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End-To-End Data Integrity Requirements For NFS

Chuck Lever <chuck.lever@oracle.com>
Consulting Member of Technical Staff

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Today’s Data Integrity Solutions

- Application
  - ADB (block poisoning)
  - Filesystem data and metadata checksumming
- Transport integrity and encryption
  - Block CRC
  - Kerberos integrity and privacy
- Storage
  - On-disk checksums
  - RAID N+1
  - Disk scrubbing

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Domain-Specific Checking Inadequate

- Silent data corruption on storage media
- Storage subsystem complexity increases failure rate
- Corruption often undetected until data is read: too late
- Checksums miss important failures
  - iSCSI can DMA the wrong pages from memory. The checksums will match the bad pages transferred
  - An array may receive incorrect data then use it to generate RAID parity blocks
  - Disks may never write data, or write it to the wrong LBA

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Protection Must Be End-To-End

- Protection should enable integrity check of I/O request at every stage of the I/O path during each write request

- Protected handoffs and conversions as the I/O transitions between domains with different protection schemes may be necessary

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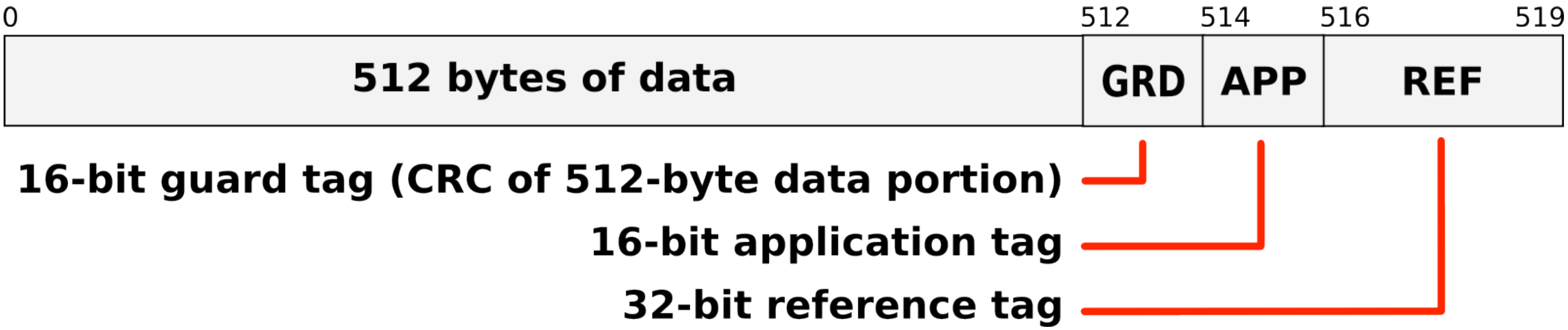
T10 Protection Information Model



16-bit guard tag (CRC of 512-byte data portion)

16-bit application tag

32-bit reference tag

- Standard 8 bytes of integrity metadata
  - Any layer of storage subsystem can re-verify the data
- Prevents content corruption and misplacement errors
- Protects path between HBA and storage device
- Protection information is interleaved with data on the wire, i.e. effectively 520-byte logical blocks

