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NVM Express® Technical Proposal (TP)

Technical Proposal ID	6035a
Revision Date	2024.05.22
Builds on Specification(s)	NVMe Management Interface Specification, Revision 1.2c
References	TP6021 Status Reporting Enhancements TP6027a Reset Behavior Clarifications TP6033 MCTP Packet Timing

Technical Proposal Author(s)

Name	Company
Austin Bolen	Dell
Myron Loewen	Solidigm

Technical Proposal Overview

This TP adds an out-of-band asynchronous event mechanism (similar to Asynchronous Event Request on the in-band interface) per TPAR6021 Status Reporting Enhancements.

Revision History

Revision Date	Author	Change Description
2023.04.17	Austin Bolen	• Initial draft.
2023.04.23	Austin Bolen	• Changed it so that only the most recent AE occurrence of a given AE Identifier is included in the AEM or in response to an AEM Ack. • Made Shutdown Status Controller-scope only and renamed to Controller Shutdown Status. • Added NVM Subsystem Shutdown Status for NVM Subsystem-scope shutdown. • Removed the NVM Subsystem Reset Occurred AE. • Overhauled the Asynchronous Event Identifier and AE Occurrence Specific Info Data Structure figures. • Fixed various technical errors. • Wordsmithing and restructuring. • Added AEM example timing diagrams to Appendix TBDAD.
2023.05.01	Austin Bolen	• Incorporated feedback from reviewers.
2023.05.08	Austin Bolen	• Allow multiple AEs of a given AE Identifier in an AEM or AEM Ack response if the combination of the AE Identifier, AE Occurrence Scope ID Info, and AE Occurrence Scope are unique in the AE Occurrence List data structure. • Permit the response to an AE Sync to use the Management Endpoint Buffer if the size exceeds the maximum NVMe-MI message size. • Added a bit to indicate a buffer overflow if an AEM or AEM Ack response exceeds the maximum NVMe-MI message size. • Added AEM Retry Count • Wordsmithing.

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Revision Date	Author	Change Description
2023.05.15	Austin Bolen	• Removed versioning requirements. • Allow the AE list bodies to get up to 4 KiB. Previously the AE list body and header together were limited to 4 KiB. • Added an implementation note that a Configuration Set command for the Asynchronous Event Configuration with the MEB set to '1' can be used to synchronize the state of the AEs between the Management Controller and the Management Endpoint in the event of an overflow. • Clarified that AEM Retry Count is not applicable for an AE Sync or an AEM Ack. • Changed it so that vendor-specific AEs do not use the AE Occurrence Specific Info field and instead only use the AE Occurrence Vendor Specific Info field. • Add a requirement that the conditions that trigger AEs shall be checked at a frequency of less than or equal to the amount of time specified by the AEM Delay field. • Controller Shutdown and NVM Subsystem Shutdown events only occur when the shutdown occurs or completes and not when the controller goes back to normal operation. • Available Spare is only applicable if the available spare capacity is NVM Subsystem scoped. • Modified the requirements to not return any events in an overflow case for AEMs instead of returning the most recent events that fit within 4 KiB. • The AE Occurrence List Total Length indicates the actual size in the event of an AE Sync/AEM Ack overflow rather than the length of everything assuming no overflow. • Require enabling the AEs in an AE Sync to be atomic with populating the return values and transitioning to the AE Armed State. • Moved PCIe Reset clarification from this TP to TP6027b. • Specified that a Management Endpoint shall not retry transmission of an AEM if the AEM Retry Delay field is cleared to 0h. • Wordsmithing.
2023.06.05	Austin Bolen	• Reverted change that ignored the MEB bit if a particular variant of a command that normally has Request Data/Response Data has no Request Data/Response Data. • Added requirements for how to set the CIAP, MEB, and MIC bits in Asynchronous Event Messages. • Wordsmithing.

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Revision Date	Author	Change Description
2023.06.12	Austin Bolen	• Added description for changes document. • Added an AEM Generation Number for detecting duplicate AEMs. • Merged Controller Shutdown and NVM Subsystem back into one AE now that the scope is included in the AE Occurrence to distinguish them. • Add all AEs being disabled as another reason for being in the AE Disarmed State in the Definitions section. • Require the MIC to not be included in Response Messages and AEMs if the IC bit is '0'. • Clarified that the packet assembly rules in the Packet Assembly into Messages section only apply to Management Endpoints. • Clarified in a few places that the AEM Retry Delay behavior only applies if the value of the AEM Retry Delay is non-zero. • Clarified that the Management Endpoints selects the Msg tag for AEMs. • Corrected the byte range formulas in the AE Occurrence data structure. • Specified the offset where a few of the structures start. • Clarified that clearing the AEM Retry Delay field to 0h causes no retries at the MCTP layer but retries may still occur at the physical layer. • Added that the AEM Transmission Failure bit is not set if an AE Sync or Management Endpoint Reset occurs. • Corrected some steps in the appendix examples. • Editorial fixes. • Wordsmithing.
2023.06.14	Austin Bolen	• Corrected shutdown complete value in CSTS.SHST from 11b to 10b. • Added AE Sync to the list of things that stop retries in the AEM Transmission Interval section. • Updated the AEM Transmission Failure text to make sure it's set when there's a transmission failure due to physical transport external to the NVM Subsystem being unavailable in the case where there are no retries. • Wordsmithing.
2023.07.31	Austin Bolen	• Updates based on member review feedback from Judy Brock and Mike Allison and workgroup review.
2023.10.06	Devin Allison	• Integrated
2023.11.27	Austin Bolen	• First draft of TP6035a. • Fixed the rules for the handling of AE Enable List Version Number by a Management Endpoint.
2023.12.04	Austin Bolen	• Updated based on feedback from MI and errata workgroups.
2024.02.25	Devin Allison	• Integrated
2024.03.02	Austin Bolen	• Specified what to do when an AEM is ready to be transmitted but the Management Endpoint is paused.
2024.03.18	Austin Bolen	• A Controller Level Reset shall have no effect on the AEM servicing model
2024.05.22	Devin Allison	• Integrated

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Description for Changes Document for the NVM Express Management Interface Specification

New Features:

- Out-of-Band Asynchronous Events (Optional)
  - Description of change:
    - Adds an out-of-band asynchronous event mechanism.
  - References
    - TP6021 Status Reporting Enhancements.
    - TP6027a Reset Behavior Clarifications

Markup Conventions:

Black:	Unchanged (however, hot links are removed)
~~Red Strikethrough~~:	Deleted
Blue:	New
Blue Highlighted:	TBD values, anchors, and links to be inserted in new text.
<Green Bracketed>:	Notes to editor or reader
Orange:	Text is pulled in from a referenced Technical Proposal

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Description of Specification Changes for NVM Express Management Interface Specification

1.8 Definitions

…

1.8.TBDD0 AE (Asynchronous Event)

A condition (e.g., a health status change event, a temperature change event, etc.) that may occur in the NVM Subsystem. Refer to Figure TBD10 for the list of Asynchronous Events.

1.8.TBDD1 AE Arm

A condition that causes the Management Endpoint to enter the AE Armed State which occurs when a Configuration Set command for the Asynchronous Event configuration is processed that results in the AE Occurrence List Overflow bit cleared to '0' and leaves one or more AEs enabled (i.e., an AE Sync or AEM Ack occurs). Refer to section 4.TBD4.1.

1.8.TBDD2 AE Armed State

A state of the Management Endpoint where AEs that occur are permitted to be transmitted in an AEM (refer to section 1.8.TBDD5) at the next available AEM Transmission Interval. Refer to section 4.TBD4.1 and section 4.TBD4.3.

1.8.TBDD3 AE Disarmed State

A state of the Management Endpoint where:

a) AEs that occur are not permitted to be transmitted in an AEM; or
b) all AEs are disabled.

Refer to section 4.TBD4.1 and section 4.TBD4.3.

1.8.TBDD4 AE Sync

A condition that occurs when a Management Endpoint processes a Configuration Set command for an Asynchronous Event configuration that does not have the Number of AE Enable Data Structures field cleared to 0h and results in the AE Occurrence List Overflow bit cleared to '0'. An AE Sync:

a) may enable and/or disable one or more AEs; and
b) is used to synchronize the state of enabled AEs between a Management Endpoint and a Management Controller by causing the Management Endpoint to return the state of all enabled AEs to the Management Controller.

Refer to section 5.2.TBD12.

1.8.TBDD5 AEM (Asynchronous Event Message)

An NVMe-MI Message transmitted from a Management Endpoint to a Management Controller containing information about one or more AEs that have occurred. Refer to section 4.TBD4.

1.8.TBDD6 AEM Ack

A condition that occurs when a Management Endpoint processes a Configuration Set command for an Asynchronous Event configuration that has the Number of AE Enable Data Structures field cleared to 0h and results in the AE Occurrence List Overflow bit cleared to '0'. An AEM Ack is used by a Management Controller to acknowledge receipt of an AEM to the Management Endpoint that transmitted the AEM. Refer to section 5.2.TBD12.

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1.8.TBDD7 AEM Delay Interval

The time a Management Endpoint delays from the start of the AE Armed State before the Management Endpoint is permitted to enter the AEM Transmission Interval to transmit an AEM for any AEs that occurred during the AE Armed State. Refer to section 4.TBD4.2.

1.8.TBDD8 AEM Transmission Interval

The time during which an AEM for AEs that occurred during the prior AE Armed State are transmitted or retried by the Management Endpoint. Refer to section 4.TBD4.3.

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3 Message Transport

…

3.1 NVMe-MI Messages

…

3.1.1 Message Fields

The format of an NVMe-MI Message consists of a Message Header in the first dword, followed by the Message Data. If the Integrity Check (IC) bit is set to '1', then the NVMe-MI Message ends with the Message Integrity Check as shown in Figure 18.

The Message Header contains a Message Type (MT) field and an Integrity Check (IC) bit that are defined by the MCTP Base Specification. The Message Type field specifies the type of payload contained in the message body and is ~~required to be~~ set to 4h in all NVMe-MI Messages (refer to the MCTP IDs and Codes specification). The Integrity Check (IC) bit indicates whether the NVMe-MI Message is protected by a Message Integrity Check. All NVMe-MI Messages in the out-of-band mechanism ~~shall be~~ are protected by a 32-bit CRC computed over the Message Body contents. The IC bit ~~shall be~~ is set to '1' in all NVMe-MI Messages in the out-of-band mechanism. The Integrity Check (IC) bit ~~shall be~~ is cleared to '0' in all NVMe-MI Messages in the in-band tunneling mechanism.

The Request or Response (ROR) bit in the Message Header specifies whether the NVMe-MI Message is a Request Message or a Response Message. The ROR bit is not applicable to Asynchronous Event Messages. The NVMe-MI Message Type (NMIMT) field specifies whether the Request Message is a Control Primitive or a specific type of Command Message (refer to Figure 25). The Command Slot Identifier (CSI) bit specifies the Command Slot with which the NVMe-MI Message is associated in the out-of-band mechanism. Refer to section 4.2 for additional information about Command Slots.

The Management Endpoint Buffer (MEB) bit in the Message Header specifies whether Message Data is contained in the associated Message Data field of an NVMe-MI Message or in the Management Endpoint Buffer. This bit should only be set to '1' in Command Messages that support Management Endpoint Buffer operation (i.e., those listed in the Management Endpoint Buffer Supported Command List data structure). If the MEB bit is set to '1' in any other Command Message, then the Management Endpoint shall respond with an Invalid Parameter Error Response with the PEL field indicating the MEB bit.

The Command Initiated Auto Pause (CIAP) bit in the Message Header of a Command Message specifies whether or not the Management Endpoint is automatically paused when a Command Message enters the Process state. A Command Message with the CIAP bit set to '1' shall be treated by the Management Endpoint as if an implicit Pause Control Primitive, as described in section 4.2.1.1, was received in the Process state with the exception that the Management Endpoint shall not transmit a Control Primitive Response Message. The Command Initiated Auto Pause Supported (CIAPS) bit in Figure 96 indicates if the port supports the Command Initiated Auto Pause (CIAP) bit in Command Messages.

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Figure 19: NVMe-MI Message Fields

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>0</td><td>MCTP Data (MCTPD): This field contains the Message Type and Integrity Check fields as defined by the MCTP Base Specification.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7</td><td>Integrity Check (IC): ~~This bit is defined by the MCTP Base Specification and indicates whether~~ If the MCTP message is covered by an overall MCTP ~~M~~message payload ~~I~~integrity ~~C~~check, then this bit is set to ‘1’. If the MCTP message is not covered by an overall MCTP message payload integrity check, then this bit is cleared to ‘0’.

