DisTRaC: Distributed Transient Ram Ceph

Accelerating High-Performance Data Processing

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About the Rosalind Franklin Institute and me

- The Rosalind Franklin Institute:
  - A United Kingdom Research Institute dedicated to developing new technologies to tackle important health research challenges. Based in Harwell Campus, Didcot and funded by the UKRI ESPRC.
  - **5 Themes**: Artificial Intelligence and Informatics, Biological Mass Spectrometry, Correlated Imaging, Next Generation Chemistry and Structural Biology
- Me:
  - Currently studying an MSc in Artificial Intelligence at Queen Mary University of London and working as a Research Software Associate at The Rosalind Franklin Institute
  - Looking for a PhD

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Contents

- Background
- The Problem
- What is DisTRaC
- Solving the Problem
- Case Studies
- Ongoing Work
- Conclusion
- Acknowledgments
- Questions

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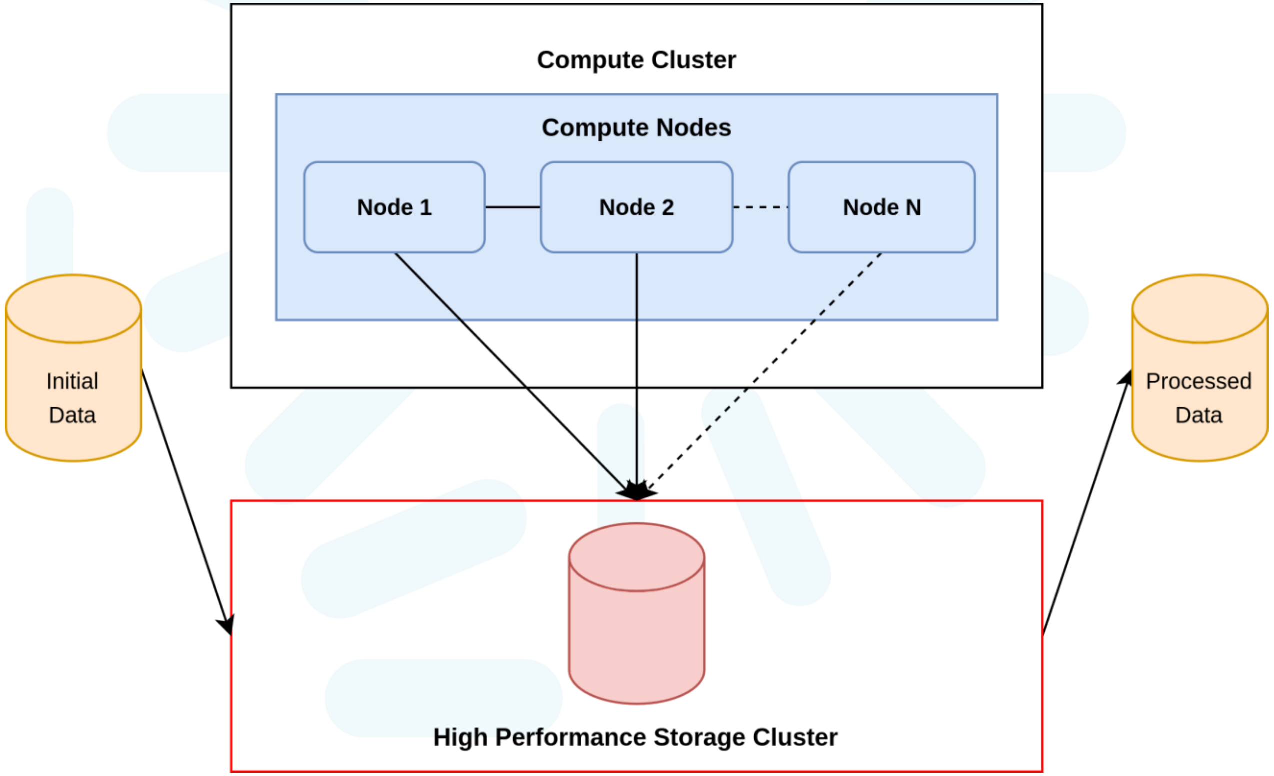
Background

