UNH–IOL
NVMe TCP Transport
Testing Service

Test Plan for NVMe TCP Transport Conformance
Version 23.0
Target Specification: NVM Express TCP Transport Specification version 1.1
Technical Document

Last Updated: January 23, 2025

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TABLE OF CONTENTS

MODIFICATION RECORD

2018 November 27 (Version 11.0) Initial Release
David Woolf:

2019 April 24 (Version 12.0) Final Release
David Woolf:

1. Updates to discussion in Test 2.1 per TP 2008.
2. Fixed typo in Test 2.1 Case 1 procedure, per TP 2008.
3. Added text to each test procedure to clarify the necessity that Testing Station and DUT are on the same fabric network, and that disconnect should be performed at the conclusion of each test.
4. Added new FYI Test 3.2 Case 2. Clarified procedure that a Set Feature command is needed to specify the KATO value.

2020 March 9 (Version 13.0) Final Release
David Woolf:

1. Tests 1.1.1, 1.2.1, 2.1.1, 3.1.1, and 3.2.1 status updated from (FYI) to (M).
2. Added Tests 4.1, 4.2, 4.3 and associated sub tests.

2020 July 21 (Version 14.0) Final Release
David Woolf:

1. Test case 2.3.1 added to address NVMe-oF v1.0 ECN 001 requirements that after the controller is enabled, it shall accept all supported Admin commands in addition to Fabrics commands
2. Test case 2.2.1 added to address NVMe-oF v1.0 ECN 002 requirements that host and controller association is preserved for at least 2 minutes after CC.EN transitions to '0'.
3. Test 2.4.1 added to address NVMe-oF v1.0 ECN 005 requirements around accepting commands on channels that are not yet authenticated/secure.
4. Test 1.3.4 added to address NVMe-oF v1.0 ECN 005 requirements around a Fabrics command that is not supported on an I/O Queue is sent on an I/O Queue, that command shall be aborted with a status code of Invalid Field in Command.
5. Test case 1.1.2 added to address NVMe-oF v1.0 ECN 005 requirements around Controller ID of FFFFh.
6. Test case 1.1.1 updated to clarify that the Contorller ID in the Connect Command in this test should be set to FFFFh. Observable results are unchanged.
7. Test cases 2.5.1 and 2.5.2 added to address NVMe-oF v1.0 ECN 005 requirements around shutdown and the CC.SHN field.
8. Test Case 1.5.1 added to address TP8001 requirements that If the controller detects an NVMe Transport connection loss, then the controller shall stop processing all commands received on I/O Queue associated with that NVMe Transport connection.
9. Test Case 1.4.4 added to address TP8001 requirements around the RECFMT field.
10. Test Case 1.4.2 added to address TP8001 requirements around the CATTR field and deletion of Individual I/O Queues.
11. Test case 1.4.3 added to to address TP8001 requirements that if a Disconnect command is submitted on an Admin Queue, then the controller shall abort the command with a status of Invalid Queue Type.
12. Test cases 1.4.1 added to address nominal operation of the Disconnect Command as well as addressing TP8001 requirements that the Completion Queue entry for the Disconnect command shall be the last entry submitted to the I/O Queue Completion queue by the controller (i.e., no completion queue entries shall be submitted to the I/O Queue Completion Queue after the Completion Queue entry for the Disconnect command). The controller shall not perform command processing for any command on an I/O queue after sending the Completion Queue entry for the Disconnect command.
13. Test case 1.1.3 added to address TP8001 requirements that a Discovery controller shall not support the Disconnect command.

14. Test Cases 1.1.4 added to address checking for AER and Keep Alive support when explicit persistent connections are supported to support TP 8002 requirements.
15. Test Cases 1.1.5 added to address the error condition when persistent connections are requests and the DUT does not support persistent connections.
16. Test case 1.3.5 added to address TP8005 for SQ Flow Control, including SQ Flow Control Negotiation, and proper behavior when SQ Flow Control is disabled.
17. Support for iWARP and transport should be added to the NVMe-oF Conformance Test Suite and these products should be made eligible for the NVMe-oF Integrators List.

2021 May 3 (Version 15.0) Final Release

David Woolf:

1. Test cases 1.3.2 and 3.2.1 status updated from (FYI) to (M).

2021 September 23 (Version 16.0) Final Release

David Woolf:

1. Test case 3.2.2 updated from FYI to M.
2. Added Test 2.6.1 per requirements in NVMe-oF V1.1 ECN 002 that SGL descriptors in a command capsule that if the SGL descriptors following the Submission Queue Entry have a total size greater than (ICDOFF * 16), then the controller shall abort the command with the status code set to Invalid Number of SGL Descriptors.
3. Added Test 2.6.2 per requirements in NVMe-oF V1.1 ECN 002 that that if the host places more SGL Data Block of Keyed SGL Data Block descriptors in a capsule than the maximum indicated in the Maximum SGL Data Block Descriptors field in the Identify Controller data structure, then the controller shall abort the command with the status code set to Invalid Number of SGL Descriptors.
4. Added Test 4.4.1 per NVMe-oF v1.1 TP 8011 to check that NVMe/TCP implementations that are compliant with v1.1 version of the NVMe/TCP specification and that support TLS shall support TLS 1.3.
5. Added Test 4.5.1 per requirements in NVMe-oF V1.1 ECN 002 that if PDU Header Digest is not enabled, then all subsequent PDUs shall not contain a HDGST field and shall have the HDGSTF flag cleared to ‘0’ in the PDU Header FLAGS field.
6. Added Test 4.5.2 per requirements in NVMe-oF V1.1 ECN 002 that if PDU Data Digest is not enabled, then the PDUs shall not contain a DDGST field and shall have the DDGSTF flag cleared to ‘0’ in the PDU Header FLAGS field.

2022 January 21 (Version 17.0) Initial Release

Tim Sheehan:

1. This is the first release of the TCP Transport Test Suite and is based on the UNH-IOL NVMe-oF Conformance Test Plan version 16.0.

2022 July 14 (Version 18.0) Final Release

Tim Sheehan:

1. Added Test cases 4.5.3 & 4 per requirements in ECN 102 2022.01.04

2023 January 04 (Version 19.0) Final Release

Tim Sheehan:

1. Added ‘Possible Problem’ in test case 2.3.1
2. New Tests added 1.2.3-6 per requirements in TP4110 Align PCIe and Fabrics HOSTID Management

2023 July 19 (Version 20.0) Final Release

Tim Sheehan:

1. Modified test case 1.2.5 for procedure step clarification
2. Modified Test 4.4.1 to removed version check
3. New Test 1.3.6 per requirements in TP4136 Should to Shall

2024 January 18 (Version 21.0) Final Release

Carter Snay:

1. Test plan number revision updated.

July 28, 2024 (Version 22.0)

Carter Snay:

New and Modified test cases

1. Added cases 6 and 7 to test 1.1 Connect to Discovery Service to address NVM Set ID requirements in the Connect command in TP8021

2025 January 23 (Version 23.0)

Carter Snay :

New and Modified test cases

1. Added test 1.2.7 to test the correct response on the Admin Submission Queue to test requirements in ECN120.
2. New test 1.1.8 to test requirements in TP8009 with automated discovery
3. New test groups 5 and 6 with tests that verify requirements in TP8009 and TP8010

ACKNOWLEDGMENTS

The UNH–IOL would like to acknowledge the efforts of the following individuals in the development of this test plan:

David Woolf	UNH InterOperability Laboratory
Tim Sheehan	UNH InterOperability Laboratory

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. This particular suite of tests has been developed to help implementers evaluate the NVMe\TCP functionality of their products. This test suite is aimed at validating products in support of the work being directed by the NVMe Promoters Group.

These tests are designed to determine if a product conforms to specifications defined in the NVM Express TCP Transport Specification version 1.0d, December 27, 2023 specification, hereafter referred to as the "NVMe TCP Specification". Successful completion of these tests provide a reasonable level of confidence that the Device Under Test (DUT) will function properly in many NVMe\TCP environments. Transport testing should also include those tests in the respective command set test plans with an over fabrics reference.

Products implementing the NVMe TCP specification use the TCP transport protocol. This transport may have distinct requirements described in a binding specification that is either within the NVMe TCP specification, or a separate document. The tests described in this Test Suite document are intended to check NVMe\TCP requirements. Therefore, requirements that are described within the binding specification do not have corresponding test items in this document.

The tests contained in this document are organized in order to simplify the identification of information related to a test, and to facilitate in the actual testing process. Tests are separated into groups, primarily in order to reduce setup time in the lab environment, however the different groups typically also tend to focus on specific aspects of device functionality. A two–number, dot–notated naming system is used to catalog the tests. This format allows for the addition of future tests in the appropriate groups without requiring the renumbering of the subsequent tests. The NVMe 2.0 refactoring effort has made it important to reference pre-2.0 test cases that have moved to a 2.0 refactored test plan. This numbering will be realized at the end of each test case with the legacy test case number noted.

The test definitions themselves are intended to provide a high–level description of the motivation, resources, procedures, and methodologies specific to each test. Formally, each test description contains the following sections:

Purpose
The purpose is a brief statement outlining what the test attempts to achieve. The test is written at the functional level.

References
This section specifies all reference material *external* to the test suite, including the specific references for the test in question, and any other references that might be helpful in understanding the test methodology and/or test results. External sources are always referenced by a bracketed number (e.g., [1]) when mentioned in the test description. Any other references in the test description that are not indicated in this manner refer to elements within the test suite document itself (e.g., "Appendix 5.A", or "Table 5.1.1–1").

Resource Requirements
The requirements section specifies the test hardware and/or software needed to perform the test. This is generally expressed in terms of minimum requirements, however in some cases specific equipment manufacturer/model information may be provided.

Last Modification
This specifies the date of the last modification to this test.

Discussion
The discussion covers the assumptions made in the design or implementation of the test, as well as known limitations. Other items specific to the test are covered here as well.

Test Setup

The setup section describes the initial configuration of the test environment. Small changes in the configuration should not be included here, and are generally covered in the test procedure section (next).

Procedure
The procedure section of the test description contains the systematic instructions for carrying out the test. It provides a cookbook approach to testing, and may be interspersed with observable results. These procedures should be the ideal test methodology, independent of specific tool limitations or restrictions.

Observable Results
This section lists the specific observable items that can be examined by the tester in order to verify that the DUT is operating properly. When multiple values for an observable are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail outcome for a particular test is generally based on the successful (or unsuccessful) detection of a specific observable.

Possible Problems
This section contains a description of known issues with the test procedure, which may affect test results in certain situations. It may also refer the reader to test suite appendices and/or other external sources that may provide more detail regarding these issues.

REFERENCES

The following documents are referenced in this text:

Old Ref : NVMe-oF version 1.1 Specification (October 22, 2019)

1. NVM Express TCP Transport Specification 1.0c October 3, 2022
2. NVM Express Base Specification 2.0c October 3, 2022
3. NVM Express Base Specification 2.1 August 5, 2024
4. NVM Express TCP Transport Specification 1.1 August 5, 2024

ABBREVIATIONS

The following abbreviations are applied to the test titles of each of the tests described in this document for indicating the status of test requirements.

M - Mandatory
FYI - FYI
IP - In Progress

The following legacy numbering is applied to the test titles of each of the tests to map the origin of the test if it is part of the 2.0 refactoring of legacy. If there is no change to the test case number then this field will be left off of the 2.0 refactored test case title.

FC – UNH-IOL NVMe-oF Conformance Test Plan version 16.0, September 23, 2021
Legacy numbering : (oFC:x.x)

Group 1: NVMe-oF Commands

Overview:

This section describes a method for performing conformance verification for NVMe/TCP products implementing NVMe-oF Commands defined in Chapter 6 of the NVMe Express Base Specification 2.0.

Notes:

The preliminary draft descriptions for the tests defined in this group are considered complete, and the tests are pending implementation (during which time additional revisions/modifications are likely to occur).

