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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 1.1 Acknowledgments

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20 2 Introduction

21 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* of hardware identities, measurement for firmware identities and session key exchange protocols to enable confidentiality and integrity protected data communication. 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.

22 2.1 Conventions

23 The following conventions apply to all SPDM specifications.

24 2.1.1 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 monospaced font.

25 2.1.2 Reserved and unassigned values

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

27 Unless otherwise specified, reserved numeric and bit fields shall be written as zero (`0`) and ignored when read.

28 2.1.3 Byte ordering

29 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).

30 2.1.4 SPDM data types

31 The SPDM data types table lists the abbreviations and descriptions for common data types that SPDM message fields and data structure definitions use. These definitions follow DSP0240.

32 **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. Each bit field can be separately defined.
`bitfield16`	Two-byte word with 16-bit fields. Each bit field can be separately defined.

33 2.1.5 Version encoding

34 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.

35 EXAMPLE:

36 Version 3.7 → `0x37`

37 Version 1.0 → `0x10`

38 Version 1.2 → `0x12`

39 An *endpoint* that supports Version 1.2 can interoperate with an older endpoint that supports Version 1.0 only, but the available functionality is limited to what SPDM specification Version 1.0 defines.

40 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`.

41 The detailed version encoding that the `VERSION` response message returns contains an additional byte that indicates specification bug fixes or development versions. See the Successful VERSION response message format table.

42 2.1.6 Notations

43 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 .

44 3 Scope

45 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.

46 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.

47 4 Normative references

48 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 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 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 01.27*, February 7, 2018
- 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
- **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
- **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)
- **RSA**
  - Table 3 in *TCG Algorithm Registry Family “2.0" Level 00 Revision 01.22*, February 9, 2015
- **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
- **Transport Layer Security 1.3**
  - TLS 1.3 RFC 8446

49 # 5 Terms and definitions

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

51 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.

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

53 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.

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

55 This specification uses these terms:

Term	Definition
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	Process of determining whether an entity is who or what it claims to be.
authentication initiator	Endpoint that initiates the authentication process by challenging another endpoint.
byte	Eight-bit quantity. Also known as an *octet*.
certificate	Digital form of identification that provides information about an entity and certifies ownership of a particular asymmetric key-pair.
certificate authority (CA)	Trusted entity that issues certificates.

Term	Definition
certificate chain	Series of two or more certificates. Each certificate is signed by the preceding certificate in the chain.
component	Physical entity similar to the PCI Express specification's definition.
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.
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.
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 a SPDM message that carries additional data.
message originator	Original transmitter, or source, of a SPDM message.
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.
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.
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.

Term	Definition
opaque data	Opaque data fields transfer data that is outside of the scope of this specification. The semantics and usage of this data are implementation specific and also outside of the scope of this specification.
payload	Information-bearing fields of a message. These fields are separate from the fields and elements, such as address fields, framing bits, checksums, and so on, 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, PCI Express™ Vendor Defined Messaging, and so on.
Platform Management Component Intercommunications (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 record is a unit or chunk of data that is either encrypted and/or authenticated.
Requester	Original transmitter, or source, of a SPDM request message. It is also the ultimate receiver, or destination, of a SPDM response message.
Responder	Ultimate receiver, or destination, of a SPDM request message. It is also the original transmitter, or source of a SPDM response message.
root certificate	First certificate in a certificate chain, which is self-signed.
session keys	Session Keys are any secrets, derived cryptographic keys or any cryptographic information bound to the session.
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`.
secure session	A secure session is a session that provides either or both of encryption or message authentication for communicating data over a transport.
SPDM message	Unit of communication in SPDM communications.
SPDM message payload	Portion of the message body of a 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 request message	Message that is sent to an endpoint to request a specific SPDM operation. A corresponding SPDM response message acknowledges receipt of a 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.

Term	Definition
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

56 # 6 Symbols and abbreviated terms

57 The abbreviations defined in DSP0004, DSP0223, and DSP1001 apply to this document.

58 The following additional abbreviations are used in this document.

Abbreviation	Definition
CA	*certificate authority*
MAC	Message Authentication Code
DMTF	Formerly the *Distributed Management Task Force*
MSB	*most significant byte*
PMCI	*Platform Management Component Intercommunications*
SPDM	Security Protocol and Data Model
TCB	*trusted computing base*
AEAD	Authenticated Encryption with Associated Data

59 # 7 SPDM message exchanges

60 The message exchanges defined in this specification are between two endpoints and are performed and exchanged through sending and receiving of SPDM messages defined in SPDM messages. 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.

61 The specification-defined message exchanges enable Requesters to:

- Discover and negotiate the security capabilities of a Responder.
- Authenticate the 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.

62 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.

63 ## 7.1 Security capability discovery and negotiation

64 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 are defined in this specification. 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.

65 ## 7.2 Identity authentication

66 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.

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

- Identity provisioning
- Runtime authentication

68 ### 7.2.1 Identity provisioning

69 Identity provisioning is the process that device vendors follow during or after hardware manufacturing. A trusted root *certificate authority (CA)* generates a *root certificate* (`RootCert`) that is provisioned to the *authentication initiator*. The authentication initiator uses this certificate to verify the validity of certificate chains. A device carries a *certificate chain*, which has the `RootCert` as the root of the certificate chain and a device certificate (`DeviceCert`) as the *leaf certificate* of the certificate chain. The device certificate contains the public key that corresponds to the device private key.

70 Through the certificate chain, the root CA indirectly endorses the per-device public/private key pair in the `DeviceCert` , where the private key is provisioned to or generated by the endpoint.

71 Alternatively to certificate chains, the vendor may 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.

72 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.

73 ### 7.2.2 Runtime authentication

74 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 to sign the challenge. The authentication initiator verifies the signature by using the public key of the Responder, and any intermediate public keys within the certificate chain by using the root certificate as the trusted anchor.

75 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.

76 ## 7.3 Firmware and configuration measurement

77 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.

78 7.4 Secure sessions

79 Many devices exchange data with other devices that may 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. This protocol of the application data usually allows for encrypted and/or authenticated data transfer.

80 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.

81 Lastly, but not least, many SPDM requests and their corresponding responses can also be afforded the same protection. See the SPDM request and response messages validity table and SPDM request and response code issuance allowance clause for more details.

82 The SPDM messaging protocol flow gives a very high-level view of when the secure session actually starts.

83 7.5 Mutual authentication overview

84 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 authentication discusses identity in regards to the Responder but the details apply to the Requester as well.

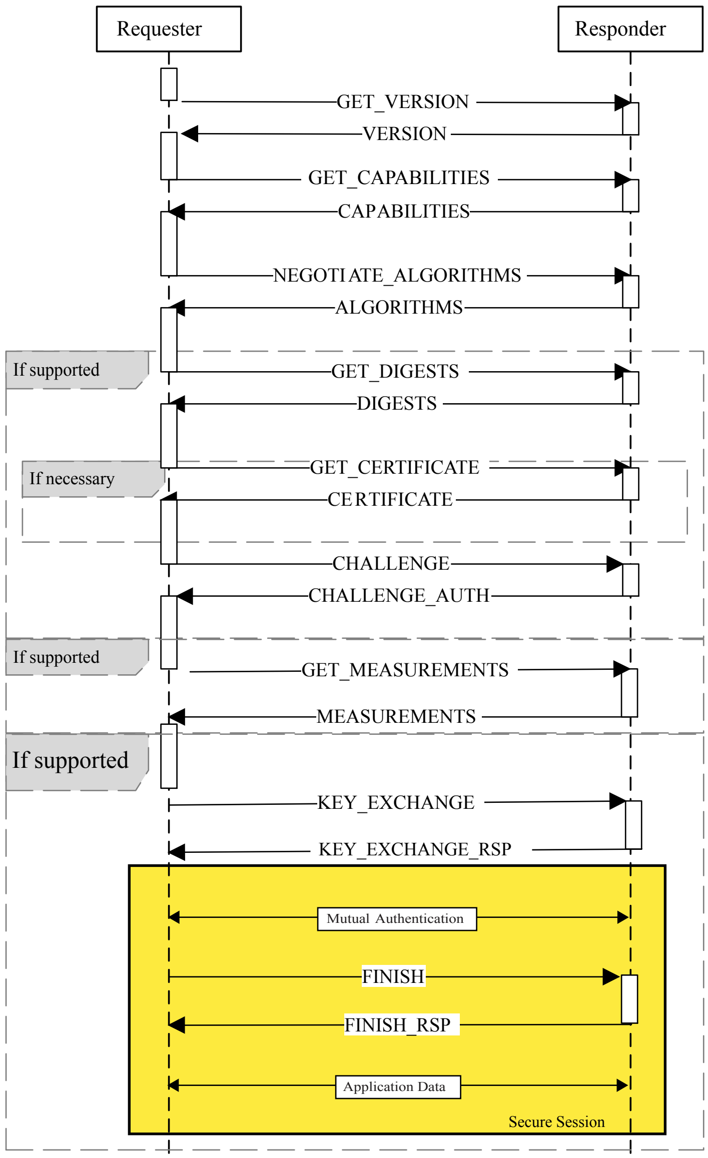
85 In general, when this specification places requirements or recommendations for Responders in the context of identity, those same rules also apply to Requesters in the context of mutual authentication. The various clauses in this specification will provide more details.

86 # 8 SPDM messaging protocol

87 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 a SPDM response message as defined in this specification unless otherwise stated in this specification.

88 The SPDM messaging protocol flow depicts the high-level request-response flow diagram for SPDM. An endpoint that acts as the *Requester* sends a SPDM request message to another endpoint that acts as the *Responder*, and the Responder returns a SPDM response message to the Requester.

89 **SPDM messaging protocol flow**



90 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 each of the request and response messages.

91 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` may be saved by the requester so that after reset the requester may skip these requests.

92 8.1 SPDM bits-to-bytes mapping

93 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.

94 **One-byte field bit map**

95 Example: A One-Byte Field

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

96 **Two-byte field bit map**

97 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

98 8.2 Generic SPDM message format

99 The Generic SPDM message field definitions table defines the fields that constitute a generic SPDM message, including the message header and payload.

100 **Generic SPDM message field definitions**

Byte	Bits	Length (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.

Byte	Bits	Length (bits)	Field	Description
`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 and Table 5 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`.
`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`.

101 ## 8.3 SPDM request codes

102 The SPDM request codes table defines the SPDM request codes. The **Implementation requirement** column indicates requirements on the Requester.

103 All SPDM-compatible implementations shall use the following SPDM request codes.

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

105 **SPDM request codes**

Request	Code value	Implementation requirement	Message format
`GET_DIGESTS`	`0x81`	Optional	GET_DIGESTS request message format
`GET_CERTIFICATE`	`0x82`	Optional	GET_CERTIFICATE request message format
`CHALLENGE`	`0x83`	Optional	CHALLENGE request message format
`GET_VERSION`	`0x84`	Required	GET_VERSION request message format
`GET_MEASUREMENTS`	`0xE0`	Optional	GET_MEASUREMENTS request message format

Request	Code value	Implementation requirement	Message format
`GET_CAPABILITIES`	`0xE1`	Required	GET_CAPABILITIES request message format
`NEGOTIATE_ALGORITHMS`	`0xE3`	Required	NEGOTIATE_ALGORITHMS request message format
`KEY_EXCHANGE`	`0xE4`	Optional	KEY_EXCHANGE request message format
`FINISH`	`0xE5`	Optional	FINISH request message format
`PSK_EXCHANGE`	`0xE6`	Optional	PSK_EXCHANGE request message format
`PSK_FINISH`	`0xE7`	Optional	PSK_FINISH request message format
`HEARTBEAT`	`0xE8`	Optional	HEARTBEAT request message format
`KEY_UPDATE`	`0xE9`	Optional	KEY_UPDATE request message format
`GET_ENCAPSULATED_REQUEST`	`0xEA`	Optional	GET_ENCAPSULATED_REQUEST request message format
`DELIVER_ENCAPSULATED_RESPONSE`	`0xEB`	Optional	DELIVER_ENCAPSULATED_RESPONSE request message format
`END_SESSION`	`0xEC`	Optional	END_SESSION request message format
`RESPOND_IF_READY`	`0xFF`	Required	RESPOND_IF_READY request message format
`VENDOR_DEFINED_REQUEST`	`0xFE`	Optional	VENDOR_DEFINED_REQUEST request message format
Reserved	`0x80` , `0x85` - `0xDF` , `0xE2` , `0xED` - `0xFD`	SPDM implementations compatible with this version shall not use the reserved request codes.	

106 ## 8.4 SPDM response codes

107 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 the following SPDM response codes.

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

109 The SPDM response codes table defines the response codes for SPDM. The **Implementation requirement** column indicates requirements on the Responder.

110 **SPDM response codes**

Response	Value	Implementation requirement	Message format
`DIGESTS`	`0x01`	Optional	Successful DIGESTS response message format
`CERTIFICATE`	`0x02`	Optional	Successful CERTIFICATE response message format
`CHALLENGE_AUTH`	`0x03`	Optional	Successful CHALLENGE_AUTH response message format
`VERSION`	`0x04`	Required	Successful VERSION response message format
`MEASUREMENTS`	`0x60`	optional	Successful MEASUREMENTS response message format
`CAPABILITIES`	`0x61`	Required	Successful CAPABILITIES response message format
`ALGORITHMS`	`0x63`	Required	Successful ALGORITHMS response message format
`KEY_EXCHANGE_RSP`	`0x64`	Optional	Successful KEY_EXCHANGE_RSP response message format
`FINISH_RSP`	`0x65`	Optional	Successful FINISH_RSP response message format
`PSK_EXCHANGE_RSP`	`0x66`	Optional	PSK_EXCHANGE_RSP response message format
`PSK_FINISH_RSP`	`0x67`	Optional	Successful PSK_FINISH_RSP response message format
`HEARTBEAT_ACK`	`0x68`	Optional	HEARTBEAT_ACK response message format
`KEY_UPDATE_ACK`	`0x69`	Optional	KEY_UPDATE_ACK response message format
`ENCAPSULATED_REQUEST`	`0x6A`	Optional	ENCAPSULATED_REQUEST response message format
`ENCAPSULATED_RESPONSE_ACK`	`0x6B`	Optional	ENCAPSULATED_RESPONSE_ACK response message format

Response	Value	Implementation requirement	Message format
`END_SESSION_ACK`	`0x6C`	Optional	END_SESSION_ACK response message format
`VENDOR_DEFINED_RESPONSE`	`0x7E`	Optional	VENDOR_DEFINED_RESPONSE response message format
`ERROR`	`0x7F`		ERROR response message format
Reserved	`0x00` , `0x05` - `0x5F` , `0x62` , `0x6D` - `0x7D`	SPDM implementations compatible with this version shall not use the reserved response codes.	

111 ## 8.5 SPDM request and response code issuance allowance

112 The SPDM request and response messages validity table describes the conditions under which a request and response can be issued.

113 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.

114 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.

115 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 may have additional restrictions. See the respective request and response clause for further details.

116 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.

117 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.

118 For details, see the Session clause.

119 **SPDM request and response messages validity**

Request	Response	Session	Outside of a session	Session phases
`GET_MEASUREMENT`	`MEASUREMENT`	Allowed	Allowed	Application Phase
`FINISH`	`FINISH_RSP`	Allowed	Allowed	Session Handshake
`PSK_FINISH`	`PSK_FINISH_RSP`	Allowed	Allowed	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
All others	All others	Prohibited	Allowed	Not Applicable

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

121 8.6 Concurrent SPDM message processing

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

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

124 8.7 Requirements for Requesters

125 A Requester shall not have multiple outstanding requests to the same Responder, with the following exception: as addressed in GET_VERSION request and VERSION response messages, a Requester may issue a `GET_VERSION` to a Responder to restart the protocol due to an internal error or reset, even if the Requester has existing outstanding requests to the same Responder.

126 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.

127 A Requester may send simultaneous request messages to different Responders.

128 8.8 Requirements for Responders

129 A Responder is not required to process more than one request message at a time.

130 A Responder that is not ready to accept a new request message shall either respond with an `ERROR` response message with `ErrorCode=Busy` or silently discard the request message.

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

132 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.

133 # 9 Timing requirements

134 The Timing specification for SPDM messages table shows the timing specifications for Requesters and Responders.

135 If the Requester does not receive a response within **T1** or **T2** time accordingly, the Requester may retry a request message. A retry of a request message shall be a complete retransmission of the original SPDM request message. Because a retried message is identical to the first, a retried message shall not be used in transcript hash calculations.

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

137 ## 9.1 Timing measurements

138 A Requester shall measure timing parameters, applicable to it, from the end of a successful transmission of a 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. The requirement assumes that the Responder has immediate access to the transport.

139 ## 9.2 Timing specification table

140 The **Ownership** column in the Timing specification for SPDM messages table specifies whether the timing parameter applies to the Responder or Requester.

141 **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 a 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 messages.
`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 `ST1` .
`CT`	Requester and Responder	$2^{CTExponent}$	μs	`CTExponent` is reported in `GET_CAPABILITIES` and `CAPABILITIES` messages. 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.
`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 `CT` .
`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. See the ResponseNotReady extended error data table for the `RDTExponent` value. For details, see `ErrorCode=ResponseNotReady` in the ResponseNotReady extended error data table.
`WT`	Requester	`RDT`	μs	Amount of time that the Requester should wait before issuing the `RESPOND_IF_READY` request message. 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 include the transmission time of the `ERROR` from the Responder to Requester as time spent waiting for `WT` to expire. For example, if a Responder indicates `WT` is two seconds and the `ERROR` response takes one second to transport to the Requester, the Requester only needs to wait an additional one second upon reception of the `ERROR` response. For details, see `RDT` .

Timing parameter	Ownership	Value	Units	Description
WT_{Max}	Requester	(RDT∗RDTM)−RTT	μs	Maximum wait time the Requester has to issue RESPOND_IF_READY request unless the Requester issued a successful RESPOND_IF_READY request message earlier. After this time the Responder is allowed to drop the response. The Requester shall take into account the transmission time of the ERROR from the Responder to Requester when calculating WT_{Max}. The RDTM value appears in the ResponseNotReady extended error data. The Responder should ensure that WT_{Max} does not result in less than WT in determination of RDTM. For details, see ErrorCode=ResponseNotReady in the ResponseNotReady extended error data table.
HeartbeatPeriod	Requester and Responder	Variable	s	See HEARTBEAT request and HEARTBEAT_ACK response for detail.

