The SAGE2 project has received funding from the European Union's Horizon2020 Research & Innovation Programme under grant agreement 800999

CORTX/Motr in Sage2

March 2021

Seagate Systems EU R&D

Ganesan.Umanesan@seagate.com (Sr staff software Eng)
Andriy.Tkachuk@seagate.com (Staff Software Eng)
Sai.Narasimhamurthy@seagate.com (Eng Director)

One Storage System to rule them all!

Extreme Computing

Changing I/O Needs

HDDs cannot Keep Up

Big Data Analysis

Avoid Data Movements

Manage and Process extremely large data sets

AI/DL

Large Memory Requirements

Storage and I/O Reqs significantly different

SAGE Project Recap [2015 - 2018]

- ✓ Storage system based CORTX Motr
- ✓ Co-designed with "BDEC" Use Cases (**B**ig **D**ata **E**xtreme **C**ompute)
- ✓ Assembled @ Seagate, UK
- ✓ Deployed @ Juelich Supercomputing, Germany
- ✓ Porting of Stack Components done
- ✓ Porting of BDEC applications done

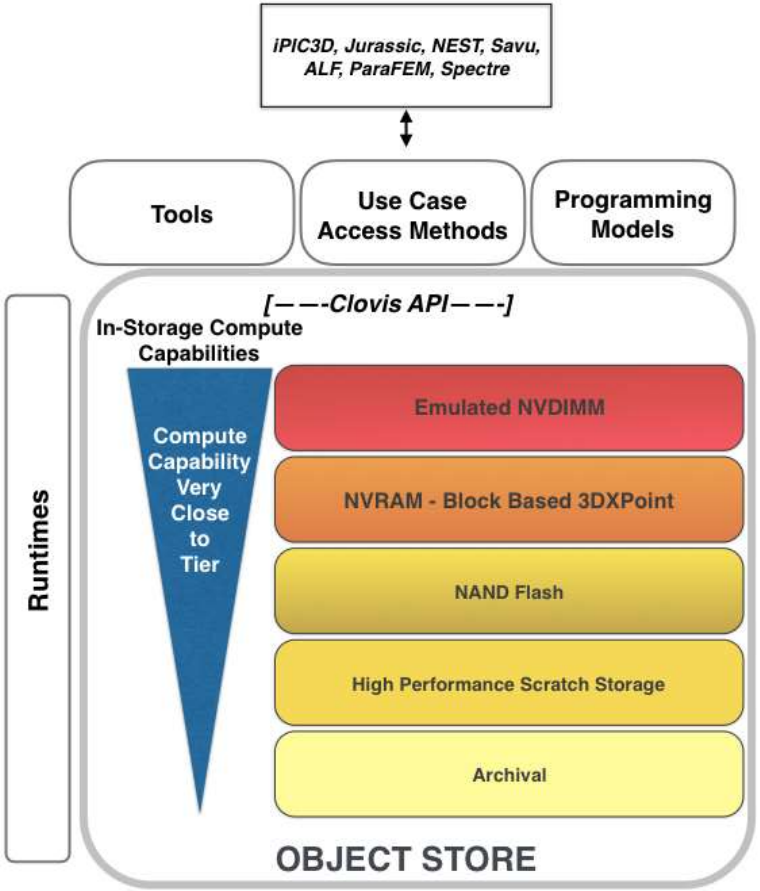
Key Takeaways from SAGE

Motr
Basic Services

- Layouts
- Containers
- Porting on different media tiers
- Function shipping (PoC)
- Clovis (Motr API) usage

Runtimes

- Cache Management
- Virtual Memory Hierarchy (Both using USM)



