SDC
STORAGE DEVELOPER CONFERENCE
SNIA ■ SANTA CLARA, 2014

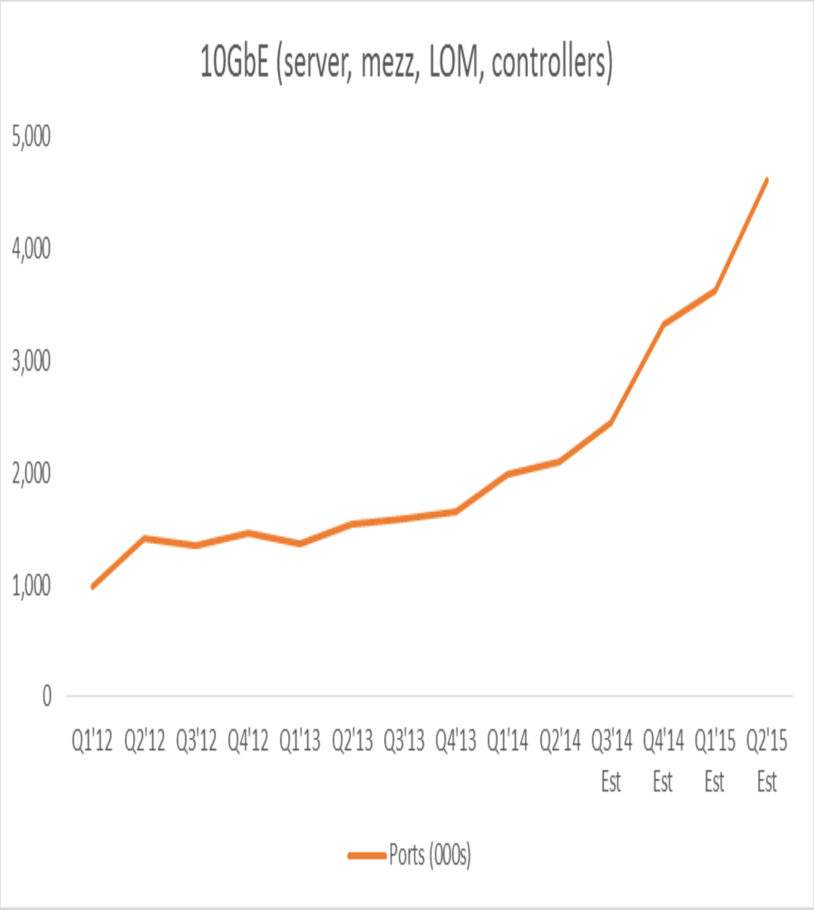
NFS/RDMA over 40Gbps iWARP

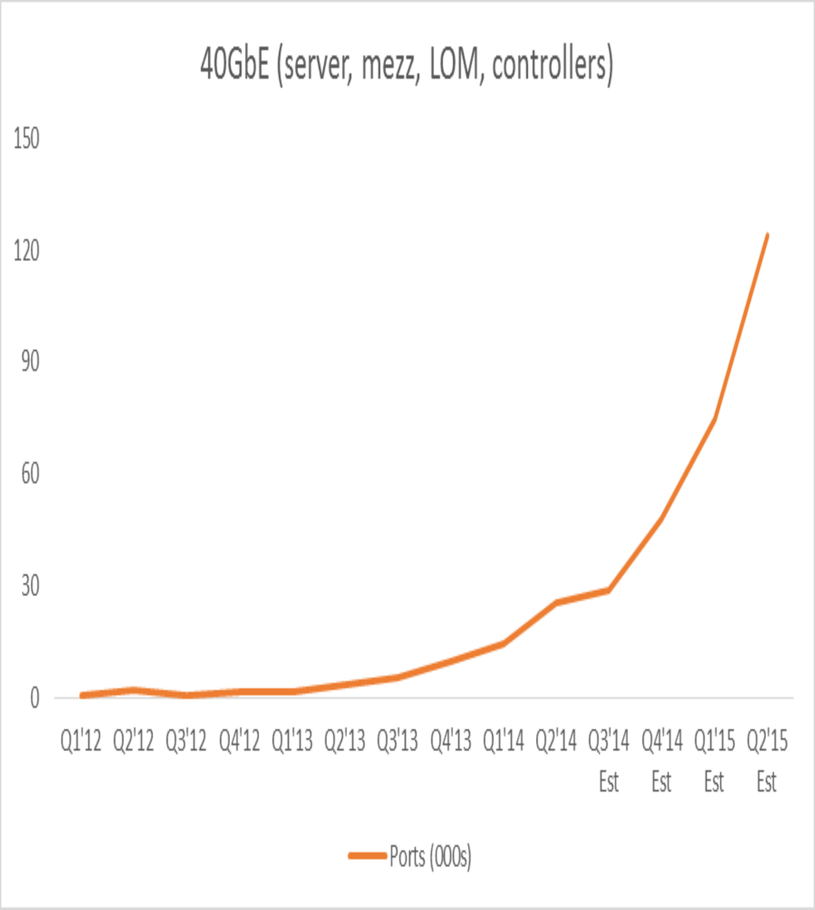
Wael Noureddine
Chelsio Communications

Outline

- RDMA
  - Motivating trends
  - iWARP
- NFS over RDMA
  - Overview
  - Chelsio T5 support
  - Performance results

