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White Paper

Domain Validation Explained

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Domain Validation is an important SCSI feature introduced in Ultra160 SCSI. Before application data transfers begin, Domain Validation provides an essential system mechanism that gets SCSI devices operational at the maximum possible operational data transfer speed. In other words, when devices can only operate on a bus using specific, perhaps sub-optimal, procedures, Domain Validation searches for the specific data transfer procedures to get the devices operating.

Domain Validation therefore helps detect and bypass (when possible) invalid, or otherwise marginal, SCSI bus configurations. Though not a substitute for good SCSI configuration design, Domain Validation provides a crucial safety net for configuration errors that can dramatically facilitate device installations and operating procedures.

Following each system power-on or SCSI bus reset, an affected SCSI bus begins operating anew. At this time, all affected SCSI bus initiators locate and individually negotiate with all SCSI targets on the SCSI bus. These negotiations establish the precise mechanics for performing subsequent data transfers.

Negotiations proceed using low-speed, lowest-common denominator procedures that involve asynchronous data exchanges. Such asynchronous data exchanges can occur at data rates as low as 5 MBytes/s. In the case of Ultra160 SCSI, this means initiators and targets can agree to a data transfer rate that is 32 times faster than the speed used to achieve the agreement. However, in practice, fulfilling such an agreement may be difficult if not completely impossible for a variety of reasons.

Historically, this failure to communicate meant target devices could be visible to initiators at 5 Mbytes/s negotiation data rates. However, they could remain invisible or otherwise inaccessible to operating systems. In other words, this maximum surprise symptom signaled problems -- often-serious problems -- for vendors and users alike.

Domain Validation is a new SCSI feature that first appeared with Ultra160 SCSI. After each Ultra160 SCSI initiator/target negotiation completes, Domain Validation performs a quick test to help ensure an initiator and target can actually transfer data at negotiated speeds. If Domain Validation determines the negotiated data transfer rate is not achievable, it signals the controller that it should renegotiate with the target to select a data transfer scheme that is less demanding. This negotiation/testing cycle continues until a suitable data transfer scheme emerges or until all possibilities are exhausted.

Preliminary Definitions and Concepts

Definitions

Physical Layer: The SCSI physical layer transports SCSI signals and helps protect them from interference. The physical layer includes terminators; cables; expanders adapter and motherboard traces; connectors; and provisions such as signal conductor impedance levels, connector spacing, cable lengths, etc.

Domain: The domain is the physical layer and all the SCSI initiator and target devices that attach to it. The domain is sometimes referred to as the SCSI configuration.

Integrity checking: The process of verifying that a domain can transfer test data between an initiator and target at their negotiated data transfer rate and width.

Fall Back: The process of re-negotiating a new data transfer scheme following integrity check failure of a negotiated data transfer rate. Fall back results in selecting one or more relaxed data transfer characteristics and may result in a lower eventual data transfer rate.

Echo Buffer: An optional 252 character buffer located on a target device. An echo buffer helps its device perform enhanced Domain Validation procedures.

Domain Validation Overview

Domain Validation presently has two testing levels:—Basic and Enhanced. An initiator first performs Basic Domain Validation. If this test determines the negotiated data transfer scheme is unsuitable, Fall Back occurs. If the Basic Domain Validation test determines the negotiated data transfer scheme is suitable, Domain Validation may proceed to the Enhanced level.

With Enhanced Domain Validation, a more extensive data transfer validation test occurs. If this test determines the negotiated data transfer scheme is unsuitable, a Fall Back occurs. A Fall Back at either the Basic or Enhanced level triggers a re-negotiation. It is the responsibility of the initiator to keep track of unsuitable data transfer schemes as it searches for a suitable data transfer scheme.

Domain Validation–Basic Level Testing

The testing consists of issuing a sequence of SCSI Inquiry commands to a selected SCSI target - first in asynchronous narrow mode and then in a pending negotiated data transfer mode. This proceeds in two phases.

