contents of both the original request and response.

354 2. The Responder shall generate:

```
Signature = SPDMsign(PrivKey, M1, "challenge_auth signing");
```

355 where:

- `SPDMsign` is described in Signature generation.
- `PrivKey` shall be the private key associated with the leaf certificate of the Responder in `slot=Param1` of the `CHALLENGE` request message. If the public key of the Responder was provisioned to the Requester, then `PrivKey` shall be the associated private key.

356 10.9.2 CHALLENGE_AUTH signature verification

357 Modifications to the previous request messages or the corresponding response messages by an active person-in-the-middle adversary or media error result in `M2!=M1` and lead to verification failure.

358 To complete the `CHALLENGE_AUTH` signature verification process, the Requester shall complete this step:

359 1. The Requester shall perform:

```
result = SPDMsignatureVerify(PubKey, Signature, M2, "challenge_auth signing");
```

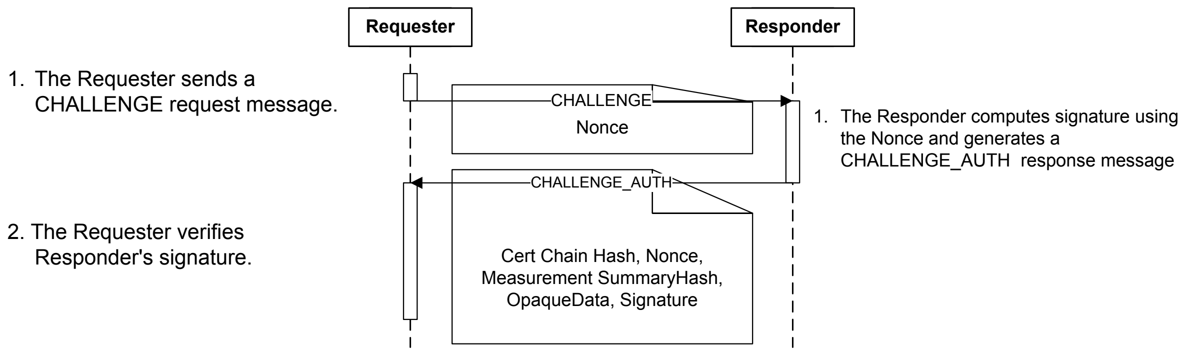
360 where:

- `SPDMsignatureVerify` is described in Signature verification. When `result` is `success` , the verification was successful.
- `PubKey` shall be the public key associated with the leaf certificate of the Responder with `slot=Param1` of the `CHALLENGE` request message. If the public key of the Responder was provisioned to the Requester, `PK` is the provisioned public key.

361 Figure 10 — Responder authentication: Runtime challenge-response flow shows the high-level request-response message flow and sequence for the authentication of the Responder for runtime challenge-response.

362 **Figure 10 — Responder authentication: Runtime challenge-response flow**

363



364 10.9.2.1 Request ordering and message transcript computation rules for M1 and M2

365 This clause applies to Responder-only authentication.

366 Table 38 — Request ordering and message transcript computation rules for M1/M2 defines how the message transcript is constructed for M1 and M2, which are used in signature calculation and verification in the `CHALLENGE_AUTH` response message.

367 The possible request orderings after Reset leading up to and including `CHALLENGE` shall be:

- `GET_VERSION` , `GET_CAPABILITIES` , `NEGOTIATE_ALGORITHMS` , `GET_DIGESTS` , `GET_CERTIFICATE` , `CHALLENGE` (A1, B1, C1)
- `GET_VERSION` , `GET_CAPABILITIES` , `NEGOTIATE_ALGORITHMS` , `GET_DIGESTS` , `CHALLENGE` (A1, B3, C1)
- `GET_VERSION` , `GET_CAPABILITIES` , `NEGOTIATE_ALGORITHMS` , `CHALLENGE` (A1, B2, C1)
- `GET_DIGESTS` , `GET_CERTIFICATE` , `CHALLENGE` (A2, B1, C1)
- `GET_DIGESTS` , `CHALLENGE` (A2, B3, C1)
- `GET_CERTIFICATE` , `CHALLENGE` (A2, B4, C1)
- `CHALLENGE` (A2, B2, C1)

368 Immediately after Reset, M1 and M2 shall be null.

369 After the Requester receives a successful `CHALLENGE_AUTH` response or the Requester sends a `GET_MEASUREMENTS` request, M1 and M2 shall be set to null. If a `Negotiated State` has been established, this will remain intact.

370 If a Requester sends a `GET_VERSION` message, the Requester and Responder shall set M1 and M2 to null, clear all `Negotiated State` and recommence construction of M1 and M2 starting with the new `GET_VERSION` message.

371 For additional rules, see General ordering rules.

372 **Table 38 — Request ordering and message transcript computation rules for M1/M2**

Requests	Implementation requirements	M1/M2=Concatenate (A, B, C)
Initial value	N/A	M1/M2= `null`
`GET_VERSION` issued	Requester issues this request to allow the Requester and Responder to determine an agreed upon `Negotiated State`. Also issued if the Requester detects an out of sync condition, when the signature verification fails or when the Responder provides an unexpected error response.	M1/M2=null
`GET_VERSION`, `GET_CAPABILITIES`, `NEGOTIATE_ALGORITHMS` Issued	Requester shall always issue these requests in this order.	`A1=VCA`
`GET_VERSION`, `GET_CAPABILITIES`, `NEGOTIATE_ALGORITHMS` Skipped	Requester skipped issuing these requests after a Reset or a completed `CHALLENGE_AUTH` response, that caused M1/M2 to re-initialize to `null`, if the Responder has previously indicated `CACHE_CAP=1`. In this case, the Requester and Responder shall proceed with the previously determined `Negotiated State`. These requests and responses are still required for M1/M2 construction.	`A2=VCA`
`GET_DIGESTS`, `GET_CERTIFICATE` issued	Requester issued these requests in this order after `NEGOTIATE_ALGORITHMS` request completion, or after a Reset or a completed `CHALLENGE_AUTH` response, that caused M1/M2 to re-initialize to `null`, if it chose to skip the previous three requests.	`B1=Concatenate(GET_DIGESTS, DIGESTS, GET_CERTFICATE, CERTIFICATE)`
`GET_DIGESTS`, `GET_CERTIFICATE` skipped	Requester skipped both requests after a Reset or a completed `CHALLENGE_AUTH` response, that caused M1/M2 to re-initialize to `null`, because it could use previously cached certificate information.	`B2=null`
`GET_DIGESTS` issued, `GET_CERTIFICATE` skipped	Requester skipped `GET_CERTIFICATE` request after a Reset or a completed `CHALLENGE_AUTH` response, that caused M1/M2 to re-initialize to `null` because it could use the previously cached `CERTIFICATE` response.	`B3=(GET DIGESTS, DIGESTS)`
`GET_DIGESTS` skipped, `GET_CERTIFICATE` issued	Requester skipped `GET_DIGESTS` request after after a Reset or a completed `CHALLENGE_AUTH` response, that caused M1/M2 to re-initialize to `null`. The Requester uses the previously cached `CERTIFICATE` response for a byte-by-byte comparison.	`B4=(GET CERTIFICATE, CERTIFICATE)`
`CHALLENGE` issued	Requester issued this request to complete security verification of current requests and responses. The Signature bytes of `CHALLENGE_AUTH` shall not be included in C.	`C1=(CHALLENGE, CHALLENGE_AUTH\Signature)`. See Table 35 — CHALLENGE request message format.
`CHALLENGE` completion	Completion of `CHALLENGE` sets M1/M2 to `null`.	`M1/M2=null`
Other issued	If the Requester issued `GET_MEASUREMENTS` or `KEY_EXCHANGE` or `FINISH` or `PSK_EXCHANGE` or `PSK_FINISH` or `KEY_UPDATE` or `HEARTBEAT` or `GET_ENCAPSULATED_REQUEST` or `DELIVER_ENCAPSULATED_RESPONSE` or `END_SESSSION` request(s) and skipped `CHALLENGE` completion, M1/M2 are set to `null`.	`M1/M2=null`

373 The Basic mutual authentication flow is DEPRECATED. Implementations should use session-based mutual authentication as Figure 21 — Session-based mutual authentication example shows or optimized session-based mutual authentication as Figure 22 — Optimized session-based mutual authentication example shows.

---

374 DEPRECATED

375 10.9.3 Basic mutual authentication

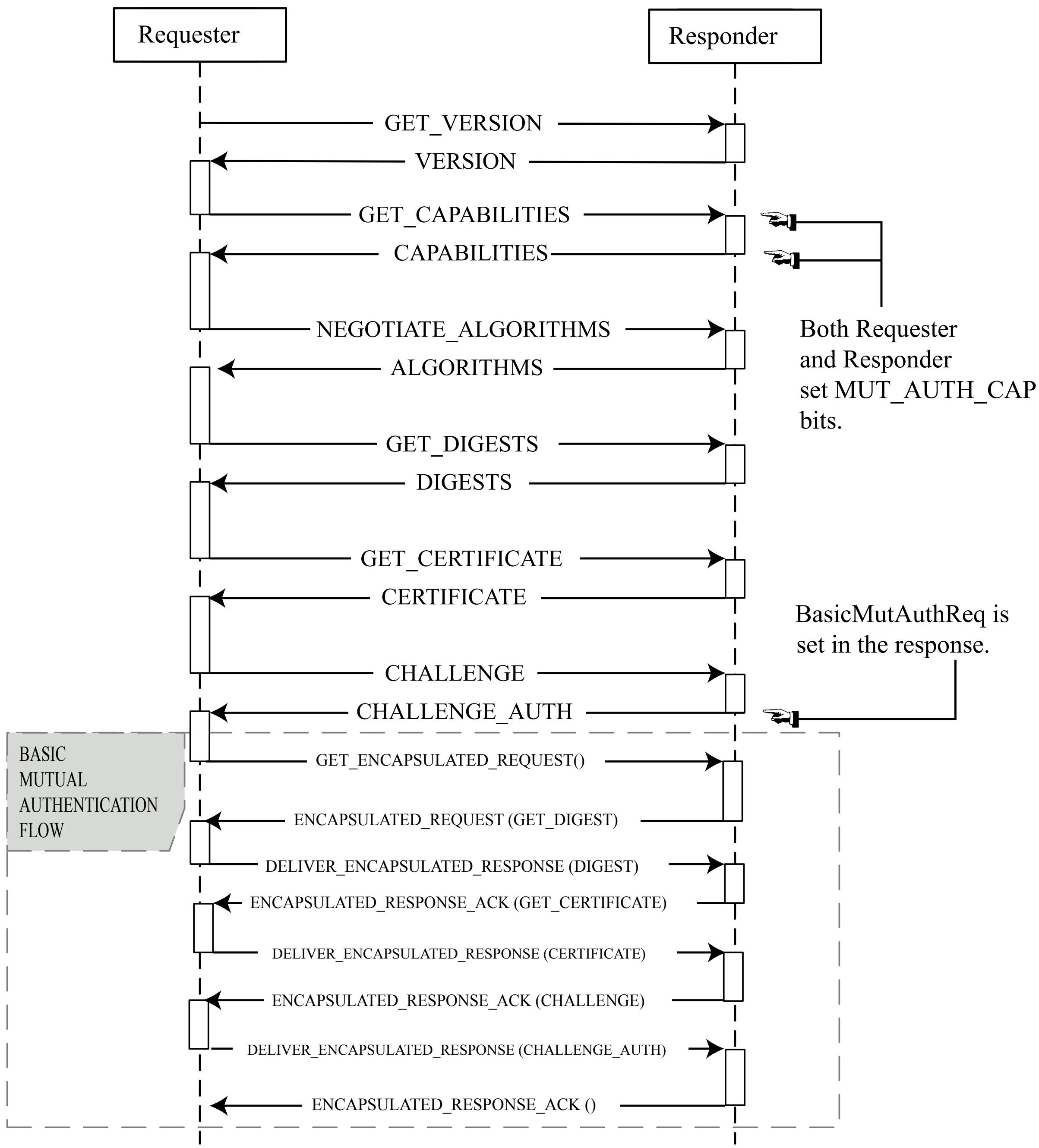
376 Unless otherwise stated, if the Requester supports mutual authentication, the requirements placed on the Responder in the CHALLENGE request and CHALLENGE_AUTH response messages clause shall also apply to the Requester. Unless otherwise stated, if the Responder supports mutual authentication, the requirements placed on the Requester in the CHALLENGE request and CHALLENGE_AUTH response messages clause shall also apply to the Responder. These two statements essentially describe a role reversal, unless otherwise stated.

377 The basic mutual authentication flow shall start when the Requester successfully receives a `CHALLENGE_AUTH` with **BasicMutAuthReq** set. This flow shall utilize message encapsulation as described in GET_ENCAPSULATED_REQUEST request and ENCAPSULATED_REQUEST response messages to retrieve request messages. The basic mutual authentication flow shall end when the encapsulated request flow ends.

378 This flow shall only allow `GET_DIGESTS` , `GET_CERTIFICATE` , `CHALLENGE` and their corresponding responses to be encapsulated. If other requests are encapsulated, the Requester can send an `ERROR` response with `ErrorCode=UnexpectedRequest` and shall terminate the flow.

379 Figure 11 — Mutual authentication basic flow illustrates, as an example, the basic mutual authentication flow.

380 **Figure 11 — Mutual authentication basic flow**

381 

382 **10.9.3.1 Mutual authentication message transcript**

383 This clause applies to the Responder authenticating the Requester in a basic mutual authentication scenario.

384 Table 39 — Basic mutual authentication message transcript defines how the message transcript is constructed for

M1 and M2, which are used in signature calculation and verification in the `CHALLENGE_AUTH` response message when the Responder authenticates the Requester.

385 The possible request orderings for the basic mutual authentication flow shall be one of the following (the Flow ID is in parenthesis):

- `GET_DIGESTS` , `GET_CERTIFICATE` , `CHALLENGE` (*BMAF0*)
- `GET_DIGESTS` , `CHALLENGE` (*BMAF1*)
- `GET_CERTIFICATE` , `CHALLENGE` (*BMAF2*)
- `CHALLENGE` (*BMAF3*)

386 When the basic mutual authentication flow starts, that is, when `GET_ENCAPSULATED_REQUEST` is issued, M1 and M2 shall be set to null.

387 **Table 39 — Basic mutual authentication message transcript**

Flow ID	M1/M2
BMAF0	Concatenate(`VCA` , `GET_DIGESTS` , `DIGESTS` , `GET_CERTIFICATE` , `CERTIFICATE` , `CHALLENGE` , `CHALLENGE_AUTH` without the signature)
BMAF1	Concatenate(`VCA` , `GET_DIGESTS` , `DIGESTS` , `CHALLENGE` , `CHALLENGE_AUTH` without the signature)
BMAF2	Concatenate(`VCA` , `GET_CERTIFICATE` , `CERTIFICATE` , `CHALLENGE` , `CHALLENGE_AUTH` without the signature)
BMAF3	Concatenate(`VCA` , `CHALLENGE` , `CHALLENGE_AUTH` without the signature)

388 For `GET_CERTIFICATE` and `CERTIFICATE` , these messages might need to be issued multiple times to retrieve the entire certificate chain. Thus, each instance of the request and response shall be part of M1/M2 in the order that they are issued.

389 DEPRECATED

390 10.10 Firmware and other measurements

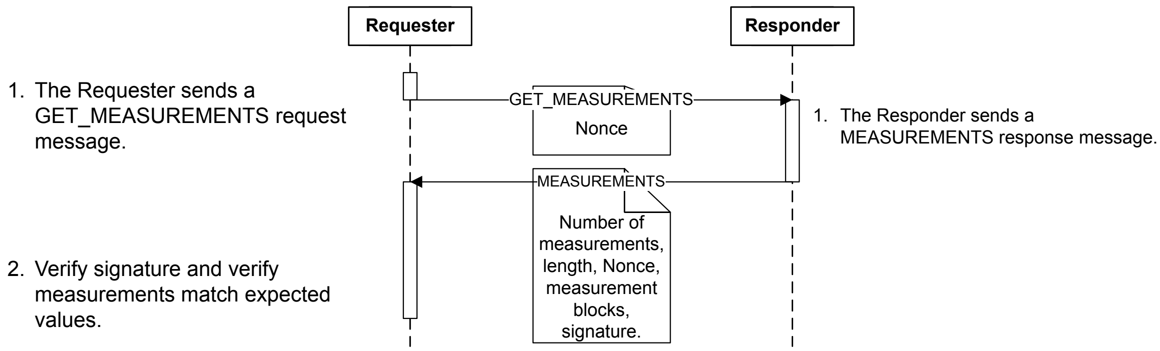
391 This clause describes request messages and response messages associated with endpoint measurement. All request messages in this clause shall be supported by an endpoint that returns `MEAS_CAP=01b` or `MEAS_CAP=10b` in `CAPABILITIES` response.

392 Figure 12 — Measurement retrieval flow shows the high-level request-response flow and sequence for endpoint measurement. If `MEAS_FRESH_CAP` bit in the `CAPABILITIES` response message returns 0, and the Requester

requires fresh measurements, the Responder shall be Reset before `GET_MEASUREMENTS` is resent. The mechanisms employed for Resetting the Responder are outside the scope of this specification.

393 **Figure 12 — Measurement retrieval flow**

394



395 10.11 GET_MEASUREMENTS request and MEASUREMENTS response messages

396 Measurements in SPDM are represented in the form of measurement *blocks*. Measurement block defines the measurement block structure. A device can present measurements of different elements of its internal state, as well as metadata to assist in the attestation of its state via measurements, as separate blocks. The `GET_MEASUREMENTS` request message enables a Requester to query a Responder for the number of individual measurement blocks it supports, and request either specific blocks or all available blocks. The `MEASUREMENTS` response message returns the requested blocks. A collection of more than one measurement blocks is called a *measurement record*.

397 Because issuing `GET_MEASUREMENTS` clears the M1/M2 message transcript, it is recommended that a Requester does not send this message until it has received at least one successful `CHALLENGE_AUTH` response message from the Responder. This ensures that the information in message pairs `GET_DIGESTS` / `DIGESTS` and `GET_CERTIFICATES` / `CERTIFICATES` has been authenticated at least once.

398 Table 40 — GET_MEASUREMENTS request message format shows the `GET_MEASUREMENTS` request message format.

399 Table 41 — GET_MEASUREMENTS request attributes shows the `GET_MEASUREMENTS` request message attributes.

400 Table 43 — Successful MEASUREMENTS response message format shows the `MEASUREMENTS` response message format. The measurement blocks in `MeasurementRecord` shall be sorted in ascending order by index.

401 **Table 40 — GET_MEASUREMENTS request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xE0` = `GET_MEASUREMENTS` . See Table 4 — SPDM request codes.
2	Param1	1	Request attributes. See Table 41 — GET_MEASUREMENTS request attributes.
3	Param2	1	`Measurement` operation. • A value of `0x0` shall query the Responder for the total number of measurement blocks available. • A value of `0xFF` shall request all measurement blocks. • A value between `0x1` and `0xFE` , inclusively, shall request the measurement block at the index corresponding to that value.
4	Nonce	`NL=32` or `NL=0`	The Requester should choose a random value. This field is only present if Bit [0] of `Param1` is `1` . See Table 41 — GET_MEASUREMENTS request attributes.
4 + NL	SlotIDParam	1	• Bit [7:4]. Reserved. • Bit [3:0]. `SlotID` . Slot number of the Responder certificate chain that shall be used for authenticating the measurement(s). If the Responder's public key was provisioned to the Requester previously, this field shall be `0xF` . This field is only present if Bit [0] of `Param1` is `1` . See Table 41 — GET_MEASUREMENTS request attributes.

402 **Table 41 — GET_MEASUREMENTS request attributes**

Bit offset	Field	Description
0	SignatureRequested	If the Responder can generate a signature (`MEAS_CAP` is `10b` in the `CAPABILITIES` response), value of `1` indicates that a signature on the measurement log, such as L1/L2 that MEASUREMENTS signature generation defines, is required. The `Nonce` field shall be present in the request where this bit is set. The Responder shall generate and send a signature in the response. Value of `0` indicates that the Requester does not require a signature. The Responder shall not generate a signature in the response. The `Nonce` field shall be absent in the request. For Responders that cannot generate a signature (`MEAS_CAP` is `01b` in the `CAPABILITIES` response) the Requester shall always use `0` .

Bit offset	Field	Description
1	RawBitStreamRequested	This bit is applicable only if the measurement specification supports only two representations, raw bit stream and digest, such as when `MeasurementSpecification` of the Measurement block format is set to `DMTF`, as Table 44 — Measurement block format describes. If the measurement specification supports other representations, this bit is ignored. If the Responder can return either a raw bit stream or a hash for the requested measurement, value `1` shall request the Responder to return the raw bit stream version of such measurement. If the Responder cannot return raw bit stream for the measurement (for example, if the raw bit stream contains confidential data that the Responder cannot expose), it shall return the corresponding hash. Value `0` shall request the Responder to return a hash version of the measurement. If the Responder cannot return hash of the measurement (for example, if the measurement represents a data structure where digest is not applicable), it shall return the corresponding raw bit stream.
[7:2]	Reserved	Reserved.

403 **Measurement index assignments**

404 This specification imposes no requirements on the scope, type or format of measurement a device associates with a particular measurement index in the range `0x1` to `0xEF`. As a result, Responders can use the same index to report different types of measurements based on their implementation. If available, a Requester can use a measurement manifest to discover information about the specific measurement types available by a particular Responder and the indices to which they correspond. When measurements follow the DMTF measurement specification format that Table 45 — DMTF measurement specification format describes, a measurement with a `DMTFSpecMeasurementValueType[6:0]` equal to `0x04` is the measurement manifest.

405 To aid interoperability, this specification reserves indices `0xF0` to `0xFE` inclusive for specific purposes. If a Responder supports a type of measurement that Table 42 — Measurement index assigned range defines, it shall always assign it to the corresponding index value. A Responder shall not assign indices `0xF0` to `0xFE` to measurements of types other than those that Table 43 — Successful MEASUREMENTS response message format defines.

406 **Table 42 — Measurement index assigned range**

Measurement Index	Measurement type	Description
0xF0 - 0xFC	Reserved	Reserved.
0xFD	Measurement manifest	Metadata on available measurements, as type `DMTFSpecMeasurementValueType[6:0]` = `0x04` defines.

Measurement Index	Measurement type	Description
0xFE	Device mode	Structured device mode information, as type `DMTFSpecMeasurementValueType[6:0]` = `0x05` defines.

407 **Table 43 — Successful MEASUREMENTS response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x60` = `MEASUREMENTS`. See Table 5 — SPDM response codes.
2	Param1	1	When `Param2` in the requested measurement operation is `0`, this parameter shall return the total number of measurement indices on the device. Otherwise, this field is reserved.
3	Param2	1	Bit [7:6]. Reserved. Bit [5:4]. content changed. If this message contains a signature, this field indicates if one or more entries in the measurement log being signed have changed. `00b` : the Responder does not support detection of runtime measurement changes, or this message does not contain a signature. `01b` : the Responder detected that one or more entries in the measurement log being signed have changed. The Requester might consider issuing `GET_MEASUREMENTS` again to acquire current measurements. `10b` : the Responder detected no change in the entries in the measurement log being signed. `11b` : reserved. Bit [3:0]. `SlotID`. If this message contains a signature, this field contains the slot number of the certificate chain specified in the `GET_MEASUREMENTS` request, or `0xF` if the Responder's public key was provisioned to the Requester previously. If this message does not contain a signature, this field shall be set to `0x0`.
4	NumberOfBlocks	1	Number of measurement blocks in the full `MeasurementRecord`. If Param2 in the requested measurement operation is `0`, this field shall be `0`.

Byte offset	Field	Size (bytes)	Description
5	MeasurementRecordLength	3	Size of the full `MeasurementRecord` in bytes. If `Param2` in the requested measurement operation is `0`, this field shall be `0`.
8	MeasurementRecordData	L= `MeasurementRecordLength`	Concatenation of all measurement blocks that correspond to the requested Measurement operation. Measurement block defines the measurement block structure.
8 + L	Nonce	32	The Responder should choose a random value. This field shall always be present.
40 + L	OpaqueDataLength	2	Size of the `OpaqueData` field that follows in bytes. The value should not be greater than 1024 bytes. Shall be `0` if no `OpaqueData` is provided.
42 + L	OpaqueData	`OpaqueDataLength`	The Responder can include Responder-specific information and/or information that its transport defines. If present, this field shall conform to the selected opaque data format in `OtherParamsSelection`.
42 + L + OpaqueDataLength	`Signature`	`SigLen`	`Signature` of the measurement log, excluding the Signature field and signed using the private key associated with the leaf certificate. The Responder shall use the asymmetric signing algorithm it selected during the last `ALGORITHMS` response message to the Requester, and `SigLen` is the size of that asymmetric signing algorithm output. This field is conditional and only present in the MEASUREMENTS response corresponding to a GET_MEASUREMENTS request with Param1[0] set to 1.

408 10.11.1 Measurement block

409 Each measurement block that the `MEASUREMENTS` response message defines shall contain a four-byte descriptor, offsets 0 through 3, followed by the measurement data that correspond to a particular measurement index and measurement type. The blocks are ordered by `Index`.

410 Table 44 — Measurement block format shows the format for a measurement block:

411 **Table 44 — Measurement block format**

Byte offset	Field	Size (bytes)	Description
0	Index	1	Index. When `Param2` of `GET_MEASUREMENTS` request is between `0x1` and `0xFE`, inclusive, this field shall match the request. Otherwise, this field shall represent the index of the measurement block, where the index starts at 1 and ends at the index of the last measurement block.
1	MeasurementSpecification	1	Bit mask. The value shall indicate the measurement specification that the requested `Measurement` follows and shall match the selected measurement specification in the `ALGORITHMS` message. See Table 21 — Successful ALGORITHMS response message format. Only one bit shall be set. Bit 0: DMTF. If this bit is set, the format of data in the `Measurement` field is as specified in the DMTF measurement specification format that Table 45 — DMTF measurement specification format describes. All other bits are reserved.
2	MeasurementSize	2	Size of `Measurement`, in bytes.
4	Measurement	`MeasurementSize`	The `MeasurementSpecification` defines the format of this field.

412 **10.11.1.1 DMTF specification for the Measurement field of a measurement block**

413 The present clause is the specification for the format of the `Measurement` field in a measurement block when the `MeasurementSpecification` field's Bit 0 (DMTF) is set. Table 45 — DMTF measurement specification format specifies this format.

414 The measurement manifest of `DMTFSpecMeasurementValueType` refers to a manifest that describes contents of other indexes. For example, the set of firmware modules running on the Responder can change at runtime. The measurement manifest tells the Requester which firmware modules' measurements are reported in this response and their indexes. The format of the measurement manifest is out of scope of this specification.