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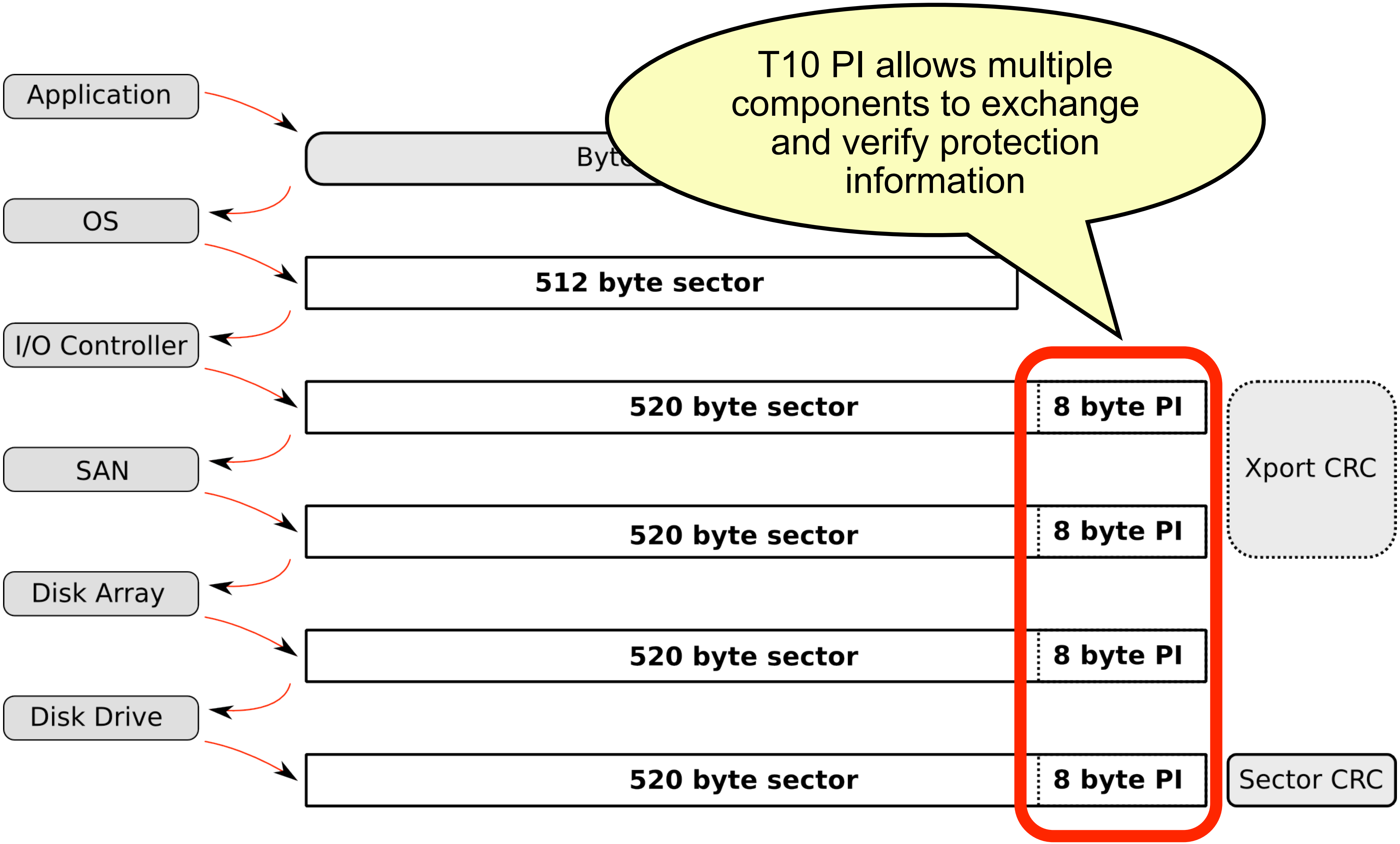
T10 Protection Information Model