142 # 10 SPDM messages

143 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
- Firmware measurements
- Key agreement for secure channel establishment

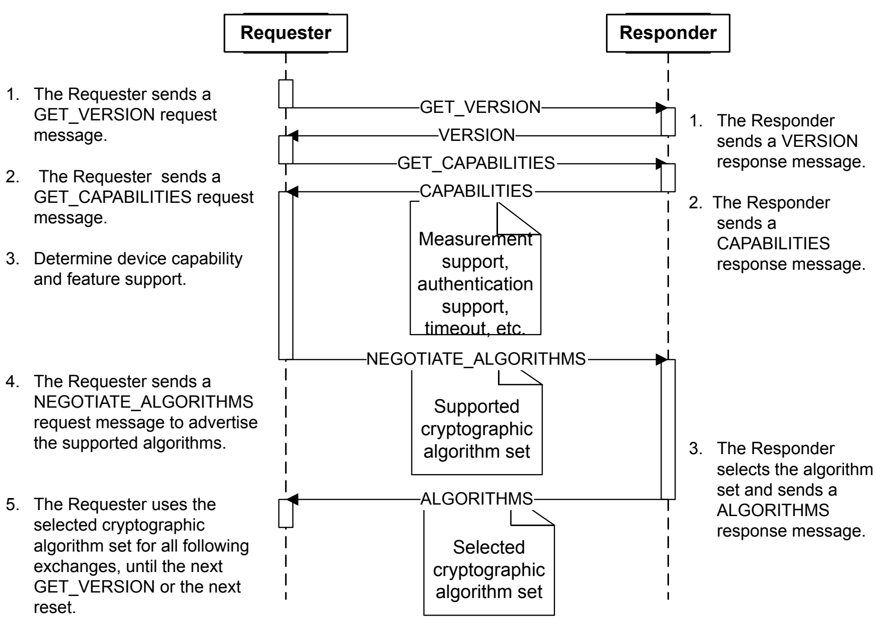
144 ## 10.1 Capability discovery and negotiation

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

146 The Capability discovery and negotiation flow shows the high-level request-response flow and sequence for the capability discovery and negotiation:

147 **Capability discovery and negotiation flow**

148



149 ## 10.2 GET_VERSION request and VERSION response messages

150 This request message shall retrieve the SPDM version of an endpoint. The GET_VERSION request message format table shows the `GET_VERSION` request message format and the Successful VERSION response message format table shows the `VERSION` response message format.

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

152 The Requester shall begin the discovery process by sending a `GET_VERSION` request message with major version `0x1`. All Responders shall always support the `GET_VERSION` request message with major version `0x1` and provide a `VERSION` response containing all supported versions, as the GET_VERSION request message format table describes.

153 The Requester shall consult the `VERSION` response to select a common supported version, which is typically 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`.

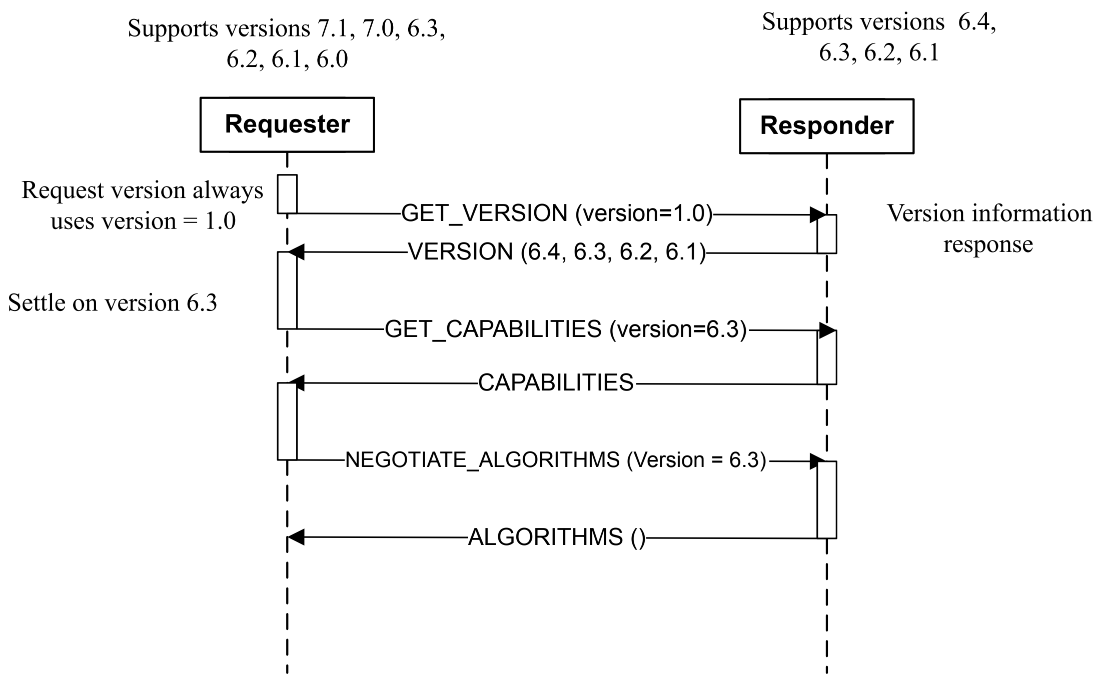
154 A Requester can issue a `GET_VERSION` request message to a Responder at any time, which is as an exception to Requirements for Requesters to allow for scenarios where a Requester shall restart the protocol due to an internal error or reset.

155 After receiving a `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, i.e., information (such as session keys, session IDs) for those sessions should not be used anymore. Additionally, this message shall clear or reset the previously *Negotiated State*, if any, in both the Requester and its corresponding Responder.

156 All Responders that have completed a firmware update shall either respond with `ErrorCode=RequestResynch` to any request until a `GET_VERSION` request is received or silently discard the request.

157 **Discovering the common major version**

158



159 **GET_VERSION request message format**

Offset	Field	Size (bytes)	Value
`0`	`SPDMVersion`	1	`V1.0 = 0x10`
`1`	`RequestResponseCode`	1	`0x84=GET_VERSION`
`2`	`Param1`	1	Reserved.
`3`	`Param2`	1	Reserved.

160 **Successful VERSION response message format**

Offset	Field	Size (bytes)	Value
`0`	`SPDMVersion`	1	`V1.0 = 0x10`
`1`	`RequestResponseCode`	1	`0x04=VERSION`
`2`	`Param1`	1	Reserved.

Offset	Field	Size (bytes)	Value
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 the VersionNumberEntry definition table.

161 **VersionNumberEntry definition**

Bit	Field	Value
[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.
[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 may not be fully interoperable. Released versions shall have an Alpha value of zero (0).

162 10.3 GET_CAPABILITIES request and CAPABILITIES response messages

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

164 The GET_CAPABILITIES request message format table shows the GET_CAPABILITIES request message format.

165 The Successful CAPABILITIES response message format table shows the CAPABILITIES response message format.

166 The Requester flag fields definitions table shows the flag fields definitions for the Requester.

167 Likewise, the Responder flag fields definitions table shows the flag fields definitions for the Responder.

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

169 **GET_CAPABILITIES request message format**

Offset	Field	Size (bytes)	Value
0	SPDMVersion	1	V1.1 = 0x11
1	RequestResponseCode	1	0xE1=GET_CAPABILITIES
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 the Timing specification for SPDM messages table. 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 the Requester flag fields definitions table.

170 **Successful CAPABILITIES response message format**

Offset	Field	Size (bytes)	Value
0	SPDMVersion	1	V1.1 = 0x11
1	RequestResponseCode	1	0x61=CAPABILITIES
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 the Timing specification for SPDM messages table. 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.

Offset	Field	Size (bytes)	Value
8	Flags	4	See the Responder flag fields definitions table.

171 ### Requester flag fields definitions

172 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.

Byte	Bit	Field	Value
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	4:3	MEAS_CAP	The corresponding bits of the Responder flag fields definitions indicate `MEASUREMENT` response capabilities. These bits shall be set to `00b`.
0	5	MEAS_FRESH_CAP	The corresponding bit of the Responder flag fields definitions indicate `MEASUREMENT` response capabilities. This bit shall be set to `0b`.
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. This capability applies to all phases of a secure session.
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. This capability applies to all phases of a secure session. `MAC_CAP` is not the same as the `HMAC` in the `RequesterVerifyData` or `ResponderVerifyData` fields of Session-Secrets-Exchange and Session-Secrets-Finish messages.
1	0	MUT_AUTH_CAP	If set, Requester supports mutual authentication.
1	1	KEY_EX_CAP	If set, Requester supports `KEY_EXCHANGE` messages. If set, one or more of `ENCRYPT_CAP` and `MAC_CAP` shall be set.

Byte	Bit	Field	Value
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, one or more of ENCRYPT_CAP and MAC_CAP shall be set.
1	4	ENCAP_CAP	If set, Requester supports GET_ENCAPSULATED_REQUEST , ENCAPSULATED_REQUEST , DELIVER_ENCAPSULATED_RESPONSE , and ENCAPSULATED_RESPONSE_ACK messages. If mutual authentication is supported, this field shall be set.
1	5	HBEAT_CAP	If set, Requester supports HEARTBEAT messages.
1	6	KEY_UPD_CAP	If set, Requester supports KEY_UPDATE messages.
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. In other words, this bit indicates whether message authentication and/or encryption (MAC_CAP and ENCRYPT_CAP) are used in the handshake phase of a secure session.
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	7:1	Reserved	Reserved.
3	7:0	Reserved	Reserved.

173 **Responder flag fields definitions**

174 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.

Byte	Bit	Field	Value
`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.
`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`	`MEASUREMENT` 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.
`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 or restart, 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, one or more of `PSK_CAP` or `KEY_EX_CAP` fields shall be specified accordingly to indicate support. This capability applies to all phases of a secure session.
`0`	`7`	`MAC_CAP`	If set, Responder supports message authentication in a secure session. If set, one or more of `PSK_CAP` or `KEY_EX_CAP` fields shall be specified accordingly to indicate support. This capability applies to all phases of a secure session. `MAC_CAP` is not the same as the `HMAC` in the `RequesterVerifyData` or `ResponderVerifyData` fields of Session-Secrets-Exchange and Session-Secrets-Finish messages.
`1`	`0`	`MUT_AUTH_CAP`	If set, Responder supports mutual authentication.
`1`	`1`	`KEY_EX_CAP`	If set, Responder supports `KEY_EXCHANGE` messages. If set, one or more of `ENCRYPT_CAP` and `MAC_CAP` shall be set.

Byte	Bit	Field	Value
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, one or more of ENCRYPT_CAP and MAC_CAP shall be set.
1	4	ENCAP_CAP	If set, Responder supports GET_ENCAPSULATED_REQUEST , ENCAPSULATED_REQUEST , DELIVER_ENCAPSULATED_RESPONSE , and ENCAPSULATED_RESPONSE_ACK messages. If mutual authentication is supported, this field shall be set.
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. In other words, this bit indicates whether message authentication and/or encryption (MAC_CAP and ENCRYPT_CAP) are used in the handshake phase of a secure session.
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 of the Responder shall be 0 .
2	7:1	Reserved	Reserved.
3	7:0	Reserved	Reserved.

175 ## 10.4 NEGOTIATE_ALGORITHMS request and ALGORITHMS response messages

176 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.

177 A Requester shall not issue any other SPDM requests, with the exception of `GET_VERSION` until it receives a successful `ALGORITHMS` response message.

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

179 The NEGOTIATE_ALGORITHMS request message format table shows the `NEGOTIATE_ALGORITHMS` request message format.

180 The Successful ALGORITHMS response message format table shows the `ALGORITHMS` response message format.

181 **NEGOTIATE_ALGORITHMS request message format**

Offset	Field	Size (bytes)	Value
`0`	`SPDMVersion`	1	`V1.1 = 0x11`
`1`	`RequestResponseCode`	1	`0xE3=NEGOTIATE_ALGORITHMS`
`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 measurement specification is used in the `MEASUREMENTS` response. Requester can set all available algorithms defined in the measurement specification format. The Requester can set zero bits if MEASUREMENTS are not supported. Bit 0: This bit shall indicate support for the DMTF-defined measurement specification. See DMTF specification for the Measurement field of a measurement block clauses for details.
`7`	`Reserved`	1	Reserved

Offset	Field	Size (bytes)	Value
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 S 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 S=256. Byte 0 Bit 1. TPM_ALG_RSAPSS_2048 where S=256. Byte 0 Bit 2. TPM_ALG_RSASSA_3072 where S=384. Byte 0 Bit 3. TPM_ALG_RSAPSS_3072 where S=384. Byte 0 Bit 4. TPM_ALG_ECDSA_ECC_NIST_P256 where S=64 (32-byte r followed by 32-byte s). Byte 0 Bit 5. TPM_ALG_RSASSA_4096 where S=512. Byte 0 Bit 6. TPM_ALG_RSAPSS_4096 where S=512. Byte 0 Bit 7. TPM_ALG_ECDSA_ECC_NIST_P384 where S=96 (48-byte r followed by 48-byte s). Byte 1 Bit 0. TPM_ALG_ECDSA_ECC_NIST_P521 where S=132 (66-byte r followed by 66-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 All other values reserved.
16	Reserved	12	Reserved

Offset	Field	Size (bytes)	Value
`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.
`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. The Extended algorithm field format table describes the format of this field.
`32 + 4*A`	`ExtHash`	4*E	List of the extended hashing algorithms supported by Requester. The Extended algorithm field format table describes the format of this field.
`32 + 4*A + 4*E`	`ReqAlgStruct`	AlgStructSize	See the `AlgStructure` request field.

182 `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.

183 **Algorithm request structure**

Offset	Field	Size (bytes)	Value
`0`	`AlgType`	1	Type of algorithm. [1:0] = Reserved 2 = DHE 3 = AEADCipherSuite 4 = ReqBaseAsymAlg 5 = KeySchedule All other values reserved.

Offset	Field	Size (bytes)	Value
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).
2	AlgSupported	FixedAlgCount	Bit mask listing Requester-supported SPDM-enumerated algorithms.
2 + FixedAlgCount	AlgExternal	4*ExtAlgCount	List of Requester-supported extended algorithms. The Extended algorithm field format table describes the format of this field.

184 The following tables describe the associated fixed fields for the individual types.

185 **DHE structure**

Offset	Field	Size (bytes)	Value
0	AlgType	1	0x2=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) All other values reserved.
4	AlgExternal	4*ExtAlgCount2	List of Requester-supported extended DHE groups. The Extended algorithm field format table describes the format of this field.

186 **AEAD structure**

Offset	Field	Size (bytes)	Value
`0`	`AlgType`	1	`0x3=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. All other values reserved.
`4`	`AlgExternal`	4*ExtAlgCount3	List of Requester-supported extended AEAD algorithms. The Extended algorithm field format table describes the format of this field.

187 **ReqBaseAsymAlg structure**

Offset	Field	Size (bytes)	Value
`0`	`AlgType`	1	`0x4=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).

Offset	Field	Size (bytes)	Value
`2`	`AlgSupported`	2	Bit mask listing Requester-supported SPDM-enumerated asymmetric key signature algorithms for the purposes 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 All other values reserved.
`4`	`AlgExternal`	4*ExtAlgCount4	List of Requester-supported extended asymmetric key signature algorithms for the purpose of signature generation. The Extended algorithm field format table describes the format of this field.

188 **KeySchedule structure**

Offset	Field	Size (bytes)	Value
`0`	`AlgType`	1	`0x5=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. The Extended algorithm field format table describes the format of this field.

189 **Successful ALGORITHMS response message format**

Offset	Field	Size (bytes)	Value
`0`	`SPDMVersion`	1	`V1.1 = 0x11`
`1`	`RequestResponseCode`	1	`0x63=ALGORITHMS`
`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 and Responder. Thus, no more than one bit shall be set. The `MeasurementSpecification` field in `NEGOTIATE_ALGORITHMS` defines the format of this field.
`7`	`Reserved`	1	Reserved
`8`	`MeasurementHashAlgo`	4	Bit mask indicating the SPDM-enumerated hashing algorithm selected for measurements. Bit 0. Raw Bit Stream Only Bit 1. TPM_ALG_SHA_256 Bit 2. TPM_ALG_SHA_384 Bit 3. TPM_ALG_SHA_512 Bit 4. TPM_ALG_SHA3_256 Bit 5. TPM_ALG_SHA3_384 Bit 6. TPM_ALG_SHA3_512 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`. 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.

Offset	Field	Size (bytes)	Value
`20`	`Reserved`	12	Reserved
`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 Response AlgStructure field format

190 `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.

191 **Response AlgStructure field format**

Offset	Field	Size (bytes)	Value
0	`AlgType`	1	Type of algorithm. [1:0] = Reserved 2 = DHE 3 = AEADCipherSuite 4 = ReqBaseAsymAlg 5 = KeySchedule All other values reserved.
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. The Extended algorithm field format table describes the format of this field.

192 The tables for each of the individual type with the associated fixed fields are described below.

193 **DHE structure**

Offset	Field	Size (bytes)	Value
0	`AlgType`	1	`0x2=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.

Offset	Field	Size (bytes)	Value
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) All other values reserved.
4	`AlgExternal`	4*ExtAlgCount2'	If present: a Requester-supported, Responder-selected, extended DHE algorithm. The Extended algorithm field format table describes the format of this field.

194 **AEAD structure**

Offset	Field	Size (bytes)	Value
0	`AlgType`	1	`0x3=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 All other values reserved.
4	`AlgExternal`	4*ExtAlgCount3'	If present: a Requester-supported, Responder-selected, extended AEAD algorithm. The Extended algorithm field format table describes the format of this field.

195 **ReqBaseAsymAlg structure**

Offset	Field	Size (bytes)	Value
0	`AlgType`	1	`0x4=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 purposes 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 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. The Extended algorithm field format table describes the format of this field.

196 **KeySchedule structure**

Offset	Field	Size (bytes)	Value
0	`AlgType`	1	`0x5=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.

Offset	Field	Size (bytes)	Value
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 reserved.
4	`AlgExternal`	4*ExtAlgCount5'	If present: a Requester-supported, Responder-selected, extended key schedule algorithm. The Extended algorithm field format table describes the format of this field.

197 **Extended Algorithm field format**

198 Describes algorithms that are external to this specification.

Offset	Field	Description
0	Registry ID	Shall represent the registry or standards body. The **ID** column in the Registry or standards body ID table describes the value of this field.
1	Reserved	Reserved
[2:3]	Algorithm ID	Shall indicate the desired algorithm. The registry or standards body owns the value of this field. For details, see the Registry or standards body ID table.