415 **Table 45 — DMTF measurement specification format**

Byte offset	Field	Size (bytes)	Description
0	DMTFSpecMeasurementValueType	1	Composed of: • Bit [7]. Indicates the representation in `DMTFSpecMeasurementValue`. • Bit [6:0]. Indicates what is being measured by `DMTFSpecMeasurementValue`. These values are set independently and are interpreted as follows: • `[7]=0b`. Digest. • `[7]=1b`. Raw bit stream. The Responder should ensure the raw bit stream does not contain secrets. • `[6:0]=00h`. Immutable ROM. • `[6:0]=01h`. Mutable firmware. • `[6:0]=02h`. Hardware configuration, such as straps. • `[6:0]=03h`. Firmware configuration, such as configurable firmware policy. • `[6:0]=04h`. Measurement manifest. When `DMTFSpecMeasurementValueType[6:0]=04h`, the Responder should support setting `DMTFSpecMeasurementValueType[7]` to either `0b` or `1b`. • `[6:0]=05h`. Structured representation of debug and device mode. See Device mode field of a measurement block. When `DMTFSpecMeasurementValueType[6:0]=05h`, `DMTFSpecMeasurementValueType[7]` shall be set to `1b`. • `[6:0]=06h`. Mutable firmware's version number. This specification does not mandate a format for firmware version number. When `DMTFSpecMeasurementValueType[6:0]=06h`, `DMTFSpecMeasurementValueType[7]` should be set to `1b`. • `[6:0]=07h`. Mutable firmware's security version number, which should be formatted as an 8-byte unsigned integer. When `DMTFSpecMeasurementValueType[6:0]=07h`, `DMTFSpecMeasurementValueType[7]` should be set to `1b`. • All other values reserved.
1	DMTFSpecMeasurementValueSize	2	Size of `DMTFSpecMeasurementValue`, in bytes. When `DMTFSpecMeasurementValueType[7]=0b`, the `DMTFSpecMeasurementValueSize` shall be derived from the measurement hash algorithm that the `ALGORITHM` response message returns.
3	DMTFSpecMeasurementValue	MS	Cryptographic hash or raw bit stream, as indicated in `DMTFSpecMeasurementValueType[7]`. For cryptographic hashes or digests, this field shall be in Hash byte order. The vendor defines the byte order for raw bit streams.

416 **10.11.1.2 Device mode field of a measurement block**

Byte offset	Field	Size (bytes)	Description
0	OperationalModeCapabilties	4	Fields with bits set to 1 indicate support for reporting the associated state in `OperationalModeState`. • Bit [0]. Indicates support for reporting device in manufacturing mode. • Bit [1]. Indicates support for reporting device in validation mode. • Bit [2]. Indicates support for reporting device in normal operational mode. • Bit [3]. Indicates support for reporting device in recovery mode. • Bit [4]. Indicates support for reporting device in Return Merchandise Authorization (RMA) mode. • Bit [5]. Indicates support for reporting device in decommissioned mode. All other values reserved.
4	OperationalModeState	4	Fields with bits set to 1 indicate true for the reported state. • Bit [0]. Indicates the device is in manufacturing mode. • Bit [1]. Indicates the device is in validation mode. • Bit [2]. Indicates the device is in normal operational mode. • Bit [3]. Indicates the device is in recovery mode. • Bit [4]. Indicates the device is in RMA mode. • Bit [5]. Indicates the device is in decommissioned mode. • All other values reserved.
8	DeviceModeCapabilties	4	Fields with bits set to 1 indicate support for reporting the associated state in `DeviceModeState`. • Bit [0]. Indicates support for reporting non-invasive debug mode is active. • Bit [1]. Indicates support for reporting invasive debug mode is active. • Bit [2]. Indicates support for reporting non-invasive debug mode has been active this Reset cycle. • Bit [3]. Indicates support for reporting invasive debug mode has been active this Reset cycle. • Bit [4]. Indicates support for reporting invasive debug mode has been active on this device at least once since exiting manufacturing mode. • All other values reserved.

Byte offset	Field	Size (bytes)	Description
12	DeviceModeState	4	Fields with bits set to 1 indicate true for the reported state. • Bit [0]. Indicates non-invasive debug mode is active. • Bit [1]. Indicates invasive debug mode is active. • Bit [2]. Indicates non-invasive debug mode has been active this Reset cycle. • Bit [3]. Indicates invasive debug mode has been active this Reset cycle. • Bit [4]. Indicates invasive debug mode has been active on this device at least once since exiting manufacturing mode. • All other values reserved.

417 **10.11.2 MEASUREMENTS signature generation**

418 While a Requester can opt to require a signature in each of the request-response messages, it is advisable that the cost of the signature generation process is minimized by amortizing it over multiple request-response messages where applicable. In this scheme, the Requester issues a number of requests without requiring signatures followed by a final request requiring a signature over the entire set of request-response messages exchanged. The steps to complete this scheme are as follows:

419 1. The Responder shall construct measurement log L1 and the Requester shall construct measurement log L2 over their observed messages:

```
L1/L2 = Concatenate(`VCA`, GET_MEASUREMENTS_REQUEST1, MEASUREMENTS_RESPONSE1, ...,
                    GET_MEASUREMENTS_REQUESTn-1, MEASUREMENTS_RESPONSEn-1,
                    GET_MEASUREMENTS_REQUESTn, MEASUREMENTS_RESPONSEn)
```

420 where:

- `Concatenate` is the standard concatenation function.
- `GET_MEASUREMENTS_REQUEST1` is the entire first `GET_MEASUREMENTS` request message under consideration, where the Requester has not requested a signature on that specific `GET_MEASUREMENTS` request.
- `MEASUREMENTS_RESPONSE1` is the entire `MEASUREMENTS` response message without the signature bytes that the Responder sent in response to `GET_MEASUREMENTS_REQUEST1`.
- `GET_MEASUREMENTS_REQUESTn-1` is the entire last consecutive `GET_MEASUREMENTS` request message under consideration, where the Requester has not requested a signature on that specific `GET_MEASUREMENTS` request.
- `MEASUREMENTS_RESPONSEn-1` is the entire `MEASUREMENTS` response message without the signature bytes that the Responder sent in response to `GET_MEASUREMENTS_REQUESTn-1`.
- `GET_MEASUREMENTS_REQUESTn` is the entire first `GET_MEASUREMENTS` request message under

consideration, where the Requester has requested a signature on that specific `GET_MEASUREMENTS` request. *n* is a number greater than or equal to `1`. When *n* equals `1`, the Requester has not made any `GET_MEASUREMENTS` requests without signature prior to issuing a `GET_MEASUREMENTS` request with signature.

- `MEASUREMENTS_RESPONSEn` is the entire `MEASUREMENTS` response message without the signature bytes that the Responder sent in response to `GET_MEASUREMENTS_REQUESTn`.

421 Any communication between Requester and Responder other than a `GET_MEASUREMENTS` request or response re-initializes L1/L2 computation to null. The `GET_MEASUREMENTS` requests and `MEASUREMENTS` responses before the L1/L2 re-initialization will not be covered by the signature in the final `MEASUREMENTS` response. Consequently, it is recommended that the Requester not use the measurements before verifying the signature.

422 An error response with `ErrorCode=ResponseNotReady` shall not re-initialize L1/L2 - Requester and Responder shall continue to construct L1/L2 with `GET_MEASUREMENTS` and `MEASUREMENTS`. An error response with any error code other than `ResponseNotReady` shall re-initialize L1/L2 to null.

423 2. The Responder shall generate:

```
Signature = SPDMsign(PrivKey, L1, "measurements signing");
```

424 where:

- `SPDMsign` is described in Signature generation.
- `PrivKey` shall be the private key of the Responder associated with the leaf certificate stored in `SlotID` of `SlotIDParam` in `GET_MEASUREMENTS`. If the public key of the Responder was provisioned to the Requester, then `PrivKey` shall be the associated private key.

425 10.11.3 MEASUREMENTS signature verification

426 To complete the `MEASUREMENTS` signature verification process, the Requester shall complete this step:

427 1. The Requester shall perform:

```
result = SPDMsignatureVerify(PubKey, Signature, L2, "measurements signing")
```

428 where:

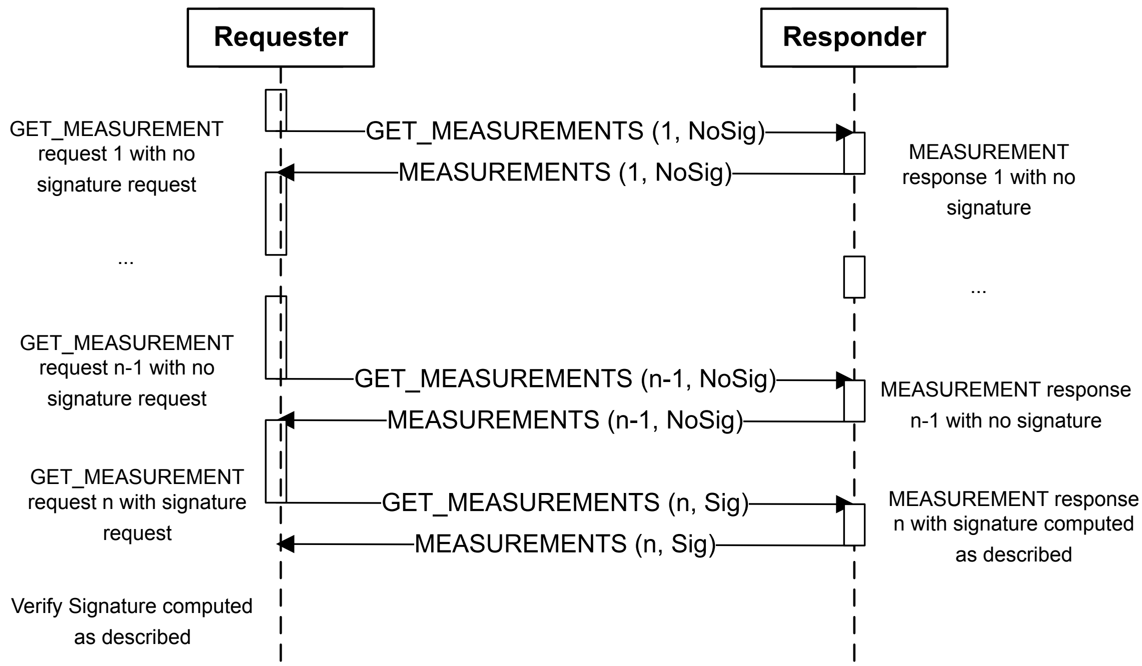
- `SPDMsignatureVerify` is described in Signature verification. A successful verification is when `result` is success.
- `PubKey` shall be the public key associated with the leaf certificate stored in `SlotID` of `SlotIDParam`

in `GET_MEASUREMENTS` . `PubKey` is extracted from the `CERTIFICATES` response. If the public key of the Responder was provisioned to the Requester, then `PubKey` shall be the provisioned public key.

429 Figure 13 — Measurement signature computation example shows an example of a typical Requester Responder protocol where the Requester issues 1 to *n*-1 `GET_MEASUREMENTS` requests without a signature, followed by a single `GET_MEASUREMENTS` request *n* with a signature.

430 **Figure 13 — Measurement signature computation example**

431



432 10.12 ERROR response message

433 For an SPDM operation that results in an error, the Responder should send an `ERROR` response message to the Requester.

434 Table 47 — ERROR response message format shows the `ERROR` response format.

435 Table 48 — Error code and error data shows the detailed error code, error data, and extended error data.

436 Table 49 — ResponseNotReady extended error data shows the `ResponseNotReady` extended error data.

437 Table 50 — Registry or standards body ID shows the registry or standards body ID.

438 Table 51 — ExtendedErrorData format for vendor or other standards-defined ERROR response message shows the `ExtendedErrorData` format definition for vendor or other standards-defined `ERROR` response message.

439 **Table 47 — ERROR response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as SPDM version describes.
1	RequestResponseCode	1	`0x7F = ERROR`. See Table 5 — SPDM response codes.
2	Param1	1	Error code. See Table 48 — Error code and error data.
3	Param2	1	Error data. See Table 48 — Error code and error data.
4	ExtendedErrorData	0-32	Optional extended data. See Table 48 — Error code and error data.

440 **Table 48 — Error code and error data**

Error code	Value	Description	Error data	`ExtendedErrorData`
Reserved	0x00	Reserved.	Reserved	Reserved
InvalidRequest	0x01	One or more request fields are invalid	`0x00`	No extended error data is provided.
Reserved	0x02	Reserved.	Reserved	No extended error data is provided.
Busy	0x03	The Responder received the request message and the Responder decided to ignore the request message, but the Responder might be able to process the request message if the request message is sent again in the future.	`0x00`	No extended error data is provided.
UnexpectedRequest	0x04	The Responder received an unexpected request message. For example, `CHALLENGE` before `NEGOTIATE_ALGORITHMS`.	`0x00`	No extended error data is provided.
Unspecified	0x05	Unspecified error occurred.	`0x00`	No extended error data is provided.
DecryptError	0x06	The receiver of the record cannot decrypt the record or verify data during the session handshake.	Reserved	No extended error data is provided.

Error code	Value	Description	Error data	`ExtendedErrorData`
UnsupportedRequest	0x07	The `RequestResponseCode` in the request message is unsupported.	`RequestResponseCode` in the request message.	No extended error data is provided
RequestInFlight	0x08	The Responder has delivered an encapsulated request to which it is still waiting for the response.	Reserved	No extended error data is provided.
InvalidResponseCode	0x09	The Requester delivered an invalid response for an encapsulated response.	Reserved	No extended error data is provided.
SessionLimitExceeded	0x0A	Maximum number of concurrent sessions reached.	Reserved	No extended error data is provided.
SessionRequired	0x0B	The Request message received by the Responder is only allowed within a session.	Reserved	No extended error data is provided.
ResetRequired	0x0C	The device requires a reset to complete the requested operation. This `ErrorCode` can be sent in response to the `GET_CSR` or `SET_CERTIFICATE` message.	`0x00`	No extended error data is provided.
ResponseTooLarge	0x0D	The response is greater than the `MaxSPDMmsgSize` of the requesting SPDM endpoint.	Reserved	See Table 52 — ExtendedErrorData format for ResponseTooLarge.
RequestTooLarge	0x0E	The request is greater than the `MaxSPDMmsgSize` of the receiving SPDM endpoint.	Reserved	Reserved
LargeResponse	0x0F	The response is greater than `DataTransferSize` of the requesting SPDM endpoint.	Reserved	See Table 53 — ExtendedErrorData format for LargeResponse.
MessageLost	0x10	The SPDM message is lost. For example, this error code can be used to indicate a Large Request, Large Response or the request in a `ResponseNotReady` has been lost.	Reserved	Reserved
Reserved	0x11 - 0x40	Reserved.	Reserved	Reserved
VersionMismatch	0x41	Requested SPDM version is not supported or is a different version from the selected version.	`0x00`	No extended error data is provided.
ResponseNotReady	0x42	See the RESPOND_IF_READY request message format.	`0x00`	See Table 49 — ResponseNotReady extended error data.

Error code	Value	Description	Error data	`ExtendedErrorData`
RequestResynch	0x43	Responder is requesting Requester to reissue `GET_VERSION` to re-synchronize. An example is following a firmware update.	`0x00`	No extended error data is provided.
Reserved	0x44 - 0xFE	Reserved.	Reserved	Reserved
Vendor or Standard Defined	0xFF	Vendor or standard defined	Shall indicate the registry or standard body using one of the values in the **ID** column in Table 50 — Registry or standards body ID.	See Table 51 — ExtendedErrorData format for vendor or other standards-defined ERROR response message for format definition.

441 **Table 49 — ResponseNotReady extended error data**

Byte offset	Field	Size (bytes)	Description
0	RDTExponent	1	Exponent expressed in logarithmic (base 2 scale) to calculate `RDT` time in μs after which the Responder can provide successful completion response. For example, the raw value 8 indicates that the Responder will be ready in 2^8=256 μs. Responder should use `RDT` to avoid continuous pinging and issue the `RESPOND_IF_READY` request message, as Table 55 — RESPOND_IF_READY request message format shows, after `RDT` time. For timing requirement details, see Table 7 — Timing specification for SPDM messages.
1	RequestCode	1	The request code that triggered this response.
2	Token	1	The opaque handle that the Requester shall pass in with the `RESPOND_IF_READY` request message, as Table 55 — RESPOND_IF_READY request message format shows. The Responder can use the value in this field to provide the correct response when the Requester issues a `RESPOND_IF_READY` request.
3	RDTM	1	Multiplier used to compute WT_{Max} in μs to indicate that the response might be dropped after this delay. The multiplier shall always be greater than 1. The Responder might also stop processing the initial request if the same Requester issues a different request. For timing requirement details, see Table 7 — Timing specification for SPDM messages.

442 **Table 50 — Registry or standards body ID**

443 For algorithm encoding in extended algorithm fields, unless otherwise specified, consult the respective registry or standards body.

ID	Vendor ID length (bytes)	Registry or standards body name	Description
0x0	0	DMTF	DMTF does not have a Vendor ID registry. At present, DMTF does not define any algorithms for use in extended algorithms fields.
0x1	2	TCG	Vendor is identified by using TCG Vendor ID Registry. For extended algorithms, see TCG Algorithm Registry.
0x2	2	USB	Vendor is identified by using the vendor ID assigned by USB.
0x3	2	PCI-SIG	Vendor is identified using PCI-SIG Vendor ID.
0x4	4	IANA	The Private Enterprise Number (PEN) assigned by the Internet Assigned Numbers Authority (IANA) identifies the vendor.
0x5	4	HDBaseT	Vendor is identified by using HDBaseT HDCD entity.
0x6	2	MIPI	The Manufacturer ID assigned by MIPI identifies the vendor.
0x7	2	CXL	Vendor is identified by using CXL vendor ID.
0x8	2	JEDEC	Vendor is identified by using JEDEC vendor ID.

444 **Table 51 — ExtendedErrorData format for vendor or other standards-defined ERROR response message**

Byte offset	Field	Size (bytes)	Description
0	1	Len	Length of the `VendorID` field. If the vendor defines the error, the value of this field shall equal the `Vendor ID Len`, as Table 50 — Registry or standards body ID describes, of the corresponding registry or standard body name. If a registry or a standard defines the error, this field shall be zero (`0`), which also indicates that the `VendorID` field is not present. The `Error Data` field in the `ERROR` message indicates the registry or standards body name (that is, `Param2`), and is one of the values in the **ID** column in Table 50 — Registry or standards body ID.
1	`Len`	VendorID	The value of this field shall indicate the Vendor ID, as assigned by the registry or standards body. Table 50 — Registry or standards body ID describes the length of this field. Shall be in little endian format. The registry or standards body name in the `ERROR` is indicated in the `Error Data` field (that is, `Param2`), and is one of the values in the **ID** column in Table 50 — Registry or standards body ID.

Byte offset	Field	Size (bytes)	Description
1 + `Len`	Variable	OpaqueErrorData	The vendor or standards define this value.

445 **Table 52 — ExtendedErrorData format for ResponseTooLarge**

Byte offset	Length	Field	Description
0	4	ActualSize	The size of the actual response.

446 **Table 53 — ExtendedErrorData format for LargeResponse**

Byte offset	Length	Field	Description
0	1	Handle	Shall be a unique value that identifies the Large SPDM Response and shall be the same value for all chunks of the same large SPDM message. The value of this field should either entirely monotonically increase or entirely monotonically decrease with each large SPDM message and with the expectation that it will wrap around after reaching the maximum or minimum value, respectively, of this field. See CHUNK_GET request and CHUNK_RESPONSE response message.

447 10.12.1 Standard body or vendor-defined header

448 This specification uses the format that Table 54 — Standard body or vendor-defined header (SVH) describes to help identify the entity that defines the format for a given payload. The clauses in the other parts of this specification indicate to which payload this header applies.

449 **Table 54 — Standard body or vendor-defined header (SVH)**

Byte offset	Field	Size (bytes)	Description
0	ID	1	Shall be one of the values in the `ID` column of Table 50 — Registry or standards body ID.
1	VendorLen	1	`Length` in bytes of the `VendorID` field. If the given payload belongs to a standards body, this field shall be 0. Otherwise, the given payload belongs to the vendor and therefore, this field shall be the length indicated in the `Vendor ID` column of Table 50 — Registry or standards body ID for the respective `ID`.

Byte offset	Field	Size (bytes)	Description
2	VendorID	`VendorLen`	If `VendorLen` is greater than zero, this field shall be the ID of the vendor corresponding to the `ID` field. Otherwise, this field shall be absent.

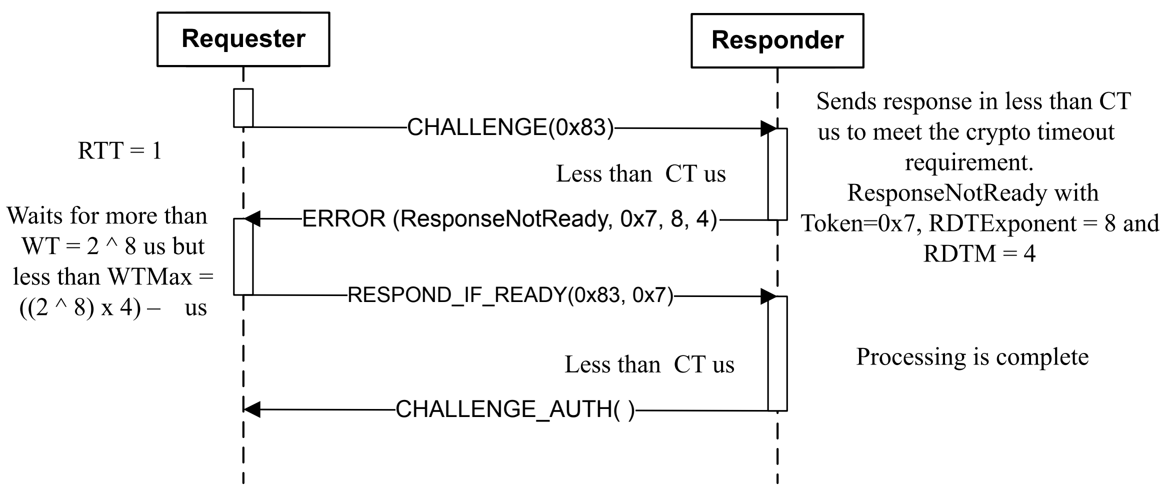
450 10.13 RESPOND_IF_READY request message format

451 This request message shall ask for the response to the original request upon receipt of `ResponseNotReady` error code. If the response to the original request is ready, the Responder shall return that response message. If the response to the original request is not ready, the Responder shall return the `ERROR` response message, set `ErrorCode` = `ResponseNotReady` and return the same token as the previous `ResponseNotReady` response message.

452 Figure 14 — RESPOND_IF_READY flow leading to completion shows the `RESPOND_IF_READY` flow:

453 **Figure 14 — RESPOND_IF_READY flow leading to completion**

454



455 Table 55 — RESPOND_IF_READY request message format shows the `RESPOND_IF_READY` request message format.

456 **Table 55 — RESPOND_IF_READY request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xFF` = `RESPOND_IF_READY` . See Table 4 — SPDM request codes.
2	Param1	1	The original request code that triggered the `ResponseNotReady` error code response. Shall match the request code returned as part of the `ResponseNotReady` extended error data.
3	Param2	1	The token that was returned as part of the `ResponseNotReady` extended error data.

457 ## 10.14 VENDOR_DEFINED_REQUEST request message

458 A Requester intending to define a unique request to meet its need can use this request message. Table 56 — VENDOR_DEFINED_REQUEST request message format defines the format.

459 The Requester should send this request message only after sending `GET_VERSION` , `GET_CAPABILITIES` , and `NEGOTIATE_ALGORITHMS` request sequence.

460 If the vendor intends that these messages are to be used before a session has been established, and the vendor wishes to have the requests authenticated, then the vendor shall indicate how the transcript and/or message transcript are changed to add the vendor-defined commands.

461 Table 56 — VENDOR_DEFINED_REQUEST request message format shows the `VENDOR_DEFINED_REQUEST` request message format.

462 **Table 56 — VENDOR_DEFINED_REQUEST request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xFE` = `VENDOR_DEFINED_REQUEST` . See Table 4 — SPDM request codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.
4	StandardID	2	Shall indicate the registry or standards body by using one of the values in the **ID** column in Table 50 — Registry or standards body ID.
6	Len	1	Length of the `Vendor ID` field. If the `VendorDefinedRequest` is standard defined, `Len` shall be `0` . If the `VendorDefinedRequest` is vendor-defined, `Len` shall equal `Vendor ID Len` , as Table 50 — Registry or standards body ID describes.

Byte offset	Field	Size (bytes)	Description
7	VendorID	Len	Vendor ID, as assigned by the registry or standards body. Shall be in little endian format.
7 + `Len`	ReqLength	2	Length of the `VendorDefinedReqPayload` .
7 + `Len` + 2	VendorDefinedReqPayload	`ReqLength`	The standard or vendor shall use this field to send the request payload.

463 ## 10.15 VENDOR_DEFINED_RESPONSE response message

464 A Responder can use this response message in response to `VENDOR_DEFINED_REQUEST` . Table 57 — VENDOR_DEFINED_RESPONSE response message format defines the format.

465 **Table 57 — VENDOR_DEFINED_RESPONSE response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x7E` = `VENDOR_DEFINED_RESPONSE` . See Table 5 — SPDM response codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.
4	StandardID	2	Shall indicate the registry or standard body using one of the values in the **ID** column in Table 50 — Registry or standards body ID.
6	Len	1	Length of the `Vendor ID` field. If the `VendorDefinedRequest` is standards-defined, length shall be `0` . If the `VendorDefinedRequest` is vendor-defined, length shall equal `Vendor ID Len` , as Table 50 — Registry or standards body ID describes.
7	VendorID	`Len`	Shall indicate the Vendor ID, as assigned by the registry or standards body. Shall be in little endian format.
7 + `Len`	RespLength	2	Length of the `VendorDefinedRespPayload`
7 + `Len` + 2	VendorDefinedRespPayload	`ReqLength`	Standard or vendor shall use this value to send the response payload.

466 10.16 KEY_EXCHANGE request and KEY_EXCHANGE_RSP response messages

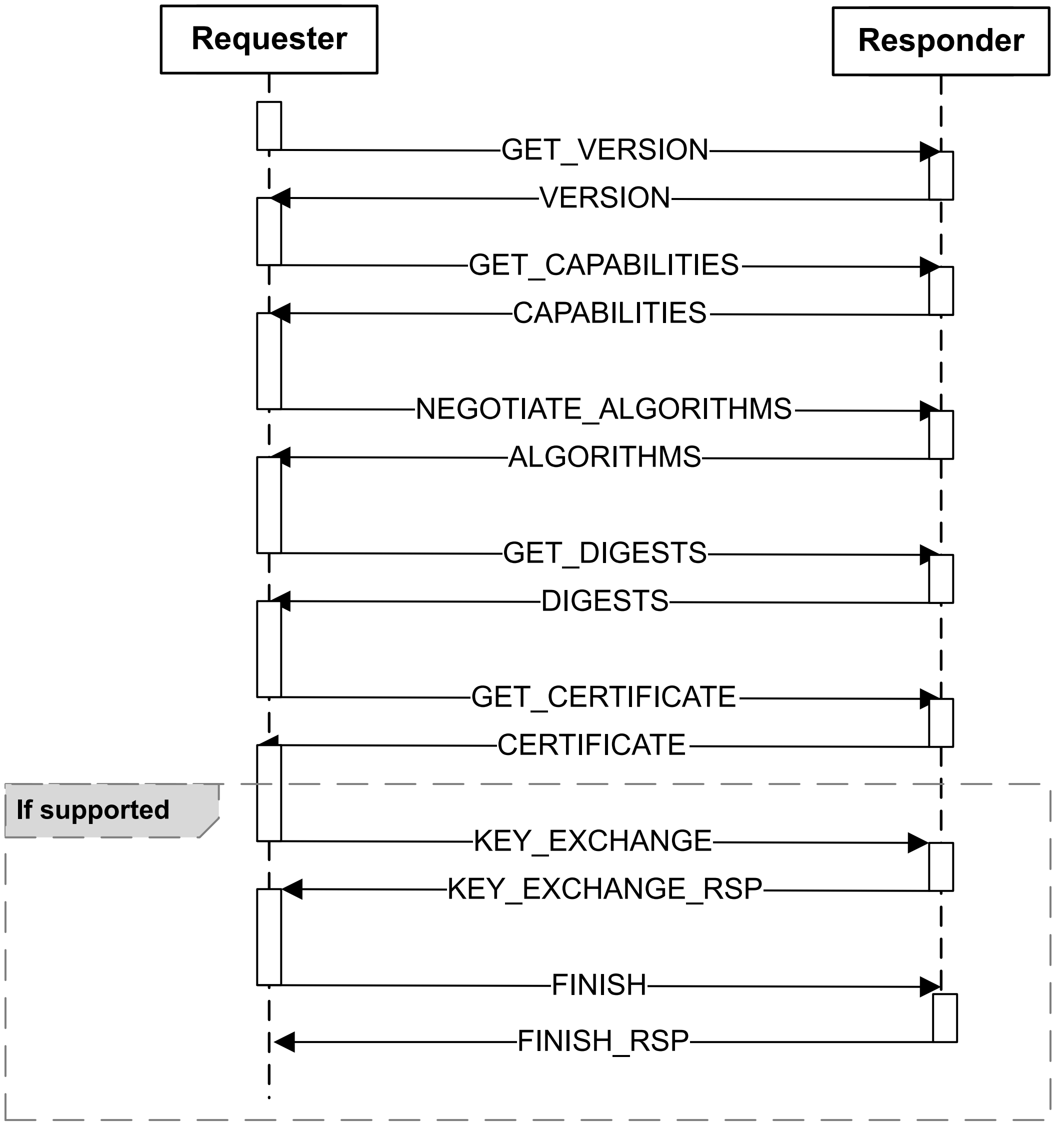
467 This request message shall initiate a handshake between Requester and Responder intended to authenticate the Responder (or optionally both parties), negotiate cryptographic parameters (in addition to those negotiated in the last `NEGOTIATE_ALGORITHMS` / `ALGORITHMS` exchange), and establish shared keying material. Table 58 — KEY_EXCHANGE request message format shows the `KEY_EXCHANGE` request message format and Table 60 — Successful KEY_EXCHANGE_RSP response message format shows the `KEY_EXCHANGE_RSP` response message format. The handshake is completed by the successful exchange of the `FINISH` request and `FINISH_RSP` response messages, presented in the next clause, and depends on the tight coupling between the two request/response message pairs.