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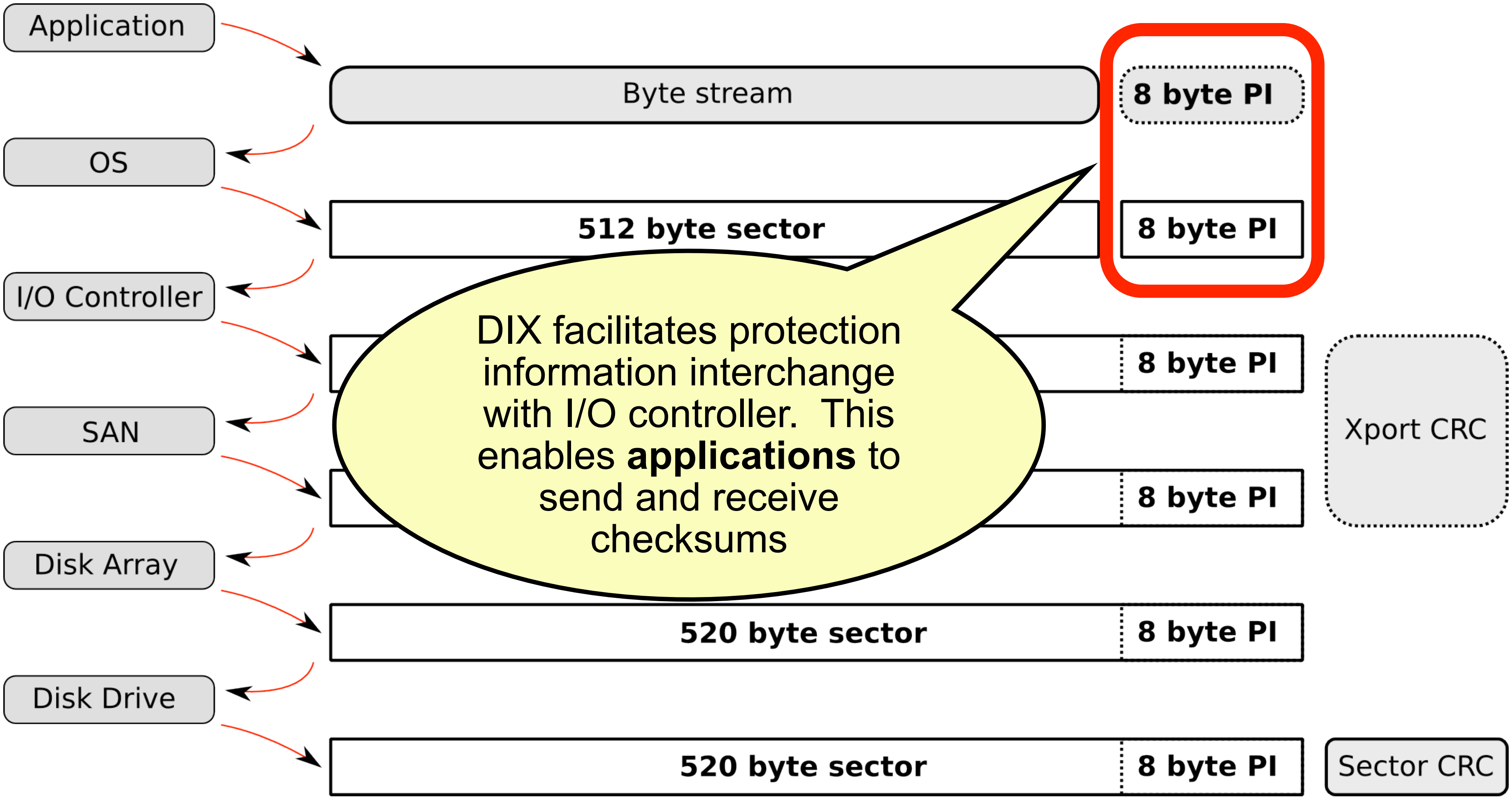
T10 Data Integrity Extensions



DIX facilitates protection information interchange with I/O controller. This enables **applications** to send and receive checksums

