



# **‘How fast is fast?’**

## **Block IO performance on a RAM disk**

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# Why Measure Performance on a RAM Disk?

- High Performance Storage is moving to the memory channel
- New NVDIMM Block IO SSDs are being released
- RAM disk Performance shows how fast Storage may get:
  - Block IO SSD devices on the memory channel
  - In memory load / store memory mapping



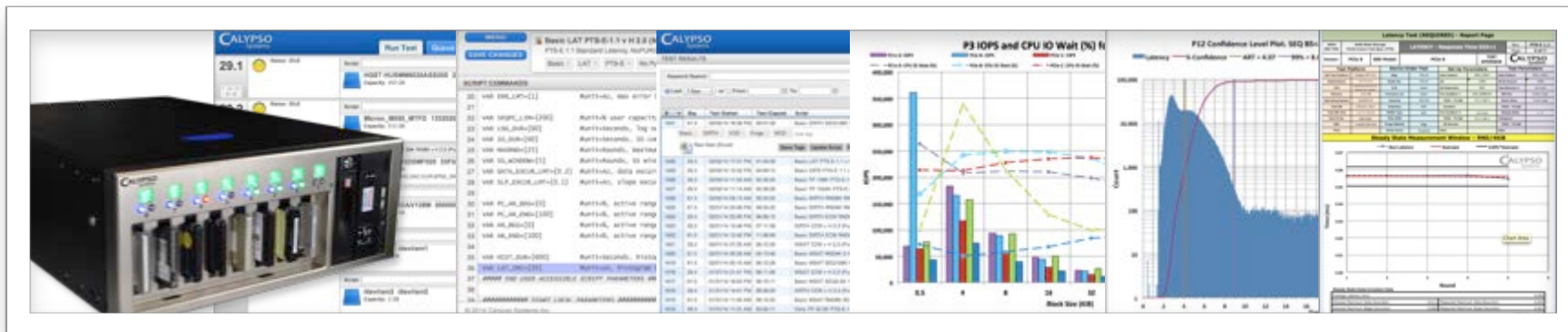
# Test Set Up

## Hardware: PTS Reference Test Platform

- Intel S2600 COE Gen 3
- Dual Xeon 8 core, 3.2Ghz E5 2687W
- 32 GB (4GB x 8) DDR3 1600 ECC
- 16GB RAM Disk

## Software:

- OS – CentOS 6.5
- Linux RAM Disk Block IO Driver 2.6.32-431.11.2.EL6.x86\_64
- Test Software - Calypso CTS BE 1.9.216



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this chart

## Year in Review 2014 - Summary Performance Comparison by Storage Class

Storage Class			IOPS FOB PTS WSAT - T4Q32	IOPS Steady State PTS IOPS - T2Q16 / T4Q32			Bandwidth PTS Throughput - T1Q32		Response Time PTS Latency - T1Q1		
Category	Device Type	Capacity	RND 4KiB 100% W	RND 4KiB 100% W	RND 4KiB 65:35 RW	RND 4KiB 100% R	SEQ 1024KiB 100% W	SEQ 1024KiB 100% R	RND 4KiB 100% W Ave	RND 4KiB 100% W Max	
HDD & SSHD											
1	SSHD	7,200 RPM 2.5" SATA Hybrid	500 GB	134	134	131	148	107 MB/s	103 MB/s	18.54 mSec	40.63 mSec
2	SAS HDD	15,000 RPM 3.5" SAS HDD	80 GB	350	340	398	401	84 MB/s	90 MB/s	55.39 mSec	97.28 mSec
CLIENT SSDs											
3	mSATA	mSATA 1.8" MLC	128 GB	45,743	1,359	1,926	36,517	187 MB/s	533 MB/s	0.74 mSec	543.41 mSec
4	M.2 x2	M.2 x2 2280 MLC	512 GB	61,506	4,185	9,532	71,282	455 MB/s	535 MB/s	0.29 mSec	24.99 mSec
5	SATA Client	SATAIII 2.5" MLC	200 GB	54,788	33,583	50,708	63,640	367 MB/s	480 MB/s	0.06 mSec	11.95 mSec
ENTERPRISE SSDs											
6	SATA 6Gb/s	SATA 6Gb/s 2.5" eMLC	800 GB	57,422	39,561	46,072	70,604	454 MB/s	504 MB/s	0.05 mSec	0.22 mSec
7	SAS 12Gb/s	SAS 12Gb/s 2.5" MLC	800 GB	97,950	41,516	72,342	145,407	448 MB/s	973 MB/s	0.05 mSec	11.84 mSec
8	SFF 8639	SFF 8639 4 lane 2.5" MLC	700 GB	149,512	44,872	166,002	397,564	564 MB/s	1,698 MB/s	0.01 mSec	0.38 mSec
9	PCIe 8 Lane	PCIe 8 Lane Edge Card MLC	1400 GB	159,926	87,419	236,227	742,674	614 MB/s	2,673 MB/s	0.01 mSec	0.56 mSec