The first Basic Level testing phase can commence immediately after a power-on or reset - before the initiator negotiates with a device to establish synchronous data transfer parameters (called synchronous negotiation). Here, the initiator first transmits an Inquiry command to the device. Since the initiator and device have not yet completed synchronous negotiation, the device should respond using the asynchronous narrow data transfer mode. Whenever a successful device Inquiry data transfer occurs, the initiator saves the first 36 characters the device returns and then performs a synchronous negotiation with the device. The synchronous negotiation determines the data transfer parameters, hence the speed, for all data transfers - all other communication continues at the asynchronous narrow mode speed

Next, the initiator attempts a second Inquiry command to the device. Because the device has just completed a synchronous negotiation, it responds using the data transfer mode selected during the synchronous negotiation. If it is unsuccessful (parity error, CRC error, or command timeout occurs), the initiator remembers the unsuccessful synchronous data transfer parameter combination and executes a Fall Back. Here, the initiator falls back to the first phase of Basic level testing, albeit a little wiser regarding what synchronous data transfer parameter combinations do not work.

However, if the synchronous data transfer is successful, the initiator compares the first 36 bytes returned with the first 36 bytes returned using the asynchronous narrow data transfer mode. If they are equal, then the initiator and device may then proceed to the Enhanced testing level. Otherwise, the initiator repeats the same test to allow the device to stabilize its response to Inquiry commands.

The Basic testing level detects many common SCSI bus configuration problems such as:

- Narrow cabling between wide initiators and devices
- Expanders that cannot support the negotiated data transfer scheme
- Damaged cables
- Improper termination
- Damaged bus transceivers

Domain Validation–Enhanced Level Testing

The Enhanced level testing consists of comparing echoed data (transmitted from the initiator to the device and then back to the initiator) for equality using a variety of data patterns. Here, the initiator transmits the data using the Write Buffer command with the echo buffer option and requests it back using the Read Buffer command with the echo buffer option. An echo buffer, if available, allows the device to use the echo buffer as temporary storage. If the device does not implement the Read Buffer and Write Buffer commands, the target device will issue a Check Condition status and an Illegal Request sense key. Enhanced level testing in this instance is implementation-dependent and may not be possible.

During Enhanced level testing, the initiator should ensure that other initiators do not interfere with the testing by communicating with the target device during the test. The precise way to accomplish this varies by environment.

Having secured the target device for exclusive use, the initiator can echo any and as many data patterns as needed -- though each data transfer requires an arbitration and selection process. However, before echoing any data, the initiator must first determine the size of the target device's echo buffer which can vary by device. To determine the echo buffer size, the initiator transmits a Read Buffer command to extract the Echo Buffer Descriptor which indicates the echo buffer size. Legacy target devices may not recognize the command and reject it.

Having determined the size of the echo buffer, data pattern echoing can commence, with each echoed data pattern no longer than the indicated echo buffer size. The standards committees are presently working to identify suitable data patterns. Here are some of the presently recommended data patterns and their names:

Counting
0001h, 0203h, 0304h,...

Alternating Ones and Zeros
0000h, FFFFh, 0000h, FFFFh,...

Crosstalk
5555h, AAAAh, 5555h, AAAAh,...

Shifting Bit
0000h, FFFEh, 0000h, FFFDh, ..., FFFFh,
0001h, FFFFh, 0002h,...

These patterns can detect a variety of data transmission sensitivities in marginal SCSI configurations. When such a sensitivity problem is detected, Fall Back occurs. Problems that this testing level detects include:

- Incorrect cable impedance
- Incorrect SCSI device spacing
- Poor or marginal termination
- Marginal transceivers
- Excessive crosstalk sensitivity
- Excessive system noise

Summary

Domain Validation introduces a new level of usability to SCSI I/O subsystems by detecting and bypassing problems that previous SCSI generations could not resolve. Combined with future improvements that are in discussion with the Desktop Management Task Force, Domain Validation will continue to set the standard for high performance, user-friendly I/O subsystems.

Finally, development plans are already in action to define and standardize Extended Domain Validation testing. This third level of Domain Validation will use techniques such as Adaptive Margining to improve signal quality further. Adaptive margining varies transmission characteristics to determine suitable transmission parameters. In this and many other manners, parallel SCSI technology will continue to raise the bar for high performance I/O Subsystems.

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