Use Case Access

- PNFS
- Apache Flink

Programming Models

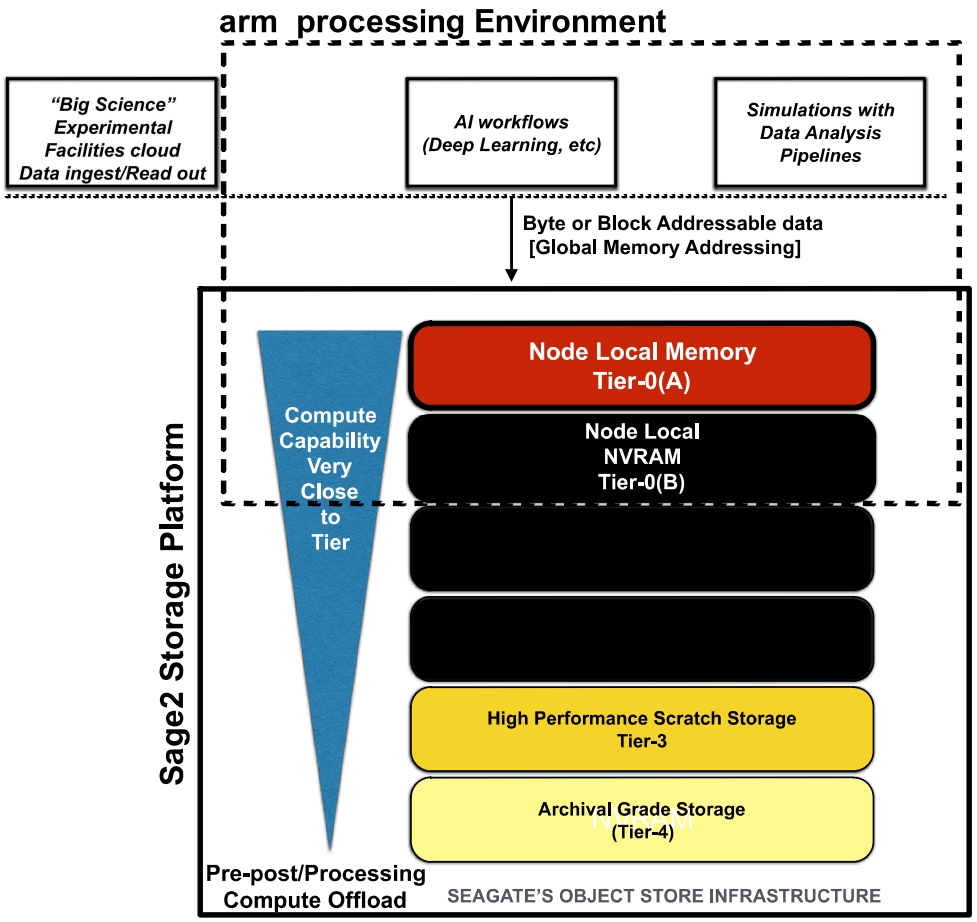
- Exploring Avoiding MPI-IO

Tools

- Allinea Performance Tools
- HSM

Sage2 - Continuing to build on the vision

Sage2 Innovation



Vision:

Extending storage systems into Compute nodes & blurring the lines between memory & storage

<u>Four</u> primary Innovations

1.**Compute node local Memories** part of storage stack

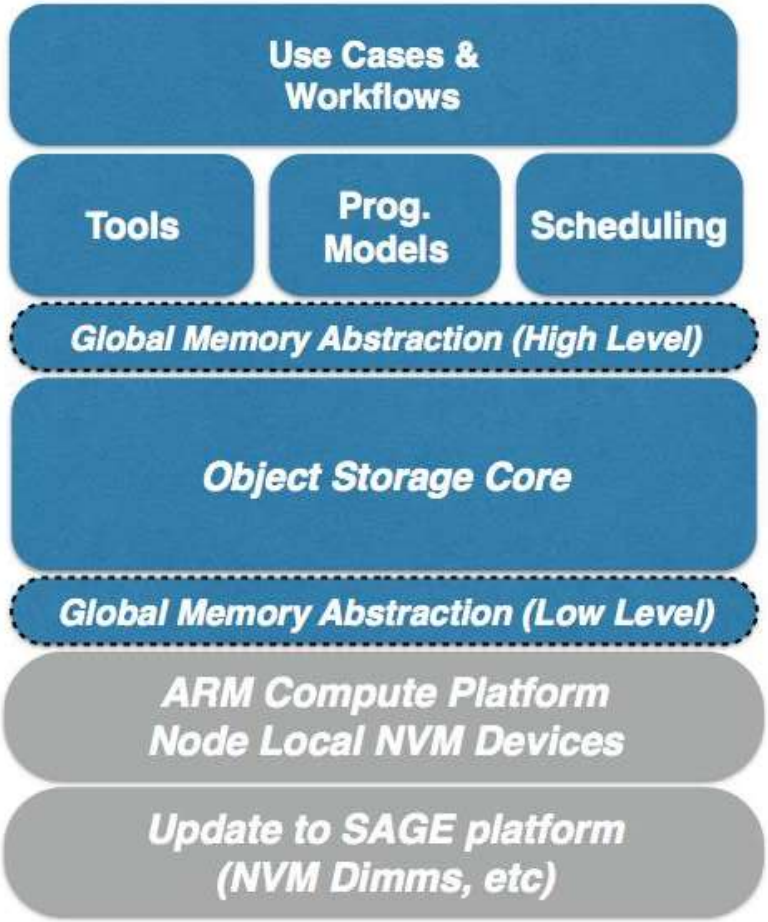
2.**Byte Addressable extensions** into Persistent storage (Global Memory Abstraction)

