



What's all the fuss about NMVe?

Presented by
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Remember User groups make you happy!



They MAY NOT make you more attractive

They MIGHT make smarter

They WILL make you sound smarter

SUPPORT YOUR LOCAL USER GROUP

IBM i is a platform like no other



- So far I have found 52 IBM i user groups
- I'm told there are many more.
- They are literally a goldmine of information
- Their members are wonderful people

One day we will be able to travel again



Make contact, drop in on an event

Make learn more than just IBM i skills



Nearly time to start the presentation

But first a Disclaimer

- ▶ You may be used to seeing IBM Disclaimers



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Photographs shown are of engineering prototypes. Changes may be incorporated in production models.



This is mine

- ▶ I tried ever so hard to get it right
- ▶ *“Opinions are like Buttocks - Everyone has them!”*
 - ▶ You are hearing mine, not Rowton’s, not the i-UGs, not IBM’s
 - ▶ My opinions are not necessarily right
 - ▶ But then again, neither are yours
- ▶ Put another “please don’t sue me”

What's he talking about now?

Agenda

What are NMVe?

Why should you care?

What do they cost?



Short version for Generation TikTok

Agenda

What are NMVe?

Where you put your stuff

Why should you care?

You find your stuff faster

What do they cost?

A lot less, so you can afford more stuff

Executive Summary

Agenda

What are NMVe?

The next generation of storage

Why should you care?

They read data 12 times faster than HDDs

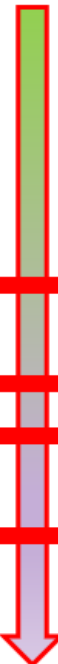
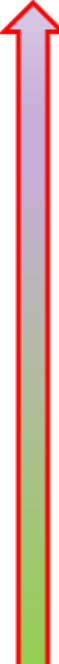
What do they cost?

30% saving on P05 server, 46% on P10

Based on typical POWER9 Total RRP Server Hardware cost

For me, it all started here, with a slide from Doug Gibbs of IBM

Is NVMe Fast?

Latency	Bus	Media	Read Lat. (us)	Write Lat. (us)	Read (IOPs)	Write (IOPs)	Read Tp (GB/s)	Write Tp (GB/s)	Approx. \$ Scale (2Q '19)	Cost
	Memory (in CEC)	DRAM	<1	<1	Not a Persistent Storage				20x	
		3DXP	<1	<1	Persistent Storage				15x	
		LL Flash (HMS)	TBD	TBD						
		3DXP	<10	<10	550K	500K	2.4	2.0	10x	
		LL Flash	<20	<20	800K	240K	3.5	3.4	1.1x	
	PCIe (NVMe)	Flash	<90	<25	1500K*	250K	6.4	3.8	1x	
		QLC Flash	>150	>60	80K	25K	2.0	0.6	0.5x	
	SAS	Flash	150	60	420K	50K	2.2	1.6	0.7 to 1x	
		SATA	Flash	>10ms	>10ms	50K	20K	0.5		
	NL-SAS / SATA	HDD	>ms	>ms	200	200	0.15	0.15	0.1x	
TAPE		"secs"	"secs"	"slow"	"slow"	"slow"	"slow"			

SCM: 3DXP from Intel/Micron. Bytes addressable in DIMM (Apache Pass) and Block addressable (M.2/U.2/AIC...) in NVMe interface.

NVMe/SCM: Performance numbers are of Intel's Optane PCIe Gen 3 x4 Add in Card. Endurance 30 DWPD.

NVMe/LL Flash: Performance numbers are of Samsung's zSSD, Gen 3 x4. NVMe QLC Client Flash are based on Intel 660p M.2, Gen 3 x4.

NVMe/Flash*: PCIe Gen 4 x4 U.2 devices. Gen 4 x8 Add In Card will have additional bandwidth and IOPS performance.

SAS SSD: Assumes 12G dual port active/active. Performance of single port operation (typical) expected to be lower.

IOPs and Latencies: Normally measured on a random 4K ops. * <1us for 1K transfer utilizing Persistent Log Buffer feature

Data throughput: Normally measured on a large sequential 256KB ops

And now for the unabridged version

I wanted to know

“what difference NVMe would make to IBM i?”

I did a quick google search.....

“About 4,380,000 results (0.57 seconds)”

That didn't help much

So, I looked in the corner, spotted a spare pair of POWER9's

Say hi to my POWER9's



Alison



Scott

My dynamic (P9) duo

“Bugger it” I thought, I’ll test it myself....