Test 1.1 – Connect to Discovery Service (M)

Purpose: To verify that an NVMe-oF Controller can properly execute a Connect command.

References:

Old Ref : NVMe-oF Specification 3.3, 4.2, 5
NVM Express Base Specification 2.0a : 6.3, 3.1.1, 2.2.3

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe\TCP transport.

Last Modification: July 28, 2024

Discussion: The host uses the well-known Discovery Service NQN (nqn.2014-08.org.nvmexpress.discovery) in the Connect command to a Discovery Service. The method that a host uses to obtain the NVMe Transport information necessary to connect to the well-known Discovery Service is implementation specific.

A Discovery Controller shall support the dynamic controller model.

The Controller ID of FFFFh shall be specified as the Controller ID in a Connect command for the Admin Queue. If the controller ID is not set to FFFFh, then a status value of Connect Invalid Parameters is returned.

A host requests an explicit persistent connection to a Discovery controller and Asynchronous Event Notifications from the Discovery controller on that persistent connection by specifying a non-zero Keep Alive Timer value in the Connect command. If the Connect command specifies a non-zero Keep Alive Timer value and the Discovery controller does not support Asynchronous Events, then the Discovery controller shall return a status value of Connect Invalid Parameters

Test Setup: See Appendix A.

Case 1: Connect to Discovery Controller (M)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery, and a Controller ID of FFFFh.
5. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Connect Response indicates status Success.

Case 2: Connect with wrong Controller ID (FYI)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery, and a Controller ID of FFFEh.
5. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Connect Response indicates status Connect Invalid Parameters.

Case 3: Disconnect Command sent to Discovery Controller (FYI)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery, and a Controller ID of FFFFh.
5. The Testing Station sends a Disconnect command to the Discovery Controller.

Observable Results:

1. Verify that the Disconnect command is aborted.

Case 4: Discovery Controller Supports Explicit Persistent Connections (FYI)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery, and a non-zero Keep Alive Timer Value to indicate that it is requesting a persistent connection.
5. The Testing Station performs a Keep Alive Command.
6. The Testing Station performs an Asynchronous Event Request Command.
7. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Connect Response indicates status Success if the DUT supports persistent connections.
2. Verify that the Keep Alive commands complete successfully.
3. Verify that the Asynchronous Event Commands complete successfully.

Case 5: Discovery Controller Does not Support Explicit Persistent Connections (FYI)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery, and a non-zero Keep Alive Timer Value to indicate that it is requesting a persistent connection.
5. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery, and a zero Keep Alive Timer Value to indicate that it is not requesting a persistent connection.
6. The Testing Station performs a Keep Alive Command.
7. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Connect Response indicates ‘Connect Invalid Parameters’ only if the DUT does not support persistent connections.
2. Verify that the Keep Alive Command does not complete successfully.

Possible Problems: None.

Case 6: Connect Command - NVMSETID Ignored For Admin Queue (FYI)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address or WWN of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. The Testing Station acting as a host will establish an association with the DUT by connecting to the controller's Admin Queue using the Fabrics Connect command. Within the Connect command, the host specifies the Host NQN, NVM Subsystem NQN, Host Identifier. The Host will also establish Admin and IO Submission and Completion queues.
5. Configure the NVMe Host to issue an Identify command to obtain the Identify Controller (CNS 01h) data structure to read bit 2 (NVM Sets) of the CTRATT field. If Bit 2 is not set to 1, then this test is not applicable.
6. Check Bit 8 (SQ Associations) of the CTRATT field of the Identify Controller Data Structure. If Bit 8 is not set to 1, then this test is not applicable.
7. Check Bit 1 of the FCATT field of the Identify Controller Data Structure. If Bit 1 is not set to 1, then this test is not applicable.
8. Perform an Identify NVM Set List command (CNS=04h) to retrieve a valid NVM Set Identifier value.
9. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.
10. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address 'nqn.2014-08.org.nvmexpress.discovery', a Controller ID of FFFFh, and NVM Set Identifier set to 0h.
11. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.
12. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address 'nqn.2014-08.org.nvmexpress.discovery', a Controller ID of FFFFh, and NVM Set Identifier set to the valid value discovered in step 8.
13. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.
14. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address 'nqn.2014-08.org.nvmexpress.discovery', a Controller ID of FFFFh, and NVM Set Identifier set to FFFFh.
15. Disconnect NVMe-oF controllers from the Testing Station acting as a Host

Observable Results:

1. Verify all Connect commands completed successfully.

Case 7: Connect Command - NVMSETID Not Defined (FYI)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address or WWN of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. The Testing Station acting as a host will establish an association with the DUT by connecting to the controller's Admin Queue using the Fabrics Connect command. Within the Connect command, the host specifies the Host NQN, NVM Subsystem NQN, Host Identifier. The Host will also establish Admin Submission and Completion queues.
5. Configure the NVMe Host to issue an Identify command to obtain the Identify Controller (CNS 01h) data structure to read bit 2 (NVM Sets) of the CTRATT field. If bit 2 is not set to 1, this test is not applicable.

6. Check Bit 8 (SQ Associations) of the CTRATT field of the Identify Controller Data Structure. If bit 8 is not set to 1, this test is not applicable.
7. Perform an Identify NVM Set List command (CNS=04h) to retrieve an NVM Set Identifier value that is not defined.
8. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery, Controller ID discovered in step 4 and an invalid NVM Set Identifier value determined in step 7.
9. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Connect command aborts with a status code of 'Invalid Field'.
2. Verify all other commands completed successfully

Case 8: Connect Command Unique and Well-known NQN (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h
3. Configure the testing station to issue a Connect command to the DUT with the NVM Subsystem NVMe Qualified Name (SUBNQN) field set to the well-known discovery service NQN (nqn.2014- 08.org.nvmexpress.discovery)
4. If the DUT reported a unique SUBNQN in the SUBNQN field of the Identify Controller data structure, the testing station should issue another Connect command with the SUBNQN field set to the unique NQN.

Observable Results:

1. Verify all Connect commands complete successfully

Test 1.2 – Connect to NVM Subsystem (M)

Purpose: To verify that an NVMe-oF Controller can properly execute a Connect command.

References:

Old Ref : NVMe-oF Specification 3.3
NVM Express Base Specification 2.0a : 6.3

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe/TCP transport.

Last Modification: November 27, 2018

Discussion: The Connect command is used to create a Submission and Completion Queue pair. If the Admin Queue is specified, then the Connect command establishes an association between a host and a controller.

Test Setup: See Appendix A.

Case 1: Connect to NVM Subsystem (M)

Test Procedure:

1. This test is not applicable to a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and can send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. The Testing Station has discovered the NVM Subsystem.
5. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT. The Connect command will have a Queue ID of 0 to establish Admin Submission and Completion Queues.
6. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Connect Response indicates status Success and provides the Controller ID allocated to the Host in DWord 0.

Case 2: Connect with Incompatible Format (FYI)

Test Procedure:

1. This test is not applicable to a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. The Testing Station has discovered the NVM Subsystem.
5. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT. The Connect command will have a Queue ID of 0 to establish Admin Submission and Completion Queues. The Record Format (RECFMT) will be a value of FEh, which is expected to be an unsupported value.
6. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the DUT responded to the received Connect Command with a status of ‘Connect Incompatible Format’.

Possible Problems: None.

Case 3: Connect with TREG(b3)=1h and HOSTID=0h (FYI)

Test Procedure:

1. Configure the NVMe Host to issue a Get Log Page to LID 70h, if bit 3 of TREQ is set to 0h this test is not applicable.
2. Configure the NVMe Host to issue a Connect command with Host Identifier value of 0h.

Observable Results:

1. Verify the NVMe host connects to the controller.

Case 4: Connect with TREG(b3)=0h and HOSTID=0h (FYI)

Test Procedure:

3. Configure the NVMe Host to issue a Get Log Page to LID 70h, if bit 3 of TREQ is set to 1h this test is not applicable.
4. Configure the NVMe Host to issue a Connect command with Host Identifier value of 0h.

Observable Results:

2. Verify the NVMe host Connect command fails.

Case 5: Connect with SRNZID=1h and HOSTID=0h (FYI)

Test Procedure:

1. Configure the NVMe Host to issue a Get Log Page to LID 70h, if bit 3 of TREQ is set to 0h this test is not applicable.
2. Configure the NVMe Host to issue a Connect command with Host Identifier equal to zero value.
3. Configure the NVMe Host to issue a Directive receive with Directive Operation 01h, if SRNZID is cleared to 0h this test is not applicable.
4. Configure the NVMe host to issue a valid Directive Send command.

Observable Results:

1. Verify the NVMe host connects to the controller.
2. Verify the Directive Send command in is aborted with status code of Host Identifier Not Initialized.

Case 6: Connect with RHII=1h and HOSTID=0h (FYI)

Test Procedure:

1. Configure the NVMe Host to issue a Get Log Page to LID 70h, if TREQ is set to 0h this test is not applicable.
2. Configure the NVMe Host to issue a Connect command with Host Identifier value of 0h.
3. Configure the NVMe Host to issue an Identify Controller command, if RHII is 0h then this test is not applicable.
4. Configure the NVMe host to issue a valid Reservation command.

Observable Results:

1. Verify the NVMe Host connects to the controller
2. Verify the Reservation command is aborted with status code of Host Identifier Not Initialized.

Case 7: Create Admin Submission Queue with Invalid Queue Size: FYI)

Test Procedure:

1. The Testing Station will transmit a Get Log Page command for the Discovery Log Page (LID=70h). Record the Admin Max SQ Size (ASQSZ).
2. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT with SQSIZE set to ASQSZ.
3. The Testing Station will send a Disconnect command on the I/O Queue, with RECFMT set to 0h.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT with SQSIZE set to ASQSZ + 1

Observable Results:

1. Verify that all commands excluding step 4 all complete with status “Success”.
2. Verify that the Connect command in step 4:
    a. Does not complete with status code of Success, or
    b. The Admin Submission Queue Size (ASQS) is set to ASQSZ.

Possible Problems:

There is no specific behavior defined in the specification yet on the expected error status that is supposed to be returned by the controller upon receiving a connect command with an invalid SQSIZE.

Test 1.3 – Property Get Command (FYI)

Purpose: To verify that an NVMe-oF Controller can properly execute a Property Get command.

References:

Old Ref : NVMe-oF Specification 3, 3.4, 3.5.1
NVM Express Base Specification 2.0a : 6.3, 6.4, 6.5

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe/TCP transport.

Last Modification: April 21, 2020

Discussion: The Property Get command is used to specify the property value to return to the host. If an invalid property or invalid offset is specified, then a status value of Invalid Field in Command shall be returned.
If a Fabrics command that is not supported on an I/O Queue is sent on an I/O Queue, that command shall be aborted with a status code of Invalid Field in Command.

Test Setup: See Appendix A.

Case 1: Get Supported Properties (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion queues.
4. Configure the Testing Station acting as a Host to send a Property Get command (FCTYPE=04h) with the proper offset value and size for each of the following properties:
    a. 00h-07h CAP
    b. 08h-0bh VS
    c. 14h-17h CC
    d. 1Ch-1Fh CSTS
5. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that each of the Property Get commands completed successfully and that the DUT returned values for each requested property.
2. Verify that CAP.DSTRD is set to 0h.
3. Verify that CAP.CQR is set to 1h.

Case 2: Get Property Invalid Offset (M)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion queues.
4. Configure the Testing Station acting as a Host to send a Property Get command (FCTYPE=04h) with the following offset value:
    a. 01h-07h CAP (an invalid offset that is not at the beginning of the property)
5. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Property Get commands completed with status “Invalid Field in Command”.

