White Paper

End-to-end Data Protection Using Oracle Linux with the FUJITSU Storage ETERNUS AF series or ETERNUS DX series, and QLogic 2600 Series FC HBA

Greatly improving the reliability of the entire system

Content

Preface

As demand for data protection has grown in recent years, ensuring the integrity of the customer's data is a very important task.
To carry out this task, data protection is not only required for the storage system but the entire system.

This White Paper explains how data protection can be implemented for the entire system using T10 Protection Information (T10 PI) that comes with the Oracle Linux with Unbreakable Enterprise Kernel (UEK), FUJITSU Storage ETERNUS AF series and ETERNUS DX series, and QLogic HBA.

The information stated in this document is current as of November 2018.

ORACLE LINUX

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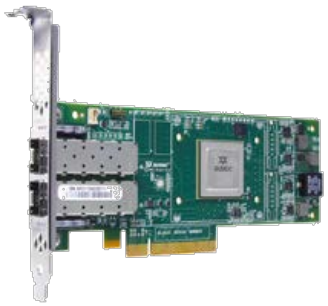

QLOGIC
The Ultimate in Performance

FUJITSU Storage ETERNUS AF series
FUJITSU Storage ETERNUS DX series

1. Data Protection with T10 PI

■1.1 What are T10 PI and DIX?

Data protection is nothing new. Each system component has data protection functions such as memory parity detection, error detection with communication protocols, CRC error detection of the storage system, and redundancy. (Figure 1.1, I. Conventional data integrity functions)

T10 PI defines the mechanism for data integrity protection that is standardized through communication paths and devices.
End-to-end data integrity from applications to drives is implemented with the combination of T10 Protection Information (T10 PI) and Data Integrity Extensions (DIX).

T10 PI adds protection information to data in the I/O controller (HBA) layer, transfers the protection information to the devices that support T10 PI in the layers lower than the I/O controller (HBA), and validates data integrity, including data written to the drive. (Figure 1.1, II. T10 PI)
However, because protection information is added to data in the I/O controller (HBA) layer, data cannot be protected in the higher layers (applications, OS).

Data protection, including applications and OSs, is implemented with the Data Integrity Extensions (DIX) which enable the T10 protection information to be exchanged between the Linux kernel and the HBA. (Figure 1.1, III. DIX)

The combination of T10 PI and DIX provides complete end-to-end data protection. (Figure 1.1, IV. DIX + T10 PI)

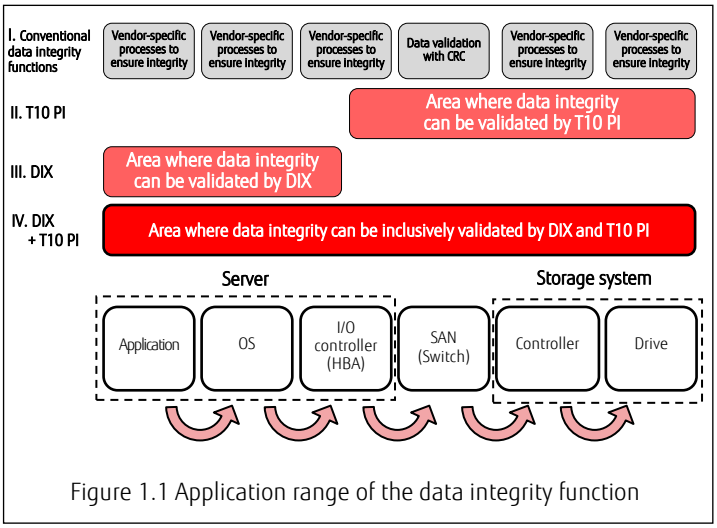

Figure 1.1 Application range of the data integrity function

■1.2 T10 PI Data Protection Field Format

An 8-byte protection information that is added by T10 PI during I/O operations consists of Reference Tag, Application Tag, and Guard Tag as shown in Figure 1.2.

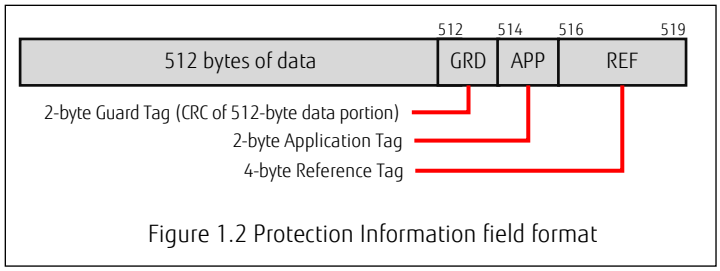

Figure 1.2 Protection Information field format

- Reference Tag:
  Detects data writing to incorrect blocks.
- Application Tag:
  Specific to applications. Application Tag defines the purpose of data.
- Guard Tag:
  Protects the data portion of the sector with CRC.