3.**Co-design** with new workflows: Mainly Data analytics pipelines w/ **AI/Deep learning**

4.**Co-design** with **ARM based environments** – moving towards European HPC Ecosystem Goals.

AI/DL use cases expected to be memory intensive & will exploit node local memory which will need to be extended

Sage2 - Key Stack Components



Tools/ Prog. Models/Schedulers

- dCache, High Speed Object Transfer, I/O Containers, TensorFlow, Slurm for Motr, Object access Prog. Mod, Simple Access Interface

GMA

- High Level – API for mapping Objects in Memory
- Low Level – Incorporating NVDIMMs

Object Storage Core

- Motr for GMA
- Motr extreme scale comps. - QoS, DTM, Function Shipping
- Motr for Sage2 (Incl. ARM port)

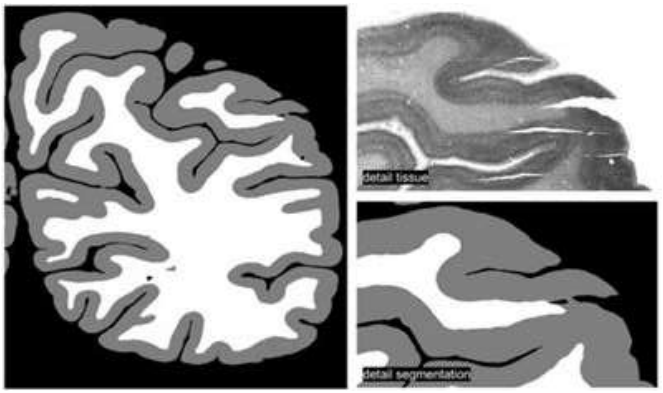
ARM

- ARM support for NVDIMMs

Sage2 Use Cases

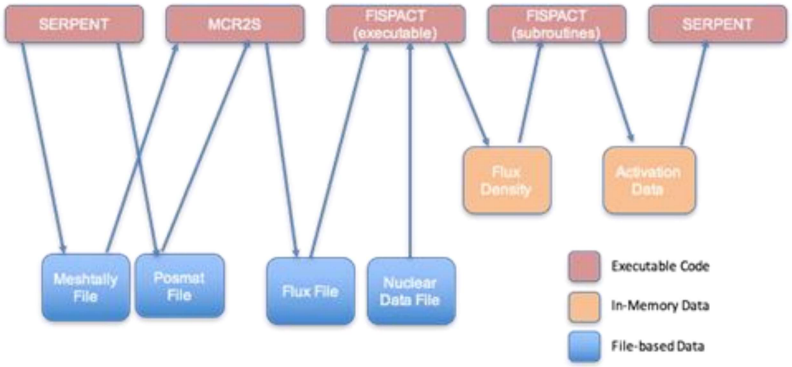
AI Based Data Analysis
[1]Cervical Cancer Diagnosis