For Request Messages in the out-of-band mechanism, this bit should be set to ‘1’. ~~All NVMe-MI~~ For Response Messages in the out-of-band mechanism and Asynchronous Event Messages, ~~shall be protected by a CRC and thus~~ this bit shall be set to ‘1’ ~~in all out-of-band NVMe-MI Messages~~.

For Request Messages in the in-band tunneling mechanism, this bit should be cleared to ‘0’. ~~All NVMe-MI~~ For Response Messages in the in-band tunneling mechanism, ~~shall not be protected by a CRC and thus~~ this bit shall be cleared to ‘0’ ~~in all in-band NVMe-MI Messages~~.</td></tr>
<tr><td>6:0</td><td>Message Type (MT): This field ~~is defined by the MCTP Base Specification for the~~ contains the message type. For Request Messages, this field should be set to 4h. For Response Messages and Asynchronous Event Messages, ~~T~~this field shall be set to 4h ~~in all NVMe-MI Messages~~. Refer to the MCTP IDs and Codes specification.</td></tr>
</table></td></tr>
</table>

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Figure 19: NVMe-MI Message Fields

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>1</td><td>
NVMe-MI Message Parameters (NMP): This field contains parameters applicable to the NVMe-MI Message.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7</td><td>Request or Response (ROR): ~~This bit indicates whether the message is a Request Message or Response Message.~~ For Request Messages, ~~T~~this bit should be ~~is~~ cleared to ‘0’ ~~for Request Messages~~.

For Response Messages, ~~T~~this bit shall be ~~is~~ set to ‘1’ ~~for Response Messages~~.

For Asynchronous Event Messages, this field is not applicable and shall be cleared to ‘0’.</td></tr>
<tr><td>6:3</td><td>NVMe-MI Message Type (NMIMT): ~~This field specifies the NVMe-MI Message Type.~~ For Request Messages, this field should specify the type of the NVMe-MI Message. For Response Messages, this field shall indicate the type of the NVMe-MI Message. For Asynchronous Event Messages, this field shall indicate a value of 5h.

Refer to the sections referenced in the table below for details about each NVMe-MI Message Type and whether they apply to the out-of-band mechanism, the in-band tunneling mechanism, or both.
<table>
<tr><th colspan="3">NVMe-MI Message Type</th></tr>
<tr><th>Value</th><th>Description</th><th>Reference Section</th></tr>
<tr><td>0h</td><td>Control Primitive</td><td>4.2.1</td></tr>
<tr><td>1h</td><td>NVMe-MI Command</td><td>5</td></tr>
<tr><td>2h</td><td>NVMe Admin Command</td><td>6</td></tr>
<tr><td>3h</td><td>Reserved</td><td>-</td></tr>
<tr><td>4h</td><td>PCIe Command</td><td>7</td></tr>
<tr><td>5h</td><td>Asynchronous Event</td><td>4.1.TBD4</td></tr>
<tr><td>~~5h~~ 6h to Fh</td><td>Reserved</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>2:1</td><td>Reserved</td></tr>
<tr><td>0</td><td>Command Slot Identifier (CSI): ~~This bit indicates the Command Slot with which the NVMe-MI Message is associated.~~ For Request Messages in the out-of-band mechanism, this bit specifies ~~indicates~~ the Command Slot with which the Request Message is associated. For Response Messages in the out-of-band mechanism, this bit shall indicate~~s~~ the Command Slot associated with the Request Message with which the Response Message is associated.

~~This bit is only applicable to NVMe-MI Messages in the out-of-band mechanism. This bit is reserved for NVMe-MI~~ For Request Messages in the in-band tunneling mechanism this bit is not applicable and shall be ignored by the Management Endpoint.

For Response Messages in the in-band tunneling mechanism, this bit is not applicable and shall be cleared to ‘0’.

For Asynchronous Event Messages, this field is not applicable and shall be cleared to ‘0’.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0b</td><td>Command Slot 0</td></tr>
<tr><td>1b</td><td>Command Slot 1</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

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Figure 19: NVMe-MI Message Fields

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>2</td><td>
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:2</td><td>Reserved</td></tr>
<tr><td>1</td><td>Command Initiated Auto Pause (CIAP): If this bit is set to ‘1’ in a Command Message, the Management Endpoint shall be automatically paused when the Command Message enters the Process state. If this bit is cleared to ‘0’ in a Command Message, the Management Endpoint shall not be automatically paused when the Command Message enters the Process state. The usage requirements for this bit are as follows:
<table>
<tr><th colspan="2">Mechanism</th><th>CIAP Value</th><th>Usage Requirement</th></tr>
<tr><td rowspan="4">Out-of-band</td><td rowspan="2">Command Messages</td><td>0</td><td>This value is permitted.</td></tr>
<tr><td>1</td><td>This value is permitted.</td></tr>
<tr><td rowspan="2">Any NVMe-MI Message other than a Command Message</td><td>0</td><td>This value is required.</td></tr>
<tr><td>1</td><td>This value is prohibited. An Invalid Parameter Error Response with the PEL field indicating this bit shall be returned.</td></tr>
<tr><td colspan="2" rowspan="2">In-band Tunneling</td><td>0</td><td>This value is required.</td></tr>
<tr><td>1</td><td>This value is prohibited. An Invalid Parameter Error Response with the PEL field indicating this bit shall be returned.</td></tr>
</table></td></tr>
<tr><td>0</td><td>Management Endpoint Buffer (MEB): This bit indicates whether the Message Data in a Command Message is contained in the Message Data field of this NVMe-MI Message or in the Management Endpoint Buffer. Refer to section 3.1.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0b</td><td>The Message Data is contained in the Message Data of this NVMe-MI Message.</td></tr>
<tr><td>1b</td><td>The Message Data is contained in the Management Endpoint Buffer.</td></tr>
</table>
The usage requirements for this bit are as follows:
<table>
<tr><th colspan="2">Mechanism</th><th>MEB Value</th><th>Usage Requirement</th></tr>
<tr><td rowspan="4">Out-of-band</td><td rowspan="2">Command Messages</td><td>0</td><td>This value is permitted.</td></tr>
<tr><td>1</td><td>This value is permitted.</td></tr>
<tr><td rowspan="2">Any NVMe-MI Message other than a Command Message</td><td>0</td><td>This value is required.</td></tr>
<tr><td>1</td><td>This value is prohibited. An Invalid Parameter Error Response with the PEL field indicating this bit shall be returned.</td></tr>
<tr><td colspan="2" rowspan="2">In-band Tunneling</td><td>0</td><td>This value is required.</td></tr>
<tr><td>1</td><td>This value is prohibited. An Invalid Parameter Error Response with the PEL field indicating this bit shall be returned.</td></tr>
</table></td></tr>
</table>
</td></tr>
<tr><td>3</td><td>Reserved</td></tr>
<tr><td>N-1:4</td><td>Message Data (DATA): This field contains the NVMe-MI Message payload. The format of this field depends on the NVMe-MI Message Type.</td></tr>
<tr><td>N+3:N</td><td>Message Integrity Check (MIC): If the Integrity Check (IC) bit is set to ‘1’ in a Request Message, then this field should specify ~~contains~~ a CRC computed over the contents of the NVMe-MI Message. If the Integrity Check (IC) bit is set to ‘1’ in a Response Message or an Asynchronous Event Message, then this field shall indicate a CRC computed over the contents of the NVMe-MI Message. Refer to section 3.1.1.1.
If the IC bit is cleared to ‘0’ in a Request Message, then this field ~~is~~ should not be included in the NVMe-MI Message. If the IC bit is cleared to ‘0’ in a Response Message or an Asynchronous Event Message, then this field shall not be included in the NVMe-MI Message.
This field is byte aligned.</td></tr>
</table>

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3.2 Out-of-Band Message Transport

…

3.2.1 MCTP Packet

…

3.2.1.1 Packet Assembly into Messages

…

In addition to the requirements outlined in the MCTP Base Specification and MCTP transport binding specifications, this specification has the following additional requirements:

- With the exception of the last packet in a Response Message or Asynchronous Event Message ~~message~~, the MCTP Transmission Unit size of all packets in a given Response Message or Asynchronous Event Message ~~message~~ shall be equal to the negotiated MCTP Transmission Unit Size;
- The MCTP Transmission Unit size of the last packet in a ~~Request Message or~~ Response Message or Asynchronous Event Message (i.e., the one with the EOM bit set in the MCTP header) shall be the smallest size required to transfer the MCTP Packet Payload for that Packet with no additional padding beyond any padding required by the physical medium-specific trailer; and
- Once a complete ~~NVMe-MI~~ Request Message has been assembled, the Message Integrity Check ~~is~~ shall be verified. If the Message Integrity Check passes, then the ~~NVMe-MI~~ Request Message ~~is~~ shall be processed. If the Message Integrity Check fails, then the ~~NVMe~~ Request Message ~~is~~ shall be discarded. Refer to section 4.2.

4 Message Servicing Model

~~NVMe-MI Messages are used for communication in both the out-of-band and in-band tunneling message servicing models and are described in section 4.1.~~ This specification defines multiple message servicing models:~~.~~

a) ~~T~~the out-of-band Request ~~m~~Message servicing model ~~is described in~~ (refer to section 4.2);~~.~~
b) ~~T~~the in-band tunneling Request ~~m~~Message servicing model ~~is described in~~ (refer to section 4.3); and
c) the AEM servicing model (refer to section 4.TBD4).

NVMe-MI Messages (refer to section 4.1) are used for communication in all message servicing models.

4.1 NVMe-MI Messages

Figure 25 illustrates the taxonomy of NVMe-MI Messages. The ~~two~~ three main categories of NVMe-MI Messages are Request Messages (refer to section 4.1.1), ~~and~~ Response Messages (refer to section 4.1.2), and Asynchronous Event Messages (AEMs, refer to section 4.1.TBD4).

In the out-of-band Request Message servicing model, Request Messages are ~~sent~~ transmitted by a Management Controller to a Management Endpoint ~~when using the out-of-band mechanism~~. In the in-band Request Message servicing model, Request Messages are ~~sent~~ transmitted by host software to an NVMe Controller ~~when using the in-band tunneling mechanism~~. The entity ~~sending~~ transmitting the Request Message is collectively referred to as the Requester and the entity receiving the Request Message is collectively referred to as the Responder. After receiving a Request Message, the Responder processes the Request Message. When processing is complete, the Responder ~~sends~~ transmits a Response Message back to the Requester.

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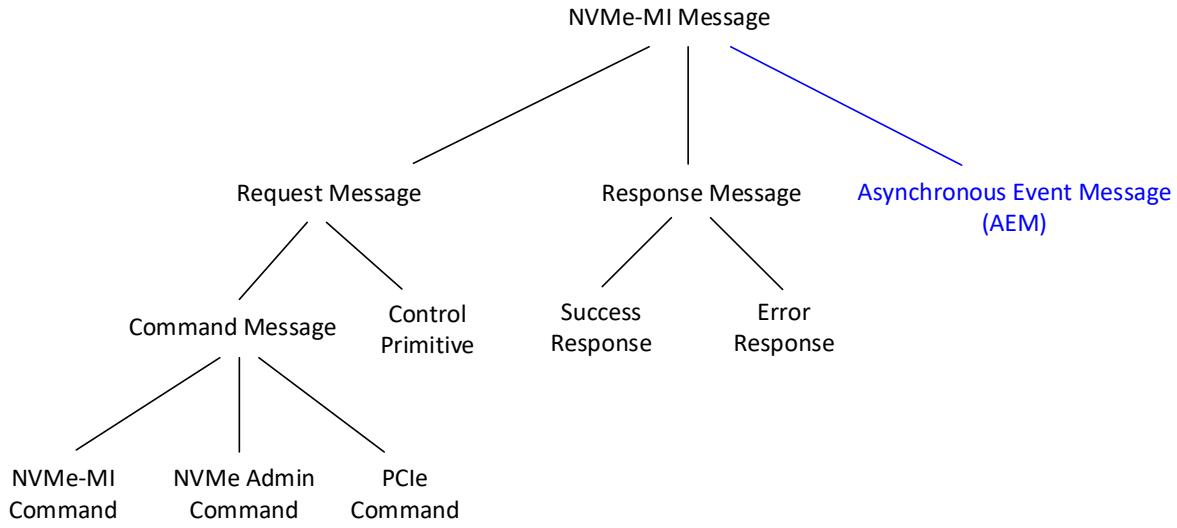
A Request Message is a Command Message or a Control Primitive. A Command Message specifies an operation to be performed by the Responder and is an NVMe-MI Command, an NVMe Admin Command, or a PCIe Command. Control Primitives are used in the out-of-band mechanism to affect the servicing of a previously issued Command Message or get the state of a Command Slot and Management Endpoint (refer to section 4.2.1).

A Response Message is a Success Response or an Error Response.