So, I built a test environment:

Everything else was identical except storage
Based on a typical hardware & software configs

- POWER9, 1 Core, 64GB RAM, LTO7 tape
- IBM i 7.4, 1.4TB storage, ASP1 70% full
- LPAR configuration, System values, User settings
- Based on 0.2TB Library Objects, 0.8TB IFS objects

The only difference was the storage

What combinations did I test?



IBM i Software Mirroring
2 x NVMe's 10 x 200GB

IBM i Software Mirroring
10 x 283GB 15K SAS HDDs

Hardware RAID6
10 x 283GB 15K SAS HDDs, with a pair SAS adaptors

What tests did a perform?



Disk performance is just like a motor car
It varies depending on the conditions

So I tested three types of workload

Heavy write

Balanced read / write

Heavy read

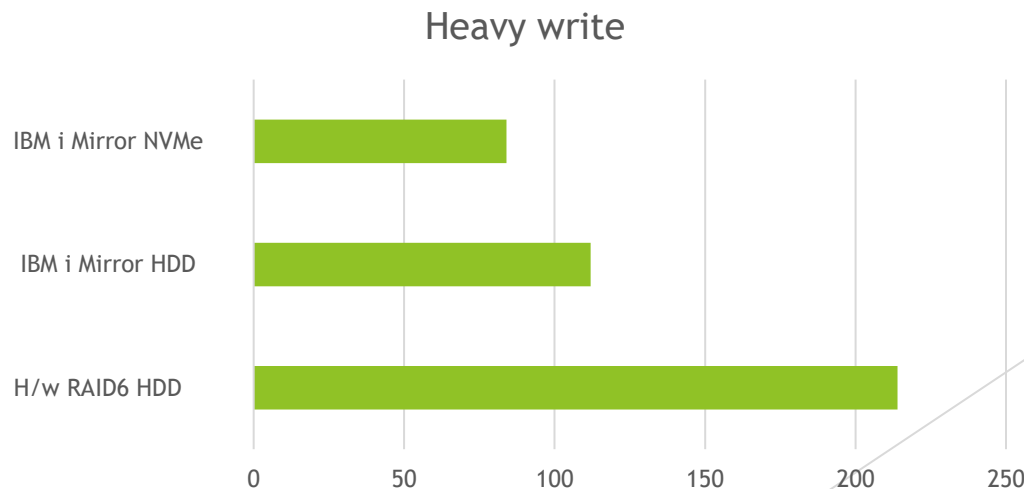
Testing the heavy write



What is the test?

I restored 4.7 million IFS objects

H/w RAID6 HDD	214 minutes
IBM i Mirror HDD	112 minutes
IBM i Mirror NVMe	84 minutes



Testing balanced read / write



What is the test?

Read 4.7M IFS objects & write attributes to file

H/w RAID6 HDDs 63 minutes

IBM i Mirror HDD 82 minutes

IBM i Mirror NVMe 31 minutes



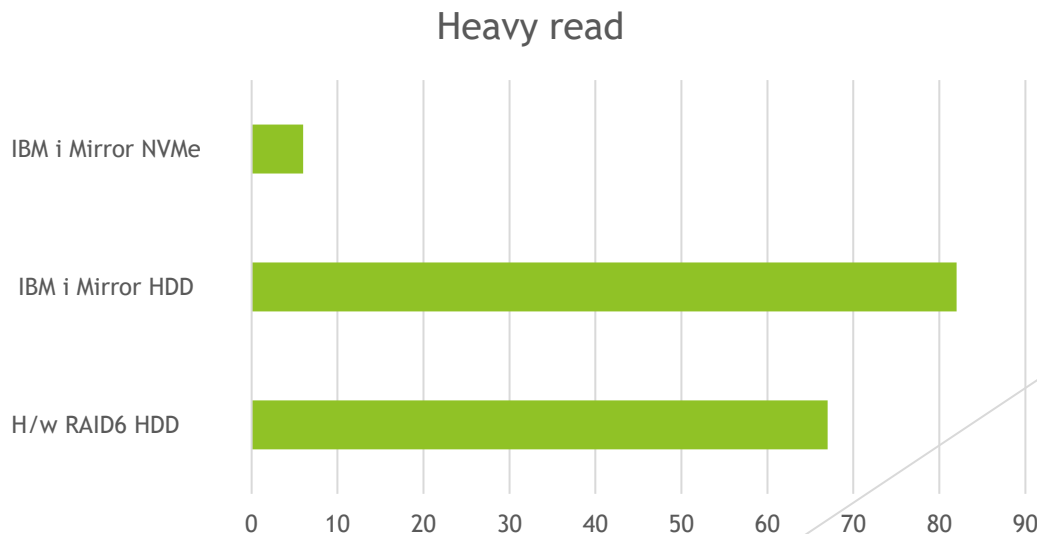
Testing the heavy read



What is the test?