AI Based Data Analysis
[2] Multi-label Classification of Large Videos



[3] Brain Image Data Analysis

[4] Radio Astronomy Data Analysis

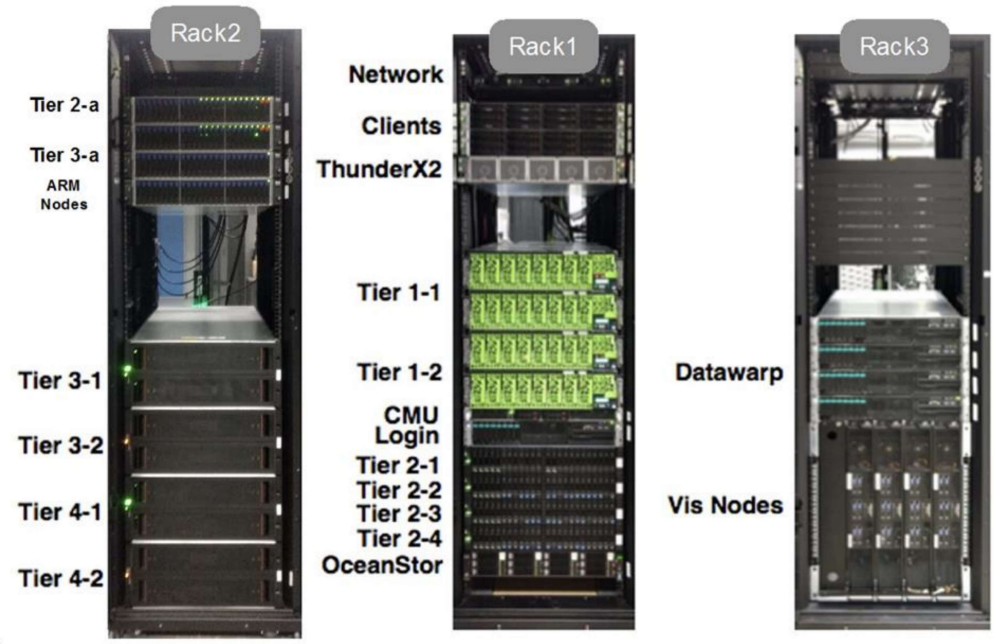


[5] Multi-Physics Multi-stage workflows (Nuclear Fusion)

[7] Classic HPC Applications

Machine Learning
[6]Tensorflow for machine learning monitoring data

Sage2 Update



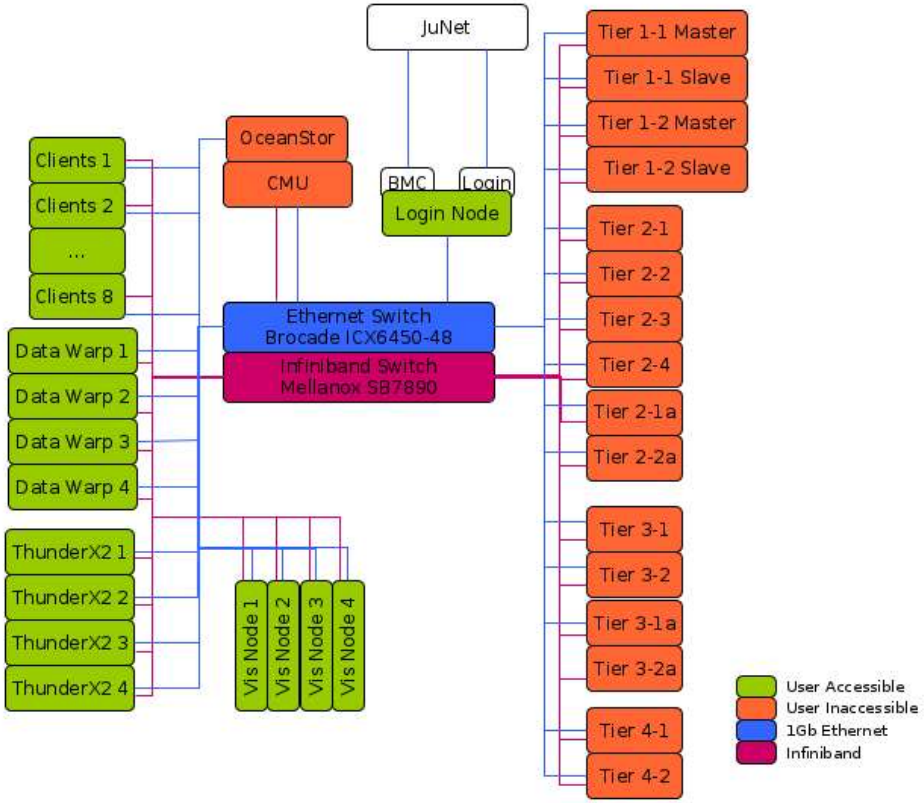
- Prototype updated with latest Motr+Hare
- Focus on Application Porting
- Completion of Prototype Implementations
- Detailed Performance analysis of CORTX on SAGE – Coming up