In the AEM servicing model, AEMs are transmitted by a Management Endpoint to a Management Controller using the out-of-band mechanism after one or more Asynchronous Events (AEs) occur. AEMs are prohibited in the in-band tunneling mechanism.

Figure 25: NVMe-MI Message Taxonomy



4.1.TBD4 Asynchronous Event Messages (AEMs) (Optional)

An Asynchronous Event Message (AEM) is an NVMe-MI Message that is transmitted by a Management Endpoint to a Management Controller after one or more Asynchronous Events (AEs) such as a health status change event, a temperature change event, or a firmware activation (refer to Figure TBD10) occurs. AEMs are posted (i.e., there is no NVMe-MI Message transmitted back from the Management Controller to the Management Endpoint in response to the AEM).

AEMs are permitted using the out-of-band mechanism. In-band communication uses the Asynchronous Event Request command (refer to the NVM Express Base Specification) for asynchronous events and therefore, AEMs are prohibited using the in-band tunneling mechanism. AEMs are optional for both NVMe Storage Devices and NVMe Enclosures.

AEMs are supported by Management Endpoints on a per port basis, and an implementation is permitted to support AEMs on Management Endpoints on a subset of the ports in the NVM Subsystem. Note that many host platforms are designed to connect a Management Controller to the SMBus/I2C Management Endpoint via an SMBus/I2C Mux. A Management Endpoint is not able to transmit an AEM while the SMBus/I2C Mux downstream channel connected to a Management Endpoint is not connected to the SMBus/I2C Mux upstream channel which, in turn, is connected to the Management Controller. Therefore, for example, an NVM Subsystem may choose to support AEMs on Management Endpoints on the PCIe port(s) but not on the SMBus/I2C port.

If AEMs are supported on a given Management Endpoint (i.e., the Asynchronous Event Messages Supported bit is set to '1' in the Port Information data structure for the port associated with the Management

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Endpoint), then at least one AE shall be supported. The list of supported AEs is returned in the Response Message to a Configuration Get command for the Asynchronous Event configuration (refer to section 5.1.TBD5).

Each AE is able to be enabled or disabled on a per Management Endpoint basis via the Configuration Set command for the Asynchronous Event configuration.

The AEM servicing model is defined in section 4.TBD4.

4.2 Out-of-Band Request Message Servicing Model

~~The out-of-band mechanism in this specification utilizes a request and response servicing model.~~ A Management Controller sends a Request Message to a Management Endpoint, the Management Endpoint processes the Request Message, and when processing has completed, sends a Response Message back the Management Controller. Under no circumstances does a Management Endpoint generate an unsolicited Response Message (i.e., a Response Message that does not correspond to a previously received Request Message).

This specification utilizes Command Slots for Command Message servicing. Each Management Endpoint contains two Command Slots that each include state information that is unique to each Command Slot and a Pause Flag that is global to the Management Endpoint ~~shared between the two Command Slots~~. The Command Slot state information and the value of the Pause Flag is returned by the Get State Primitive (refer to section 4.2.1.4).

…

4.2.1 Control Primitives

…

4.2.1.1 Pause

The Pause Control Primitive shall set the Pause Flag to '1' and then suspend (i.e., pause) transmission of Response Messages for Command Messages or AEMs on a packet boundary.

…

4.2.1.2 Resume

The Resume Control Primitive is the complement to the Pause Control Primitive. The Resume Control Primitive shall clear the Pause Flag to '0'. After transmitting the Response Message for the Resume Control Primitive, the Management Endpoint shall resume paused transmissions ~~from each Command Slot~~.

It is not an error to process a Resume Control Primitive while the Pause Flag is cleared to '0'.

The CSI bit in a Resume Control Primitive is not used and should be cleared to '0'. If the CSI bit is set to '1', then the Management Endpoint shall respond with an Invalid Parameter Error Response with the PEL field indicating the CSI bit.

Note that the Resume Control Primitive causes a Management Endpoint to transmit the packet after the last packet the Management Endpoint transmitted prior to being paused. If the last Response Message packet that was transmitted was not received by the Management Controller, then the Management Controller should detect an out-of-sequence packet sequence number in the resumed Response Message and drop that ~~e~~ Response Message. To avoid this synchronization issue, the Management Controller should issue a Replay Control Primitive specifying the packet number in the Response Replay Offset field from which the Response Message is replayed.

The CPSP field for the Resume Control Primitive is reserved. The CPSR field in the Control Primitive Success Response is reserved.

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4.2.1.5 Replay

The Replay Control Primitive shall cause the Management Endpoint to transmit a Response Message Status of Success and then shall clear the Pause Flag to '0' before retransmitting the Response Message for the last Command Message processed in the specified Command Slot. Packets within a given Response Message are transmitted in order as required by the MCTP Base Specification, but there are no packet ordering requirements between different Response Messages and so replayed packets from the specified Command Slot may be interleaved with packets from the other Command Slot. Control Primitive Response Messages and AEMs shall not be replayed.

4.2.3 Management Endpoint Buffer

…

If the Management Endpoint Buffer (MEB) bit is set to '1' in a Command Message that normally contains Request Data and supports the Management Endpoint Buffer operation (i.e., the Command Message is listed in the Management Endpoint Buffer Supported Command List data structure), then unless otherwise specified:

a) Request Data shall not be transferred in the Command Message itself and the required Request Data shall be transferred from the Management Endpoint Buffer~~.~~;
b) ~~T~~the Request Data shall start~~s~~ at a zero offset from the start of the Management Endpoint Buffer~~.~~; and
c) ~~I~~if the~~at~~ Command Message contains Request Data or does not support Request Data, then the Management Endpoint shall respond~~s~~ with an Invalid Parameter Error Response with the PEL field indicating the Request Data field of the Command Message.

If the Management Endpoint Buffer (MEB) bit is set to '1' in a Command Message that normally results in Response Data and supports the Management Endpoint Buffer operation, then no Response Data is transferred in the corresponding Response Message itself and the Response Data is instead transferred to the Management Endpoint Buffer. The Response Data starts at a zero offset from the start of the Management Endpoint Buffer.

4.3 In-Band Tunneling Request Message Servicing Model

The in-band tunneling mechanism in this specification utilizes two NVMe Admin Commands (NVMe-MI Send and NVMe-MI Receive). Figure 61 specifies whether an NVMe-MI Command is tunneled via the NVMe-MI Send command or the NVMe-MI Receive command.

…

4.TBD4 Out-of-Band AEM Servicing Model

If a Management Endpoint supports AEMs, then the Management Endpoint is in the AE Armed State or the AE Disarmed State as specified in section 4.TBD4.1. AEs that occur (refer to section 4.TBD4.5) are transmitted in an AE Occurrence data structure in an AEM. AEMs do not include AE Occurrence data structures for AEs that have not occurred.

AEMs are transmitted by a Management Endpoint during the AEM Transmission Interval as specified in section 4.TBD4.3. AEMs are not transmitted outside of the AEM Transmission Interval.

AEMs shall not occupy Command Slots. Like Control Primitives, AEMs may be transmitted while the Command Slot is in any command servicing state and should be transmitted as soon as possible by the Management Endpoint. For example, if the Management Endpoint is in the middle of receiving a multi-packet Request Message when an AE occurs, then it is recommended that the Management Endpoint transmit the AEM prior to the completion of the Request Message transfer if an AEM Transmission Interval is permitted during that time (refer to section 4.TBD4.3). Likewise, if the Management Endpoint is in the middle of transmitting a multi-packet Response Message when an AE occurs, then it is recommended that the Management Endpoint transmit the AEM prior to the completion of the Response Message transfer if an AEM Transmission Interval is permitted during that time. AEMs shall not change the command servicing state of the Command Slots.

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4.TBD4.1 Management Endpoint AE Armed State and AE Disarmed State

A Management Endpoint that supports AEMs is either in the AE Armed State or in the AE Disarmed State.

An AE Arm (refer to section 1.8.TBDD1 and section 5.2.TBD12.2) occurs when the Management Endpoint processes an AE Sync or AEM Ack that leaves one or more AEs enabled.

The AE Armed State shall start when an AE Arm occurs. The AE Armed State shall end when the AE Disarmed State starts.

The AE Disarmed State shall start when:

a) all supported AEs are disabled (e.g., by an AE Sync or by a Management Endpoint Reset); or
b) the AEM Transmission Interval starts.

The AE Disarmed State shall end when the AE Armed State starts.

If a Management Endpoint in the AE Armed State has one or more AEs occur, then the Management Endpoint shall transmit an AEM during the next AEM Transmission Interval (refer to section 4.TBD4.3) unless otherwise specified (e.g., a Management Endpoint Reset occurs prior to the next AEM Transmission Interval).

4.TBD4.2 AEM Delay Interval

The AEM Delay Interval is the time during which a Management Endpoint shall wait before transmitting an AEM for any AEs that have occurred during that AEM Delay Interval. The AEM Delay Interval shall start when the Management Endpoint enters the AE Armed State. The AEM Delay Interval shall end once the amount of time specified by the AEM Delay field has elapsed since the start of the AEM Delay Interval or the Management Endpoint enters the AE Disarmed State.

4.TBD4.3 AEM Transmission Interval

AEMs for AEs that have occurred during an AE Armed State shall only be transmitted during the subsequent AEM Transmission Interval.

That AEM Transmission Interval shall start once:

a) the amount of time specified by the AEM Delay field has elapsed since the start of the current AE Armed State; and
b) at least one AE has occurred during the current AE Armed State (refer to section 4.TBD4.5).

Once the AEM Transmission Interval starts, the Management Endpoint shall transmit a single AEM. Once the AEM Transmission Interval starts, the AEM should be transmitted as soon as possible. The contents of an AEM are defined in section 4.TBD4.4.

That AEM Transmission Interval shall end once:

a) an AE Sync occurs (refer to section 5.2.TBD12);
b) an AEM Ack occurs (refer to section 5.2.TBD12);
c) an AEM transmission failure occurs (refer to the AEM Transmission Failure bit); or
d) a Management Endpoint Reset occurs.

Before exiting the AEM Transmission Interval, if an AEM transmission is in progress, then the Management Endpoint shall stop transmitting the AEM and should stop transmitting the AEM as soon as possible.

If the AEM Retry Delay field is not cleared to 0h and the amount of time specified by the AEM Retry Delay field elapses from:

a) the end of transmitting an AEM without receiving an AEM Ack; or
b) when a failure to transmit an AEM occurs due to the physical transport external to the NVM Subsystem being unavailable (e.g., an AEM on a PCIe VDM Management Endpoint is unable to be transmitted due to the PCIe link being down),

then the Management Endpoint shall retry the AEM transmission and should retry the AEM transmission as soon as possible until:

a) there have been 8 total attempts to transmit the AEM (the first transmission attempt and seven retries);

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b) an AE Sync occurs (refer to section 5.2.TBD12);
c) an AEM Ack occurs (refer to section 5.2.TBD12); or
d) a Management Endpoint Reset occurs.

If an AEM transmission is retried, then the contents of the AEM shall exactly match the contents of the AEM transmitted during the first transmission attempt with the exception that the AEM Retry Count field is incremented each time the AEM transmission is retried. The retried AEM transmission shall not include an AE Occurrence data structure for any AEs that have occurred since the start of the AEM Transmission Interval. AEs that have occurred since the start of the AEM Transmission Interval are returned in the Response Message of an AEM Ack (refer to section 5.2.TBD12).

4.TBD4.4 AEM Format

The format of an AEM is shown in Figure TBD20 and the fields are described in Figure TBD21.

Figure TBD20: Asynchronous Event Message (AEM) Format

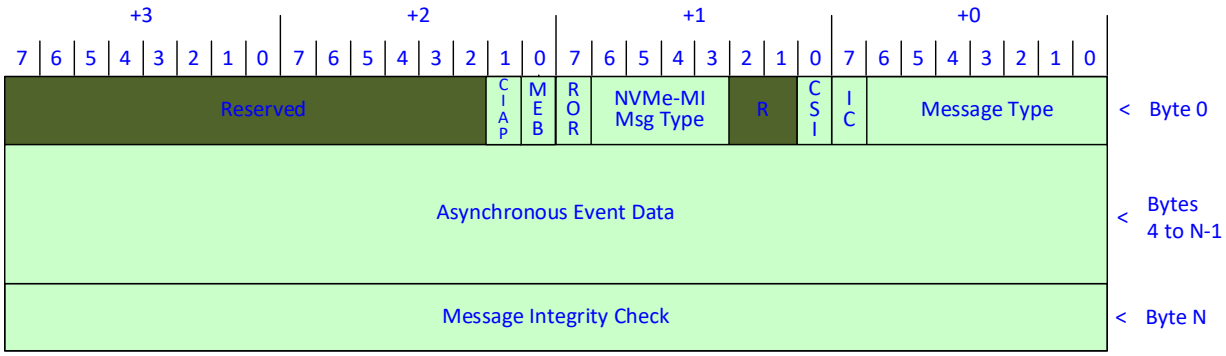

Figure TBD21: Asynchronous Event Message (AEM) Fields

Bytes	Description
3:0	**NVMe-MI Message Header (NMH):** Refer to section 3.1.
N-1:4	**Asynchronous Event Data (AED):** This field contains an AE Occurrence List data structure (refer to Figure TBD17).
N+3:N	**Message Integrity Check (MIC):** Refer to section 3.1.