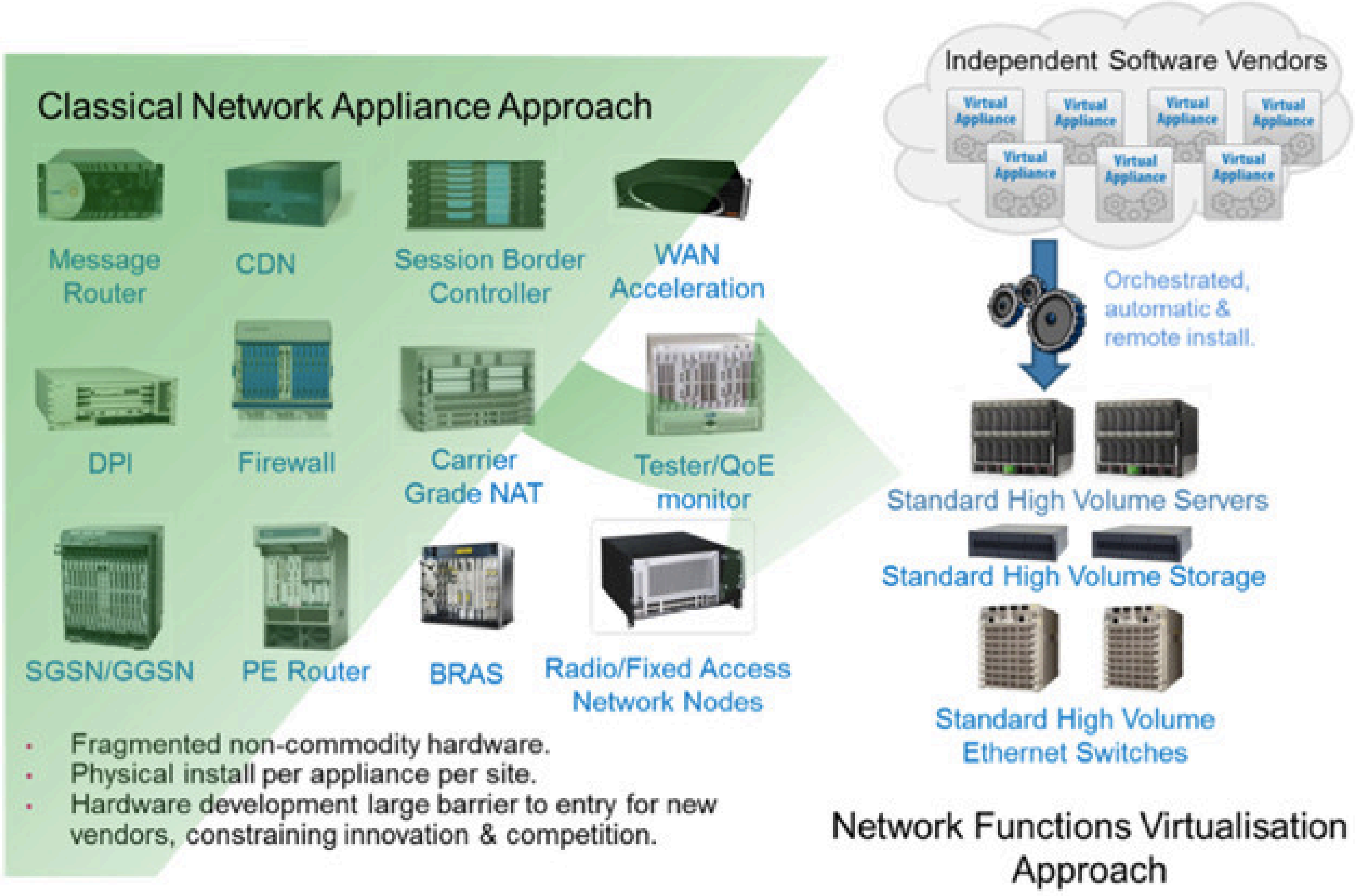
Adoption Rate of 40GbE





Source: Crehan Research - 2Q14 CREHAN Quarterly Market Share Tables

Software Defined Everything


Classical Network Appliance Approach
Message Router
CDN
Session Border Controller
WAN Acceleration
DPI
Firewall
Carrier Grade NAT
Tester/QoE monitor
SGSN/GGSN
PE Router
BRAS
Radio/Fixed Access Network Nodes
Independent Software Vendors
Virtual Appliance
Virtual Appliance
Virtual Appliance
Virtual Appliance
Virtual Appliance
Virtual Appliance
Virtual Appliance
Orchestrated, automatic & remote install.
Standard High Volume Servers
Standard High Volume Storage
Standard High Volume Ethernet Switches
Network Functions Virtualisation Approach

- Fragmented non-commodity hardware.
- Physical install per appliance per site.
- Hardware development large barrier to entry for new vendors, constraining innovation & competition.

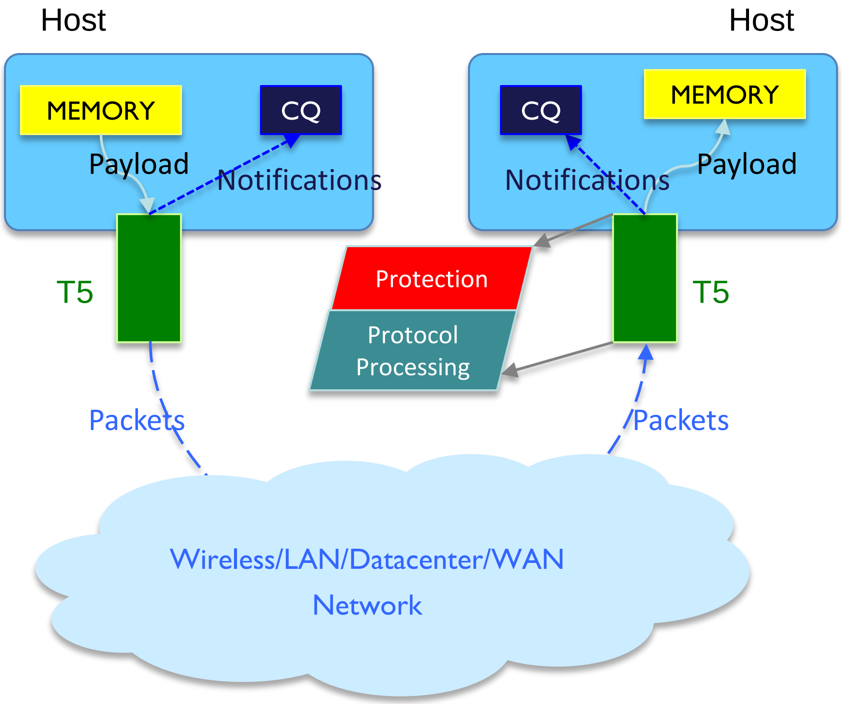
Source: European Telecommunications Standards Institute *http://portal.etsi.org/nfv/nfv_white_paper.pdf* *October, 2012*

Motivating Trends

- Unprecedented curve in 40GbE growth (and pricing)
- Consolidation and virtualization
  - Software defined storage (everything) using commodity hardware
  - Rise of the data center
  - Power efficiency
- High speed, ultra low latency SSDs
- Need for high performance, high efficiency fabric
  - Ethernet remains the preferred technology
  - TCP/IP for scalability, reliability, robustness and reach

iWARP RDMA over Ethernet

RDMA Overview



Performance and efficiency in return for new communication paradigm

- Direct memory-to-memory transfer
- All protocol processing handled by the NIC
  - Must be in hardware
- Protection handled by the NIC
  - User space access requires both local and remote enforcement
- Asynchronous communication model
  - Reduced host involvement
- Performance
  - Latency – polling
  - Throughput
- Efficiency
  - Zero copy
  - Kernel bypass (user space I/O)
  - CPU bypass

iWARP RDMA over Ethernet

- IETF RFCs in 2007
  - Open standard
  - Multiple vendors
- Ongoing standardization
  - Extensions to maintain API uniformity with InfiniBand
  - Recent RFC 7306 by Broadcom, Chelsio and Intel
- Mature stack
  - 3rd generation hardware
- RDMA over TCP/IP/Ethernet
  - TCP reliability, scalability, congestion and flow control
  - IP routability
  - Ethernet ubiquity

- Wireless ready
  - Near 10Gbps, low latency
- Cloud ready
  - Standard TCP/IP foundation
  - No network restrictions
- Full featured implementation
  - All RDMA benefits
- High performance
  - High packet rate
  - Low latency (1.5usec user-to-user)
  - Line rate 40Gb with single connection