Sage2 – Ongoing POCs/ Implementations (In Motr, & on top of Motr API)

- QoS (HSM & Performance Throttling) with Motr
- CORTX Arm Porting with Motr
- TensorFlow on Motr API
- dCache on Motr API
- 3DXPoint NVDIMM Interoperability
- Deployed AI applications on Motr
- Slurm CORTX Burst Buffer Plugin on Motr API
- Global Memory Abstraction APIs & Motr Driver on Motr API
- Function Shipping in Motr
- Simple Access Interface on Motr API
- Distributed Transactions in Objects (Motr)
- Clovis Apps Framework on Motr API
- Go binding on Motr MPI

Open-Source Code (Incl. Documentation) (Q3, Q4 2021)

More on SAGE prototype



	Rack 3	Rack 1	Rack 2
42		Mellanox SB7890 Infiniband Swtich	
41		Mellanox SX6036 Infiniband Swtich	
40		Brocade ICX6430-24 Ethernet Switch	
39		Brocade ICX6450-48 Ethernet Switch	
38		**Clients**	**Tier2-1a**
37		Supermicro 2U 4-Server	ARM server
36	**Visualisation Nodes**	**Clients**	**Tier2-2a**
35	visnode-01	Supermicro 2U 4-Server	ARM server
34	visnode-02	**ThunderX2 Nodes**	**Tier3-1a**
33	visnode-03	client-tx2-[1-4]	ARM server
32	visnode-04		**Tier3-2a**
31			ARM server
30			
29			
28			
27		**Tier1-1 Master**	
26		Bull Bullion Server	
25			
24		**Tier1-1 Slave**	
23		Bull Bullion Server	
22	**Data Warp Nodes**		
21	datawarp-01	**Tier1-2 Master**	
20	datawarp-02	Bull Bullion Server	**Tier3-1**
19	datawarp-03		Seagate 5U84 Enclosure
18	datawarp-04	**Tier1-2 Slave**	
17		Bull Bullion Server	
16			
15		**CMU** Bull R421-E4 Server	**Tier3-2**
14		**Login** Cray S2600WTTR Server	Seagate 5U84 Enclosure
13			
12		**Tier2-1**	
11		Seagate 2U24 Enclosure	
10		**Tier2-2**	**Tier4-1**
9		Seagate 2U24 Enclosure	Seagate 5U84 Enclosure
8		**Tier2-3**	
7		Seagate 2U24 Enclosure	
6		**Tier2-4**	
5		Seagate 2U24 Enclosure	**Tier4-2**
4		**Scratch Storage** OceanStor	Seagate 5U84 Enclosure
3			
2			
1			

SAGE – Tiers 1 and 2

Node	Model	CPU	Memory (usable/installed)
sage-tier1-1	BULL bullion S	4 Xeon(R) CPU E7-4830 v3 @ 2.10GHz	1511/1536GiB
sage-tier1-2	BULL bullion S	4 Xeon(R) CPU E7-4830 v3 @ 2.10GHz	1511/1536GiB

Dev	Disk size	FS	Mount point	Model
/dev/sda	292GB	xfs	/	MR9363-4i
/dev/nvme0n1	350GB	n/a	n/a	Intel Optane
/dev/nvme1n1	1.5TB	n/a	n/a	Seagate Nytro XP7102

Node	Model	CPU	Memory (usable/installed)
sage-tier2-1a	GIGABYTE R281-T91-00	2 Cavium ThunderX2(R) CPU CN9975 v2.2 @ 2.0GHz	127/128GiB
sage-tier2-2a	GIGABYTE R281-T91-00	2 Cavium ThunderX2(R) CPU CN9975 v2.2 @ 2.0GHz	127/128GiB

Node	Number of disks	Size	Model
sage-tier2-1a	2 11	SSDPE2KX010T8 745.2G	INTEL XS800LE70004
sage-tier2-2a	2 11	SSDPE2KX010T8 745.2G	INTEL XS800LE70004