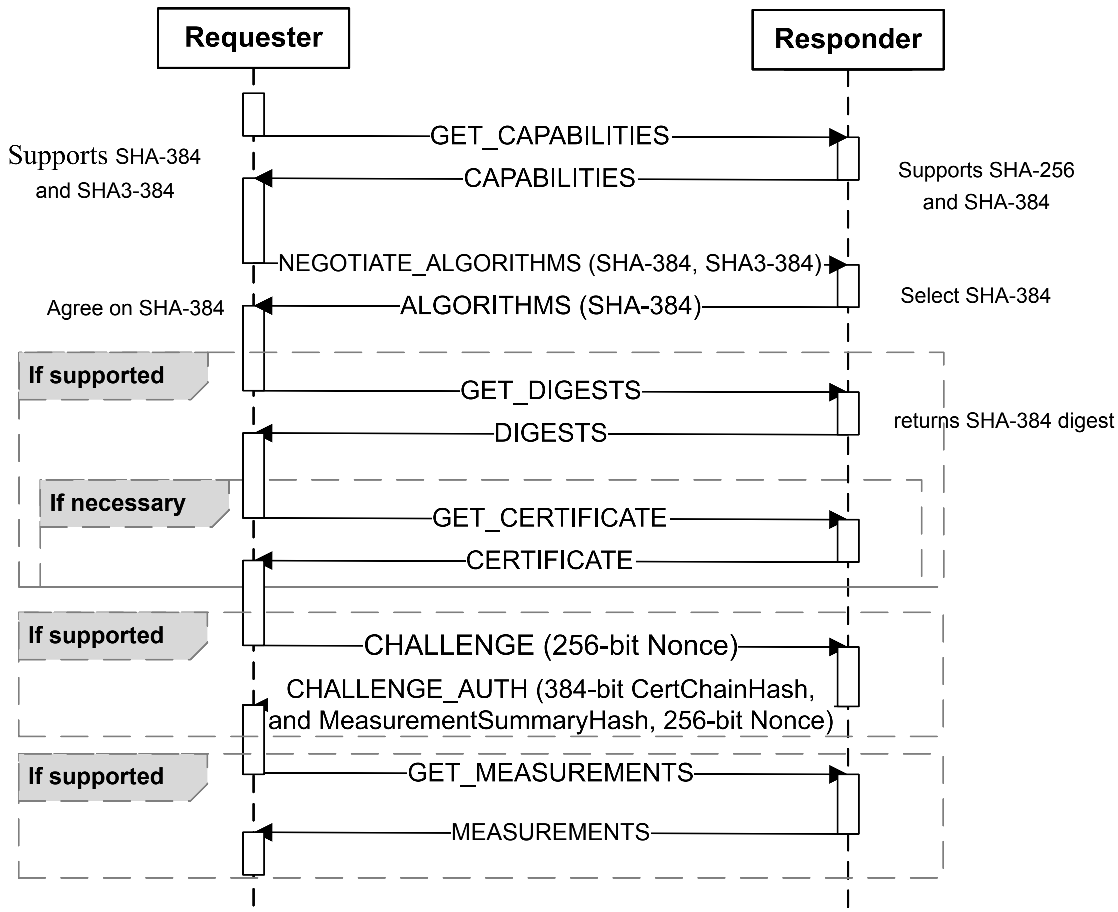
199 For each algorithm type, a Responder shall not select both a SPDM-enumerated algorithm and an extended algorithm.

200 Hashing algorithm selection: Example 1 illustrates how two endpoints negotiate a base hashing algorithm.

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

202 **Hashing algorithm selection: Example 1**

203



204 The SPDM protocol accounts for the possibility that both endpoints may issue `NEGOTIATE_ALGORITHMS` request messages independently of each other. In this case, the endpoint A Requester and endpoint B Responder communication pair may select a different algorithm compared to the endpoint B Requester and endpoint A Responder communication pair.

205 10.4.1 Behavior after VERSION, CAPABILITIES and ALGORITHMS

206 With the successful completion of the `ALGORITHMS` message, all of the parameters for further SPDM message exchanges between the same pair of Requester and Responder have been determined. Thus, all SPDM message exchanges after the `VERSION`, `CAPABILITIES` AND `ALGORITHMS` 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. The Responder selects the `TPM_ALG_RSASSA_2048` asymmetric algorithm in `BaseAsymSel`

and the `TPM_ALG_SHA_256` hash algorithm in `BaseHashSel`. If the corresponding Requester 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.

207 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, the corresponding Responder shall either silently discard the request or return an `ERROR` message with an appropriate error code.

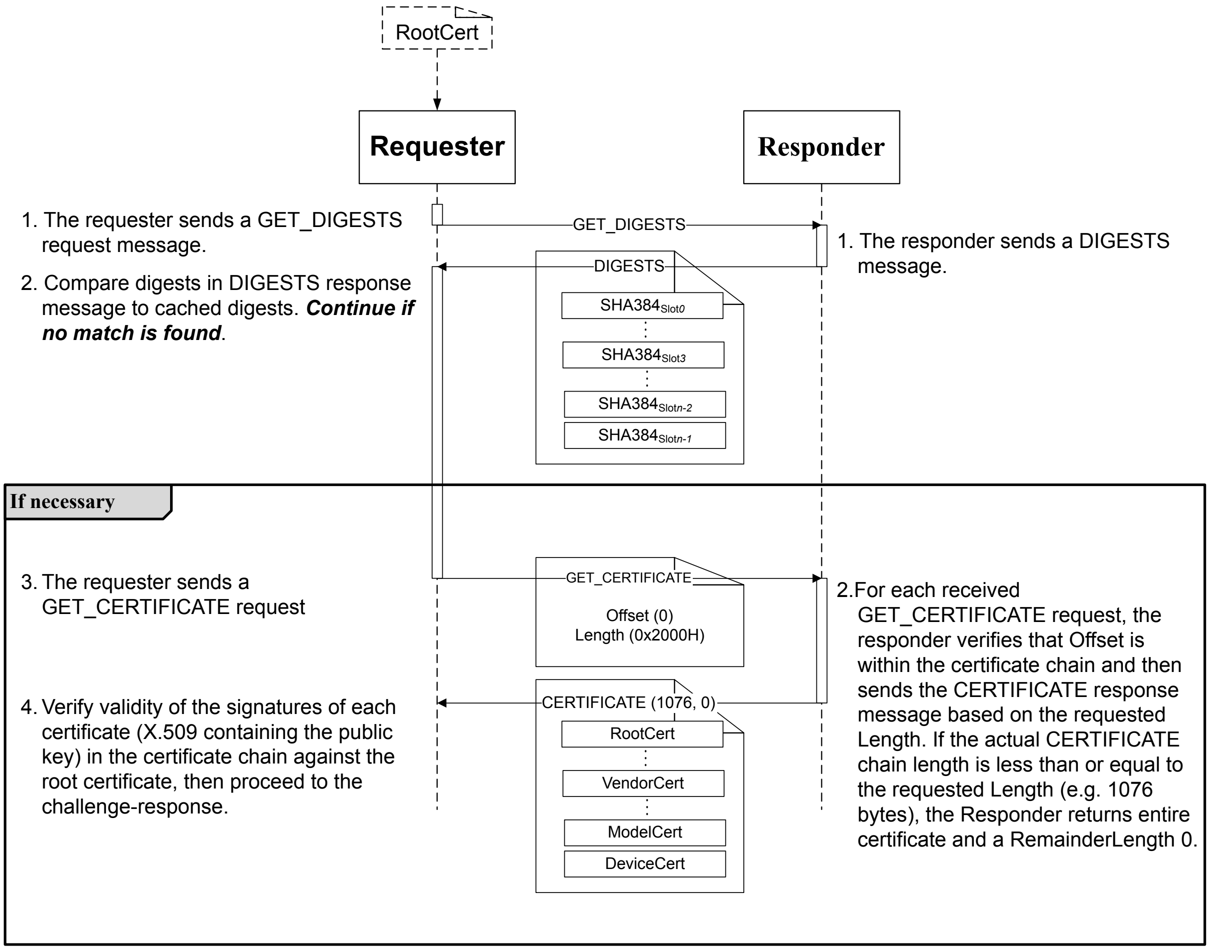
208 10.5 Responder identity authentication

209 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 defined in this clause 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.

210 The Responder authentication: Example certificate retrieval flow shows the high-level request-response message flow and sequence for *certificate* retrieval.

211 **Responder authentication: Example certificate retrieval flow**

212



213 The `GET_DIGESTS` request message and `DIGESTS` response message may 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.

214 For the runtime challenge-response flow, the signature field in the `CHALLENGE_AUTH` response message payload shall be signed by using the device private key over the hash of the message transcript. See the Request ordering and message transcript computation rules for M1/M2 table.

215 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.

216 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.

217 ## 10.6 Requester identity authentication

218 If the Requester supports mutual authentication, the requirements placed on the Responder in Responder identity authentication shall also apply to the Requester.

219 If the Responder supports mutual authentication, the requirements placed on the Requester in Responder identity authentication shall also apply to the Responder. These two statements essentially describe a role reversal.

220 ### 10.6.1 Certificates and certificate chains

221 Each SPDM endpoint that supports identity authentication using certificates shall carry at least one certificate chain. A certificate chain contains an ordered list of certificates, presented as the binary (byte) concatenation of the fields that the Certificate chain format shows.

222 Each certificate 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. The minimum number of certificates within a chain shall be one, in which case the single certificate is the device-specific certificate. The SPDM endpoint shall contain a single public-private key pair per supported algorithm for its hardware identity, regardless of how many certificate chains are stored on the device. The Responder selects a single asymmetric key signature algorithm per Requester.

223 Certificate chains are stored in locations called slots. Each slot shall either be empty or contain one complete certificate chain. A device shall not contain more than eight slots. Slot 0 is populated by default. 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.

224 In this document, `H` refers to the output size, in bytes, of the hash algorithm agreed upon in `NEGOTIATE_ALGORITHMS`.

225 **Certificate chain format**

Offset	Field	Size	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 big endian.

Offset	Field	Size	Description
4 + H	`Certificates`	Length - (4 + H)	One or more ASN.1 DER-encoded X.509 v3 certificates where the first certificate is signed by the Root Certificate or is the Root Certificate itself and each subsequent certificate is signed by the preceding certificate. The last certificate is the *leaf certificate*. This field shall be big endian.

226 10.7 GET_DIGESTS request and DIGESTS response messages

227 This request message shall be used to retrieve the certificate chain digests.

228 The GET_DIGESTS request message format table shows the `GET_DIGESTS` request message format.

229 The Successful DIGESTS response message table shows the `DIGESTS` response message format.

230 The digests in the Successful DIGESTS response message table shall be big endian, and the digest shall be computed over the certificate chain as shown in Certificate chain format.

231 **GET_DIGESTS request message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x81=GET_DIGESTS`
2	`Param1`	1	Reserved
3	`Param2`	1	Reserved

232 **Successful DIGESTS response message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x01=DIGESTS`
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.

Offset	Field	Size (bytes)	Value
4	`Digest[0]`	H	Digest of the first certificate chain.
...	...	...	...
4 + (H * (n -1))	`Digest[n-1]`	H	Digest of the last (n^{th}) certificate chain.

233 ## 10.8 GET_CERTIFICATE request and CERTIFICATE response messages

234 This request message shall retrieve the certificate chains.

235 The GET_CERTIFICATE request message format table shows the `GET_CERTIFICATE` request message format.

236 The Successful CERTIFICATE response message table shows the `CERTIFICATE` response message format.

237 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.

238 **GET_CERTIFICATE request message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x82=GET_CERTIFICATE`
2	`Param1`	1	Slot number of the target certificate chain to read from. The value in this field shall be between 0 and 7 inclusive.
3	`Param2`	1	Reserved
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 for a given slot, the Requester shall set this field to 0. For subsequent requests, `Offset` is set to the next portion of the certificate in that slot.

Offset	Field	Size (bytes)	Value
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. If `offset=0` and `length=0xFFFF`, the Requester is requesting the entire chain.

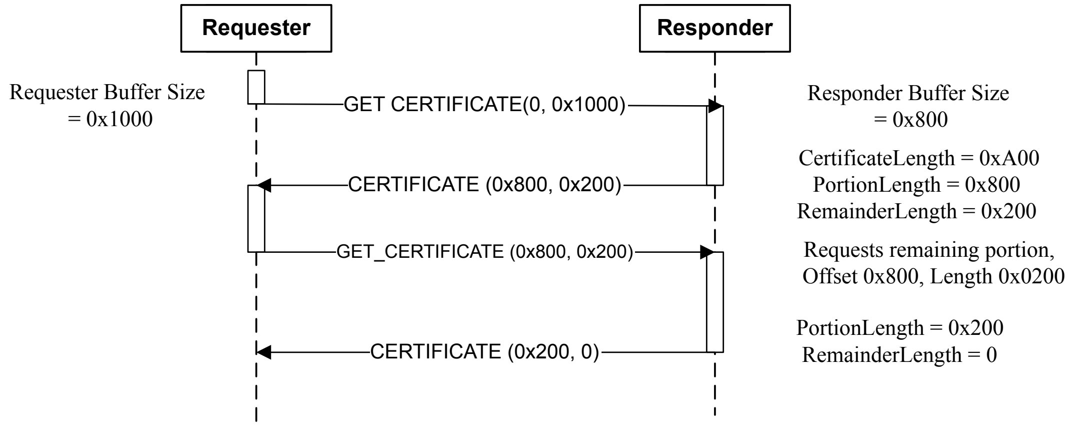
239 **Successful CERTIFICATE response message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x02=CERTIFICATE`
2	`Param1`	1	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.

240 The Responder unable to 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.

241 **Responder unable to return full length data flow**

242



243 10.8.1 Mutual authentication requirements for GET_CERTIFICATE and CERTIFICATE messages

244 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 describes a role reversal.

245 10.8.2 Leaf certificate

246 The SPDM endpoints for authentication shall be provisioned with DER-encoded X.509 v3 format certificates. The leaf certificate shall be signed by a trusted CA and provisioned to the device. For endpoint devices to verify the certificate, the following required fields shall be present. In addition, to provide device information, use the `Subject Alternative Name` certificate extension `otherName` field. See the Definition of otherName using the DMTF OID.

247 **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.

Field	Description
`Subject Name`	Subject name shall be present and shall represent the distinguished name associated with the leaf certificate.
`Validity`	Certificates may include this attribute. See RFC5280 for further details.
`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.

248 Optional fields

Field	Description
`Basic Constraints`	If present, the CA value shall be `FALSE` .
`Subject Alternative Name otherName`	In some cases, it might be desirable to provide device specific information as part of the device 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 device certificate. See the Definition of otherName using the DMTF OID.

249 Definition of otherName using the DMTF OID

```
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 1 412 274 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})
```

250 The Leaf certificate example shows an example leaf certificate.

251 10.9 CHALLENGE request and CHALLENGE_AUTH response messages

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

253 The CHALLENGE request message format table shows the `CHALLENGE` request message format.

254 The Successful CHALLENGE_AUTH response message table shows the `CHALLENGE_AUTH` response message format.

255 **CHALLENGE request message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x83=CHALLENGE`
2	`Param1`	1	Slot number of the certificate chain of the Responder 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.
3	`Param2`	1	Requested measurement summary hash Type: `0x0` . No measurement summary hash. `0x1` . TCB measurement hash. `0xFF` . All measurements hash. All other values reserved. When Responder does not support any measurements, Requester shall set this value to `0x0` .
4	`Nonce`	32	The Requester should choose a random value.

256 **Successful CHALLENGE_AUTH response message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x03=CHALLENGE_AUTH`

Offset	Field	Size (bytes)	Value
2	`Param1`	1	Response Attribute Field. Please see CHALLENGE_AUTH Response Attribute Table for details.
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.
4	`CertChainHash`	H	Hash of the certificate chain 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 is big endian.
4 + H	`Nonce`	32	Responder-selected random value.
36 + H	`MeasurementSummaryHash`	H	When the Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response) or requested `Param2` =0, this field shall be absent. When the requested `Param2` =1, 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. When the requested `Param2` =1 and there are no measurable components in the TCB required to generate this response, this field shall be `0` . When requested `Param2=0xFF` , this field is computed as the hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ..., MeasurementBlock[n])) of all supported measurement blocks 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.
36 + 2H	`OpaqueLength`	2	Size of the `OpaqueData` field. The value shall not be greater than 1024 bytes.
38 + 2H	`OpaqueData`	`OpaqueLength`	Free-form field, if present. The Responder may include Responder-specific information and/or information defined by its transport.
38 + 2H + `OpaqueLength`	`Signature`	S	S 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.

257 **CHALLENGE_AUTH response attribute**

Bit Offset	Field Name	Description
[3:0]	SlotID	This field shall contain the slot number 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	BasicMutAuthReq	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 for more details. If mutual authentication is not supported, this bit shall be zero; otherwise, it should be considered an error.

258
10.9.1 CHALLENGE_AUTH signature generation

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

260 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.

261 where:

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

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

264 Concatenation function is performed on the contents of both the original request and the response received during `RESPOND_IF_READY` .

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

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

267 2. The Responder shall generate:

```
Signature = Sign(SK, Hash(M1));
```

268 where:

269 ◦ `Sign`

270 Asymmetric signing algorithm that the Responder selected through the last `ALGORITHMS` response message that the Responder sent.

271 The Successful ALGORITHMS response message format table describes the `BaseAsymSel`, `ExtAsymSel` and `RespAlgStruct` (when `AlgType` == `ReqBaseAsymAlg`) fields.

272 ◦ `SK`

273 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 `SK` is the associated private key.

274 ◦ `Hash`

275 Hashing algorithm the Responder selected through the last `ALGORITHMS` response message that the Responder sent.

276 The Successful ALGORITHMS response message format table describes the `BaseHashSel` and `ExtHashSel` fields.

277 10.9.2 CHALLENGE_AUTH signature verification

278 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.

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

280 1. The Requester shall perform:

```
Verify(PK, Hash(M2), Signature);
```

281 where:

282 ◦ `Verify`

283 Asymmetric verification algorithm that the Responder selected through the last `ALGORITHMS` response message that the Requester received.

284 The Successful ALGORITHMS response message format table describes the `BaseAsymSel`, `ExtAsymSel` and `RespAlgStruct` (when `AlgType` == `ReqBaseAsymAlg`) fields.

285 ◦ `PK`

286 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, then `PK` is the provisioned public key.

287 ◦ `Hash`

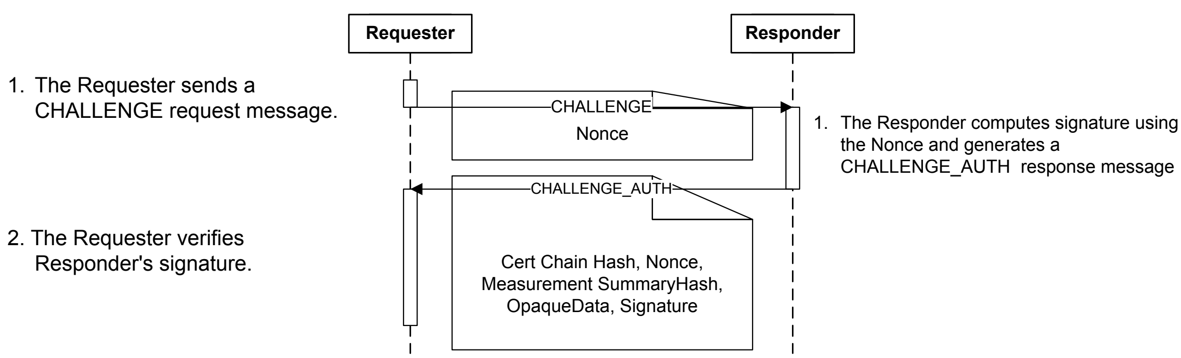
288 Hashing algorithm the Responder selected through the last sent `ALGORITHMS` response message as received by the Requester.

289 The Successful ALGORITHMS response message format table describes the `BaseHashSel` and `ExtHashSel` fields.

290 The 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.

291 **Responder authentication: Runtime challenge-response flow**

292



293 10.9.2.1 Request ordering and message transcript computation rules for M1 and M2

294 This clause applies to Responder-only authentication.

295 The Request ordering and message transcript computation rules for M1/M2 table 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.

296 The possible request orderings after reset leading up to and including `CHALLENGE` are:

- `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)
- `CHALLENGE` (A2, B2, C1)

297 Immediately after reset, M1 and M2 shall be null.

298 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.