Case 3: Get Reserved Property (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion queues.
4. Configure the Testing Station acting as a Host to send a Property Get command (FCTYPE=04h) with the following offset value:
    a. 0Ch-0Fh INTMS
    b. 10h-13h INTMC
    c. 18h-1Bh Reserved
    d. 24h-27h AQA
    e. 28h-2Fh ASQ
    f. 30h-37h ACQ
    g. 38h-3Bh CMBLOC
    h. 3Ch-3Fh CMBSZ
    i. 40h-EFFh Reserved
    j. F00h-FFFh Reserved
    k. 1000h-12FFh Reserved
5. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Property Get commands completed with status “Success” and all values returned were 0h.

Case 4: Fabrics Commands on Wrong Queue (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and I/O Submission and Completion queues.
4. Configure the Testing Station acting as a Host to send each of the following Fabrics Commands on the I/O Queue:
    a. Property Set
    b. Property Get
5. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that each of the Fabrics Commands were aborted with status ‘Invalid Field in Command’.

Case 5: SQHD in Fabrics Commands when SQ Flow Control Disabled (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and I/O Submission and Completion queues. In the Connect command SQ Flow Control should be disabled.
4. Configure the Testing Station acting as a Host to send each of the following Fabrics Commands on the Admin Queue:
    a. Property Set

   b. Property Get
5. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:
1. Verify that each of the Fabrics Commands responses had the SQHD field set to 0.

Possible Problems: None known.

Case 6: Invalid Fabrics Command Type (FYI)

Test Procedure:
1. Establish an NVM connection and Admin and IO Submission and Completion queues.
2. Configure the NVMe host to issue a Fabrics command with an Invalid Fabrics Command Type

Observable Results:
1. Verify that the Fabrics command aborts with the status code of Invalid Field in Command.

Possible Problems: None known.

Test 1.4 – Disconnect Command (FYI)

Purpose: To verify that an NVMe-oF Controller can properly execute a Disconnect command.

References:
Old Ref : NVMe-oF Specification 3.3, 4.2, 5
NVM Express Base Specification 2.0 : 6.3, 3.1.1, 2.2.3

Resource Requirements:
Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport.

Last Modification: April 21, 2020

Discussion: If a Disconnect command is submitted on an Admin Queue, then the controller shall abort the command with a status of Invalid Queue Type.

The host indicates support for the deletion of an individual I/O Queue by setting bit 3 to '1' in the CATTR field in the Connect command used to create the Admin Queue. The controller indicates support for the deletion of an individual I/O Queue by setting bit 0 to '1' in the OFCS field in the Identify Controller Attributes region of the Identify Controller data structure.

If both the host and the controller support deletion of an individual I/O Queue, then the termination of an individual I/O Queue impacts only that I/O Queue (i.e., the association and all other I/O Queues and their associated NVMe Transport connections are not impacted). If either the host or the controller does not support deletion of an individual I/O Queue, then the deletion of an individual I/O Queue or the termination of an NVMe Transport connection causes the association to be terminated.

Test Setup: See Appendix A.

Case 1: Disconnect Submitted on I/O Queue (FYI)

Test Procedure:
1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. The Testing Station has discovered the NVM Subsystem.

4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT. The Connect command will have a Queue ID of 0 to establish Admin Submission and Completion Queues and I/O Submission and Completion Queues.
5. The Testing Station will send a Disconnect command on the I/O Queue, with RECFMT set to 0h.
6. The Testing Station will send a READ command on the I/O Queue.

Observable Results:
1. Verify that the Disconnect Command submitted on the I/O Queue completes successfully and the I/O Queue is deleted.
2. Verify that the READ command is not processed by the Controller.

Case 2: Disconnect Submitted on Individual I/O Queue (FYI)

Test Procedure:
1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. The Testing Station has discovered the NVM Subsystem.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT. The Connect command will have a Queue ID of 0 to establish Admin Submission and Completion Queues and at least 2 I/O Submission and Completion Queues. The Connect Command will also have CATTR Bit 3 set to 1 to indicate support for deletion of individual I/O Queues.
5. Check the Connect Response. If bit 0 in the OFCS field is set to 1, to indicate that the DUT supports deletion of individual queues, proceed to the next step. If Bit 0 in the OFCS field is set to 0, this test case is not applicable.
6. The Testing Station will send I/O operations on all I/O Queues.
7. The Testing Station will send a Disconnect command on a single I/O Queue.
8. The Testing Station will send I/O operations on the remaining I/O Queues.

Observable Results:
1. Verify that the Disconnect Command submitted on the I/O Queue completes successfully and the I/O Queue is deleted.
2. Verify that the I/O commands on the remaining I/O queues complete successfully.

Case 3: Disconnect Submitted on Admin Queue (FYI)

Test Procedure:
1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. The Testing Station has discovered the NVM Subsystem.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT. The Connect command will have a Queue ID of 0 to establish Admin Submission and Completion Queues.
5. The Testing Station will send a Disconnect command on the Admin Queue.
6. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:
1. Verify that the Disconnect Command submitted on the Admin Queue is aborted with status 85h ‘Invalid Queue Type’.

Case 4: Unsupported RECFMT (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. The Testing Station has discovered the NVM Subsystem.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT. The Connect command will have a Queue ID of 0 to establish Admin and I/O Submission and Completion Queues.
5. The Testing Station will send a Disconnect command on the I/O Queue with RECFMT set to FFh.
6. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Disconnect Command submitted on the Admin Queue is aborted with status 80h 'Incompatible Format'.

Possible Problems: None known.

Test 1.5 – Connection Loss (FYI)

Purpose: To verify that an NVMe-oF Controller properly handles connection loss events.

References:

Old Ref : NVMe-oF Specification 1.5.9
NVM Express Base Specification 2.0a : 3.1.1

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe/TCP transport.

Last Modification: April 21, 2020

Discussion: If the controller detects an NVMe Transport connection loss, then the controller shall stop processing all commands received on I/O Queue associated with that NVMe Transport connection. Until the controller detects an NVMe Transport connection loss or sends a successful completion for a Disconnect command, outstanding commands may continue being processed by the controller.

Test Setup: See Appendix A.

Case 1: Connection Loss (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. The Testing Station has discovered the NVM Subsystem.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT. The Connect command will have a Queue ID of 0 to establish Admin Submission and Completion Queues and I/O Submission and Completion Queues.
5. The Testing Station will send a WRITE command on the I/O Queue.
6. The Testing Station will cause a temporary Connection Loss event before a response to the WRITE command is generated.
7. The Testing Station will reconnect to the DUT and perform a READ operation to the same location as the WRITE operation was attempted to.

Observable Results:

1. Verify that the WRITE command is not processed by the Controller.

Possible Problems: Ensuring that connection loss events are caused in a uniform and timely way may vary between transports.

Group 2: Controller Architecture

Overview:

This section describes a method for performing conformance verification for the Controller Architecture of NVMe\TCP products defined in Chapter 3 of the NVM Express Base Specification 2.0.

Notes:

The preliminary draft descriptions for the tests defined in this group are considered complete, and the tests are pending implementation (during which time additional revisions/modifications are likely to occur).

Test 2.1 – Identify Controller Data Structure Enhancements (M)

Purpose: To verify that an NVMe Controller can properly populate Identify controller fields specific to NVMe over Fabrics.

References:

Old Ref : NVMe Specification 4.1
NVM Express Base Specification 2.0a : 5

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe\TCP transport interface.

Last Modification: April 2, 2019

Discussion: Identify Controller Data Structure has enhancements specific for NVMe-oF implementations.

Test Setup: See Appendix A.

Case 1: CNS=01h Identify Controller Data Structure (M)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion.
4. Configure the Testing Station acting as a Host to perform an Identify Controller Data Structure (CNS=01h).
5. In the Data Structure return, read the following values:
    a. Byte 1795:1792 I/O Queue Command Capsule Supported Size (IOCCSZ)
    b. Byte 1799:1796 I/O Queue Response Capsule Supported Size (IORCSZ)
    c. Byte 1801:1800 In Capsule Data Offset (ICDOFF)
    d. Byte 1802 Fabrics Controller Attributes (FCATT)
    e. Byte 1803 Maximum SGL Data Block Descriptors (MSDBD)
    f. Byte 2047:1804
6. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the IOCCSZ has a value of 4 or greater, corresponding to 64 bytes or greater.
2. Verify that the IORCSZ has a value of 1 or greater, corresponding to 16 bytes or greater.
3. Verify that the FCATT field has bits 7:1 set to 0, as they are reserved.
4. Verify that Bytes 2047:1804 are set to 0, as they are Reserved.

Possible Problems: None known.

Test 2.2 – Controller Association after Reset (FYI)

Purpose: To verify that host and controller association is preserved for at least 2 minutes after CC.EN transitions to '0'.

References:

Old Ref : NVMe-oF Specification 4.4, 4.5
NVM Express Base Specification 2.0 : 3.3.2.4, 5

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport interface.

Last Modification: April 21, 2020

Discussion: Host to Controller associations require an Admin Queue, which can only be deleted when an association is removed. Host to Controller associations are maintained for at least 2 minutes after a reset operation. To verify this in the following test, a Admin Queue, and therefore an association are established. Then a reset operation is performed. Within 2 minutes, the testing station attempts to use the previously established Admin Queue, and expects operations to that Admin Queue to be successful, since the Host to Controller association is maintained for at least 2 minutes after shutdown.

Test Setup: See Appendix A.

Case 1: CC.EN transitions to '0', then to '1' within 2 minutes due to reset (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. The Testing Station acting as a host will establish an association with the DUT by connecting to the controller's Admin Queue using the Fabrics Connect command. Within the Connect command, the host specifies the Host NQN, NVM Subsystem NQN, Host Identifier. The Host will also establish Admin and IO Submission and Completion queues.
4. The Testing Station will perform a READ operation using the established IO Submission and Completion queues and the same Host NQN and Host Identifier used in the connect command.
5. Configure the Testing Station acting as a Host to perform a Controller Level Reset.
6. The Testing Station will poll CC.EN until it is set to 0.
7. The Testing Station will poll CC.EN until it is set to 1. If this does not occur within 2 minutes this test is not applicable.
8. The Testing Station will poll CSTS.RDY until it is set to 1.
9. The Testing Station will perform a Connect Command to the same Controller using a different Host NQN and Host Identifier than what was used in the original Connect command.
10. The Testing Station will perform a Identify operation using the previously established Admin Submission and Completion queues and the same Host NQN and Host Identifier than what was used in the connect command.
11. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Connect Command after the reset operation failed with status 84h 'Connect Invalid Host'.
2. Verify that the Identify operation after the Controller Level Reset was successful, and that it was able to be performed on the original Admin Queue, without establishing a new Admin Queue.

Possible Problems: None known.

Test 2.3 – Admin Command Support (FYI)

Purpose: To verify that an NVMe-oF Controller can properly execute all supported Admin commands.

References:

Old Ref : NVMe-oF Specification 1.5.7, 4.3
NVM Express Base Specification 2.0a : 3.3.2.3, 5

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe\TCP transport.

Last Modification: April 21, 2020

Discussion: When an Admin Queue is first created, the associated controller is disabled (i.e., CC.EN is initialized to '0'). A disabled controller shall abort all commands other than Fabrics commands on the Admin Queue with a status of Command Sequence Error. After the controller is enabled, it shall accept all supported Admin commands in addition to Fabrics commands.

NVMe over Fabrics does not support the Admin commands associated with I/O Queue creation and deletion (Create I/O Completion Queue, Create I/O Submission Queue, Delete I/O Completion Queue, Delete I/O Submission Queue) defined in the NVMe Base specification.

Test Setup: See Appendix A.

Case 1: All Supported Commands (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion queues.
4. Configure the Testing Station acting as a Host to send each of the following Admin Commands:
    a. Get Log Page
    b. Identify
    c. Abort
    d. Set Feature
    e. Get Feature
    f. Device Self Test (Short)
    g. Device Self Test (Extended)
5. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that each of the Admin commands completed successfully.

Possible Problems: When setting the Host Identifier and it currently is non-zero value at the start of the test, the set feature will be aborted with a status of "Command Sequence Error" on some later 2.0 Base drives.