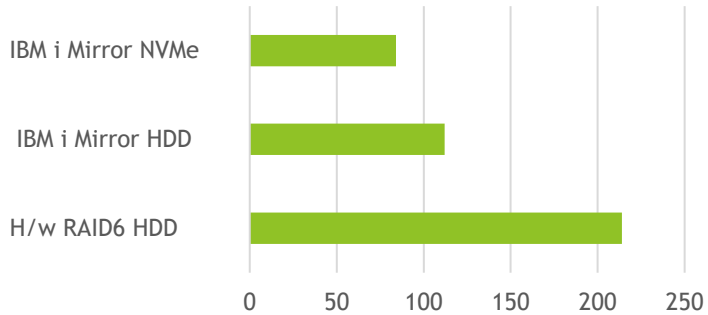
ARE Damage Object Detector – reads all objects

H/w RAID6 HDDs	67 minutes
IBM i Mirror HDDs	82 minutes
IBM i Mirror NVMe	6 minutes



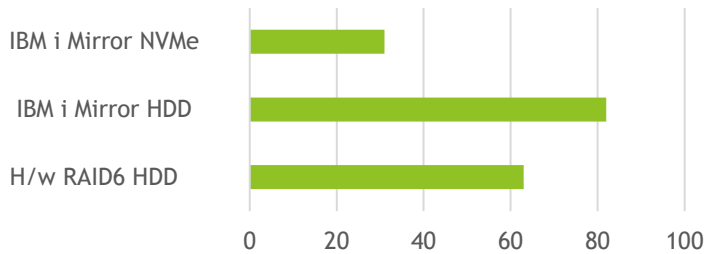
What did I learn?

Heavy write



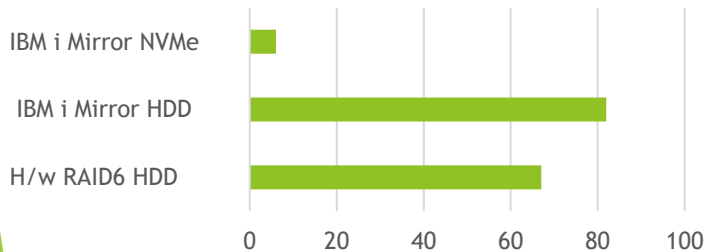
NVMe heavy write 61% faster than RAID6

Balanced read / write



NVMe read/write 62% faster than HDD mirror

Heavy read



NVMe heavy read 1267% faster than HDD mirror

NVMe wins everytime



What do they cost ?



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What do they cost

IBM RRP Typical **HDD** P05 server hardware only

Product	Description	Qty	Extended Purchase
9009-41G	Server 1:9009 Model 41G	1	4,640.77
0040	Mirrored System Disk Level, Specify Code	1	N/C
0267	IBM i Operating System Partition Specify	1	N/C
2145	Primary OS - IBM i	1	N/C
2319	Factory Deconfiguration of 1-core	3	N/C
4650	Rack Indicator- Not Factory Integrated	1	N/C
5000	Software Preload Required	1	N/C
5550	Sys Console On HMC	1	N/C
5899	PCIe2 4-port 1GbE Adapter	1	488.46
6458	Power Cord 4.3m (14-ft), Drawer to IBM PDU (250V/10A)	2	23.38
9300	Language Group Specify - US English	1	N/C
9441	New IBM i License Core Counter	1	N/C
EB2M	AC Power Supply - 1400W for Server (200-240 VAC)	2	742.28
EB74	IBM i 7.4 Indicator	1	N/C
EJ1D	Expanded Function Storage Backplane 18 SFF-3 Bays/Dual IOA with Write Cache/Opt Ext SAS port	1	5,085.38
EJ1P	PCIe1 SAS Tape/DVD Dual-port 3Gb x8 Adapter	1	1,020.67
EJTZ	Rack-mount Rail Kit	1	246.89
EJUF	Front IBM Bezel 18-Bay Backplane	1	248.13
ELUJ	#ESNJ Load Source Specify (283GB HDD SFF-3)	1	N/C
EM63	32 GB DDR4 Memory	2	1,871.36
EP50	4-core Typical 2.3 to 3.8 Ghz (max) POWER9 Processor	1	2,429.92
EP60	One Processor Core Activation for #EP50	4	N/C
EPA0	Deactivation of LPM (Live Partition Mobility)	1	N/C
ESC6	S&H-b	1	350.55
ESNJ	283GB 15K RPM SAS SFF-3 4k Block Cached Disk Drive (IBM i)	10	8,029.00
EU0B	Operator Panel LCD Display	1	495.02
EU19	Cable Ties & Labels	1	26.06
EU2C	Express Edition 4 core (IBM i)	1	N/C
Serial: N/A		Total	GBP 25,697.87