Node	Model	CPU	Memory (usable/installed)
sage-tier2-1	Seagate Laguna Seca	1 Xeon(R) CPU E5-2648L v3 @ 1.80GHz	125/128GiB
sage-tier2-2	Seagate Laguna Seca	1 Xeon(R) CPU E5-2648L v3 @ 1.80GHz	125/128GiB
sage-tier2-3	Seagate Laguna Seca	1 Xeon(R) CPU E5-2618L v3 @ 2.30GHz	125/128GiB
sage-tier2-4	Seagate Laguna Seca	1 Xeon(R) CPU E5-2648L v3 @ 1.80GHz	125/128GiB

Node	Number of disks	Size	Model
sage-tier2-1	1 3	119.2G 745.2G	Micron_M600_MTFD ST800FM0183
sage-tier2-2	1 7	119.2G 745.2G	Micron_M600_MTFD ST800FM0183
sage-tier2-3	1 6	119.2G 745.2G	Micron_M600_MTFD ST800FM0183
sage-tier2-4	1 6	119.2G 745.2G	Micron_M600_MTFD ST800FM0183

SAGE – Tiers 3 and 4

Node	Model	CPU	Memory (usable/installed)
sage-tier3-1	Seagate 5U84 Laguna Seca	1 Xeon(R) CPU E5-2618L v3 @ 2.30GHz	125/128GiB
sage-tier3-2	Seagate 5U84 Laguna Seca	1 Xeon(R) CPU E5-2618L v3 @ 2.30GHz	125/128GiB

Node	Number of disks	Size	Model
sage-tier3-1	1 49	119.2G 3.7T	Micron_M600_MTFD ST4000NM0031
sage-tier3-2	1 19	119.2G 7.3T	Micron_M600_MTFD ST8000NM0055-1RM

Node	Model	CPU	Memory (usable/installed)
sage-tier3-1a	GIGABYTE R281-T91-00	2 Cavium ThunderX2(R) CPU CN9975 v2.2 @ 2.0GHz	127/128GiB
sage-tier3-2a	GIGABYTE R281-T91-00	2 Cavium ThunderX2(R) CPU CN9975 v2.2 @ 2.0GHz	127/128GiB

Node	Number of disks	Size	Model
sage-tier3-1a	1	279.4G	ST300MP0006
sage-tier3-2a	1	279.4G	ST300MP0006

Node	Model	CPU	Memory (usable/installed)
sage-tier4-1	Seagate 5U84 Laguna Seca	1 Xeon(R) CPU E5-2618L v3 @ 2.30GHz	125/128GiB
sage-tier4-2	Seagate 5U84 Laguna Seca	1 Xeon(R) CPU E5-2648L v3 @ 1.80GHz	125/128GiB

Node	Number of disks	Size	Model
sage-tier4-1	1	119.2G	Micron_M600_MTFD
sage-tier4-2	1 1	119.2G 745.2G	Micron_M600_MTFD ST800FM0183

SAGE – The 16 Clients

Node	Model	CPU	Memory (usable/installed)	PDU Port
client-21	Supermicro X8DTT-H	2 Xeon(R) CPU E5630 @ 2.53GHz	23/24GiB	AA4
client-22	Supermicro X8DTT-H	2 Xeon(R) CPU E5630 @ 2.53GHz	23/24GiB	AA4
client-23	Supermicro X8DTT-H	2 Xeon(R) CPU E5630 @ 2.53GHz	23/24GiB	AA4
client-24	Supermicro X8DTT-H	2 Xeon(R) CPU E5620 @ 2.40GHz	23/24GiB	AA4
client-25	Supermicro X8DTT	2 Xeon(R) CPU E5620 @ 2.40GHz	19/20GiB	AA5
client-26	Supermicro X8DTT	2 Xeon(R) CPU E5504 @ 2.00GHz	15/16GiB	AA5
client-27	Supermicro X8DTT	2 Xeon(R) CPU E5504 @ 2.00GHz	15/16GiB	AA5
client-28	Supermicro X8DTT	2 Xeon(R) CPU E5504 @ 2.00GHz	15/16GiB	AA5