Test 2.4 – Authentication (FYI)

Purpose: Verify that a controller associated with an NVM subsystem that requires a fabric secure channel shall not accept any commands (i.e., Fabrics commands, Admin commands, or I/O commands) on an NVMe Transport until a secure channel is established.

References:

Old Ref : NVMe-oF Specification 1.5.8, 4.4
NVM Express Base Specification 2.0a : 2.2.5, 3.5.2

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe\TCP transport.

Last Modification: April 21, 2020

Discussion: A controller associated with an NVM subsystem that requires a fabric secure channel shall not accept any commands (i.e., Fabrics commands, Admin commands, or I/O commands) on an NVMe Transport until a secure channel is established.

Test Setup: See Appendix A.

Case 1: Secure Channel Required but Not Established (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT. The Connect command will have a Queue ID of 0 to establish Admin Submission and Completion Queues.
4. Check the AUTHREQ field in the Connect Command response. If AUTHREQ=0 this test is not applicable.
5. If AUTHREQ=1, configure the Testing Station acting as a Host to send each of the following Admin Commands before Authentication can be completed:
    a. Get Log Page
    b. Identify
    c. Abort
    d. Set Feature
    e. Get Feature
    f. Device Self Test (Short)
    g. Device Self Test (Extended)
6. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that none of the Admin commands completed successfully.

Possible Problems: None known.

Test 2.5 – Shutdown (FYI)

Purpose: Verify that a controller uses CC.SHN properly.

References:

Old Ref : NVMe-oF Specification 4.6
NVM Express Base Specification 2.0a : 3.6.2

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe\TCP transport.

Last Modification: April 21, 2020

Discussion: To initiate a shutdown of a controller, the host should use the Property Set command (refer to section 3.6) to set the Shutdown Notification (CC.SHN) field.

From the time a shutdown is initiated until:

- a Controller Level Reset occurs; or
- the controller, if dynamic, is removed from the NVM subsystem,

the controller shall:

- process only Fabrics commands; and
- disable the Keep Alive timer, if supported.

Test Setup: See Appendix A.

Case 1: Normal Shutdown (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion queues.
4. Configure the Testing Station acting as a Host to send a Property Set command to set CC.SHN to 01b, Normal Shutdown.
5. Send an Identify Command
6. Send a Property Get Command for any supported property.
7. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that each of the Property Get commands completed successfully.
2. Verify that the Identify command is not processed.
3. Verify that the Shutdown completes.

Case 2: Abrupt Shutdown (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion queues.
4. Configure the Testing Station acting as a Host to send a Property Set command to set CC.SHN to 10b, Abrupt Shutdown.
5. Send an Identify Command
6. Send a Property Get Command for any supported property.

7. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:
1. Verify that each of the Property Get commands completed successfully.
2. Verify that the Identify command is not processed.
3. Verify that the Shutdown completes successfully.

Possible Problems: None known.

Test 2.6 – SGLs within Command Capsule (FYI)

Purpose: To verify that an NVMe Controller can properly populate Identify controller fields specific to NVMe over Fabrics.

References:

Old Ref : NVMe Specification 4.1
NVM Express Base Specification 2.0a : 5.17

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe\TCP transport interface.

Last Modification: June 22, 2021

Discussion: Identify Controller Data Structure has enhancements specific for NVMe-oF implementations.

Test Setup: See Appendix A.

Case 1: ICDOFF is Non-Zero (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion.
4. Configure the Testing Station acting as a Host to perform an Identify Controller Data Structure (CNS=01h).
5. In the Data Structure return, read the following values:
    a. Byte 1801:1800 In Capsule Data Offset (ICDOFF)
6. If ICDOFF is set to 0 this test is not applicable.
7. The Testing Station should issue a command capsule with SGL descriptors such that the Submission Queue Entry has a size greater than ICDOFF * 16.

Observable Results:

1. Verify that the DUT aborted the command with status code set to Invalid Number of SGL Descriptors.

Case 2: SGL Data Block Exceeds MSDBD (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion.
4. Configure the Testing Station acting as a Host to perform an Identify Controller Data Structure (CNS=01h).
5. In the Data Structure return, read the following values:
    a. Byte 1803 Maximum SGL Data Block Descriptors (MSDBD)
6. The Testing Station should issue a command capsule with more SGL Data Block of Keyed SGL Data Block descriptors in a capsule than the maximum indicated in the MSDBD field in the Identify Controller data structure.

Observable Results:

1. Verify that the DUT aborted the command with status code set to Invalid Number of SGL Descriptors.

Possible Problems: None known.

Group 3: Discovery Service

Overview:

This section describes a method for performing conformance verification for NVMe\TCP products implementing the Discovery Service defined in Chapter 3 of the NVM Express Base Specification 2.0.

Notes:

The preliminary draft descriptions for the tests defined in this group are considered complete, and the tests are pending implementation (during which time additional revisions/modifications are likely to occur).

Test 3.1 – Initialize Discovery Controller (M)

Purpose: To verify that an NVMe Controller can properly initialize a Discovery Controller.

References:

Old Ref : NVMe Specification 4.1
NVM Express Base Specification 2.0a : 3.1

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe\TCP transport.

Last Modification: November 27, 2018

Discussion: The initialization process for the Discovery controller is described below:

1. NVMe in-band authentication is performed if required;
2. The host determines the controller's capabilities by reading the Controller Capabilities property;
3. The host configures the controller's settings by writing the Controller Configuration property, including setting CC.EN to '1' to enable command processing;
4. The host waits for the controller to indicate it is ready to process commands. The controller is ready to process commands when CSTS.RDY is set to '1' in the Controller Status property; and
5. The host determines the features and capabilities of the controller by issuing the Identify command, specifying the Controller data structure.
6. After initializing the Discovery controller, the host reads the Discovery Log Page.

Test Setup: See Appendix A.

Case 1: Initialize Discovery Controller (M)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery.
5. The Testing Station acting as a Host will use the Get Property Command to read the Controller Capabilities.
6. The Testing Station acting as a Host will use the Set Property Command to set CC.EN to 1.
7. The Testing Station acting as a Host will use the Get Property Command to read CSTS.RDY. Repeat until CSTS.RDY=1.
8. The Testing Station will transmit an Identify Controller Data Structure (CNS=01h).
9. The Testing Station will transmit a Get Log Page Command for the Discovery Log Page (LID=70h)
10. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Connect Response indicates status Success.
2. Verify that the Get Properties commands indicates status Success.
3. Verify that the Set Properties command indicates status Success.
4. Verify that the Identify command indicates status Success and the following fields are populated correctly:
    a. Firmware Revision (FR)
    b. Maximum Data Transfer Size (MDTS)
    c. Controller ID (CNTLID)
    d. Version (VER)
    e. Log Page Attributes (LPA)
    f. Error Log Page Attributes (ELPE)

   g. Maximum Outstanding Commands (MAXCMD)
   h. SGL Support (SGLS)
   i. NVM Subsystem NVMe Qualified Name (SUBNQN)
5. Verify that the DUT returns the Discovery Log Page and the following fields are populated correctly:
   a. Transport Type (TRTYPE) should reflect the transport being used.
   b. Address Family (ADRFAM) should reflect the address and transport being used.
   c. Admin Max SQ Size (ASQSZ) indicates a minimum of 32.
   d. Transport Service Identifier (TRSVCID) reflects the transport being used.
   e. Record Format (RECFMT) is 0h.

Possible Problems: None known.

Test 3.2 – Keep Alive Timeout (M)

Purpose: To verify that an NVMe Controller can properly process a Keep Alive Timeout.

References:

Old Ref : NVMe-oF Specification 7.1.2
NVM Express Base Specification 2.0a : 3.9

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe\TCP transport.

Last Modification: November 29, 2018

Discussion: The controller shall treat a Keep Alive Timeout in the same manner as connection loss. If the Keep Alive feature is in use and the timer expires, then the controller shall:

- stop processing commands and set the Controller Fatal Status (CSTS.CFS) bit to '1';
- terminate the NVMe Transport connection; and
- break the host to controller association.

After completing these steps, a controller may accept a Connect command for the Admin Queue from the same or another host in order to form a new association.

Test Setup: See Appendix A.

Case 1: Keep Alive Timeout (M)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller and a transport that requires the Keep Alive feature.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery and a Set Feature command to set the desired KATO value.
5. The Testing Station acting as a Host will use the Get Property Command to read the Controller Capabilities.
6. The Testing Station acting as a Host will use the Set Property Command to set CC.EN to 1.
7. The Testing Station acting as a Host will use the Get Property Command to read CSTS.RDY. Repeat until CSTS.RDY=1.
8. The Testing Station will transmit an Identify Controller Data Structure (CNS=01h).
9. The Testing Station will transmit a Get Log Page Command for the Discovery Log Page (LID=70h).
10. The Testing Station should send at least 3 Keep Alive Commands using the prescribed Keep Alive Timeout. After sending 3 Keep Alive commands, the testing station should cease sending Keep Alive commands. Allow the Keep Alive timer to timeout.
11. The Testing Station will use the Get Property Command to read the CSTS.CFS bit.
12. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery.
13. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that when the Keep Alive Timer times out the DUT sets CSTS.CFS to 1.
2. Verify that the final Connect command completes with status "Success".

Case 2: Traffic Based Keep Alive (M)

Test Procedure:

1. This test is only applicable to DUTs which implement a Discovery Controller and a transport that requires the Keep Alive feature.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
3. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
4. Check CTRATT Bit 6. If CTRATT Bit 6 is not set to 1, then the DUT does not support TBKAT and this test is not applicable.
5. Configure the Testing Station acting as a Host to issue a Connect command (FCTYPE=01h) to the DUT using well known address nqn.2014-08.org.nvmexpress.discovery and a Set Feature command to set the desired KATO value.
6. The Testing Station acting as a Host will use the Get Property Command to read the Controller Capabilities.
7. The Testing Station acting as a Host will use the Set Property Command to set CC.EN to 1.
8. The Testing Station acting as a Host will use the Get Property Command to read CSTS.RDY. Repeat until CSTS.RDY=1.
9. The Testing Station will transmit an Identify Controller Data Structure (CNS=01h).
10. The Testing Station will transmit a Get Log Page Command for the Discovery Log Page (LID=70h).
11. The Testing Station should send at least 3 Keep Alive Commands using the prescribed Keep Alive Timeout.
12. After sending 3 Keep Alive commands, the testing station should cease sending Keep Alive command but continue performing READ commands separated by no more than the current KATO value. At least one KATO should expire with no Keep Alive Command being sent, but instead READ commands should be sent.
13. After sending 3 at least 3 READ commands, the testing station should cease sending READ commands but continue performing Identify commands separated by no more than the current KATO value. At least one KATO should expire with no Keep Alive or READ Commands being sent, but instead Identify commands should be sent.
14. The Testing Station will use the Get Property Command to read the CSTS.CFS bit.
15. Disconnect NVMe-oF controllers from the Testing Station acting as a Host.

Observable Results:

1. Verify that the Keep Alive Timer does not expire, and CSTS.CFS (Controller Fatal Status) is not set to 0 during the test execution.
2. Verify that the Keep Alive, READ, and Identify commands all complete with status “Success”.

Possible Problems: None known.

Group 4: NVMe/TCP Binding

Overview:

This section describes a method for performing conformance verification for NVM\TCP products implementing the NVMe/TCP, and is only applicable to those products, defined in Chapter 3 of the NVM Express TCP Transport Specification 1.0a.

Notes:

The preliminary draft descriptions for the tests defined in this group are considered complete, and the tests are pending implementation (during which time additional revisions/modifications are likely to occur).

Test 4.1 – ICReq Errors (FYI)

Purpose: To verify that an NVMe Controller can properly handle errored ICReq PDUs.

References:

Old Ref : NVMe-oF Specification
NVM Express TCP Transport Specification 1.0a : 3

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport.