An AEM shall be transmitted to the entity that most recently caused an AE Arm. All fields in the MCTP packet header (refer to Figure 23) of an AEM shall be set as specified by the MCTP Base Specification with the following additional requirements:

a) the Msg tag shall be selected by the Management Endpoint and the Tag Owner bit shall be set to '1' since the AEM originates from the Management Endpoint; and
b) the Destination Endpoint ID shall be set to the value of the Source Endpoint ID of the of the entity that most recently caused an AE Arm.

For an AEM originating from a PCIe VDM Management Endpoint, all PCIe VDM header fields shall be set as specified in the MCTP PCIe VDM Transport Binding Specification with the following additional requirements:

a) the PCI Target ID field shall be set to the value of the PCI Requester ID of the entity that most recently caused an AE Arm; and
b) bits 2:0 of the Type field shall be set to a value of 010b to indicate the PCIe message routing is Route by ID.

The values for any fields specific to an AEM originating from an SMBus/I2C Management Endpoint are outside the scope of this specification.

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The Asynchronous Event Data field shall contain an AE Occurrence List data structure (refer to Figure TBD17) and shall be minimally sized (i.e., if there is one AE Occurrence data structure, then the AE Occurrence List data structure is the length of that AE Occurrence data structure plus the length of the AE Occurrence List Header). The AE Occurrence List data structure shall start at offset 0h of the Asynchronous Event Data field.

If the number of AEs that have occurred do not result in the length of the AE Occurrence List Body exceeding 4 KiB, then:

a) the AE Occurrence List Overflow bit shall be cleared to '0';
b) the AE Occurrence List Body shall contain an AE Occurrence data structure for the most recent occurrence of each AE of a given AE Unique ID that occurred in the prior AE Armed State;
c) the AE Occurrence List Body shall not contain an AE Occurrence data structure for any AEs that did not occur during the prior AE Armed State; and
d) each AE Occurrence data structure shall indicate the state of the AE at the time the AE occurred which is used to resynchronize the state of the AEs between the Management Controller and the Management Endpoint.

If the number of AEs that have occurred would result in the length of the AE Occurrence List Body exceeding 4 KiB if the AE Occurrence data structure for each AE that has occurred was included in the AE Occurrence List Body, then:

a) the AE Occurrence List Overflow bit shall be set to '1'; and
b) the AE Occurrence List data structure shall contain the AE Occurrence List Header and shall not contain an AE Occurrence List Body.

Figure TBD17: AE Occurrence List Data Structure

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><th colspan="2">AE Occurrence List Header</th></tr>
<tr><td>0</td><td>Number of AE Occurrence Data Structures (NUMAEO): This field shall indicate the number of AE Occurrence data structures (refer to Figure TBD18) in the AE Occurrence List Body.
If there are no AE Occurrence data structures in the AE Occurrence List Body, then this field shall be cleared to 0h.</td></tr>
<tr><td>1</td><td>AE Occurrence List Version Number (AELVER): This field indicates the version number of the AE Occurrence List data structure and the AE Occurrence data structure. This field shall be cleared to 0h.</td></tr>
<tr><td>4:2</td><td>AE Occurrence List Length Info (AEOLLI): This field indicates info about the length of the AE Occurrence List data structure.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>23</td><td>AE Occurrence List Overflow: This bit indicates if an AE Occurrence List data structure overflow has occurred. If an AE Occurrence List data structure overflow occurs, then an AE Sync is able to be used to resynchronize the state of the AEs between the Management Controller and the Management Endpoint.
Refer to section 5.2.TBD12 and this section for more details.</td></tr>
<tr><td>22:00</td><td>AE Occurrence List Total Length (AEOLTL): This field indicates the length in bytes of the AE Occurrence List data structure. This field shall be set to a value equal to the value of the AE Occurrence List Header Length field plus the sum of the lengths in bytes of each AE Occurrence data structure in the AE Occurrence List Body.
If the AE Occurrence List Overflow bit is set to '1', then this field shall be cleared to 0h.</td></tr>
</table></td></tr>
<tr><td>5</td><td>AE Occurrence List Header Length (AEOLHL): This field shall indicate the length in bytes of the AE Occurrence List Header. This field shall be set to 7h.</td></tr>
</table>

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Figure TBD17: AE Occurrence List Data Structure

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>6</td><td>AEM Transmission Info (AEMTI): This field indicates information about the AEM transmission. For the AE Occurrence List data structure in the Response Message to an AEM Ack or an AE Sync, this field is not applicable and shall be cleared to 0h.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:3</td><td>AEM Generation Number: This field shall indicate a value that is incremented on the first attempt to transmit an AEM (i.e., the AEMRC field is cleared to 0h) and shall not be incremented for any other reason (e.g., this field is not incremented when an AEM transmission is retried).

If the value of this field is 1Fh, then this field shall be cleared to 0h when incremented (i.e., rolls over to 0h).

Note that there are race cases where a Management Endpoint retries an AEM transmission due to a timeout at the same time the Management Controller is transmitting the AEM Ack for the AEM. In this scenario, the Management Controller may receive duplicate AEMs. This field is used to determine whether the AEM is a duplicate (e.g., if the value in the Generation Number field in the most recently received AEM is the same as the value in the Generation Number field of the prior AEM, then the AEM is a duplicate and should be ignored by the Management Controller).</td></tr>
<tr><td>2:0</td><td>AEM Retry Count (AEMRC): For an AEM, this field shall indicate the number of times the AEM has been retried. A value of 0h indicates the first attempt to transmit the AEM, a value of 1h indicates the second attempt (i.e., the first retry) to transmit the AEM, etc.</td></tr>
</table></td></tr>
<tr><th colspan="2">AE Occurrence List Body</th></tr>
<tr><td>AEOLHL+(L-1):AEOLHL</td><td>AE Occurrence 0 (AEO0): This field shall indicate the first AE Occurrence data structure (refer to Figure TBD18), if any, where L is the length in bytes of this AE Occurrence data structure.</td></tr>
<tr><td>AEOLHL+L+(M-1):
AEOLHL+L</td><td>AE Occurrence 1 (AEO1): This field shall indicate the second AE Occurrence data structure, if any, where L is the length in bytes of the first AE Occurrence data structure and M is the length in bytes of this AE Occurrence data structure.</td></tr>
<tr><td colspan="2">…</td></tr>
<tr><td>AEOLTL-1: AEOLTL-N</td><td>AE Occurrence N (AEON): This field shall indicate the last AE Occurrence data structure, if any, where N is the length in bytes of this AE Occurrence data structure.</td></tr>
</table>

Figure TBD18: AE Occurrence Data Structure

Bytes	Description
	AE Occurrence Header
0	**AE Occurrence Header Length (AELHLEN):** This field shall indicate the length in bytes of the AE Occurrence Header. This field shall be set to 9h.
1	**AE Occurrence Specific Info Length (AEOSIL):** This field shall indicate the length in bytes of the AE Occurrence Specific Info field. If there is no AE Occurrence Specific Info field for this AE, then this field shall be cleared to 0h. If this AE is vendor specific (i.e., the AE Identifier is in the range C0h to FFh), then this field shall be cleared to 0h.
2	**AE Occurrence Vendor Specific Info Length (AEOVSIL):** This field shall indicate the length in bytes of the AE Occurrence Vendor Specific Info field. If there is no AE Occurrence Vendor Specific Info field for this AE, then this field shall be cleared to 0h.

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Figure TBD18: AE Occurrence Data Structure

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>8:3</td><td>
AE Occurrence Unique ID (AEOUI): This field indicates an identifier for the AE Occurrence data structure that is unique within a given AE Occurrence List data structure.
<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>0</td><td>AE Occurrence ID (AEOI): This field shall indicate the identifier of the AE (refer to Figure TBD10).</td></tr>
<tr><td>4:1</td><td>AE Occurrence Scope ID Info (AEOCIDI): This field indicates info about the scope identifier associated with the AE. The format of this field is defined in Figure TBDSI. The scope of the AE is indicated by the AE Occurrence Scope field.</td></tr>
<tr><td>5</td><td>AE Occurrence Scope Info (AESSI): This field indicates info about the scope of the AE.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:4</td><td>Reserved</td></tr>
<tr><td>3:0</td><td>AE Occurrence Scope (AESS): This field shall indicate the scope of the AE.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0h</td><td>Namespace</td></tr>
<tr><td>1h</td><td>Controller</td></tr>
<tr><td>2h</td><td>NVM Subsystem</td></tr>
<tr><td>3h</td><td>Management Endpoint</td></tr>
<tr><td>4h</td><td>Port</td></tr>
<tr><td>5h</td><td>Endurance Group</td></tr>
<tr><td>6h to Fh</td><td>Reserved</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>
</td></tr>
<tr><th colspan="2">AE Occurrence Specific Info</th></tr>
<tr><td>AEOSIL+ AELHLEN-1:AELHLEN</td><td>AE Occurrence Specific Info (AEOSI): This field shall indicate info specific to the AE (refer to Figure TBD19), if applicable. If the value of the AEOSIL field is 0h, then this field is not included.</td></tr>
<tr><td>N:M</td><td>
AE Occurrence Vendor Specific Info (AEOSI): This field indicates vendor-specific info specific to this AE, if applicable. If the value of the AEOVSIL field is 0h, then this field is not included.

M is equal to the value indicated by the AEOSIL field plus the value indicated by the AELHLEN field. N is equal to the value of the AELHLEN field plus the value of the AEOSIL field plus the value of the AEOVSIL field minus 1.
<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>M</td><td>AE Occurrence Vendor Specific Header (AEOVSH): This field indicates information about the AE occurrence vendor-specific information.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7</td><td>Vendor specific</td></tr>
<tr><td>6:0</td><td>AE Occurrence Vendor Specific UUID Index (AEOVSUI): If this field is set to a non-zero value, then the value of this field shall indicate the index of a UUID in the UUID List (refer to the NVM Express Base Specification) corresponding to the vendor that defined the AE Occurrence Vendor Specific Info.

If no UUID index is specified, then this field shall be cleared to 0h.</td></tr>
</table>
</td></tr>
<tr><td>N:M+1</td><td>Vendor specific</td></tr>
</table>
</td></tr>
</table>

4.TBD4.5 AE Identifier Information

The AEs, AE Identifiers, AE scope, and the only conditions that trigger an AE occurrence are defined in Figure TBD10. If the AEM Delay field (refer to Figure TBD30) is greater than 0h, then the conditions that trigger an AE occurrence shall be checked at a frequency of less than or equal to the amount of time specified by the AEM Delay field. If the AEM Delay field is equal to 0h, then the conditions that trigger an AE occurrence shall be checked at a frequency of less than or equal to 1 s. For example, if the AEM Delay

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field specifies a value of 5 seconds and the Composite Temperature AE is enabled, then the Management Endpoint shall check for a change in composite temperature at least once every 5 seconds.

Figure TBD10: Asynchronous Events

Identifier	Scope	AE	AE Occurrence Trigger when the AE is Enabled
00h	Controller	Controller Ready	The controller ready state changes. This is the same ready state that is indicated by the CSTS.RDY bit (refer to the NVM Express Base Specification).
01h	Controller	Controller Fatal Status	The controller fatal status changes. This is the same controller fatal status that is indicated by the CSTS.CFS (refer to the NVM Express Base Specification).
02h	Controller or NVM Subsystem	Shutdown Status	The following conditions, as defined by the NVM Express Base Specification, trigger this AE to occur with NVM Subsystem scope: • an NVM Subsystem Shutdown starts; or • an NVM Subsystem Shutdown completes. Note that even though every Controller in the NVM Subsystem indicates when the NVM Subsystem Shutdown starts or completes, a single Shutdown Status AE occurrence is triggered for the entire NVM Subsystem when the NVM Subsystem Shutdown starts, and a single Shutdown Status AE occurrence is triggered for the entire NVM Subsystem when the NVM Subsystem Shutdown completes. The following conditions, as defined by the NVM Express Base Specification, trigger this AE to occur with Controller scope: • a Controller shutdown starts; or • a Controller shutdown completes.
03h	Controller	Controller Enable	The controller enable state changes. This is the same controller enable state that is reported by the CC.EN bit (refer to the NVM Express Base Specification).
04h	Controller	Namespace Attribute Changed	One or more Namespace attributes change. These are the same Namespaces attribute changes reported by the Namespace Attribute Changed bit in the Controller Status field in the Controller Health Data Structure.
05h	NVM Subsystem	Firmware Activated	Firmware activation status changes. This is the same firmware activation status that is reported by the Firmware Activated bit in the Composite Controller Status field in the NVM Subsystem Health Data Structure.
06h	NVM Subsystem	Composite Temperature	The composite temperature changes. This is the same composite temperature that is reported by the Composite Temperature field in the NVM Subsystem Health data structure.
07h	NVM Subsystem	Percentage Drive Life Used	The percentage of NVM Subsystem life used changes. This is the same NVM Subsystem life used that is reported by the Percentage Drive Life Used field in the NVM Subsystem Health data structure.
08h	NVM Subsystem	Available Spare	The amount of available spare capacity in the NVM Subsystem changes. This is the same available spare capacity that is reported by the Available Spare bit in the Composite Controller Status Flags. <Note to Reader: Composite Controller Status Flags is defined in TP6021.> If the amount of available spare capacity is not NVM Subsystem scoped, then this AE shall not be supported.