Node	Model	CPU	Memory (usable/installed)
visnode-01	Cray Inc. S2600TPR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB
visnode-02	Cray Inc. S2600TPR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB
visnode-03	Cray Inc. S2600TPR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB
visnode-04	Cray Inc. S2600TPR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB

Node	Model	CPU	Memory (usable/installed)
datawarp-01	Cray Inc. S2600WTTR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB
datawarp-02	Cray Inc. S2600WTTR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB
datawarp-03	Cray Inc. S2600WTTR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB
datawarp-04	Cray Inc. S2600WTTR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB

SAGE – Login Node and CMU/ Software

Node	Model	CPU	Memory (usable/installed)
sage-login	Cray Inc. S2600WTTR	2 Intel(R) Xeon(R) CPU E5-2680 v4 @ 2.40GHz	125/128GiB

Node	Model	CPU	Memory (usable/installed)
sage-cmu	Bull SAS R421-E4	2 Xeon(R) CPU E5-2650 v3 @ 2.30GHz	109/112GiB

server nodes
CentOS Linux release 7.9.2009 (Core)
cortx-motr-1.0.0-1_git89f7737_3.10.0_1127.19.1.el7.x86_64
cortx-hare-1.0.0-1_git28f3372.el7.x86_64
kmod-lustre-client-2.12.4.2_171_g9356888-1.el7.x86_64

compute nodes
CentOS Linux release 7.8.2003 (Core)
cortx-motr-1.0.0-1_git89f7737_3.10.0_1127.19.1.el7.x86_64
cortx-hare-1.0.0-1_git28f3372.el7.x86_64
kmod-lustre-client-2.12.4.2_171_g9356888-1.el7.x86_64

Usage of the SAGE System with Clovis Apps (Demo)

- **`c0ct`**
  `Read motr object to a file`
- **`c0cp`**
  `Write motr object from a file`
- **`c0rm`**
  `Remove motr object`

- All three applications run natively on Motr clients.
- They use the Motr client interface (Clovis) to connect directly to servers for performing object I/O.
- All IO and other operations performed on native/raw motr objects.
- Do not handle composite objects yet.
- Not at all S3 and other high-level objects.

Git Repo:
https://gitlab.version.fz-juelich.de/sage2/clovis-sample-apps
(Ongoing work to consolidate repository)

HSM Demo

HSM_Summary

```
m0hsm> help
Usage: m0hsm <action> <fid> [...]
  actions:
    create <fid> <tier>
    show <fid>
    dump <fid>
    write <fid> <offset> <len> <seed>
    write_file <fid> <path>
    read <fid> <offset> <len>
    copy <fid> <offset> <len> <src_tier> <tgt_tier> [options: mv,keep_prev,w2dest]
    move <fid> <offset> <len> <src_tier> <tgt_tier> [options: keep_prev,w2dest]
    stage <fid> <offset> <len> <tgt_tier> [options: mv,w2dest]
    archive <fid> <offset> <len> <tgt_tier> [options: mv,keep_prev,w2dest]
    release <fid> <offset> <len> <tier> [options: keep_latest]
    multi_release <fid> <offset> <len> <max_tier> [options: keep_latest]
    set_write_tier <fid> <tier>


  <fid> parameter format is [hi:]lo. (hi == 0 if not specified.)
  The numbers are read in decimal, hexadecimal (when prefixed with `0x')
  or octal (when prefixed with `0') formats.
m0hsm>
```

Git Repo

https://github.com/Seagate/cortx-motr

https://github.com/Seagate/cortx-motr/tree/main/hsm

Note "first cut" performance for tiers as follows:

Tier1 – 2.6 GB/s (4 NVME devs)
Tier2 – 1.9 GB/s (4 SSD devs)
Tier3 – 0.6 GB/s (4 HDD devs)