Last Modification: December 1, 2019

Discussion: An NVMe/TCP target should properly handle ICReq errors. This test is only applicable to products implementing the NVMe/TCP transport.

Test Setup: See Appendix A.

Case 1: Illegal Header in ICReq (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem
3. Send ICReq PDU to the NVMe-oF NVM Subsystem with illegal Header
4. After response is received, close all open TCP connections.

Observable Results:

1. Verify that the DUT sends C2HTerm in response with error status of invalid PDU Header.

Case 2: PFV=1 (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem
3. Send ICReq PDU with PFV=1 to the NVMe-oF NVM Subsystem.
4. After response is received, close all open TCP connections.

Observable Results:

1. Verify that the DUT sends C2HTerm in response with error status of invalid PDU Header.

Case 3: Incorrect Initial PDU (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem
3. Send a TCP PDU which is not an ICReq PDU to the NVMe-oF NVM Subsystem.
4. After response is received, close all open TCP connections.

Observable Results:

1. Verify that the DUT sends C2HTerm in response with error status of Sequence Error.

Case 4: Duplicate ICReq (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem
3. Send valid ICReq to the NVMe-oF NVM Subsystem with legal Header.
4. Send valid ICReq to the NVMe-oF NVM Subsystem with legal Header, identical to the ICReq sent in the previous step.
5. After response is received, close all open TCP connections.

Observable Results:
1. Verify that the first ICReq PDU completes successfully.
2. Verify that for the second ICReq, DUT sends C2HTerm in response with error status of Sequence Error.

Possible Problems: None known.

Test 4.2 – NVMe Connection Errors (FYI)

Purpose: To verify that an NVMe Controller can properly handle errored NVMe Connection Requests.

References:

Old Ref : NVMe-oF Specification
NVM Express TCP Transport Specification 1.0a : 3

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport.

Last Modification: December 1, 2019

Discussion: An NVMe/TCP target should properly handle connection request errors. This test is only applicable to products implementing the NVMe/TCP transport.

Test Setup: See Appendix A.

Case 1: Incorrect Subsystem NQN (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem, with an incorrect Subsystem NQN.

Observable Results:

1. Verify that the NVMe Connect does not complete successfully.

Case 2: Incorrect Host NQN (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem, with an incorrect Host NQN.

Observable Results:

1. Verify that the NVMe Connect does not complete successfully.

Case 3: Incorrect CTRL ID (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem, with an incorrect CTRL ID.

Observable Results:

1. Verify that the NVMe Connect does not complete successfully.

Case 4: Incorrect RecFMT (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.

2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem, with an incorrect RecFMT.

Observable Results:
1. Verify that the NVMe Connect does not complete successfully.

Case 5: Out of Range Queue ID (FYI)

Test Procedure:
1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem, with an out of range Queue ID.

Observable Results:
1. Verify that the NVMe Connect does not complete successfully.

Possible Problems: None known.

Test 4.3 – Queue Depth Exceeded (FYI)

Purpose: To verify that an NVMe Controller can properly handle Queue Depth errors.

References:

Old Ref : NVMe-oF Specification
NVM Express TCP Transport Specification 1.0a : 3

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport.This test is only applicable to products implementing the NVMe/TCP transport.

Last Modification: December 1, 2019

Discussion: An NVMe/TCP target should properly handle Queue Depth errors.

Test Setup: See Appendix A.

Case 1: IO Queue Depth Exceeded (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem
3. Send valid ICReq to the NVMe-oF NVM Subsystem with legal Header.
4. Establish Admin Completion and Submission queues.
5. Establish IO Completion and Submission queues.
6. Send n valid READ commands to a single queue in the NVMe-oF NVM Subsystem, where n is greater than the maximum queue depth supported by the DUT. (i.e. if Max Queue Depth is 128, send 256 READ commands).
7. After response is received, close all open TCP connections.

Observable Results:

1. Verify that the first ICReq PDU completes successfully.
2. Verify that the connection remains open.

Case 2: Queue Depth Exceeded (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem
3. Send 256 identical ICReq commands to the NVMe-oF NVM Subsystem.
4. After response is received, close all open TCP connections.

Observable Results:

1. Verify that the connection remains open.

Possible Problems: None known.

Test 4.4 – TLS Support (FYI)

Purpose: To verify that an NVMe Controller supports the proper version of TLS if supported.

References:

Old Ref : NVMe-oF Specification
NVM Express TCP Transport Specification 1.0a : 3

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport. This test is only applicable to products implementing the NVMe/TCP transport.

Last Modification: June 22, 2021

Discussion: An NVMe/TCP target should properly handle Queue Depth errors.

Test Setup: See Appendix A.

Case 1: TLS Supported (FYI)

Test Procedure:

1. Check the VS field of the Discovery Controller properties.
2. Configure the Testing Station to read the Discovery Log Page of the DUT.

Observable Results:

1. Verify that the Discovery Log Page returned indicates a TSAS SECTYPE of either 00 (TLS not supported) or 03 (TLS v1.3 supported).

Possible Problems: None known.

Test 4.5 – Digest Support (FYI)

Purpose: To verify that an NVMe Controller can properly enable and disable Digests.

References:

Old Ref : NVMe-oF Specification 7.4.6
NVM Express TCP Transport Specification 1.0a : 3.3.1.1

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport interface.

Last Modification: June 22, 2021

Discussion: Identify Controller Data Structure has enhancements specific for NVMe-oF implementations.

Test Setup: See Appendix A.

Case 1: PDU Header Digests Not Enabled (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion queues. Configure the Testing Station to issue an ICReq PDU with HDGST_ENABLE set to 0 so that Header Digests are not used on the connection.
4. Configure the Testing Station acting as a Host to perform Write and Read operations to the DUT.

Observable Results:

1. Verify that all subsequent PDUs from the DUT did not contain a HDGST field and had the HDGSTF flag cleared to ‘0’ in the PDU Header FLAGS field.

Case 2: PDU Data Digests Not Enabled (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station knows the network address of the DUT and is able to send packets to the DUT.
2. All NVMe-oF NVM Subsystems are disconnected from the Testing Station acting as a Host.
3. Establish an NVM connection and Admin and IO Submission and Completion queues. Configure the Testing Station to issue an ICReq PDU with DDGST_ENABLE set to 0 so that Data Digests are not used on the connection.
4. Configure the Testing Station acting as a Host to perform Write and Read operations to the DUT.

Observable Results:

1. Verify that all subsequent PDUs from the DUT did not contain a DDGST field and had the DDGSTF flag cleared to ‘0’ in the PDU Header FLAGS field.

Case 3: PDU Header Digests Enabled (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem.
3. Send ICReq PDU to the NVMe-oF NVM Subsystem with HDGST_ENABLE set to 1. If ICResp PDU clears the HDGST_ENABLE flag to 0 this test is not applicable.

4. Configure the Testing Station acting as a Host to perform Write and Read operations to the DUT.

Observable Results:

1. Verify that after Step 3 all subsequent PDUs from the DUT contain a valid HDGST field and had the HDGSTF flag if defined set to '1' in the PDU Header FLAGS field. (H2CTermReq and C2HTermReq PDUs are except)

Case 4: PDU Data Digests Enabled (FYI)

Test Procedure:

1. Establish a TCP Connection between the Host and NVMe-oF NVM Subsystem.
2. Perform an NVMe Connect command to connect the Host and NVMe-oF NVM Subsystem.
3. Send ICReq PDU to the NVMe-oF NVM Subsystem with DDGST_ENABLE set to 1. If ICResp PDU clears the DDGST_ENABLE flag to 0 this test is not applicable.
4. Configure the Testing Station acting as a Host to perform Write and Read operations to the DUT.

Observable Results:

1. Verify that after Step 3 all subsequent Command Capsule PDUs containing in-capsule data, H2CData PDUs and C2HData PDUs from the DUT contain a valid DDGST field and had the DDGSTF flag if defined set to '1' in the PDU Header FLAGS field.

Possible Problems: None known.

Group 5: Centralized Discovery Controller

Overview:

This section describes a method for performing conformance verification for NVM\TCP centralized discovery controllers (CDC), and is only applicable to those products, defined in Section 8 3 of the NVM Express Base Specification 2.1 and behavior defined in NVM Express TCP Transport Specification, Revision 1.1.

Notes:

The preliminary draft descriptions for the tests defined in this group are considered complete, and the tests are pending implementation (during which time additional revisions/modifications are likely to occur).

Test 5.1 Centralized Discovery Commands (FYI)

Purpose: To verify that an NVMe Controller can properly execute a Get Log Page command on a centralized discover controller.

References:

NVM Express Base specification 2.1 : 8.3.2

Resource Requirements:

Tools capable of monitoring and decoding traffic on the NVMe interface**.**

Last Modification: January 23, 2025

Case 1: Get Log Page - NUMEXAT is a Non-Zero Value in Host Extended Discovery Log Page (FYI)

Test Procedure:

1. This test is only applicable to Discovery Controllers.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
3. Configure the Testing Station to issue a Get Log Page for the Supported Log Pages Log Page (LID = 00h)
4. Verify that the LID Specific Parameter (LIDSP) field for Log Page Identifier Supported 113 (71h) has bit 0 set to 1 (LID Supported (LSUPP)). If the LSUPP bit is not set to 1 for LID 71h, this test is not applicable.
5. Configure the Testing Station to issue a Get Log Page command for the Host Discovery Log Page (LID = 71h).

Observable Results:

1. Verify that the Number of Extended Attributes (NUMEXAT) field of the Host Extended Discovery Log Page is greater than 0.
2. Verify that the Host Extended Discovery Log Page Entry contains at least one extended attribute containing a Host Identifier

Case 2: Get Log Page - EXATLEN is a multiple of 4 (FYI)

Test Procedure:

1. This test is only applicable to Discovery Controllers.
2. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
3. Configure the Testing Station to issue a Get Log Page for the Supported Log Pages Log Page (LID = 00h).
4. Verify that the LID Specific Parameter (LIDSP) field for Log Page Identifier Supported 112 (70h) has bit 0 set to 1 (Extended Discovery Log Page Entry Supported (EXTDLPES)). If the EXTDLPES bit is not set to 1, this test is not applicable.
5. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h) with bit 8 of the Log Specific Parameter Field (Extended Discovery Log Page Entries) set to 1.
6. Verify that the Log Page that is returned contains at least one Extended Discovery Log Page Entry by checking the Extended (EXTEND) bit in the Discovery Log Page Flags (DLPF) field of the Discovery Log Page. If the log page returned does not contain an Extended Discovery Log Page Entry, this test is not applicable.
7. Record the Extended Discovery Log Page, and for at least one extended attribute within the Extended Discovery Log Page Entry, modify the Extended Attribute Length (EXATLEN) field in the recorded data structure to a number that is not a multiple of 4
8. Configure the Testing Station to issue a Discovery Information Management Command to the DUT, with the TAS field cleared to 0h, and using the Extended Discovery Log Page that was saved and altered in step 7 in the Discovery Information Entry 0 (DIE0) field.

Observable Results:

1. Verify that the Discovery Information Management Command aborts with status “Invalid Field in Command”.

Case 3: Get Log Page - NCC bit = 0b - Not Extended (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h.
3. Verify the Discovery Controller Type (DCTYPE) field is set to a value of 1h, otherwise this test is not applicable.
4. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h) to a Discovery Controller that is not a CDC.

Observable Results:

1. Verify that any Discovery Log Page Entry that describes a Discovery Controller that is not a CDC has the No CDC (NCC) bit set to 0b in the Entry Flags (EFLAGS) field.