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

300 **Request ordering and message transcript computation rules for M1/M2**

Requests	Implementation requirements	M1/M2=Concatenate (A, B, C)
Reset	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=Concatenate(GET_VERSION, VERSION, GET_CAPABILITIES, CAPABILITIES, NEGOTIATE_ALGORITHMS, ALGORITHMS)`
`GET_VERSION` , `GET_CAPABILITIES` , `NEGOTIATE_ALGORITHMS` Skipped	Requester skipped issuing these requests after a new reset if the Responder has previously indicated `CACHE_CAP=1` . In this case, the Requester and Responder shall proceed with the previously determined `Negotiated State` .	`A2=null`
`GET_DIGESTS` , `GET_CERTIFICATE` issued	Requester issued these requests in this order after `NEGOTIATE_ALGORITHMS` request completion or immediately after reset, 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 new reset since it could use previously cached certificate information.	`B2=null`
`GET_DIGESTS` issued, `GET_CERTIFICATE` skipped	Requester skipped `GET_CERTIFICATE` request after a new reset since it could use the previously cached `CERTIFICATE` response.	`B3=(GET DIGESTS, DIGESTS)`

Requests	Implementation requirements	M1/M2=Concatenate (A, B, C)
`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 the CHALLENGE request message format table.
`CHALLENGE` completion	Completion of `CHALLENGE` resets M1 and M2.	`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 and M2 are reset to `null`.	`M1/M2=null`

301 ### 10.9.3 Basic mutual authentication

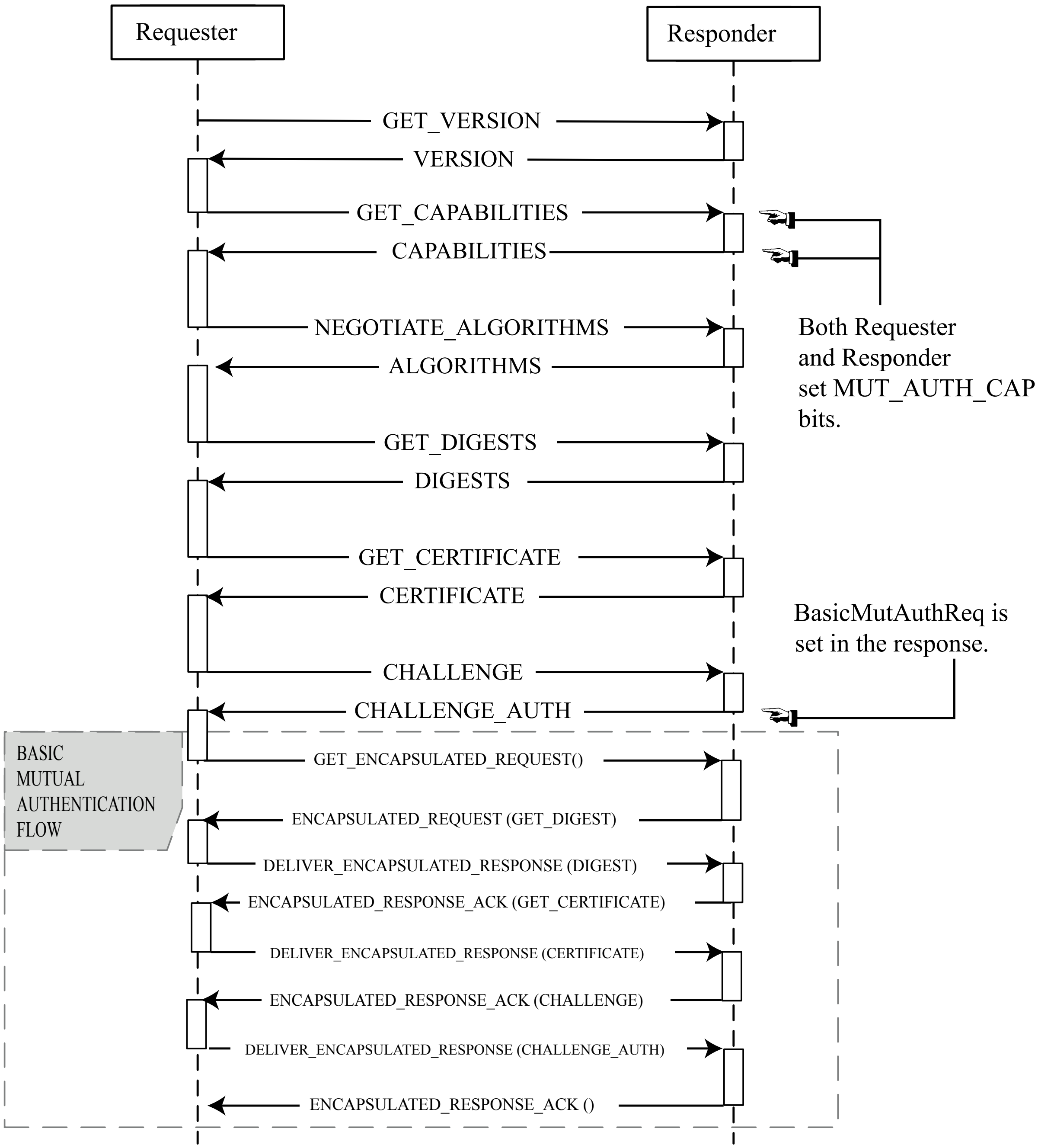
302 Unless otherwise stated, if the Requester supports mutual authentication, the requirements placed on the Responder in the CHALLENGE request and CHALLENGE_AUTH response messages clause shall also apply to the Requester. Unless otherwise stated, if the Responder supports mutual authentication, the 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.

303 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.

304 This flow shall only allow `GET_DIGESTS`, `GET_CERTIFICATE`, `CHALLENGE` and their corresponding responses to be encapsulated.

305 The Mutual authentication basic flow illustrates, as an example, the basic mutual authentication flow.

306 **Mutual authentication basic flow**

307 

308 **10.9.3.1 Mutual authentication message transcript**

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

310 The Basic mutual authentication message transcript table 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.

311 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*)

312 When the basic mutual authentication flow starts (i.e., when `GET_ENCAPSULATED_REQUEST` is issued) M1 and M2 shall be set to NULL.

313 **Basic mutual authentication message transcript**

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

314 For `GET_CERTIFICATE` and `CERTIFICATE` , these messages may 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.

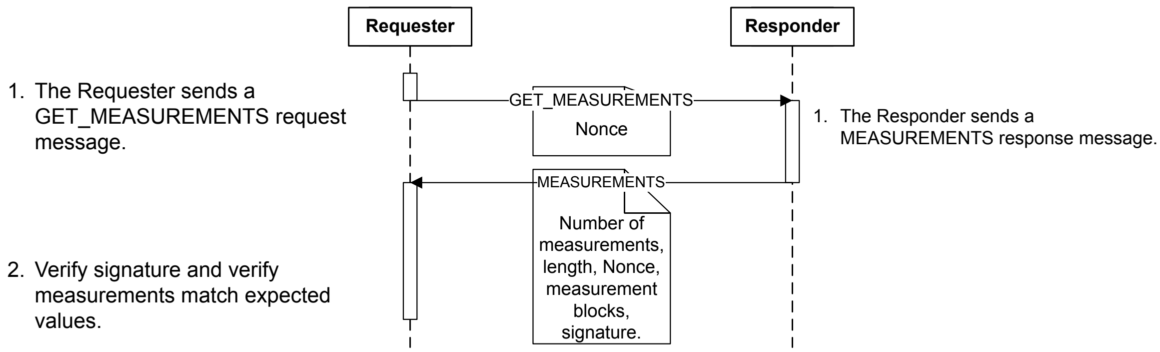
315 10.10 Firmware and other measurements

316 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.

317 The 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.

318 **Measurement retrieval flow**

319



320 10.11 GET_MEASUREMENTS request and MEASUREMENTS response messages

321 This request message shall retrieve measurements in the form of measurements blocks. A Requester should not send this message until it has received at least one successful `CHALLENGE_AUTH` response message from the Responder, or should send this message in a secure session. The successful `CHALLENGE_AUTH` response may have been received before the last reset.

322 The GET_MEASUREMENTS request message format table shows the `GET_MEASUREMENTS` request message format.

323 The GET_MEASUREMENTS request attributes table shows the `GET_MEASUREMENTS` request message attributes.

324 The Successful MEASUREMENTS response message format table shows the `MEASUREMENTS` response message format. The measurement blocks in `MeasurementRecord` shall be placed contiguously from index 1.

325 **GET_MEASUREMENTS request message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xE0=GET_MEASUREMENTS`
2	`Param1`	1	Request attributes. See the GET_MEASUREMENTS request attributes table.

Offset	Field	Size (bytes)	Value
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`	32	The Requester should choose a random value. This field is only present if a signature is required on the response. See the GET_MEASUREMENTS request attributes table.
36	`SlotIDParam`	1	Bit[7:4] = Reserved. Bit[3:0] = SlotID. Slot number of the certificate chain of the Responder 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 a signature is required on the response. See the GET_MEASUREMENTS request attributes table.

326 **GET_MEASUREMENTS request attributes**

Bits	Value	Description
`0`	`1`	If the Responder can generate a signature (`MEAS_CAP` is `10b` in the `CAPABILITIES` response), the value of this bit shall indicate to the Responder that a signature is required. The Responder shall generate a signature in the corresponding response. The `Nonce` field shall be present in the request.
`0`	`0`	For Responders that can generate signatures, the value of this bit shall indicate 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 this value.
`[7:1]`	Reserved	Reserved

327 **Successful MEASUREMENTS response message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x60=MEASUREMENTS`

Offset	Field	Size (bytes)	Value
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[7:4] = 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 (N) in `MeasurementRecord`. If Param2 in the requested measurement operation is `0`, this field shall be `0`.
5	`MeasurementRecordLength`	3	Size of the `MeasurementRecord` field in bytes. If `Param2` in the requested measurement operation is `0`, this field shall be `0`.
8	`MeasurementRecord`	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.
40 + L	`OpaqueLength`	2	Size of the `OpaqueData` field in bytes. The value shall not be greater than 1024 bytes.
42 + L	`OpaqueData`	`OpaqueLength`	Free-form field, if present. The Responder may include Responder-specific information and/or information defined by its transport.
42 + L + `OpaqueLength`	`Signature`	S	Signature of the `GET_MEASUREMENTS` request and `MEASUREMENTS` response messages, excluding the Signature field and signed using the device private key. The Responder shall use the asymmetric signing algorithm it selected during the last `ALGORITHMS` response message to the Requester, and S is the size of that asymmetric signing algorithm output. This field is conditional.

328 10.11.1 Measurement block

329 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`.

330 The Measurement block format table shows the format for a measurement block:

331 **Measurement block format**

Offset	Field	Size (bytes)	Value
0	`Index`	1	Index. Shall represent the index of the measurement. In the range of [1, N].
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 the Successful ALGORITHMS response message format table. Only one bit shall be set in the measurement block. Bit 0=DMTF, as specified in the Measurement field format when MeasurementSpecification field is Bit 0 = DMTF table. All other bits are reserved.
2	`MeasurementSize`	2	Size of `Measurement`, in bytes.
4	`Measurement`	MeasurementSize	The `MeasurementSpecification` defines the format of this field.

332 **10.11.1.1 DMTF specification for the Measurement field of a measurement block**

333 The present clause is the specification for the format of the `Measurement` field in a measurement block when the `MeasurementSpecification` field selects Bit 0=DMTF. This format is specified in Measurement field format when MeasurementSpecification field is Bit 0 = DMTF.

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

335 **Measurement field format when MeasurementSpecification field is bit 0 = DMTF**

Offset	Field	Size (bytes)	Value
0	`DMTFSpecMeasurementValueType`	1	Composed of: Bit [7] indicates the representation in `DMTFSpecMeasurementValue` . Bits [6:0] indicate what is being measured by `DMTFSpecMeasurementValue` . These values are set independently and are interpreted as follows: `[7]=0b` . Digest. `[7]=1b` . Raw bit stream. `[6:0]=00h` . Immutable ROM. `[6:0]=01h` . Mutable firmware. `[6:0]=02h` . Hardware configuration, such as straps, debug modes. `[6:0]=03h` . Firmware configuration, such as configurable firmware policy. `[6:0]=04h` . Measurement manifest. 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`	`DMTFSpecMeasurementValueSize`	`DMTFSpecMeasurementValueSize` bytes of cryptographic hash or raw bit stream, as indicated in `DMTFSpecMeasurementValueType[7]` .

336 10.11.2 MEASUREMENTS signature generation

337 While a Requester may opt to require a signature in each individual `MEASUREMENTS` response, it is advisable that the cost of the signature generation process is minimized by amortizing it over multiple `MEASUREMENTS` responses where applicable. In this scheme, the Requester issues a number of `GET_MEASUREMENTS` requests without requiring signatures followed by a final `GET_MEASUREMENTS` request requiring a signature over the entire set of

`GET_MEASUREMENTS` requests and corresponding `MEASUREMENTS` responses exchanged. The steps to complete this scheme are as follows:

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

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

339 where:

340 ◦ `Concatenate()`

341 Standard concatenation function.

342 ◦ `GET_MEASUREMENTS_REQUEST1`

343 Entire first `GET_MEASUREMENTS` request message under consideration, where the Requester has not requested a signature on that specific `GET_MEASUREMENTS` request.

344 ◦ `MEASUREMENTS_RESPONSE1`

345 Entire `MEASUREMENTS` response message without the signature bytes that the Responder sent in response to `GET_MEASUREMENTS_REQUEST1`.

346 ◦ `GET_MEASUREMENTS_REQUESTn-1`

347 Entire last consecutive `GET_MEASUREMENTS` request message under consideration, where the Requester has not requested a signature on that specific `GET_MEASUREMENTS` request.

348 ◦ `MEASUREMENTS_RESPONSEn-1`

349 Entire `MEASUREMENTS` response message without the signature bytes that the Responder sent in response to `GET_MEASUREMENTS_REQUESTn-1`.

350 ◦ `GET_MEASUREMENTS_REQUESTn`

351 Entire first `GET_MEASUREMENTS` request message under consideration, where the Requester has requested a signature on that specific `GET_MEASUREMENTS` request.

352 *n* is a number greater than or equal to `1`.

353 When *n* equals `1`, the Requester has not made any `GET_MEASUREMENTS` requests without signature prior to issuing a `GET_MEASUREMENTS` request with signature.

354 ◦ `MEASUREMENTS_RESPONSEn`

355 Entire `MEASUREMENTS` response message without the signature bytes that the Responder sent in response to `GET_MEASUREMENTS_REQUESTn`.

356 Any communication between Requester and Responder other than a `GET_MEASUREMENTS` request or response resets L1/L2 computation to null.

357 2. The Responder shall generate:

```
Signature = Sign(SK, Hash(L1));
```

358 where:

359 ◦ `Sign`

360 Asymmetric signing algorithm that the Responder selected through the last `ALGORITHMS` response message that the Responder sent.

361 The Successful ALGORITHMS response message format table describes the `BaseAsymSel` and `ExtAsymSel` fields.

362 ◦ `SK`

363 Private key of the Responder associated with the leaf certificate stored in `SlotID`. If the public key of the Responder was provisioned to the Requester, then `SK` is the associated private key.

364 ◦ `Hash`

365 Hashing algorithm that the Responder selected through the last `ALGORITHMS` response message that the Responder sent.

366 The Successful ALGORITHMS response message format table describes the `BaseHashSel` and `ExtHashSel` fields.

367 10.11.3 MEASUREMENTS signature verification

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

369 1. The Requester shall perform:

```
Verify(PK, Hash(L2), Signature)
```

370 where:

- 371 `PK`

  372 Public key associated with the slot 0 certificate of the Responder. `PK` is extracted from the `CERTIFICATES` response. If the public key of the Responder was provisioned to the Requester, then `PK` is the provisioned public key.

- 373 `Verify`

  374 Asymmetric verification algorithm that the Responder selected through the last `ALGORITHMS` response message that the Requester received.

  375 The Successful ALGORITHMS response message format table describes the `BaseAsymSel` and `ExtAsymSel` fields.

- 376 `Hash`

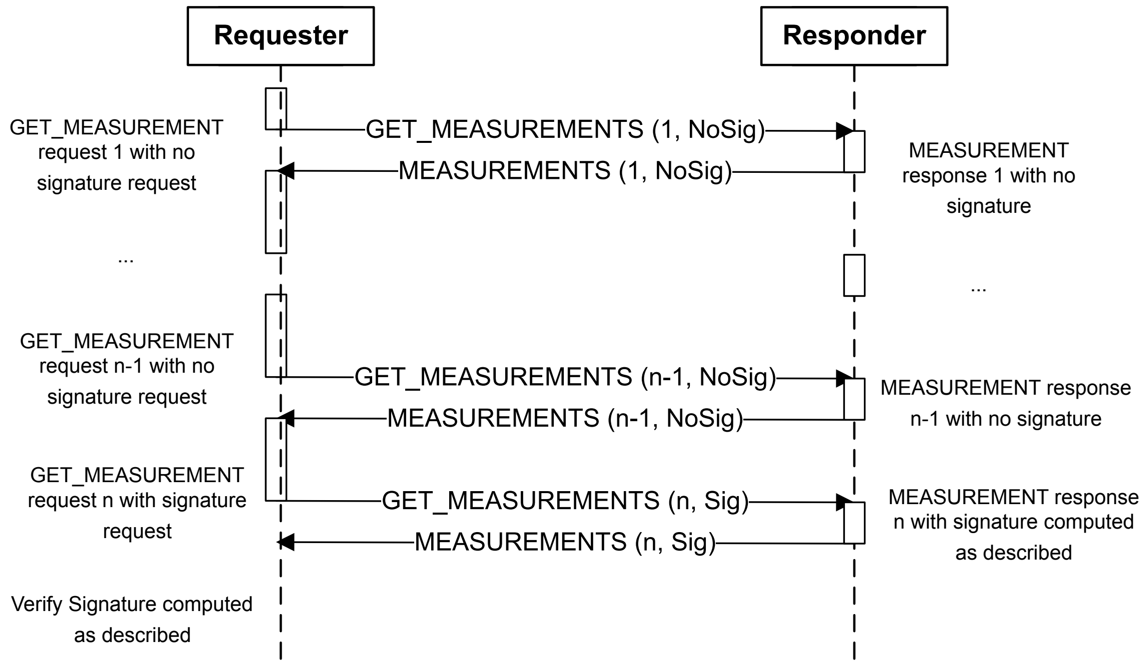
  377 Hashing algorithm the Responder selected through the last sent `ALGORITHMS` response message that the Requester sent.

  378 The Successful ALGORITHMS response message format table describes the `BaseHashSel` and `ExtHashSel` fields.

379 The 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.

380 **Measurement signature computation example**

381



382 10.12 ERROR response message

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

384 The ERROR response message format table shows the `ERROR` response format.

385 The Error code and error data table shows the detailed error code, error data, and extended error data.

386 The ResponseNotReady extended error data table shows the `ResponseNotReady` extended error data.

387 The Registry or standards body ID table shows the registry or standards body ID.

388 The ExtendedErrorData format for vendor or other standards-defined ERROR response message table shows the `ExtendedErrorData` format definition for vendor or other standards-defined `ERROR` response message.