iWARP Benefits

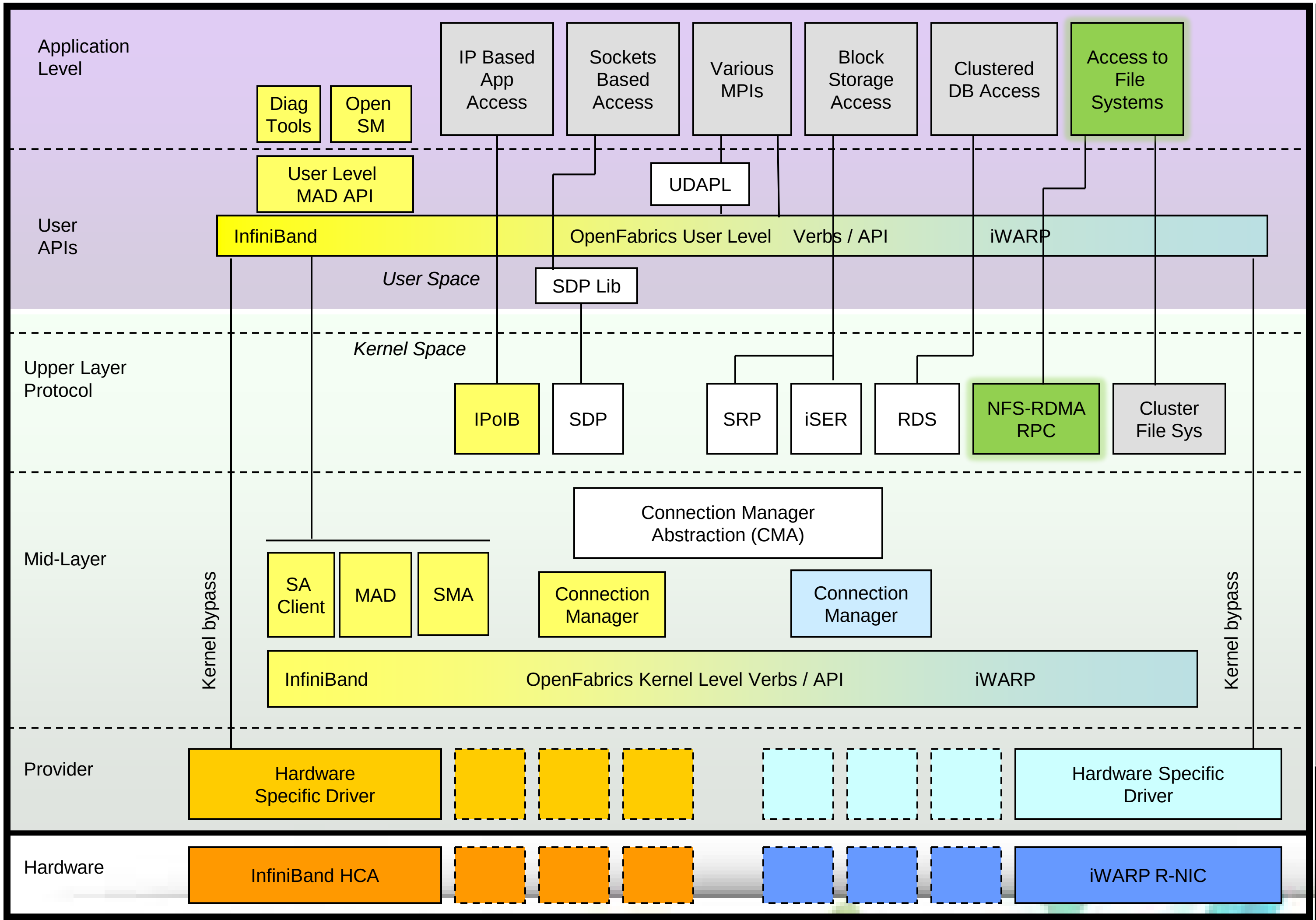
- Convergence
  - Coexists with all other traffic on same port
  - No special treatment needed
- Familiar protocol stack
  - Standard tools for monitoring/debugging
  - Standard network function appliances (security, load balancing…)
- Plug-and-play
  - No need for lossless network operation
  - Leverages existing infrastructure
  - Less expensive network hardware

✓ Easy to deploy and manage

- Leverages decades of TCP/IP experience
  - Congestion avoidance and control
  - Critical for network stability
- Reliability at hardware speeds
  - Retransmission and re-ordering
- Routable
  - Goes wherever IP is spoken
- Scalable across
  - Network size
  - Network architecture
  - Distance

✓ Reliable, robust, scalable

Linux RDMA Architecture



SA	Subnet Administrator
MAD	Management Datagram
SMA	Subnet Manager Agent
PMA	Performance Manager Agent
IPoIB	IP over InfiniBand
SDP	Sockets Direct Protocol
SRP	SCSI RDMA Protocol (Initiator)
iSER	iSCSI RDMA Protocol (Initiator)
RDS	Reliable Datagram Service
UDAPL	User Direct Access Programming Lib
HCA	Host Channel Adapter
R-NIC	RDMA NIC

Key

- Common
- InfiniBand
- iWARP
- Apps & Access Methods for using OF Stack

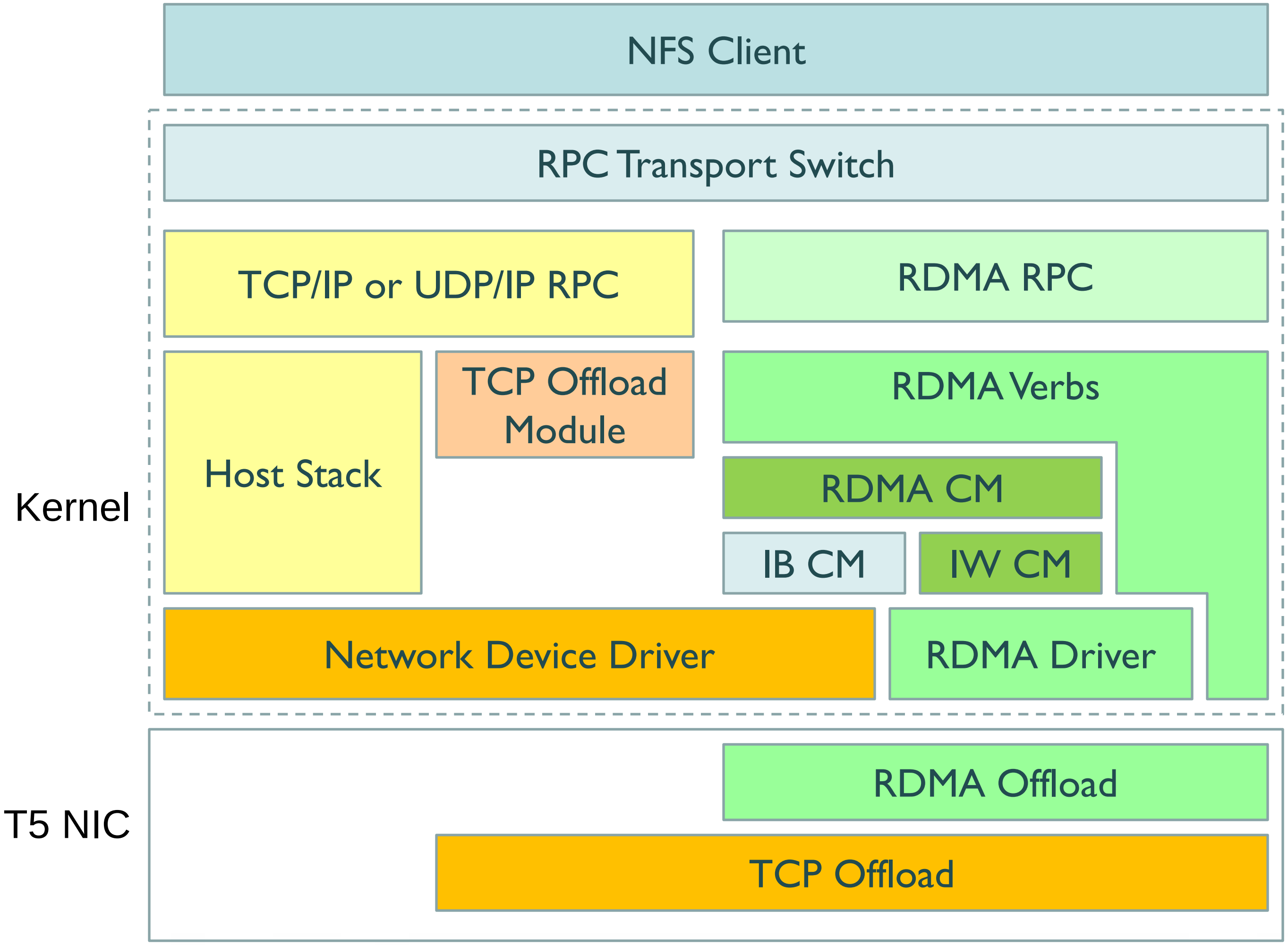
NFS over RDMA Timeline

- NetApp/Sun 2007
- IETF RFCs
  - RFC 5532 problem statement in 2009
  - RFC 5666 RDMA for RPC in 2010
  - RFC 5667 NFS DDP in 2010
- Renewed effort with rise in RDMA interest
  - Under active development – mostly client side
  - Chelsio, Emulex, Intel, LANL, Mellanox, NASA, NetApp, Oracle…

