UNH-IOL
NVMe Testing Service

NVMe Integrators List Policy
Version   20.0
Policy Document

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MODIFICATION RECORD

2012 October 29 (Version 1.0 DRAFT)
      David Woolf: Initial Release

2012 November 19 (Version 1.0 DRAFT)
      David Woolf: Changed Windows Driver requirement from being exclusively the Windows OFA reference driver to being any Windows driver.

2012 December 3 (Version 1.0 DRAFT)
      David Woolf: Added 'Definitions' section. Added requirement for testing against Linux Reference Driver. Clarified requirements for NVMe Devices vs. NVMe Host Platforms.

2013 April 30 (Version 1.0 DRAFT)
      David Woolf: Modified information to be included in each device listing.

2013 May 9 (Version 1.0)
      David Woolf: Final Release

2013 July 29 (Version 1.1 DRAFT)
      David Woolf: Modified information to be included in each device listed. Increased number of test platforms used from 4 to 5, and increased number of passing test platforms from 3 to 4. Specified that a Host Platform need only be tested using one operating system.

2013 August 7 (Version 1.1 DRAFT)
      David Woolf: Editorial fixes.

2013 November 7 (Version 1.1 DRAFT)
   David Woolf: Added exception for test 1.5 which only needs to be tested with one test platform. Added proposed wording for High Volume Listings policy.

2013 December 13 (Version 1.1 DRAFT)
   David Woolf: Reformatted policy document. Removed wording for High Volume Listing Policy. Added wording to clarify that all potential NVMe form factors are eligible for the list, and that drives in the same family but different form factors may be listed by similarity.

2013 December 16 (Version 1.1 DRAFT)
   David Woolf: Added cross reference to UNH-IOL equipment list to show what platforms are available for interoperability testing. Removed reference to boot test requirements.

2013 December 19 (Version 1.1)
   David Woolf: Added links to UNH-IOL NVMe Test Suites page to help readers find the necessary test procedures.

2014 July 14 (Version 1.1b)
   David Woolf: Upgraded requirements for interop testing in section 4. Updated Test Suite references.

2014 September 30 (Version 1.1b)
   David Woolf: Downgraded requirements for interop testing in section 4 per direction from NVM Express Organization.

2014 October 20 (Version 1.1b)
   David Woolf: Added clarification that devices advertising support for an earlier revision of the NVMe specification may still be eligible for newer revisions of the NVMe Integrators List.

2015 February 12 (Version 1.2)
    David Woolf: Added new requirements based on NVMe Promoters group feedback.

2015 April 7 (Version 1.2)
    David Woolf: Clarifications, editorial fixes.

2015 April 13 (Version 1.2)
    David Woolf: Added Group 7 and Group 8 tests to Table 1.

2015 April 14 (Version 1.2)
    David Woolf: Fixed broken web links in Section 4.

2015 November 5 (Version 1.2.1)
    David Woolf: Replaced references to SFF-8639 with U.2. Modified requirements for Boot Test to be performed with 2 hosts.

2015 November 23 (Version 1.2.1)
    David Woolf: Updated table 2 to reflect updates to conformance test suite.

2015 December 11 (Version 1.2.1)
    David Woolf: Updated Table 1 to reflect that interop Test 1.5, may not be required for certain types of FPGA based NVMe IP Devices.

2016 January 28 (Version 1.2.1)
    David Woolf: Updated Table 1 to match changes made to the NVMe Interoperability Test Suite v1.2.1 document in November 2015, indicating that the Boot Test is mandatory for hosts.

2016 May 17 (Version 6.0 r01)
    David Woolf: Updated document name to reflect new numbering scheme.

2016 May 24 (Version 6.0 r02)
    David Woolf: Removed tables of Mandatory/FYI tests and moved them to the respective test suite documents. Updated references.

2016 May 31 (Version 6.0 r03)
    David Woolf: Added reference to Appendix G of NVMe Interop Test Suite. Removed text outlining Integrators List test requirements, since this is now documented in Appendix G of the NVMe Interop Test Suite.