389 **ERROR response message format**

Offset	Field	Size (bytes)	Value
0	SPDMVersion	1	V1.1 = 0x11
1	RequestResponseCode	1	0x7F=ERROR
2	Param1	1	Error Code. See Error code and error data.
3	Param2	1	Error Data. See Error code and error data.
4	ExtendedErrorData	0-32	Optional extended data. See Error code and error data.

390 **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	Reserved
Busy	0x03	The Responder received the request message and the Responder decided to ignore the request message, but the Responder may 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.
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.

Error code	Value	Description	Error data	ExtendedErrorData
`SessionLimitExceeded`	`0x0A`	Maximum number of concurrent sessions reached.	Reserved	No extended error data is provided.
Reserved	`0x0b` - `0x40`	Reserved	Reserved	Reserved
`MajorVersionMismatch`	`0x41`	Requested SPDM Major Version is not supported.	`0x00`	No extended error data provided.
`ResponseNotReady`	`0x42`	See the RESPOND_IF_READY request message format.	`0x00`	See the ResponseNotReady extended error data table.
`RequestResynch`	`0x43`	Responder is requesting Requester to reissue `GET_VERSION` to resynchronize. An example is following a firmware update.	`0x00`	No extended error data provided.
Reserved	`0x44` - `0xFE`	Reserved	Reserved.	Reserved
Vendor/Other Standards Defined	`0xFF`	Vendor or Other Standards defined	Shall indicate the registry or standard body using one of the values in the **ID** column in the Registry or standards body ID table.	See the ExtendedErrorData format for vendor or other standards-defined ERROR response message table for format definition.

391 **ResponseNotReady extended error data**

Offset	Field	Size (bytes)	Value
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. Requester should use `RDT` to avoid continuous pinging and issue the `RESPOND_IF_READY` request message after `RDT` time. For timing requirement details, see the Timing specification for SPDM messages table.
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.

Offset	Field	Size (bytes)	Value
3	`RDTM`	1	Multiplier used to compute `WT Max` in μs to indicate the response may be dropped after this delay. The multiplier shall always be greater than 1. The Responder may also stop processing the initial request if the same Requester issues a different request. For timing requirement details, see the Timing specification for SPDM messages table.

392 **Registry or standards body ID**

393 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 have any algorithms defined 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.

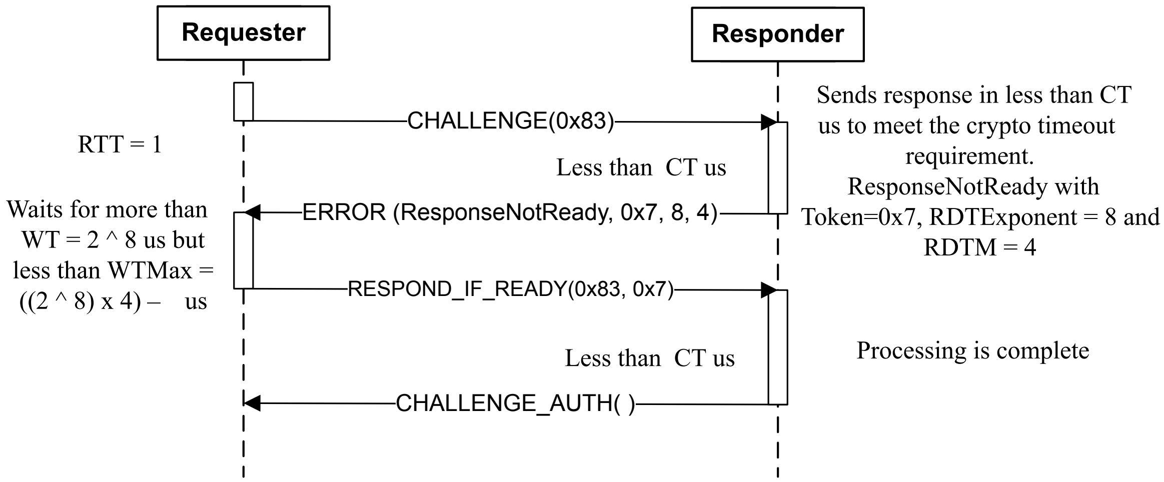
394 **ExtendedErrorData format for vendor or other standards-defined ERROR response message**

Byte offset	Length	Field name	Description
0	1	Len	Length of the `VendorID` field. If the `ERROR` is vendor defined, the value of this field shall equal the `Vendor ID Len`, as the Registry or standards body ID table describes, of the corresponding registry or standard body name. If the `ERROR` is defined by a registry or a standard, 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, such as `Param2`, and is one of the values in the **ID** column in the Registry or standards body ID table.
1	Len	VendorID	The value of this field shall indicate the Vendor ID, as assigned by the registry or standards body. The Registry or standards body ID table 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, such as `Param2`, and is one of the values in the **ID** column in the Registry or standards body ID table.
1 + Len	Variable	OpaqueErrorData	Defined by the vendor or other standards.

395 10.13 RESPOND_IF_READY request message format

396 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.

397



398 The RESPOND_IF_READY request message format table shows the `RESPOND_IF_READY` request message format.

399 **RESPOND_IF_READY request message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xFF=RESPOND_IF_READY`
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.

400 10.14 VENDOR_DEFINED_REQUEST request message

401 A Requester intending to define a unique request to meet its need can use this request message. The VENDOR_DEFINED_REQUEST request message format table defines the format.

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

403 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 hashes and/or message transcript are changed to add the vendor defined commands.

404 The VENDOR_DEFINED_REQUEST request message format table shows the `VENDOR_DEFINED_REQUEST` request message format.

405 **VENDOR_DEFINED_REQUEST request message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xFE=VENDOR_DEFINED_REQUEST`
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 the Registry or standards body ID table.
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 the Registry or standards body ID table describes.
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.

406 ## 10.15 VENDOR_DEFINED_RESPONSE response message

407 A Responder can use this response message in response to `VENDOR_DEFINED_REQUEST`. The VENDOR_DEFINED_RESPONSE response message format table defines the format.

408 The VENDOR_DEFINED_RESPONSE response message format table shows the response message format.

409 **VENDOR_DEFINED_RESPONSE response message format**

Offset	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x7E=VENDOR_DEFINED_RESPONSE`
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 the Registry or standards body ID table.
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 the Registry or standards body ID table 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.

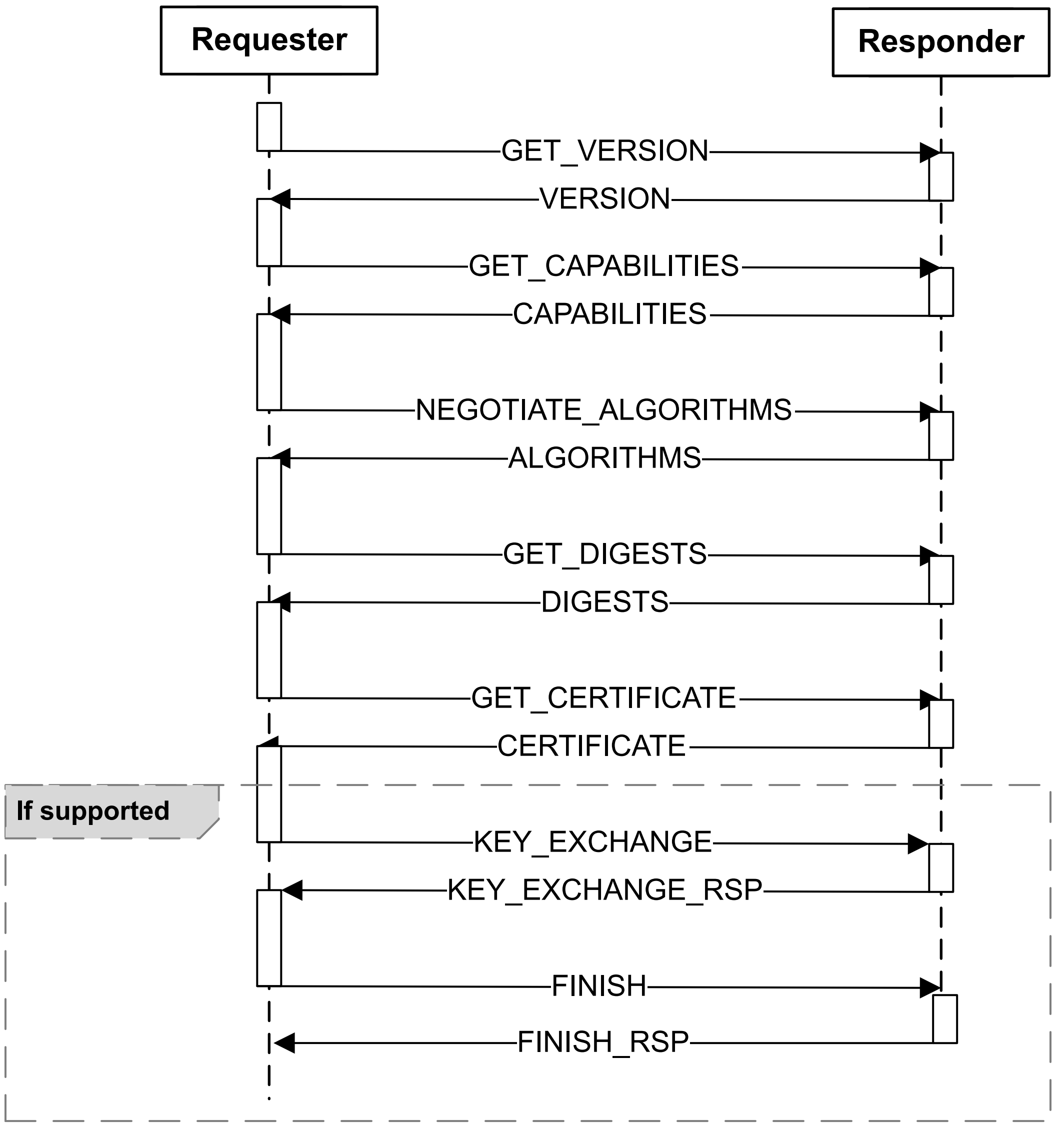
410 10.16 KEY_EXCHANGE request and KEY_EXCHANGE_RSP response messages

411 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. The KEY_EXCHANGE request message format table shows the `KEY_EXCHANGE` request message format and the Successful KEY_EXCHANGE_RSP response message format table 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.

412 The Requester and Responder pair may 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.

413 **Responder authentication key exchange example**

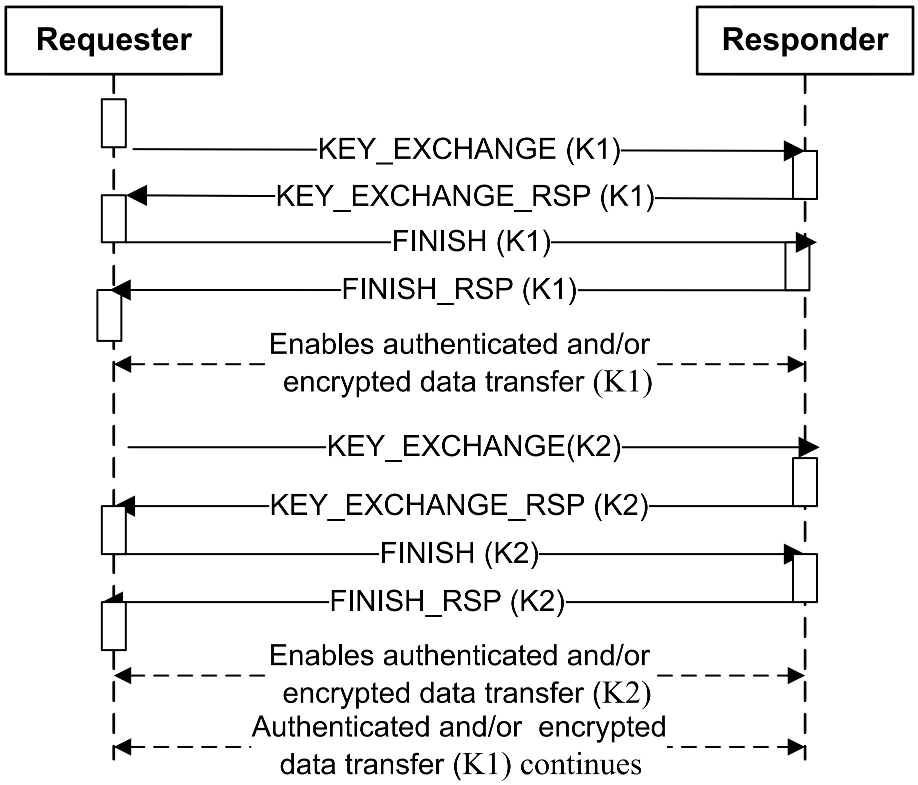
414



415 The Responder authentication multiple key exchange example provides 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 may generate an `ErrorCode=Busy` response to the second `KEY_EXCHANGE` request message until the first `FINISH_RSP` response message is complete.

416 **Responder authentication multiple key exchange example**

417



418 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 RFC 8446. Assuming that the public keys were received correctly, both the Requester and Responder generate identical DHE secrets from which session secrets are generated.

419 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 RFC 8446. 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 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.

420 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.

421 **KEY_EXCHANGE request message format**

Offset	Field	Size in bytes	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xE4 = KEY_EXCHANGE`
2	`Param1`	1	Requested `MeasurementSummaryHash` type: `0x0` . No measurement summary hash. `0x1` . TCB measurement hash. `0xFF` . All measurements hash. All other values reserved. When Responder does not support any measurements, Requester shall set this value to `0x0` .
3	`Param2`	1	The slot number of the target certificate chain that the Responder will use for authentication. The value in this field shall be between 0 and 7 inclusive to identify a valid certificate slot. 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	`Reserved`	2	Reserved
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.

Offset	Field	Size in bytes	Value
40 + D	`OpaqueDataLength`	2	Size of the `OpaqueData` field that follows in 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.

422 **Successful KEY_EXCHANGE_RSP response message format**

Offset	Field	Size in bytes	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x64 = KEY_EXCHANGE_RSP`
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 (mutual authentication) without using the encapsulated request flow. Bit 1 - If set, Responder is requesting mutual authentication with the encapsulated request flow. Bit 2 - If set, Responder is requesting 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 details on the encapsulated request flow or the optimized encapsulated request flow, see the GET_ENCAPSULATED_REQUEST request and ENCAPSULATED_REQUEST response messages clause.

Offset	Field	Size in bytes	Value
7	`SlotIDParam`	1	Bit[7:4] = Reserved. Bit[3:0] = SlotID. The slot number of the certificate chain of the Requester to be used for mutual authentication. 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. If `MutAuthRequested` = `0x00` this field shall be set to `0` and ignored by the Requester.
8	`RandomData`	32	Responder-provided random data.
40	`ExchangeData`	D	DHE public information generated by the Responder. 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	When the Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response) or requested `Param1` =0, this field shall be absent. When the requested `Param1` =1, 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. When the requested `Param1` =1 and there are no measurable components in the TCB required to generate this response, this field shall be `0` . When requested `Param1=0xFF` , this field is computed as the hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ..., MeasurementBlock[n])) of all supported measurement blocks 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.
40 + D + H	`OpaqueDataLength`	2	Size of the `OpaqueData` field that follows in bytes. Shall be `0` if no `OpaqueData` is provided.
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.

Offset	Field	Size in bytes	Value
42 + D + H + `OpaqueDataLength`	`Signature`	S	Signature over the transcript hash. S is the size of the asymmetric signing algorithm output the Responder selected via the last `ALGORITHMS` response message using the private key of the leaf certificate of the Responder. The construction of the transcript hash is defined in Transcript Hash for `KEY_EXCHANGE_RSP` signature.
42 + D + H + `OpaqueDataLength` + S	`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 Transcript Hash for `KEY_EXCHANGE_RSP` HMAC. 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 RFC 2104. If both the Requester and Responder set `HANDSHAKE_IN_THE_CLEAR_CAP` to 1, then this field shall be absent.

423 10.16.1 Mutual authentication

424 To perform authentication of the Requester in the `KEY_EXCHANGE` flow, either the encapsulated request flow or the optimized encapsulated request flow shall be used. For details and illustration of this flow, see GET_ENCAPSULATED_REQUEST request and ENCAPSULATED_REQUEST response messages.

425 The only messages that shall be encapsulated in this case are `GET_DIGESTS` , `DIGESTS` , `GET_CERTIFICATE` , and `CERTIFICATE` .

426 10.16.2 Specifying Requester certificate for mutual authentication

427 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.

428 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` and `SlotID` is set to `0`, the Responder shall use a `ENCAPSULATED_RESPONSE_ACK` request with `Param2` = `0x02` and an 1-byte long `Encapsulated Request` field containing the `SlotID` value. This shall be interpreted by the Requester as a valid request indicating the slot number to be used, and the `SlotID` field in `KEY_EXCHANGE_RSP` shall be ignored.

429 If Bit 0 of `MutAuthRequested` is set, then mutual authentication shall be performed without exchanging any messages between `KEY_EXCHANGE_RSP` and `FINISH` request. The certificate chain of the Requester is determined by the value of `SlotID`. This is useful for Responders which have obtained a certificate chains of the Requester in a previous interaction.

430 10.17 FINISH request and FINISH_RSP response messages

431 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 identify of each party to the exchanged keys and protect the entire handshake against manipulation by an active attacker. The FINISH request message format table shows the `FINISH` request message format and the Successful FINISH_RSP response message format table shows the `FINISH_RSP` response message format.

432 **FINISH request message format**

Offset	Field	Size in bytes	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xE5 = FINISH`
2	`Param1`	1	Bit 0 – If set, the Signature field is included. This bit shall be set when mutual authentication occurs. All other bits reserved.
3	`Param2`	1	Slot ID. Only valid if `Param1` = `0x01`, otherwise reserved. Slot number of the Requester Certificate Chain being 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`	S	Signature over the transcript hash. S is the size of the asymmetric signing algorithm output the Responder selected via the last `ALGORITHMS` response message using the private key of the leaf certificate of the Requester. S is zero and field not present if `Param1` = `0x00`. The construction of the transcript hash is defined in Transcript Hash for `FINISH` signature, mutual authentication.

Offset	Field	Size in bytes	Value
4+S	`RequesterVerifyData`	H	This field 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 Transcript Hash for `FINISH` HMAC, mutual authentication. Otherwise, it shall be the Transcript Hash for `FINISH` HMAC, Responder-only authentication. The `finished_key` shall be derived from Request Direction Handshake Secret and is described in the finished_key derivation clauses. HMAC is described in RFC 2104.

433 **Successful FINISH_RSP response message format**

Offset	Field	Size in bytes	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x65 = FINISH_RSP`
2	`Param1`	1	Reserved.
3	`Param2`	1	Reserved.
4	`ResponderVerifyData`	H	Conditional field. If the Session Handshake Phase is encrypted and/or message authenticated (i.e., 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 mutual authentication, the transcript shall be the Transcript Hash for `FINISH_RSP` HMAC, mutual authentication. Otherwise, the transcript hash shall be the Transcript Hash for `FINISH_RSP` HMAC, Responder Only authentication. The `finished_key` shall be derived from Response Direction Handshake Secret and is described in the finished_key derivation clause. HMAC is described in RFC 2104.

434 10.17.1 Transcript hash calculation rules

435 The transcript hash is calculated by hashing the concatenation of the prescribed full messages or message fields in order. For messages that are encrypted, the plaintext messages shall be used in calculating the transcript hash.