All measurements taken on the RTP 3.0 CTS 6.5 Reference Test Platform pursuant to the SNIA PTS-E 1.1.

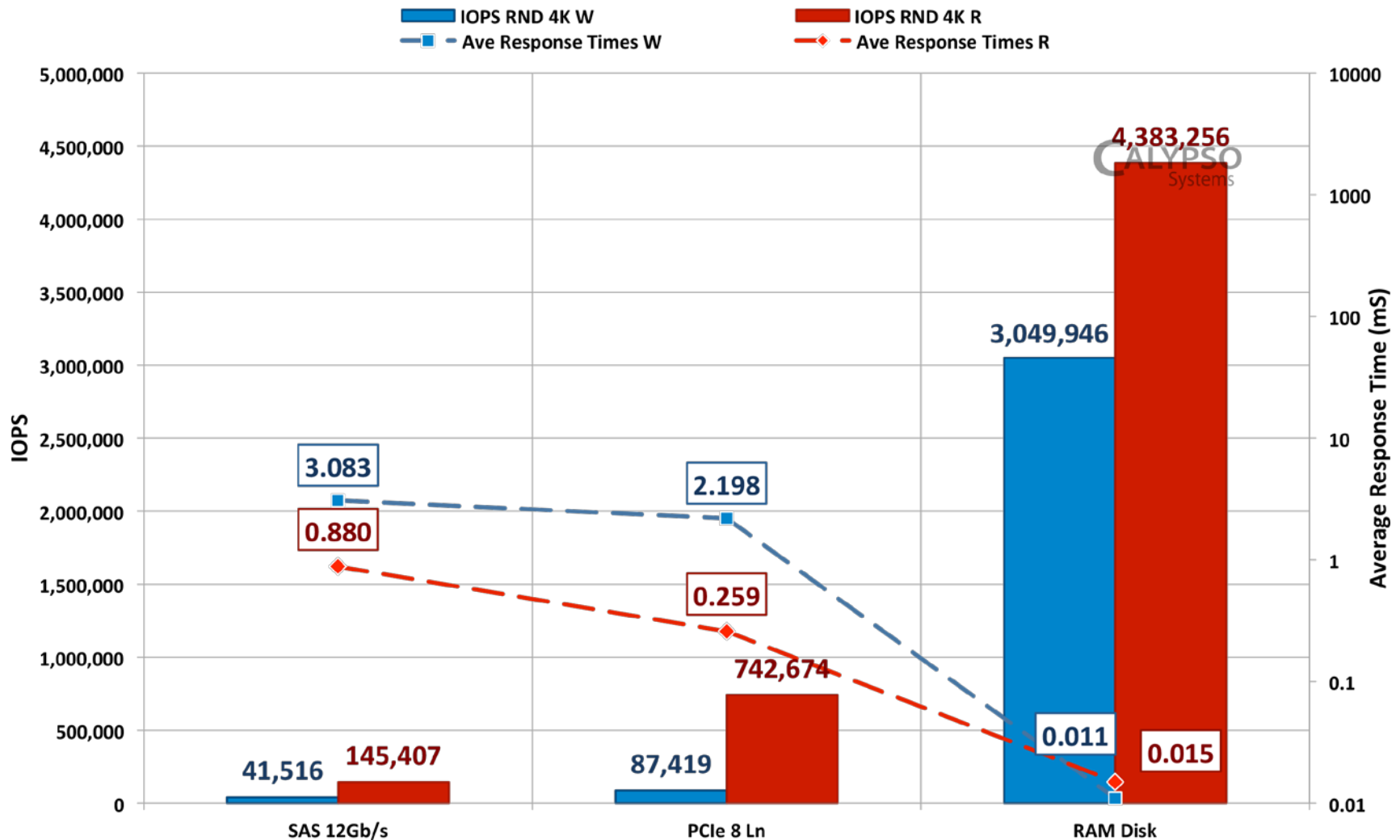
NOTE: Thread and Queue settings for PTS IOPS are T2Q16 for HDD/SSHD & Client SSDs and T4Q32 for Enterprise SSDs.