2016 December 8 (Version 6.0 r04)
    David Woolf: Added Section 7 discussing Appeals process.

2017 January 26 (Version 7.0 r01)
    David Woolf: Added section discussing NVMe-MI Integrators List.

2017 February 7 (Version 7.0 r02)
    David Woolf: Edits to eligibility requirements to enhance readability.

2017 March 22 (Version 7.0)
    David Woolf: Final release to UNH-IOL website ahead of May 2017 Plugfest #7.

2017 June 17 (Version 7.0a)
David Woolf: Added text to section 7 to describe escalation of waiver requests. Added Section 8 to clarify expectations of how ECNs and TPs will be handled.

2017 August 28 (Version 8.0)
David Woolf: Added section on NVMe Fabrics Integrators List.

2017 September 12 (Version 8.0a)
David Woolf: Added Fibre Channel and Ethernet Switches as eligible products for the NVMe over Fabrics Integrators List.

2017 November 28 (Version 8.0b)
David Woolf: Added switch port count as an item allowable for Listing by Similarity. Adjusted nomenclature for NVMe-oF targets and NVMe Drives.

2017 December 7 (Version 9.0 draft)
David Woolf: Updated table with acceptable device types and applicable test suites. Updated uses of 'list' to be 'lists' since the policy now references multiple Integrators Lists. Updated references section to reference v9.0 test suites documents.

2018 August 30 (Version 10.0 Release)
David Woolf: 10.0 Release.

2018 November 20 (Version 11.0 Release)
David Woolf: Added NVMe/TCP as an eligible product type for the NVMe-oF Integrators List. Updated References section to refer to v11.0 documents added NVMe-oF Conformance Test to References and Integrators List Eligibility table. Updated product nomenclature in Eligibility Table to match current NVMe Org guidelines.

2019 April 2 (Version 12.0 Release)
David Woolf:
● Updates to information included in listing of product on Integrators List according to TP 2008.

2020 March 9 (Version 13.0 Release)
David Woolf:
● Updates were made to the Integrators List Policy document to replace the terms "NVMe SSD" or "NVMe Drive" with the broader term "NVMe Device" in future iterations of the NVMe Integrators List.
● Updates were made to clarify that companies listing products on the Integrators List must be members of the NVMe Organization.

2020 July 21 (Version 14.0 Release)
David Woolf:
● Updates were made to indicate that iWARP products could be eligible for the NVMe-oF Integrators List.

2021 May 13 (Version 15.0 Release)
David Woolf:
• Program revision update.

2021 September 23 (Version 16.0 Release)
David Woolf:
• Updates were made to indicate that iWARP products could be eligible for the NVMe-oF Integrators List.

2021 December 20 (Version 17.0 Release)
 Timothy Sheehan:

- 2.0 Refactor for Plugfest 17

2022 July 14 (Version 18.0 Release)
 Timothy Sheehan:
Program Revision update

2023 January 04 (Version 19.0 Release)
 Timothy Sheehan:

- Program Revision update

2023 July 19 (Version 20.0 Release)
 Timothy Sheehan:

- Updated Section 5 Listing Information to include the following: "For MI testing include the interface type used in testing."

INTRODUCTION

The University of New Hampshire's InterOperability Laboratory (IOL) is an institution designed to improve the interoperability of standards-based products by providing a neutral environment where a product can be tested against other implementations of a common standard, both in terms of interoperability and conformance. The NVMe Organization and UNH-IOL have worked closely to define test procedures and policies for a public NVMe Integrators List. This document describes the Integrators List, how to qualify products for it, and policies surrounding the Integrators List. The goal of the NVMe Integrators List is to help implementers evaluate the NVMe functionality of their products.

REFERENCES

The following documents are referenced in this text:

1. UNH-IOL_NVMe-PCIe_Interoperability_v20.0
2. UNH-IOL_NVMe-MI_Conformance_v20.0
3. UNH-IOL_ NVMe_PCIe_Transport_Conformance_v20.0
4. UNH-IOL_NVM_RDMA_Transport_Conformance_v20.0
5. UNH-IOL_NVM_TCP_Transport_Conformance_v20.0
6. UNH-IOL_NVMe_RDMA_TCP_Interoperability_209.0
7. UNH-IOL_NVM_Command_Set_Conformance_v20.0
8. UNH-IOL_ZNS_Command_Set_Conformance_v20.0

Section 1: Integrators Lists Policies

Overview: This section describes policies and procedures for listing qualifying products on the various NVMe Integrators Lists.