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Figure TBD10: Asynchronous Events

Identifier	Scope	AE	AE Occurrence Trigger when the AE is Enabled
09h	NVM Subsystem	SMART Warnings	The critical warning state of any Controller in the NVM Subsystem changes. This is the same critical warning state that is reported by the Critical Warning field in the SMART / Health Information log page in the NVM Express Base Specification and the SMART Warnings field in the NVM Subsystem Health data structure.
0Ah	Controller or NVM Subsystem	Telemetry Controller-Initiated Data Available	Telemetry Controller-Initiated log page generation status changes. This is the same Telemetry Controller-Initiated log page generation status that is reported by the Telemetry Controller-Initiated Data Available bit in the Composite Controller Status Flags and the Telemetry Controller-Initiated Data Available bit in the Controller Health Data Structure. <Note to Reader: Composite Controller Status Flags and Telemetry Controller-Initiated Data Available are defined in TP6021.>
0Bh	Port	PCIe Link Active	The link active state changes. This is the same link active state that is reported by the Port 0 PCIe Link Active bit in the NVM Subsystem Health data structure and the Port 1 PCIe Link Active bit in the NVM Subsystem Health data structure. The AE Occurrence Port Type bit for this AE shall be set '1' to indicate that the AE Occurrence Port ID field contains the NVMe-MI port associated with the event.
0Ch	NVM Subsystem	Sanitize Failure Mode	The sanitize failure state changes. This is the same sanitize failure state that is reported by the Sanitize Failure Mode bit.
0Dh to BFh	Reserved		
C0h to FFh	Vendor specific		

Figure TBDSI AE Occurrence Scope ID Info Format

Scope	Value
Namespace	**Namespace Scope ID Info (NSI):** If this AE is Namespace scoped (i.e., the value of the AE Occurrence Scope field is 0h), then this field indicates info related to the AE Occurrence Scope ID of the Namespace. **Bits** / **Description** 31:00 — **AE Occurrence Namespace ID (AEONSID):** This field shall indicate the NSID of the Namespace associated with the AE.
Controller	**Controller Scope ID Info (CSI):** If this AE is Controller scoped (i.e., the value of the AE Occurrence Scope field is 1h), then this field indicates info related to the AE Occurrence Scope ID of the Controller. **Bits** / **Description** 31:16 — Reserved 15:00 — **AE Occurrence Controller ID (AEOCID):** This field shall indicate the Controller ID of the Controller associated with the AE.
NVM Subsystem	**NVM Subsystem Scope ID Info (NSSI):** If this AE is NVM Subsystem scoped (i.e., the value of the AE Occurrence Scope field is 2h), then his field indicates info related to the AE Occurrence Scope ID of the NVM Subsystem. **Bits** / **Description** 31:00 — Reserved

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<table>
<tr><td>Management Endpoint</td><td>Management Endpoint Scope ID Info (MESI): If this AE is Management Endpoint scoped (i.e., the value of the AE Occurrence Scope field is 3h), then this field indicates info related to the AE Occurrence Scope ID of the Management Endpoint.
<table><tr><th>Bits</th><th>Description</th></tr><tr><td>31:08</td><td>Reserved</td></tr><tr><td>07:00</td><td>AE Occurrence Management Endpoint ID (AEOMEID): This field shall indicate the Endpoint ID of the Management Endpoint associated with the AE.</td></tr></table></td></tr>
<tr><td>Port</td><td>Port Scope ID Info (PSI): If this AE is port scoped (i.e., the value of the AE Occurrence Scope field is 4h), then this field indicates info related to the AE Occurrence Scope ID of the port.
<table><tr><th>Bits</th><th>Description</th></tr><tr><td>31:17</td><td>Reserved</td></tr><tr><td>16</td><td>AE Occurrence Port Type (AEOPT): If the AE is associated with an NVM Subsystem port (refer to the NVM Express Base Specification), then this bit shall be cleared to ‘0’.
If the AE is associated with an NVMe-MI port, then this bit shall be set to ‘1’.</td></tr><tr><td>15:00</td><td>AE Occurrence Port ID (AEOPID): If the AEOPT field is cleared to ‘0’, then this field shall contain the Port Identifier of the NVM Subsystem port (refer to the NVM Express Base Specification) associated with the AE.
If the AEOPT field is set to ‘1’, then:
a) the least-significant byte of this field shall contain the Port Identifier of the NVMe-MI port associated with the AE; and
b) the most-significant byte of this field shall be cleared to 0h.</td></tr></table></td></tr>
<tr><td>Endurance Group</td><td>Endurance Group ID Info (EGI): If this AE is Endurance Group scoped (i.e., the value of the AE Occurrence Scope field is 5h), then this field indicates info related to the AE Occurrence Scope ID of the Endurance Group.
<table><tr><th>Bits</th><th>Description</th></tr><tr><td>31:16</td><td>Reserved</td></tr><tr><td>15:00</td><td>AE Occurrence Endurance Group ID (AEOEGID): This field shall indicate the Endurance Group ID of the Endurance Group associated with the AE.</td></tr></table></td></tr>
</table>

4.TBD4.6 AE Occurrence Specific Information

The format of the AE Occurrence Specific Info field for each Asynchronous Event Identifier is specified in Figure TBD19.

Figure TBD19: AE Occurrence Specific Info Data Structure

<table>
<tr><th>Asynchronous Event ID</th><th>Description</th></tr>
<tr><td>00h
(Ready)</td><td>Ready Info (RI): This field defines the contents of the AE Occurrence Specific Info field for the Ready AE.
<table><tr><th>Bits</th><th>Description</th></tr><tr><td>7:1</td><td>Reserved</td></tr><tr><td>0</td><td>Ready Value (RV): This bit shall indicate the value of the CSTS.RDY (refer to the NVM Express Base Specification) bit.</td></tr></table></td></tr>
<tr><td>01h
(Controller Fatal Status)</td><td>Controller Fatal Status Info (CFSI): This field defines the contents of the AE Occurrence Specific Info field for the Controller Fatal Status AE.
<table><tr><th>Bits</th><th>Description</th></tr><tr><td>7:1</td><td>Reserved</td></tr><tr><td>0</td><td>Controller Fatal Status Value (CFSV): This bit shall indicate the value of the CSTS.CFS (refer to the NVM Express Base Specification) bit.</td></tr></table></td></tr>
</table>

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Figure TBD19: AE Occurrence Specific Info Data Structure

<table>
<tr><th>Asynchronous Event ID</th><th>Description</th></tr>
<tr><td>02h (Shutdown Status)</td><td>Shutdown Status Info (SSI): This field defines the contents of the AE Occurrence Specific Info field for the Shutdown Status AE.

<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:3</td><td>Reserved</td></tr>
<tr><td>2</td><td>Shutdown Type Value (STV): This field shall indicate the value of the Shutdown Type (refer to the NVM Express Base Specification) bit.</td></tr>
<tr><td>1:0</td><td>Shutdown Status Value (SSV): This field shall indicate the value of the CSTS.SHST (refer to the NVM Express Base Specification) field.</td></tr>
</table></td></tr>
<tr><td>03h (Controller Enable)</td><td>Controller Enable Info (CEI): This field defines the contents of the AE Occurrence Specific Info field for the Controller Enable AE.

<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:2</td><td>Reserved</td></tr>
<tr><td>1</td><td>Controller Ready Independent of Media Enable (CRIME): This bit shall indicate the value of the CC.CRIME (refer to the NVM Express Base Specification) bit.</td></tr>
<tr><td>0</td><td>Controller Enable Value (CEV): This bit shall indicate the value of the CC.EN (refer to the NVM Express Base Specification) bit.</td></tr>
</table></td></tr>
<tr><td>04h (Namespace Attribute Changed)</td><td>There shall be no AE Occurrence Specific Info defined for this AE.</td></tr>
<tr><td>05h (Firmware Activated)</td><td>There shall be no AE Occurrence Specific Info defined for this AE.</td></tr>
<tr><td>06h (Composite Temperature)</td><td>Composite Temperature Info (CTI): This field defines the contents of the AE Occurrence Specific Info field for the Composite Temperature AE.

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>0</td><td>Composite Temperature Value (CTV): This field shall indicate the value of the Composite Temperature field in the NVM Subsystem Health data structure.</td></tr>
</table></td></tr>
<tr><td>07h (Percentage Drive Life Used)</td><td>Percentage Drive Life Used Info (PUI): This field defines the contents of the AE Occurrence Specific Info field for the Percentage Drive Life Used AE.

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>0</td><td>Percentage Drive Life Used Value (PUV): This field shall indicate the value of the Percentage Used field in the NVM Subsystem Health data structure.</td></tr>
</table></td></tr>
<tr><td>08h (Available Spare)</td><td>Available Spare Info (ASI): This field defines the contents of the AE Occurrence Specific Info field for the Available Spare AE.

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>0</td><td>Available Spare Value (ASV): This field shall indicate the value of the Available Spare (refer to the NVM Express Base Specification) field of any Controller in the NVM Subsystem.</td></tr>
</table></td></tr>
</table>

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Figure TBD19: AE Occurrence Specific Info Data Structure

<table>
<tr><th>Asynchronous Event ID</th><th>Description</th></tr>
<tr><td>09h (SMART Warnings)</td><td>SMART Warnings Info (CWI): This field defines the contents of the AE Occurrence Specific Info field for the SMART Warnings AE.

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>0</td><td>SMART Warnings Value (CWV): This field shall indicate the value of the SMART Warnings field in the NVM Subsystem Health data structure.</td></tr>
</table></td></tr>
<tr><td>0Ah (Telemetry Controller-Initiated Data Available)</td><td>There shall be no AE Occurrence Specific Info defined for this AE.</td></tr>
<tr><td>0Bh (PCIe Link Active)</td><td>PCIe Link Active Info (PLAI): This field defines the contents of the AE Occurrence Specific Info field for the PCIe Link Active AE.

<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:1</td><td>Reserved</td></tr>
<tr><td>0</td><td>PCIe Link Active Value (PLAV): If the Port Scope ID Info field indicates the AE is associated with PCIe Port 0, then this bit shall indicate the value of the PCIe Port 0 PCIe Link Active bit in the NVM Subsystem Health Data Structure.

If the Port Scope ID Info field indicates the AE is associated with PCIe Port 1, then this bit shall indicate the value of the PCIe Port 1 PCIe Link Active bit in the NVM Subsystem Health Data Structure.</td></tr>
</table></td></tr>
<tr><td>0Ch (Sanitize Failure Mode)</td><td>Sanitize Failure Mode Info (SFMI): This field defines the contents of the AE Occurrence Specific Info field for the Sanitize Failure Mode AE.

<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:1</td><td>Reserved</td></tr>
<tr><td>0</td><td>Sanitize Failure Mode Value (SFMV): This bit shall indicate the value of the Sanitize Failure Mode bit in the NVM Subsystem Health Data Structure.</td></tr>
</table></td></tr>
<tr><td>0Dh to BFh</td><td>Reserved</td></tr>
<tr><td>C0h to FFh</td><td>There shall be no AE Occurrence Specific Info defined for these AEs.</td></tr>
</table>

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5 Management Interface Command Set

…

5.1 Configuration Get

…

Modify Figure 66 as follows:

Figure 66: NVMe Management Interface Configuration Identifiers

Configuration Identifier	Out-of-Band Mechanism O/M/P[1]	In-Band Tunneling Mechanism O/M/P[1]	Description
00h	-	-	Reserved
01h	M	P	SMBus/I2C Frequency
02h	M	M	Health Status Change
03h	M	P	MCTP Transmission Unit Size
04h	O[2]	P	Asynchronous Event
~~04h~~ 05h to BFh	-	-	Reserved
C0h to FFh	O	O	Vendor Specific
Notes: 1. O/M/P definition: O = Optional, M = Mandatory, P = Prohibited from being supported. 2. This configuration is optional for both PCIe VDM Management Endpoints and SMBus/I2C Management Endpoints; however, the specifics of how this configuration works for SMBus/I2C Management Endpoints is outside the scope of this specification.			