Case 4: Get Log Page - NCC bit = 0b - Extended (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h.
3. Verify the Discovery Controller Type (DCTYPE) field is set to a value of 1h, otherwise this test is not applicable.
4. Configure the Testing Station to issue a Get Log Page for the Supported Log Pages Log Page (LID = 00h)
5. Verify that the LID Specific Parameter (LIDSP) field for Log Page Identifier Supported 112 (70h) has bit 0 set to 1 (Extended Discovery Log Page Entry Supported (EXTDLPES)). If the EXTDLPES bit is not set to 1, this test is not applicable.
6. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h) with bit 8 of the Log Specific Parameter Field (Extended Discovery Log Page Entries) set to 1 to a Discovery Controller that is not a CDC.
7. Verify that the Log Page that is returned contains at least one Extended Discovery Log Page Entry by checking that byte 1028 of the Discovery Log Page Entry (Number of Extended Attributes (NUMEXAT)), is a non-zero value. If the log page returned does not contain an Extended Discovery Log Page Entry, this test is not applicable.

Observable Results:

1. Verify that any Discovery Log Page Entry that describes a Discovery Controller that does not implement a CDC has the No CDC (NCC) bit set to 0b in the Entry Flags (EFLAGS) field.

Case 5: Get Log Page - EXTDLPES bit = 1b - CDC (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h.
3. Verify the Discovery Controller Type (DCTYPE) field is set to a value of 2h, otherwise this test is not applicable.
4. Configure the Testing Station to issue a Get Log Page command with LID=00h for Supported Log Pages

Observable Results:

1. Verify the Extended Discovery Log Page Entry Supported (EXTDLPES) bit is set to 1 in the LID Specific Parameter field in the LID Supported and Effects Data Structure for LID=70h.

Case 6: Get Log Page - EXTDLPES bit = 0b - DDC (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h.
3. Verify the Discovery Controller Type (DCTYPE) field is set to a value of 1h, otherwise this test is not applicable.
4. Configure the Testing Station to issue a Get Log Page command with LID=00h for Supported Log Pages
5. If the Extended Discovery Log Page Entry Supported (EXTDLPES) bit is set to 1 then this test is not applicable.
6. Issue a Get Log Page command with LID=70h and the Extended Discovery Log Page Entries (EXTDLPE) field set to 0.

Observable Results:

1. Verify the returned Discovery Log Page only returns Basic Discovery Log Page Entries.

Case 7: Get Log Page - PLEO = 0b and ALLSUBE = 1b (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h.
3. Verify the Discovery Controller Type (DCTYPE) field is set to a value of 1h, otherwise this test is not applicable.
4. Configure the Testing Station to issue a Get Log Page for the Supported Log Pages Log Page (LID = 00h)
5. Verify that the LID Specific Parameter (LIDSP) field for Log Page Identifier Supported 112 (70h) has bit 2 set to 1 (All NVM Subsystem Entries Supported (ALLSUBES)). If the ALLSUBES bit is not set to 1, this test is not applicable.
6. Configure the Testing Station to issue a Get Log Page with LID=70h, All NVM Subsystem Entries bit (ALLSUBE) set to 1, and Port Local Entries Only (PLEO) set to 0.

Observable Results:

1. Verify that in the Log Page, all registered NVM subsystem ports shall be returned without filtering.

Case 8: Get Log Page - PLEO = 1b (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h.
3. Verify the Discovery Controller Type (DCTYPE) field is set to a value of 1h, otherwise this test is not applicable.
4. Configure the Testing Station to issue a Get Log Page for the Supported Log Pages Log Page (LID = 00h)
5. Verify that the LID Specific Parameter (LIDSP) field for Log Page Identifier Supported 112 (70h) has bit 1 set to 1 (Port Local Entries Only Supported (PLEOS)). If the PLEOS bit is not set to 1, this test is not applicable.
6. Configure the Testing Station to issue a Get Log Page with LID=70h, and Port Local Entries Only bit set to 1

Observable Results:

1. Verify that in the Log Page, the Discovery controller returns records for only NVM subsystem ports that are presented through the same NVM subsystem port that received the Get Log Page command

Case 9: Get Log Page - Explicit Persistent Connection Support (EPCSD) (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h)
3. Issue a Connect command for each Entry in the returned Discovery Log Page with a non-zero value in the Keep Alive Timer value

Observable Results:

1. For Discovery Controllers with the EPCSD bit set to 1, verify the Connect command completes successfully
2. For Discovery Controllers with the EPCSD bit set to 0, verify the Connect returns a status of Connect Invalid Parameters
3. Verify for Entries with the Subtype field set to 2h, the EPCSD bit is cleared to 0

Case 10: Get Log Page - Duplicate Returned Information (DUPRETINFO) (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h)

Observable Results:

1. Verify Discovery Log Page Entries with the Subtype field set to a value other than 3h have the Duplicate Returned Information bit cleared to 0

Case 11: Get Log Page - Total Discovery Log Page Length (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h) with the Extended Discovery Log Page Entry (EXTDLPE) bit cleared to 0

Observable Results:

1. Verify the Total Discovery Log Page Length (TDLPL) field is cleared to 0
2. Verify the byte position of the Nth Discovery Log Page Entry follows the format: (((N + 2) * 1024) - 1):((N + 1) * 1024)

Case 12: Get Log Page - Host Discovery Log Page All Hosts (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command with LID=00h for Supported Log Pages
3. Verify that the LID Specific Parameter (LIDSP) field for Log Page Identifier Supported 113 (71h) has bit 0 set to 1 (LID Supported (LSUPP)). If the LSUPP bit is not set to 1 for LID 71h, this test is not applicable.
4. Verify that the LID Specific Parameter (LIDSP) field for Host Discovery Log Page (71h) has bit 0 set to 1 (All Host Entries Supported (ALLHOSTES)). If the ALLHOSTES bit is not set to 1, this test is not applicable.
5. Configure the Testing Station to issue a Get Log Page command with LID=71h for the Host Discovery Log Page with the All Host Entries (ALLHOSTE) bit set to 1 in the Log Specific Parameter Field

Observable Results:

1. Verify the Host Discovery Log Page returned has bit 0 (All Hosts) of the Host Discovery Log Page Flags (HDLPF) field set to 1
2. Verify the returned Discovery Log Page has entries for all hosts that are registered

Case 13: Get Log Page - Log Page Index Offset (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command with LID=00h for the Supported Log Pages log page.
3. Verify the LID Supported and Effects Data Structure for LID=70h has the Index Offset Supported (IOS) bit set to 1, if this bit is cleared to 0 this test is not applicable
4. Configure the Testing Station to issue a Get Log Page command with LID=70h for Discovery with the Offset Type (OT) bit in Command Dword 14 set to 1, the Log Page Offset Lower cleared to 0 in Command Dword 12, and the Log Page Offset Upper cleared to 0 in Command Dword 13.
5. Configure the Testing Station to issue a Get Log Page command with LID=70h for Discovery with the Offset Type (OT) bit in Command Dword 14 set to 1, and the Log Page Offset Lower set to 1

Observable Results:

1. Verify the first Get Log Page command for Discovery only returns the Discovery Log Page Header
2. Verify the second Get Log Page command for Discovery only returns Discovery Log Entries and not the header
3. Verify the Number of Records (NUMREC) field in the Discovery Log Page returned in the first Get Log command matches the number of entries returned in the second Get Log Page command

Case 14: Get Log Page - Host Discovery Generation Counter Multiple Get Log Commands (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command with LID=00h for the Supported Log Pages log page.
3. Verify that the LID Specific Parameter (LIDSP) field for Log Page Identifier Supported 113 (71h) has bit 0 set to 1 (LID Supported (LSUPP)). If the LSUPP bit is not set to 1 for LID 71h, this test is not applicable.
4. Verify the LID Supported and Effects Data Structure for LID=71h has the Index Offset Supported bit set to 1, if this bit is cleared to 0 this test is not applicable
5. Configure the Testing Station to issue a Get Log Page command with LID=71h for Host Discovery with the Offset Type (OT) bit in Command Dword 14 set to 1, the Log Page Offset Lower cleared to 0 in Command Dword 12, and the Log Page Offset Upper cleared to 0 in Command Dword 13.
6. Configure the Testing Station to issue a Get Log Page command with LID=71h for Discovery with the Offset Type (OT) bit in Command Dword 14 set to 1, and the Log Page Offset Lower set to 1
7. Configure the Testing Station to issue a Get Log Page command with LID=71h for Host Discovery.

Observable Results:

1. Verify the value in the Generation Counter (GENCTR) field in the Host Discovery Log Page does not change between the value read in the first and last Host Discovery Log Page commands.

Case 15: Get Log Page - Host Discovery Asynchronous Event Notification (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.

2. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h), if the Explicit Persistent Connection Support for Discovery (EPCSD) bit is cleared to 0 then this test is not applicable.
3. Configure the Testing Station to issue a Set Features Command with the Host Discovery Log Page Change Notification (HDLPCN) bit set to 1 to the Discovery Controller.
4. In the connect command sent to the Discovery Controller, ensure that the Keep Alive Timer value is set to a non-zero value.
5. Configure the Testing Station to issue an Asynchronous Event Request command.
6. Configure the host to issue a Discovery Information Management command with modified Discovery Information Entries to the Discovery Controller to update the Host Discovery Log Page.

Observable Results:

1. Verify that the completion queue entry for the Asynchronous Event Request command is properly formatted with the Log Page Identifier (LID) field set to 71h, the Asynchronous Event Information (AEI) field set to F1h, and the Asynchronous Event Type (AET) field set to 010b.

Case 16: Get Log Page - Discovery Asynchronous Event Notification (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h), if the Explicit Persistent Connection Support for Discovery (EPCSD) bit is cleared to 0 then this test is not applicable.
3. Configure the Testing Station to issue a Set Features Command with the Discovery Log Page Change Notification (DLPCN) bit set to 1 to the Discovery Controller.
4. In the connect command sent to the Discovery Controller, ensure that the Keep Alive Timer value is set to a non-zero value.
5. Configure the Testing Station to issue an Asynchronous Event Request command.
6. Configure the host to issue a Discovery Information Management command with modified Discovery Information Entries to the Discovery Controller to update the Discovery Log Page.

Observable Results:

1. Verify that the completion queue entry for the Asynchronous Event Request command is properly formatted with the Log Page Identifier (LID) field set to 70h, the Asynchronous Event Information (AEI) field set to F0h, and the Asynchronous Event Type (AET) field set to 010b.

Group 6: Automated Discovery of NVMe-oF Discovery

Overview:

This section describes a method for performing conformance verification for NVM\TCP automated discovery of NVMe-oF Discovery Controllers and is only applicable to those products, defined in Section 8 3 of the NVM Express Base Specification 2.1.

Notes:

The preliminary draft descriptions for the tests defined in this group are considered complete, and the tests are pending implementation (during which time additional revisions/modifications are likely to occur).

Test 6.1 – Automated Discovery (FYI)

Purpose: To verify that an NVMe Discovery Controller can properly automatically discover subsystems using mDNS.

References:

NVM Express Base Specification 2.1: 8.3.1

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport interface.

Last Modification: January 23, 2025

Discussion: Identify Controller Data Structure has enhancements specific for NVMe-oF implementations.

Test Setup: See Appendix A.

Case 1: DNS PTR Record in Queries Follow Correct Format (FYI)

Test Procedure:

1. Configure the Discovery Controller to be in a state capable of sending mDNS queries.

Observable Results:

1. Verify with a packet inspection tool that mDNS queries from the DUT are in the form of "_nvme-disc.<protocol>.<domain>"; or "_<subtype>._sub._nvme-disc.<protocol>.<domain>"

Case 2: DNS PTR Record in Responses Follow Correct Format (FYI)

Test Procedure:

1. Configure the Discovery Controller to be in a state capable of sending mDNS queries.

Observable Results:

1. Verify with a packet inspection tool that mDNS responses with PTR records from the DUT are in the form of "_nvme-disc.<protocol>.<domain>"; or "_<subtype>._sub._nvme-disc.<protocol>.<domain>

Case 3: DNS SRV Record in Responses Follow Correct Format (FYI)

Test Procedure:

1. Configure the Discovery Controller to be in a state capable of responding to mDNS queries.

Observable Results:

1. Verify with a packet inspection tool that mDNS SRV responses from the DUT are in the form of "<Instance>.<Service Name>.<Protocol>.<Domain>"
2. Verify the service name field is "_tcp.local" or "_udp.local" depending on the transport protocol used
3. Verify the protocol field is set to "_nvme-disc"

Case 4: DNS TXT Record in Responses Follow Correct Format (FYI)

Test Procedure:

1. Configure the Discovery Controller to be in a state capable of responding to mDNS queries
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h to record the SUBNQN value.