436 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`).

437 **Transcript hash for KEY_EXCHANGE_RSP signature**

```
1. [GET_VERSION].∗ (if issued)
2. [VERSION].∗ (if issued)
3. [GET_CAPABILITIES].∗ (if issued)
4. [CAPABILITIES].∗ (if issued)
5. [NEGOTIATE_ALGORITHMS].∗ (if issued)
6. [ALGORITHMS].∗ (if issued)
7.  Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE Param2)
8. [KEY_EXCHANGE].∗
9. [KEY_EXCHANGE_RSP].∗ except the `Signature` and `ResponderVerifyData` fields.
```

438 **Transcript hash for KEY_EXCHANGE_RSP HMAC**

```
1. [GET_VERSION].∗ (if issued)
2. [VERSION].∗ (if issued)
3. [GET_CAPABILITIES].∗ (if issued)
4. [CAPABILITIES].∗ (if issued)
5. [NEGOTIATE_ALGORITHMS].∗ (if issued)
6. [ALGORITHMS].∗ (if issued)
7.  Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE Param2)
8. [KEY_EXCHANGE].∗
9. [KEY_EXCHANGE_RSP].∗ except the `ResponderVerifyData` field.
```

439 **Transcript hash for FINISH signature, mutual authentication**

```
1. [GET_VERSION].∗ (if issued)
2. [VERSION].∗ (if issued)
3. [GET_CAPABILITIES].∗ (if issued)
4. [CAPABILITIES].∗ (if issued)
5. [NEGOTIATE_ALGORITHMS].∗ (if issued)
6. [ALGORITHMS].∗ (if issued)
7.  Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE Param2)
8. [KEY_EXCHANGE].∗
9. [KEY_EXCHANGE_RSP].∗
10. Hash of the specified certificate chain in DER format (i.e., FINISH Param2)
11. [FINISH].SPDM Header Fields
```

440 **Transcript hash for FINISH HMAC, Responder-only authentication**

```
1. [GET_VERSION].∗ (if issued)
```

```
2. [VERSION].∗ (if issued)
3. [GET_CAPABILITIES].∗ (if issued)
4. [CAPABILITIES].∗ (if issued)
5. [NEGOTIATE_ALGORITHMS].∗ (if issued)
6. [ALGORITHMS].∗ (if issued)
7.  Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE’s request Param2)
8. [KEY_EXCHANGE].∗
9. [KEY_EXCHANGE_RSP].∗
10. [FINISH].SPDM Header Fields
```

441 **Transcript hash for FINISH HMAC, mutual authentication**

```
1. [GET_VERSION].∗ (if issued)
2. [VERSION].∗ (if issued)
3. [GET_CAPABILITIES].∗ (if issued)
4. [CAPABILITIES].∗ (if issued)
5. [NEGOTIATE_ALGORITHMS].∗ (if issued)
6. [ALGORITHMS].∗ (if issued)
7.  Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE’s request Param2)
8. [KEY_EXCHANGE].∗
9. [KEY_EXCHANGE_RSP].∗
10. Hash of the specified certificate chain in DER format (i.e., FINISH’s Param2).
11. [FINISH].SPDM Header Fields
12. [FINISH].Signature
```

442 **Transcript hash for FINISH_RSP HMAC, Responder-only authentication**

```
1. [GET_VERSION].∗ (if issued)
2. [VERSION].∗ (if issued)
3. [GET_CAPABILITIES].∗ (if issued)
4. [CAPABILITIES].∗ (if issued)
5. [NEGOTIATE_ALGORITHMS].∗ (if issued)
6. [ALGORITHMS].∗ (if issued)
7.  Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE’s request Param2)
8. [KEY_EXCHANGE].∗
9. [KEY_EXCHANGE_RSP].∗
10. [FINISH].∗
11. [FINISH_RSP].SPDM Header fields
```

443 **Transcript hash for FINISH_RSP HMAC, mutual authentication**

```
1. [GET_VERSION].∗ (if issued)
2. [VERSION].∗ (if issued)
3. [GET_CAPABILITIES].∗ (if issued)
```

```
4. [CAPABILITIES].* (if issued)
5. [NEGOTIATE_ALGORITHMS].* (if issued)
6. [ALGORITHMS].* (if issued)
7.  Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE’s request Param2)
8. [KEY_EXCHANGE].*
9. [KEY_EXCHANGE_RSP].*
10. Hash of the specified certificate chain in DER format (i.e., FINISH’s Param2).
11. [FINISH].*
12. [FINISH_RSP].SPDM Header fields
```

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

445 10.18 PSK_EXCHANGE request and PSK_EXCHANGE_RSP response messages

446 The Pre-Shared Key (PSK) key exchange scheme provides an option for a Requester and a Responder to perform mutual authentication and 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.

447 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 may know the value of the PSK.

448 A Requester may be paired with multiple Responders. Likewise, a Responder may be paired with multiple Requesters. A pair of Requester and Responder may be provisioned with one or more PSKs. If both endpoints can act as Requester or Responder, then the endpoints shall use different PSKs for each role.

449 An endpoint may act as a Requester to one device and simultaneously a Responder to another device. 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.

450 The PSK may be provisioned in a trusted environment, for example, during the secure manufacturing process. In an untrusted environment, the PSK may 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 may be communicated to the peer. Therefore, SPDM commands `GET_CAPABILITIES` and `NEGOTIATE_ALGORITHMS` are not required during session key establishment with the PSK option.

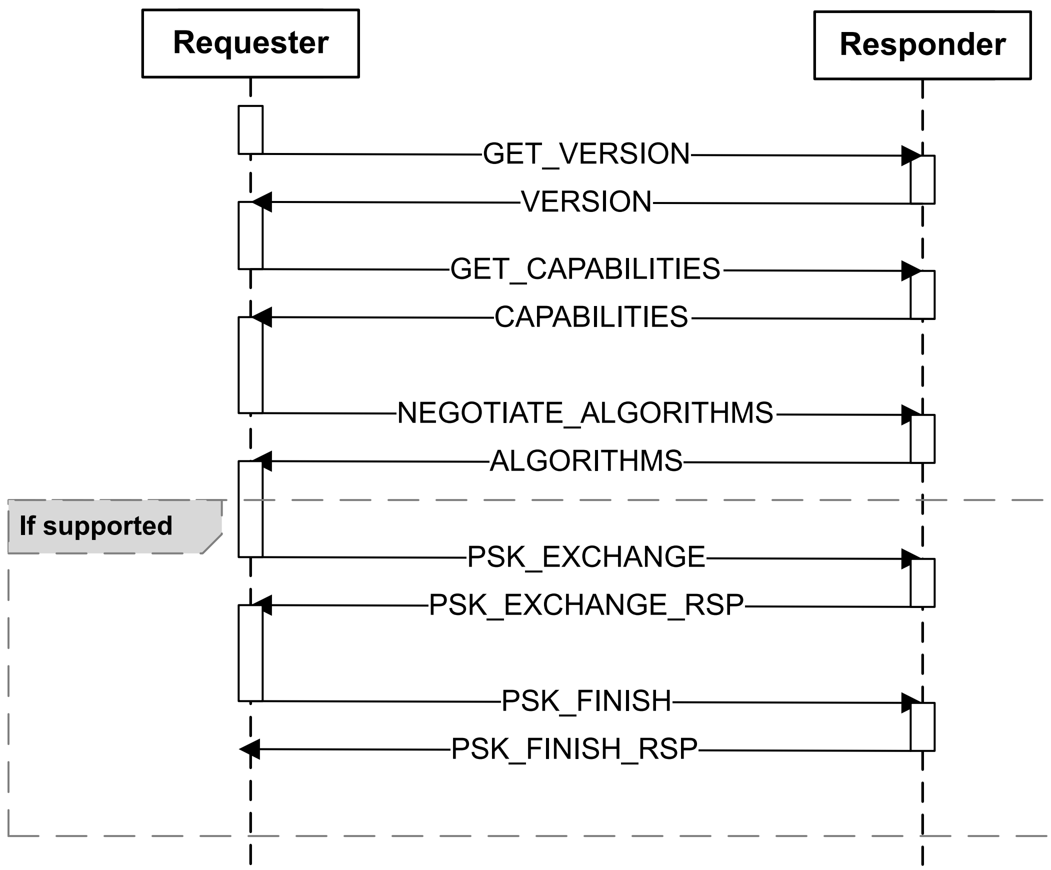
451 Two message pairs are defined for this option: `PSK_EXCHANGE` / `PSK_EXCHANGE_RSP` and `PSK_FINISH` / `PSK_FINISH_RSP`.

452 The `PSK_EXCHANGE` message carries three responsibilities:

1. Prompts the Responder to retrieve the specific PSK.
2. Exchanges contexts 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.

453 **PSK_EXCHANGE: Example**

454



455 **PSK_EXCHANGE request message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xE6 = PSK_EXCHANGE`
2	Param1	1	Requested measurement summary hash Type: `0x0` . No measurement summary hash. `0x1` . TCB measurement hash. `0xFF` . All measurements hash. All other values reserved. When Responder does not support any measurements, Requester shall set this value to `0x0` .
3	Param2	1	Reserved.
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	Length of OpaqueData in bytes.
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 the information belonging to 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.

456 The field PSKHint is optional (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 session.
- The Responder does not store the 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 may be derived from the UDS or its derivative and a non-secret salt known by the Requester. During session key establishment, the same salt 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.

457 The RequesterContext is the contribution of the Requester to session key derivation. It shall contain a nonce of at least 32 bytes to make sure that the derived session keys are ephemeral to mitigate against replay attacks. It is recommended that the Requester use random number as the nonce. If a random number generator is not available, the Requester may use a monotonic counter with protection against reset attacks. The RequesterContext may also contain other information from the Requester.

458 Upon receiving 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.

459 **PSK_EXCHANGE_RSP response message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x66 = PSK_EXCHANGE_RSP`
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	Length of OpaqueData in bytes.

Offsets	Field	Size in bytes	Value
12	`MeasurementSummaryHash`	H	When the Responder does not support measurements (`MEAS_CAP=00b` in `CAPABILITIES` response) or requested `Param1` =0, this field shall be absent. When the requested `Param1` =1, 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. When the requested `Param1` =1 and there are no measurable components in the TCB required to generate this response, this field shall be `0` . When requested `Param1=0xFF` , this field is computed as the hash(Concatenation(MeasurementBlock[0], MeasurementBlock[1], ..., MeasurementBlock[n])) of all supported measurement blocks 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.
12 + H	ResponderContext	Q	Context of the Responder. Optional. If present, shall include a nonce and/or information belonging to 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.
12 + H + Q + OpaqueDataLength	ResponderVerifyData	H	Data to be verified by the Requester using the `finished_key` of the Responder.

460 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. Because the Responder may be a constrained device that is not able to generate a nonce, ResponderContext is optional. However, the Responder is required to use ResponderContext if it can generate a nonce.

461 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 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.

462 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 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.

463 To calculate `ResponderVerifyData`, the Responder calculates a HMAC. The HMAC key is the `finished_key` of the Responder. The data is the hash of the concatenation of specific messages, listed in ResponderVerifyData messages, needed to fully establish the new session between the Requester and the Responder. For messages that are encrypted, the plaintext messages shall be used in calculating the hash.

464 **ResponderVerifyData messages**

```
1. [GET_VERSION].* (if issued)
2. [VERSION].* (if issued)
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
```

465 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 aborts 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.

466 10.19 PSK_FINISH request and PSK_FINISH_RSP response messages

467 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 the PSK_FINISH only if ResponderContext is present in PSK_EXCHANGE_RSP.

468 **PSK_FINISH request message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xE7 = PSK_FINISH`
2	Param1	1	Reserved.

Offsets	Field	Size in bytes	Value
3	Param2	1	Reserved.
4	RequesterVerifyData	H	Data to be verified by the Responder by using the `finished_key` of the Requester.

469 To calculate RequesterVerifyData, the Requester calculates a 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 shall be used in calculating the hash.

```
1. [GET_VERSION].* (if issued)
2. [VERSION].* (if issued)
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
```

470 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.

471 **Successful PSK_FINISH_RSP response message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x67 = PSK_FINISH_RSP`
2	Param1	1	Reserved.
3	Param2	1	Reserved.

472 10.20 HEARTBEAT request and HEARTBEAT_ACK response messages

473 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 may retry `HEARTBEAT` requests.

474 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`.

475 For further details of session termination, see Session termination phase.

476 The HEARTBEAT request message format describes the message format.

477 **HEARTBEAT request message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xE8 = HEARTBEAT` Request
2	Param1	1	Reserved.
3	Param2	1	Reserved.

478 The HEARTBEAT_ACK response message formatdescribes the format for the Heartbeat Response.

479 **HEARTBEAT_ACK response message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x68 = HEARTBEAT_ACK` Response
2	Param1	1	Reserved.
3	Param2	1	Reserved.

480 10.20.1 Heartbeat additional information

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

482 10.21 KEY_UPDATE request and KEY_UPDATE_ACK response messages

483 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 request for the same direction shall be considered a retry of the original KEY_UPDATE request.

484 **KEY_UPDATE request message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xE9 = KEY_UPDATE` Request
2	Param1	1	Key Operation. See KEY_UPDATE Operations Table.
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.

485 **KEY_UPDATE_ACK response message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x69 = KEY_UPDATE_ACK` Response
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.

486 **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

487 10.21.1 Session key update synchronization

488 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.

489 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.

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

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

492 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.

493 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.

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

495 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 may 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 may start using the new keys.

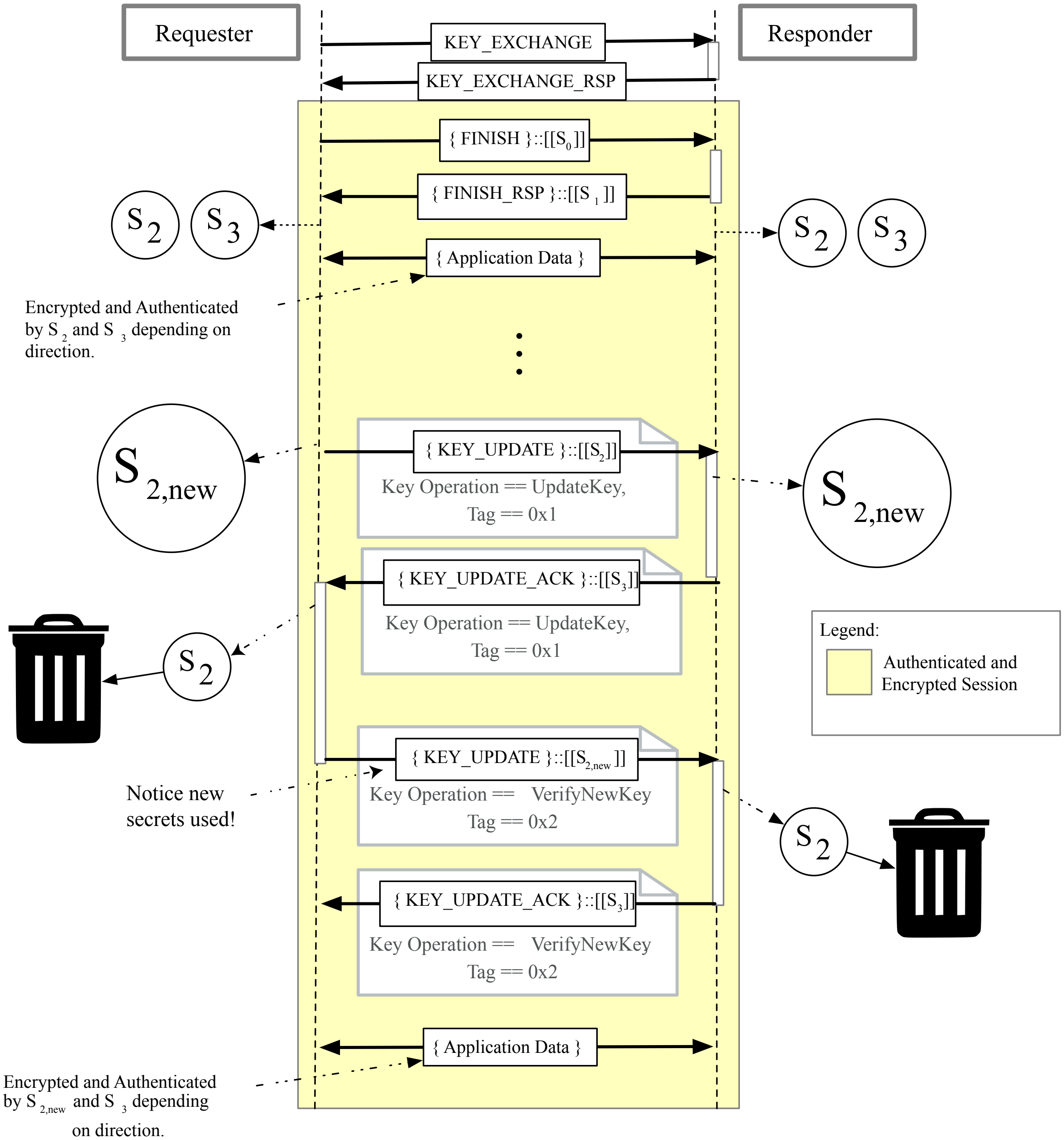
496 In certain scenarios, the receiver may need additional time to process the `KEY_UPDATE` request such as processing data already in its buffer. Thus, the receiver may reply with an `ERROR` message with `ErrorCode=Busy`. The sender should retry the request after a reasonable period of time with a reasonable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

497 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.