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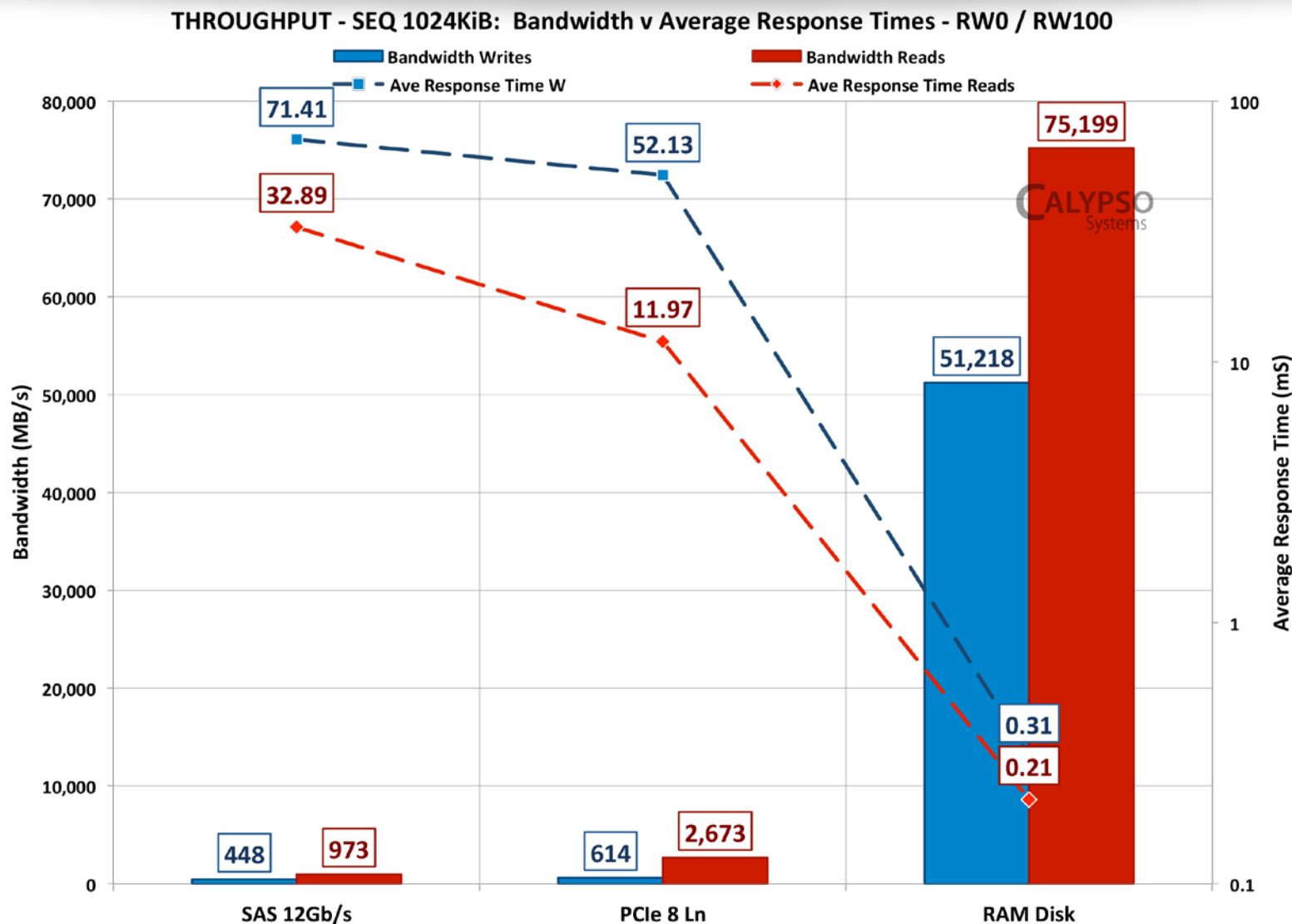
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Systems