1 - Purpose

This document outlines the policies for the NVMe and NVMe-oF Integrators Lists, hereafter referred to collectively as the Integrators Lists (ILs). This document will show how companies participating in UNH-IOL testing services can have their products included in these public Integrators Lists.

       The Integrators Lists will serve as a means for component suppliers to indicate conformance to NVMe specifications and interoperability with other NVMe products. While listing on any of the Integrators Lists does not guarantee conformance or interoperability it provides a reasonable degree of confidence that a tested product will work well in a multi-vendor environment.

2 - Location

The Integrators Lists will be hosted on the UNH-IOL website at www.iol.unh.edu. The exact URLs will be published by UNH-IOL. Each Integrators List will be linked to from nvmexpress.org. The lists will be maintained by UNH-IOL. Each Integrators List site will link back to nvmexpress.org.

3 - Definitions

NVMe Device - an NVMe SSD, SSD Controller, or SSD Controller IP, or any device which implements an NVMe interface.

NVMe-MI Device - an NVMe SSD, SSD Controller, or SSD Controller IP, or any device which implements an NVMe interface and which supports NVMe-MI.

NVMe-ZNS Device - an NVMe SSD, SSD Controller, or SSD Controller IP, or any device which implements an NVMe interface and which supports NVMe-ZNS.

NVMe-oF Target - an NVMe device accessed via a fabric transport. May also include software solutions.

NVMe Host Platform - Any combination of PCIe Host hardware (Motherboard or add-in card), NVMe Host Software (OS/Driver), and/or IP, that allows communication with an NVMe enabled SSD. Examples of an NVMe Host Platform are: server, server board, motherboard, add-in card, RAID Controller, or IP device.

NVMe-MI Host Platform - Any combination of PCIe Host hardware (Motherboard or add-in card), NVMe Host Software (OS/Driver), and/or IP, that allows communication with an NVMe-MI enabled SSD and supports NVMe-MI. Examples of an NVMe-MI Host Platform are: server, server board, motherboard, add-in card, RAID Controller, or IP device.

NVMe-ZNS Host Platform - Any combination of PCIe Host hardware (Motherboard or add-in card), NVMe Host Software (OS/Driver), and/or IP, that allows communication with an NVMe-ZNS enabled SSD and supports NVMe-ZNS. Examples of an NVMe-ZNS Host Platform are: server, server board, motherboard, add-in card, RAID Controller, or IP device.

NVMe-oF Host Platform - Any combination of Host Hardware (i.e. RoCE FC, or TCP interface), NVMe-oF Host Software (OS/Driver), and/or IP, that allows communication across a fabric to an NVMe-oF Target..

Product Under Test - The product being tested to determine eligibility for the Integrators Lists.

Interop Configuration – A combination of products that is tested with the Product Under Test according to the appropriate Interop Test Suite Document to determine the eligibility of the Product Under Test for an Integrators List. Interop Configurations are described in the Interop Test Suite document.

4 - Eligibility

The following table outlines what sorts of product types are eligible for each Integrators List. Additionally, the table shows what Test Suites contain tests that are applicable for product type, as well as what test reports are required for a product to qualify for a particular Integrators List.

In order for a product to be eligible for any Integrators List there must be a UNH-IOL Test Report for the product with no failing mandatory items. The Test Report must be completed according to the most recent version of the UNH-IOL NVMe Conformance Test Suite (CTS) Documents and UNH-IOL NVMe Interoperability Test Suite (ITS) Documents available publicly on the UNH-IOL website (https://www.iol.unh.edu/testing/storage/nvme/test-suites). Additionally, the company requesting that a product be listed on the Integrators List must be a member in good standing of the NVMe Organization.

Listing of any 'Additional Specifications Tested' beyond the NVMe Base Specification require that there are existing Mandatory tests in the associated test suite and that the DUT has passed all Mandatory tests.