468 The Requester and Responder pair can support two modes of handshakes. If `HANDSHAKE_IN_THE_CLEAR_CAP` is set in both the Requester and the Responder all SPDM messages exchanged during the Session Handshake Phase are sent in the clear (outside of a secure session). Otherwise both the Requester and the Responder use encryption and/or message authentication during the Session Handshake Phase using the Handshake secret derived at the completion of `KEY_EXCHANGE_RSP` message for subsequent message communication until `FINISH_RSP` message completion.

469 Figure 15 — Responder authentication key exchange example shows an example of a Responder authentication key exchange:

470 **Figure 15 — Responder authentication key exchange example**

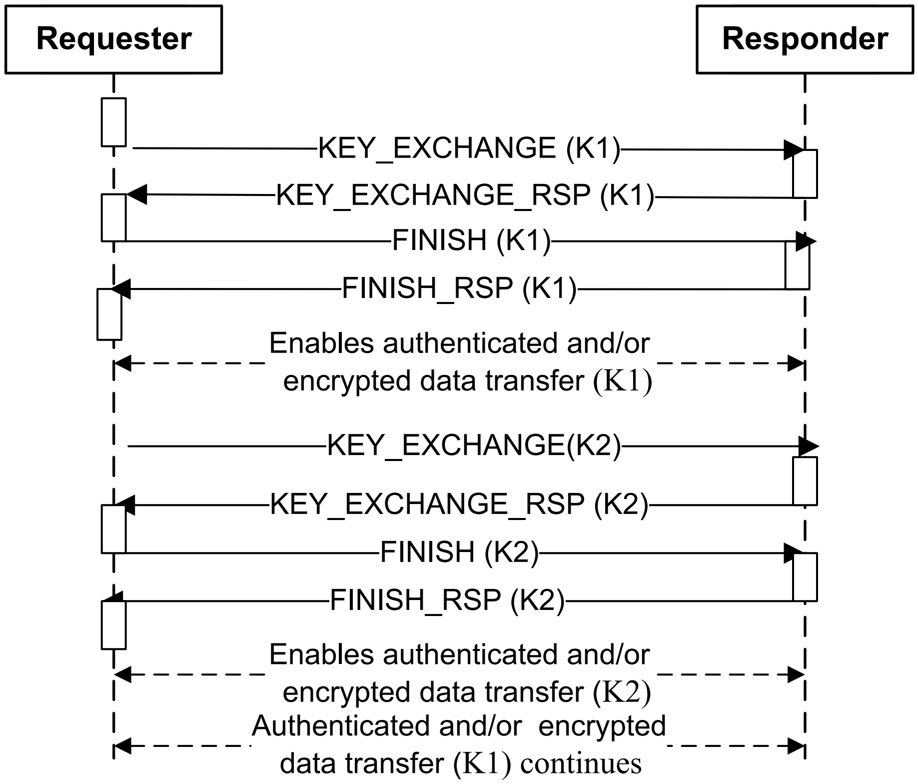
471



472 Figure 16 — Responder authentication multiple key exchange example shows an example of multiple sessions using two independent sets of root session keys that coexist at the same time. The specification does not require a specific temporal relationship between the second `KEY_EXCHANGE` request message and the first `FINISH_RSP` response message. To simplify implementation, however, a Responder might generate an `ErrorCode=Busy` response to the second `KEY_EXCHANGE` request message until the first `FINISH_RSP` response message is complete.

473 **Figure 16 — Responder authentication multiple key exchange example**

474



475 The handshake includes an ephemeral Diffie-Hellman (DHE) key exchange in which the Requester and Responder each generate an ephemeral (that is, temporary) Diffie-Hellman key pair and exchange the public keys of those key pairs in the `ExchangeData` fields of the `KEY_EXCHANGE` request message and `KEY_EXCHANGE_RSP` response message. The Responder generates a DHE secret by using the private key of the DHE key pair of the Responder and the public key of the DHE key pair of the Requester provided in the `KEY_EXCHANGE` request message. Similarly, the Requester generates a DHE secret by using the private key of the DHE key pair of the Requester and the public key of the DHE key pair of the Responder provided in the `KEY_EXCHANGE_RSP` response message. The DHE secrets are computed as specified in clause 7.4 of RFC8446. Assuming that the public keys were received correctly, both the Requester and Responder generate identical DHE secrets from which session secrets are generated.

476 Diffie-Hellman group parameters are determined by the DHE group in use, which is selected in the most recent `ALGORITHMS` response. The contents of the `ExchangeData` field are computed as specified in clause 4.2.8 of RFC8446. Specifically, if the DHE key exchange is based on finite-fields (FFDHE), the `ExchangeData` field in `KEY_EXCHANGE` and `KEY_EXCHANGE_RSP` shall contain the computed public value (Y = g^X mod p) for the specified group (see Table 17 — DHE structure for group definitions) encoded as a big-endian integer and padded to the left with zeros to the size of p in bytes. If the key exchange is based on elliptic curves (ECDHE), the `ExchangeData` field in `KEY_EXCHANGE` and `KEY_EXCHANGE_RSP` shall contain the serialization of X and Y, which are the binary

representations of the x and y values respectively in network byte order, padded on the left by zeros if necessary. The size of each number representation occupies as many octets as implied by the curve parameters selected. Specifically, X is [0: C - 1] and Y is [C : D – 1], where C and D are determined by the group (see Table 17 — DHE structure).

477 For SM2_P256 key exchange, an additional identifier, ID_A and ID_B, that the GB/T 32918.3-2016 specification defines, is needed to derive the shared secret. If this algorithm is selected, the ID for the Requester (that is, ID_A) shall be the concatenation of "Requester-KEP-dmtf-spdm-v" and `SPDMversionString`. Likewise, the ID for the Responder shall be the concatenation of "Responder-KEP-dmtf-spdm-v" and `SPDMversionString`.

478 A Requester should generate a fresh DHE key pair for each `KEY_EXCHANGE` request message that the Requester sends. A Responder should generate a fresh DHE key pair for each `KEY_EXCHANGE_RSP` response message that the Responder sends.

479 **Table 58 — KEY_EXCHANGE request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xE4` = `KEY_EXCHANGE`. See Table 4 — SPDM request codes.
2	Param1	1	Type of measurement summary hash requested: `0x0`: No measurement summary hash requested. `0x1`: TCB measurements only. `0xFF`: All measurements. All other values reserved. If a Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response), the Requester shall set this value to `0x0`.
3	Param2	1	`SlotID`. Slot number of the Responder certificate chain that shall be used for authentication. The value in this field shall be between 0 and 7 inclusive. It shall be `0xFF` if the public key of the Responder was provisioned to the Requester previously.
4	ReqSessionID	2	Two-byte Requester contribution to allow construction of a unique four-byte session ID between a Requester-Responder pair. The final session ID = Concatenate (ReqSessionID, RspSessionID).
6	SessionPolicy	1	See Table 59 — Session policy.
7	Reserved	1	Reserved.

Byte offset	Field	Size (bytes)	Description
8	RandomData	32	Requester-provided random data.
40	ExchangeData	D	DHE public information generated by the Requester. If the DHE group selected in the most recent `ALGORITHMS` response is finite-field-based (FFDHE), the `ExchangeData` represents the computed public value. If the selected DHE group is elliptic curve-based (ECDHE), the `ExchangeData` represents the X and Y values in network byte order. Specifically, X is [0: C - 1] and Y is [C : D – 1]. In both cases the size of D (and C for ECDHE) is derived from the selected DHE group.
40 + `D`	OpaqueDataLength	2	Size of the `OpaqueData` field that follows in bytes. The value should not be greater than 1024 bytes. Shall be `0` if no `OpaqueData` is provided.
42 + `D`	OpaqueData	`OpaqueDataLength`	If present, `OpaqueData` sent by the Requester. Used to indicate any parameters that Requester wishes to pass to the Responder as part of key exchange. If present, this field shall conform to the selected opaque data format in `OtherParamsSelection`.

480 **Table 59 — Session policy**

Bit offset	Field	Description
0	TerminationPolicy	This field specifies the behavior of the Requester when the Responder completes a runtime code or configuration update which affects the hardware or firmware measurement of the Responder. The Requester selects the value. If not set, the Responder shall terminate the session when the runtime update has taken effect. If set, the Responder shall decide whether to terminate or continue with the session based on its own policy. A policy example is one where the Responder terminates the session whenever an update to configuration or runtime code changes the security version of the firmware that manages SPDM sessions. The policy of the Responder is outside of the scope of this specification. To terminate a session, the Responder shall respond with `ErrorCode=RequestResynch` to any SPDM request received within the session, or silently discard any request received within the session, until a `GET_VERSION` request is received.
[7:1]	Reserved	Reserved

481 **Table 60 — Successful KEY_EXCHANGE_RSP response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x64` = `KEY_EXCHANGE_RSP`. See Table 5 — SPDM response codes.

Byte offset	Field	Size (bytes)	Description
2	Param1	1	HeartbeatPeriod The value of this field shall be zero if Heartbeat is not supported. Otherwise, the value shall be in units of seconds. Zero is a legal value if Heartbeat is supported, but means that a heartbeat is not desired on this session.
3	Param2	1	Reserved.
4	RspSessionID	2	Two-byte Responder contribution to allow construction of a unique four-byte session ID between a Requester-Responder pair. The final session ID = Concatenate (ReqSessionID, RspSessionID).
6	MutAuthRequested	1	Bit 0 - If set, the Responder is requesting to authenticate the Requester (Session-based mutual authentication) without using the encapsulated request flow. Bit 1 - If set, Responder is requesting Session-based mutual authentication with the encapsulated request flow. Bit 2 - If set, Responder is requesting Session-based mutual authentication with an implicit GET_DIGESTS request. The Responder and Requester shall follow the optimized encapsulated request flow. Bit [7:3] - Reserved. Only one of Bit 0, Bit 1 and Bit 2 shall be set. For encapsulated request flow and the optimized encapsulated request flow details, see the GET_ENCAPSULATED_REQUEST request and ENCAPSULATED_REQUEST response messages clause.
7	SlotIDParam	1	Bit [7:4]. Reserved. Bit [3:0]. `SlotID`. Slot number of the Requester certificate chain that shall be used for mutual authentication, if `MutAuthRequested` Bit 0 is set. The value in this field shall be between 0 and 7 inclusive, or `0xF` if the public key of the Requester was provisioned to the Responder through other means. All other values Reserved. For any other value of `MutAuthRequested` this field shall be set to `0` and ignored by the Requester.
8	RandomData	32	Responder-provided random data.

Byte offset	Field	Size (bytes)	Description
40	ExchangeData	D	DHE public information generated by the Requester. If the DHE group selected in the most recent `ALGORITHMS` response is finite-field-based (FFDHE), the `ExchangeData` represents the computed public value. If the selected DHE group is elliptic curve-based (ECDHE), the `ExchangeData` represents the X and Y values in network byte order. Specifically, X is [0: C - 1] and Y is [C : D – 1]. In both cases the size of D (and C for ECDHE) is derived from the selected DHE group.
40 + D	MeasurementSummaryHash	H	If the Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response) or requested `Param1` = `0x0` , this field shall be absent. If the requested `Param1` = `0x1` , this field shall be the combined hash of measurements of all measurable components considered to be in the TCB required to generate this response, computed as `hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ...))` where `MeasurementBlock[x]` denotes a measurement of an element in the TCB. Measurements are concatenated in ascending order based on their measurement index as Table 44 — Measurement block format describes. When the requested `Param1` = `0x1` and there are no measurable components in the TCB required to generate this response, this field shall be `0` . If requested `Param1` = `0xFF` , this field shall be computed as `hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ..., MeasurementBlock[n]))` of all supported measurements available in the measurement index range `0x01` - `0xFE` , concatenated in ascending index order. Indices with no associated measurements shall not be included in the hash calculation. See the Measurement index assignments clause. If the Responder supports both raw bit stream and digest representations for a given measurement index, then the Responder shall use the digest form. This field shall be in Hash byte order.
40 + D + H	OpaqueDataLength	2	Size of the `OpaqueData` field that follows in bytes. The value should not be greater than 1024 bytes. Shall be `0` if no `OpaqueData` is provided.

Byte offset	Field	Size (bytes)	Description
42 + D + H	OpaqueData	`OpaqueDataLength`	If present, `OpaqueData` sent by the Responder. Used to indicate any parameters that the Responder wishes to pass to the Requester as part of key exchange. If present, this field shall conform to the selected opaque data format in `OtherParamsSelection` .
42 + D + H + `OpaqueDataLength`	Signature	`SigLen`	`Signature` over the transcript. `SigLen` is the size of the asymmetric signing algorithm output the Responder selected via the last `ALGORITHMS` response message to the Requester. The Transcript for KEY_EXCHANGE_RSP signature defines the construction of the transcript.
42 + D + H + `OpaqueDataLength` + `SigLen`	ResponderVerifyData	H	Conditional field. If the Session Handshake Phase is encrypted and/or message authenticated, then this field shall be of length H and it shall equal the HMAC of the transcript hash, using `finished_key` as the secret key and using the negotiated hash algorithm as the hash function. The transcript hash shall be the hash of the transcript for `KEY_EXCHANGE_RSP` HMAC as Transcript for KEY_EXCHANGE_RSP HMAC shows. The `finished_key` shall be derived from the Response Direction Handshake Secret and is described in the finished_key derivation clause. HMAC is described in RFC2104. If both the Requester and Responder set `HANDSHAKE_IN_THE_CLEAR_CAP` to 1, then this field shall be absent.

482 ### 10.16.1 Session-based mutual authentication

483 Mutual authentication for `KEY_EXCHANGE` occurs in the session handshake phase of a session.

484 To perform authentication of a Requester, the Responder sets the appropriate bit in the `MutAuthRequested` field of the `KEY_EXCHANGE_RSP` message. When either Bit 1 or Bit 2 of `MutAuthRequested` are set, the encapsulated request flow or the optimized encapsulated request flow shall be used accordingly to enable the Responder to obtain the certificate chains and certificate chain digests of the Requester. For flow details and illustrations, see GET_ENCAPSULATED_REQUEST request and ENCAPSULATED_REQUEST response messages.

485 When either bit 1 or bit 2 of `MutAuthRequested` are set, the only allowed messages in this phase of the session shall be `GET_DIGESTS` , `DIGESTS` , `GET_CERTIFICATE` , `CERTIFICATE` and `ERROR` . If the Requester receives other requests during this flow, the Requester can respond with an `ERROR` message using `ErrorCode=UnexpectedRequest` and shall terminate the session.

486 If Bit 0 of `MutAuthRequested` is set, then mutual authentication shall be performed without exchanging any

messages between KEY_EXCHANGE_RSP and FINISH request. This is useful for Responders that have obtained a Requester's certificate chains in a previous interaction.

487 **10.16.1.1 Specify Requester certificate for session-based mutual authentication**

488 The SPDM key exchange protocol is optimized to perform key exchange with the least number of messages exchanged. When Responder-only authentication, or mutual authentication where the Responder has obtained the certificate chains of the Requester in a previous interaction is performed, key exchange is carried out with two request/response message pairs (KEY_EXCHANGE , KEY_EXCHANGE_RSP , FINISH and FINISH_RSP). In other cases where mutual authentication is desired, additional encapsulated messages are exchanged between KEY_EXCHANGE_RSP and FINISH to enable the Responder to obtain the certificate chains and certificate chain digests of the Requester. However, in all cases the certificate chain (or raw public key) the Requester should authenticate against is specified by the Responder via the SlotID field in KEY_EXCHANGE_RSP , which precedes the aforementioned encapsulated messages. This means that a Responder authenticating a Requester whose certificates it has not obtained in a previous interaction, using a slot other than the default (slot 0), has no way of knowing in advance which SlotID value to use.

489 To address this case, the Responder explicitly designates the certificate chain to be used via the final ENCAPSULATED_RESPONSE_ACK request issued inside the encapsulated request flow. Specifically, if either Bit 1 or 2 in MutAuthRequested is set to 1 , the Responder shall use a ENCAPSULATED_RESPONSE_ACK request with Param2 = 0x02 and an 1-byte long Encapsulated Request field containing the SlotID value. The Requester shall use the certificate chain corresponding to the slot specified in the Encapsulated Request field.

490 If Bit 0 of MutAuthRequested is set, then no encapsulated messages are exchanged after KEY_EXCHANGE_RSP and the certificate chain of the Requester is determined by the value of SlotIDParam in KEY_EXCHANGE_RSP .

491 10.17 FINISH request and FINISH_RSP response messages

492 This request message shall complete the handshake between Requester and Responder initiated by a KEY_EXCHANGE request. The purpose of the FINISH request and FINISH_RSP response messages is to provide key confirmation, bind the identity of each party to the exchanged keys and protect the entire handshake against manipulation by an active attacker. Table 61 — FINISH request message format shows the FINISH request message format and Table 62 — Successful FINISH_RSP response message format shows the FINISH_RSP response message format.

493 **Table 61 — FINISH request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the SPDMVersion as described in SPDM version.
1	RequestResponseCode	1	0xE5 = FINISH . See Table 4 — SPDM request codes.

Byte offset	Field	Size (bytes)	Description
2	Param1	1	Bit 0 – If set, the Signature field is included. This bit shall be set when Session-based mutual authentication occurs. All other bits reserved.
3	Param2	1	`SlotID`. Only valid if `Param1` = `0x01`, otherwise reserved. Slot number of the Requester certificate chain that shall be authenticated in Signature field. The value in this field shall be between 0 and 7 inclusive. It shall be `0xFF` if the public key of the Requester was provisioned to the Responder through other means.
4	Signature	SigLen	`Signature` over the transcript. `SigLen` is the size of the asymmetric signing algorithm (`BaseAsymSel` or `ExtAsymSel`) output the Responder selected via the last `ALGORITHMS` response message to the Requester. If `Param1` = `0x00`, `SigLen` is zero and this field shall not be present. Transcript for FINISH signature, mutual authentication defines the construction of the transcript, signature generation, and verification.
4+ `SigLen`	RequesterVerifyData	H	Shall be an HMAC of the transcript hash using the `finished_key` as the secret key and using the negotiated hash algorithm as the hash function. For mutual authentication, the transcript hash shall be the hash of the transcript for `FINISH` HMAC, mutual authentication as Transcript for FINISH HMAC, mutual authentication shows. Otherwise, it shall be the hash of the transcript for `FINISH` HMAC, Responder-only authentication as Transcript for FINISH HMAC, Responder-only authentication shows. The `finished_key` shall be derived from Request Direction Handshake Secret and is described in the finished_key derivation clauses. HMAC is described in RFC2104.

494 The following clause applies when the handshake is performed in the clear, that is, when both Requester and Responder have set `HANDSHAKE_IN_THE_CLEAR_CAP` to 1:

495 If `KEY_EXCHANGE_RSP.MutAuthRequested` equals either `0x02` or `0x04`, upon receiving `FINISH` the Responder shall confirm that the value in `FINISH.Param2` matches the value that the Responder specified in the final `ENCAPSULATED_RESPONSE_ACK.EncapsulatedRequest`.

496 **Table 62 — Successful FINISH_RSP response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x65` = `FINISH_RSP`. See Table 5 — SPDM response codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.

Byte offset	Field	Size (bytes)	Description
4	ResponderVerifyData	H	Conditional field. If the Session Handshake Phase is encrypted and/or message authenticated (that is, if either the Requester or the Responder set `HANDSHAKE_IN_THE_CLEAR_CAP` to 0), this field shall be absent. If both the Requester and Responder support `HANDSHAKE_IN_THE_CLEAR_CAP` field, this field shall be of length H and it shall equal the HMAC of the transcript hash using `finished_key` as the secret key and using the negotiated hash algorithm as the hash function. For Session-based mutual authentication, the transcript hash shall be the hash of the transcript for `FINISH_RSP` HMAC, mutual authentication as Transcript for FINISH_RSP HMAC, mutual authentication shows. Otherwise, the transcript hash shall be the hash of the transcript for `FINISH_RSP` HMAC, Responder-only authentication as Transcript for FINISH_RSP HMAC, Responder-only authentication shows. The `finished_key` shall be derived from Response Direction Handshake Secret and is described in the finished_key derivation clause. HMAC is described in RFC2104.

497 10.17.1 Transcript and transcript hash calculation rules

498 The transcript is a concatenation of the prescribed full messages or message fields in order. Consequently, the transcript hash is the hash of the transcript using the negotiated hash algorithm (that is, `BaseHashSel` or `ExtHashSel` of `ALGORITHMS`). In general, the transcript is used in signature fields and the transcript hash is used in calculating the HMAC in `KEY_EXCHANGE` , `FINISH` and their corresponding responses. For messages that are encrypted, the plaintext messages are used in the transcript. Where this clause indicates that the hash of the specified certificate chain is used, the hash of the certificate chain is calculated over the specified certificate chain, as Table 28 — Certificate chain format describes.

499 The notation `[${message_name}]` . `${field_name}` is used, where:

- `${message_name}` is the name of the request or response message.
- `${field_name}` is the name of the field in the request or response message. The asterisk (`*`) means all fields in that message, except from any conditional fields that are empty (for example `KEY_EXCHANGE` . `OpaqueData`).

500 Transcript for KEY_EXCHANGE_RSP signature shows the transcript for the `KEY_EXCHANGE_RSP` signature:

501 **Transcript for KEY_EXCHANGE_RSP signature**

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used
3. `[KEY_EXCHANGE]` . `*`
4. `[KEY_EXCHANGE_RSP]` . `*` except the `Signature` and `ResponderVerifyData` fields.

502 The Responder shall generate the `KEY_EXCHANGE_RSP` signature from:

```
SPDMsign(PrivKey, transcript, "key_exchange_rsp signing")
```

503 where

- `SPDMsign` is described by the Signature generation clause.
- `PrivKey` shall be the private key of the leaf certificate of the Responder.
- `transcript` shall be the concatenation of the messages for a `KEY_EXCHANGE_RSP` signature.

504 The leaf certificate of the Responder shall be the one indicated by `SlotID` in `Param2` of `KEY_EXCHANGE` request.

505 Likewise, the Requester shall verify the `KEY_EXCHANGE_RSP` signature using `SPDMsignatureVerify(PubKey, signature, transcript, "key_exchange_rsp signing")` where `transcript` is the concatenation of the messages for a `KEY_EXCHANGE_RSP` signature and the `PubKey` is the public key of the leaf certificate of the Responder. The leaf certificate of the Responder shall be the one indicated by `SlotID` in `Param2` of `KEY_EXCHANGE` request. `SPDMsignatureVerify` is described in Signature verification. A successful verification shall be when `SPDMsignatureVerify` returns success.

506 Transcript for KEY_EXCHANGE_RSP HMAC shows the transcript for `KEY_EXCHANGE_RSP` HMAC:

507 **Transcript for `KEY_EXCHANGE_RSP` HMAC**

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used
3. `[KEY_EXCHANGE].*`
4. `[KEY_EXCHANGE_RSP].*` except the `ResponderVerifyData` field.

508 Transcript for FINISH signature, mutual authentication shows the transcript for the `FINISH` signature with mutual authentication:

509 **Transcript for `FINISH` signature, mutual authentication**

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used
3. `[KEY_EXCHANGE].*`
4. `[KEY_EXCHANGE_RSP].*`
5. Hash of the specified certificate chain in DER format (that is, `Param2` of `FINISH`) or hash of the public key in its provisioned format, if a certificate is not used
6. `[FINISH].SPDM Header Fields`

510 The Requester shall generate the `FINISH` signature from `SPDMsign(PrivKey, transcript, "finish signing")` where `transcript` is the concatenation of the messages for `FINISH` signature and the `PrivKey` is the private key of the leaf certificate of the Requester. The leaf certificate of the Requester shall be the one indicated in `SlotID` in `Param2` of `FINISH` request. `SPDMsign` is described in Signature generation.

511 Likewise, the Responder shall verify the `FINISH` signature using `SPDMsignatureVerify(PubKey, signature, transcript, "finish signing")` where `transcript` is the concatenation of the messages for a `FINISH` signature and the `PubKey` is the public key of the leaf certificate of the Requester. The leaf certificate of the Requester shall be the one indicated in `SlotID` in `Param2` of `FINISH` request. `SPDMsignatureVerify` is described in Signature verification. A successful verification is when `SPDMsignatureVerify` returns success.

512 Transcript for FINISH HMAC, Responder-only authentication shows the transcript for `FINISH` HMAC with Responder-only authentication:

513 **Transcript for `FINISH` HMAC, Responder-only authentication**

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used
3. `[KEY_EXCHANGE]`.`*`
4. `[KEY_EXCHANGE_RSP]`.`*`
5. `[FINISH]`.`SPDM Header Fields`

514 Transcript for FINISH HMAC, mutual authentication shows the transcript for `FINISH` HMAC with mutual authentication:

515 **Transcript for `FINISH` HMAC, mutual authentication**

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used.
3. `[KEY_EXCHANGE]`.`*`
4. `[KEY_EXCHANGE_RSP]`.`*`
5. Hash of the specified certificate chain in DER format (that is, `Param2` of `FINISH`) or hash of the public key in its provisioned format, if a certificate is not used.
6. `[FINISH]`.`SPDM Header Fields`
7. `[FINISH]`.`Signature`

516 Transcript for FINISH_RSP HMAC, Responder-only authentication shows the transcript for `FINISH_RSP` HMAC with Responder-only authentication:

517 **Transcript for `FINISH_RSP` HMAC, Responder-only authentication**

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used
3. `[KEY_EXCHANGE]`.`*`
4. `[KEY_EXCHANGE_RSP]`.`*`
5. `[FINISH]`.`*`
6. `[FINISH_RSP]`.`SPDM Header fields`

518 Transcript for FINISH_RSP HMAC, mutual authentication shows the transcript for `FINISH_RSP` HMAC with mutual authentication:

519 **Transcript for `FINISH_RSP` HMAC, mutual authentication**

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used
3. `[KEY_EXCHANGE]`.`*`
4. `[KEY_EXCHANGE_RSP]`.`*`
5. Hash of the specified certificate chain in DER format (that is, `Param2` of `FINISH`) or hash of the public key in its provisioned format, if a certificate is not used
6. `[FINISH]`.`*`
7. `[FINISH_RSP]`.`SPDM Header fields`

520 When multiple session keys are being established between the same Requester and Responder pair, Signature over the transcript during `FINISH` request is computed using only the corresponding `KEY_EXCHANGE`, `KEY_EXCHANGE_RSP` and `FINISH` request parameters.