HDD Config RRP £25,698

What do they cost

IBM RRP Typical **NVMe** P05 server hardware only



9009-41G	Server 1:9009 Model 41G	1	4,640.77
0040	Mirrored System Disk Level, Specify Code	1	N/C
0267	IBM i Operating System Partition Specify	1	N/C
2145	Primary OS - IBM i	1	N/C
2319	Factory Deconfiguration of 1-core	3	N/C
4650	Rack Indicator- Not Factory Integrated	1	N/C
5000	Software Preload Required	1	N/C
5550	Sys Console On HMC	1	N/C
5899	PCIe2 4-port 1GbE Adapter	1	488.46
6458	Power Cord 4.3m (14-ft), Drawer to IBM PDU (250V/10A)	2	23.38
9300	Language Group Specify - US English	1	N/C
9441	New IBM i License Core Counter	1	N/C
EB2M	AC Power Supply - 1400W for Server (200-240 VAC)	2	742.28
EB74	IBM i 7.4 Indicator	1	N/C
EJ1P	PCIe1 SAS Tape/DVD Dual-port 3Gb x8 Adapter	1	1,020.67
EJ1T	Storage Backplane Gen4 with 2 NVMe U.2 drive slots	1	749.90
EJTZ	Rack-mount Rail Kit	1	246.89
EJUI	Front IBM Bezel for 6 SAS + 4 NVMe -Bays BackPlane	1	248.13
ELS3	#ES1F Load Source Specify (1.6 TB 4K NVMe U.2 SSD PCIe4 for IBM i)	1	N/C
EM63	32 GB DDR4 Memory	2	1,871.36
ENSA	200 GB IBM i NVMe Load Source Namespace size	1	N/C
EP50	4-core Typical 2.3 to 3.8 Ghz (max) POWER9 Processor	1	2,429.92
EP60	One Processor Core Activation for #EP50	4	N/C
EPA0	Deactivation of LPM (Live Partition Mobility)	1	N/C
ES1F	Enterprise 1.6 TB SSD PCIe4 NVMe U.2 module for IBM i	2	4,777.10
ESC6	S&H-b	1	350.55
EU0B	Operator Panel LCD Display	1	495.02
EU19	Cable Ties & Labels	1	26.06
EU2C	Express Edition 4 core (IBM i)	1	N/C