Integrators List	Accepts Product Types	Applicable Test Suites	Required Test Reports
NVMe	NVMe/PCIe Host Platform	UNH-IOL NVMe Interop Test Suite	UNH-IOL NVMe Interop Test Report
	NVMe/PCIe Device	UNH-IOL NVM Command Set Conformance Test Suite UNH-IOL NVMe_PCIe Transport Conformance Test Suite UNH-IOL NVMe-MI Conformance Test Suite (if MI supported) UNH-IOL ZNS Command Set Conformance Test Suite (if ZNS supported)	UNH-IOL NVM Command Set Conformance Test Report UNH-IOL NVMe_PCIe Transport Conformance Test Report UNH-IOL NVMe-MI Conformance Test Suite (if MI supported) UNH-IOL ZNS Command Set Conformance Test Suite (if ZNS supported)
	NVMe/PCIe Switch	UNH-IOL NVMe-PCIe Interop Test Suite	UNH-IOL NVMe-PCIe Interop Test Report
NVMe-oF	NVMe/FC Target NVMe/RoCE Target NVMe/TCP Target NVMe/iWARP Target NVMe-oF Software Target (RoCE, FC, TCP, iWARP)	UNH-IOL NVMe_RDMA_TCP Interop Test Suite UNH-IOL NVM Command Set Conformance Test Suite ('OF' tests only) UNH-IOL NVM RDMA Transport Conformance Test Suite (if supported) UNH-IOL NVM TCP Transport Conformance Test Suite (if supported)	UNH-IOL NVMe_RDMA_TCP Interop Test Report UNH-IOL NVM Command Set Conformance Test Report UNH-IOL NVM RDMA Transport Conformance Test Report UNH-IOL NVM TCP Transport Conformance Test Report
	NVMe/FC Initiator NVMe/RoCE Initiator NVMe/TCP Initiator NVMe/iWARP Initiator	UNH-IOL NVMe_RDMA_TCP Interoperability Test Suite	UNH-IOL NVMe_RDMA_TCP Interoperability Test Report
	FC Switch Ethernet Switch	UNH-IOL NVMe_RDMA_TCP Interoperability Test Suite	UNH-IOL NVMe_RDMA_TCP Interoperability Test Report

The Interop and Conformance Test Suites define the interop and conformance test requirements, showing which items are 'Mandatory', 'FYI', or 'In Progress', as well as how many interop configurations a test must be performed with.

Tests that are marked as Mandatory must be performed and the product under test must pass that test, unless the test is Not Applicable. Each test procedure provides a means to determine if a given test is Not Applicable . If a Product Under Test does not support certain optional features, those items would be marked as 'Not Applicable' in the Conformance Test Report, would not be considered a failing item, and would not disqualify a device from the Integrators List. If a Product Under Test claims support for an optional feature, and that feature is included in the current CTS document test requirements, the Product Under Test must pass the test for that feature in order to be eligible for the Integrators List.

Some tests in the respective Interop and Conformance Test Suite may be defined as 'FYI' or 'In Progress' and are not considered necessary to qualify a Product Under Test for an Integrators List. Tests defined as FYI may become Mandatory in the future.

If a Product Under Test advertises support for an earlier revision of the specification but supports all mandatory requirements in a newer version of the NVMe specification, the product would still be eligible for listing under the newer version of the associated Integrators List. This may be the case if a new Integrator's List Program Revision introduced support for new optional features, but no new mandatory features.

When UNH-IOL issues reports for a product, they will include a notice on whether the Product Under Test is eligible for the associated Integrators List or not. In order to have an eligible product included on the Integrators List, the participating company must specifically request UNH-IOL to list the eligible products. Products will not be automatically listed. UNH-IOL will not list products that are not eligible. UNH-IOL will not list products that the participating company has not requested to have listed on the Integrators List.

A participating company could request conformance and interop testing according to the most recent version of the CTS and ITS, but not immediately request a product be posted to the IL, perhaps waiting for the product to be announced publicly. If the CTS or ITS changes after the product is tested, but before the request for listing occurs, the product would remain eligible for listing, but the listing would indicate which CTS and ITS version the test was performed to.

A participating company may request testing be performed on their product according to the previous version of the CTS or ITS (rather than the most recent version). If the testing is performed using the previous version of the CTS or ITS, within 6 months of the release date of the newest CTS or ITS, the product would be eligible for the Integrators List. If the testing is performed using the previous version of the CTS or ITS, more than 6 months after the release date of the newest CTS or ITS, the product would not be eligible for the Integrators List.

5 - Information in Listing

The following information must be provided with each listing request, this information will be included in the listing on the public Integrators Lists.