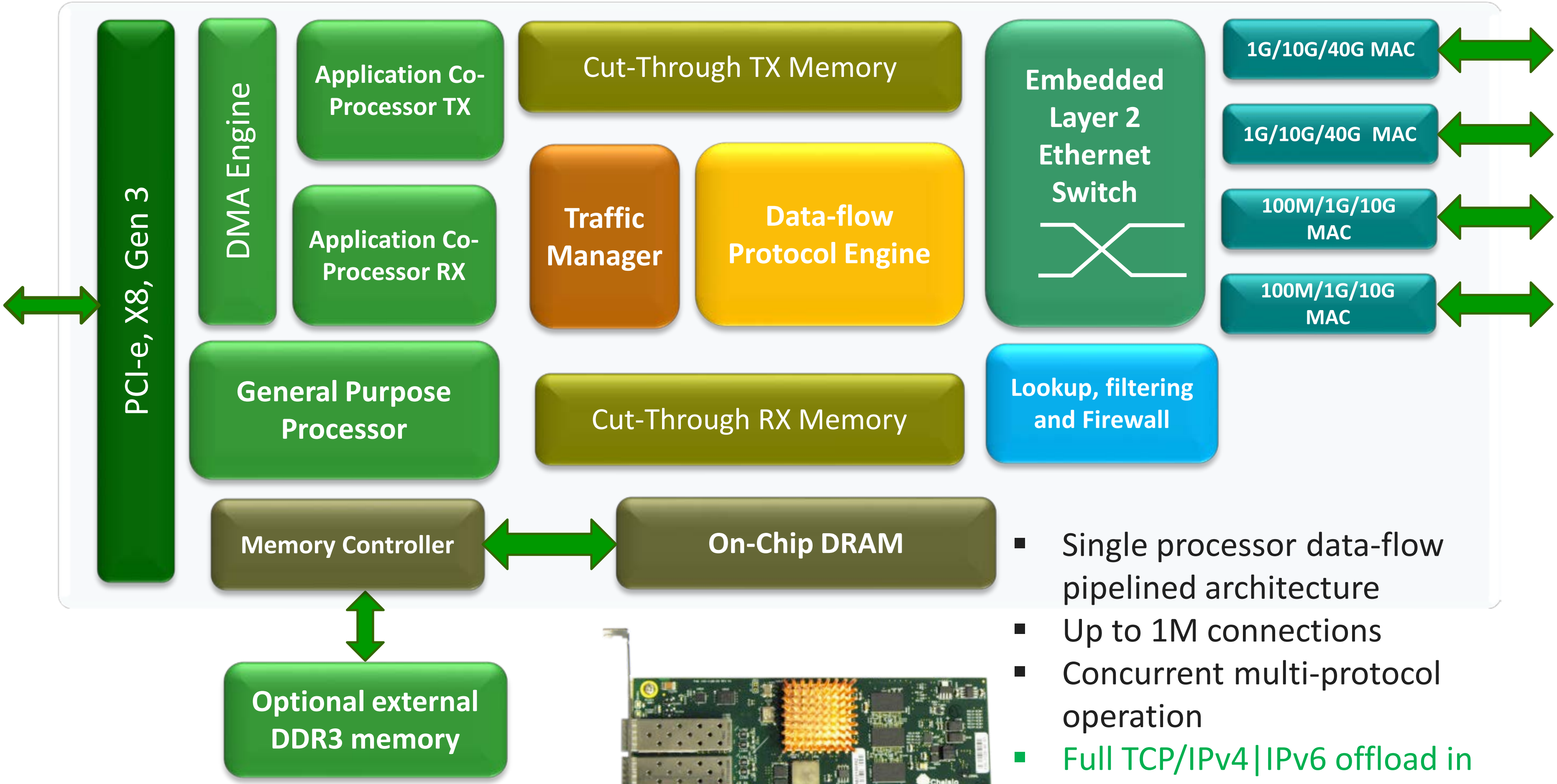
NFS over RDMA Overview

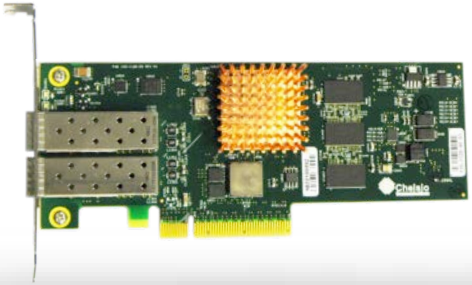
- NFS extensions to use RDMA fabric (for NFSv2,3,4)
- Client sends RPC in RDMA messages
- Server initiates RDMA data transfer transactions
  - Reduces client side CPU utilization
  - Eliminates client side data copies
  - Leverages low latency fabric
  - Requires NIC with RDMA offload at both server and client ends

NFS Client Stack



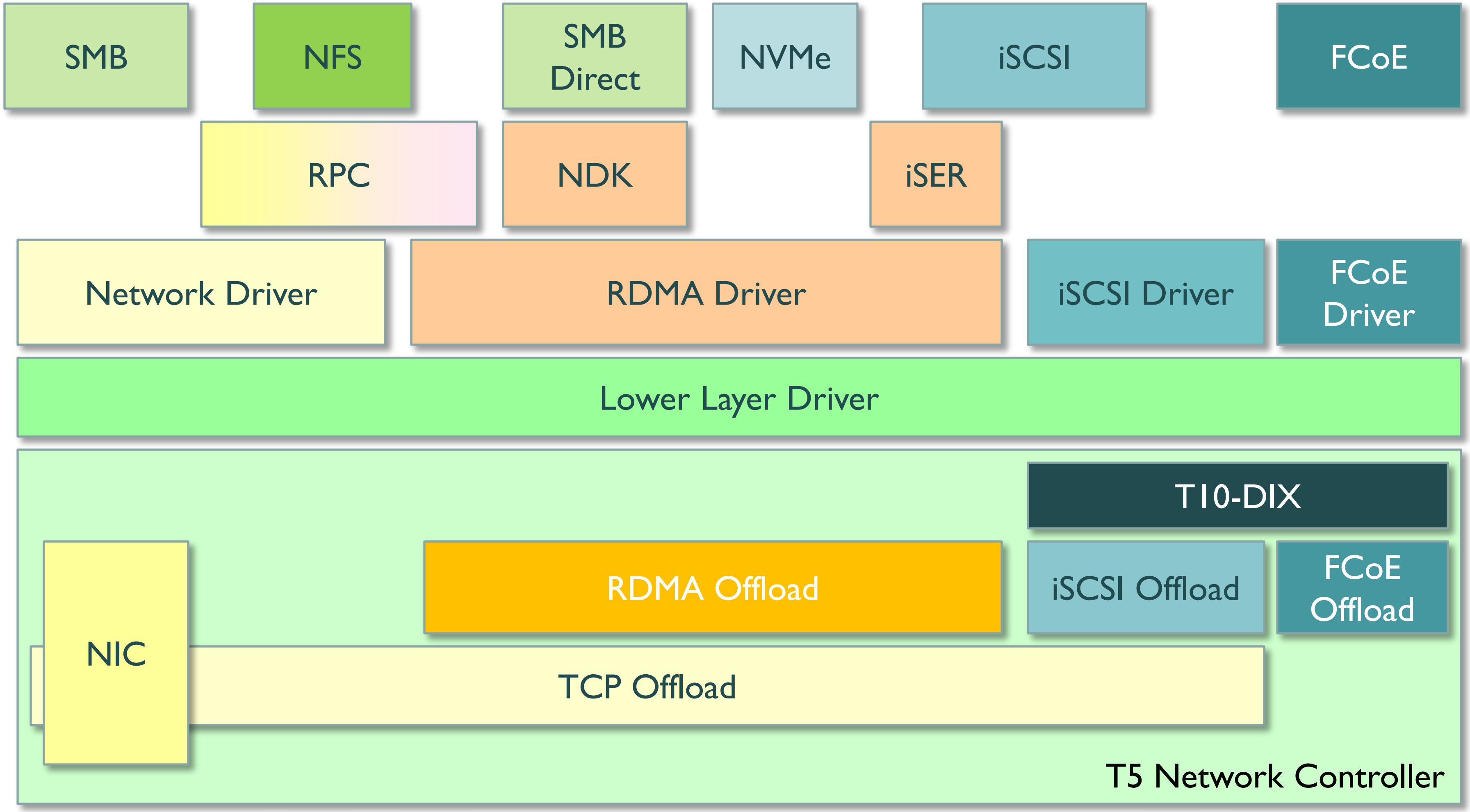
Chelsio T5 Ethernet Controller ASIC


PCI-e, X8, Gen 3
DMA Engine
Application Co-Processor TX
Application Co-Processor RX
Cut-Through TX Memory
Traffic Manager
Data-flow Protocol Engine
Embedded Layer 2 Ethernet Switch
1G/10G/40G MAC
1G/10G/40G MAC
100M/1G/10G MAC
100M/1G/10G MAC
General Purpose Processor
Cut-Through RX Memory
Lookup, filtering and Firewall
Memory Controller
On-Chip DRAM
Optional external DDR3 memory