Serial: N/A

Total

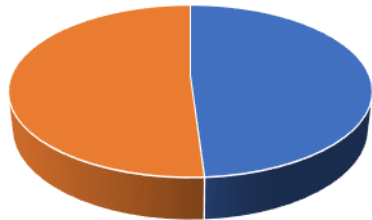
GBP 18,110.49

NVMe Config RRP £18,110

Comparing typical P05 Configs

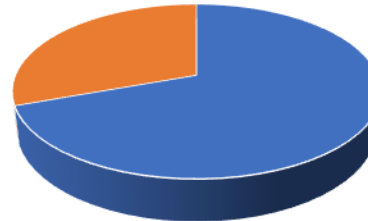


POWER9 with 10 x SAS HDD



■ Other Server Hardware ■ Storage Hardware Element

POWER9 with NMVe



■ Other Server Hardware ■ Storage Hardware Element

POWER9 with 10 x SAS HDD

Server hardware £25,698

Storage element £13,114

51% of the total cost is storage

POWER9 with NMVe

Server hardware £18,110

Storage element £5,527

31% of the total cost is storage



What do they cost

IBM RRP Typical **HDD** P10 server hardware only

9009-41G	Server 1:9009 Model 41G	1	4,640.77
0040	Mirrored System Disk Level, Specify Code	1	N/C
0267	IBM i Operating System Partition Specify	1	N/C
2145	Primary OS - IBM i	1	N/C
2319	Factory Deconfiguration of 1-core	4	N/C
4650	Rack Indicator- Not Factory Integrated	1	N/C
5000	Software Preload Required	1	N/C
5550	Sys Console On HMC	1	N/C
5899	PCIe2 4-port 1GbE Adapter	1	488.46
6458	Power Cord 4.3m (14-ft), Drawer to IBM PDU (250V/10A)	2	23.38
6672	Power Cord 2M (6.5-foot), Drawer to IBM PDU, 250V/10A	2	23.38
9200	Language Group Specify - US English	1	N/C
9441	New IBM i License Core Counter	1	N/C
EB2M	AC Power Supply - 1400W for Server (200-240 VAC)	2	742.28
EB74	IBM i 7.4 Indicator	1	N/C
ECBJ	SAS X Cable 3m - HD Narrow 6Gb 2-Adapters to Enclosure	2	1,246.68
ECDU	3.0M SAS Y012 Cable (Adapter to Enclosure)	1	254.34
ECE2	3.0M SAS AA12 Cable	2	508.68
EJ0J	PCIe3 RAID SAS Adapter Quad-port 6Gb x8	1	2,379.64
EJ14	PCIe3 12GB Cache RAID PLUS SAS Adapter Quad-port 6Gb x8	2	19,362.66
EJ1D	Expanded Function Storage Backplane 18 SFF-3 Bays/Dual IOA with Write Cache/Opt Ext SAS port	1	5,085.38
EJ1P	PCIe1 SAS Tape/DVD Dual-port 3Gb x8 Adapter	1	1,020.67
EJ72	Rack-mount Rail Kit	1	246.89
EJUF	Front IBM Bezel 18-Bay Backplane	1	248.13
EJW1	Specify Mode-1 & (1)EJ0J/EJ0M/EL3B/EL59 & (1)Y012 for EXP24SX #ESLS/ELLS	1	N/C
ELUJ	#ESNJ Load Source Specify (283GB HDD SFF-3)	1	N/C
EM63	32 GB DDR4 Memory	4	3,742.72
EP51	6-core Typical 2.3 to 3.8 Ghs (max) POWER9 Processor	1	4,839.66
EP61	One Processor Core Activation for #EP51	6	N/C
EPA0	Deactivation of LPM (Live Partition Mobility)	2	N/C
ESC6	S&H-b	1	350.55
ESLA	Specify AC Power Supply for EXP12SX/EXP24SX Storage Enclosure	1	N/C
ESLS	EXP24SX SAS Storage Enclosure	1	6,600.12
ESNJ	283GB 15K RPM SAS SFF-3 4k Block Cached Disk Drive (IBM i)	18	14,452.20
ESNL	283GB 15K RPM SAS SFF-2 4k Block Cached Disk Drive (IBM i)	24	19,269.60
EU0B	Operator Panel LCD Display	1	495.02
EU19	Cable Ties & Labels	1	26.06
EU2D	Express Edition 6-core (IBM i)	1	N/C

Serial: N/A Total **GBP 86,047.27**

HDD Config RRP £86,047

What do they cost

IBM RRP Typical **NVMe** P server hardware only



19009-41G	Server 1:9009 Model 41G	1	4,640.77
0040	Mirrored System Disk Level, Specify Code	1	N/C
0267	IBM i Operating System Partition Specify	1	N/C
2145	Primary OS - IBM i	1	N/C
2319	Factory Deconfiguration of 1-core	4	N/C
4650	Rack Indicator- Not Factory Integrated	1	N/C
5000	Software Preload Required	1	N/C
5550	Sys Console On HMC	1	N/C
5899	PCIe2 4-port 1GbE Adapter	1	488.46
6458	Power Cord 4.3m (14-ft), Drawer to IBM PDU (250V/10A)	2	23.38
9300	Language Group Specify - US English	1	N/C
9441	New IBM i License Core Counter	1	N/C
EB2M	AC Power Supply - 1400W for Server (200-240 VAC)	2	742.28
EB74	IBM i 7.4 Indicator	1	N/C
EC5W	Enterprise 6.4 TB SSD PCIe4 NVMe U.2 module for IBM i	4	28,361.88
EJ1P	PCIe1 SAS Tape/DVD Dual-port 3Gb x8 Adapter	1	1,020.67
EJ1U	Storage Backplane Gen4 with 4 NVMe U.2 drive slots	1	1,363.46
EJTZ	Rack-mount Rail Kit	1	246.89
EJUI	Front IBM Bezel for 6 SAS + 4 NVMe -Bays BackPlane	1	248.13
ELUW	EC5W Load Source Specify (6.4 TB 4K NVMe U.2 SSD for IBM i)	1	N/C
EM63	32 GB DDR4 Memory	4	3,742.72
ENSB	400 GB IBM i NVMe Load Source Namespace size	1	N/C
EP51	6-core Typical 2.3 to 3.8 Ghz (max) POWER9 Processor	1	4,839.66
EP61	One Processor Core Activation for #EP51	6	N/C
EPA0	Deactivation of LPM (Live Partition Mobility)	2	N/C
ESC6	S&H-b	1	350.55
EU0B	Operator Panel LCD Display	1	495.02
EU19	Cable Ties & Labels	1	26.06
EU2D	Express Edition 6-core (IBM i)	1	N/C