- Product, includes Manufacturer, Model Name and Family Name (i.e. different capacities of one SSD are in a single family)
- Product type (see table above for accepted Product Types for each Integrators List).
- Supported version of NVMe Base Specification. Only major specification versions will be listed (i.e. 1.3, 1.4, 2.0 etc..). Interim, or errata specification releases indicated with a letter (i.e. 1.3b, 1.4a etc…) will not be listed. This applies to all indications of specification support in the IL.
- Supported version of Additional Tested Specifications (if applicable, e.g. MI, ZNS). For MI listings, include the interface type used in testing.
- Supported version of NVMe-oF Specification (if applicable).
- SSD Form Factor (U.2, M.2, AIC, E1.L, etc…)
- Transport type and Generation or Data Rate.
- Operating System (Host Platforms Only)
- Driver (Host Platforms Only)

- Firmware revision (NVMe Devices Only)
- Interop Program Revision (i.e. 6.0, 7.0, 8.0 etc…)
- Date of listing
- Test ID
- Further Information (primary contact or website)

IL listing is considered permanent. If the CTS or ITS is revised, listings for previously tested products will remain on the public IL (i.e. listings for products tested against version 1.0, are not removed when version 1.1 becomes available).

6 - Listing by Similarity

It is expected that some products will have differences that do not affect NVMe operation, such as form factor, storage capacity, endurance parameters, or port count in the case of switches. In cases such as this, a participating company can request that certain products be added to a product listing, thus they are listed by similarity. The listing company confirms that the products are materially similar with no substantive changes to the NVMe interface or NVMe protocol support. A Listing by Similarity request form will need to be submitted to UNH-IOL.

7 - Appeals

While every effort is made to ensure that Integrators List testing is performed accurately, and that the test cases are based on the specification, it is possible that there will be cases of tests being performed improperly, implemented improperly, or being invalid. Sometimes this may result in a Failing test result, which hinders a product from being added to an Integrators List. This section defines appeals process whereby a company can appeal a failing result and obtain a waiver for a particular test result to allow the product to be listed.

This process is intended to be used when a test has been performed at the UNH-IOL, either during a plugfest or during scheduled testing, and the company whose product has been tested believes that the test was performed improperly, implemented improperly, or the test itself is invalid. If a test has not yet been performed on the product at UNH-IOL, its best to raise the issue with the NVMe Interop and Compliance committee (NVMe-ICC), and allow review of the test implementation, or if the test case itself is valid or not. This appeals process can be utilized for both 'FYI' and 'Mandatory' tests.

If a company wishes to file an appeal, the following information should be provided to UNH-IOL via nvmelab@iol.unh.edu:

- Company Name
- Company Representative
- Product Name
- Name of failing test being appealed
- Version of test software being used
- Complete test logs showing the test failure
- Brief written justification for the appeal, describing whether the company believes that the test was performed improperly, the test is implemented improperly, or the test case itself is invalid.

The following is a description of how different types of appeals will be dealt with:

Test Performed Improperly: If an appeal asserts that a test has been performed improperly, UNH-IOL will examine the appeal request and any test logs provided. If UNH-IOL agrees with the appealing company that the test was performed improperly, a new test report will be provided with the corrected test results. This may or may not require a retest. UNH-IOL will make every effort to perform this review in a timely fashion. The new test report will indicate "Passed Appeal #ABCD".

Test Implemented Improperly: If an appeal asserts that a test has been implemented improperly, UNH-IOL will raise the appeal for discussion on the next scheduled NVMe-ICC conference call. UNH-IOL will not identify the company raising the appeal. The NVMe-ICC will examine the test implementation to determine if the test is properly implemented or not. If the NVMe-ICC reaches consensus that the test is implemented correctly, no further

action is taken. If the NVMe-ICC reaches consensus that the test is not implemented correctly, the following steps will be taken:

- UNH-IOL and NVMe-ICC will work together to outline what is necessary to correct the test implementation. UNH-IOL will make every effort to perform these corrections in a timely fashion.
- UNH-IOL will provide a corrected test report with an indication that the previously failing test case is now considered "Passed Appeal #ABCD Granted" due to an appeal to the NVMe-ICC. The test case will thereafter not be considered necessary for integrators list qualification. The corrected test report will include a brief description of the appeal on either the cover page or Appendix.