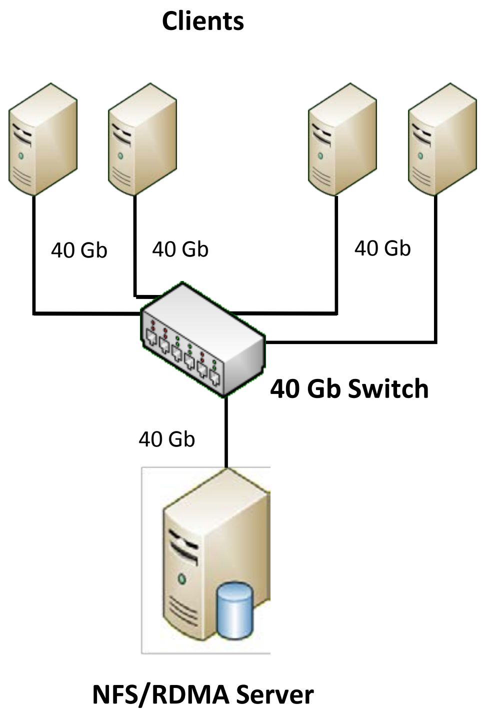


- Single processor data-flow pipelined architecture
- Up to 1M connections
- Concurrent multi-protocol operation
- Full TCP/IPv4|IPv6 offload in 4CLK @500MHz

T5 Storage Protocol Support



Test Configuration

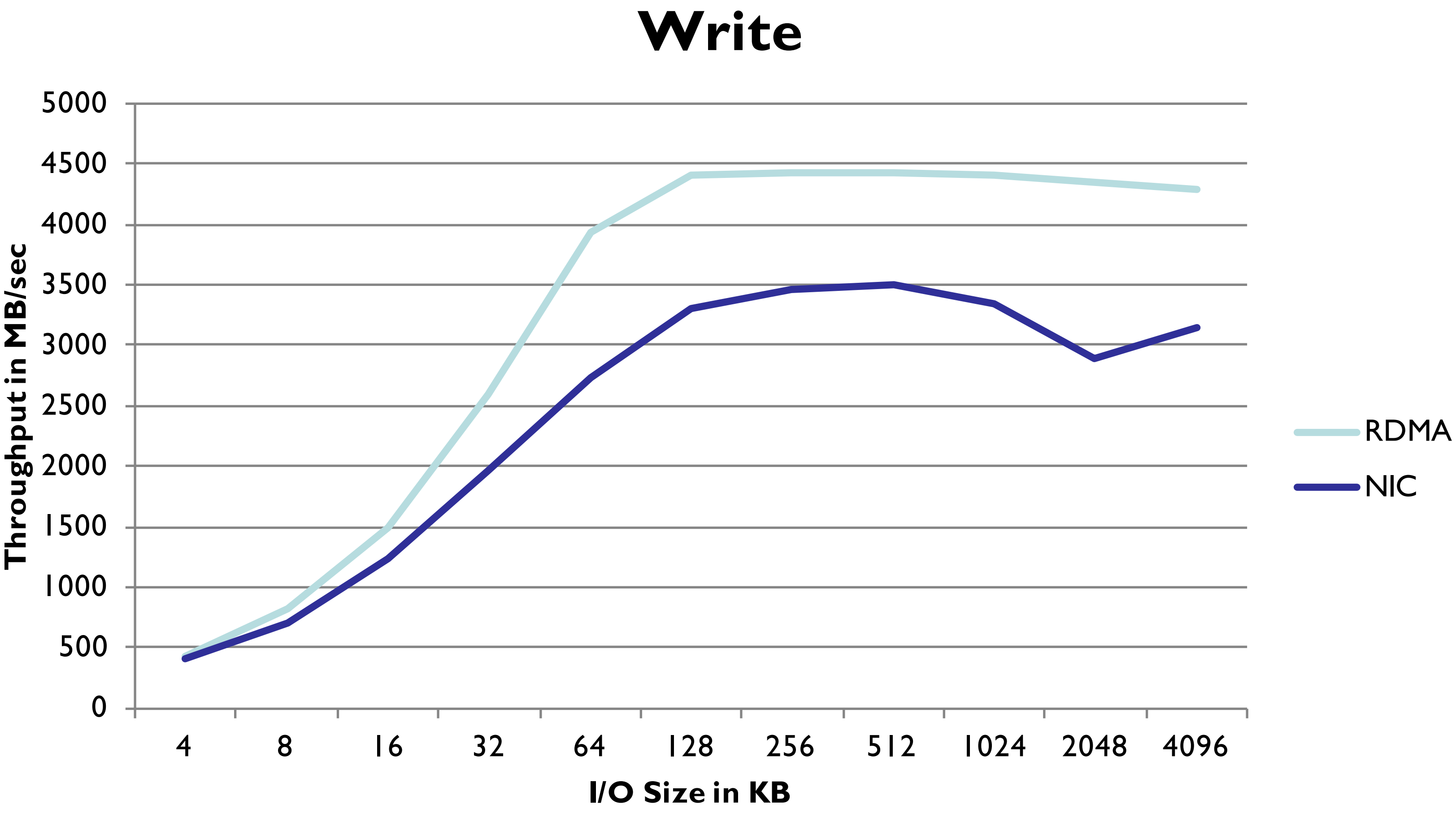


- *Clients connected through switch to server with all 40Gbps links*
- *Sequential I/O direct (no buffer caching)*
- *Need OFED 3.12+ for 40G iWARP support*