■1.3 I/O Processing With T10 PI

T10 PI adds protection information (8-byte PI) to data in the I/O controller (HBA) and validates data integrity within the layers lower than the I/O controller.
Figure 1.3 indicates I/O processing with T10 PI.

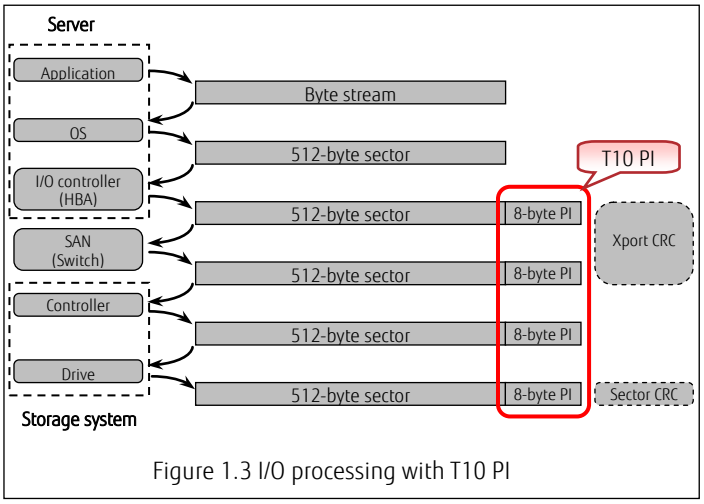

Figure 1.3 I/O processing with T10 PI

- The application transfers data to be written to the OS.
- The OS (file system) transfers the data to be written to the I/O controller (HBA) as a logical block with 512 bytes per sector.
- The I/O controller generates and adds the protection information, and sends data with 520 bytes per sector to the SAN.
- The controller (storage system) validates the protection information and destination.
- The drive validates the protection information before writing the data.

■1.4 I/O Processing With DIX

DIX validates data integrity in applications and OSs.

Figure 1.4 indicates I/O processing with DIX.

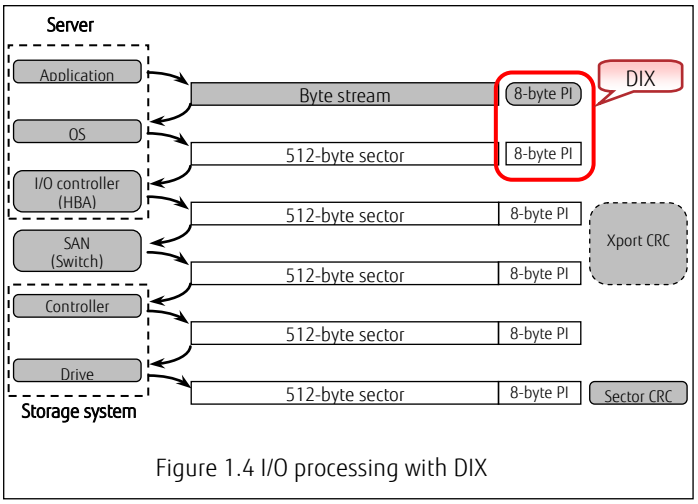

Figure 1.4 I/O processing with DIX

- Data integrity processing that is specific to applications generates protection information for data and transfers both the data to be written and the protection information to the OS as required.
- The OS transfers the data and the protection information to the I/O controller (HBA).
  If the protection information is not generated, the OS automatically generates and adds the protection information to the data.
- The I/O controller merges the data and the protection information, and sends them as data with 520 bytes per sector to the SAN.
- The following processes are the same as those described in "■1.3 I/O Processing With T10 PI".

The combination of T10 PI and DIX enables end-to-end data integrity as described above.

2. Components that Enable End-to-end Data Integrity

This section explains the three components that enable end-to-end data integrity (OS, I/O controller (HBA), storage system).

- Oracle Linux with Unbreakable Enterprise Kernel (UEK)
- QLogic 2600 Series Fibre Channel HBA
- FUJITSU Storage ETERNUS AF series and ETERNUS DX series

■Oracle Linux

Oracle Linux integrates latest innovations in the Linux mainline and provides excellent performance, high scalability, and reliability for enterprise systems and applications.
Oracle Linux provides the latest tools, and features that enable customers to innovate, collaborate, and create solutions across traditional, cloud-based, and virtual environments.

Oracle Linux with UEK efficiently runs on systems with many cores, threads and NUMA nodes.
Developed and tested to support demanding workloads, such as the Oracle Database, it is one of the most reliable, fast, and scalable OS for the enterprise implementations.
In addition to this, Unbreakable Enterprise Kernel contains many new features that are relevant to Linux running in the data center, including support for T10 PI and the Data Integrity Extensions.

