iSCSI Design

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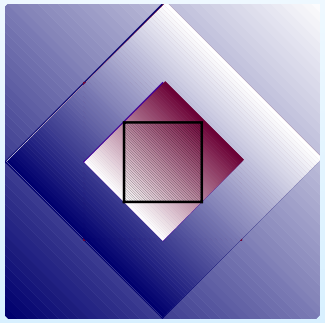
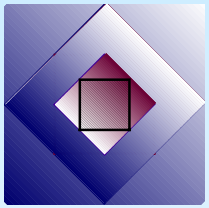
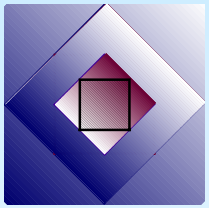




Overview

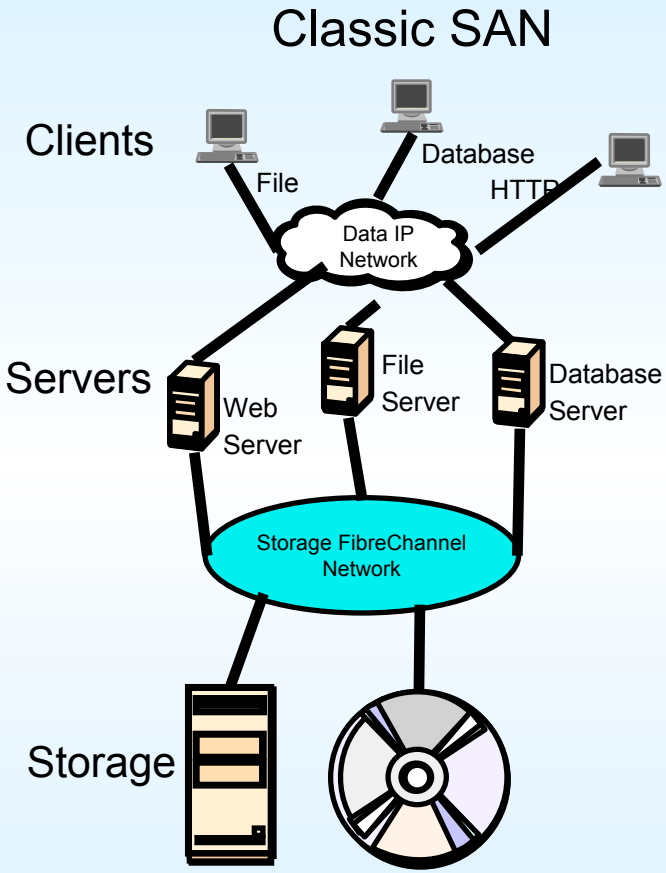
- What is iSCSI?
- Why TCP?
- Alternatives to TCP
- Drawbacks of TCP
- Data Transfer Model
- Data Placement
- Recovery