521 For additional rules, see General ordering rules.

522 10.18 PSK_EXCHANGE request and PSK_EXCHANGE_RSP response messages

523 The Pre-Shared Key (PSK) key exchange scheme provides an option for a Requester and a Responder to perform session key establishment with symmetric-key cryptography. This option is especially useful for endpoints that do not support asymmetric-key cryptography or certificate processing. This option can also be leveraged to expedite the session key establishment, even if asymmetric-key cryptography is supported.

524 This option requires the Requester and the Responder to have prior knowledge of a common PSK before the handshake. Essentially, the PSK serves as a mutual authentication credential and the base of the session key establishment. As such, only the two endpoints and potentially a trusted third party that provisions the PSK to the two endpoints know the value of the PSK. For these same reasons, the `HANDSHAKE_IN_THE_CLEAR_CAP` is not applicable

in a PSK key exchange. Thus, for PSK-based session establishment both the Responder and the Requester shall ignore the `HANDSHAKE_IN_THE_CLEAR_CAP` bit.

525 A Requester can be paired with multiple Responders. Likewise, a Responder can be paired with multiple Requesters. A Requester and Responder pair can be provisioned with one or more PSKs. An endpoint can act as a Requester to one device and simultaneously a Responder to another device. If both endpoints can act as Requester or Responder, then the endpoints shall use different PSKs for each role. It is the responsibility of the transport layer to identify the peer and establish communication between the two endpoints, before the PSK-based session key exchange starts.

526 The PSK can be provisioned in a trusted environment, for example, during the secure manufacturing process. In an untrusted environment, the PSK can be agreed upon between the two endpoints using a secure protocol. The mechanism for PSK provisioning is out of scope of this specification. The size of the provisioned PSK is determined by the requirement of security strength of the application, but should be at least 128 bits and recommended to be 256 bits or larger, to resist dictionary attacks especially when the Requester and Responder cannot both contribute sufficient entropy during the exchange. During PSK provisioning, the capabilities of an endpoint and supported algorithms can be communicated to the peer. Therefore, SPDM commands `GET_CAPABILITIES` and `NEGOTIATE_ALGORITHMS` are not required during session key establishment with the PSK option, and `Negotiated State` shall not be supported.

527 Two message pairs are defined for this option:

- `PSK_EXCHANGE` / `PSK_EXCHANGE_RSP`
- `PSK_FINISH` / `PSK_FINISH_RSP`

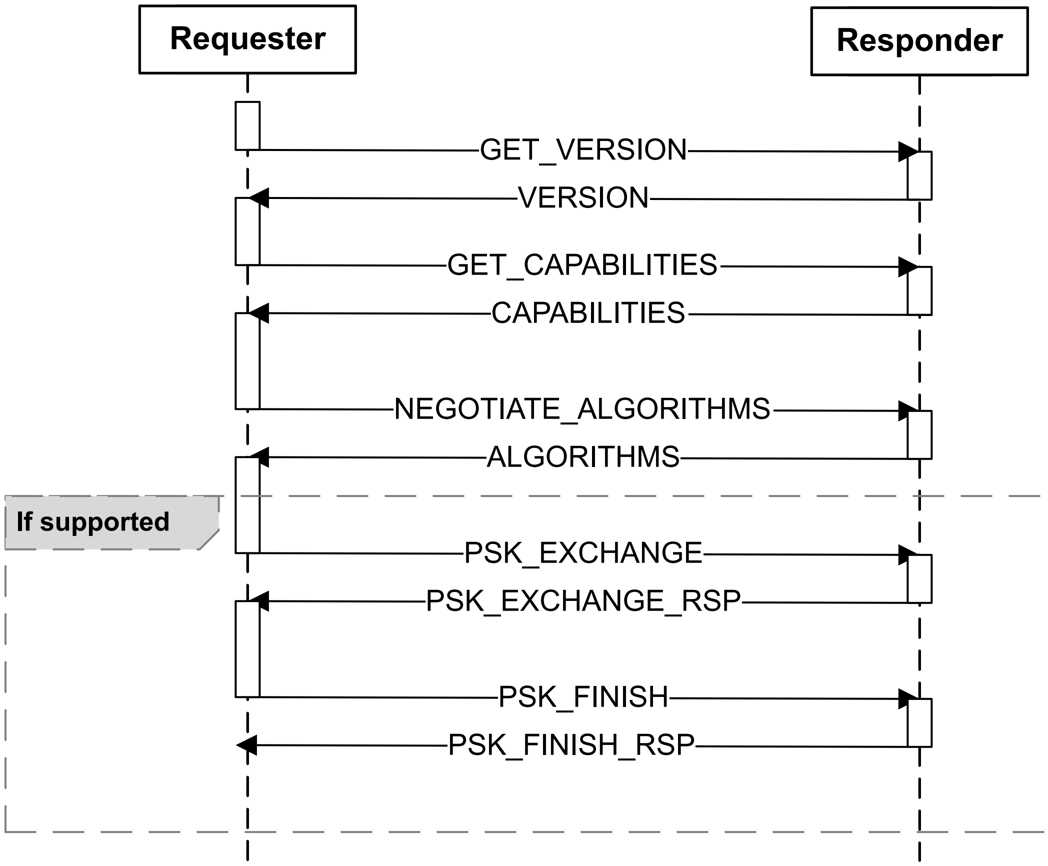
528 The `PSK_EXCHANGE` message carries three responsibilities:

1. Prompts the Responder to retrieve the specific PSK.
2. Exchanges contextual information between the Requester and the Responder.
3. Proves to the Requester that the Responder knows the correct PSK and has derived the correct session keys.

529 Figure 17 — PSK_EXCHANGE: Example shows an example of the `PSK_EXCHANGE` message:

530 **Figure 17 — PSK_EXCHANGE: Example**

531



532 **Table 63 — PSK_EXCHANGE request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xE6` = `PSK_EXCHANGE`. See Table 4 — SPDM request codes.

Byte offset	Field	Size (bytes)	Description
2	Param1	1	Type of measurement summary hash requested: `0x0` : No measurement summary hash requested. `0x1` : TCB measurements only. `0xFF` : All measurements. All other values reserved. If a Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response), the Requester shall set this value to `0x0` .
3	Param2	1	Session policy. See Table 59 — Session policy.
4	ReqSessionID	2	Two-byte Requester contribution to allow construction of a unique four-byte session ID between a Requester-Responder pair. The final session ID = Concatenate (ReqSessionID, RspSessionID).
6	P	2	Length of `PSKHint` in bytes.
8	R	2	Length of `RequesterContext` in bytes. R shall be equal to or greater than H, where H is the size of the underlying HMAC used in the context of the Requester.
10	OpaqueDataLength	2	Size of the `OpaqueData` field that follows in bytes. The value should not be greater than 1024 bytes. Shall be `0` if no `OpaqueData` is provided.
12	PSKHint	`P`	Information required by the Responder to retrieve the PSK. Optional.
12 + `P`	RequesterContext	`R`	The context of the Requester. Shall include a nonce (random number or monotonic counter) of at least 32 bytes and optionally relevant information contributed by the Requester.
12 + `P` + `R`	OpaqueData	`OpaqueDataLength`	Optional. If present, the `OpaqueData` sent by the Requester is used to indicate any parameters that Requester wishes to pass to the Responder as part of PSK-based key exchange. If present, this field shall conform to the selected opaque data format in `OtherParamsSelection` .

533 The field `PSKHint` is optional. It is absent if P is set to 0. It is introduced to address two scenarios:

- The Responder is provisioned with multiple PSKs and stores them in secure storage. The Requester uses `PSKHint` as an identifier to specify which PSK will be used in this particular session.
- The Responder does not store the actual value of the PSK, but can derive the PSK using `PSKHint` . For example, if the Responder has an immutable UDS (Unique Device Secret) in fuses, then during provisioning, a PSK can be derived from the UDS or a derivative value and a non-secret salt known by the Requester. During session key establishment, the salt value is sent to the Responder in `PSKHint` of `PSK_EXCHANGE` . This mechanism allows the Responder to support any number of PSKs, without consuming secure storage.

534 The `RequesterContext` is the contribution of the Requester to session key derivation. It shall contain a nonce (random number or monotonic counter) to ensure that the derived session keys are ephemeral to mitigate against replay attacks. If a monotonic counter is used as the nonce, the monotonic counter shall not be reset for the lifetime of the device. The `RequesterContext` can also contain other information from the Requester.

535 Upon receiving a `PSK_EXCHANGE` request, the Responder:

1. Generates PSK from `PSKHint`, if necessary.
2. Generates `ResponderContext`, if supported.
3. Derives the `finished_key` of the Responder by following Key schedule.
4. Constructs `PSK_EXCHANGE_RSP` response message and sends to the Requester.

536 **Table 64 — PSK_EXCHANGE_RSP response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x66` = `PSK_EXCHANGE_RSP`. See Table 5 — SPDM response codes.
2	Param1	1	HeartbeatPeriod The value of this field shall be zero if Heartbeat is not supported. Otherwise, the value shall be in units of seconds. Zero is a legal value if Heartbeat is supported, but means that a heartbeat is not desired on this session.
3	Param2	1	Reserved.
4	RspSessionID	2	Two-byte Responder contribution to allow construction of a unique four-byte session ID between a Requester-Responder pair. The final session ID = Concatenate (ReqSessionID, RspSessionID).
6	Reserved	2	Reserved.
8	Q	2	Length of ResponderContext in bytes.
10	OpaqueDataLength	2	Size of the `OpaqueData` field that follows in bytes. The value should not be greater than 1024 bytes. Shall be `0` if no `OpaqueData` is provided.

Byte offset	Field	Size (bytes)	Description
12	MeasurementSummaryHash	`H`	If the Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response) or requested `Param1` = `0x0` , this field shall be absent. If the requested `Param1` = `0x1` , this field shall be the combined hash of measurements of all measurable components considered to be in the TCB required to generate this response, computed as `hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ...))` where `MeasurementBlock[x]` denotes a measurement of an element in the TCB. Measurements are concatenated in ascending order based on their measurement index as Table 44 — Measurement block format describes. When the requested `Param1` = `0x1` and there are no measurable components in the TCB required to generate this response, this field shall be `0` . If requested `Param1` = `0xFF` , this field shall be computed as `hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ..., MeasurementBlock[n]))` of all supported measurements available in the measurement index range `0x01` - `0xFE` , concatenated in ascending index order. Indices with no associated measurements shall not be included in the hash calculation. See the Measurement index assignments clause. If the Responder supports both raw bit stream and digest representations for a given measurement index, then the Responder shall use the digest form. This field shall be in Hash byte order.
12 + `H`	ResponderContext	`Q`	Context of the Responder. Optional. If present, shall include a nonce and/or information contributed by the Responder.
12 + `H` + `Q`	OpaqueData	`OpaqueDataLength`	Optional. If present, the `OpaqueData` sent by the Responder is used to indicate any parameters that Responder wishes to pass to the Requester as part of PSK-based key exchange. If present, this field shall conform to the selected opaque data format in `OtherParamsSelection` .
12 + `H` + `Q` + `OpaqueDataLength`	ResponderVerifyData	`H`	Data to be verified by the Requester using the `finished_key` of the Responder.

537 The `ResponderContext` is the contribution of the Responder to session key derivation. It should contain a nonce (random number or monotonic counter) and other information of the Responder. If a monotonic counter is used as the nonce, the monotonic counter shall not be reset for the lifetime of the device. Because the Responder can be a

constrained device that cannot generate a nonce, `ResponderContext` is optional. However, the Responder is required to use `ResponderContext` if it can generate a nonce.

538 It should be noted that the nonce in `ResponderContext` is critical for anti-replay. If a nonce is not present in `ResponderContext`, then the Responder is not challenging the Requester for real-time knowledge of the PSK. Such a session is subject to replay attacks - a man-in-the-middle attacker could record and replay prior `PSK_EXCHANGE` and `PSK_FINISH` messages and set up a session with the Responder. But the bogus session would not leak secrets, so long as the PSK or session keys of the prior replayed session are not compromised.

539 If `ResponderContext` is absent, such as when `PSK_CAP` in the `CAPABILITIES` of the Responder is `01b`, the Requester shall not send `PSK_FINISH`, because the session keys are solely determined by the Requester and the Session immediately enters the Application Phase. If and only if the `ResponderContext` is present in the response, such as when `PSK_CAP` in the `CAPABILITIES` of the Responder is `10b`, the Requester shall send `PSK_FINISH` with `RequesterVerifyData` to prove that it has derived correct session keys.

540 To calculate `ResponderVerifyData`, the Responder calculates an HMAC. The HMAC key is the `finished_key` of the Responder. The data is the hash of the concatenation of all messages sent up to this point between the Requester and the Responder. For messages that are encrypted, the plaintext messages are used in calculating the hash.

```
1. [GET_VERSION].*
2. [VERSION].*
3. [GET_CAPABILITIES].* (if issued)
4. [CAPABILITIES].* (if issued)
5. [NEGOTIATE_ALGORITHMS].* (if issued)
6. [ALGORITHMS].* (if issued)
7. [PSK_EXCHANGE].*
8. [PSK_EXCHANGE_RSP].* except the ResponderVerifyData field
```

541 Note that, even if `CERTIFICATES`, `CHALLENGE_AUTH`, and/or `MEASUREMENTS` were issued, these messages would not be included in the data for calculating `ResponderVerifyData`. In other words, the identity of the signer of `CHALLENGE_AUTH` and/or `MEASUREMENTS` is not bound to identity of the sender of `PSK_EXCHANGE_RSP`. Therefore, to mitigate Responder identity impersonation, the Requester should not issue `PSK_EXCHANGE` if it has received `CHALLENGE_AUTH` and/or `MEASUREMENTS` with a signature from the Responder.

542 Upon receiving PSK_EXCHANGE_RSP, the Requester:

1. Derives the `finished_key` of the Responder by following Key schedule.
2. Verify `ResponderVerifyData` by calculating the HMAC in the same manner as the Responder. If verification fails, the Requester terminates the session.
3. If the Responder contributes to session key derivation, such as when `PSK_CAP` in the `CAPABILITIES` of the Responder is `10b`, construct `PSK_FINISH` request and send to the Responder.

543 ## 10.19 PSK_FINISH request and PSK_FINISH_RSP response messages

544 The `PSK_FINISH` request proves to the Responder that the Requester knows the PSK and has derived the correct session keys. This is achieved by an HMAC value calculated with the `finished_key` of the Requester and messages of this session. The Requester shall send `PSK_FINISH` only if `ResponderContext` is present in `PSK_EXCHANGE_RSP`.

545 Table 65 — PSK_FINISH request message format describes the `PSK_FINISH` request message format:

546 **Table 65 — PSK_FINISH request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xE7` = `PSK_FINISH`. See Table 4 — SPDM request codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.
4	RequesterVerifyData	`H`	Data to be verified by the Responder by using the `finished_key` of the Requester.

547 To calculate `RequesterVerifyData`, the Requester calculates an HMAC. The key is the `finished_key` of the Requester, as described in Key schedule. The data is the hash of the concatenation of all messages sent so far between the Requester and the Responder. For messages that are encrypted, the plaintext messages are used in calculating the hash.

```
1. [GET_VERSION].*
2. [VERSION].*
3. [GET_CAPABILITIES].* (if issued)
4. [CAPABILITIES].* (if issued)
5. [NEGOTIATE_ALGORITHMS].* (if issued)
6. [ALGORITHMS].* (if issued)
7. [PSK_EXCHANGE].*
8. [PSK_EXCHANGE_RSP].*
9. [PSK_FINISH].* except the RequesterVerifyData field
```

548 For additional rules, see General ordering rules.

549 Upon receiving `PSK_FINISH` request, the Responder derives the `finished_key` of the Requester and calculates the HMAC independently in the same manner and verifies the result matches `RequesterVerifyData`. If verified, the

Responder constructs `PSK_FINISH_RSP` response and sends to the Requester. Otherwise, the Responder sends `ERROR` response with error code `InvalidRequest` to the Requester.

550 Table 66 — Successful PSK_FINISH_RSP response message format describes the successful `PSK_FINISH_RSP` response message format:

551 **Table 66 — Successful PSK_FINISH_RSP response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x67` = `PSK_FINISH_RSP`. See Table 5 — SPDM response codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.

552 ## 10.20 HEARTBEAT request and HEARTBEAT_ACK response messages

553 This request shall keep a session alive if `HEARTBEAT` is supported by both the Requester and Responder. The `HEARTBEAT` request shall be sent periodically as indicated in `HeartbeatPeriod` in either `KEY_EXCHANGE_RSP` or `PSK_EXCHANGE_RSP` response messages. The Responder shall terminate the session if session traffic is not received in twice `HeartbeatPeriod`. Likewise, the Requester shall terminate the session if session traffic, including `ERROR` response, is not received in twice `HeartbeatPeriod`. Session traffic includes encrypted data at the transport layer. How SPDM is informed of encrypted data at the transport layer is outside of the scope of this specification. The Requester can retry `HEARTBEAT` requests.

554 The timer for the Heartbeat period shall start at the transmission, for Responders, or reception, for Requester, of either the `FINISH_RSP` or `PSK_FINISH_RSP` response messages. When determining the value of HeartbeatPeriod, the Responder should ensure this value is sufficiently greater than `T1`.

555 For session termination details, see Session termination phase.

556 Table 67 — HEARTBEAT request message format describes the message format.

557 **Table 67 — HEARTBEAT request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xE8` = `HEARTBEAT` request. See Table 4 — SPDM request codes.

Byte offset	Field	Size (bytes)	Description
2	Param1	1	Reserved.
3	Param2	1	Reserved.

558 Table 68 — HEARTBEAT_ACK response message formatdescribes the format for the Heartbeat Response.

559 **Table 68 — HEARTBEAT_ACK response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x68` = `HEARTBEAT_ACK` response. See Table 5 — SPDM response codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.

560 10.20.1 Heartbeat additional information

561 The transport layer might allow the `HEARTBEAT` request to be sent from the Responder to the Requester. This is recommended for transports capable of asynchronous bidirectional communication.

562 10.21 KEY_UPDATE request and KEY_UPDATE_ACK response messages

563 To update session keys, this request shall be used. There are many reasons for doing this but an important one is when the per-record nonce will soon reach its maximum value and rollover. The `KEY_UPDATE` request can be issued by the Responder as well using the `GET_ENCAPSULATED_REQUEST` mechanism. A `KEY_UPDATE` request shall update session keys in the direction of the request only. Because the Responder can also send this request, it is possible that two simultaneous key updates, one for each direction, can occur. However, only one KEY_UPDATE request for a single direction shall occur. Until the session key update synchronization successfully completes, subsequent `KEY_UPDATE` requests for the same direction shall be considered a retry of the original `KEY_UPDATE` request.

564 Table 69 — KEY_UPDATE request message format describes the `KEY_UPDATE` request message format:

565 **Table 69 — KEY_UPDATE request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xE9` = `KEY_UPDATE` Request. See Table 4 — SPDM request codes.
2	Param1	1	Key operation. See Table 70 — KEY_UPDATE_ACK response message format.
3	Param2	1	Tag. This field shall contain a unique number to aid the Responder in differentiating between the original and retry request. A retry request shall contain the same tag number as the original.

566 Table 70 — KEY_UPDATE_ACK response message format describes the `KEY_UPDATE_ACK` response message format:

567 **Table 70 — KEY_UPDATE_ACK response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x69` = `KEY_UPDATE_ACK` response. See Table 5 — SPDM response codes.
2	Param1	1	Key Operation. This field shall reflect the Key Operation field of the request.
3	Param2	1	Tag. This field shall reflect the Tag number in the `KEY_UPDATE` request.

568 Table 71 — KEY_UPDATE operations describes the `KEY_UPDATE` operations:

569 **Table 71 — KEY_UPDATE operations**

Value	Operation	Description
0	Reserved	Reserved.
1	UpdateKey	Update the single-direction key.
2	UpdateAllKeys	Update keys for both directions.
3	VerifyNewKey	Ensure the key update is successful and the old keys can be safely discarded.
4 - 255	Reserved	Reserved.

570 10.21.1 Session key update synchronization

571 For clarity, in the key update process, the term, sender, means the SPDM endpoint that issued the `KEY_UPDATE`

request and the term, receiver, means the SPDM endpoint that received the `KEY_UPDATE` request. To ensure the key update process is seamless while still allowing the transmission and reception of records, both sender and receiver shall follow the prescribed method described in this clause.

572 The data transport layer shall ensure that data transfer during key updates is managed in such a way that the correct keys are used before, during, and after the key update operation. How this is accomplished by the data transport layer is outside of the scope of this specification.

573 Both the sender and the receiver shall derive the new keys as detailed in Major secrets update.

574 The sender shall not use the new transmit key until after reception of the `KEY_UPDATE_ACK` response.

575 The sender and receiver shall use the new key on the `KEY_UPDATE` request with `VerifyNewKey` command and all subsequent commands until another key update is performed.

576 In the case of `KEY_UPDATE` request with `UpdateAllKeys`, the receiver shall use the new transmit key for the `KEY_UPDATE_ACK` response. The `KEY_UPDATE` request with `UpdateAllKeys` should only be used with physical transports that are single master to ensure that simultaneous `UpdateAllKeys` requests do not occur.

577 If the sender has not received `KEY_UPDATE_ACK`, the sender can retry or end the session. The sender shall not proceed to the next step until successfully receiving the corresponding `KEY_UPDATE_ACK`.

578 Upon the successful reception of the `KEY_UPDATE_ACK`, the sender shall transmit a `KEY_UPDATE` request with `VerifyNewKey` operation using the new session keys. The sender can retry until the corresponding `KEY_UPDATE_ACK` response is received. However, the sender shall be prohibited, at this point, from restarting this process or going back to a previous step. Its only recourse in error handling is either to retry the same request or to terminate the session. Upon successful reception of the KEY_UPDATE with VerifyNewKey operation, the receiver can now discard the old session keys. After the sender successfully receives the corresponding `KEY_UPDATE_ACK`, the transport layer can start using the new keys.

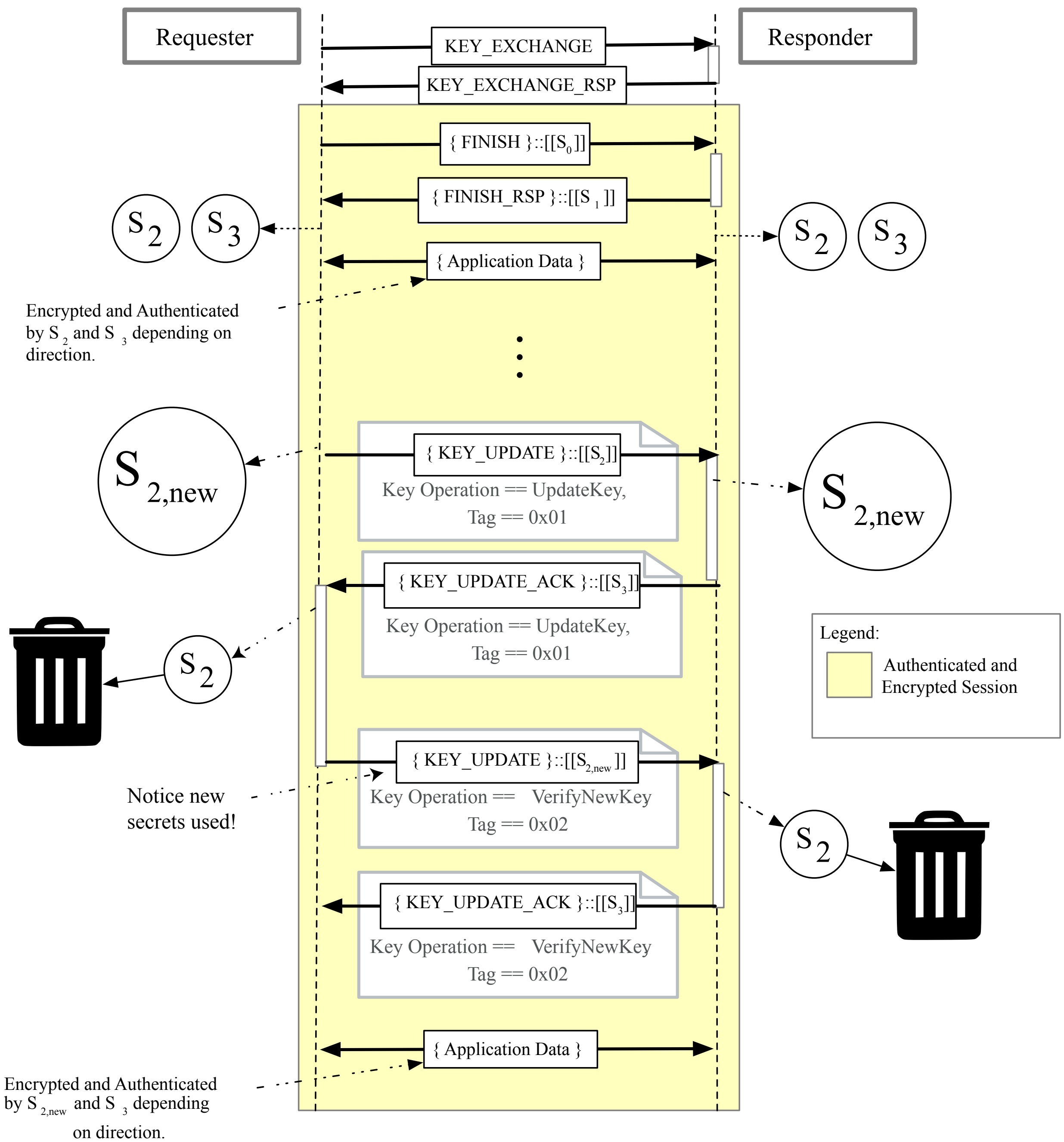
579 In certain scenarios, the receiver might need additional time to process the `KEY_UPDATE` request such as processing data already in its buffer. Thus, the receiver can reply with an `ERROR` message with `ErrorCode=Busy`. The sender should retry the request after a reasonable period of time with a reasonable amount of retries to prevent premature session termination.

580 Finally, it bears repeating that a key update in one direction can happen simultaneously with a key update in the opposite direction. Still, the aforementioned synchronization process occurs independently but simultaneously for each direction.

581 Figure 18 — KEY_UPDATE protocol example flow illustrates a typical key update initiated by the Requester to update its secret. In this example, the Responder and Requester are both capable of message authentication and encryption.