498 The KEY_UPDATE protocol example flow figure 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.

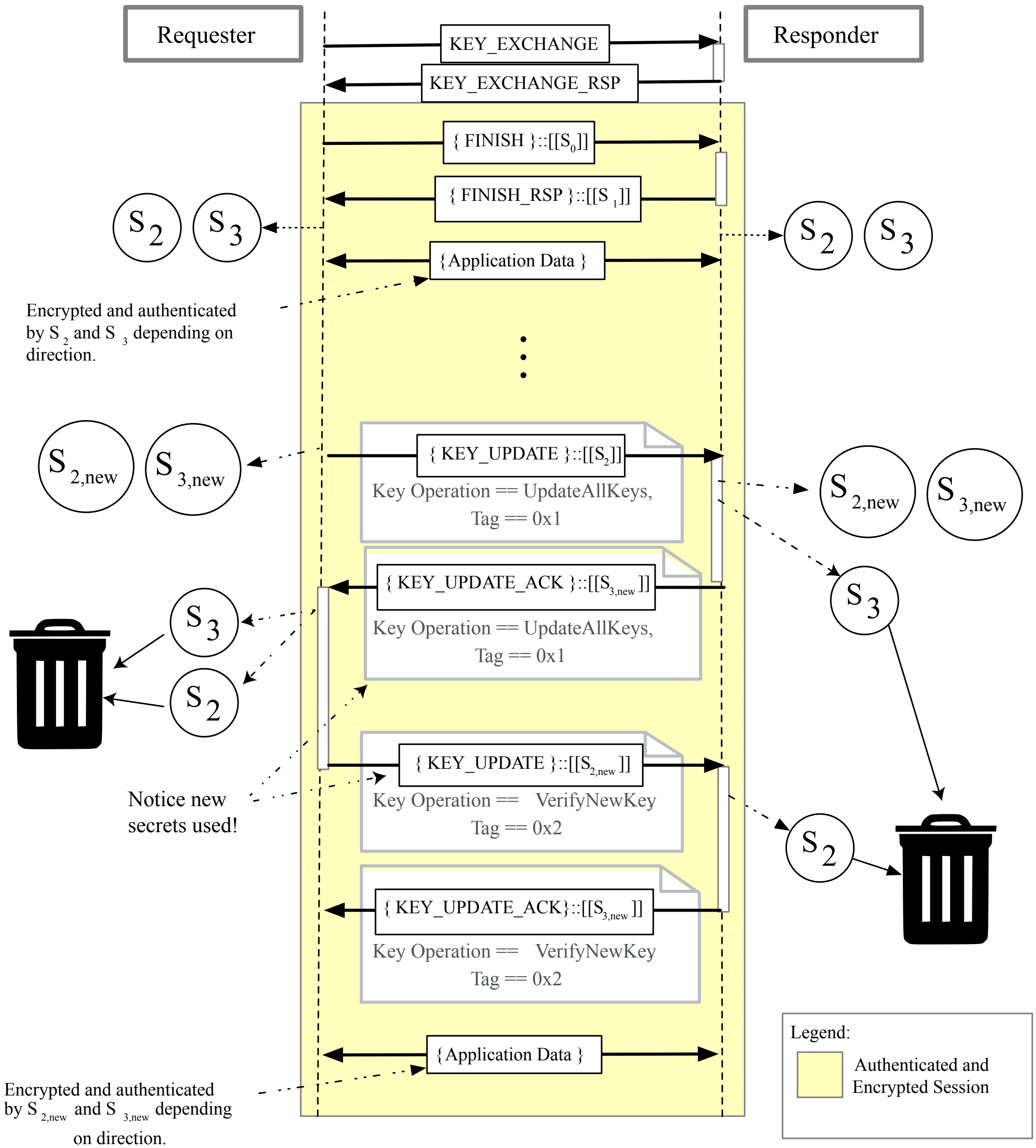
499 **KEY_UPDATE protocol example flow**

500



501 The 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.

502 **KEY_UPDATE protocol change all keys example flow**

503 

504 10.21.2 KEY_UPDATE transport allowances

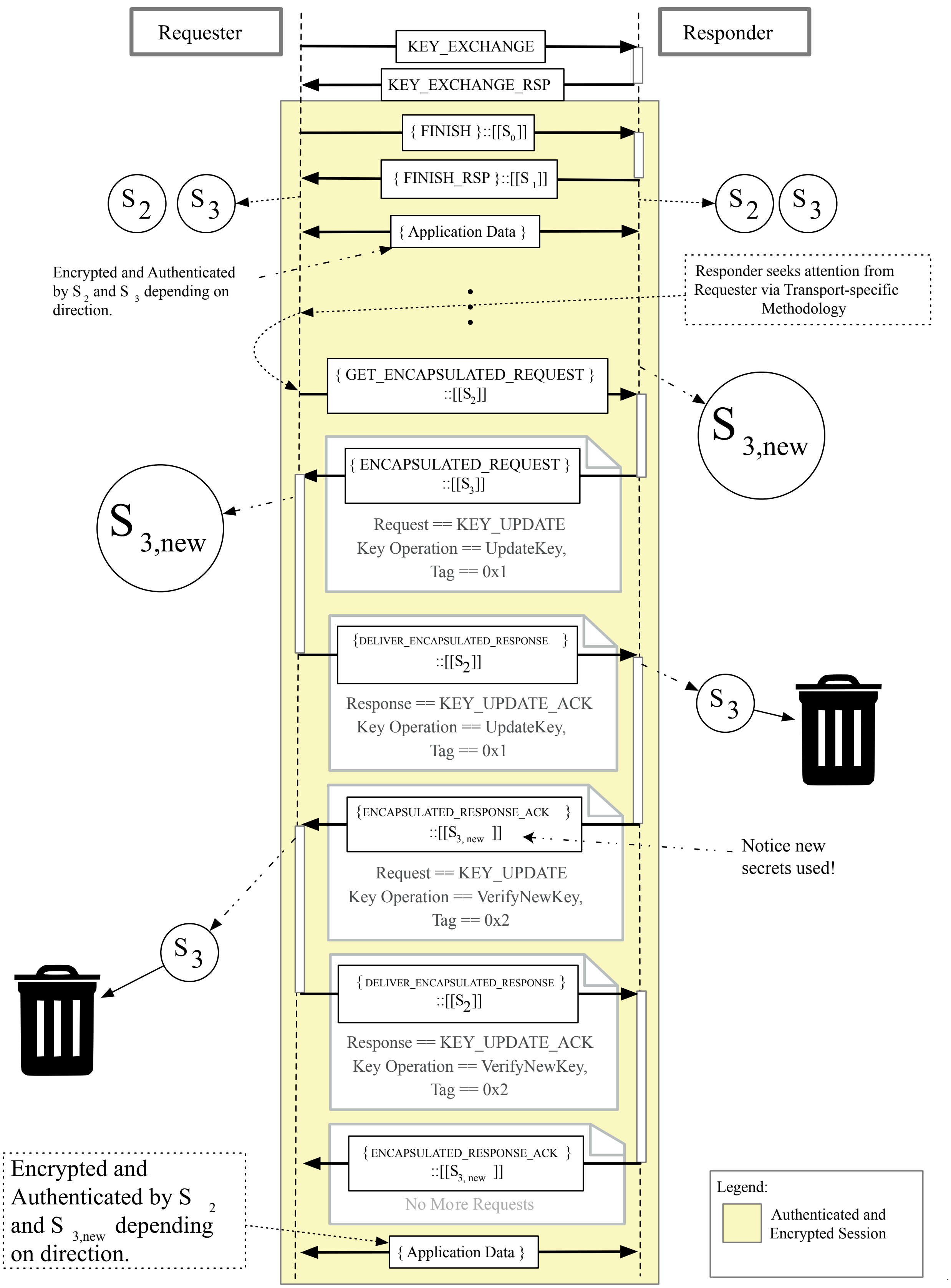
505 On some transports, bidirectional communication can occur asynchronously. On such transports, the transport may allow or disallow the `KEY_UPDATE` to be sent asynchronously without using the `GET_ENCAPSULATED_REQUEST`

mechanism. The actual method to use should be defined by the transport and is outside the scope of this specification.

506 The 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 via a sideband 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.

507 **KEY_UPDATE protocol example flow 2**

508


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 == 0x1
{DELIVER_ENCAPSULATED_RESPONSE } ::[[S2]]
Response == KEY_UPDATE_ACK
Key Operation == UpdateKey,
Tag == 0x1
{ENCAPSULATED_RESPONSE_ACK } ::[[S3, new]]
Notice new secrets used!
Request == KEY_UPDATE
Key Operation == VerifyNewKey,
Tag == 0x2
{ DELIVER_ENCAPSULATED_RESPONSE } ::[[S2]]
Response == KEY_UPDATE_ACK
Key Operation == VerifyNewKey,
Tag == 0x2
{ 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

509 ## 10.22 GET_ENCAPSULATED_REQUEST request and ENCAPSULATED_REQUEST response messages

510 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. The Mutual authentication key exchange figure and Optimized mutual authentication key exchange example figure are examples that illustrate the use of this scheme.

511 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. The request message format is described in `GET_ENCAPSULATED_REQUEST` request format table. The Responder shall use the same SPDM version the Requester used.

512 ### 10.22.1 Encapsulated request flow

513 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 Mutual authentication key exchange.

514 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` .

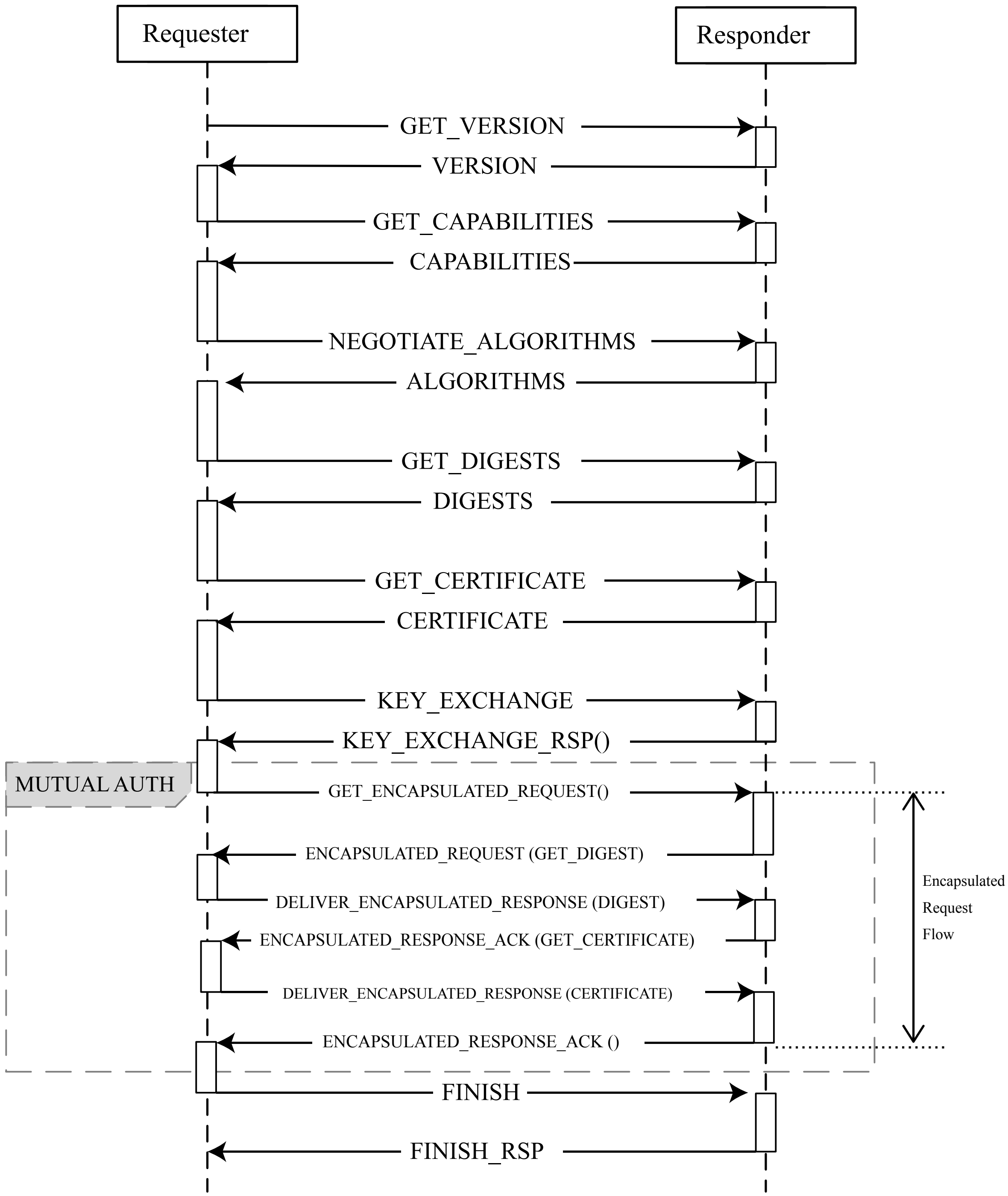
515 ### 10.22.2 Optimized encapsulated request flow

516 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. This is also illustrated in Optimized mutual authentication key exchange.

517 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.

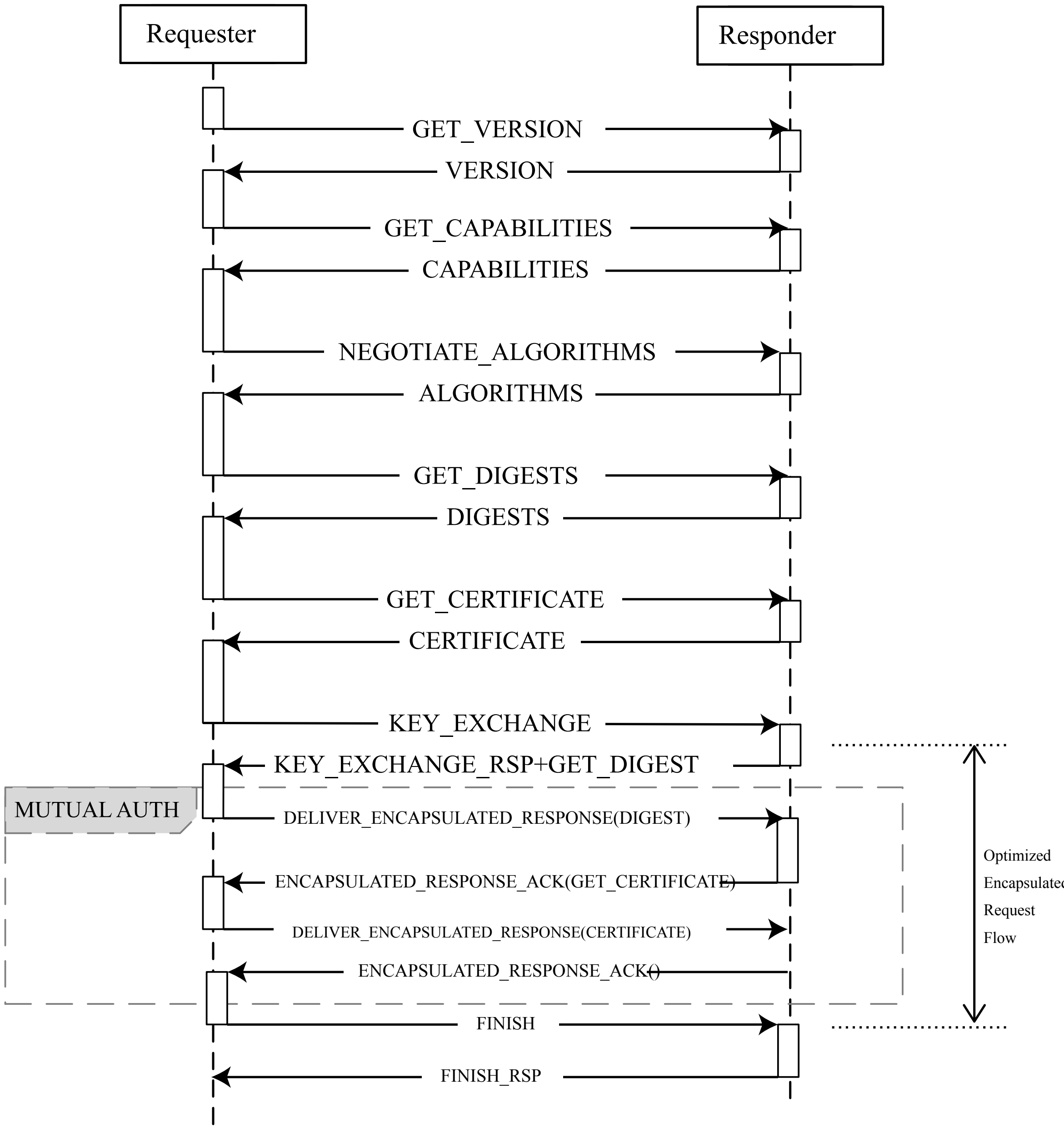
The Requester shall not issue any other requests except for `DELIVER_ENCAPSULATED_RESPONSE`, `RESPOND_IF_READY` and `GET_VERSION`. If a Responder receives a request other than `DELIVER_ENCAPSULATED_RESPONSE`, `RESPOND_IF_READY`, `GET_VERSION` or Session-Secrets-Exchange, then the Responder should respond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

518 **Mutual authentication key exchange example**

519 

520 **Optimized mutual authentication key exchange example**

521



522 **GET_ENCAPSULATED_REQUEST request message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xEA = GET_ENCAPSULATED_REQUEST`
2	Param1	1	Reserved.
3	Param2	1	Reserved.

523 The ENCAPSULATED_REQUEST response message format describes the format this response.

524 **ENCAPSULATED_REQUEST response message format**

Offsets	Field	Size in bytes	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x6A = ENCAPSULATED_REQUEST` Response
2	Param1	1	Request ID. This field should be unique to help the Responder match response to request.
3	Param2	1	Reserved.
4	Encapsulated Request	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.

525 10.22.3 Triggering `GET_ENCAPSULATED_REQUEST`

526 Once a session has been established, the Responder may 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.

527 10.22.4 Additional constraints

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

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

529 10.23 DELIVER_ENCAPSULATED_RESPONSE request and ENCAPSULATED_RESPONSE_ACK response messages

530 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.

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

532 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`.

533 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.

534 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 for more details.

535 The request message format is described in `DELIVER_ENCAPSULATED_RESPONSE` Request Message Format Table.

536 **DELIVER_ENCAPSULATED_RESPONSE request message format**

Offsets	Field	Size (bytes)	Value
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xEB = DELIVER_ENCAPSULATED_RESPONSE` Request
2	Param1	1	Request ID. The Requester shall use the same `Request ID` as provided by the Responder in the corresponding `ENCAPSULATED_REQUEST` or `ENCAPSULATED_RESPONSE_ACK`.
3	Param2	1	Reserved.

Offsets	Field	Size (bytes)	Value
4	Encapsulated Response	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.

537 The ENCAPSULATED_RESPONSE_ACK response message format describes the response message format.

538 **ENCAPSULATED_RESPONSE_ACK response message format**

Offsets	Field	Size (bytes)	Value
0	`SPDMVersion`	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x6B = ENCAPSULATED_RESPONSE_ACK`
2	`Param1`	1	Request ID. If a request is encapsulated (`Param2` = `0x01`) 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 `Encapsulated_Request` field is absent. If set to `0x01` the `Encapsulated_Request` field follows. If set to `0x02` a 1-byte `Encapsulated_Request` field follows containing the slot number corresponding to the certificate chain the Requester shall authenticate against. All other values Reserved.

Offsets	Field	Size (bytes)	Value
4	Encapsulated Request	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 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 shall respond with ErrorCode=UnexpectedRequest if these requests are encapsulated. If Param2 = 0x02 , the value of this filed shall contain the slot number corresponding to the certificate chain the Requester shall authenticate against. The field size shall be 1 Byte. If Param2 = 0x00 , this field shall be absent.

539 ### 10.23.1 Additional information

540 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 may cause additional mistakes to occur.

541 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 Responder may return ErrorCode=ResponseNotReady .

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

543 ## 10.24 END_SESSION request and END_SESSION_ACK response messages

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

545 The END_SESSION request message format table describes this format.

546 **END_SESSION request message format**

Offset	Value	Field	Description
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0xEC = END_SESSION`
2	Param1	1	See the End session request attributes table.
3	Param2	1	Reserved.

547 **End session request attributes**

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.
0	1	Negotiated State Preservation Indicator	If the Responder supports Negotiated State caching, the Responder shall also clear the Negotiated State as part of session termination.
[7:1]	Reserved	Reserved	Reserved.