Observable Results:

1. Verify with a packet inspection tool that mDNS TXT responses from the DUT are in the form of "<length byte><Protocol><length byte><NQN.of.Discovery.Subsystem>"
2. Verify if the NQN field in included then it is set to the well-known NQN

3. If the NQN field is not set to the well-known NQN, verify the field is set to the value in the SUBNQN field in the Identify Controller data structure

Case 5: CDC Only Responds to Well-Formatted mDNS Queries (FYI)

Test Procedure:

1. Configure the Discovery Controller to be in a state capable of responding to mDNS queries
2. Configure the testing station to issue multiple mDNS queries that do not follow the format of "_nvme-disc.<protocol>.local"; or "_cdc_sub._nvme-disc.<protocol>.local"
3. Configure the testing station to issue an mDNS query for each format the CDC responds to.

Observable Results:

1. Verify if the CDC responds. to any mDNS queries, it only responds to the queries sent in step 3, and none of the queries sent in step 2.

Test 6.2 – Zoning Configuration (FYI)

Purpose: To verify that an NVMe Centralized Discovery Controller can properly provide access control via fabrics zoning in an NVMe-oF IP based fabric.

References:

NVM Express Base Specification 2.1: 8.3.2

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport interface.

Last Modification: January 23, 2025

Discussion: Identify Controller Data Structure has enhancements specific for NVMe-oF implementations.

Test Setup: See Appendix A.

Case 1: CDC Unique ZoneGroup Keys (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to create multiple ZoneGroups
3. Configure the testing station to Issue an FZL command for each ZoneGroup created, with the Operation Type (OTYP) field set to 1h, and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to values used in step 2. Record the Zoning Data Key (ZDK) value in each Completion Queue Entry Dword 0.

Observable Results:

1. Verify the Zoning data Key (ZDK) returned in Completion Queue Entry Dword 0 of each FZL command has a unique value for each command.

Case 2: GAZ Operation Increments ZoneGroup Generation Number (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to create a ZoneGroup
3. Initiate a GAZ operation from the DDC by sending a FZL command to the CDC with Operation Type (OTYP) bit set to 1h, and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) set to the values used for creating the ZoneGroup in step 2
4. Using the ZoneGroup Key returned from the CDC in Completion Queue Entry Dword 0, issue an FZR command with the Zoning Data Key (ZDK) field in Command Dword 10 set to the returned ZoneGroup Key. Record the value in the ZoneGroup Generation Number (ZGGN) field.
5. Repeat steps 3 & 4.

Observable Results:

1. Verify the first ZoneGroup Generation Number (ZGGN) returned from the first FZR command is one less than the ZoneGroup Generation Number returned in the second FZR command.

Case 3: CDC Fabric Zoning Disabled (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to disable zoning on the CDC.
3. Configure the testing station to issue an FZL command to the CDC with arbitrary values.
4. Configure the testing station to issue an FZR command to the CDC with arbitrary values.
5. Configure the testing station to issue an FZS command to the CDC with arbitrary values.

Observable Results:

1. Verify for each zoning command sent from the DDC, the CDC responds with a status of Requested Function Disabled (33h).

Case 4: ZoneGroup Does not Exist on CDC (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an FZL command with the Operation Type (OTYP) field set to 1h, and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to values that do not exist on the CDC.

Observable Results:

1. Verify the CDC responds to the FZL command with a status of Zoning Data Structure Not Found (31h)

Case 5: FZR Fragmented Data - Last Fragment has LF bit set to 1 (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to have a ZoneGroup which would exceed the incapsule data limit for Fabrics (8,192 bytes)
3. Configure the testing station to initiate a GAZ operation by sending an FZL command with the Operation Type (OTYP) set to 1h, and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to the ZoneGroup created in step 2
4. Configure the testing station to issue an FZR command with the Zoning Data Key (ZDK) field set to the key returned from the FZL command.

Observable Results:

1. Verify in the resulting FZR completion queue entries that the last FZR command has the Last Fragment (LF) bit set to 1 in Completion Queue Entry Dword 0, and the previous FZR commands have the LF bit set to 0

Case 6: GAZ Operation - FZR command with ZoneGroup key that DNE (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to create a ZoneGroup
3. Initiate a GAZ operation by sending an FZL command with the Operation Type (OTYP) set to 1h, the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) set to the ZoneGroup created in step 2.
4. Once the Zoning Data key is received, remove the ZoneGroup through an administrative interface on the CDC
5. Configure the testing station to issue an FZR command with the Zoning Data Key (ZDK) field in Command Dword 10 set to the key returned in step 3.

Observable Results:

1. Verify the FZR command responds with a status of Zoning Data Structure Not Found in Completion Queue Entry Dword 0.

Case 7: AAZ Operation FZS Comand - Creating Empty ZoneGroup (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to remove any existing ZoneGroups
3. Initiate an AAZ operation by configuring the testing station to issue an FZL command with the Operation Type (OTYP) field set to 3h, and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to values non-existent on the cdc
4. Configure the testing station to issue an FZS command with the Operation Type (OTYP) field set to 4h, the Zoning Data Key (ZDK) field set to the key returned in step 3, and the ZoneGroup Fragment (ZGF) field set to an arbitrary ZoneGroup
5. Configure the testing station to issue an FZR command with the Zoning Data Key (ZDK) field in Command Dword 10 set to the key returned from step 3.

Observable Results:

1. Verify the ZoneGroup key is returned in Completion Queue Entry Dword 0 of step 3.
2. Verify the FZR command returns the same ZoneGroup from the FZS command in step 4.

Case 8: AAZ Operation FZS Command - ZoneGroup Key DNE (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an FZS command with the Operation Type (OTYP) field set to 4h, and the Zoning Data Key (ZDK) field set to a non-existent value on the CDC.

Observable Results:

1. Verify the FZS command returns a status code of Zoning Data Structure Not Found in the Completion Queue Entry.

Case 9: Receiving Only Full ZoneGroup Increments Generation Number (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to create a ZoneGroup
3. Configure the testing station to initiate a GAZ operation by issuing an FZL command with the Operation Type (OTYP) field set to 1h, and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to the created ZoneGroup in the previous step
4. Configure the testing station to issue an FZR command with the Zoning Data Key (ZDK) field set to the key returned in the previous step in Command Dword 10, record the ZoneGroup Generation Number (ZGGN)
5. Configure the testing station to initiate an AAZ operation by issuing an FZL command with the Operation Type (OTYP) field set to 3h, and ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) set to the created ZoneGroup
6. Configure the testing station to issue an FZS command with the Operation Type (OTYP) field set to 4h, the Zoning Data Key (ZDK) field set to the key returned in the Completion Queue Entry from step 3, the ZoneGroup Fragment (ZGF) field set to a fragment of a new ZoneGroup, and the Last Fragment (LF) bit set to 0
7. Wait a minimum of 30 seconds for the AAZ operation to expire
8. Configure the testing station to initiate the same GAZ operation from steps 3-4, record the value in the ZoneGroup Generation Number (ZGGN) field

9. Configure the testing station to initiate the same AAZ operation from steps 5-6, with the Last Fragment (LF) bit set to 1
10. Configure the testing station to initiate the same GAZ operation from steps 3-4, record the value in the ZoneGroup Generation Number (ZGGN) field.

Observable Results:
1. Verify the generation number recorded in step 8 is 1 more than the value recorded in step 4.
2. Verify the generation number recorded in step 10 is 2 more than the value recorded in step 8

Case 10: AEN for Add/Remove Zone (FYI)

Test Procedure:
1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h) to the CDC, for Log Page Entries with the Explicit Persistent Connection Support for Discovery (EPCSD) bit cleared to 0, this test is not applicable.
3. Configure the testing station to issue a set features command to the CDC to Feature Identifier 0Bh (Asynchronous Event Configuration) with bit 31 (Discovery Log Page Change Notification) of Command Dword 11 set to 1.
4. Configure entries with the EPCSD bit set to 1 to issue an Asynchronous Event Request to the CDC
5. Configure the CDC through an administrative interface to create a ZoneGroup that has the Testing Station and an arbitrary NVMe Subsystem as members
6. Configure entries with the EPCSD bit set to 1 to issue an Asynchronous Event Request to the CDC
7. Using an administrative interface, remove the ZoneGroup from the CDC.

Observable Results:
1. Verify that all members of the ZoneGroup created in step 5 received an Asynchronous Event Notification after creating the Zone in step 5.
2. Verify that all members of the ZoneGroup created in step 5 received an Asynchronous Event Notification after removing the Zone in step 7.

Case 11: AEN for Add/Remove Zone Member (FYI)

Test Procedure:
1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h) to the CDC, for Log Page Entries with the Explicit Persistent Connection Support for Discovery (EPCSD) bit cleared to 0, this test is not applicable
3. Configure the testing station to issue a set features command to the CDC to Feature Identifier 0Bh (Asynchronous Event Configuration) with bit 31 (Discovery Log Page Change Notification) of Command Dword 11 set to 1
4. Configure the CDC through an administrative interface to create a ZoneGroup and add the Testing Station as well an arbitrary NVMe Subsystem to the ZoneGroup
5. Using an administrative interface, configure the CDC to remove the NVMe subsystem as a Zone member from the ZoneGroup created in step 4.
6. Using an administrative interface, configure the CDC to add the NVMe subsystem as a Zone member from the ZoneGroup created in step 4.
7. Using an administrative interface, configure the CDC to remove the Testing Station as a Zone member from the ZoneGroup created in step 4.
8. Using an administrative interface, configure the CDC to add the Testing Station as a Zone member from the ZoneGroup created in step 4.

Observable Results:

1. Verify that after adding or removing a Zone member, all remaining members of the Zone receive an Asynchronous Event Notification with the Asynchronous Event Type field set to Notice (2h).

Case 12: RAZ Operation - Non-Existent ZoneGroup (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to initiate an RAZ operation by issuing an FZL command with the Operation Type (OTYP) field set to 5h, and ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) set to a value that is not equal to the ZGORIG or ZGNAME field respectively for any ZoneGroup that exists on the CDC.

Observable Results:

1. Verify that the FZL command issued in step 2 is aborted with status “Zoning Data Structure Not Found”

Case 13: Fabric Zoning Send/Receive - NUMD = 0h (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Identify command with the Controller or Namespace Structure (CNS) field set to 1h.
3. Verify the Discovery Controller Type (DCTYPE) field is set to a value of 2h, otherwise this test is not applicable.
4. Configure the testing station to send a Fabric Zoning Send command with the NUMD field in CDW12 cleared to 0h to the DUT
5. Configure the testing station to send a Fabric Zoning Receive command with the NUMD field in CDW12 cleared to 0h to the DUT

Observable Results:

1. Verify that in steps 3 and 4 the Fabric Zoning Send/Receive commands abort with status “Invalid Field in Command”.

Case 14: AAZ Operation FZL Command Lock is Released After 30 Seconds (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue a FZL command to initiate an AAZ operation with the Operation Type (OTYP) field set to 3h
3. Configure the testing station to issue a FZL command to initiate a GAZ operation with the Operation Type (OTYP) field set to 1h and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to the same values as step 2
4. After 30 seconds of sending the FZL command in step 2, configure the testing station to issue a FZL command to initiate a GAZ operation with the Operation Type (OTYP) field set to 1h and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to the same values as step 2.

Observable Results:

1. Verify the second FZL command in step 3 is aborted with a status code of Zoning Data Structure Locked
2. Verify the third FZL command in step 4 is successful indicating the lock is released.