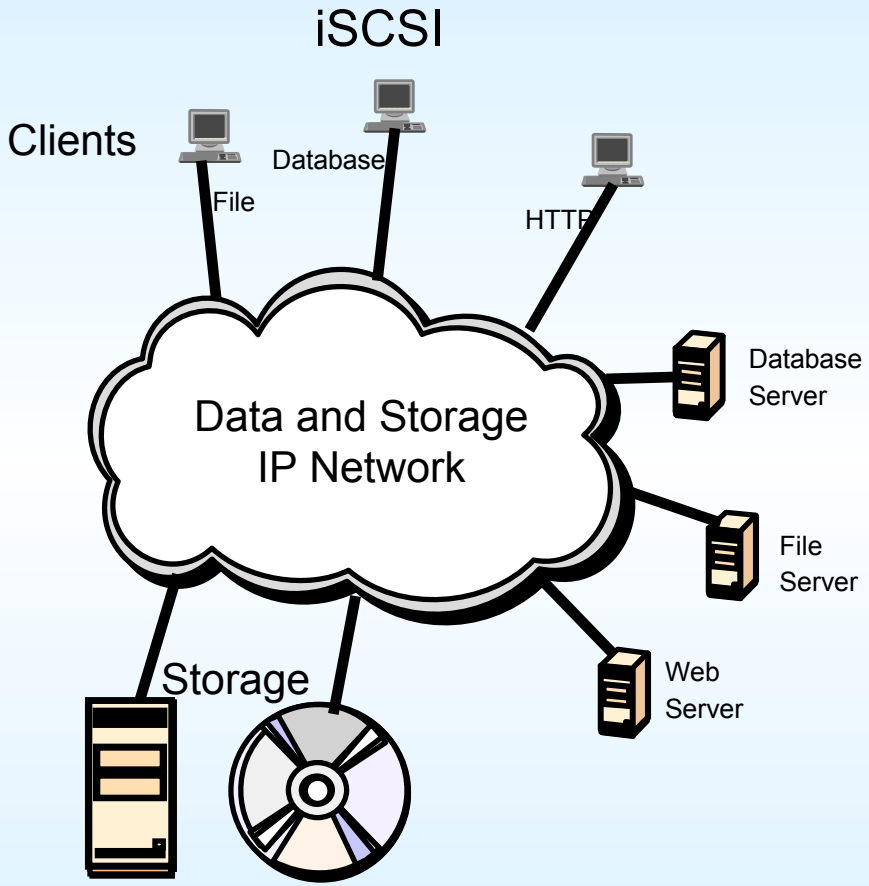


What is iSCSI?

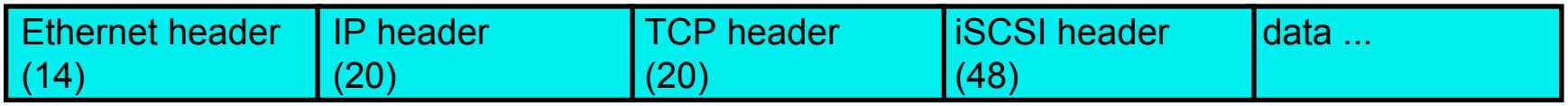
- SCSI is a protocol for I/O devices such as disk, tape, CD ROM
- iSCSI = Internet SCSI = SCSI over TCP/IP
  - send SCSI commands over an IP network
- Related SCSI transport technologies
  - SCSI Fibre Channel Protocol (FCP)
  - Serial Storage Architecture (SSA)
  - Serial Bus Protocol (SBP)
  - SCSI over Infiniband?

Classic SAN vs. iSCSI





Layered Packet Format

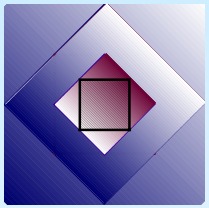


Why TCP?

- Reliable connection protocol
- Works over a variety of physical media
- Implemented on a wide variety of machines
- Field proven and scalable
- End-to-end connection model independent of the underlying network

SCSI over TCP Alternatives

- SCSI over ...
  - Ethernet
  - IP
  - UDP
  - SCTP

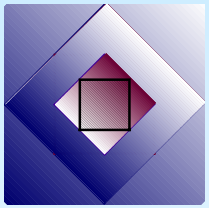


Exploit features of TCP/IP

- TCP features
  - automatic acknowledgment
  - retransmission of lost and corrupted packets
  - guaranteed in-order delivery
  - congestion control
- IP-family features
  - IPSec (security)
  - SLP (discovery)
  - DHCP (configuration)