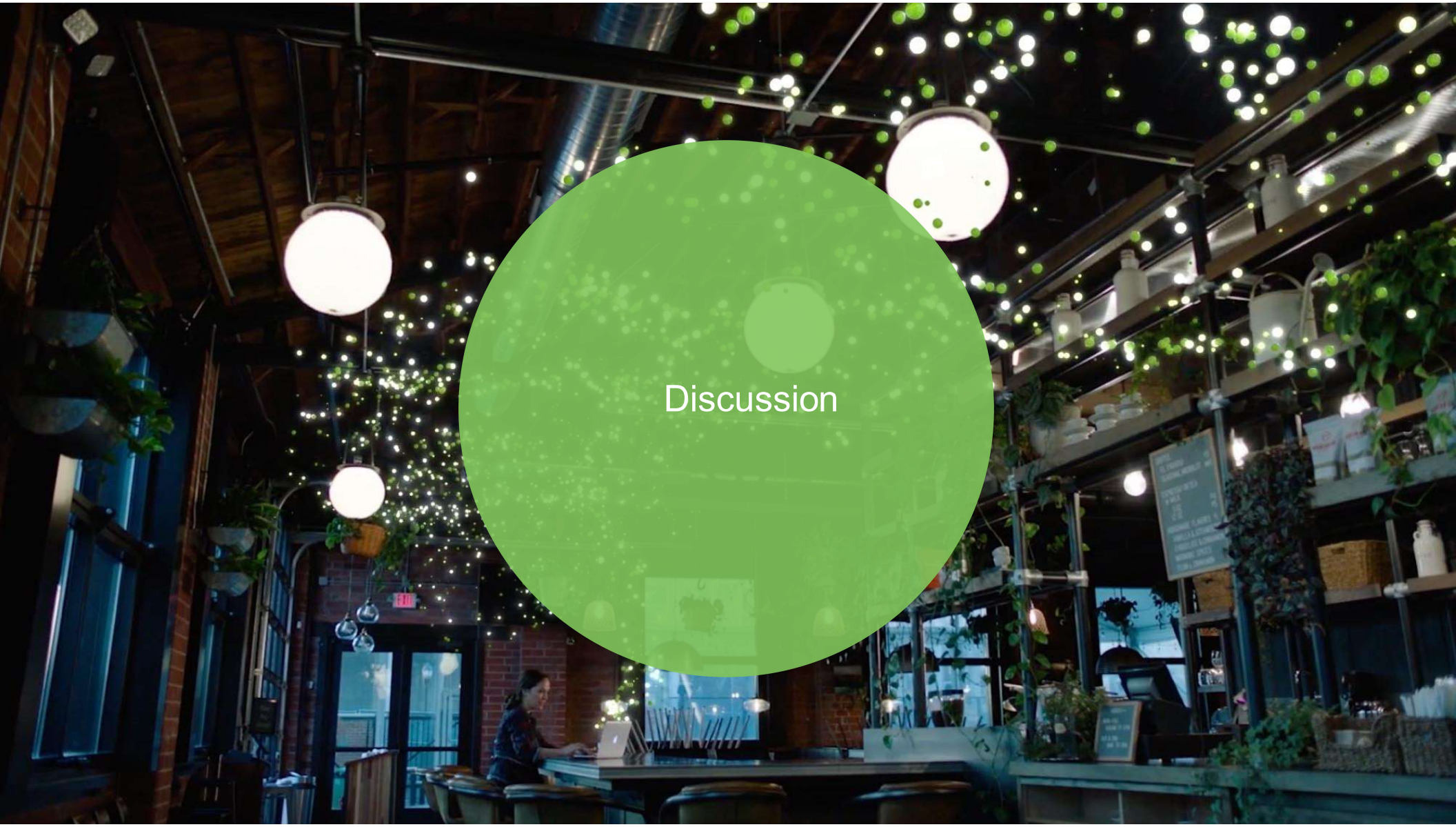
(Note: the pool width of 4 devices was used in Tier2 and Tier3 (as in Tier1) to make the perf measurements comparable.

Additional Notes (Code & software management)

- Performance tests currently being run by mcp utility (written in Go) (We are getting multiple GB/s across tiers – more detailed performance characterizations TBD)

- Code that will be available (Many will be integrated/linked from CORTX github)

  - MIO in Maestro (Seagate) - currently in Maestro gitlab repos
    - https://github.com/Seagate/cortx-mio
  - TensorFlow
  - DCache
  - Slurm Interface
  - Clovis Driver for GMA
  - Simple Access Interface
  - ESDM Middleware work in EsiWACE2 (Seagate) - currently in DKRZ gitlab repos


Discussion