Case 15: FZR Command Zoning Data Offset (ZDO) (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to create a ZoneGroup

3. Configure the testing station to issue a FZL command with the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to values from the ZoneGroup created in step 2
4. Configure the testing station to issue a FZS command with the Zoning Data Offset (ZDO) field bits 1:0 set to 11b, and the Zoning Data Key (ZDK) field set to the key returned in step 3
5. Configure the testing station to issue a FZS command with the Zoning Data Offset (ZDO) field set to a value greater than the size of the Zoning Data Structure created in step 2.

Observable Results:

1. Verify the FZS command in step 4 either completes successfully as if bits 1:0 are cleared to 0, otherwise verify the command is aborted with a status code of Invalid Field in Command
2. Verify the FZS command in step 5 aborts with a status code of Invalid Field in Command

Case 16: Discovery Information Management Command NULL TRADDR (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue a Discovery Information Management command with the Task (TAS) field set to 0h, and with two Extended Discovery Information Entries, each of which with the first byte of the Transport Address (TRADDR) field cleared to 00h.

Observable Results:

1. Verify the Discovery Information Management command in step 2 aborts with a status of Invalid Field in Command

Case 17: Change in ZoneGroup Generation Number when Transferred through Multiple Fragments (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the CDC through an administrative interface to create a ZoneGroup
3. Configure the testing station to issue a FZL command to initiate a GAZ operation with the Operation Type (OTYP) field set to 1h, and the ZoneGroup Originator (ZGORIG) and ZoneGroup Name (ZGNAME) fields set to the created ZoneGroup in the previous step
4. Configure the testing station to issue an FZR command with the Zoning Data Key (ZDK) field set to the value returned from the FZL command in step 2
5. Configure the testing station to issue a custom packet to mock a FZR command completion with the ZoneGroup Generation Number (ZGGN) cleared to 0
6. Configure the testing station to issue another custom packet to mock another FZR command completion with the ZoneGroup Generation Number (ZGGN) set to 1.

Observable Results:

1. Verify the ZoneGroup is not processed by the Discovery Controller.

Test 6.3 – Registration (FYI)

Purpose: To verify that an NVMe Discovery Controller can properly handle push and pull registrations.

References:

NVM Express Base Specification 2.1: 8.3.2

Resource Requirements:

Tools capable of monitoring and decoding traffic on the chosen NVMe-oF transport interface.

Last Modification: January 23, 2025

Discussion: Identify Controller Data Structure has enhancements specific for NVMe-oF implementations.

Test Setup: See Appendix A.

Case 1: KDReq - PDO is Multiple of CPDA (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to send a Initialize Connection Request (ICReq) PDU with bit 7 of byte 1 (Kickstart Discovery Connection (KDCONN)) set to 1 to the DUT
3. Configure the testing station to send a Kickstart Discovery Request (KDReq) PDU to the DUT.

Observable Results:

1. Verify that the DUT sends an ICResp PDU in response to the ICReq PDU sent in step 2
2. Verify using a packet sniffer tool that byte 3 of the KDReq PDU (PDO) is a multiple of the data alignment specified by the CPDA field in the ICResp PDU (byte 10) that was sent by the CDC in response to the ICReq sent in step 2.

Case 2: KDResp - PDO is Multiple of HPDA (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to send a Initialize Connection Request (ICReq) PDU with bit 7 of byte 1 (Kickstart Discovery Connection (KDCONN)) set to 1 to the DUT
3. Configure the testing station to send a Kickstart Discovery Request (KDReq) PDU to the DUT.

Observable Results:

1. Verify that the DUT sends an ICResp PDU in response to the ICReq PDU sent in step 2
2. Verify using a packet sniffer tool that byte 3 of the KDResp PDU (PDO) is a multiple of the data alignment specified by the HPDA field in the ICReq PDU (byte 10) that was sent by the testing station in step 2.

Case 3: Pull De-registration Requested by DDC has NUMDIE = 0h (FYI)

Test Procedure:

1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue a Discovery Information Management command with the Task (TAS) field set to 0h to register discovery information with the CDC
3. Configure the testing station to issue an Initialize Connection Request PDU (ICReq) with the Kickstart Discovery Connection (KDCONN) bit set to 1 in the Flags field

4. Configure the testing station to issue a Kickstart Discovery Request PDU (KDReq) with the Number of Discovery Information Entries (NUMDIE) field set to 0h
5. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h).

Observable Results:
1. Verify the discovery entry for the DUT is not listed in the Discovery Log Page Entries data structure from step 5

Case 4: KDReq with Failure Does Not Perform Pull Registration (FYI)

Test Procedure:
1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Initialize Connection Request PDU (ICReq) with the Kickstart Discovery Connection (KDCONN) bit set to 1 in the Flags field
3. Configure the testing station to issue a Kickstart Discovery Request PDU (KDReq) with the Transport Type (TRTYPE) field set to 255 in the Kickstart Record, a reserved value
4. Configure the Testing Station to issue a Get Log Page command for the Discovery Log Page (LID = 70h).

Observable Results:
1. Verify the Kickstart Discovery Response PDU (KDResp) returned has the Failure bit set to 1 in the Kickstart Status (KSSTAT) field
2. Verify the Kickstart Discovery Response PDU (KDResp) returned has the Failure Reason (FAILRSN) field bit 2 set to 1
3. Verify the Discovery Log Page Entries returned in step 4 does not have an entry for the DUT

Case 5: Kickstart Discovery Request and Response Sequence (FYI)

Test Procedure:
1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Initialize Connection Request PDU (ICReq) with the Kickstart Discovery Connection (KDCONN) bit set to 1 in the Flags field
3. Configure the testing station to issue a Kickstart Discovery Request PDU (KDReq).

Observable Results:
1. Verify with a packet sniffer tool that the CDC responds with an Initialize Connection Response PDU (ICResp)
2. Verify with a packet sniffer tool that the CDC responds with a Kickstart Discovery Response PDU (KDResp)
3. Verify the KDResp PDU has the Kickstart Status (KSSTAT) field bit 0 set to 1 for SUCCESS
4. Verify with a packet sniffer tool that the CDC performs a pull registration after sending the KDResp PDU by sending a Connect command to the DDC, and then sending a Get Log Page command to the DDC

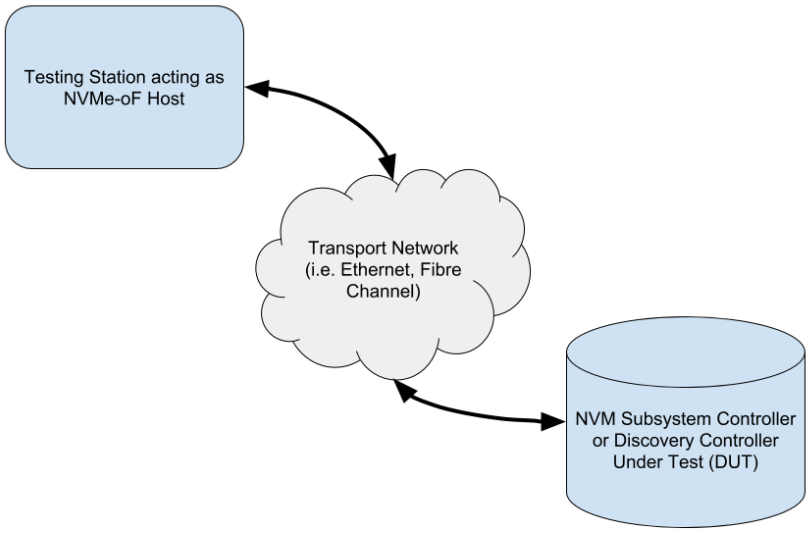
Case 6: Kickstart Discovery Request - NUMDIE Exceeding CDC Capacity (FYI)

Test Procedure:
1. The Testing Station and the DUT are on the same fabric network. The Testing Station is able to send packets to the DUT.
2. Configure the testing station to issue an Initialize Connection Request PDU (ICReq) with the Kickstart Discovery Connection (KDCONN) bit set to 1 in the Flags field
3. Configure the testing station to issue a Kickstart Discovery Request PDU (KDReq) with the Number of Discovery Information Entries (NUMDIE) field set to FFFFh.

Observable Results:
1. Verify the Kickstart Discovery is unsuccessful

Appendix A: TEST SETUP

The diagram below outlines a simple test setup for testing NVMe-oF products for conformance. While a network is shown, it is also possible to perform the tests using a direct connection.



Appendix B: NOTES ON TEST PROCEDURES

There are scenarios where in test procedures it is desirable to leave certain aspects of the testing procedure as general as possible. In these cases, the steps in the described test procedure may use placeholder values, or may intentionally use non–specific terminology, and the final determination of interpretation or choice of values is left to the discretion of the test technician. The following is an attempt to capture and describe all such instances used throughout the procedures.

Ports on Testing Station and Device Under Test

In general, any NVMe-oF capable Port on the Testing Station or Device Under Test may be used as an interface with a test station or interoperability partner. There is *assumed* to be no difference in behavior, with respect to the protocols involved in this test suite, between any two NVMe-oF ports on the Testing Station or Device Under Test. Hence, actual ports used may be chosen for convenience. However, it is recommended that the port used in the test configuration is recorded by the test technician.

Use of "various"

To maintain generality, some steps will specify that "various other values" (or the like) should be used in place of a given parameter. Ideally, all possible values would be tested in this case. However, limits on available time may constrain the ability of the test technician to attempt this. Given this, a subset of the set of applicable values must generally be used.

When deciding how many values should be used, it should be noted that the more values that are tested, the greater the confidence of the results obtained (although there is a diminishing return on this).

When deciding which specific values to use, it is generally recommended to choose them at pseudo–randomly yet deterministically. However, if there exist subsets of the applicable values with special significance, values from each subset should be attempted.

Appendix C: TEST TOOLS

The Tests described in this document can be performed using available IOL INTERACT NVMe-oF Test Software available from UNH–IOL. As of the writing of this document, version of this tool were available that support NVMe/FC, NVMe/RoCE, NVME/TCP, and NVMe/iWARP transports.

If using the PC Edition of the IOL INTERACT NVMe-oF Test Software, UNH-IOL recommends using v16.0 or higher. This software is available via https://www.iol.unh.edu/solutions/test-tools/interact.

Appendix D: NVME-OF INTEGRATORS LIST REQUIREMENTS

Purpose: To provide guidance on what tests are required for NVMe-oF Integrators List Qualification

References:

[1] NVMe Integrators List Policy Document

Resource Requirements:

NVMe Host Platform and Device.

Last Modification: April 21, 2020

Discussion: Each Test defined in this document is defined as being Mandatory (M), FYI, or In Progress (IP). This primary designation is shown in the title of the test case and is understood to apply to any NVMe-oF product. The following examples are provided:

Test 1.1 Example Name (M)– Test is mandatory for all NVMe-oF products.
Test 2.1 Example Name (FYI)– Test is FYI for all NVMe-oF products.
Test 3.1 Example Name (IP)- Test is still under development, and is considered FYI all for NVMe-oF products.

If a Test is designated as Mandatory, a product must pass this test in order to qualify for the NVMe-oF Integrators List. For tests that deal with features defined as optional in the NVMe-oF specification, a check is performed at the beginning of the test to determine if the optional feature is supported or not. If the optional feature is not supported the test is marked as 'Not Applicable' and does not impact qualification for the Integrators List.

If a Test is designated as FYI, a device does not need to pass this test in order to qualify for the NVMe-oF Integrators List. Tests designated as FYI may become Mandatory tests in the future.

If a Test is designated as In Progress, a device does not need to pass this test in order to qualify for the NVMe-oF Integrators List. These test cases are still under development. Tests designated as In Progress may become FYI or Mandatory tests in the future.

Any Test may have a Case within it with a different designation as the Test itself (i.e. a Mandatory test may include FYI cases). In this case, only the Mandatory Cases are required for NVMe-oF Integrators List qualification.