…

5.1.TBD5 Asynchronous Event (Configuration Identifier 04h)

The Asynchronous Event configuration indicates information about AEs for the Management Endpoint that processes the Configuration Get command.

The configuration-specific fields in the NVMe Management Dword 0 field are shown in Figure TBD6. The configuration-specific fields in the NVMe Management Dword 1 field are reserved.

Figure TBD6: Asynchronous Event – NVMe Management Dword 0

Bits	Description
31:08	Reserved
07:00	**Configuration Identifier:** This field specifies the identifier of the Configuration that is being read. Refer to Figure 66.

Upon successful completion of the Configuration Get command, the data in Figure TBD7 shall be returned in the NVMe Management Response field and the data structure in Figure TBD8 shall be returned in the Response Data.

Figure TBD7: Asynchronous Event – NVMe Management Response

Bits	Description
23:08	Reserved
07:00	**AE Enable List Version Number (AEELVER):** This field shall indicate the version number of the AE Enable List data structure and the AE Enable data structure supported by the Management Endpoint. This field shall be cleared to 0h.

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The AE Supported List data structure indicates a list of AEs that the Management Endpoint supports and shall be minimally sized (i.e., if there is one AE Supported data structure, then the length of the AE Supported List data structure is equal to the value of the AESL field plus the value of the AESLHL field). The AE Supported List data structure shall start at offset 0h of the Response Data field. The length of the AE Supported List Body shall be less than or equal to 4 KiB.

Figure TBD8: AE Supported List Data Structure

Bytes	Description
AE Supported List Header	
0	**Number of AE Supported Data Structures (NUMAES):** This field shall indicate the number of AE Supported data structures (refer to Figure TBD9) in the AE Supported List Body. This field shall be set to a value that is greater than or equal to 1h.
1	**AE Supported List Version Number (AESLVER):** This field shall indicate the version number of the AE Supported List data structure and the AE Supported data structure. This field shall be cleared to 0h.
3:2	**AE Supported Total Length (AESTL):** This field indicates the length in bytes of the AE Supported List data structure. This field shall be set to a value equal to the value of the AE Supported List Header Length field plus the sum of the lengths in bytes of each AE Supported data structure in the AE Supported List Body.
4	**AE Supported List Header Length (AESLHL):** This field shall indicate the length in bytes of the AE Supported List Header. This field shall be set to 5h.
AE Supported List Body	
AESLHL+(L-1):AESLHL	**AE Supported 0 (AES0):** This field shall indicate the first AE Supported data structure (refer to Figure TBD9), where L is the length in bytes of this AE Supported data structure.
AESLHL+L+(M-1): AESLHL+L	**AE Supported 1 (AES1):** This field shall indicate the second AE Supported data structure, if any, where L is the length in bytes of the first AE Supported data structure and M is the length in bytes of this AE Supported data structure.
…	
AESTL-1:AESTL-N	**AE Supported N (AESN):** This field shall indicate the last AE Supported data structure, if any, where N is the length in bytes of this AE Supported data structure.

Figure TBD9: AE Supported Data Structure

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>0</td><td>AE Supported Length (AESL): This field shall indicate the length in bytes of the AE Supported data structure. This field shall be set to 3h.</td></tr>
<tr><td>2:1</td><td>AE Supported Info (AESI): This field shall indicate information about the asynchronous event.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>15</td><td>AE Supported Enable (AESE): If the AE indicated by the AE Supported ID field is enabled, then this this bit shall be set to ‘1’.

If the AE indicated by the AE Supported ID field is disabled, then this bit shall be cleared to ‘0’.

A Management Endpoint Reset shall clear this bit to ‘0’.</td></tr>
<tr><td>14:08</td><td>Reserved</td></tr>
<tr><td>07:00</td><td>AE Supported ID (AESI): This field shall indicate the identifier of the AE (refer to Figure TBD10).</td></tr>
</table></td></tr>
</table>

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5.2 Configuration Set

…

5.2.TBD12 Asynchronous Event (Configuration Identifier 04h)

The Asynchronous Event (AE) configuration has two variations:

a) an AE Sync; and
b) an AEM Ack.

An AE Sync shall occur when a Configuration Set command for the Asynchronous Event configuration is processed by the Management Endpoint that does not have the Number of AE Enable Data Structures field in the Configuration Set command cleared to 0h and results in the AE Occurrence List Overflow bit cleared to '0' (refer to section 5.2.TBD12.1). The Response Message for an AE Sync includes the current state of all enabled AEs which is used to synchronize the state of the AEs between the Management Controller and the Management Endpoint.

An AEM Ack acknowledges receipt of an AEM to a Management Endpoint. An AEM Ack shall occur when a Configuration Set command for the Asynchronous Event configuration is processed by the Management Endpoint that has the Number of AE Enable Data Structures field in the Configuration Set command cleared to 0h and results in the AE Occurrence List Overflow bit cleared to '0'. An AEM Ack during the AE Disarmed State following one or more AE occurrences in the prior AE Armed State shall cause those AE occurrences to be discarded (i.e., it is not permitted to transmit those AE occurrences again once receipt of the AEM for those AE occurrences has been acknowledged by the Management Controller). The Response Message for an AEM Ack transmitted during the AE Disarmed State when one or more AEs are enabled includes an AE Occurrence data structure for each AE that occurred during the AE Disarmed State which is used to resynchronize the state of the AEs between the Management Controller and the Management Endpoint.

If the length of the AE Occurrence List Body in the Response Data is able to exceed 4 KiB, then the Management Endpoint shall support the use of the Management Endpoint Buffer to retrieve the Response Data. The size of the Management Endpoint Buffer shall be greater than or equal to the maximum possible Response Data size.

The Request Data for a Configuration Set command for the Asynchronous Event configuration is not permitted to be transferred using the MEB. The Management Endpoint shall retrieve the Request Data from the Request Message regardless of whether the MEB bit is set to '1' or cleared to '0'.

The configuration specific fields in the NVMe Management Dword 0 field are shown in Figure TBD30. The configuration specific fields in the NVMe Management Dword 1 field are reserved.

Figure TBD30: Asynchronous Event – NVMe Management Dword 0

Bits	Description
31:27	Reserved
26	**Enable SR-IOV Virtual Functions AE (ENVFA):** If this bit is set to '1' in an AE Sync, then controller-scoped AEs shall be enabled on SR-IOV Virtual Functions. If this bit is cleared to '0' in an AE Sync, then controller-scoped AEs shall be disabled on SR-IOV Virtual Functions. It shall not be treated as an error if this bit is set to '1' and SR-IOV Virtual Functions do not exist. This bit is not applicable and shall be ignored for an AEM Ack.

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Figure TBD30: Asynchronous Event – NVMe Management Dword 0

Bits	Description
25	**Enable SR-IOV Physical Functions AE (ENPFA):** If this bit is set to '1' in an AE Sync, then controller-scoped AEs shall be enabled on SR-IOV Physical Functions. If this bit is cleared to '0' in an AE Sync, then controller-scoped AEs shall be disabled on SR-IOV Physical Functions. It shall not be treated as an error if this bit is set to '1' and SR-IOV Physical Functions do not exist. This bit is not applicable and shall be ignored for an AEM Ack.
24	**Enable PCI Functions AE (ENCFA):** If this bit is set to '1' in an AE Sync, then controller-scoped AEs shall be enabled on non-SR-IOV PCI Functions. If this bit is cleared to '0' in an AE Sync, then controller-scoped AEs shall be disabled on non-SR-IOV PCI Functions. It shall not be treated as an error if this bit is set to '1' and non-SR-IOV PCI Functions do not exist. This bit is not applicable and shall be ignored for an AEM Ack.
23:16	**AEM Delay (AEMD):** For an AE Sync, this field specifies the amount of time in seconds the Management Endpoint shall delay after entering the AE Armed State before the Management Endpoint is permitted to enter the AEM Transmission Interval to transmit an AEM for any AEs that occurred during the AE Armed State (refer to section 1.8.TBDD7).
15:08	**AEM Retry Delay (AERD):** If this field is not cleared to 0h in an AE Sync, then the Management Endpoint shall wait the amount of time in 100 ms units specified by this field before attempting to retry transmission of an unacknowledged or failed AEM transmission (refer to section 4.TBD4.3). If this field is cleared to 0h in an AE Sync, then the Management Endpoint shall not attempt to retry transmission of any AEM at the MCTP layer. Note that retries may still occur at the physical layer (e.g., due to a NACK on SMBus/I2C) when this field is cleared to 0h. This field is not applicable and shall be ignored for an AEM Ack.
07:00	**Configuration Identifier (CID):** This field specifies the identifier of the Configuration that is being written. Refer to Figure 66.

The AE Enable List data structure is transferred in the Request Data field and may specify a list of AEs that the Management Endpoint shall configure. The AE Enable List data structure should be minimally sized (i.e., if there is one AE Enable data structure, then the AE Enable List data structure should be the length of that AE Enable data structure plus the length of the AE Enable List Header). If the AE Enable List data structure is not minimally sized, then the Management Endpoint shall ignore the additional data. The AE Enable List data structure should start at offset 0h of the Request Data field. If the AE Enable List Body is greater than 4 KiB, then the Management Endpoint shall respond with a Response Message Status of Invalid Command Input Data Size.

If the Configuration Set command initiates an AE Sync and is processed in the AE Armed State while there are AEs that have occurred but have not been transmitted in an AEM, then those AE occurrences shall be discarded (e.g., those AE occurrences shall not be transmitted during any AEM Transmission Interval or transmitted in the Response Message for an AEM Ack).

If an AE Sync or AEM Ack is occurs during the AEM Transmission Interval, then:

a) if an AEM transmission is in flight at the time the AE Sync or AEM Ack occurs, then the Management Endpoint stops the AEM transmission as defined in section 4.TBD4.3; and
b) any AEs that have occurred in the prior AE Armed State shall be discarded (e.g., those AE occurrences shall not be transmitted during any AEM Transmission Interval or transmitted in the Response Message for an AEM Ack).

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Figure TBD14: AE Enable List Data Structure

Bytes	Description
AE Enable List Header	
0	**Number of AE Enable Data Structures (NUMAEE):** This field specifies the number of AE Enable data structures (refer to Figure TBD15) in the AE Enable List Body. If there are no AE Enable data structures in the AE Enable List Body, then this field should be cleared to 0h. A value of 0h is used to initiate an AEM Ack (refer to section 1.8.TBDD6).
1	**AE Enable List Version Number (AEELVER):** This field specifies the version number of the AE Enable List data structure and the AE Enable data structure. This field should be cleared to 0h. A Management Endpoint designed to support version N of these data structures: a) shall not generate an error for any value in this field; b) shall process these data structures as defined by version N of these data structures regardless of the version of this field; c) shall ignore non-zero values in fields that are reserved in version N of these data structures; and d) shall not perform any functionality related to these data structures that is not defined by version N of these data structures.
3:2	**AE Enable Total Length (AEETL):** This field specifies the length in bytes of the AE Enable List data structure. This field should be set to a value equal to the value of the AE Enable List Header Length field plus the sum of the lengths in bytes of each AE Enable data structure in the AE Enable List Body.
4	**AE Enable List Header Length (AEELHL):** This field specifies the length in bytes of the AE Enable List Header. This field should be set to 5h.
AE Enable List Body	
AEELHL+(L-1):AEELHL	**AE Enable 0 (AEE0):** This field specifies the first AE Enable data structure (refer to Figure TBD15), if any, where L is the length in bytes of this AE Occurrence data structure.
AEELHL+L+(M-1): AEELHL+L	**AE Enable 1 (AEE1):** This field specifies the second AE Enable data structure, if any, where L is the length in bytes of the first AE Occurrence data structure and M is the length in bytes of this AE Enable data structure.
…	
AEETL-1:AEETL-N	**AE Enable N (AEEN):** This field specifies the last AE Enable data structure, if any, where N is the length in bytes of this AE Enable data structure.

Figure TBD15: AE Enable Data Structure

Bytes	Description
0	**AE Enable Length (AEEL):** This field specifies the length in bytes of the AE Enable data structure. This field should be set to 3h.
2:1	**AE Enable Info (AEEI):** This field specifies information about the asynchronous event. **Bits** / **Description** 15 — **AE Enable (AEE):** If this bit is set to '1', then the asynchronous event indicated by the AE Enable ID field shall be enabled. If this bit is cleared to '0', then the asynchronous event indicated by the AE Enable ID field shall be disabled. 14:8 — Reserved 7:0 — **AE Enable ID (AEEI):** This field specifies the identifier of the asynchronous event (refer to Figure TBD10).