Drawbacks of using TCP

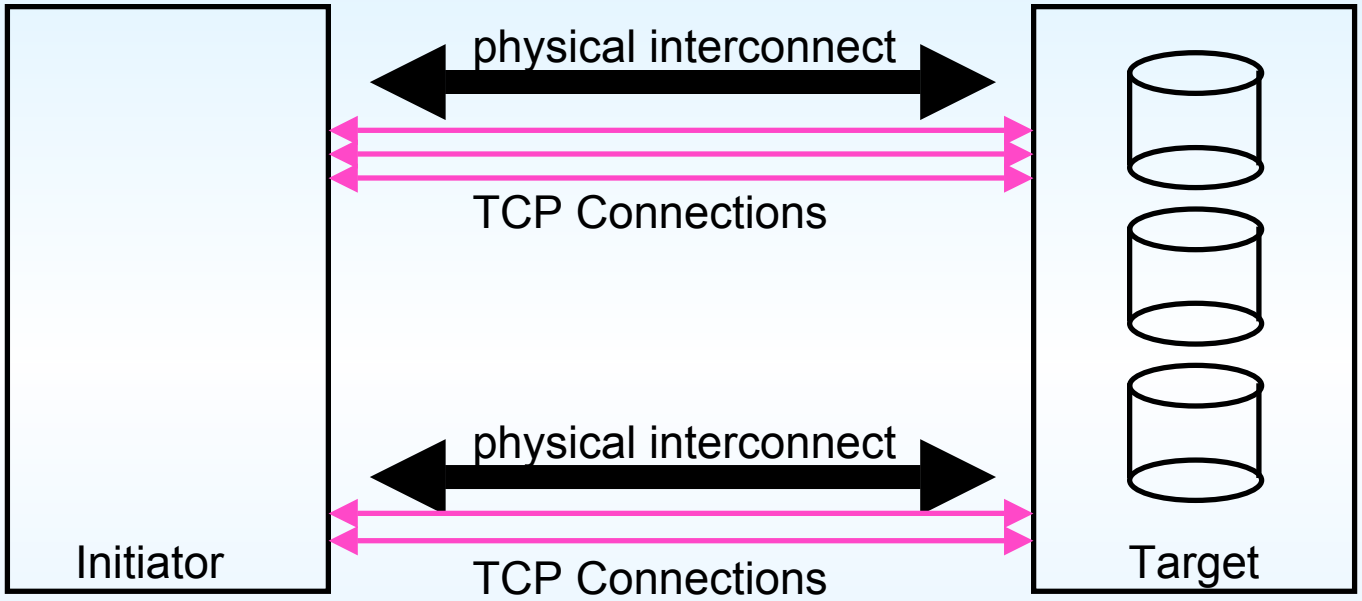
- Limited by TCP window size
  - cannot achieve maximum throughput on a single TCP connection
- Lost TCP packet causes delay in delivery of subsequent packets
  - if lose TCP packet, don't know where to find next iSCSI header(s)
- TCP checksum not sufficient for storage data integrity
- TCP usually entails multiple copying of data

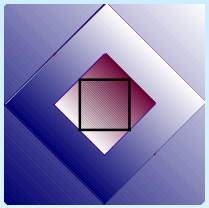


Sessions

- Collection of TCP connections between an Initiator and a Target
  - overcome bandwidth limitations imposed by TCP window size
  - utilize multiple CPUs in an SMP
- Connections of a session may traverse different physical interconnects
  - aggregate bandwidth from multiple interconnects
- Must now coordinate between multiple TCP connections

Sessions (cont.)



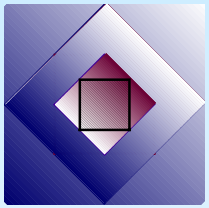


Data Transfer Model

- Asymmetric
  - single control channel
  - multiple data channels
  - control channel used to transfer commands, status, task management
- Symmetric
  - all channels identical
  - send data and status over same channel as corresponding command