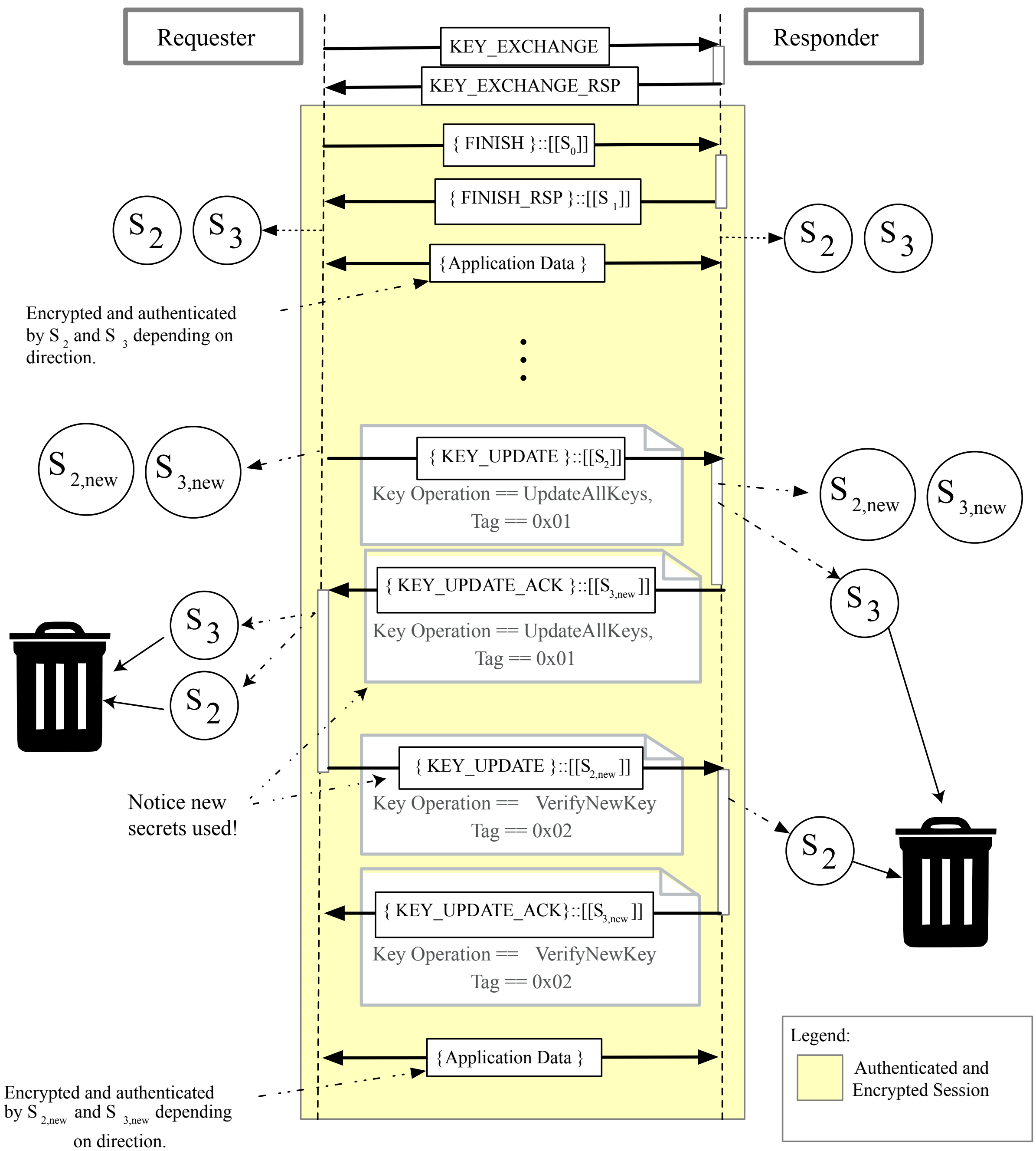
582 **Figure 18 — KEY_UPDATE protocol example flow**

583



584 Figure 19 — KEY_UPDATE protocol change all keys example flow illustrates a typical key update initiated by the Requester to update all secrets. In this example, the Responder and Requester are both capable of message authentication and encryption.

585 **Figure 19 — KEY_UPDATE protocol change all keys example flow**

586 

587 ### 10.21.2 KEY_UPDATE transport allowances

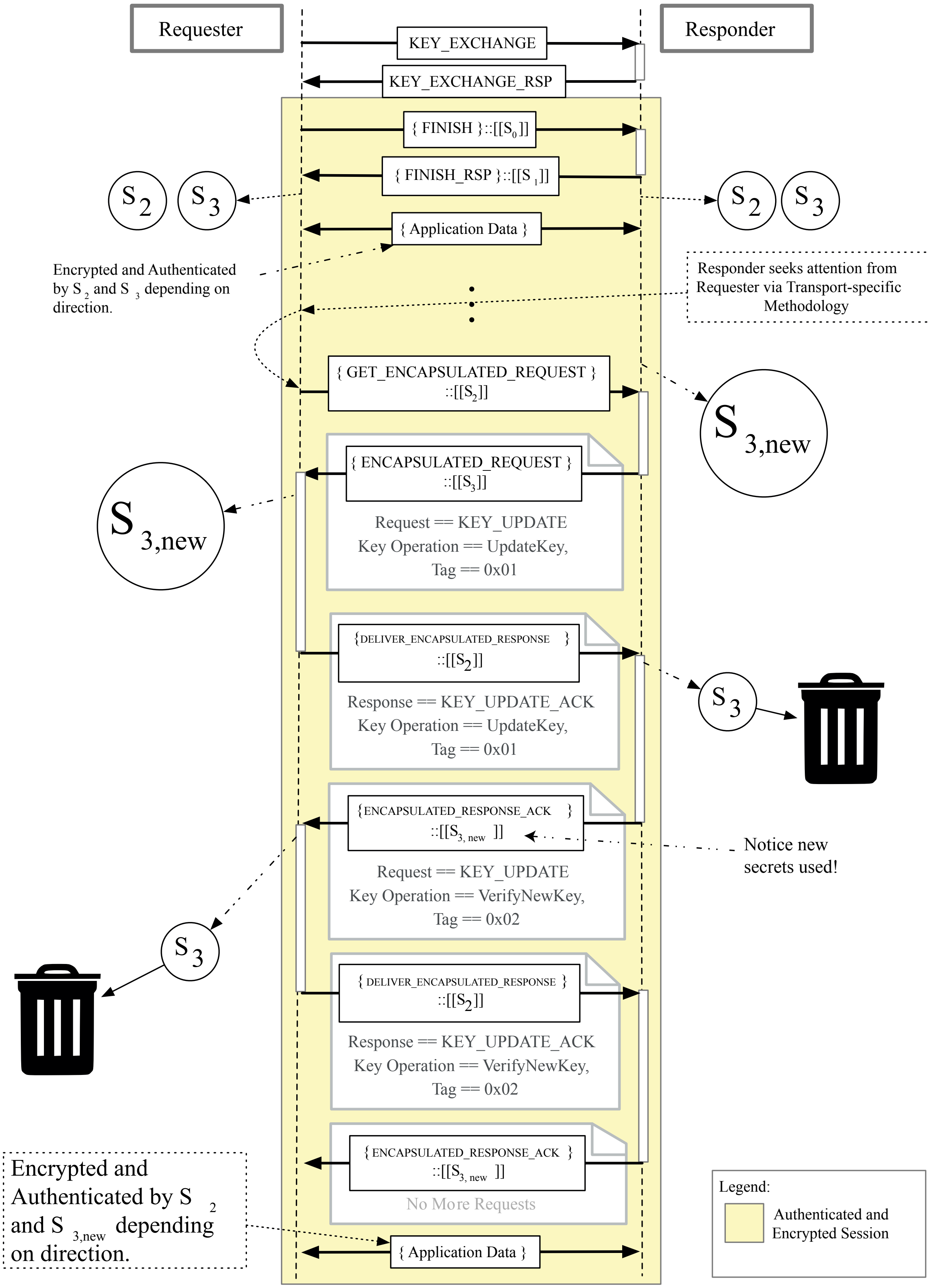
588 On some transports, bidirectional communication can occur asynchronously. On such transports, the transport can allow or disallow the `KEY_UPDATE` to be sent asynchronously without using the `GET_ENCAPSULATED_REQUEST`

mechanism. The transport should define the actual method to use. That definition is outside the scope of this specification.

589 Figure 20 — KEY_UPDATE protocol example flow 2 illustrates a key update over a physical transport that has a limitation whereby only a single device (often called the master) is allowed to initiate all transactions on that bus. This physical transport specifies that a Responder shall alert the Requester through a side-band mechanism and to utilize the `GET_ENCAPSULATED_REQUEST` mechanism to fulfill SPDM-related requirements. Also, in this same example, the Requester and Responder are both capable of encryption and message authentication.

590 **Figure 20 — KEY_UPDATE protocol example flow 2**

591



Requester
Responder
KEY_EXCHANGE
KEY_EXCHANGE_RSP
{ FINISH }::[[S0]]
{ FINISH_RSP }::[[S1]]
S2
S3
{ Application Data }
Encrypted and Authenticated by S2 and S3 depending on direction.
Responder seeks attention from Requester via Transport-specific Methodology
{ GET_ENCAPSULATED_REQUEST } ::[[S2]]
S3,new
{ ENCAPSULATED_REQUEST } ::[[S3]]
Request == KEY_UPDATE
Key Operation == UpdateKey,
Tag == 0x01
{DELIVER_ENCAPSULATED_RESPONSE } ::[[S2]]
Response == KEY_UPDATE_ACK
Key Operation == UpdateKey,
Tag == 0x01
{ENCAPSULATED_RESPONSE_ACK } ::[[S3, new]]
Notice new secrets used!
Request == KEY_UPDATE
Key Operation == VerifyNewKey,
Tag == 0x02
{ DELIVER_ENCAPSULATED_RESPONSE } ::[[S2]]
Response == KEY_UPDATE_ACK
Key Operation == VerifyNewKey,
Tag == 0x02
{ ENCAPSULATED_RESPONSE_ACK } ::[[S3, new]]
No More Requests
Encrypted and Authenticated by S2 and S3,new depending on direction.
{ Application Data }
Legend:
Authenticated and Encrypted Session

592 ## 10.22 GET_ENCAPSULATED_REQUEST request and ENCAPSULATED_REQUEST response messages

593 In certain use cases, such as mutual authentication, the Responder needs the ability to issue its own SPDM request messages to the Requester. Certain transports prohibit the Responder from asynchronously sending out data on that transport. Cases like these are addressed through message encapsulation, which preserves the roles of Requester and Responder as far as the transport is concerned, but enables the Responder to issue its own requests to the Requester. Message encapsulation is only allowed in certain scenarios. Figure 21 — Session-based mutual authentication example and Figure 22 — Optimized session-based mutual authentication example illustrate the use of this scheme.

594 A Requester issues a `GET_ENCAPSULATED_REQUEST` request message to retrieve an encapsulated SPDM request message from the Responder. The response to this message (`ENCAPSULATED_REQUEST`) encapsulates the SPDM request message as if the Responder was acting as a Requester. Table 72 — GET_ENCAPSULATED_REQUEST request message format describes the request message format. The Responder shall use the same SPDM version the Requester used.

595 ### 10.22.1 Encapsulated request flow

596 The encapsulated request flow starts with the Requester sending a `GET_ENCAPSULATED_REQUEST` message and ends with an `ENCAPSULATED_RESPONSE_ACK` that carries no more encapsulated requests. The `GET_ENCAPSULATED_REQUEST` shall only be issued once with the exception of retries. This is also illustrated in Figure 21 — Session-based mutual authentication example.

597 When the Requester issues a `GET_ENCAPSULATED_REQUEST` , the encapsulated request flow shall start. Upon the successful reception of the `ENCAPSULATED_REQUEST` and when the encapsulated response is ready, the Requester shall continue the flow by issuing the `DELIVER_ENCAPSULATED_RESPONSE` . During this period, with the exception of `GET_VERSION` , `RESPOND_IF_READY` and `DELIVER_ENCAPSULATED_RESPONSE` , the Requester shall not issue any other message. If a Responder receives a request other than `DELIVER_ENCAPSULATED_RESPONSE` , `RESPOND_IF_READY` or `GET_VERSION` , the Responder should respond with `ErrorCode=RequestInFlight` .

598 ### 10.22.2 Optimized encapsulated request flow

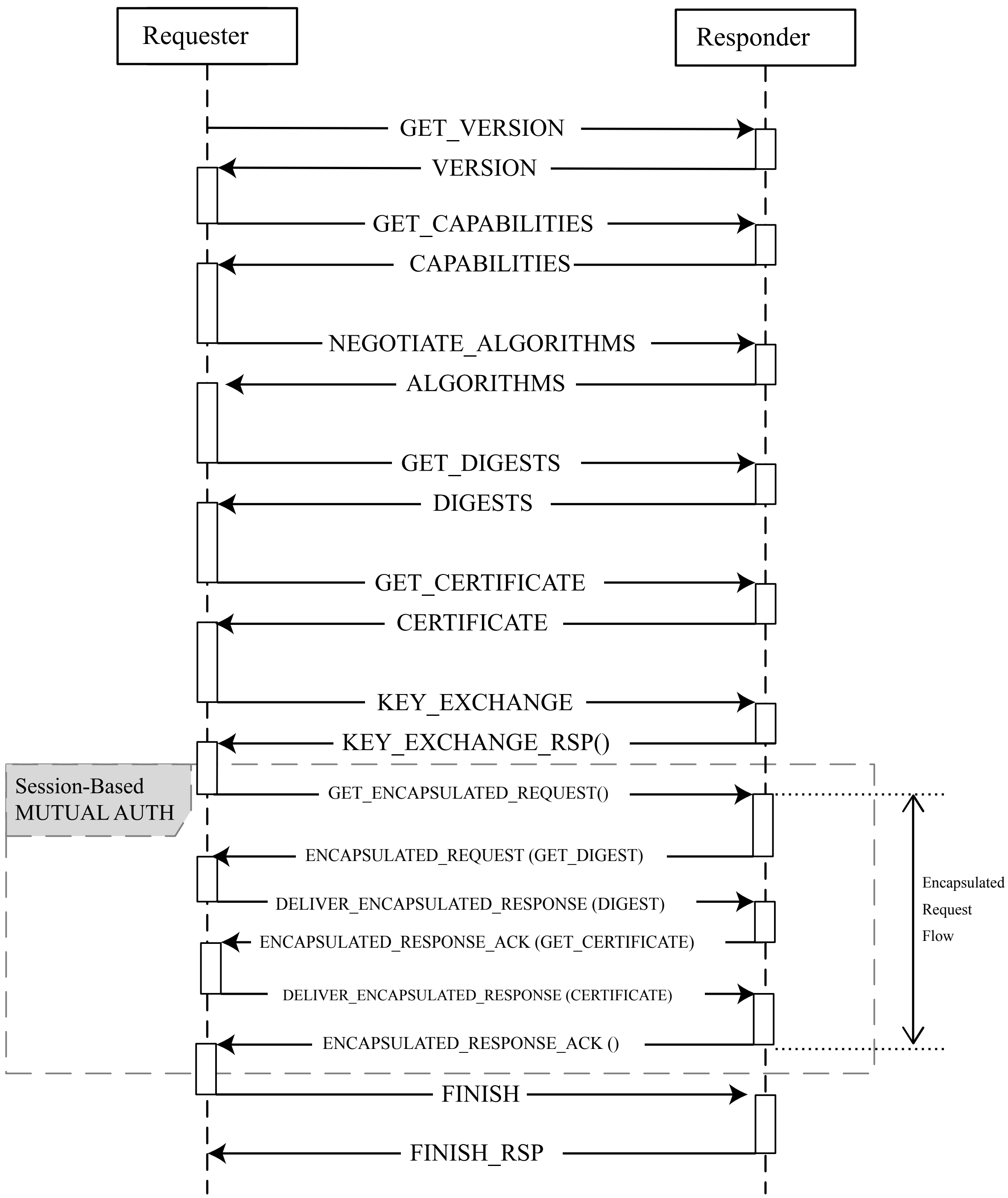
599 The optimized encapsulated request flow is similar to the encapsulated request flow but without the need of `GET_ENCAPSULATED_REQUEST` . This is because the encapsulated request accompanies one of the `Session-Secrets-Exchange` responses; thereby, removing the necessity on the Requester from issuing a `GET_ENCAPSULATED_REQUEST` . When the Responder includes an encapsulated requests with a `Session-Secrets-Exchange` response, the optimized encapsulated request flow shall start. See Figure 22 — Optimized session-based mutual authentication example.

600 When the Requester successfully receives a Session-Secrets-Exchange response with an included encapsulated request, the Requester shall send a `DELIVER_ENCAPSULATED_RESPONSE` after processing the encapsulated request.

The Requester shall not issue any other requests except for `DELIVER_ENCAPSULATED_RESPONSE`, `RESPOND_IF_READY` and `GET_VERSION`. If a Responder receives a request other than `DELIVER_ENCAPSULATED_RESPONSE`, `RESPOND_IF_READY`, `GET_VERSION` or Session-Secrets-Exchange, then the Responder should respond with `ErrorCode=RequestInFlight`.

601 Figure 21 — Session-based mutual authentication example shows an example of session-based mutual authentication:

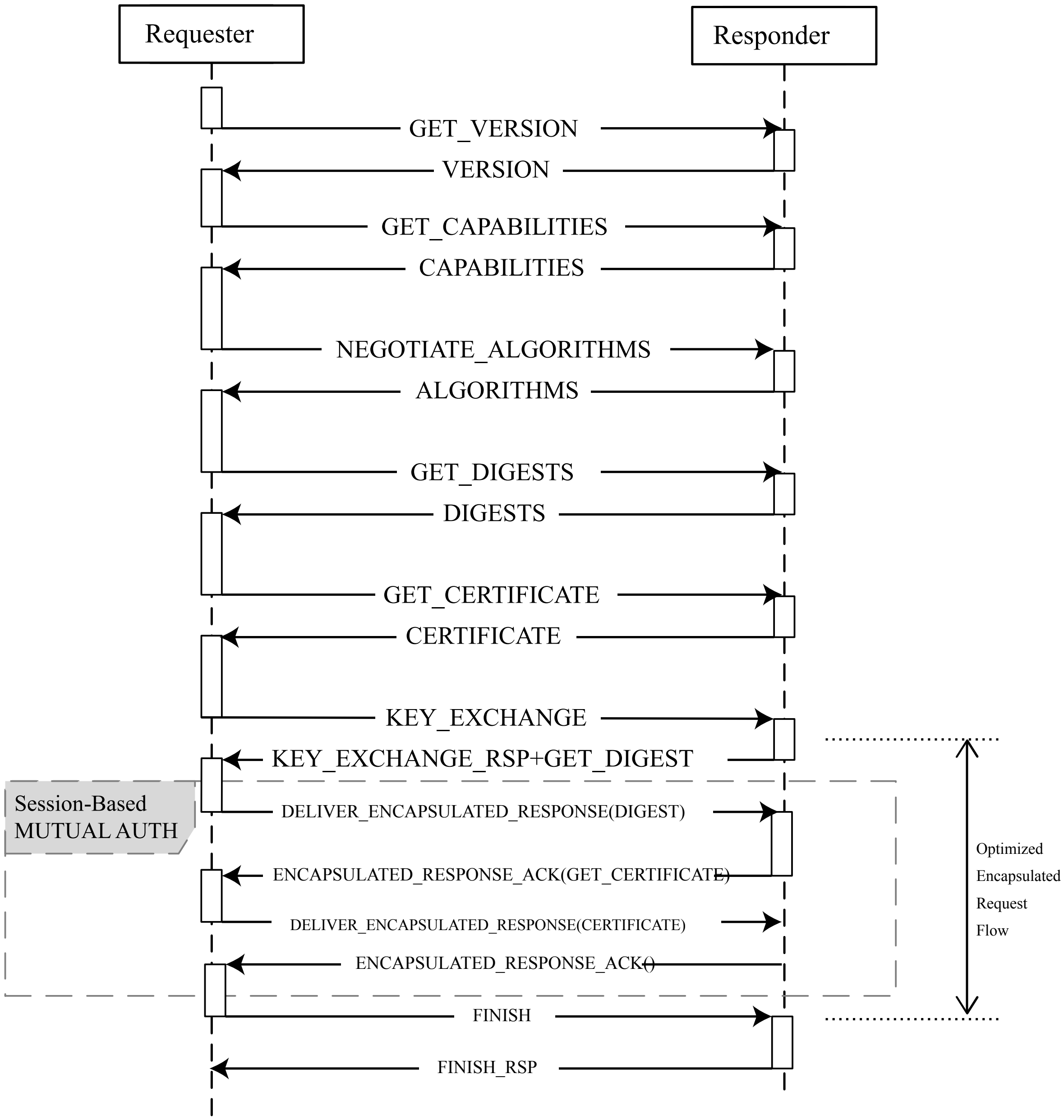
602 **Figure 21 — Session-based mutual authentication example**

603 

604 Figure 22 — Optimized session-based mutual authentication example shows an example of optimized session-based mutual authentication:

605 **Figure 22 — Optimized session-based mutual authentication example**

606



607 **Table 72 — GET_ENCAPSULATED_REQUEST request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xEA` = `GET_ENCAPSULATED_REQUEST`. See Table 4 — SPDM request codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.

608 Table 73 — ENCAPSULATED_REQUEST response message format describes the format this response.

609 **Table 73 — ENCAPSULATED_REQUEST response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x6A` = `ENCAPSULATED_REQUEST` response. See Table 5 — SPDM response codes.
2	Param1	1	Request ID. This field should be unique to help the Responder match response to request.
3	Param2	1	Reserved.
4	EncapsulatedRequest	Variable	SPDM Request Message. The value of this field shall represent a valid SPDM request message. The length of this field is dependent on the SPDM Request message. The field shall start with the `SPDMVersion` field. The `SPDMVersion` field of the `Encapsulated Request` shall be the same as `SPDMVersion` of the `ENCAPSULATED_REQUEST` response. Both `GET_ENCAPSULATED_REQUEST` and `DELIVER_ENCAPSULATED_RESPONSE` shall be invalid requests and the Requester should respond with `ErrorCode=UnexpectedRequest` if these requests are encapsulated.

610 10.22.3 Triggering `GET_ENCAPSULATED_REQUEST`

611 Once a session has been established, the Responder might wish to send a request asynchronously, such as a `KEY_UPDATE` request but cannot due to the limitations of the physical bus or transport protocol. In such a scenario, the transport and/or physical layer is responsible for defining an alerting mechanism for the Requester. Upon receiving the alert, the Requester shall issue a `GET_ENCAPSULATED_REQUEST` to the Responder.

612 10.22.4 Additional constraints

613 The `GET_ENCAPSULATED_REQUEST` and `ENCAPSULATED_REQUEST` messages shall only be allowed to encapsulate

certain requests in certain scenarios. For constraint details, see the Session, Basic mutual authentication, and KEY_UPDATE request and KEY_UPDATE_ACK response messages clauses.

614 ## 10.23 DELIVER_ENCAPSULATED_RESPONSE request and ENCAPSULATED_RESPONSE_ACK response messages

615 As a Requester processes an encapsulated request, it needs a mechanism to deliver back the corresponding response. That mechanism shall be the `DELIVER_ENCAPSULATED_RESPONSE` and `ENCAPSULATED_RESPONSE_ACK` messages. The `DELIVER_ENCAPSULATED_RESPONSE`, which is an SPDM request, encapsulates the response and delivers it to the Responder. The `ENCAPSULATED_RESPONSE_ACK`, which is an SPDM response, acknowledges the reception of the encapsulated response.

616 Furthermore, if there are additional requests from the Responder, the Responder shall provide the next request in the `ENCAPSULATED_RESPONSE_ACK` response message.

617 In an encapsulated request flow and after the successful reception of the first encapsulated request, the Requester shall not send any other requests with the exception of `DELIVER_ENCAPSULATED_RESPONSE`, `RESPOND_IF_READY` and `GET_VERSION`. After the successful reception of the first `DELIVER_ENCAPSULATED_RESPONSE` and if a Responder receives a request other than `DELIVER_ENCAPSULATED_RESPONSE`, `RESPOND_IF_READY` or `GET_VERSION`, the Responder should respond with `ErrorCode=RequestInFlight`.

618 If `Param2` of `ENCAPSULATED_RESPONSE_ACK` is set to `0x00` or `0x02` then this shall be the final encapsulated flow message that the Responder shall issue and the encapsulated flow shall be completed.

619 The timing parameters for the response shall depend on the encapsulated request. This enables the Responder to process the response before delivering the next request. See Additional information.

620 Table 74 — DELIVER_ENCAPSULATED_RESPONSE request message format describes the request message format.

621 **Table 74 — DELIVER_ENCAPSULATED_RESPONSE request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xEB` = `DELIVER_ENCAPSULATED_RESPONSE` Request. See Table 4 — SPDM request codes.
2	Param1	1	Request ID. The Requester shall use the same `Request ID` (that is, `Param1`), as provided by the Responder in the corresponding of either `ENCAPSULATED_REQUEST` or `ENCAPSULATED_RESPONSE_ACK`.

Byte offset	Field	Size (bytes)	Description
3	Param2	1	Reserved.
4	EncapsulatedResponse	Variable	SPDM Response Message. The value of this field shall represent a valid SPDM response message. The length of this field is dependent on the SPDM Response message. The field shall start with the `SPDMVersion` field. The `SPDMVersion` field of the `Encapsulated Response` shall be the same as `SPDMVersion` of the `DELIVER_ENCAPSULATED_RESPONSE` request. Both `ENCAPSULATED_REQUEST` and `ENCAPSULATED_RESPONSE_ACK` shall be invalid responses and the Responder should respond with `ErrorCode=InvalidResponseCode` if these responses are encapsulated.

622 Table 75 — ENCAPSULATED_RESPONSE_ACK response message format describes the response message format.

623 **Table 75 — ENCAPSULATED_RESPONSE_ACK response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x6B` = `ENCAPSULATED_RESPONSE_ACK`. See Table 5 — SPDM response codes.
2	Param1	1	Request ID. If `EncapsulatedRequest` is present and `Param2` = `0x01`, then this field should contain a unique, non-zero number to help the Responder match response to request. Otherwise, this field shall be `0x00`.
3	Param2	1	Payload Type. If set to `0x00` no request message is encapsulated and the `EncapsulatedRequest` field is absent. If set to `0x01` the `EncapsulatedRequest` field follows. If set to `0x02` a 1-byte `EncapsulatedRequest` field follows containing the `SlotID` of the Requester's certificate chain used for mutual authentication. The value in this field shall be between 0 and 7 inclusive. All other values Reserved.
4	AckRequestID	1	Shall be the same as `Param1` of the `DELIVER_ENCAPSULATED_RESPONSE` request message. The purpose of this field is to help the Requester distinguish between new requests and a retry.
5	Reserved	3	Reserved.

Byte offset	Field	Size (bytes)	Description
8	EncapsulatedRequest	Variable	If `Param2` = `0x01` , the value of this field shall represent a valid SPDM request message. The length of this field is dependent on the SPDM Request message. The field shall start with the `SPDMVersion` field. The `SPDMVersion` field of the `EncapsulatedRequest` shall be the same as `SPDMVersion` of the `ENCAPSULATED_REQUEST` response. Both `GET_ENCAPSULATED_REQUEST` and `DELIVER_ENCAPSULATED_RESPONSE` shall be invalid requests and the Requester shall respond with `ErrorCode=UnexpectedRequest` if these requests are encapsulated. If `Param2` = `0x02` , the value of this field shall contain the `SlotID` corresponding to the certificate chain the Requester shall use for mutual authentication. The field size shall be 1 byte. If `Param2` = `0x00` , this field shall be absent.

624 10.23.1 Additional information

625 Using a unique request ID is highly recommended to aid the Responder in avoiding confusion between a retry and a new `DELIVER_ENCAPSULATED_RESPONSE` message. For example, if the Responder sent the `ENCAPSULATED_RESPONSE_ACK` with a new encapsulated request and that failed in transmission over the wire, the Requester would send a retry but that retry would still contain the response to the previous encapsulated request. Without a different request ID, the Responder might mistake the retried `DELIVER_ENCAPSULATED_RESPONSE` for a new request when, in fact, it was a retry. This mistake might cause additional mistakes to occur.

626 In general, the response timing for `ENCAPSULATED_RESP_ACK` shall be subject to the same timing constraints as the encapsulated request. For example, if the encapsulated request was `CHALLENGE_AUTH` , the Responder, too, shall adhere to `CT` timing rules when it has a subsequent request. The Requester can return `ErrorCode=ResponseNotReady` .

627 The `DELIVER_ENCAPSULATED_RESPONSE` and `ENCAPSULATED_RESPONSE_ACK` messages shall only be allowed to encapsulate certain requests in certain scenarios. For constraint details, see Session, Basic mutual authentication, and KEY_UPDATE request and KEY_UPDATE_ACK response messages clauses.