Serial: N/A

Total

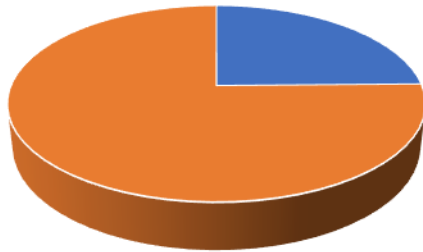
 GBP 46,589.93

NVMe Config RRP £46,589

Comparing typical P10 Configs

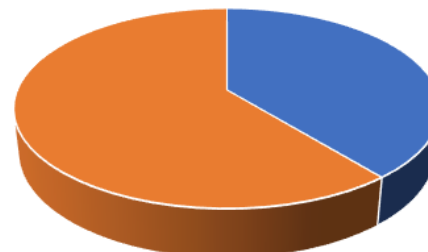


POWER9 with 42 x SAS HDD



■ Other Server Hardware ■ Storage Hardware Element

POWER9 with NMVe



■ Other Server Hardware ■ Storage Hardware Element

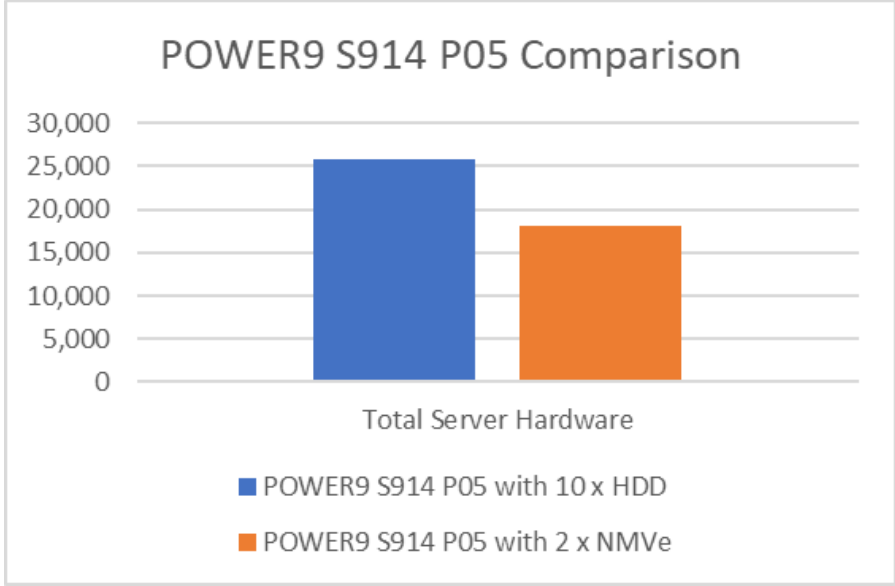
POWER9 with 42 x SAS HDD	POWER9 with NMVe
Server hardware £86,047	Server hardware £46,589
Storage element £64,770	Storage element £28,362
75% of the total cost is storage	61% of the total cost is storage