5.2.TBD12.1 AE Occurrence List Overflow Handling

If the length of the AE Occurrence List Body:

a) does not exceed 4 KiB; or

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b) does exceed 4 KiB and the MEB bit is set to ‘1’,

then the AE Occurrence List Overflow bit shall be cleared to ‘0’.

If the number of AE Occurrence data structures available to return in the AE Occurrence List Body would result in the length of the AE Occurrence List Body exceeding 4 KiB if the AE Occurrence data structure for each AE available to return was included in the AE Occurrence List Body and the MEB bit is cleared to ‘0’, then the AE Occurrence List Overflow bit shall be set to ‘1’.

5.2.TBD12.2 Asynchronous Event Response

Upon completion of the Configuration Set command, a Response Message shall be transmitted. The NVMe Management Response field is reserved. The Response Data field shall indicate an AE Occurrence List data structure (refer to Figure TBD17) and shall be minimally sized (i.e., if there is one AE Occurrence data structure, then the AE Occurrence List data structure is the length of that AE Occurrence data structure plus the length of the AE Occurrence List Header). The AE Occurrence List data structure shall start at offset 0h of the Response Data field.

If this command results in the AE Occurrence List Overflow bit is set to ‘1’, then the AE Occurrence List data structure shall contain the AE Occurrence List Header and shall not contain an AE Occurrence List Body.

If a supported AE is not in the AE Enable List data structure, then that AE’s configuration shall not be changed. If an unsupported AE is in the AE Enable List data structure, then the AE Enable data structure for that AE shall be ignored by the Management Endpoint.

For an AEM Ack:

a) if the Configuration Set command is processed when no AEs are enabled or during the AE Armed State, then a Success Response shall be returned; or
b) if the Configuration Set command is processed during the AE Disarmed State when one or more AEs are enabled, then:
   - the AE Occurrence List Body shall contain an AE Occurrence data structure (refer to Figure TBD18) for each AE of a given AE Unique ID that has occurred during that AE Disarmed State;
   - if multiple AEs of a given AE Unique ID occurred during that AE Disarmed State, then only the AE Occurrence data structure for the most recent occurrence of the AE associated with that AE Unique ID is included in the AEM;
   - the AE Occurrence List Body shall not contain an AE Occurrence data structure for any AEs that did not occur during that AE Disarmed State; and
   - each AE Occurrence data structure shall indicate the state of the AE at the time the AE occurred.

For an AE Sync:

a) the AEM Transmission Failure bit is cleared to ‘0’ (refer to Figure 91);
b) the AE Occurrence List data structure shall contain an AE Occurrence data structure for each AE that was enabled by the Configuration Set command or that was already enabled; and
c) each AE Occurrence data structure shall indicate the state of the AE at the time the Configuration Set command was processed.

If this command leaves one or more AEs enabled and results in the AE Occurrence List Overflow bit cleared to ‘0’, then an AE Arm shall occur. If am AE Arm occurs, then the Management Endpoint shall perform the following steps atomically:

a) for each supported AE in the AE Enable List data structure, the AE is enabled or disabled as specified by the AE Enable bit in the AE Enable data structure for the AE;
b) for each AE Occurrence data structure in the AE Occurrence List data structure, populate the current state of the AE in the AE Occurrence Specific Info field, if any, and AE Occurrence Vendor Specific Info field, if any, in the AE Occurrence data structure in the Response Data; and
c) transition the Management Endpoint to the AE Armed State.

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5.6 NVM Subsystem Health Status Poll

…

Modify Figure 91 as follows:

Figure 91: NVM Subsystem Health Data Structure (NSHDS)

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>0</td><td>NVM Subsystem Status (NSS): This field indicates the status of the NVM Subsystem.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7~~:6~~</td><td>~~Reserved~~AEM Transmission Failure (ATF): If there is an AEM transmission failure on any Management Endpoint in the NVM Subsystem, then this bit shall be set to ‘1’.

An AEM transmission failure on a given Management Endpoint occurs when:
a) the AEM Retry Delay field is not cleared to 0h and the amount of time specified by the AEM Retry Delay has elapsed since the end of transmission of the final attempt (refer to section 4.TBD4.3) to transmit the AEM without processing an AEM Ack;
b) the AEM Retry Delay field is cleared to 0h and 5 s has elapsed since the end of transmission of the first attempt to transmit the AEM without processing an AEM Ack, an AE Sync, or a Management Endpoint Reset; or
c) the physical transport external to the NVM Subsystem is unavailable when the Management Endpoint attempts the final transmission of an AEM (e.g., an AEM on a PCIe VDM Management Endpoint is unable to be transmitted due to the PCIe link being down).

This bit shall be cleared to ‘0’ if:
a) an AE Sync occurs; or
b) a Management Endpoint Reset occurs.</td></tr>
<tr><td>6</td><td>Sanitize Failure Mode (SFM): If the NVM Subsystem is in the Sanitize failure mode, then this bit shall be set to ‘1’. If the NVM Subsystem is not in the Sanitize failure mode, then this bit shall be cleared to ‘0’. The NVM Subsystem is in the Sanitize failure mode when the most recent sanitize operation failed and no recovery action has been completed successfully (refer to the NVM Express Base Specification).</td></tr>
<tr><td>5</td><td>Drive Functional (DF): This bit is set to ‘1’ to indicate an NVM Subsystem is functional. If cleared to ‘0’, then there is an unrecoverable failure detected in the NVM Subsystem.</td></tr>
<tr><td>4</td><td>Reset Not Required (RNR): This bit is set to ‘1’ to indicate the NVM Subsystem does not require a reset to resume normal operation. If cleared to ‘0’, then the NVM Subsystem has experienced an error that prevents continued normal operation. A Controller Level Reset is required to resume normal operation.</td></tr>
<tr><td>3</td><td>Port 0 PCIe Link Active (P0LA): This bit is set to ‘1’ to indicate the first port’s PCIe link is up (i.e., the Data Link Control and Management State Machine is in the DL_Active state). If cleared to ‘0’, then the PCIe link is down.</td></tr>
<tr><td>2</td><td>Port 1 PCIe Link Active (P1LA): This bit is set to ‘1’ to indicate the second port’s PCIe link is up. If cleared to ‘0’, then the second port’s PCIe link is down or not present.</td></tr>
<tr><td>1:0</td><td>Reserved</td></tr>
</table></td></tr>
<tr><td>…</td><td>…</td></tr>
</table>

5.7 Read NVMe-MI Data Structure

…

Modify Figure 96 as follows:

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Figure 96: Port Information Data Structure

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>00</td><td>Port Type: Specifies the port type.
<table>
<tr><th>Value</th><th>Definition</th></tr>
<tr><td>0h</td><td>Inactive</td></tr>
<tr><td>1h</td><td>PCIe</td></tr>
<tr><td>2h</td><td>SMBus/I2C</td></tr>
<tr><td>3h to FFh</td><td>Reserved</td></tr>
</table></td></tr>
<tr><td>01</td><td>Port Capabilities: This field contains information about the capabilities of the port.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:2~~1~~</td><td>Reserved</td></tr>
<tr><td>1</td><td>Asynchronous Event Messages Supported (AEMS): If this bit is set to ‘1’, then all Management Endpoints on this port shall support AEMs (refer to section 4.TBD4) and the Asynchronous Event configuration (i.e., Configuration Identifier 04h). If this bit is cleared to ‘0’, then all Management Endpoints on this port shall not support AEMs or the Asynchronous Event configuration.</td></tr>
<tr><td>0</td><td>Command Initiated Auto Pause Supported (CIAPS): If this bit is set to ‘1’, then the Command Initiated Auto Pause (CIAP) bit is supported in Command Messages on this port. If this bit is cleared to ‘0’, then the CIAP bit is not supported in Command Messages on this port.</td></tr>
</table></td></tr>
<tr><td>…</td><td>…</td></tr>
</table>

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8 Management Architecture

…

8.3 Reset

…

Modify section 8.3.2 as follows:

8.3.2 Controller Level Reset

…

The actions performed on a Controller Level Reset are outlined in the NVM Express Base Specification. A Controller Level Reset shall have no effect on the Controller Management Interface associated with that Controller, the PCI Express port associated with that Controller, or a Management Endpoint associated with that port. A Controller Level Reset shall not stop the servicing of the Management Interface Command Set, NVM Express Admin Command Set commands, or Control Primitives (e.g., NVM Express Admin Command Set commands are still serviced even though the NVMe Controller may be disabled or held in reset). A Controller Level Reset shall have no effect on the AEM servicing model (refer to section 4.TBD4).

A Controller Level Reset may prevent PCIe Commands from being processed on that Controller (refer to section 8.1). If a PCIe Command is prevented from being processed due to a Controller Level Reset, then that PCIe Command shall be completed with status PCIe Inaccessible.

…

Modify section 8.3.3 as follows:

8.3.3 Management Endpoint Reset

The following shall cause a Management Endpoint Reset:

- an NVM Subsystem Reset of the NVM Subsystem containing the Management Endpoint; or
- the conditions for resetting an MCTP endpoint outlined in the MCTP Base Specification or the associated MCTP transport binding specifications.

In addition to these conditions, a Management Endpoint Reset shall be initiated on the Management Endpoint associated with a PCI Express port when that PCI Express port undergoes a PCIe Reset (refer to section 8.3.TBD) or is powered on. A Management Endpoint Reset shall be initiated on the Management Endpoint associated with an SMBus/I2C port when that SMBus/I2C port undergoes an SMBus Reset (refer to section 8.3.4) or is powered on.

If a Management Endpoint Reset is initiated, then:

- each Command Slot in that Management Endpoint shall behave as if an implicit Abort Control Primitive (refer to section 4.2.1.3) was received with the exception that the Management Endpoint shall not transmit any Abort Control Primitive Response Messages;
- any Control Primitives being processed by that Management Endpoint shall be dropped (silently discarded); and
- any internal state of that Management Endpoint should be returned to its power-on condition.

A Management Endpoint Reset of a Management Endpoint shall not affect any other Management Endpoint or entity in the NVM Subsystem. Note that for implementations compliant to version 1.1 and earlier of this specification, implementations may block MCTP accesses on additional Management Endpoints during a PCI Express conventional reset of a PCIe VDM Management Endpoint.

Additional requirements and recommendations for Management Endpoint Resets are specified elsewhere in this specification. For example, a Management Endpoint Reset:

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- resets bits and fields that are dedicated to the out-of-band mechanism as defined in Figure 80, Figure 81, and Figure 90;
- disables all supported AEs as defined by Figure TBD9;
- stops transmission of any AEM as defined in section 4.TBD4.3;
- causes the Management Endpoint to transition to the AE Disarmed State as defined in section 4.TBD4.1;
- clears the AEM Transmission Failure bit as defined in Figure 91;
- resets the value of the MCTP Transmission Unit Size field as defined by Figure 69; and
- clears the Control Primitive Specific Response field to 0h as defined in Figure 42.

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Appendix TBDAD AEM Example Timing Diagrams

Figure TBDAD1 shows an example where the AEM Retry Delay field is not cleared to 0h and with:

a) multiple unique AEs occurring during the AEM Delay Interval and during the AEM Transmission Interval;
b) a failed AEM transmission; and
c) a successful retry of the failed AEM transmission.