628 10.23.2 Allowance for encapsulated requests

629 Only certain requests can be encapsulated in any encapsulated request flow. Their corresponding response, including `ERROR` , can be encapsulated too. Additionally, these requests are only allowed in certain flows, such as Basic Mutual Authentication, and are described in various parts of this specification. The consolidated list of requests allowed to be encapsulated shall be these requests:

- `CHALLENGE`
- `GET_CERTIFICATE`
- `GET_DIGESTS`
- `KEY_UPDATE`

630 If a request is not in the list, then the request and its corresponding response shall be prohibited from being encapsulated.

631 10.23.3 Certain error handling in encapsulated flows

632 These clauses describe special error scenarios and their handling requirements.

633 10.23.3.1 Response not ready

634 In an encapsulated request flow, a Responder can issue an encapsulated request that can take up to `CT` time to fulfill. When the Requester delivers an `ERROR` message with a `ResponseNotReady` error code, the Responder shall not encapsulate another request by setting `Param2` in `ENCAPSULATED_RESPONSE_ACK` to a value of zero. This effectively and naturally terminates the encapsulated request flow.

635 The Responder should wait the amount of time indicated in the `ERROR` message for this particular error code.

636 When the timeout is near expiration, the Responder should perform the following:

1. Trigger its transport-defined alert mechanism to initiate the Encapsulated request flow.
2. When the Requester issues a `GET_ENCAPSULATED_REQUEST`, the Responder should encapsulate the `RESPOND_IF_READY` request populated with the information from the previous `ERROR` with `ResponseNotReady` message.
    - If the Responder does not, the Requester can drop the original response.

637 10.23.3.2 Timeouts

638 If the Responder is not receiving a response to its encapsulated request, the Responder can trigger its transport-defined alert mechanism. When this occurs, if the Requester is in the middle of an existing encapsulated request flow with the same Responder, then the existing flow shall terminate and the Requester shall restart the encapsulated request flow.

639 Both Responder and Request should comply with the timing requirements laid forth in Timing requirements.

640 10.24 END_SESSION request and END_SESSION_ACK response messages

641 This request shall terminate a session. Further communication between the Requester and Responder using the same session ID shall be prohibited. See the Session termination phase clause.

642 Table 76 — END_SESSION request message format and Table 776 — End session request attributes describe this format.

643 **Table 76 — END_SESSION request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xEC` = `END_SESSION`. See Table 4 — SPDM request codes.
2	Param1	1	See Table 77 — End session request attributes.
3	Param2	1	Reserved.

644 **Table 77 — End session request attributes**

Byte offset	Value	Field	Description
0	0	Negotiated State Preservation Indicator	If the Responder supports Negotiated State caching (`CACHE_CAP=1`), the Responder shall preserve the Negotiated State. Otherwise, this field shall be ignored.
0	1	Negotiated State Preservation Indicator	If the Responder supports Negotiated State caching (`CACHE_CAP=1`), the Responder shall also clear the Negotiated State as part of session termination. If there is no Negotiated State to be cleared due to a previous `END_SESSION` request message with this field set to 1, this field shall be ignored. If the Responder does not support Negotiated State caching (`CACHE_CAP=1`), this field shall be ignored.
[7:1]	Reserved	Reserved	Reserved.

645 Table 78 — END_SESSION_ACK response message format describes the response message.

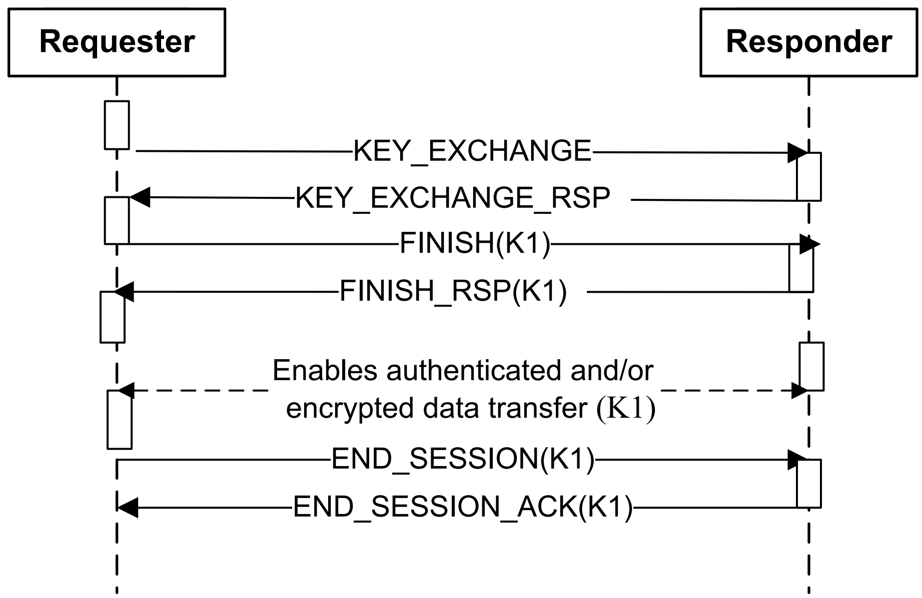
646 **Table 78 — END_SESSION_ACK response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x6C` = `END_SESSION_ACK`. See Table 5 — SPDM response codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.

647 Figure 23 — END_SESSION protocol flow shows the `END_SESSION` protocol flow:

648 **Figure 23 — END_SESSION protocol flow**

649



650 10.25 Certificate provisioning

651 These clauses describe the request and response messages used for provisioning a device with certificate chains. Provisioning of Slot 0 should be only done in a secure environment (such as a secure manufacturing environment).

652 10.25.1 GET_CSR request and CSR response messages

653 The `GET_CSR` request message shall retrieve a Certificate Signing Request (CSR) from the Responder. For the provisioning of Slot 0, this command should be run in a secure environment (such as a secure manufacturing environment). For all additional slots, the Requester shall issue this command inside a secure session. Verification of request authorization for slots 1-7 is outside the scope of the current revision of the specification.

654 A Responder shall only process a `GET_CSR` request if it already possesses an appropriate asymmetric key pair for each of the signature suites (algorithms and associated parameters) it supports. If more than one signature suites are supported, selection of the appropriate signature suite (and thus key pair) shall be determined via the most recent `ALGORITHMS` response. Upon receiving a `GET_CSR` request, a Responder shall generate and sign a CSR for the corresponding public key. The CSR shall be populated with a combination of attributes provided by the Requester via the `RequesterInfo` field, and others contributed by the Responder itself. `RequesterInfo` format shall comply to the PKCS #10 specification in RFC2986, specifically the `CertificationRequestInfo` format. OEM extensions (that is, OEM OIDs) shall be encoded using the `Attributes` type. The Responder shall return an `ERROR` message with error code `InvalidRequest` if it cannot support all of the fields included in the `RequesterInfo`. If the

device requires a reset to complete the `GET_CSR` request, then the device shall respond with an `ErrorCode=ResetRequired` response.

655 The attributes of the resulting CSR and their values shall comply with the clauses presented in the SPDM certificate requirements and recommendations section. If the device conforms to the `DeviceCert` model (`ALIAS_CERT_CAP=0b` in `CAPABILITIES` response), the resulting CSR shall be for a Device Certificate. If the device conforms to the `AliasCert` model (`ALIAS_CERT_CAP=1b` in `CAPABILITIES` response), the resulting CSR shall be for a Device Certificate CA. See Identity provisioning for more details.

656 Table 79 — GET_CSR request message format shows the `GET_CSR` request message format.

657 Table 80 — CSR response message format shows the `CSR` response message format.

658 The resulting CSR contained in a successful `CSR` response will have to be signed by an appropriate Certificate Authority. The details of the Public Key Infrastructure used to verify and sign the CSR, and make the final certificate available for provisioning are outside the scope of this specification.

659 **Table 79 — GET_CSR request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xED` = `GET_CSR` . See Table 4 — SPDM request codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.
4	RequesterInfoLength	2	Length of `RequesterInfo` field in bytes provided by the Requester. This field can be 0.
6	OpaqueDataLength	2	Size of the `OpaqueData` field that follows in bytes. The value should not be greater than 1024 bytes. Shall be `0` if no `OpaqueData` is provided.
8	RequesterInfo	`RequesterInfoLength`	Optional information provided by the Requester.
8 + `RequesterInfo`	OpaqueData	`OpaqueDataLength`	The Requester can include vendor-specific information for the Responder to generate the CSR. This field is optional. If present, this field shall conform to the selected opaque data format in `OtherParamsSelection` .

660 **Table 80 — CSR response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x6D` = `CSR` . See Table 5 — SPDM response codes.
2	Param1	1	Reserved.
3	Param2	1	Reserved.
4	CSRLength	2	Length of the `CSRdata` in bytes.
6	Reserved	2	Reserved.
8	CSRdata	`CSRLength`	Requested contents of the CSR. DER-encoded.

661 The `CSRdata` format shall comply to the PKCS #10 specification in RFC2986.

662 10.25.2 SET_CERTIFICATE request and SET_CERTIFICATE_RSP response messages

663 For Slot 0 provisioning, the Requester should issue `SET_CERTIFICATE` only in a secure environment (such as a secure manufacturing environment). The Requester shall issue `SET_CERTIFICATE` inside a secure session for slot 1-7 provisioning. Responder verification of Requester authorization to issue this request is outside the scope of this specification. The device might require a reset to complete the `SET_CERTIFICATE` request, potentially so that the device can generate `AliasCert` certificates using lower firmware layers. If the device requires a reset to complete the `SET_CERTIFICATE` request, then the device shall respond with an `ErrorCode=ResetRequired` response.

664 Table 81 — SET_CERTIFICATE request message format shows the `SET_CERTIFICATE` request message format.

665 Table 82 — Successful SET_CERTIFICATE_RSP response message format shows the `SET_CERTIFICATE_RSP` response message format.

666 **Table 81 — SET_CERTIFICATE request message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0xEE` = `SET_CERTIFICATE` . See Table 4 — SPDM request codes.
2	Param1	1	Bit [7:4]. Reserved. Bit [3:0]. `SlotID` where the new certificate is written The value in this field shall be between 0 and 7 inclusive.
3	Param2	1	Reserved.

Byte offset	Field	Size (bytes)	Description
4	CertChain	Variable	Contents of target certificate chain, as specified in Certificates and certificate chains. If the Responder uses the `AliasCert` model (`ALIAS_CERT_CAP=1b` in `CAPABILITIES` response), this field shall contain a partial certificate chain from the root CA, or the certificate that is signed by the root CA, to the Device Certificate CA.

667 **Table 82 — Successful SET_CERTIFICATE_RSP response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x6E` = `SET_CERTIFICATE_RSP` . See Table 5 — SPDM response codes.
2	Param1	1	Bit [7:4]. Reserved. Bit [3:0]. `SlotID` where the new certificate is written The value in this field shall be between 0 and 7 inclusive.
3	Param2	1	Reserved.

668 10.26 Large SPDM message transfer mechanism

669 A large SPDM message is an SPDM message whose size is greater than the `DataTransferSize` of the receiving SPDM endpoint. These clauses provide a transport agnostic mechanism to transfer large SPDM messages. This mechanism will be used only when the size of an SPDM message exceeds the `DataTransferSize` of the receiving SPDM endpoint. Additionally, the transport may provide an alternative method to transfer large SPDM messages. For SPDM messages that are less than or equal to the `DataTransferSize` of the receiving SPDM endpoint, the sending SPDM endpoint shall not utilize this transfer mechanism.

670 This transfer mechanism divides a large SPDM message into smaller fragments. With the exception of the first and last fragment, all fragments are equal in size. These fragments are called chunks. The chunks shall be numbered and shall transfer in sequence. The chunks and transfer sequence are as such:

- The first chunk shall be assigned a numeric value of 0, the second chunk shall be assigned a numeric value of 1, the third chunk shall be assigned a numeric value of 2 and this pattern shall continue until the last chunk. These numeric values are called a chunk sequence number.
- The first chunk shall contain the first set of bytes of the large SPDM message, the second chunk shall contain the second set of bytes, the third chunk shall contain the third set of bytes and this pattern shall continue until the last chunk.
- All chunks shall represent all bytes of the large SPDM message without altering the message in any way.

- The sequence of transfer shall start with chunk sequence number 0 and shall continue in a monotonically increasing chunk sequence number until the last chunk.
- `CHUNK_SEND`, `CHUNK_GET` and their corresponding Responses shall be used to transfer these chunks.

671 The `ChunkSeqNo` fields indicate the chunk sequence number for a given chunk.

672 The requests and responses, which these clauses define, handle the transfer of each chunk.

673 10.26.1 CHUNK_SEND request and CHUNK_SEND_ACK response message

674 `CHUNK_SEND` request and `CHUNK_SEND_ACK` response shall be used to send a request to an SPDM endpoint when the size of the request is greater than the `DataTransferSize` of the receiving SPDM endpoint.

675 Table 83 — CHUNK_SEND request format table describes the format for the request.

676 Table 84 — Chunk sender attributes describes the chunk sender attributes:

677 **Table 83 — CHUNK_SEND request format table**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x85` = `CHUNK_SEND` request. See Table 4 — SPDM request codes.
2	Param1	1	Request Attributes. See Table 84 — Chunk sender attributes.
3	Param2	1	Handle. This field should uniquely identify the transfer of a large SPDM message. The value of this field shall be the same for all chunks of the same large SPDM message. The value of this field should either entirely monotonically increase or entirely monotonically decrease with each large SPDM message and with the expectation that it will wrap around after reaching the maximum or minimum value, respectively, of this field.
4	ChunkSeqNo	2	Shall identify the chunk number associated with `SPDMChunk`.
6	Reserved	2	Reserved.
8	ChunkSize	4	Shall indicate the size of `SPDMchunk`. See Additional chunk transfer requirements.
12	LargeMessageSize	L0 = 0 or 4	Shall indicate the size of the large SPDM message being transferred. This field shall only be present when `ChunkSeqNo` is zero and shall have a non-zero value. The value of this field should be greater than the `DataTransferSize` of the receiving SPDM endpoint.
12 + `L0`	SPDMchunk	Variable	Shall contain the chunk of the large SPDM request message associated with `ChunkSeqNo`.

678 **Table 84 — Chunk sender attributes**

Bit offset	Field	Description
0	LastChunk	If set, the chunk, indicated by `ChunkSeqNo`, shall represent the last chunk of the large SPDM message.
[7:1]	Reserved	Reserved.

679 Table 85 — CHUNK_SEND_ACK response message format describes the format for the response.

680 **Table 85 — CHUNK_SEND_ACK response message format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x05` = `CHUNK_SEND_ACK` response. See Table 5 — SPDM response codes.
2	Param1	1	Response attributes. See Table 86 — Chunk receiver attributes.
3	Param2	1	Handle. This field should uniquely identify the transfer of a large SPDM message. The value of this field shall be the same for all chunks of the same SPDM message.
4	ChunkSeqNo	2	Shall be the same as `ChunkSeqNo` in the corresponding request.
6	ResponseToLargeRequest	Variable	Shall be present on the last chunk (that is when `LastChunk` is set), or when the `EarlyErrorDetected` bit in `Param1` is set. This field shall contain the response to the large SPDM request message. When the `EarlyErrorDetected` bit in `Param1` is set, this field shall contain an `ERROR` message.

681 Table 86 — Chunk receiver attributes describes the chunk receiver attributes:

682 **Table 86 — Chunk receiver attributes**

Bit offset	Field	Description
0	EarlyErrorDetected	If set, the receiver of a large SPDM request message detected an error in the Request before the last chunk was received. If set, the sender of the large SPDM request message shall terminate the transfer of any remaining chunks. After addressing the issue, the sender of the failed large SPDM request message can transfer the fixed large SPDM request message as a new transfer.
[7:1]	Reserved	Reserved.

683 Table 85 — CHUNK_SEND_ACK response message format describes the format for the response.

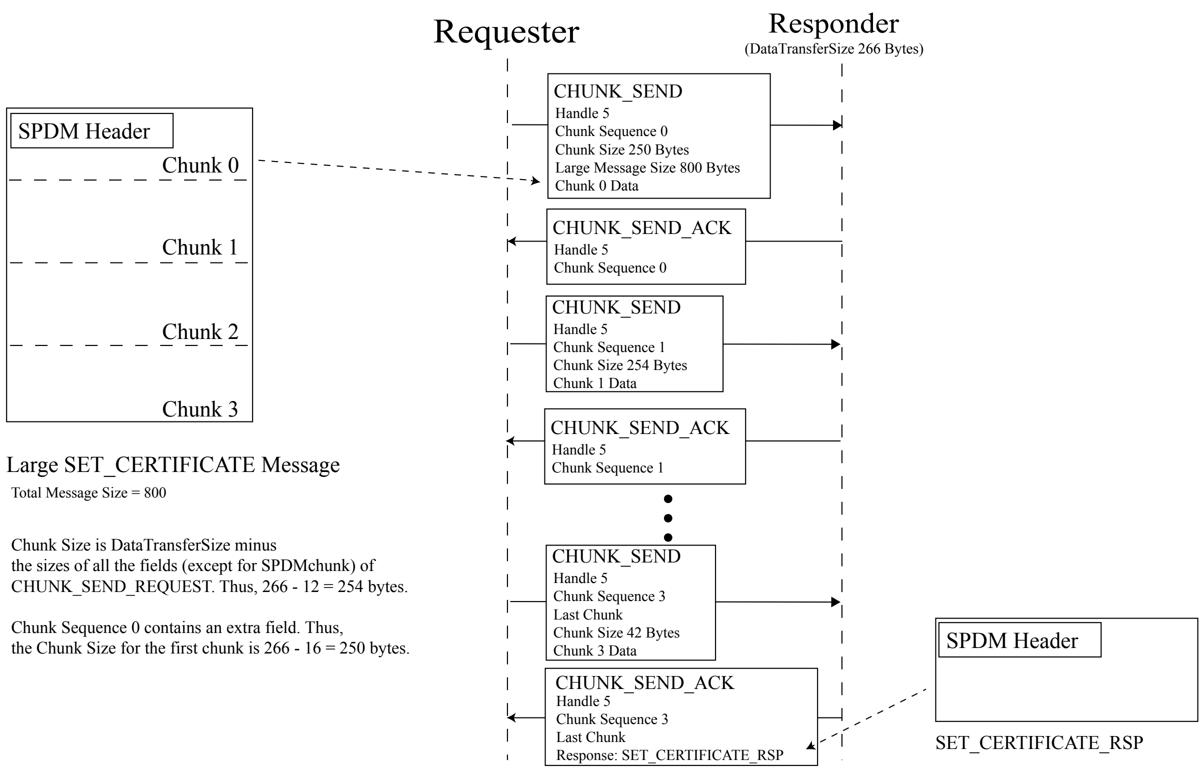
684 Upon reception of the last chunk, the receiving SPDM endpoint shall respond with the response corresponding to the

large SPDM request message in `ResponseToLargeRequest`. If placing the response in `ResponseToLargeRequest` causes the size of the `CHUNK_SEND_ACK` to exceed `DataTransferSize`, the receiving end point shall, instead, respond to `CHUNK_SEND` with an `ERROR` message using `ErrorCode == LargeResponse`. An `ERROR` message with an `ErrorCode == LargeResponse` shall not be allowed in `ResponseToLargeRequest`. An `ERROR` messages with other `ErrorCodes` can be placed in `ResponseToLargeRequest` to distinguish between an `ERROR` message to the `CHUNK_SEND` request and an `ERROR` message that is a response to the large SPDM request message.

685 Figure 24 — Large SET_CERTIFICATE example illustrates the sending of a large SPDM request message to a Responder.

686 **Figure 24 — Large SET_CERTIFICATE example**

687



688 10.26.2 CHUNK_GET request and CHUNK_RESPONSE response message

689 `CHUNK_GET` request and `CHUNK_RESPONSE` response shall be used to retrieve a Large SPDM Response from an SPDM endpoint when the size of the Response is greater than the `DataTransferSize` of the SPDM endpoint receiving the Response.

690 When responding to a Request of any size, if the corresponding response will be a Large SPDM Response, the responding SPDM endpoint shall respond with an `ERROR` message using `ErrorCode == LargeResponse`. This `ERROR` message contains a handle to uniquely identify the given Large SPDM Response. The handle shall be used

for all `CHUNK_GET` Requests retrieving the same large SPDM message. The value of the handle is indicated in the `Handle` field of the `ERROR` message with `ErrorCode == LargeResponse`.

691 Table 87 — CHUNK_GET request format describes the format for the request.

692 **Table 87 — CHUNK_GET request format**

Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x86` = `CHUNK_GET` request. See Table 4 — SPDM request codes.
2	Param1	1	Reserved.
3	Param2	1	Handle. This field shall be the same value as given in the `Handle` field of the `ERROR` message with `ErrorCode = LargeResponse`.
4	ChunkSeqNo	2	Shall indicate the desired chunk sequence number of the Large SPDM Response to retrieve.

693 Table 88 — CHUNK_RESPONSE response format describes the format for the response.

694 **Table 88 — CHUNK_RESPONSE response format**

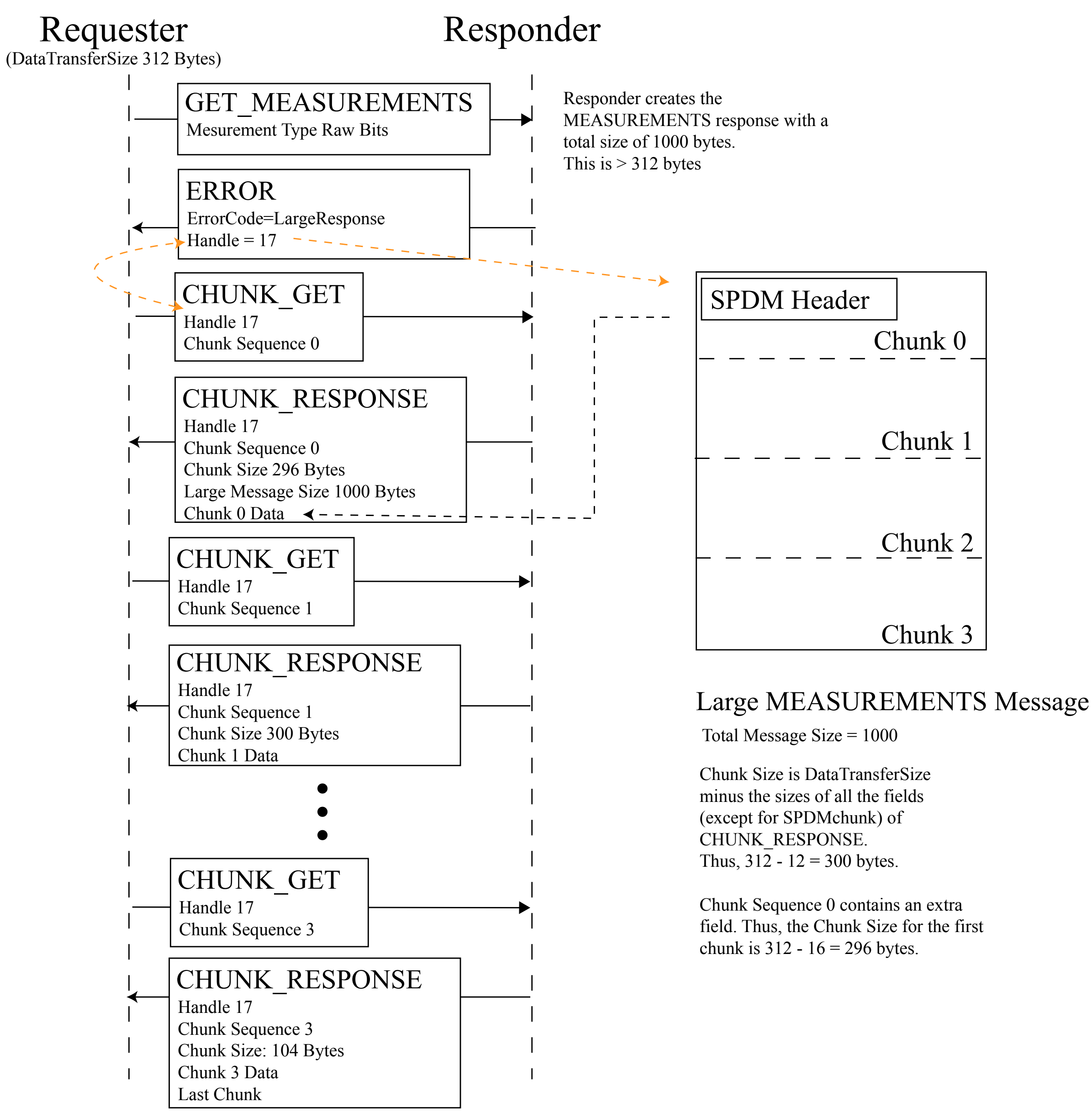
Byte offset	Field	Size (bytes)	Description
0	SPDMVersion	1	Shall be the `SPDMVersion` as described in SPDM version.
1	RequestResponseCode	1	`0x06` = `CHUNK_RESPONSE` response. See Table 5 — SPDM response codes.
2	Param1	1	Response attributes. See Table 84 — Chunk sender attributes.
3	Param2	1	Handle. This field shall be the same for all chunks of the same Large SPDM Response. The value of this field shall be the same value as in `Param2` field of `CHUNK_GET`.
4	ChunkSeqNo	2	Shall identify the chunk sequence number associated with `SPDMChunk`. The value of this field shall be the same value as `ChunkSeqNo` in the `CHUNK_GET`.
6	Reserved	2	Reserved.
8	ChunkSize	4	Shall indicate the size of `SPDMchunk`. See Additional chunk transfer requirements.
12	LargeMessageSize	L0 = 0 or 4	Shall indicate the size of the large SPDM message being transferred. Shall only be present when `ChunkSeqNo` is zero and shall have a non-zero value. The value of this field should be greater than the `DataTransferSize` of the receiving SPDM endpoint.

Byte offset	Field	Size (bytes)	Description
12 + L0	SPDMchunk	Variable	Shall contain the chunk of the large SPDM request message associated with ChunkSeqNo .

695 Figure 25 — Large MEASUREMENT example illustrates the sending and retrieval of a Large SPDM Response to a Requester that issued a GET_MEASUREMENT request.

696 **Figure 25 — Large MEASUREMENT example**

697



698 10.26.3 Additional chunk transfer requirements

699 When transferring a large SPDM message, an SPDM endpoint shall be prohibited from transferring a chunk sequence number (that is, `ChunkSeqNo`) less than the current chunk sequence number. In other words, an SPDM endpoint cannot go backwards in the transfer or re-send or re-retrieve a chunk sequence number less than the current one in the transfer. However, due to retries, an SPDM endpoint might re-send or re-retrieve the current chunk number in the transfer. Additionally, if the receiving SPDM endpoint receives an out-of-order chunk sequence

number, the receiving SPDM endpoint shall silent discard the request or respond with an `ERROR` message with `ErrorCode = InvalidRequest`.

700 In general, the value of `ChunkSize` fields shall be one that ensures the total size of `CHUNK_SEND` or `CHUNK_RESPONSE` does not exceed the `DataTransferSize` of the receiving SPDM endpoint. For all chunks that are not the last chunk, `ChunkSize` shall be a value where the total size of `CHUNK_SEND` or `CHUNK_RESPONSE` shall equal the `DataTransferSize` of the receiving SPDM endpoint. For the last chunk, `ChunkSize` shall be a value where the total size of `CHUNK_SEND` or `CHUNK_RESPONSE` shall be equal to or less than the `DataTransferSize` of the receiving SPDM endpoint.

701 While this transfer mechanism can carry any Request or Response, this transfer mechanism shall prohibit `CHUNK_SEND`, `CHUNK_GET` and their corresponding responses to be transferred as chunks themselves. Additionally to ensure reliability of this transfer mechanism and general interoperability, these messages shall be prohibited from being transferred in chunks using this transfer mechanism:

- `GET_VERSION`
- `GET_CAPABILITIES`
- `CAPABILITIES`
- `ERROR`
  - An `ERROR` message with `ErrorCodes` other than `LargeResponse` can be placed in `ResponseToLargeRequest` of `CHUNK_SEND_ACK` response.