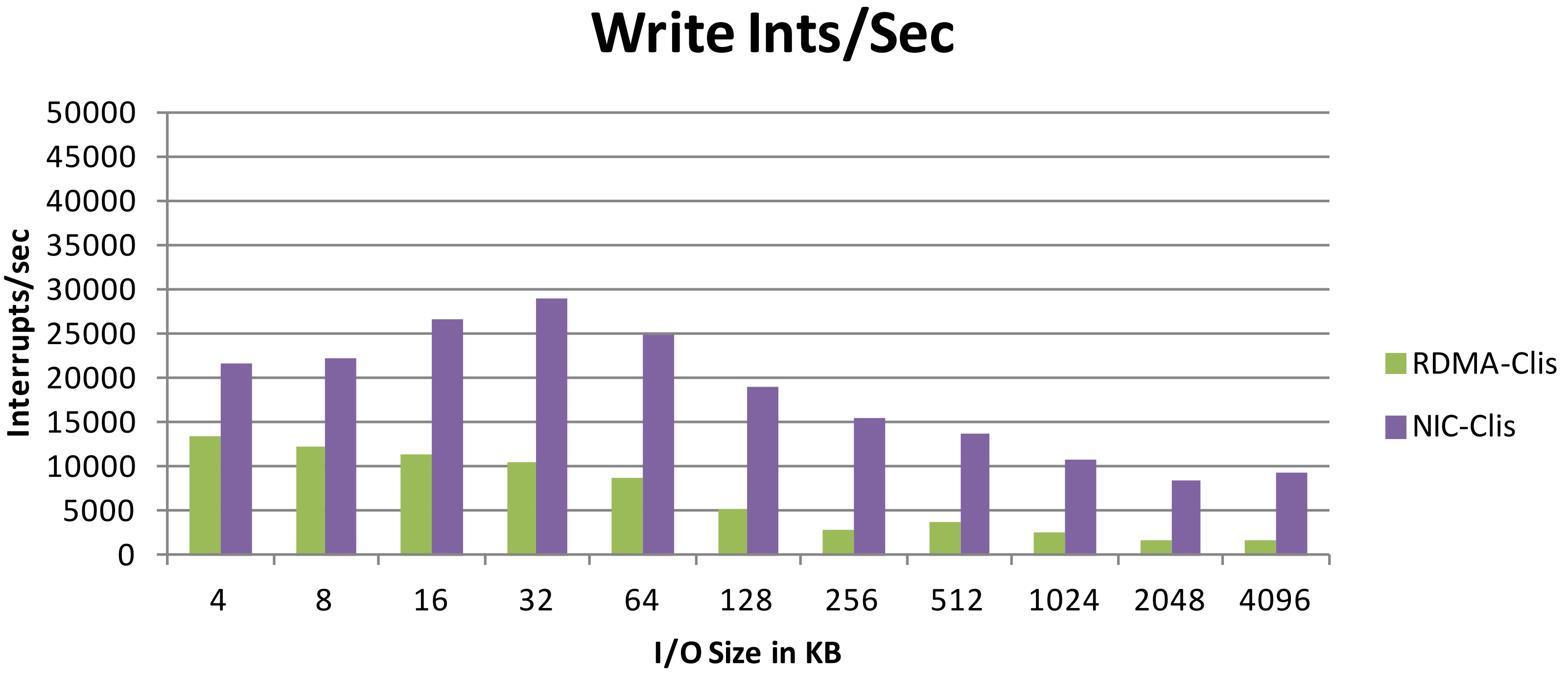
Clients (x4)	
OS	RHEL6.5
Kernel	3.16.0, NFSv4 + latest NFSRDMA fixes
Processor	Intel(R) Xeon(R) CPU E5-2687W v2@3.40GHz
No of Processors	2
No of Cores Total	16 (HT Disabled)
RAM	64 GB
Card Type	T580-CR
Card Core Clock	500MHz

Server	
OS	RHEL6.1
Kernel	3.16.0, NFSv4 + latest NFSRDMA fixes
Processor	Intel(R) Xeon(R) CPU E5-2687W @ 3.10GHz
No of Processors	2
No of Cores Total	16 (HT Disabled)
RAM	64 GB
Card Type	T580-CR
Card Core Clock	500MHz
Share	32GB ramdisk w/ ext2 filesystem.