Added Bonus

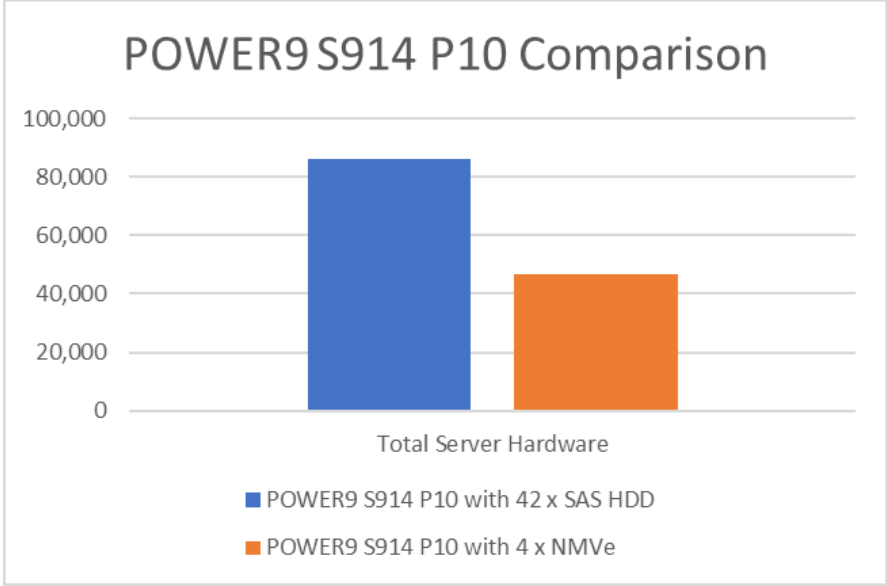
NVMe costs HWMA £2,820 less per year

As you don't pay HWMA on the disk expansion drawer

Total server hardware cost



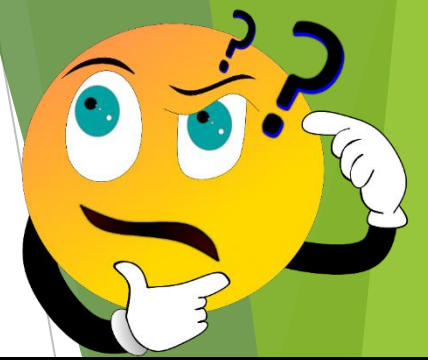
30% Saving



46% Saving

What's different about NVMe?

“They’re bloody well faster”



What is NVMe?



NVMe Controller

- PCIe Attached
- Parallel Architecture (Multi Q, Q pairs ...)
- Low Latency Design
- Fabrics Attach Friendly
- Self Encryption & Sanitize
- Virtualization (Multiple Namespace, SR-IOV)
- IO Determinism
- Zoned Namespace
- Management Interface Support (in & out of band)
- Computational Storage
- ... More Innovations



Media

- NAND TLC (most widely used)
- Optane 3DXP
- LL NAND
- NAND QLC
- DRAM – Flash backed
- MRAM
- .. More to come

Form Factors: M.2, U.2 (2.5" thin & thick), EDSFF (E1.S, E1.L, E3.S, E3.L thin & thick), Add in card
Software Infrastructure: Investment protected by re-using on multiple vendor devices

Why are NVMe better?



Not limited by Serial data access

Data access via PCIe bus

No need for expensive disk controllers

More storage in less physical space

Less to go wrong

Use less electrical power

What's do they look like?



U.2 Hot plug



AIC Adapter



Questions?



Questions I've been asked



- 1) Isn't software mirroring bad**
No, it's usually less efficient, NVMe is so fast it more than makes up for any inefficiency.
- 2) I heard you cannot hotswap NVMe**
That's true for the AiC but not the U.2
- 3) If one NVMe fails do I lose many disks**
Yes, but who cares, they are all mirrored, so no downtime.
- 4) Do NVMe's wear out**
Yes, eventually, but more robust than an SSD
There is a fuel gauge to report health status.

Tech Specs for the U.2 NVMe

Enterprise U.2 NVMe

Hardware Features

- NVMe Specs. 1.3 Compliant
- PCIe Gen 4 x 4 (1 x4 and 2 x2 modes)
- Multiple Name Space (64)
 - NS Granularity 8KB
- SFF U.2 (2.5") 15mm z-Height
- Power Modes ($\leq$ 25W, 18W(default) & 12W)
- Block Size 4096(AIX/Linux), 512, 4160 (IBM i)
- End-To-End Protection: T10 DIF & DIX
- Non Volatile Write Buffer
- Endurance 3 DWPD
- PCIe Vendor VPD Support (IBM Provides content)
- Boot: Option ROM BAR 128KB (IBM Provides content)
- Warranty 5 years
- Hot Plug capable (Managed)
- ECC $\geq$ 100 bits per 4KB
- RAIF: Tolerant of single flash die failures
- MTBF $\geq$ 2 million hours
- End Of Life Data Retention $\geq$ 3 months
- EEH Support
- Live Firmware update
- NVMe-MI Support (SMBUS)
- TCG OPAL SED