Data Transfer Model *(continued)*

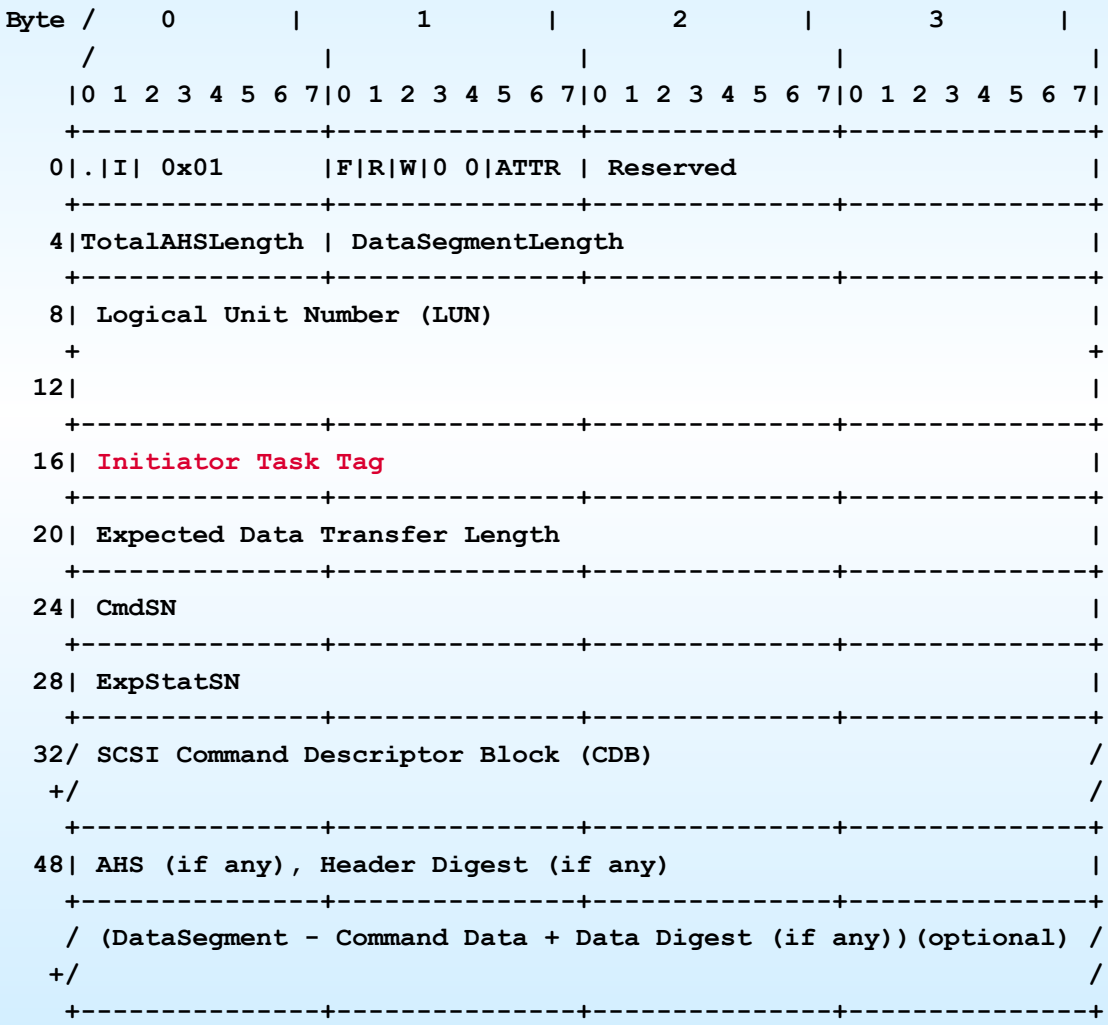
- Advantages of Asymmetric model
  - no backlog of data to block control channel
  - Task Management operation can always be timely delivered
- Advantages of Symmetric model
  - iSCSI adapter can be self-contained
  - no need to transfer command between adapters
  - simpler software implementations