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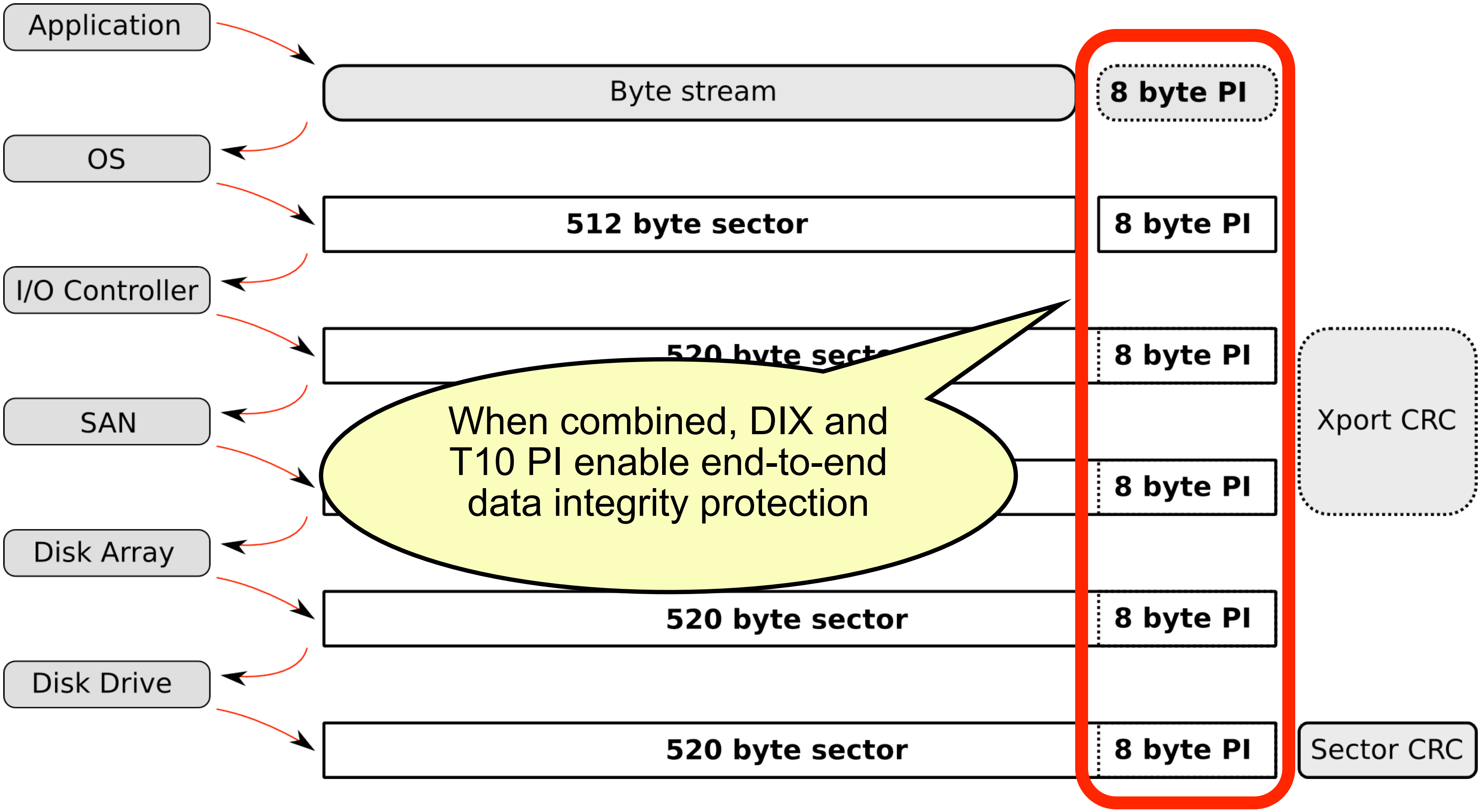
Data Integrity Extensions + T10 PI



When combined, DIX and T10 PI enable end-to-end data integrity protection

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Marrying NFS with T10 PI + DIX

- When PI-capable storage is available on an NFS server, enable applications on NFS clients to access and update PI
  - Use of a maturing standard enables choice of access
  - Proposed optional feature of NFSv4.(n+1)

- Challenges to make this work for byte-stream access model
  - Obvious fit with pNFS block layout
  - PI-enabled NFS I/O and locking must be block aligned
  - Initial use mostly by non-POSIX NFS clients

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High-Level Requirements

- Applications can read or write PI-protected data via SCSI, a pNFS layout, or non-pNFS NFS
- NFS servers can indicate that a particular share’s underlying storage supports PI
  - Not all classes of NFS servers may support PI, and not all FSIDs on one server may support it
  - Report supported T10 PI classes
  - Report data-to-PI size ratio of underlying storage
- NFS clients access PI data via an NFSv4 protocol extension
  - Must allow concurrent READ_PLUS variations (*e.g.* ADB)
  - Each READ contains one or more 8-byte PI values

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Additional Considerations

- T10 PI + DIX is not owned by IETF
  - How to reference T10 work items in an IETF standard

- Security considerations
  - Ignore, recommend or require integrity-capable transport

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