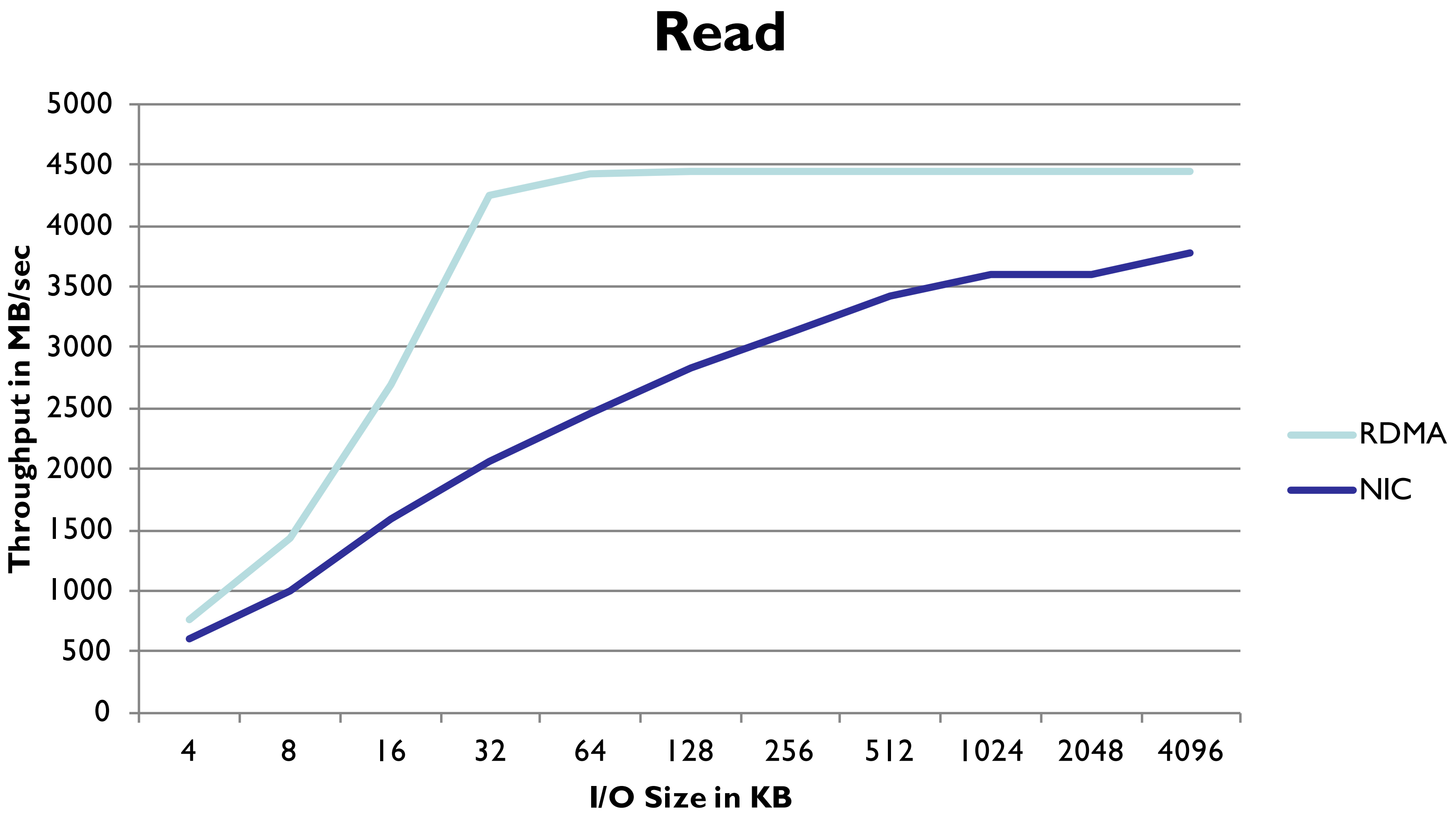
NFS Write – iWARP vs. L2 NIC



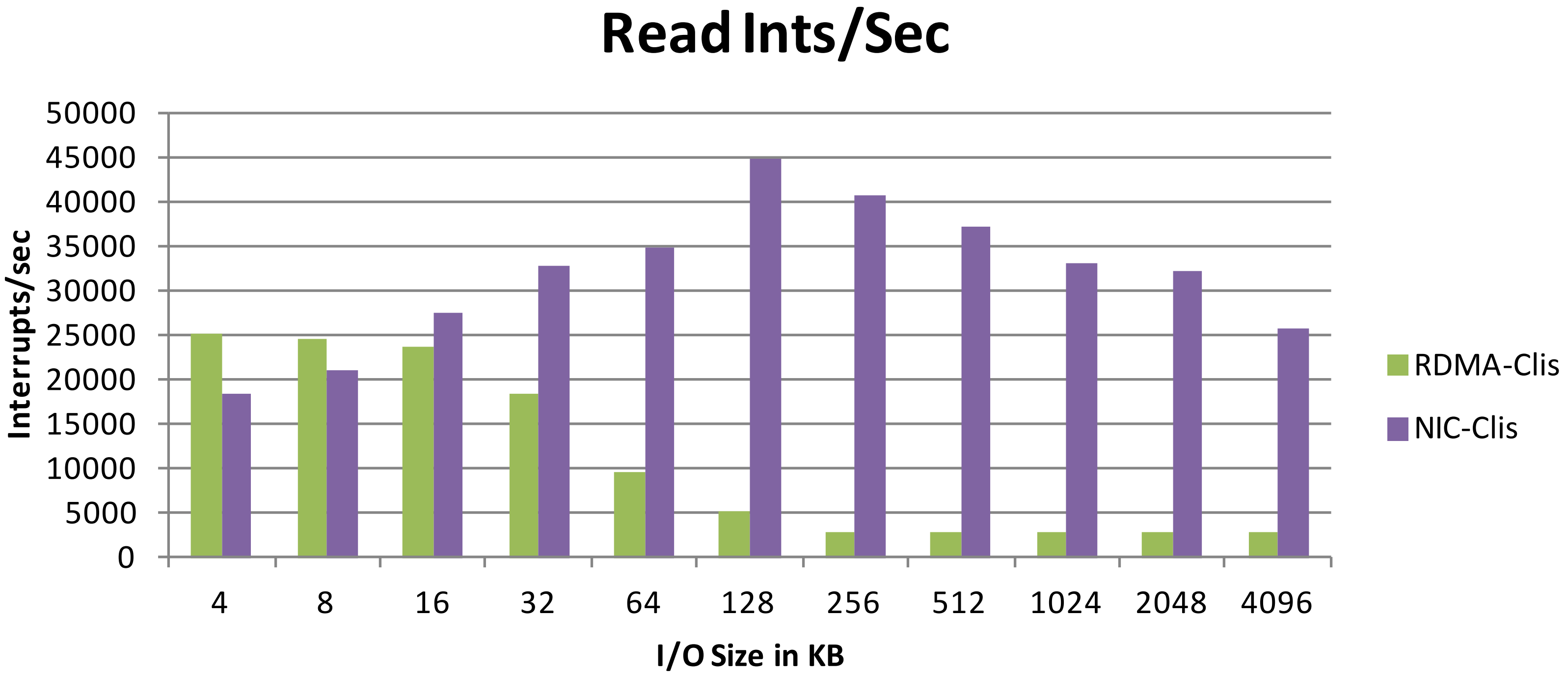
NFS Write Client Ints/sec – iWARP vs. L2 NIC