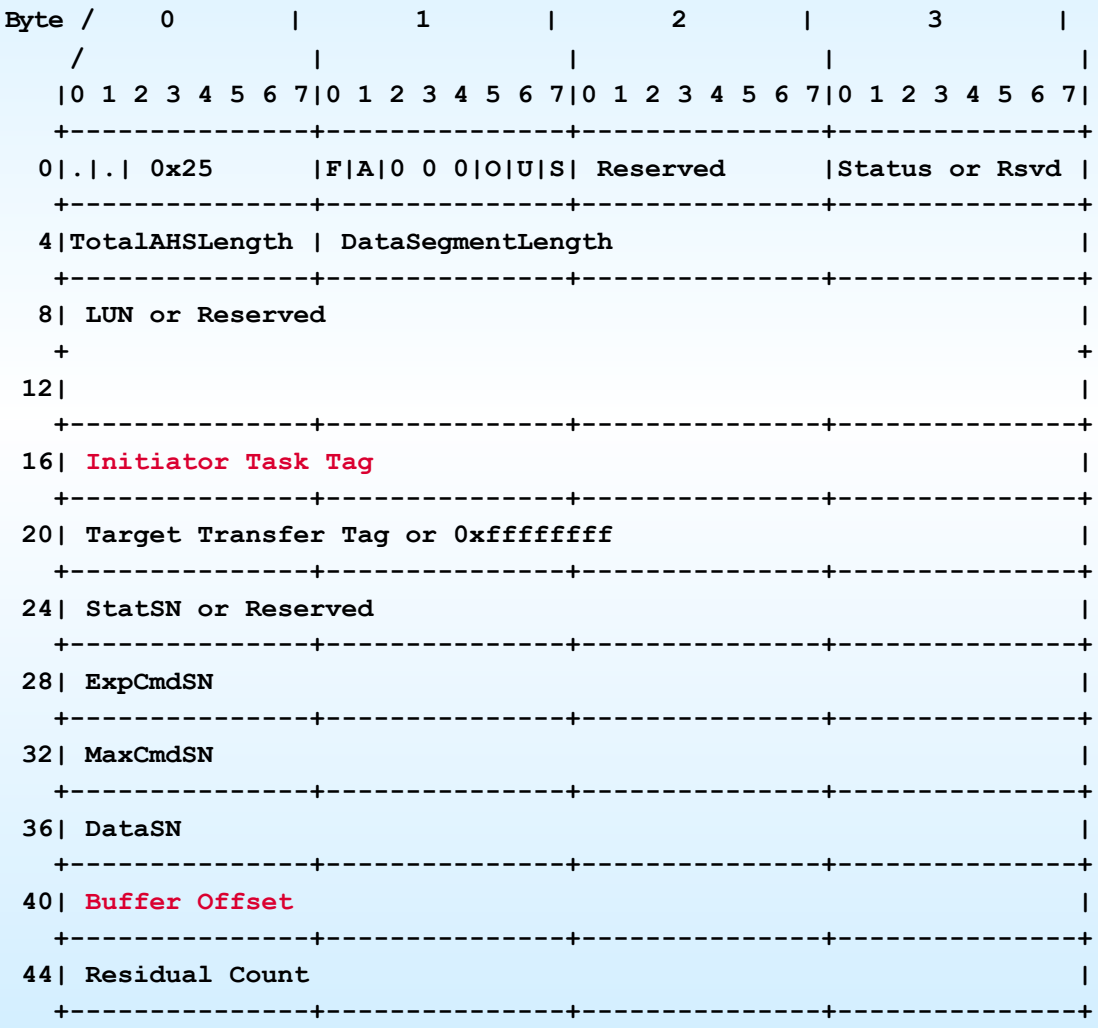
RDMA descriptors

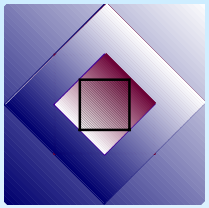
- iSCSI Task Tags can be RDMA descriptors
  - used together with offset and length fields
- Initiator Task Tag
  - provided in Command PDUs
  - copied to Data-In PDUs
- Target Task Tag
  - provided on R2T
  - copied to Data-out PDUs

SCSI Command PDU



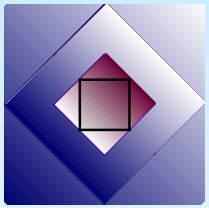
Data-in PDU


Byte / 0 | 1 | 2 | 3 |
/ | | | |
|0 1 2 3 4 5 6 7|0 1 2 3 4 5 6 7|0 1 2 3 4 5 6 7|0 1 2 3 4 5 6 7|
0|.|.| 0x25 |F|A|0 0 0|O|U|S| Reserved |Status or Rsvd |
4|TotalAHSLength | DataSegmentLength |
8| LUN or Reserved |
12|
16| Initiator Task Tag |
20| Target Transfer Tag or 0xffffffff |
24| StatSN or Reserved |
28| ExpCmdSN |
32| MaxCmdSN |
36| DataSN |
40| Buffer Offset |
44| Residual Count |
48



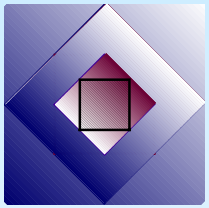
Out of Order Data Placement

- TCP delivers data in order
- If packet is dropped (at 10 Gb) or have digest error, have big data backlog
  - either store data on adapter (100s of MBs)
  - save data in temporary host memory and copy
  - drop data after missing packet
- Use markers (or framing) to find next iSCSI PDU
- Place data (from next PDU) in memory
  - don't yet inform application of data arrival
  - preserve TCP ordering semantics



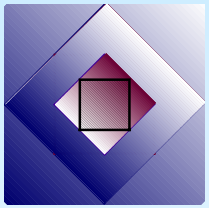
Framing

- Can we tell from TCP packet where next iSCSI/ULP (Upper Level Protocol) packet begins?
- Needed when a packet is dropped or corrupted to jump to next iSCSI/ULP packet
- IETF Working Group looking into problem
- No agreed upon mechanism yet



iSCSI Recovery

- Main reasons for iSCSI-level recovery
  - TCP connections occasionally break
    - maintain session across new connection
  - Digest errors
- Critical for long distance and tape operations
  - do not want to restart a large data transfer due to a transient TCP problem
- Levels of Recovery
  - Session Recovery (required)
  - Connection Recovery
  - Recovery within connection
  - Recovery within command



Summary

- iSCSI leverages existing features of TCP and the IP family of protocols
- iSCSI was designed with features to overcome TCP limitations
  - sessions with multiple connections
  - CRC digests
  - possible out of order data placement
- Multiple recovery options for different environments