Supported Platforms

- P9 Scale Out Gen4 Refresh

	PCIe3 1.6TB NVMe Flash Adapter III x8		
	1.6TB	3.2TB	6.4TB
AIX/Linux	ES1E	ES1G	EC5V
IBM i	ES1F	ES1H	EC5W

Performance

Workload	Target (1.6 TB)	Target (3.2 / 6.4 TB)	
Read (IOPS)	1M	1.5M	
Write (IOPS)	220K	250K	
Mixed R/W (70/30)	300K		
Read Data Tp (GB/s)	7.0	7.4	7.2
Write Data Tp (GB/s)	2.5	3.4	3.8
Read Latency (us)	80		
Write Latency (us)	20		

Notes:

1. IOPs and Latency #'s on random 4K
2. Data throughput #'s are on sequential 256KB workload



Software Support

- Linux RHEL 8.1, SLES 15
- AIX (7.1c & 7.2Q), VIOS (2.2.6)
- IBM i 7.4TR2 or later
- Load Source
- Software RAID 0, 1, 5 & 6 (Linux)
- OS Mirroring (AIX, IBM i)
- DIAG Support



Tech Specs for the AIC NVMe

Enterprise PCIe Gen4 Add in Card

Hardware Features

- NVMe Specs. 1.3 Compliant
- NVMe Over Fabrics 1.0 Capable
- **PCIe Gen 4 x 8**
- **Controller Memory Buffer (CMB) ≥ 4MB (Linux only)**
- Multiple Name Space (64)
 - NS Granularity 8KB
- Half Height Half Length (HH-HL)
- Power ≤ 25W
- Block Size 4096 (Default), 512, 4160
- End-To-End Protection: T10 DIF & DIX
- Non Volatile Write Buffer
- Endurance 3 DWPD
- PCIe Vendor VPD Support (IBM Provides content)
- Boot: Option ROM BAR 128KB (IBM Provides content)
- Warranty ≥ 5 years
- Hot Plug capable
- ECC ≥ 100 bits per 4KB
- RAiF: Tolerant of single flash die failures
- MTBF ≥ 2 million hours
- End Of Life Data Retention ≥ 3 months
- EEH Support
- Live Firmware update
- NVMe-MI (Optional)
- TCG OPAL SED

	PCIe4 NVMe Flash Adapter III x8		
	1.6TB	3.2TB	6.4TB
FC (LP/FH)	EC7A / EC5B	EC7C / EC7D	EC7E / EC7F
IBM i FCs (LP/FH)	EC7J / EC7K	EC7L / EC7M	EC7N / EC7P

Performance

Workload	Target (1.6 TB)	Target (3.2/6.4)
Read (IOPS)	1M	1.5M
Write (IOPS)	250K	250K
Mixed R/W (70/30)	300K	300K
Read Data Tp (GB/s)	8.0	8.0
Write Data Tp (GB/s)	2.5	3.8
Read Latency (us)	80	80
Write Latency (us)	20	20

Notes:

1. IOPs and Latency #'s on random 4K
2. Data throughput #'s are on sequential 256KB workload



Software Support

- Linux
 - Power VM: RHEL 8.2LE, SLES 15 SP2 LE
 - Power NV: RHEL 8.2LE, Ubuntu 20.4
- AIX (7.2V), VIOS (2.2.6)
- IBM i 7.4TR3 or later
- Load Source
- Software RAID 0, 1, 5 & 6 (Linux)
- OS Mirroring (AIX, IBMi)
- DIAG Support



1 NVMe can look like 16 IBM i disks

Recommended PCIe Gen4 NVMe Namespace Sizes

- New PCIe Gen4 NVMe devices have a hardware boundary of 8 KB for name spaces, and up to 64 name spaces per device
- IBM recommends namespaces of 200 GB or 400 GB (the e-Config default)
- U.2 NVMe and the new PCIe card NVMe devices are both Gen4 and use the same IBM i load source name space sizes:
 - #ENSA 200GB IBM i NVMe LOAD SOURCE NAME SPACE SIZE
 - #ENSB 400GB IBM i NVMe LOAD SOURCE NAME SPACE SIZE
- Note that PCIe Gen3 card NVMe can only mirror to PCIe PCIe Gen3 card NVMe
- U.2 NVMe and new PCIe card NVMe devices are both Gen4 and can mirror each other if using the same namespace sizes



Questions?



One More thing



<https://www.common.org/education-events/i-show-podcast>



Thank you