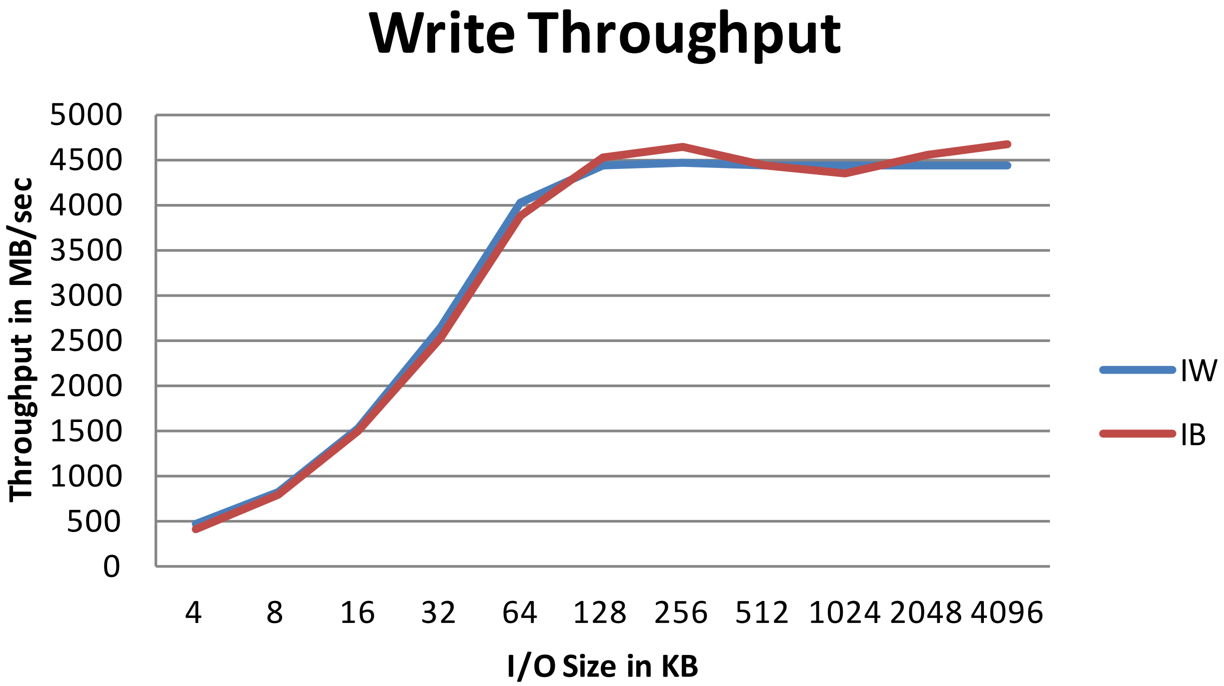
NFS Read – iWARP vs. L2 NIC



NFS Read Client Ints/sec – iWARP vs. L2 NIC

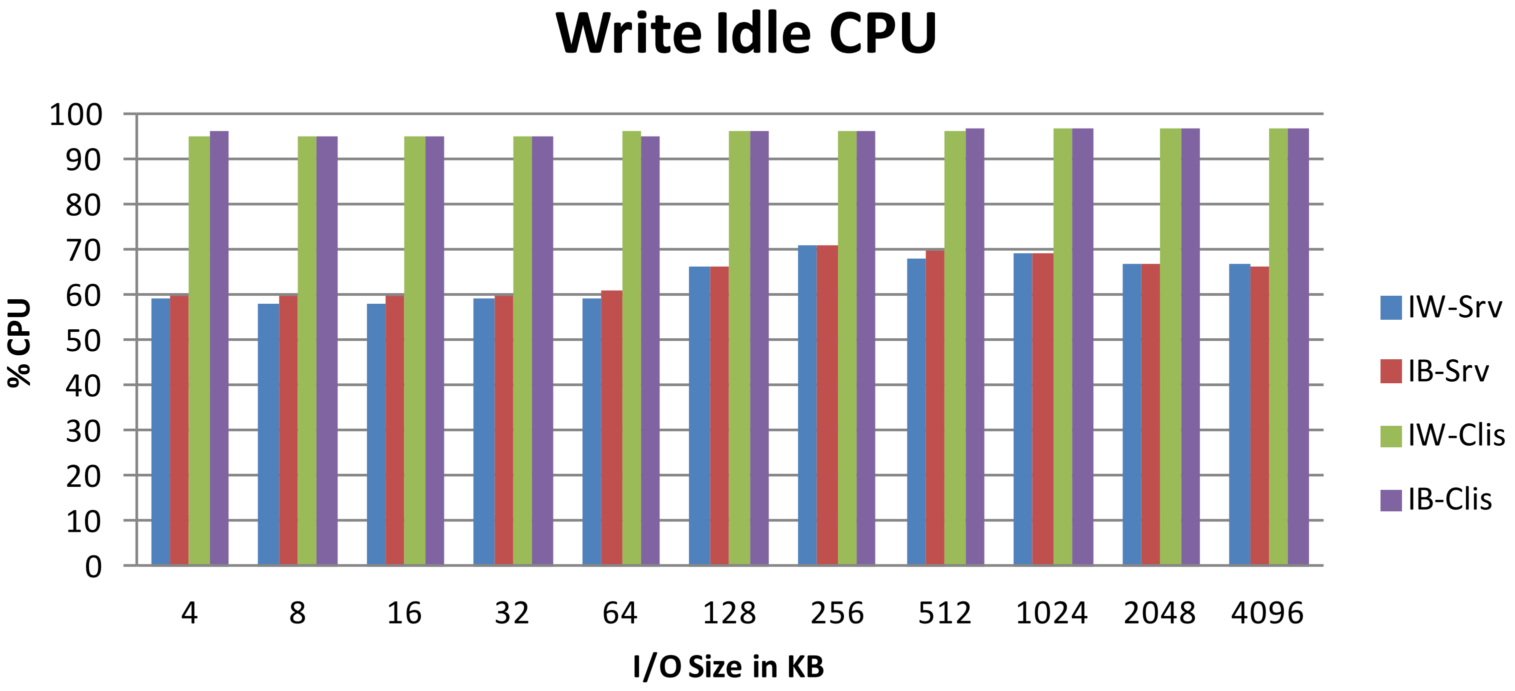


NFS Write – iWARP vs. InfiniBand

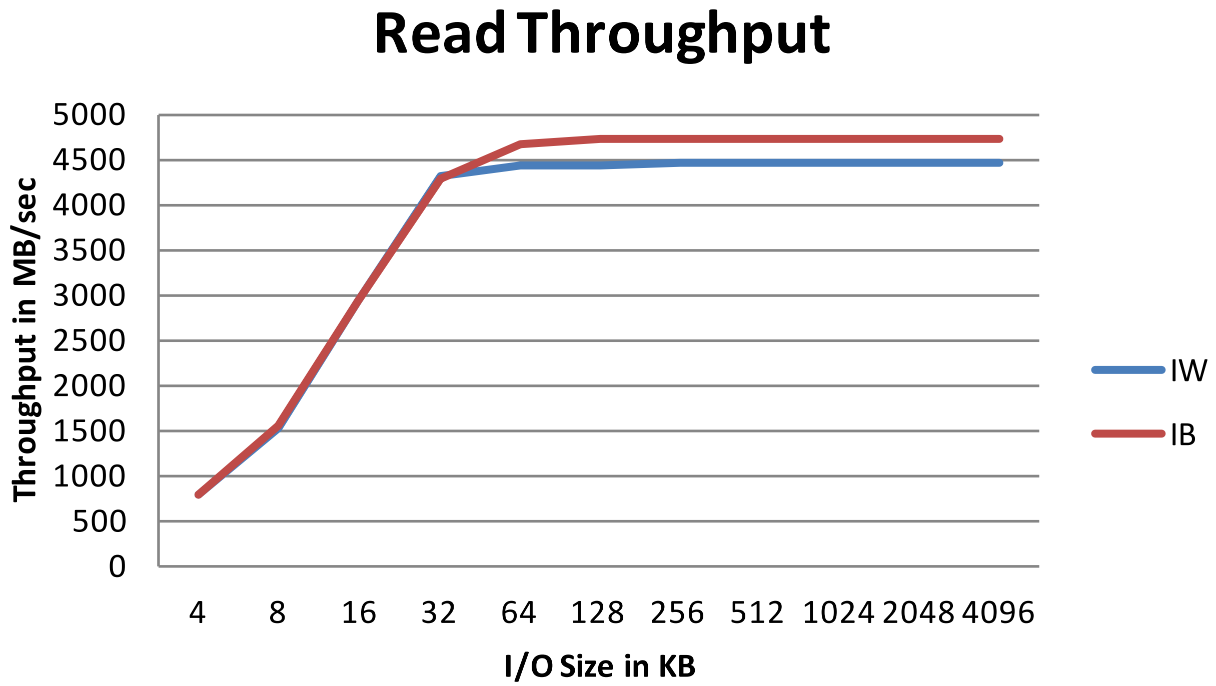


RHEL6.4, NFS Share: 40GB ramdisk, ext2 file system
Kernel: 3.16.0 + NFSv4 + latest NFSRDMA/cxgb4 fixes, default settings
CPU: Intel(R) Xeon(R) CPU E5-2687W 0 @ 3.10GHz 64GB RAM 2 CPUs, 16 cores total, no HT
IW HW: Chelsio Communications Inc T580-LP-CR Unified Wire Ethernet Controller
IB HW: Mellanox Technologies MT27500 Family [ConnectX-3] FDR

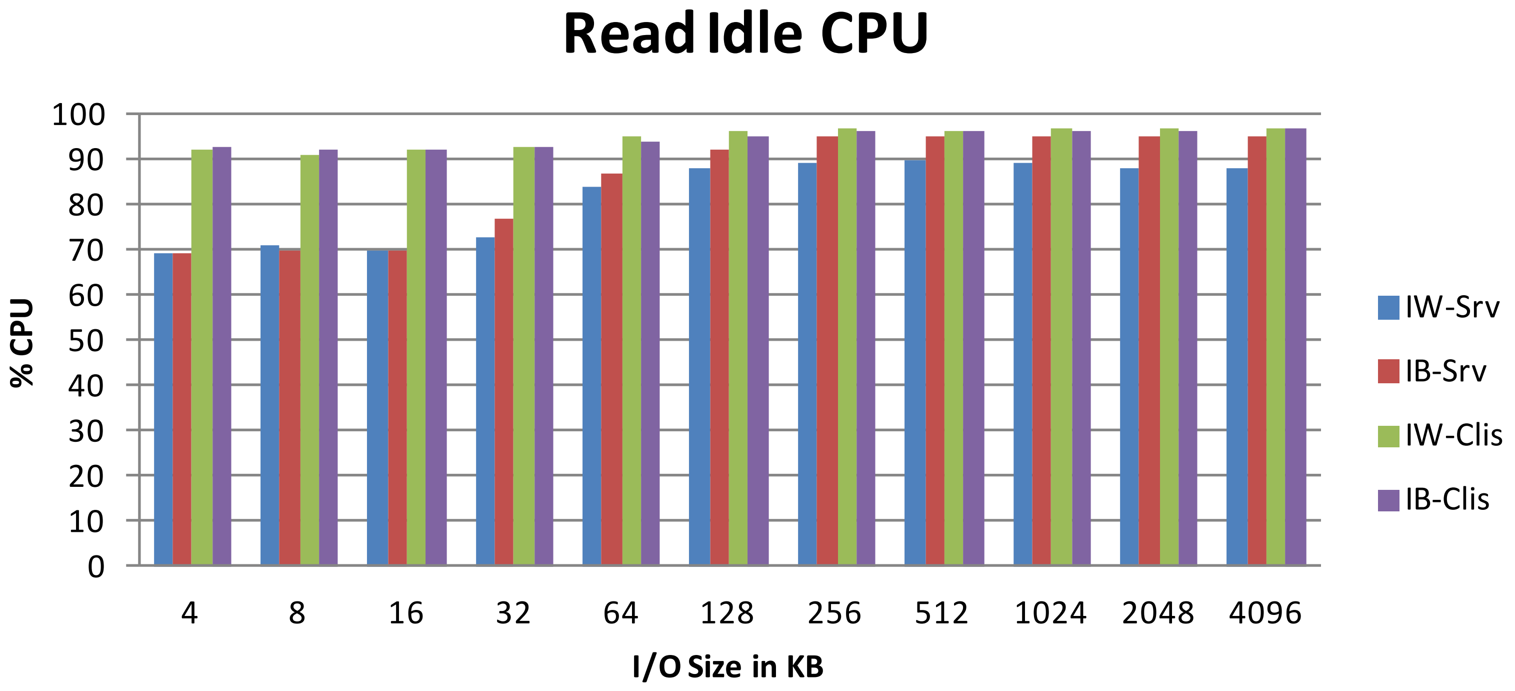
NFS Write – iWARP vs. FDR InfiniBand



NFS Read – iWARP vs. InfiniBand



NFS Read – iWARP vs. InfiniBand



Conclusions

- RDMA fabric offers potential for improved efficiency
  - SMB v3.0 RDMA transport demonstrated significant gains
- Renewed interest in NFS/RDMA
  - Work in progress
  - Performance benefits compared to NIC
- iWARP RDMA is shipping at 40Gbps
  - High performance Ethernet alternative to InfiniBand
- Chelsio adapter enables simultaneous operation of RDMA, NIC, TOE, iSCSI, FCoE…
  - TCP/IP for Wireless, LAN, Datacenter and Cloud networking
  - Remains "a great all-in-one adapter"*
- Call to action
  - Contribute to RDMA and NFS/RDMA in Linux
  - Mailing lists linux-rdma and linux-nfs on vger.kernel.org

* Helen Chen et al. OFA NFS/RDMA Presentation 2007

Thank You

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