Oracle Linux with the Unbreakable Enterprise Kernel, including the data integrity features, is provided under the GNU General Public License (GPL) and is available to anyone in both binary and source form.
Oracle Linux with the default Unbreakable Enterprise Kernel can be downloaded for free from edelivery.oracle.com/linux
Existing or new Oracle Linux support customers will receive full support for this kernel as part of their existing support subscriptions.
Bug fixes and security errata are delivered via ULN and announced via the el-errata mailing list.

■QLogic 2600 Series Fibre Channel HBA

The QLogic 2600 Series of Fibre Channel Host Bus Adapters provides industry-standard T10 Protection Information (PI), formerly known as Data Integrity Field (DIF). T10 PI is an important standard that confirms QLogic's commitment to end-to-end data integrity validation. QLogic's T10 PI prevents silent data corruption, ensuring that incomplete and incorrect data cannot go undetected and can never overwrite good data.

The QLogic controller validates that the data, metadata protection information and storage target location match prior to sending data to the storage. When fully implemented as part of a holistic ecosystem strategy, including Host Bus Adapter, storage array controller, and drive media, T10 PI ensures data integrity from application to storage.

- QLogic 2600 Series
  - 16Gbit/s Gen 5 Fibre Channel
  - PCI Express 3.0
  - High performance with more than 1.2 million IOPS
  - High-availability port isolation architecture
  - Flexibility for use even as 10GbE adapters (CNAs)
  - Single-Port Host Bus Adapter (QLogic QLE2670)
    (Fujitsu product name: PFC EP QLE2670, product ID: S26361-F5313-L501)
  - Dual-Port Host Bus Adapter (QLogic QLE2672)
    (Fujitsu product name: PFC EP QLE2672, product ID: S26361-F5313-L502)

■ FUJITSU Storage ETERNUS AF series and ETERNUS DX series
The ETERNUS AF series and the ETERNUS DX series feature data protection and flexibility functions to meet highest business- centric requirements and provide excellent reliability.

The protection information generated by the OS is secured in the UEK and the HBA using T10 PI and DIX functions. It is then transferred to the storage system, ensuring data integrity until all data is written to drive.

Besides T10 PI, the ETERNUS AF series and the ETERNUS DX series improve data reliability with the unique "Data Block Guard" function. This function adds a check code to each block of data being written to drive and validates data integrity at multiple check points. In the case of drive failures incorrect data will be detected, thus data integrity is validated and ensured throughout the storage system.

The ETERNUS AF series, and the ETERNUS DX S3 series and later* support T10 PI.
*The ETERNUS DX8100 S4 is excluded.

3. Combination of Components and Functions that Achieves Data Integrity

The relationship between components and data integrity functions that achieves data integrity is shown in Figure 3.

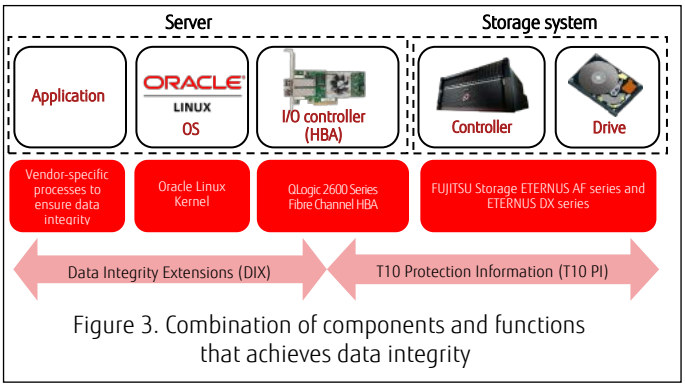

Figure 3. Combination of components and functions that achieves data integrity

- DIX validates data integrity from the application to the I/O controller (HBA).
- T10 PI validates data integrity from the I/O controller (HBA) to the drive.

4. Summary

The T10 PI and DIX functions enable data protection for the entire system including data write processes from applications to drives.

Data protection for the entire system can improve system reliability by protecting the system from damaged or inconsistent data to minimize downtime and reduce end-user maintenance costs.

For other specifications and functions of the components that are described in this document, refer to the following URLs:

- Oracle Linux
  https://www.oracle.com/linux/operating-system/index.html
- QLogic 2600 Series Fibre Channel HBA
  http://www.qlogic.com/Products/adapters/Pages/FibreChannelAdapters.aspx
- FUJITSU Storage ETERNUS AF series and ETERNUS DX series
  http://www.fujitsu.com/global/products/computing/storage/

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