# 4K IOPS: 3-4 Million; .01mS ART

IOPS v Average Response Times for RND 4K RW0 / RW100

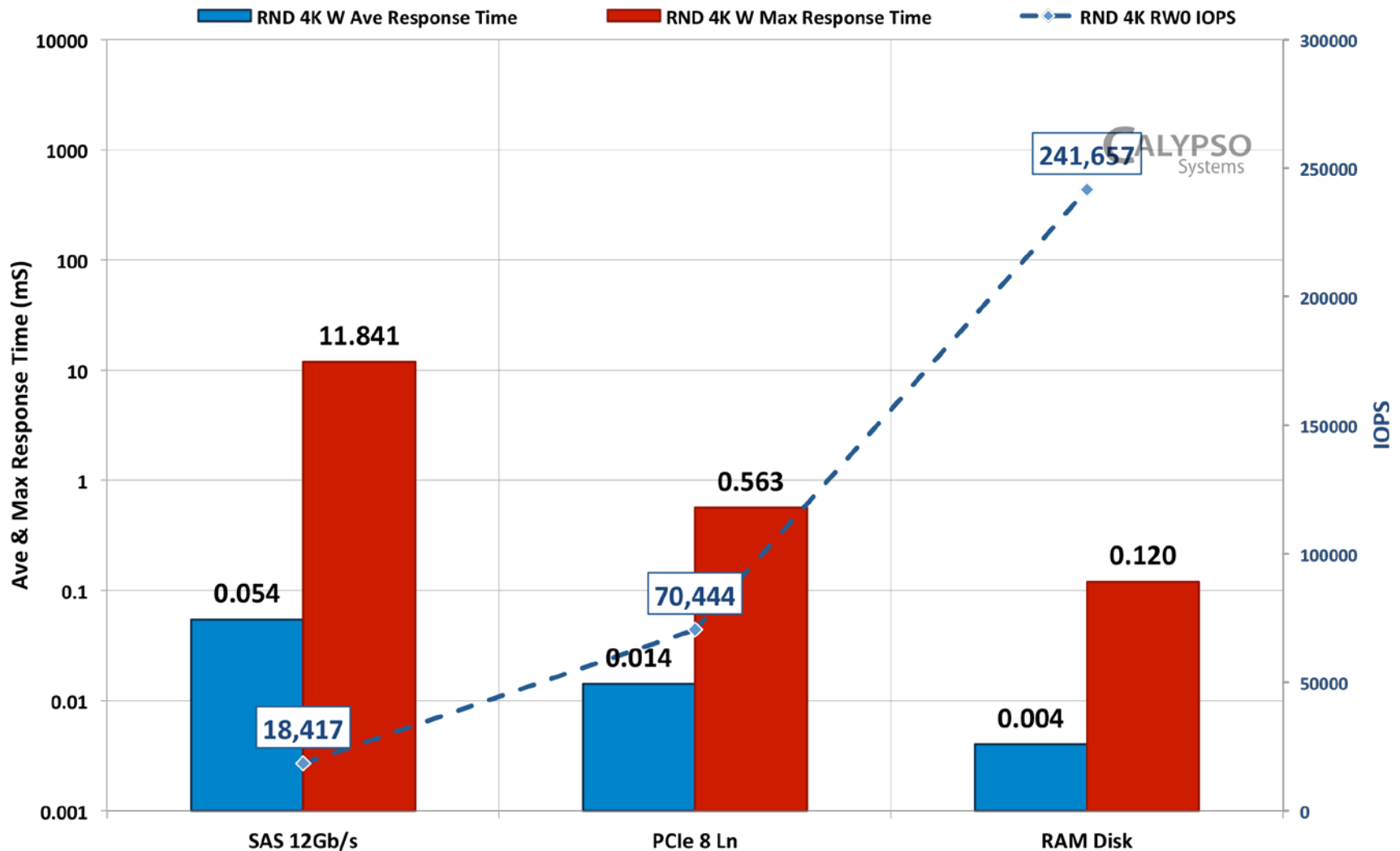


# SEQ TP 1024K: 75GB/s Read



# 4K W Latency T1Q1: 0.004mS ART

Latency Test: RND 4KRW0 T1Q1: Ave v Max Response Time