702 This transfer mechanism can carry Requests and Responses that are involved in signature generation or verification and other cryptographic computations. However, this transfer mechanism is not part of any signature generation or verification or cryptographic computation. In other words, `CHUNK_SEND`, `CHUNK_GET` and their corresponding responses shall not become part of any data or bit stream, such as message transcript, transcript, and so on, that are used to verify or generate a signature or other cryptographic information. Signature generation, signature verification and other cryptographic computation operate on the large SPDM messages, themselves, which other parts of this specification define.

703 The response to a `CHUNK_SEND` or `CHUNK_GET` request, themselves, shall not be `ErrorCode == ResponseNotReady`. However, the `ResponseToLargeRequest` can contain an `ERROR` message with `ErrorCode == ResponseNotReady`.

704 While a large SPDM message is being transferred in chunks, the large SPDM message is not considered a complete SPDM message until the last chunk is received. Therefore, as soon as the `CHUNK_SEND` request begins transmission, the large SPDM request message is considered to be outstanding.

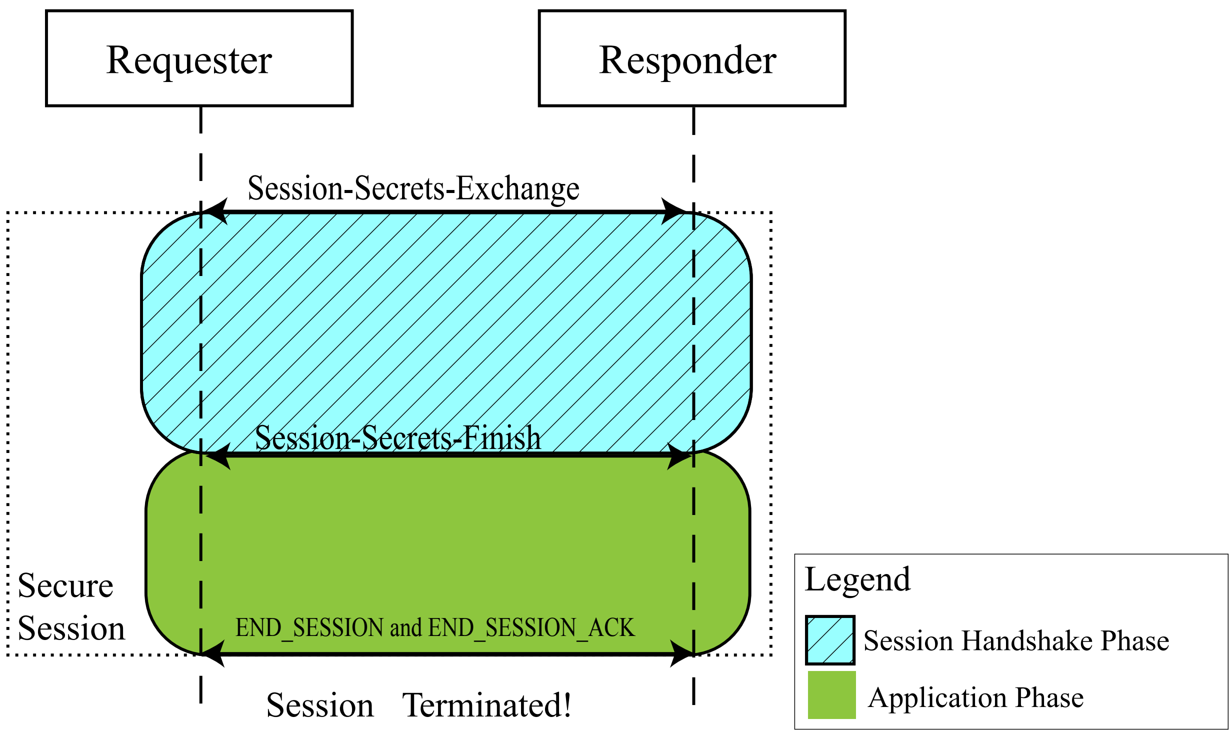
705 # 11 Session

706 Sessions enable a Requester and Responder to have multiple channels of communication. More importantly, it enables a Requester and Responder to build a secure communication channel with cryptographic information that is bound ephemerally. Specifically, an SPDM session provides either or both of encryption or message authentication.

707 A session has three phases, as Figure 26 — Session phases shows:

- The handshake
- The application
- Termination

708 **Figure 26 — Session phases**

709 

710 ## 11.1 Session handshake phase

711 The session handshake phase begins with either `KEY_EXCHANGE` or `PSK_EXCHANGE`. This phase also allows for authentication of the Requester if the Responder indicated that earlier in `ALGORITHMS` response. Furthermore, this phase of the session uses the handshake secrets to secure the communication as described in the Key schedule.

712 The purpose of this phase is to build trust between the Responder and Requester, first, before either side can send application data. Additionally, it also ensures the integrity of the handshake and to a certain degree, synchronicity with the derived handshake secrets.

713 In this phase of the session, `GET_ENCAPSULATED_REQUEST` and `DELIVER_ENCAPSULATED_RESPONSE` shall be used to obtain requests from the Responder to complete the authentication of the Requester, if the Responder indicated this in `ALGORITHMS` message. The only requests allowed to be encapsulated shall be `GET_DIGESTS` and `GET_CERTIFICATE`. The Requester shall provide a signature in the `FINISH` request, as the FINISH request and FINISH_RSP response messages clause describes.

714 If an error occurs in this phase with `ErrorCode = DecryptError`, the session shall immediately terminate and proceed to session termination.

715 A successful handshake ends with either `FINISH_RSP` or `PSK_FINISH_RSP` and the application phase begins.

716 11.2 Application phase

717 Once the handshake completes and all validation passes, the session reaches the application phase where either the Responder and Requester can send application data.

718 During this phase, a Requester can send SPDM messages such as `GET_MEASUREMENT`. These messages might involve transcript calculations and if such calculations are required, they shall be calculated on a per session basis.

719 The application phase ends when either the `HEARTBEAT` requirements fail, `END_SESSION` or an `ERROR` message with `ErrorCode = DecryptError`. The next phase is the session termination phase.

720 11.3 Session termination phase

721 This phase signals the end of the application phase and the enactment of internal clean-up procedures by the endpoints. Requesters and Responders can have various reasons for terminating a session, outside the scope of this specification.

722 SPDM provides the `END_SESSION` / `END_SESSION_ACK` message pair to explicitly trigger the session termination phase if needed, but depending on the transport, it might simply be an internal phase with no explicit SPDM messages sent or received.

723 When a session terminates, both Requester and Responder shall destroy or clean up all session secrets such as derived major secrets, DHE secrets and encryption keys. Endpoints might have other internal data associated with a session that they should also clean up.

724 11.4 Simultaneous active sessions

725 If a Responder supports key exchanges, the maximum number of simultaneous active sessions shall be a minimum of one. If the `KEY_EXCHANGE` or `PSK_EXCHANGE` request will exceed the maximum number of simultaneous active sessions of the Responder, the Responder shall respond with an `Errorcode = SessionLimitExceeded`.

726 This specification does not prohibit concurrent sessions in which the same Requester and Responder reverses role. For example, SPDM endpoint ABC, acting as a Requester, can establish a session to SPDM endpoint XYZ, which is acting as a Responder. At the same time, SPDM endpoint XYZ, now acting as a Requester, can establish a session to SPDM endpoint ABC, now acting as a Responder. Because these two sessions are distinct and separate, the two endpoints should ensure they do not mix sessions. To ensure proper session handling, each endpoint should ensure their portion of the session IDs are unique at time of Session-Secrets-Exchange. This would form a final unique session ID for that new session. Additionally, the endpoints can use information at the transport layer to further ensure proper handling of sessions.

727 11.5 Records and session ID

728 When the session starts, the communication of secured data is done using records. A record represents a chunk or unit of data that is either or both encrypted or authenticated. This data can be either an SPDM message or application data. Usually, the record contains the session ID resulting from one of the Session-Secrets-Exchange messages to aid both the Responder and Requester in binding the record to the respective derived session secrets.

729 The actual format and other details of a record is outside the scope of this specification. It is generally assumed that the transport protocol will define the format and other details of the record.

730 # 12 Key schedule

731 A key schedule describes how the various keys such as encryption keys used by a session are derived, and when each key is used. The default SPDM key schedule makes heavy use of `HMAC`, which RFC2104 defines, and `HKDF-Expand`, which RFC5869 describes. SPDM defines the following additional functions:

```
BinConcat(Length, Version, Label, Context)
```

732 where

- `BinConcat` shall be the concatenation of binary data, in the order that Table 89 — BinConcat details shows:

733 **Table 89 — BinConcat details**

Order	Data	Type	Endianness	Size
1	Length	Binary	Little	16 bits
2	Version	Text	Text	8 bytes
3	Label	Text	Text	Variable
4	Context	Binary	Little	`Hash.Length`

734 If `Context` is null, `BinConcat` is the concatenation of the first three components only.

735 Table 90 — Version details describes the version details.

736 **Table 90 — Version details**

SPDM version	Version text
SPDM 1.1	"spdm1.1 "

737 The `HKDF-Expand` function prototype, as used by the default SPDM key schedule, is as follows:

```
HKDF-Expand(secret, context, Hash.Length)
```

738 The `HMAC-Hash` function prototype is described as follows:

```
HMAC−Hash(salt, IKM);
```

739 where

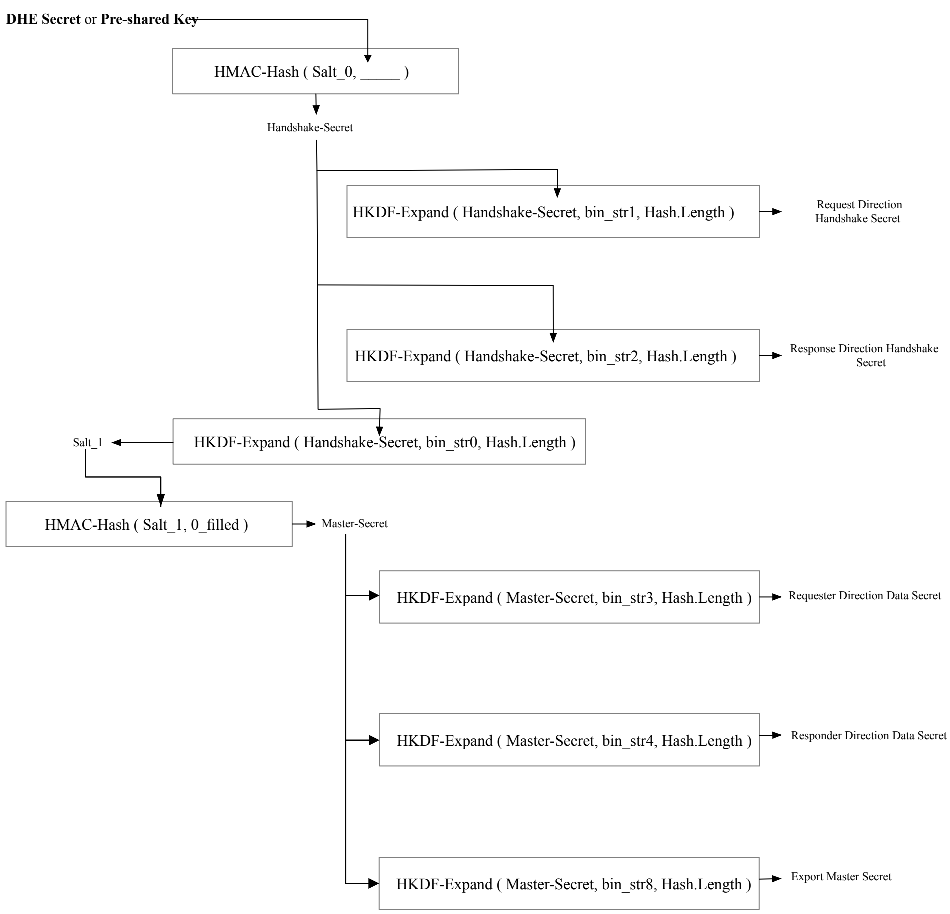
- IKM is the Input Keying Material and HMAC-Hash uses `HMAC`, which RFC2104 defines.

740 For `HKDF−Expand` and `HMAC−Hash`, the hash function shall be the selected hash function in `ALGORITHMS` response. `Hash.Length` shall be the length of the output of the hash function selected by the `ALGORITHMS` response.

741 Both Responder and Requester shall use the key schedule that Figure 27 — Key schedule shows.

742 **Figure 27 — Key schedule**

743



744 In the figure, arrows going out of the box are outputs of that box. Arrows going into the box are inputs into the box and point to the specific input parameter they are used in. All boxes represent a single function producing a single output and are given a name for clarity.

745 Table 91 — Key schedule accompanies the figure to complete the Key Schedule. The Responder and Requester shall also adhere to the definition of this table.

746 **Table 91 — Key schedule**

Variable	Definition
Salt_0	A zero-filled array of `Hash.Length` length.
0_filled	A zero-filled array of `Hash.Length` length.
bin_str0	`BinConcat(Hash.Length, Version, "derived", NULL)`
bin_str1	`BinConcat(Hash.Length, Version, "req hs data", TH1)`
bin_str2	`BinConcat(Hash.Length, Version, "rsp hs data", TH1)`
bin_str3	`BinConcat(Hash.Length, Version, "req app data", TH2)`
bin_str4	`BinConcat(Hash.Length, Version, "rsp app data", TH2)`
DHE Secret	This shall be the secret derived from `KEY_EXCHANGE/KEY_EXCHANGE_RSP`
Pre-shared Key	PSK

747 > **Note:** With common hash functions, any label longer than 12 characters requires an additional iteration of the hash function to compute. As in RFC8446, the previously defined labels have all been chosen to fit within this limit.

748 ## 12.1 DHE secret computation

749 The DHE secret is a shared secret and its computation is different per algorithm or algorithm class. These clauses define the format and computation for DHE algorithms.

750 For `ffdhe2048`, `ffdhe4096`, `secp256r1`, `secp384r1`, and `secp521r1`, the format and computation of the DHE secret shall be the shared secret, which section 7.4 of RFC8446 defines.

751 For `SM2_P256`, the parameters of this curve are defined in the TCG Algorithm Registry. The DHE secret shall be K_A and K_B as defined in GB/T 32918.3-2016. The Requester shall compute K_A and the Responder shall compute K_B to arrive to the same secret value. K_A and K_B are the results of a KDF. This specification shall use the KDF as defined by the GB/T 32918.3-2016. The size of the DHE secret, referred to as `klen` in the KDF of GB/T 32918.3 specification, shall be the key size of the selected AEAD algorithm in `RespAlgStruct`. Lastly, GB/T 32918.3 allows

for a flexible hash algorithm. The hash algorithm shall be the selected hash algorithm in `BashHashSel` or `ExtHashSel`.

752 12.2 Transcript hash in key derivation

753 The key schedule uses two transcript hashes:

- **TH1**
- **TH2**

754 12.3 TH1 definition

755 If the Requester and Responder used `KEY_EXCHANGE` / `KEY_EXCHANGE_RSP` to exchange initial keying information, then **TH1** shall be the output of applying the negotiated hash function to the concatenation of the following:

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used
3. `[KEY_EXCHANGE]` . `*`
4. `[KEY_EXCHANGE_RSP]` . `*` except the `ResponderVerifyData` field

756 If the Requester and Responder used `PSK_EXCHANGE` / `PSK_EXCHANGE_RSP` to exchange initial keying information, then **TH1** shall be the output of applying the negotiated hash function to the concatenation of the following:

1. `VCA`
2. `[PSK_EXCHANGE]` . `*`
3. `[PSK_EXCHANGE_RSP]` . `*` except the `ResponderVerifyData` field

757 12.4 TH2 definition

758 If the Requester and Responder used `KEY_EXCHANGE` / `KEY_EXCHANGE_RSP` to exchange initial keying information, then **TH2** shall be the output of applying the negotiated hash function to the concatenation of the following:

1. `VCA`
2. Hash of the specified certificate chain in DER format (that is, `Param2` of `KEY_EXCHANGE`) or hash of the public key in its provisioned format, if a certificate is not used
3. `[KEY_EXCHANGE]` . `*`
4. `[KEY_EXCHANGE_RSP]` . `*`
5. Hash of the specified certificate chain in DER format (that is, `Param2` of `FINISH`) or hash of the public key in its provisioned format, if a certificate is not used. (Valid only in mutual authentication)

6. [FINISH].*
7. [FINISH_RSP].*

759 If the Requester and Responder used PSK_EXCHANGE / PSK_EXCHANGE_RSP to exchange initial keying information, then **TH2** shall be the output of applying the negotiated hash function to the concatenation of the following:

1. VCA
2. [PSK_EXCHANGE].*
3. [PSK_EXCHANGE_RSP].*
4. [PSK_FINISH].* (if issued)
5. [PSK_FINISH_RSP].* (if issued)

760 12.5 Key schedule major secrets

761 The key schedule produces four major secrets:

- Request-direction handshake secret (S_0)
- Response-direction handshake secret (S_1)
- Request-direction data secret (S_2)
- Response-direction data secret (S_3)

762 Each secret applies in a certain direction of transmission and only valid during a certain time frame. These four major secrets, each, will be used to derive their respective encryption key and IV to be used in the AEAD function as selected in the ALGORITHMS response.

763 12.5.1 Request-direction handshake secret

764 This secret shall only be used during the session handshake phase and shall be applied to all requests after KEY_EXCHANGE or PSK_EXCHANGE up to and including FINISH or PSK_FINISH.

765 12.5.2 Response-direction handshake secret

766 This secret shall only be used during the session handshake phase and shall be applied to all responses after KEY_EXCHANGE_RSP or PSK_EXCHANGE_RSP up to and including FINISH_RSP or PSK_FINISH_RSP.

767 12.5.3 Requester-direction data secret

768 This secret shall be used for any data transmitted during the application phase of the session. This secret shall only be applied for all data traveling from the Requester to the Responder.

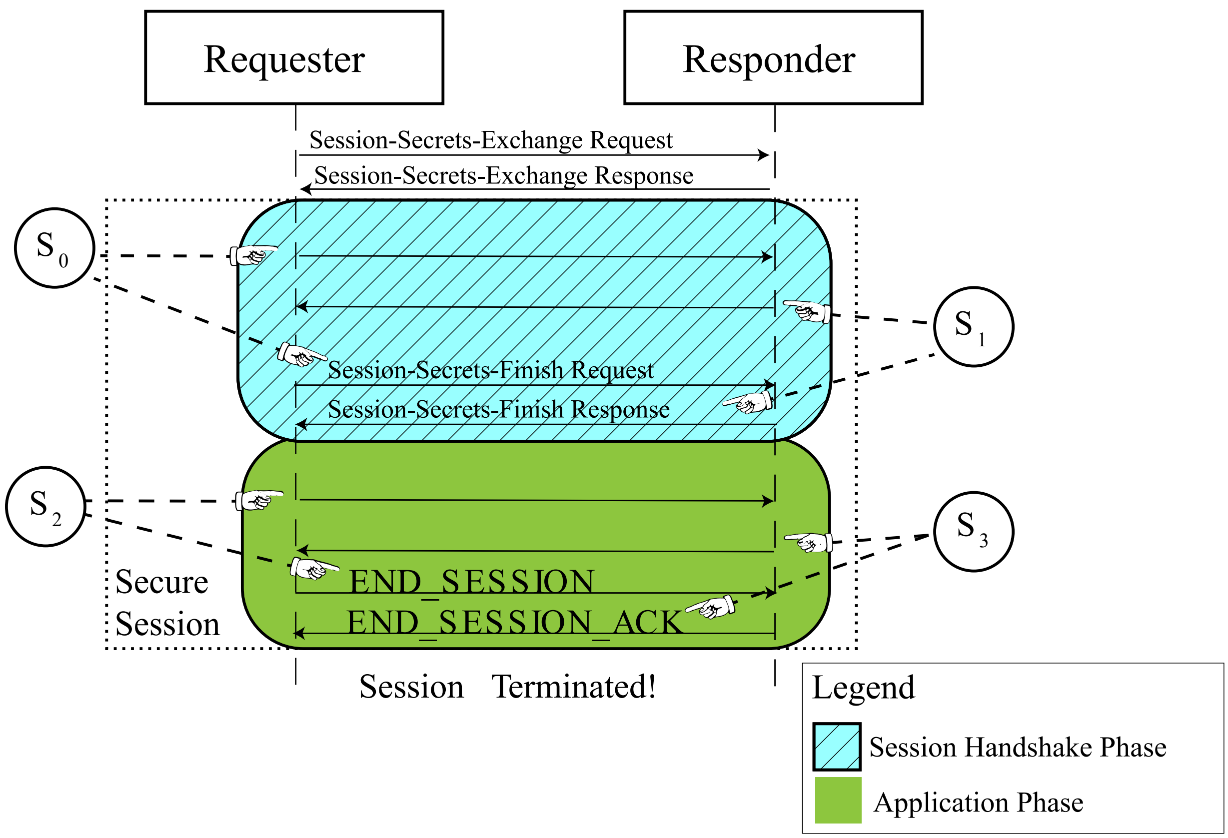
769 ### 12.5.4 Responder-direction data secret

770 This secret shall be used for any data transmitted during the application phase of the session. This secret shall only be applied for all data traveling from the Responder to the Requester.

771 Figure 28 — Secrets usage illustrates where each of the major secrets are used, as described previously.

772 **Figure 28 — Secrets usage**

773



774 ## 12.6 Encryption key and IV derivation

775 For each key schedule major secret, the following function shall be applied to obtain the encryption key and IV value.

```
EncryptionKey = HDKF-Expand(major-secret, bin_str5, key_length);
IV = HKDF-Expand(major-secret, bin_str6, iv_length);
```

```
bin_str5 = BinConcat(key_length, Version, "key", NULL);
bin_str6 = BinConcat(iv_length, Version, "iv", NULL);
```

776 Both `key_length` and `iv_length` shall be the lengths associated with the selected AEAD algorithm in `ALGORITHMS` message.

777 12.7 finished_key derivation

778 This key shall be used to compute the `RequesterVerifyData` and `ResponderVerifyData` fields used in various SPDM messages. The key, `finished_key` is defined as follows:

```
finished_key = HKDF-Expand(handshake-secret, bin_str7, Hash.Length);
bin_str7 = BinConcat(Hash.Length, Version, "finished", NULL);
```

779 The handshake-secret shall either be request-direction handshake secret or response-direction handshake secret.

780 12.8 Deriving additional keys from the Export Master Secret

781 After a successful SPDM key exchange, additional keys can be derived from the Export Master Secret. How keys are derived is outside the scope of this specification.

```
Export Master Secret = HKDF-Expand(Master-Secret, bin_str8, Hash.Length);
bin_str8 = BinConcat(Hash.Length, Version, "exp master", TH2);
```

782 12.9 Major secrets update

783 The major secrets can be updated during an active session to avoid the overhead of closing down a session and recreating the session. This is achieved by issuing the `KEY_UPDATE` request.

784 The major secrets are re-keyed as a result of this. To compute the new secret for each new major data secret, the following algorithm shall be applied.

```
new_secret = HKDF-Expand(current_secret, bin_str9, Hash.Length);
bin_str9 = BinConcat(Hash.Length, Version, "traffic upd", NULL);
```

785 In computing the new secret, `current_secret` shall either be the current Requester-Direction Data Secret or

Responder-Direction Data Secret. As a consequence of updating these secrets, new encryption keys and salts shall be derived from the new secrets and used immediately.

786 13 Application data

787 SPDM utilizes authenticated encryption with associated data (AEAD) cipher algorithms in much the same way that TLS 1.3 does to protect both the confidentiality and integrity of data that shall remain secret, as well as the integrity of data that need to be transmitted in the clear, such as protocol headers, but shall be protected from manipulation. AEAD algorithms provide both encryption and message authentication. Each algorithm specifies the details such as the size of the nonce, the position and length of the MAC and many other factors to ensure a strong cryptographic algorithm.

788 AEAD functions shall provide the following functions and comply with the requirements defined in RFC5116:

```
AEAD_Encrypt(encryption_key, nonce, associated_data, plaintext);
AEAD_Decrypt(encryption_key, nonce, associated_data, ciphertext);
```

789 where

- `AEAD_Encrypt` is the function that fully encrypts the `plaintext`, computes the MAC across both the `associated_data` and `plaintext`, and produces the `ciphertext`, which includes the MAC.
- `AEAD_Decrypt` is the function that verifies the MAC and if validation is successful, fully decrypts the `ciphertext` and produces the original `plaintext`.
- `encryption_key` is the derived encryption key for the respective direction. See the Key schedule clause.
- `nonce` is the nonce computation. See the Nonce derivation clause.
- `associated_data` is the associated data.
- `plaintext` is the data to encrypt.
- `ciphertext` is the data to decrypt.

790 13.1 Nonce derivation

791 Certain AEAD ciphers have specific requirements on nonce construction because their security properties can be compromised by the accidental reuse of a nonce value. Implementations should follow the requirements, such as those provided in RFC5116 for nonce derivation.

792 # 14 General opaque data format

793 The general opaque data format allows for a mixture of vendors, standard organizations or transport-specific data to accompany an SPDM message without namespace collisions.

794 If the `OpaqueDataFmt1` bit is selected in `OtherParamsSelection` of `ALGORITHMS` , then all opaque data fields in SPDM messages shall use the format that Table 92 — General opaque data format defines.

795 **Table 92 — General opaque data format**

Byte offset	Field	Size (bytes)	Description
0	TotalElements	1	Shall be the total number of elements in `OpaqueList` .
1	Reserved	3	Reserved.
4+	OpaqueList	Variable	Shall be a list of opaque elements. See Table 93 — Opaque element.

796 Table 93 — Opaque element defines the format for each element in `OpaqueList` .

797 **Table 93 — Opaque element**

Byte offset	Field	Size (bytes)	Description
0	ID	1	Shall be one of the values in the `ID` column of Table 50 — Registry or standards body ID.
1	VendorLen	1	Length in bytes of the `VendorID` field. If the data in `OpaqueElementData` belongs to a standards body, this field shall be 0. Otherwise, the data in `OpaqueElementData` belongs to the vendor and therefore, this field shall be the length indicated in the `Vendor ID` column of Table 50 — Registry or standards body ID for the respective `ID` .
2	VendorID	`VendorLen`	If `VendorLen` is greater than zero, this field shall be the ID of the vendor corresponding to the `ID` field. Otherwise, this field shall be absent.
2 + `VendorLen`	OpaqueElementDataLen	2	Shall be the length of `OpaqueElementData` .
4 + `VendorLen`	OpaqueElementData	`OpaqueElementDataLen`	Shall be the data defined by the vendor or standards body.

Byte offset	Field	Size (bytes)	Description
4 + `VendorLen` + `OpaqueElementDataLen`	AlignPadding	`AlignPaddingSize` = 0, 1, 2, or 3	If 4 + `VendorLen` + `OpaqueElementDataLen` does not fall on a 4-byte boundary, this field shall be present and of the correct length to ensure 4 + `VendorLen` + `OpaqueElementDataLen` + `AlignPaddingSize` is a multiple of 4. The value of this field shall be all zeros and the size of this field shall be 0, 1, 2 or 3.

798 # 15 Signature generation

799 The `SPDMsign` function, used in various part of this specification, defines the signature generation algorithm while accounting for the differences in the various supported cryptographic signing algorithms in `ALGORITHMS` message.