Test Case Invalid: For all appeals of this sort, UNH-IOL will raise the appeal for discussion on the next scheduled NVMe-ICC conference call. UNH-IOL will not identify the company raising the appeal. The NVMe-ICC will examine the test case to determine if the test is valid or not. If the NVMe-ICC reaches consensus that the test is valid, no further action is taken. If the NVMe-ICC reaches consensus that the test is invalid, the following steps will be taken:

- UNH-IOL and NVMe-ICC will work together to determine if the test case should be corrected or removed.
- UNH-IOL will provide a corrected test report with an indication that the previously failing test case is now considered "Passed Appeal #ABCD Granted" due to an appeal to the NVMe-ICC. The test case will thereafter not be considered necessary for integrators list qualification. The corrected test report will include a brief description of the appeal on either the cover page or Appendix.

In all cases, if the appeal is successful, a new test report is issued, and any failure related to that appeal will no longer be considered as part of Integrators List qualification. If an appeal is denied, a new test report will be issued with the test case result as "Fail Appeal #ABCD Denied".

UNH-IOL will maintain a record of appeals, with pertinent information, and the decision of the ICC.

Escalation of Appeals: The following describes the expected order of escalation of appeals that may be followed.

1. Appeal to UNH-IOL for Retest
   a. If it is believed that the test was not run correctly, then UNH-IOL may re-run the test **as documented**, time permitting.
2. Written appeal to the ICC

   a. If an ICC result, test, documentation, or anything else is in question, then a written appeal can be submitted to the ICC for decision.
2. Written appeal to the NVMe Org Board of Directors.

   a. If an incompatible change breaks ICC testing (ex. ECN, TP, specification revision, etc.), then the ICC will submit a written request to the Board regarding guidance for waivers, deadlines, policy, etc. This may result in a 7-day online vote from the Board.
   b. If the written appeal to the ICC results in an unsatisfactory decision, then the customer may request the appeal to be submitted to the Board for final decision. This may result in a 7-day online vote from the Board.
   c. If the ICC requires clarification, then the ICC will submit a written request to the Board. This may result in a 7-day online vote from the Board.
   d. If the ICC recommends a waiver for a valid test, then the ICC will submit a written request to the Board. This may result in a 7-day online vote from the Board.

8 – Specification Versions, ECNs, TPs
- There are currently no plans to deprecate versions of the specifications.
- The following outlines compliance policy regarding ECNs and TPs that are backwards compatible.

- Behavior associated with ECNs and TPs that are backward compatible take effect as soon as they are ratified.
- Backward Compatible TPs and ECNs may be implemented in products that advertise any previous specification version as long as everything works as specified
  - It is the responsibility of the device manufacturer to ensure that the new behavior is fully implemented and that this behavior does not in any way conflict or break behaviors associated with the old spec revision (this may not be possible in all cases)
- The behavior of TPs or ECNs that are backward compatible are tested whenever a test exists and the feature, behavior, or command is discovered
  - Returning a non-zero value in a bit, byte, word, field or opcode that is reserved (i.e., set-aside for future standardization) is considered a compliance violation if:
    - A new behavior is defined in any spec revision and the behavior is not implemented as specified
    - The bit, byte, word, field or opcode is reserved in the latest ratified TPs, ECNs, or specification
  - Conformance tests may test reserved bits, bytes, words, fields or opcodes
- The following outlines compliance policy regarding ECNs and TPs that are not backwards compatible.
- Behavior associated with ECNs and TPs that are not backward compatible take effect at the next minor version of the specification.
- TPs that are not backward compatible shall not be implemented in previous specification revisions
- ECNs that are not backward compatible may be implemented in any previous specification revision that is applicable (e.g., implements other required TP features or has text relevant to a ECN)
  - Known incompatible changes are noted in the ECN. This makes the old behavior and/or any reasonable interpretation as well as the new behavior allowed in previous specification revisions.
- TPs and ECNs that are not backward compatible are tested in specification versions greater than or equal to that where it takes effect
- Policies regarding TPs, ECNs, and specification versions that are not backwards compatible will be decided by the Board via a written appeal to the NVMe Org Board of Directors.
- The "Specification" defines interactions at the NVMe interface. Common layers at the interface include protocol, transport, link, and phy. The host may have any combination of hardware, software, or firmware to initiate actions in a device using the NVMe interface. The device may have any combination of hardware, software, or firmware to respond to a host using the NVMe interface.