# Factors Affecting Performance

## NAND Flash SSDs:

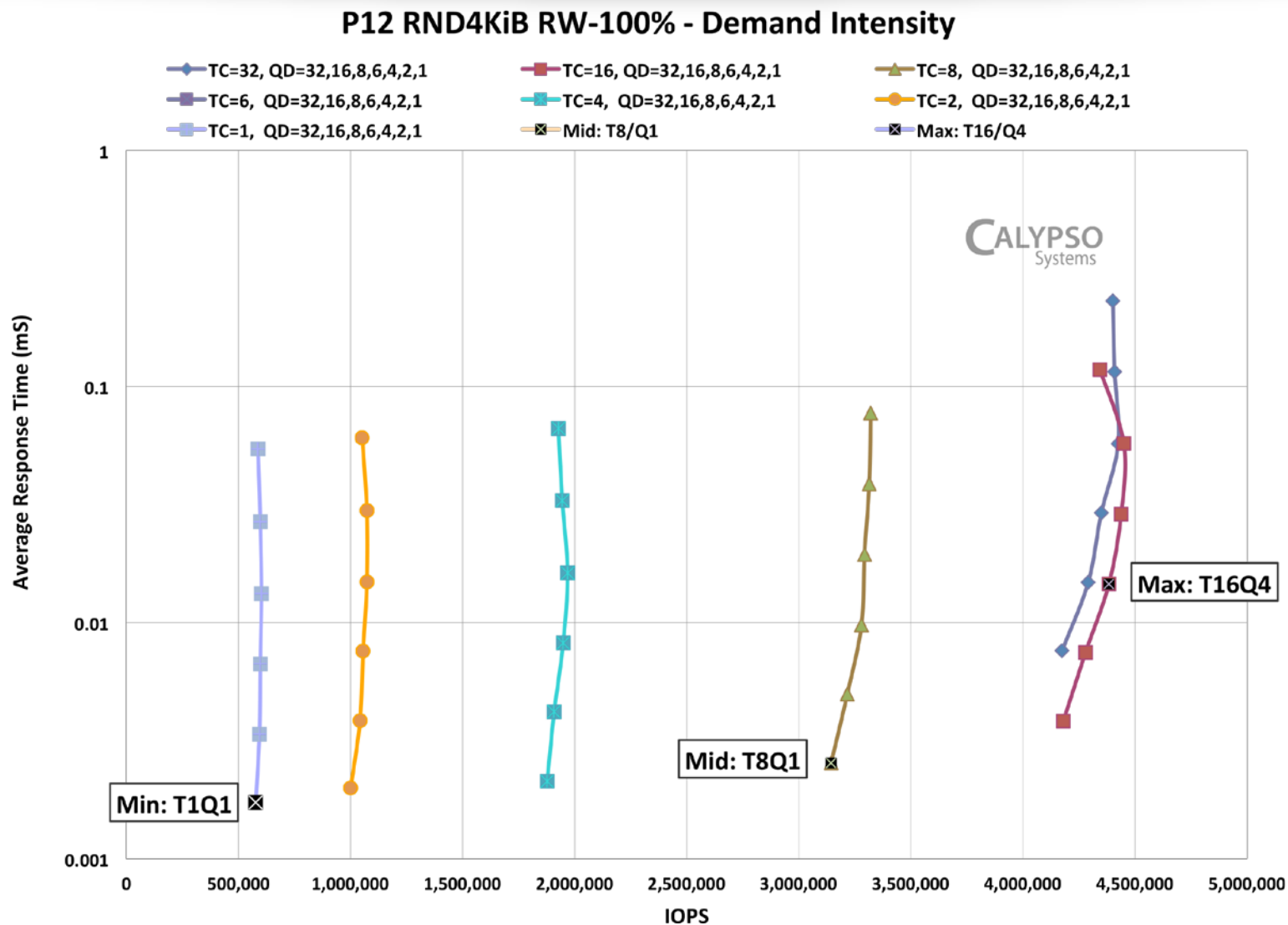
- ✓ Pre-conditioning & Active Range
- ✓ Steady State & Write History
- ✓ Workload & Access Patterns