The sequence of events in Figure TBDAD1 is as follows:

1. At the end of Management Endpoint Reset, the Management Endpoint is in the AE Disarmed State.
2. AEs are enabled via the Configuration Set command for the Asynchronous Event configuration.
    a. The Management Controller specifies the duration of the AEM Delay Interval in the AEM Delay field.
    b. The Management Controller specifies the amount of time to delay before retrying an AEM transmission due to transmission failure in the AEM Retry Delay field.
    c. The Management Endpoint transitions to the AE Armed State.
    d. The AEM Delay Interval starts.
3. The first AE occurs but an AEM is not yet transmitted since it occurred during the AEM Delay Interval.
4. The second AE occurs but an AEM is not yet transmitted since it occurred during the AEM Delay Interval.
5. After the AEM Delay Interval ends, the AEM Transmission Interval starts immediately since there are AEs that have occurred during the AEM Delay Interval.
    a. When the AEM Transmission Interval started, the Management Endpoint transitioned to the AE Disarmed State.
6. The Management Endpoint transmits a single AEM containing an AE Occurrence data structure for each unique AE that occurred during the prior AE Armed State (i.e., AE #1 and AE #2 in this example) with the AEM Generation Number field cleared to 0h and the AEM Retry Count field cleared to 0h.
    a. The Management Endpoint should minimize the amount of time between entering the AEM Transmission Interval and transmitting the AEM.
    b. After transmitting the AEM, the Management Endpoint waits the amount of time specified by the AEM Retry Delay field to receive an AEM Ack.
7. The third AE occurs but an AEM is not yet transmitted since it occurred during the AEM Transmission Interval.
8. After waiting the amount of time specified AEM Retry Delay field for the AEM Ack, the Management Endpoint times out waiting for an AEM Ack.
9. The Management Endpoint retries the AEM transmission from step 6 with the AEM Generation Number field cleared to 0h and the AEM Retry Count field set to 1h.
    a. Since this is a retry of the AEM transmission in step 6, an AE Occurrence data structure for AE #3 is not included.
    b. The Management Endpoint should minimize the amount of time between the end of the AEM Retry Delay interval and retrying the AEM transmission.
    c. After retrying the AEM transmission, the Management Endpoint waits the amount of time specified by the AEM Retry Delay field to receive an AEM Ack.
10. The Management Endpoint receives an AEM Ack to acknowledge receipt of the AEM containing AE #1 and AE #2 prior to the AEM Retry Delay interval ending.
    a. The Response Message for the AEM Ack contains any AEs that have occurred since the start of the AEM Transmission Interval (i.e., AE #3 in this example).
    b. The AEM Transmission Interval Ends.
    c. The Management Endpoint transition back to the AE Armed State.
    d. The next AEM Delay Interval starts.
    e. The Management Endpoints waits for the next AE to occur.

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Figure TBDAD1: AEM Example 1

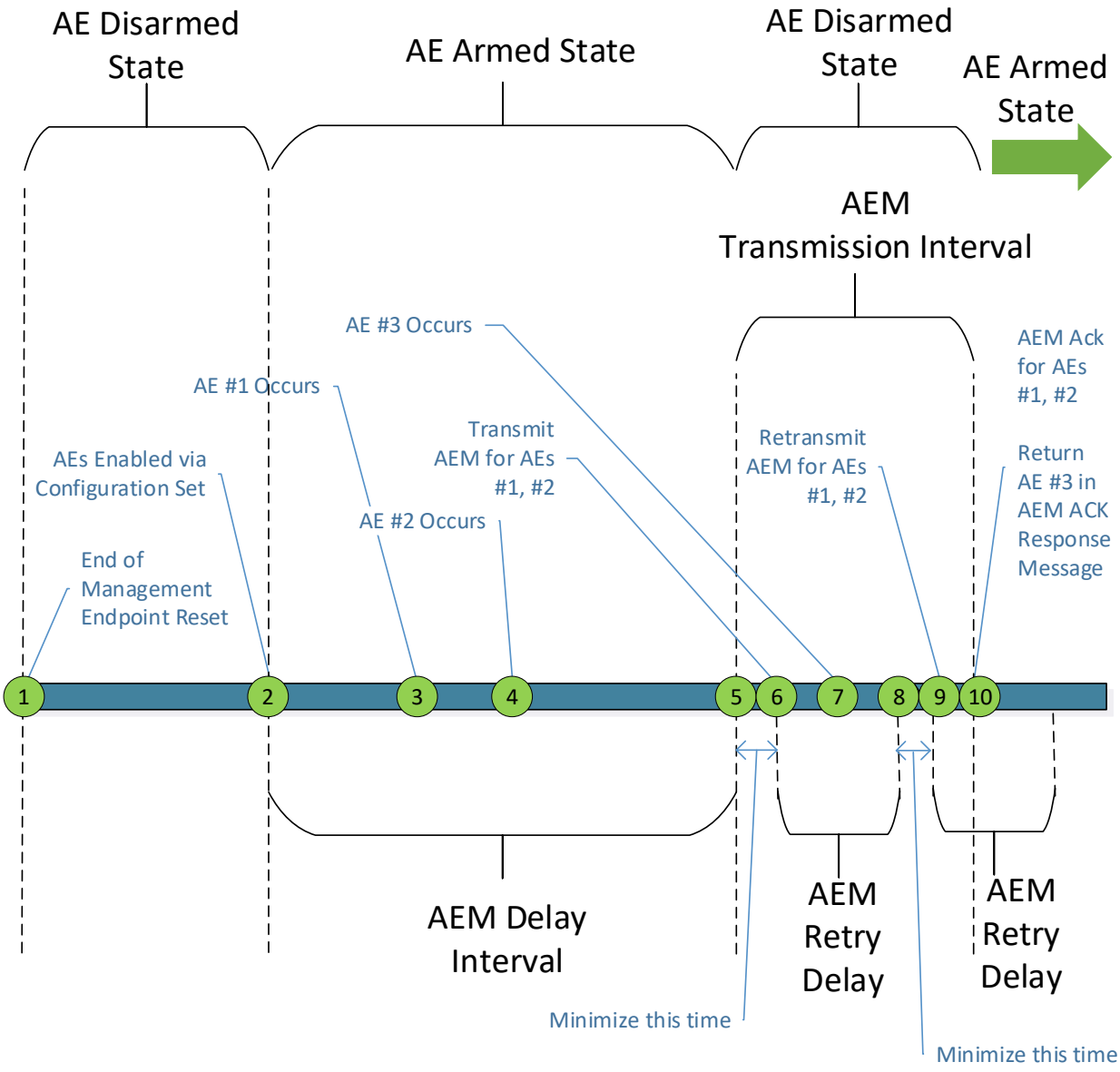

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Figure TBDAD2 shows an example where an AE occurs after the AEM Delay Interval, the Management Endpoint exhausts its AEM transmission retries without getting an AEM Ack assuming the AEM Retry Delay field is not cleared to 0h, then another AE occurs after AEM Transmission Interval.

The sequence of events in Figure TBDAD2 is as follows:

1. AEs are enabled via the Configuration Set command for the Asynchronous Event configuration.
    a. The Management Controller specifies the duration of the AEM Delay Interval in the AEM Delay field.
    b. The Management Controller specifies the amount of time to delay before retrying an AEM transmission due to transmission failure in the AEM Retry Delay field.
    c. The Management Endpoint transitions to the AE Armed State.
    d. The AEM Delay Interval starts.
2. The first AE occurs after the AEM Delay Interval has ended.
    a. Since the AEM Delay Interval has already ended, the AEM Transmission Interval starts as soon as the first AE occurs.
    b. When the AEM Transmission Interval started, the Management Endpoint transitioned to the AE Disarmed State.
3. The Management Endpoint transmits a single AEM containing an AE Occurrence data structure for each AE that occurred during the prior AE Armed State (i.e., AE #1 in this example) with the AEM Generation Number field cleared to 0h and the AEM Retry Count field cleared to 0h.
    a. The Management Endpoint should minimize the amount of time between entering the AEM Transmission Interval and transmitting the AEM.
    b. After transmitting the AEM, the Management Endpoint waits the amount of time specified by the AEM Retry Delay field to receive an AEM Ack.
4. After waiting the amount of time specified AEM Retry Delay field for the AEM Ack, the Management Endpoint times out waiting for an AEM Ack.
5. The Management Endpoint retries the AEM transmission from step 3 with the AEM Generation Number field cleared to 0h and the AEM Retry Count field incremented by one.
    a. The Management Endpoint should minimize the amount of time between the end of the AEM Retry Delay interval and retrying the AEM transmission.
    b. After retrying the AEM transmission, the Management Endpoint waits the amount of time specified by the AEM Retry Delay field to receive an AEM Ack.
6. The Management Controller remains unresponsive (e.g., due to being reset) and does not transmit an AEM Ack and so steps 4 and 5 are repeated until all AEM transmission attempts have been exhausted (8 total transmission attempts).
7. After waiting the amount of time specified by the AEM Retry Delay field after the final AEM transmission attempt, no AEM Ack has been received and the AEM Transmission Interval Ends.
    a. The Management Endpoint sets the AEM Transmission Failure bit in the NVM Subsystem Health Data Structure.
8. The second AE occurs but an AEM containing an AE Occurrence data structure for the second AE is not permitted to be transmitted since the Management Endpoint is in the AE Disarmed State.
    a. As long as the Management Endpoint is in the AE Disarmed State, no AEMs are permitted to be transmitted.
    b. If the Management Controller times out waiting for an AEM, the Management Controller may issue an NVM Subsystem Health Poll command and check the AEM Transmission Failure bit to determine if an AEM transmission failure has occurred.
9. Once the Management Controller becomes responsive, the Management Controller resyncs with the Management Endpoint to get the current state of the AEs.
    a. If the Management Controller never received any of the AEMs containing an AE Occurrence data structure for the first AE, then note that an AEM Ack at this point could not be used to resync since the AEM Ack would only return an AE Occurrence data structure for the second AE and not the first AE.
    b. If the Management Controller does not know which AEs are enabled, then the Management Controller may issue a Configuration Get command for the Asynchronous Event configuration to get the enable/disable state of all supported AEs.

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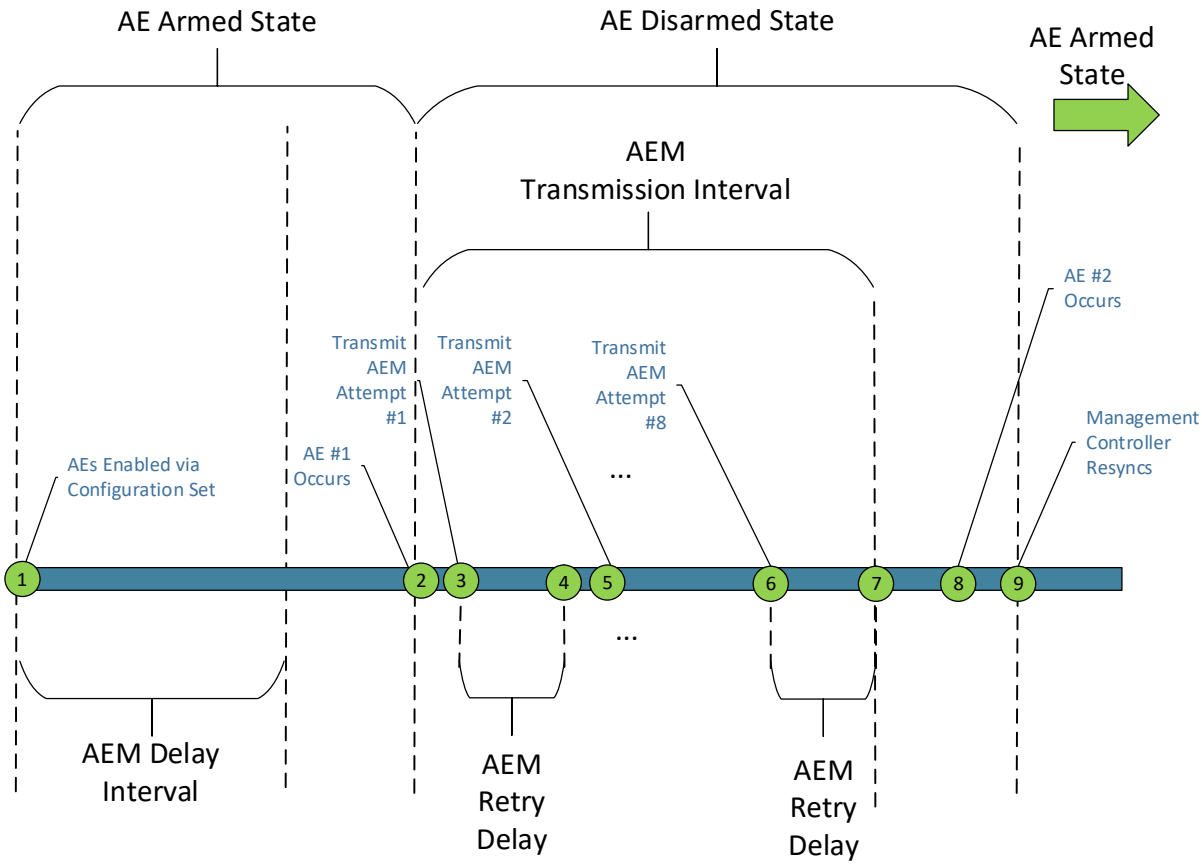
c. The Management Controller may issue a Configuration Set command for the Asynchronous Event configuration to disable or enable AEs.
d. In response to the Configuration Set command in step 9c, the Management Endpoint returns an AE Occurrence data structure for each AE that was enabled by the Configuration Set command or that was already enabled which resyncs the Management Endpoint and Management Controller.
e. The Management Endpoint transitions to the AE Armed State.
f. The next AEM Delay Interval starts.
g. The Management Endpoints waits for the next AE to occur.

Figure TBDAD2: AEM Example 2



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