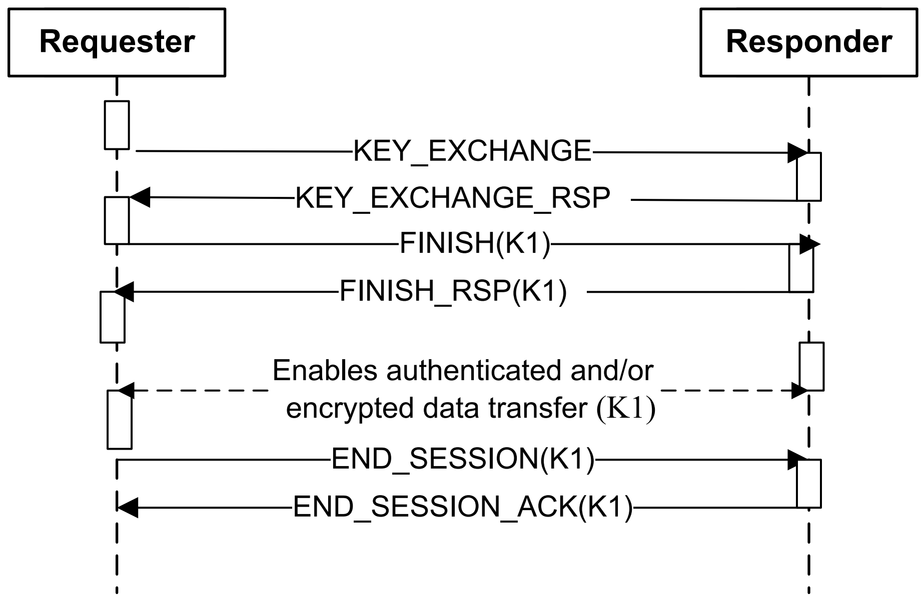
548 The END_SESSION_ACK response message format describes the response message.

549 **END_SESSION_ACK response message format**

Offset	Value	Field	Description
0	SPDMVersion	1	`V1.1 = 0x11`
1	`RequestResponseCode`	1	`0x6C = END_SESSION_ACK`
2	Param1	1	Reserved.
3	Param2	1	Reserved.

550 **END_SESSION protocol flow**

551


Requester
Responder
KEY_EXCHANGE
KEY_EXCHANGE_RSP
FINISH(K1)
FINISH_RSP(K1)
Enables authenticated and/or
encrypted data transfer (K1)
END_SESSION(K1)
END_SESSION_ACK(K1)

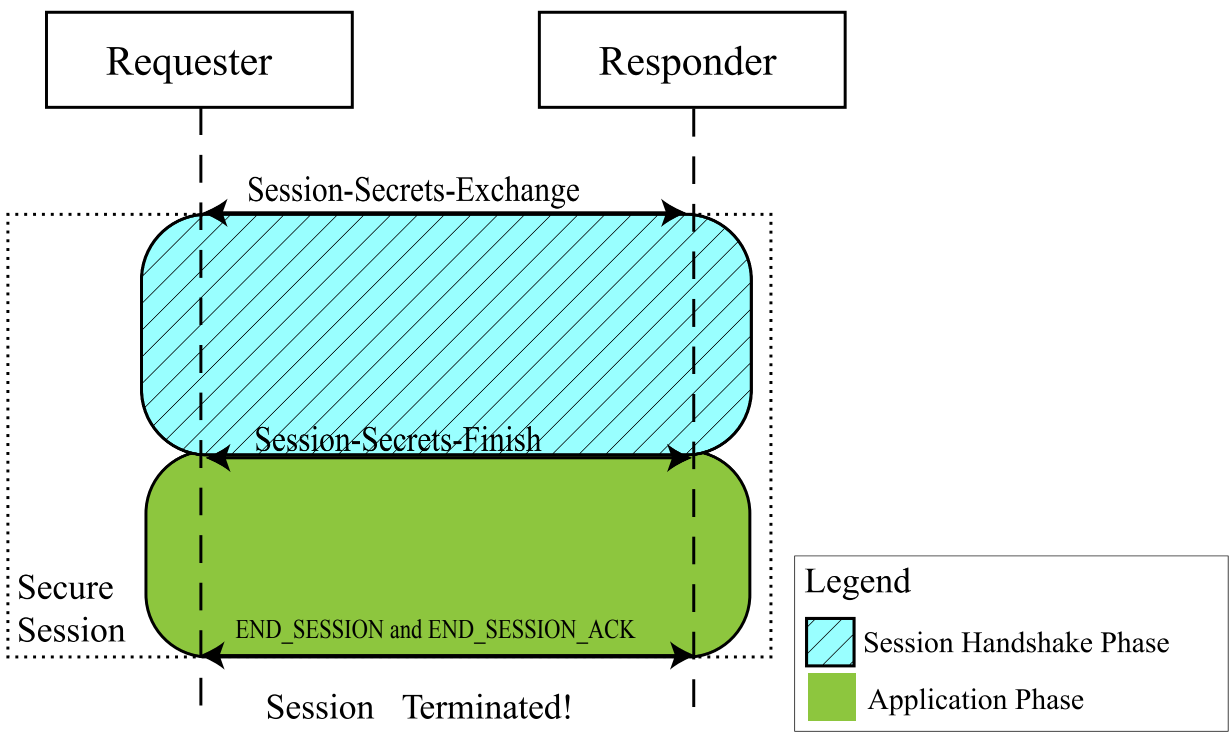
552 # 11 Session

553 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.

554 There are three phases in a session, as Session phases shows: the handshake, the application, and termination.

555 **Session phases**

556



557 ## 11.1 Session handshake phase

558 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.

559 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.

560 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.

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

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

563 11.2 Application phase

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

565 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.

566 11.3 Session termination phase

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

568 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 may simply be an internal phase with no explicit SPDM messages sent or received.

569 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 may have other internal data associated with a session that they should also clean up.

570 11.4 Simultaneous active sessions

571 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`.

572 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. Since 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 may use information at the transport layer to further ensure proper handling of sessions.

573 11.5 Records and session ID

574 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.

575 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.

576 # 12 Key schedule

577 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` as defined by RFC2104 and `HKDF-Expand` as described in RFC5869. SPDM defines the following additional functions:

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

578 where `BinConcat` shall be the concatenation of binary data, in the order shown in BinConcat Details Table:

579 **BinConcat details**

Order	Data	Form	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

580 If Context is NULL, then `BinConcat` is the concatenation of the first three components only.

581 **Version details**

SPDM version	Version text
SPDM 1.1	"spdm1.1 "

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

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

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

```
HMAC-Hash(salt, IKM);
```

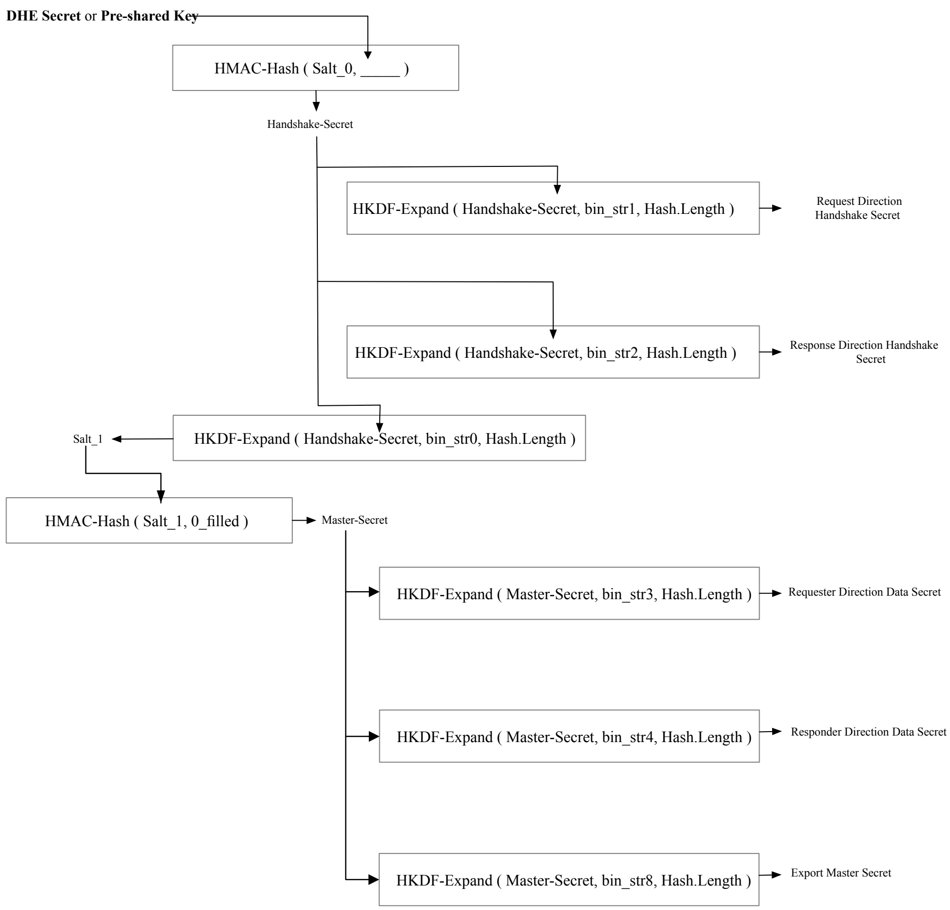
584 where IKM is the Input Keying Material and HMAC-Hash uses `HMAC` as defined in RFC2104.

585 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.

586 Both Responder and Requester shall use the key schedule shown in the Key Schedule Figure.

587 **Key schedule**

588



589 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.

590 The Key Schedule table accompanies the figure to complete the Key Schedule. The Responder and Requester shall also adhere to the definition of this table.

591 **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

592 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 labels defined above have all been chosen to fit within this limit.

593 12.1 Transcript hash in key derivation

594 There are two transcript hashes used in the key schedule, namely, **TH1** and **TH2**.

595 12.2 TH1 definition

596 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. `[GET_VERSION].*` (if issued)
2. `[VERSION].*` (if issued)
3. `[GET_CAPABILITIES].*` (if issued)
4. `[CAPABILITIES].*` (if issued)
5. `[NEGOTIATE_ALGORITHMS].*` (if issued)
6. `[ALGORITHMS].*` (if issued)
7. Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE Param2)
8. `[KEY_EXCHANGE].*`
9. `[KEY_EXCHANGE_RSP].*` except the `ResponderVerifyData` field

597 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. `[GET_VERSION].*` (if issued)
2. `[VERSION].*` (if issued)
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

598 12.3 TH2 definition

599 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. `[GET_VERSION].*` (if issued)
2. `[VERSION].*` (if issued)
3. `[GET_CAPABILITIES].*` (if issued)
4. `[CAPABILITIES].*` (if issued)
5. `[NEGOTIATE_ALGORITHMS].*` (if issued)
6. `[ALGORITHMS].*` (if issued)
7. Hash of the specified certificate chain in DER format (i.e., KEY_EXCHANGE Param2)
8. `[KEY_EXCHANGE].*`
9. `[KEY_EXCHANGE_RSP].*`
10. Hash of the specified certificate chain in DER format (i.e., FINISH's Param2). (Valid only in mutual authentication)
11. `[FINISH].*`
12. `[FINISH_RSP].*`

600 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. `[GET_VERSION].*` (if issued)
2. `[VERSION].*` (if issued)
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].*` (if issued)
10. `[PSK_FINISH_RSP].*` (if issued)

601 12.4 Key schedule major secrets

602 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)

603 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.

604 12.4.1 Request-direction handshake secret

605 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`.

606 12.4.2 Response-direction handshake secret

607 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`.

608 12.4.3 Requester-direction data secret

609 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.

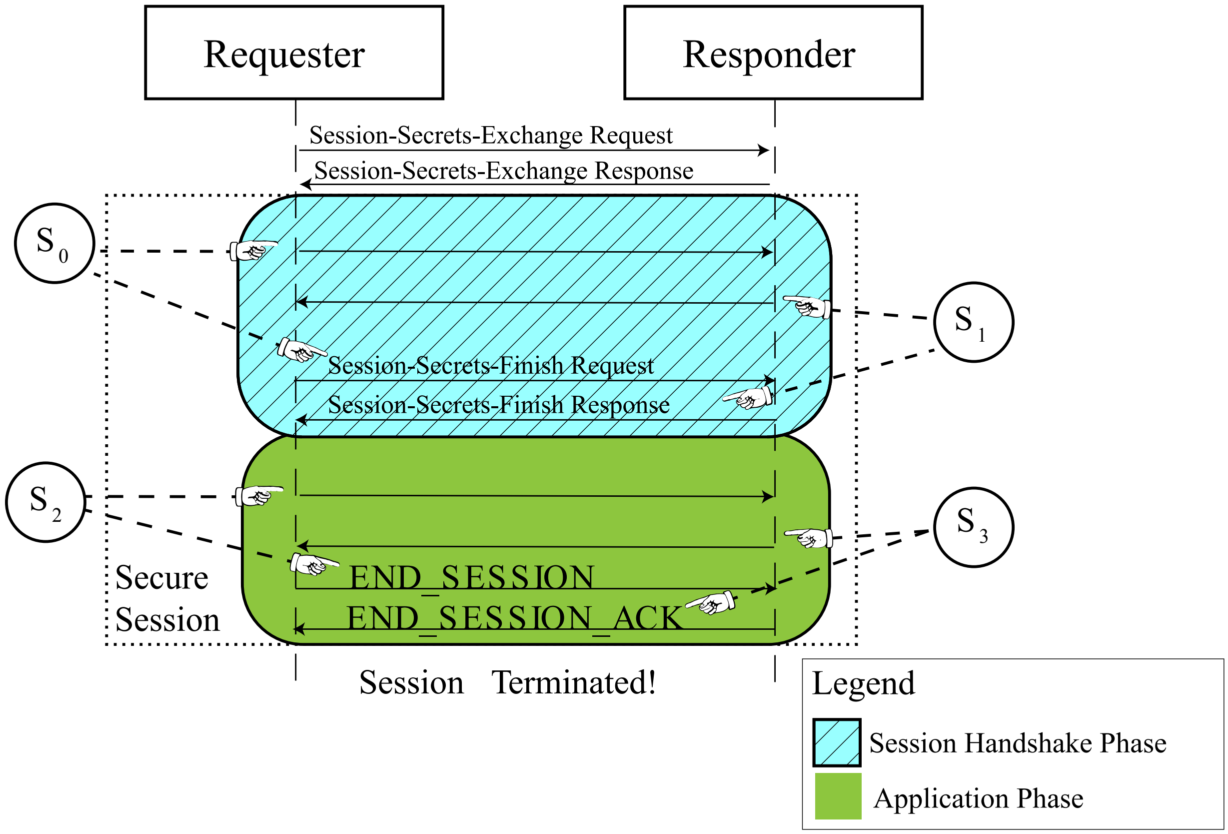
610 12.4.4 Responder-direction data secret

611 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.

612 The Secrets Usage Figure illustrates where each of the major secrets are used as described previously.

613 **Secrets usage**

614



615 ## 12.5 Encryption key and IV derivation

616 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);
```

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

618 ## 12.6 finished_key derivation

619 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);
```

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

621 12.7 Deriving additional keys from the Export Master Secret

622 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);
```

623 12.8 Major secrets update

624 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.

625 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);
```

626 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.

627 # 13 Application data

628 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.

629 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);
```

630 where

Value	Description
`AEAD_Encrypt`	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`	Function that verifies the MAC and if validation is successful, fully decrypts the `ciphertext` and produces the original `plaintext`.
`encryption_key`	Derived encryption key for the respective direction. For details, see the Key schedule clause.
`nonce`	Nonce computation. For details, see the Nonce derivation clause.
`associated_data`	Associated data.
`plaintext`	Data to encrypt.
`ciphertext`	Data to decrypt.

631 ## 13.1 Nonce derivation

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

633 # 14 ANNEX A (informative) TLS 1.3

634 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.

635 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 DTLS 1.3, which at the time of this specification is still in draft form.

636 15 ANNEX B (normative) Leaf certificate example

637 The Leaf certificate example shows an example leaf certificate:

638 **Leaf certificate example**

```
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=w0123456789
    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;UTF8STRING:ACME:WIDGET:0123456789
        Signature Algorithm: ecdsa-with-SHA256
        Signature Value:
```

```
30:45:02:21:00:fc:8f:b0:ad:6f:2d:c3:2a:7e:92:6d:29:1d:
c7:fc:0d:48:b0:c6:39:5e:c8:76:d6:40:9a:12:46:c3:39:0e:
36:02:20:1a:ea:3a:59:ca:1e:bc:6d:6e:61:79:af:a2:05:7c:
7d:da:41:a9:45:6d:cb:04:49:43:e6:0b:a8:8d:cd:da:e
```

639 # 16 ANNEX C (informative) Change log

640 ## 16.1 Version 1.0.0 (2019-10-16)

- Initial Release

641 ## 16.2 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.
- 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.

642 ## 16.3 Version 1.1.1 (2021-05-12)

- Fix improper reference in `DMTFSpecMeasurementValue` field in "Measurement field format when MeasurementSpecification field is Bit 0 = DMTF" table.
- Certificate digests in `DIGEST` calculation clarified.
- Format of certificate in `CertChain` parameter of `CERTIFICATE` message clarified.

- Validity period of X.509v3 certificate clarified in Required Fields
- Clarify which algorithms in `NEGOTIATE_ALGORITHMS` or `ALGORITHMS` are for signature generation or verification.
- Remove `InvalidSession` error code.
- Clarified transport responsibilities in `PSK_EXCHANGE` and `PSK_EXCHANGE_RSP`.
- Clarified the usage of `MutAuthRequested` field in `KEY_EXCHANE_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 that plaintext messages are used when calculating the transcript hash.
- `ERROR` responses are no longer required in most error scenarios.
- In Sign()and Verify() operations, referenced the correct fields in `ALGORITHMS`.
- Clarify which key to use in `Signature` fields of `KEY_EXCHANGE_RSP` and `FINISH`.
- Clarify messages to hash for `ResponderVerifyData` in `PSK_EXCHANGE_RSP`.

643 16.4 Version 1.1.2 (2022-03-22)

- Fix typo and inconsistency in description of PSK_FINISH.
- Clarified measurement specification related fields in `NEGOTIATE_ALGORITHMS` and `ALGORITHMS`.
- Changed Measurement Summary Hash concatenation function inputs.
- Clarified minimum timing for HEARTBEAT request and HEARTBEAT_ACK response messages to be sufficiently greater than `T1`. Removed command specific guidance on retry timing.
- Clarify that Responder Timing measurements are measured under the assumption that the Responder can access the bus.
- Clarified that `ENCRYPT_CAP` and `MAC_CAP` apply to all phases of a secure session.
- Clarified the relationship between `MAC_CAP` and `ResponderVerifyData` or `RequesterVerifyData` in Session-Secret-Exchange and Session-Secret-Finish messages.
- Provide more description for `HANDSHAKE_IN_THE_CLEAR_CAP` in `GET_CAPABILITIES` and `CAPABILITIES` messages.
- Clarified `Offset` and `Length` fields in `GET_CERTIFICATE` message.
- Clarified how retried messages affect transcript hash in Timing requirements.
- Clarified that extended algorithms are external to this specification.
- Added definition of opaque data.
- Fixed typo in the `ExchangeData` field of table "Successful KEY_EXCHANGE_RSP response message format".

644 17 Bibliography

645 DMTF DSP4014, *DMTF Process for Working Bodies 2.6*.