## RAM Disk:

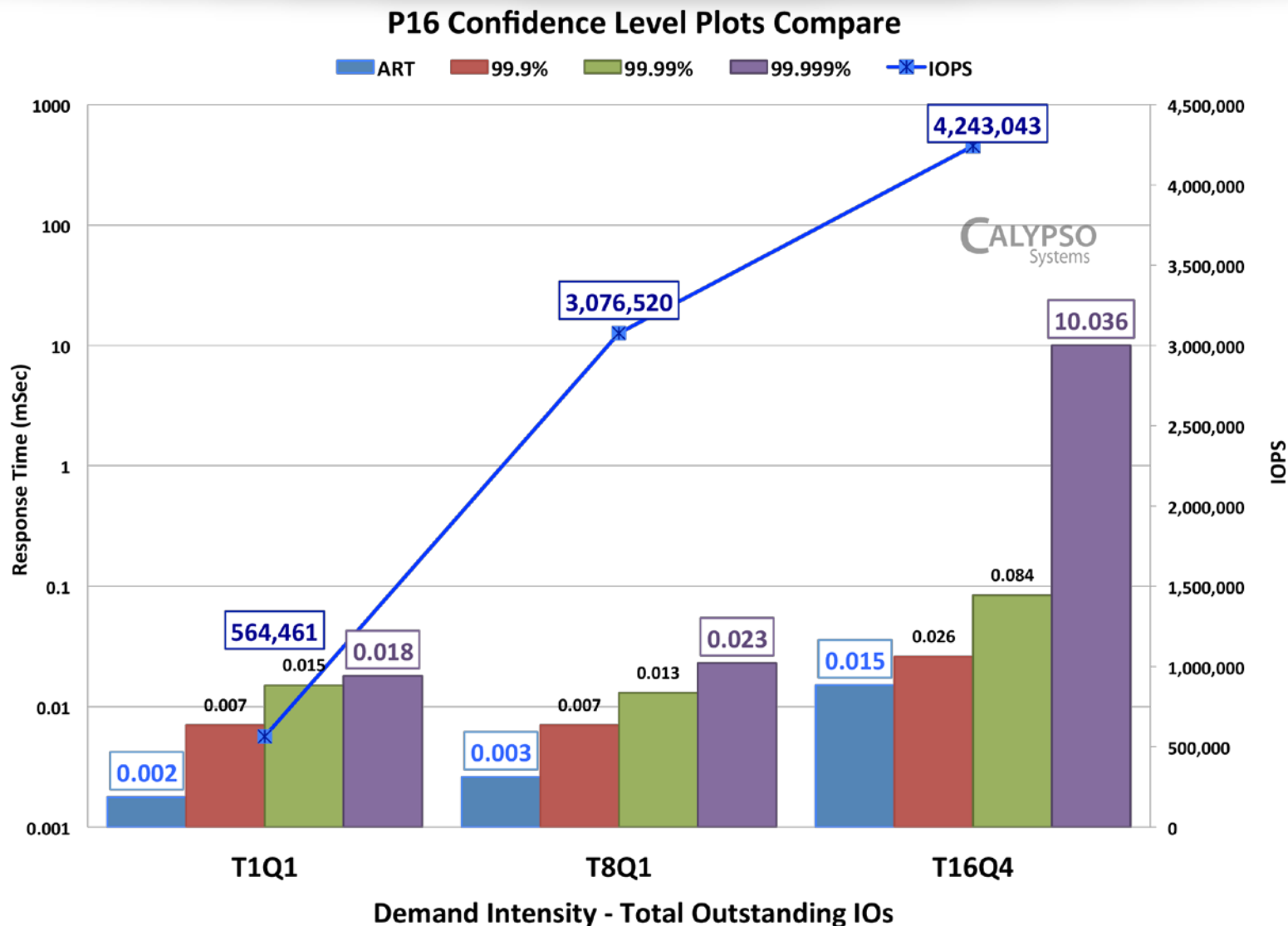
- ✓ Demand Intensity / Outstanding IOs (Threads & Queues)
- ✓ Number of CPUs and CPU cores
- ✓ Number of Memory Channels & Parallelism