800 The signature generation function takes this form:

```
signature = SPDMsign(PrivKey, data_to_be_signed, context);
```

801 The `SPDMsign` function shall take these input parameters:

- `Privkey` : a secret key
- `data_to_be_signed` : a bit stream of the data that will be signed
- `context` : a string

802 The function shall output a signature using `PrivKey` and a selected cryptographic signing algorithm.

803 The signing function shall follow these steps to create `spdm_prefix` and `spdm_context` (See Text or string encoding for encoding rules):

1. Create `spdm_prefix` . The `spdm_prefix` shall be the repetition, four times, of the concatenation of "dmtf-spdm-v", `SPDMversionString` and ".*". This will form a 64 character string.
2. Create `spdm_context` . If the Requester is generating the signature, then `spdm_context` shall be the concatenation of "requester-" and `context` . If the Responder is generating the signature, the `spdm_context` shall be the concatenation of "responder-" and `context` .

804 Here is an example, named Example 1:

805 If the version of this specification is 1.4.3, the Responder is generating a signature and `context` is "my example context". The `sdpm_prefix` is "dmtf-spdm-v1.4.*dmtf-spdm-v1.4.*dmtf-spdm-v1.4.*dmtf-spdm-v1.4.*". The `spdm_context` is "responder-my example context".

806 Next, form `combined_spdm_prefix` . The `combined_spdm_prefix` shall be the concatenation of `spdm_prefix` , a byte with a value of zero, `zero_pad` and `spdm_context` . The size of `zero_pad` shall be the number of bytes needed to ensure the length of `combined_spdm_prefix` is 100 bytes. The size of `zero_pad` can be zero. The value of `zero_pad` shall be zero.

807 Continuing Example 1, Table 94 — Combined SPDM prefix shows the `combined_spdm_prefix` with offsets. Offsets increase from left to right and top to bottom. As shown, the length of `combined_spdm_prefix` is 100 bytes. Furthermore, a number surrounded by double quotation marks indicates the ASCII value of that number is used. See Text or string encoding for encoding rules.

808 **Table 94 — Combined SPDM prefix**

Offset	0x0	0x1	0x2	0x3	0x4	0x5	0x6	0x7	0x8	0x9	0xA	0xB	0xC	0xD	0xE	0xF
0	d	m	t	f	-	s	p	d	m	-	v	"1"	.	"4"	.	*
0x10	d	m	t	f	-	s	p	d	m	-	v	"1"	.	"4"	.	*
0x20	d	m	t	f	-	s	p	d	m	-	v	"1"	.	"4"	.	*
0x30	d	m	t	f	-	s	p	d	m	-	v	"1"	.	"4"	.	*
0x40	0x0	0x0	0x0	0x0	0x0	0x0	0x0	0x0	r	e	s	p	o	n	d	e
0x50	r	-	m	y	space (0x20)	e	x	a	m	p	l	e	space (0x20)	c	o	n
0x60	t	e	x	t												

809 The next step is to form the `message_hash`. The `message_hash` shall be the hash of `data_to_be_signed` using the selected hash function in either `BaseHashSel` or `ExtHashSel`. Many hash algorithms allow implementations to compute an intermediate hash, sometimes called a running hash. An intermediate hash allows for the updating of the hash as each byte of the ordered data of the message becomes known. Consequently, the ability to compute an intermediate hash allows for memory utilization optimizations where an SPDM endpoint can discard bytes of the message that are already covered by the intermediate hash while waiting for more bytes of the message to be received.

810 If the Responder is generating the signature, the selected cryptographic signing algorithm is indicated in exactly one of `BaseAsymSel` or `ExtAsymSel` in `ALGORITHMS` message. If the Requester is generating the signature, the selected cryptographic signing algorithm is indicated in `ReqBaseAsymAlg` of `RespAlgStruct` in `ALGORITHMS` message.

811 Because each cryptographic signing algorithm is vastly different, these clauses define the binding of `SPDMsign` to those algorithms.

812 15.1 Signing algorithms in extensions

813 If an algorithm is selected in either the `ExtAsymSel` or `AlgExternal` of `ReqBaseAsymAlg` of `RespAlgStruct` in `ALGORITHMS` response, its binding is out of scope of this specification.

814 15.2 RSA and ECDSA signing algorithms

815 All RSA and ECDSA specifications do not define a specific hash function. Thus, the hash function to use shall be the hash function selected by the Responder in `BaseHashSel` or `ExtHashSel`.

816 The private key, defined by the specification for these algorithms, shall be `PrivKey`.

817 In the specification for these algorithms, the letter `M` denotes the message to be signed. `M` shall be the concatenation of `combined_spdm_prefix` and `message_hash`.

818 For ECDSA algorithms, these algorithms shall follow section 6 of FIPS PUB 186-4.

819 15.3 EdDSA signing algorithms

820 These algorithms are described in RFC8032.

821 The private key, defined by RFC8032, shall be `PrivKey`.

822 In the specification for these algorithms, the letter `M` denotes the message to be signed.

823 15.3.1 Ed25519 sign

824 This specification only defines Ed25519 usage and not its variants.

825 `M` shall be the concatenation of `combined_spdm_prefix` and `message_hash`.

826 15.3.2 Ed448 sign

827 This specification only defines Ed448 usage and not its variants.

828 `M` shall be the concatenation of `combined_spdm_prefix` and `message_hash`.

829 Ed448 defines a context string, `C`. `C` shall be the `spdm_context`.

830 15.4 SM2 signing algorithm

831 This algorithm is described in GB/T 32918.2-2016. GB/T 32918.2-2016 also defines the variable `M` and ID_A.

832 The private key, defined by GB/T 32918.2-2016, shall be `PrivKey`.

833 In the specification for SM2, the letter `M` denotes the message to be signed. `M` shall be the concatenation of `combined_spdm_prefix` and `message_hash`.

834 The SM2 specification does not define a specific hash function. Thus, the hash function to use shall be the hash function selected by the Responder in `BaseHashSel` or `ExtHashSel`.

835 Lastly, SM2 expects a distinguishing identifier, which identifies the signer, and is indicated by the variable ID_A. If this algorithm is selected, the ID shall be an empty string of size 0.

836 # 16 Signature verification

837 The `SPDMsignatureVerify` function, used in various part of this specification, defines the signature verification algorithm while accounting for the differences in the various supported cryptographic signing algorithms in `ALGORITHMS` message.

838 The signature verification function takes this form:

```
SPDMsignatureVerify(PubKey, signature, unverified_data, context);
```

839 The `SPDMsignatureVerify` function shall take these input parameters:

- `PubKey` : the public key
- `signature` : a digital signature
- `unverified_data` : a bit stream of data that needs to be verified
- `context` : a string

840 The function shall verify the `unverified_data` using `signature`, `PubKey`, and a selected cryptographic signing algorithm. `SPDMsignatureVerify` shall return success if the signature verifies correctly and failure otherwise. Each cryptographic signing algorithm states the verification steps or criteria for successful verification.

841 The verifier of the signature shall create `spdm_prefix`, `spdm_context` and `combined_spdm_context` as described in Signature generation.

842 The next step is to form the `unverified_message_hash`. The `unverified_message_hash` shall be the hash of `unverified_data` using the selected hash function in either `BaseHashSel` or `ExtHashSel`.

843 If the Responder generated the signature, the selected cryptographic signature verification algorithm is indicated in exactly one of `BaseAsymSel` or `ExtAsymSel` in `ALGORITHMS` message. If the Requester generated the signature, the selected cryptographic signature verification algorithm is indicated in `ReqBaseAsymAlg` of `RespAlgStruct` in `ALGORITHMS` message.

844 Because each cryptographic signature verification algorithm is vastly different, these clauses define the binding of `SPDMsignatureVerify` to those algorithms.

845 ## 16.1 Signature verification algorithms in extensions

846 If an algorithm is selected in either the `ExtAsymSel` or `AlgExternal` of `ReqBaseAsymAlg` of `RespAlgStruct` in `ALGORITHMS` response, its binding is out of scope of this specification.

847 16.2 RSA and ECDSA signature verification algorithms

848 All RSA and ECDSA specifications do not define a specific hash function. Thus, the hash function to use shall be the hash function selected by the Responder in `BaseHashSel` or `ExtHashSel`.

849 The public key, defined in the specification for these algorithms, shall be `PubKey`.

850 In the specification for these algorithms, the letter `M` denotes the message that is signed. `M` shall be concatenation of the `combined_spdm_prefix` and `unverified_message_hash`.

851 For ECDSA algorithms, these algorithms shall follow section 6 of FIPS PUB 186-4.

852 For RSA algorithms, `SPDMsignatureVerify` shall return success when the output of the signature verification operation, as defined in the RSA specification, is "valid signature". Otherwise, `SPDMsignatureVerify` shall return a failure.

853 For ECDSA algorithms, `SPDMsignatureVerify` shall return success when the output of "Verification with the Public Key" as defined in ANSI X9.62-2005 is `"valid"`. Otherwise, `SPDMsignatureVerify` shall return failure.

854 16.3 EdDSA signature verification algorithms

855 RFC8032 describes these algorithms. RFC8032, also, defines the `M`, `PH`, and `C` variables.

856 The public key, also defined in RFC8032, shall be `PubKey`.

857 In the specification for these algorithms, the letter `M` denotes the message to be signed.

858 16.3.1 Ed25519 verify

859 `M` shall be the concatenation of `combined_spdm_prefix` and `unverified_message_hash`.

860 `SPDMsignatureVerify` shall return success when step 1 does not result in an invalid signature and the constraints of the group equation in step 3 are met as described in RFC8032 section 5.1.7. Otherwise, `SPDMsignatureVerify` shall return failure.

861 16.3.2 Ed448 verify

862 `M` shall be the concatenation of `combined_spdm_prefix` and `unverified_message_hash`.

863 Ed448 defines a context string, `C`. `C` shall be the `spdm_context`.

864 `SPDMsignatureVerify` shall return success when step 1 does not result in an invalid signature and the constraints of

the group equation in step 3 are met as described in RFC8032 section 5.2.7. Otherwise, `SPDMsignatureVerify` shall return failure.

865 16.4 SM2 signature verification algorithm

866 This algorithm is described in GB/T 32918.2-2016, which also defines the variable `M` and ID_A.

867 The public key, also defined in GB/T 32918.2-2016, shall be `PubKey`.

868 In the specification for SM2, the variable `M'` is used to denote the message that is signed. `M'` shall be the concatenation of `combined_spdm_prefix` and `unverified_message_hash`.

869 The SM2 specification does not define a specific hash function. Thus, the hash function to use shall be the hash function selected by the Responder in `BaseHashSel` or `ExtHashSel`.

870 Lastly, SM2 expects a distinguishing identifier, which identifies the signer, and is indicated by the variable ID_A. See SM2 signing algorithm to create the value for ID_A.

871 `SPDMsignatureVerify` shall return success when the Digital signature verification algorithm, as described in GB/T 32918.2-2016, outputs an "accept". Otherwise, `SPDMsignatureVerify` shall return failure.

872 # 17 General ordering rules

873 With the exception of `GET_VERSION`, a Responder shall either return an `ERROR` message with `ErrorCode=UnexpectedRequest` or silently discard the request if the request is sent out of order. Additionally, the Responder might continue to silently discard all requests or return an `ERROR` message with `ErrorCode=RequestResynch` until the Requester issues a `GET_VERSION`. A Requester can retry messages but the retries shall be identical to the first, excluding transport variances. However, if the Responder sees two or more non-identical `GET_CAPABILITIES` or `NEGOTIATE_ALGORITHMS`, the Responder shall return an `ERROR` message with `ErrorCode=UnexpectedRequest` or silently discard non-identical messages. Furthermore, the Responder can continue to silently discard all messages or return an `ERROR` message until the Requester issues a `GET_VERSION`.

874 For `CHALLENGE` and Session-Secrets-Exchange, the Responder should ensure it can distinguish between the respective retry and the respective original message. Failure to distinguish correctly might lead to an authentication failure, session handshake failures, and other failures. The response to a retried request should be identical to the original response.

875

18 ANNEX A (informative) TLS 1.3

876 This specification heavily models TLS 1.3. TLS 1.3 and consequently this specification assumes the transport layers provide these capabilities or attributes:

- Reliability in transmission and reception of data.
- Transmission of data is either in order or the order of data can be reconstructed at reception.

877 While not all transports are created equal, if a transport cannot meet these capabilities, adoption of SPDM is still possible. In these transports, this specification recommends The Datagram Transport Layer Security (DTLS) Protocol Version 1.3, which at the time of this specification is still a draft.

878 19 ANNEX B (normative) Device certificate example

879 Device certificate example shows an example device certificate:

880 **Device certificate example**

```
-----
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 8 (0x8)
        Signature Algorithm: ecdsa-with-SHA256
        Issuer: C = CA, ST = NC, L = city, O = ACME, OU = ACME Devices, CN = CA
        Validity
            Not Before: Jan  1 00:00:00 1970 GMT
            Not After : Dec 31 23:59:59 9999 GMT
        Subject: C = US, ST = NC, O = ACME Widget Manufacturing, OU = ACME Widget Manufacturing Unit, CN = w0123456
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                RSA Public-Key: (2048 bit)
                Modulus:
                    00:ba:67:47:72:78:da:28:81:d9:81:9b:db:88:03:
                    e1:10:a4:91:b8:48:ed:6b:70:3c:ec:a2:68:a9:3b:
                    5f:78:fc:ae:4a:d1:1c:63:76:54:a8:40:31:26:7f:
                    ff:3e:e0:bf:95:5c:4a:b4:6f:11:56:ca:c8:11:53:
                    23:e1:1d:a2:7a:a5:f0:22:d8:b2:fb:43:da:dd:bd:
                    52:6b:e6:a5:3f:0f:3b:60:b8:74:db:56:08:d9:ee:
                    a0:30:4a:03:21:1e:ee:60:ad:e4:00:7a:6e:6b:32:
                    1c:28:7e:9c:e8:c3:54:db:63:fd:1f:d1:46:20:9e:
                    ef:80:88:00:5f:25:db:cf:43:46:c6:1f:50:19:7f:
                    98:23:84:38:88:47:5d:51:8e:11:62:6f:0f:28:77:
                    a7:20:0e:f3:74:27:82:70:a7:96:5b:1b:bb:10:e7:
                    95:62:f5:37:4b:ba:20:4e:3c:c9:18:b2:cd:4b:58:
                    70:ab:a2:bc:f6:2f:ed:2f:48:92:be:5a:cc:5c:5e:
                    a8:ea:9d:60:e8:f8:85:7d:c0:0d:2f:6a:08:74:d1:
                    2f:e8:5e:3d:b7:35:a6:1d:d2:a6:04:99:d3:90:43:
                    66:35:e1:74:10:a8:97:3b:49:05:51:61:07:c6:08:
                    01:1c:dc:a8:5f:9e:30:97:a8:18:6c:f9:b1:2c:56:
                    e8:67
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            X509v3 Key Usage:
                Digital Signature, Non Repudiation, Key Encipherment
            X509v3 Subject Alternative Name:
                othername: 1.3.6.1.4.1.412.274.1::ACME:WIDGET:0123456789
```

```
    Signature Algorithm: ecdsa-with-SHA256
    Signature Value:
        30:45:02:20:1e:5a:a6:ed:5c:b6:2b:f5:9e:22:28:9c:ef:c7:
        aa:db:1c:87:83:48:c1:50:cb:25:04:ab:c9:6e:7c:f5:6b:01:
        02:21:00:da:48:d4:49:a5:65:5c:2c:83:fc:05:00:66:48:98:
        f8:f0:cb:63:b7:2e:87:db:c8:63:58:6c:21:91:7a:68:95
-----BEGIN CERTIFICATE-----
MIIC4jCCAoigAwIBAgIBCDAKBggqhkjOPQQDAjBcMQswCQYDVQQGEwJDQTELMAkG
A1UECAwCTkMxDTALBgNVBAcMBGNpdHkxDTALBgNVBAoMBEFDTUUxFTATBgNVBAsM
DEFDTUUgRGV2aWNlczELMAkGA1UEAwwCQ0EwIBcNNzAwMTAxMDAwMDAwWhgPOTk5
OTEyMzEyMzU5NTlaMH0xCzAJBgNVBAYTAlVTMQswCQYDVQQIDAJOQzEiMCAGA1UE
CgwZQUNNRSBXaWRnZXQgTWFudWZhY3R1cmluZzEnMCUGA1UECwweQUNNRSBXaWRn
ZXQgTWFudWZhY3R1cmluZyBVbml0MRQwEgYDVQQDDAt3MDEyMzQ1Njc4OTCCASIw
DQYJKoZIhvcNAQEBBQADggEPADCCAQoCggEBALpnR3J42iiB2YGb24gD4RCkkbhI
7WtwPOyiaKk7X3j8rkrRHGN2VKhAMSZ//z7gv5VcSrRvEVbKyBFTI+Edonql8CLY
svtD2t29UmvmpT8PO2C4dNtWCNnuoDBKAyEe7mCt5AB6bmsyHCh+nOjDVNtj/R/R
RiCe74CIAF8l289DRsYfUBl/mCOEOIhHXVGOEWJvDyh3pyAO83QngnCnllsbuxDn
lWL1N0u6IE48yRiyzUtYcKuivPYv7S9Ikr5azFxeqOqdYOj4hX3ADS9qCHTRL+he
Pbc1ph3SpgSZ05BDZjXhdBColztJBVFhB8YIARzcqF+eMJeoGGz5sSxW6GcCAwEA
AaNNMEswCQYDVR0TBAIwADALBgNVHQ8EBAMCBeAwMQYDVR0RBCowKKAmBgorBgEE
AYMcghIBoBgMFkFDTUU6V0lER0VUOjAxMjM0NTY3ODkwCgYIKoZIzj0EAwIDSAAw
RQIgHlqm7Vy2K/WeIiic78eq2xyHg0jBUMslBKvJbnz1awECIQDaSNRJpWVcLIP8
BQBmSJj48Mtjty6H28hjWGwhkXpolQ==
-----END CERTIFICATE-----
```

881 # 20 ANNEX C (informative) OID reference

882 Table 95 — Object identifiers (OIDs) lists all object identifiers (OIDs) that this specification defines:

883 **Table 95 — Object identifiers (OIDs)**

OID	Identifier	Definition	Use
{ 1 3 6 1 4 1 412 }	id-DMTF	DMTF OID	Enterprise ID for DMTF
{ id-DMTF 274 }	id-DMTF-spdm	SPDM OID	Base OID for all SPDM OIDs
{ id-DMTF-spdm 1 }	id-DMTF-device-info	SPDM certificate requirements and recommendations	Certificate device information.
{ id-DMTF-spdm 2 }	id-DMTF-hardware-identity	Identity provisioning	Hardware certificate identifier.
{ id-DMTF-spdm 3 }	id-DMTF-eku-responder-auth	Extended Key Usage authentication OIDs	Certificate Extended Key Usage - SPDM Responder Authentication.
{ id-DMTF-spdm 4 }	id-DMTF-eku-requester-auth	Extended Key Usage authentication OIDs	Certificate Extended Key Usage - SPDM Requester Authentication.
{ id-DMTF-spdm 5 }	id-DMTF-mutable-certificate	Identity provisioning	Mutable certificate identifier.
{ id-DMTF-spdm 6 }	id-DMTF-SPDM-extension	SPDM Non-Critical Certificate OID	To contain other OIDs in a certificate extension.

884
21 ANNEX D (informative) variable name reference

885 Throughout this document, various sizes and offsets are referred to by a variable. Table 96 — Variables lists variables used in this document, the definition of the variable, and the location in this document that shows how the variable is set.

886 **Table 96 — Variables**

Symbol	Definition	Set location
A	Number of Requester-supported extended asymmetric key signature algorithms.	Table 15 — NEGOTIATE_ALGORITHMS request message format
A'	Number of extended asymmetric key signature algorithms selected by the Requester.	Table 21 — Successful ALGORITHMS response message format
D	The size of D (and C for ECDHE) is derived from the selected DHE group.	See the `KEY_EXCHANGE` request message format in Table 58 — KEY_EXCHANGE request message format.
E	Number of Requester-supported extended hashing algorithms.	Table 15 — NEGOTIATE_ALGORITHMS request message format
E'	The number of extended hashing algorithms selected requested by the Requester.	Table 21 — Successful ALGORITHMS response message format
H	The output size, in bytes, of the hash algorithm agreed upon in `NEGOTIATE_ALGORITHMS` .	Table 21 — Successful ALGORITHMS response message format
MS	The length of the cryptographic hash or raw bit stream, as indicated in `DMTFSpecMeasurementValueType[7]` .	Table 45 — DMTF measurement specification format
NL	The length of the Nonce field in the `GET_MEASUREMENTS` request and the `MEASUREMENTS` response.	GET_MEASUREMENTS request attributes
n	Number of version entries in the VERSION response message.	Table 9 — Successful VERSION response message format
Q	Length of the ResponderContext.	Table 64 — PSK_EXCHANGE_RSP response message format
P	Length of the `PSKHint` .	Table 63 — PSK_EXCHANGE request message format
R	Length of the `RequesterContext` .	Table 63 — PSK_EXCHANGE request message format

Symbol	Definition	Set location
`SigLen`	The size of the asymmetric-signing algorithm output, in bytes, that the Responder selected through the last ALGORITHMS response message.	Table 21 — Successful ALGORITHMS response message format

887 # 22 ANNEX E (informative) change log

888 ## 22.1 Version 1.0.0 (2019-10-16)

- Initial Release

889 ## 22.2 Version 1.1.0 (2020-07-15)

- Minor typographical fixes
- USB Authentication Specification 1.0 link updated
- Tables are no longer numbered. They are now named.
- Fix internal document links in SPDM response codes table.
- Added sentence to paragraph 97 to clarify on the potential to skip messages after a reset.
- Removed text at paragraph 181.
- `Subject Alternative Name otherName` field in Optional fields references DMTF OID section.
- `DMTFOtherName` definition changed to properly meet ASN.1 syntax.
- Text in figures are now searchable.
- Corrected example of a leaf certificate in Annex A.
- Minor edits to figures for clarity.
- Clarified that transcript hash could include hash of the raw public key if a certificate is not used.
- New:
    - Added Session support.
        - Added SPDM request and response messages to support initiating, maintaining and terminating a secure session.
        - Added Key schedule for session secrets derivation.
        - Added Application Data to provide overview of how data is encrypted and authenticated in a session.
    - Introduce new terms and definitions.
    - Added Measurement Manifest to `DMTFSpecMeasurementValueType`.
    - Added mutual authentication.
    - Added Encapsulated request flow to support master-slave types of transports.

890 ## 22.3 Version 1.2.0 (2021-11-01)

- Clarified SPDM version selection after receiving `VERSION` Response with error handling for certain scenarios.
- Fix improper reference in `DMTFSpecMeasurementValue` field in "Measurement field format when MeasurementSpecification field is Bit 0 = DMTF" table.

- Certificate digests in `DIGESTS` calculation clarified.
- Format of certificate in `CertChain` parameter of `CERTIFICATE` message clarified.
- Validity period of X.509 v3 certificate clarified in Required Fields
- Remove `InvalidSession` error code.
- Clarified transport responsibilities in `PSK_EXCHANGE` and `PSK_EXCHANGE_RSP`.
- Clarified the usage of `MutAuthRequested` field in `KEY_EXCHANGE_RSP`.
- Added recommendation of PSK usage when an SPDM endpoint can be a Requester and Responder.
- Added recommendation for usage of `RequesterContext` in PSK scenarios.
- Clarified capabilities for Requester and Responder in `GET_CAPABILITIES` and `CAPABILITIES` messages.
- Clarified timing requirements for encapsulated requests.
- Clarified out of order and retries
- Clarified error handling actions when unexpected requests occurs during various mutual authentication flows.
- Refer to slot number fields as `SlotID` and normalize `SlotID` fields to 4 bits where possible.
- Changed `PSK_FINISH` and `FINISH` changes in Table 6 — SPDM request and response messages validity.
- Clarified `HANDSHAKE_IN_THE_CLEAR_CAP` usage in `PSK_EXCHANGE`.
- Change `SPDMVersion` field in every request and response message, except `GET_VERSION` / `VERSION` messages, to point to a central location in this specification where it explains the appropriate value to populate for this field.
- Clarified use case for `Token` field in `ResponseNotReady`.
- Clarified the format of the of the certificate chain used in the Transcript hash calculation in Transcript hash calculation rules.
- Renamed `Measurement field format when MeasurementSpecification field is Bit 0 = DMTF` table to Table 45 — DMTF measurement specification format.
- Clarified the `ENCAP_CAP` field in the capabilities of the Requester and Responder.
- Renamed Mutual Authentication in `KEY_EXCHANGE` to Session-based mutual authentication.
- `ERROR` responses are no longer required in most error scenarios.
- Clarify the definition of backwards compatible changes in Version encoding.
- Enhanced requirements for when a firmware update occurred on a Responder in GET_VERSION request and VERSION response messages.
- Clarified error code `ResponseNotReady` for M1/M2 and L1/L2 computation.
- Clarified byte order for ASN.1 encoded data, hashes and digests.
- Requester should not use PSK_EXCHANGE if CHALLENGE_AUTH and/or MEASUREMENTS with signature was received from Responder.
- Required `GET_VERSION`, `VERSION`, `GET_CAPABILITIES`, `CAPABILITIES`, `NEGOTIATE_ALGORITHMS`, and `ALGORITHMS` in transcript even if negotiated state is supported.
- Enhanced signature generation and verification with a prefix to mitigate signature misuse attacks.
- Clarified behavior of `END_SESSION` with respect to Negotiated State when there are multiple active sessions.
- Added new defined term `Reset` to mean device reset. Updated use of the word reset for M1/M2, L1/L2.

- Clarified that a Measurement Manifest should support both hash and raw bit stream formats.
- Clarified Measurement Summary Hash construction rules.
- Clarified minimum timing for HEARTBEAT request and HEARTBEAT_ACK response messages to be sufficiently greater than `T1`. Removed command specific guidance on retry timing.
- Table codification changed to be consistent with DMTF template.
- New:
  - Added support for `AliasCert` s.
    - Compliant Requesters must support a Responder that uses either `DeviceCerts` or `AliasCert` s.
  - Added Certain error handling in encapsulated flows
  - Added Slot 0 certificate provisioning methodology.
  - Added Allowance for encapsulated requests.
  - Allowed `GET_CERTIFICATE` followed by `CHALLENGE` flow after a reset in `M1` and `M2` message transcript.
  - Added new features for `GET_MEASUREMENTS` and `MEASUREMENTS` :
    - More measurement value types.
    - Allow Requester to request hash or raw bit stream for measurement from the Responder.
  - Added Advice.
  - Added structured representation of device mode Device mode field of a measurement block.
  - Added Text or string encoding.
  - Signature Clarification:
    - Added Signature generation and Signature verification for clarity and interoperability.
    - Change `Sign` and `Verify` abstract function to `SPDMsign` and `SPDMsignatureVerify` respectively.
  - Added General ordering rules and references to it, to describe additional requirements for the various transcript and message transcripts.
  - Added additional clause for checking `FINISH.Param2` if handshake is in the clear.
  - Added OIDs to represent:
    - Hardware certificate identifier (Identity provisioning)
    - Certificate Extended Key Usage - SPDM Responder Authentication (Extended Key Usage authentication OIDs)
    - Certificate Extended Key Usage - SPDM Requester Authentication (Extended Key Usage authentication OIDs)
    - Mutable certificate identifier (Identity provisioning)
  - Added SM2 to Base Asymmetric Algorithms and Key Exchange Protocols.
  - Added SM3 to Base Hash Algorithms and Measurement Hash Algorithms.
  - Added SM4 to AEAD Algorithms.
  - Changed symbol "S" denoting signature size to "SigLen" throughout document.
  - Removed potentially confusing mention of "mutual authentication" in `PSK_EXCHANGE` section.
  - Add method to transfer large SPDM messages. See Large SPDM message transfer mechanism.
  - Changed Measurement Summary Hash concatenation function inputs.
  - Clarified requirements for compliant certificate chains.

- Tables and figures are now numbered. Though these numbers might change in future versions of specification, the titles will remain the same.
- Allowed Requester to specify session termination policy when Responder completes firmware or configuration update.

891
23 Bibliography

892 DMTF DSP4014, *DMTF Process for Working Bodies 2.6*.