# RAM Disk Scaling: Add Threads, not Queues



# IOPS & 'QoS' RTs at different OIO



# Application Workload Comparison

Compare 3 devices:

- RAM Disk 16GB DDR3 4x 4GB
- PCIe x8 SSD 700GB MLC
- SAS 12G/s 800GB MLC

Apply Database OLTP Workload

- db OLTP = RND 8K 70:30 RW
- Run to Steady State
- Map drive by varying the OIO (Thread Count x Queue Depth combinations)
- Select highest IOPS & lowest RT at the optimal OIO combination

# Application Workload – db OLTP

## Confidence Level Plot Compare (CLPC)

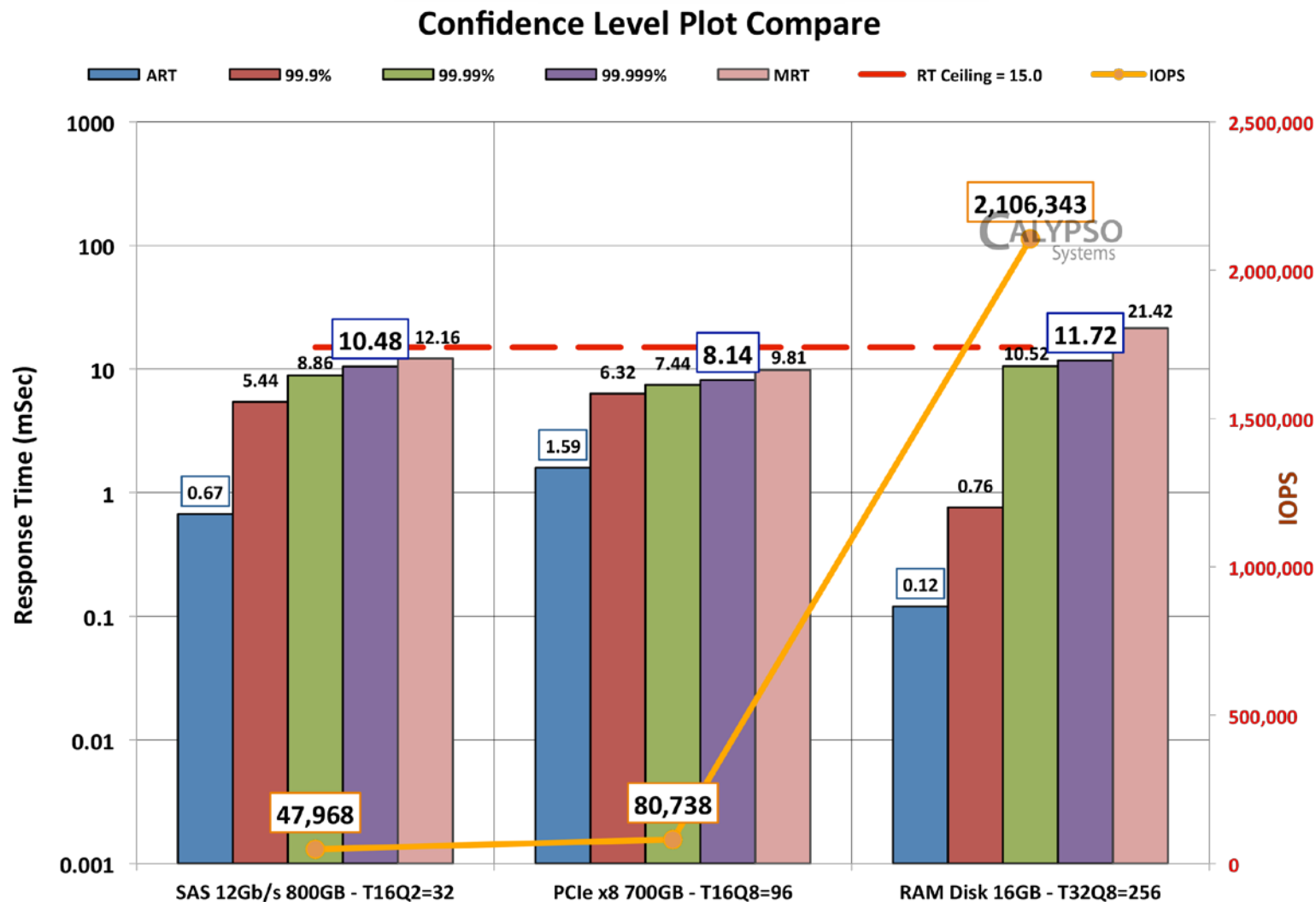
- Select the 'optimal' IOPS/RT OIO for each of the three drives
- IOPS are shown as the blue bar

## Quality of Service (QoS) = High Percentile Response Times (RTs)

- RT Quality of Service (QoS) tracks:
  - ART (average Response Time)
  - "Number of 9's" percentile response times (3,4 and 5 9's)
  - Note: 5 9's is 99,9999 out of 100,000 IOs
- RT Ceiling (red dotted line)
  - Maximum response time allowed by the application
  - RT goal for device & system optimization

# db OLTP – SAS v PCIe v RAM Disk

## 2.1M IOPS, 5 9's QoS 11.72mS





# TAKE AWAYS

RAM Disk Block IO Performance is much higher than NAND Flash

NVDIMM RAM Block IO can approach the level of RAM Disk Block IO

RAM Disk Block IO Performance Depends on Settings

Applications can run much faster with RAM Disk and/or NVDIMM SSD

RAM Disk / NVDIMM SSD offer new Storage Tiering Opportunities

감사합니다 Natick  
Grazie Danke Ευχαριστίες Dalu  
Thank You Köszönöm  
Спасибо Dank Tack  
谢谢 Merci Seé  
ありがとう obrigado

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