High Performance Compute Cluster

- Job scheduler
- Compute - lots of RAM
- Storage
- Networking - Storage and Interconnect

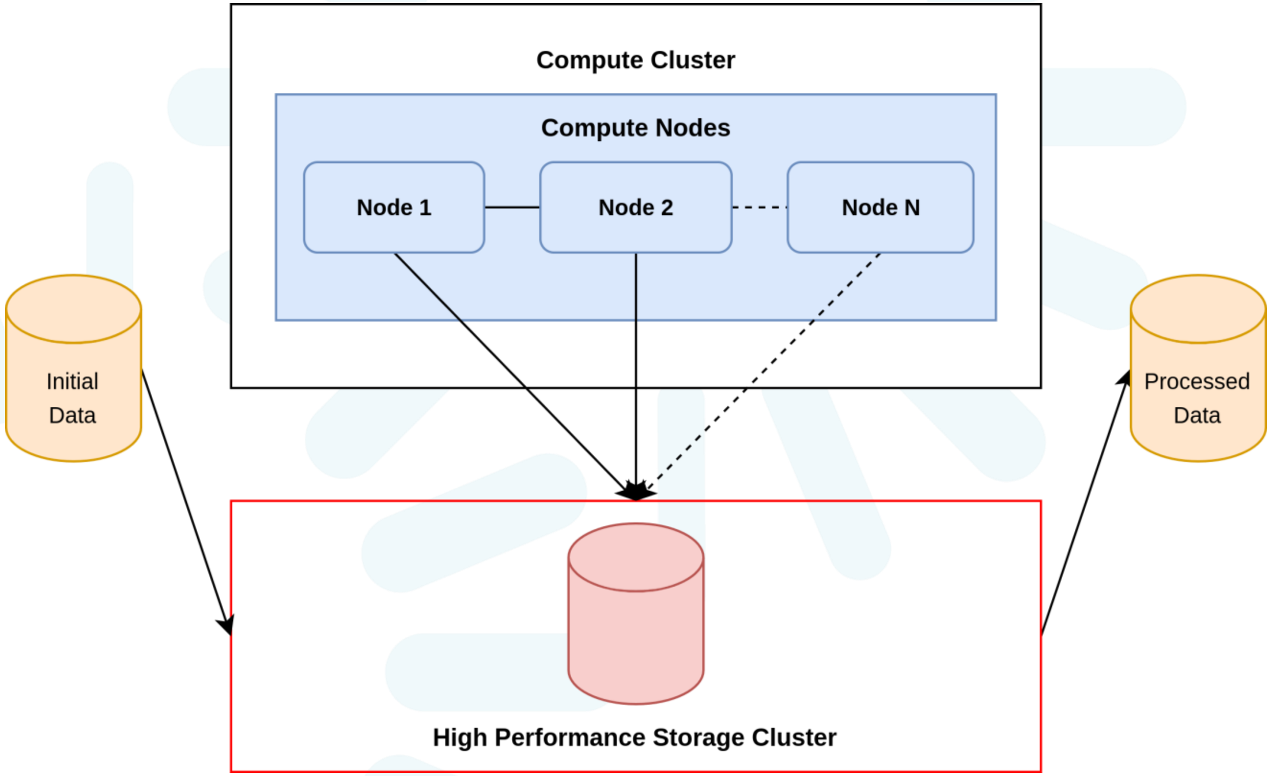


Traditional High Performance Compute Cluster Setup

What is the Problem

Problem

- Network connection limits IO Bound Applications
- Shared Storage Resourced
  - Users' can affect the performance of others
- Storing of Intermediate Data
- Storage clusters are expensive, hard to maintain and set up, especially in cloud
- Inefficient use of resources



Traditional High Performance Compute Cluster Setup

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Solution?

DisTRaC

https://github.com/rosalindfranklininstitute/DisTRaC

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What is DisTRaC?

- Distributed Transient Ram Ceph
- A program for deploying a transient Ceph [1] cluster onto HPC infrastructure utilising RAM in a scalable and efficient manner.
- Creating a job persistent and isolated in-memory file/object store for HPC applications.

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Why DisTRaC and not another deployment tool

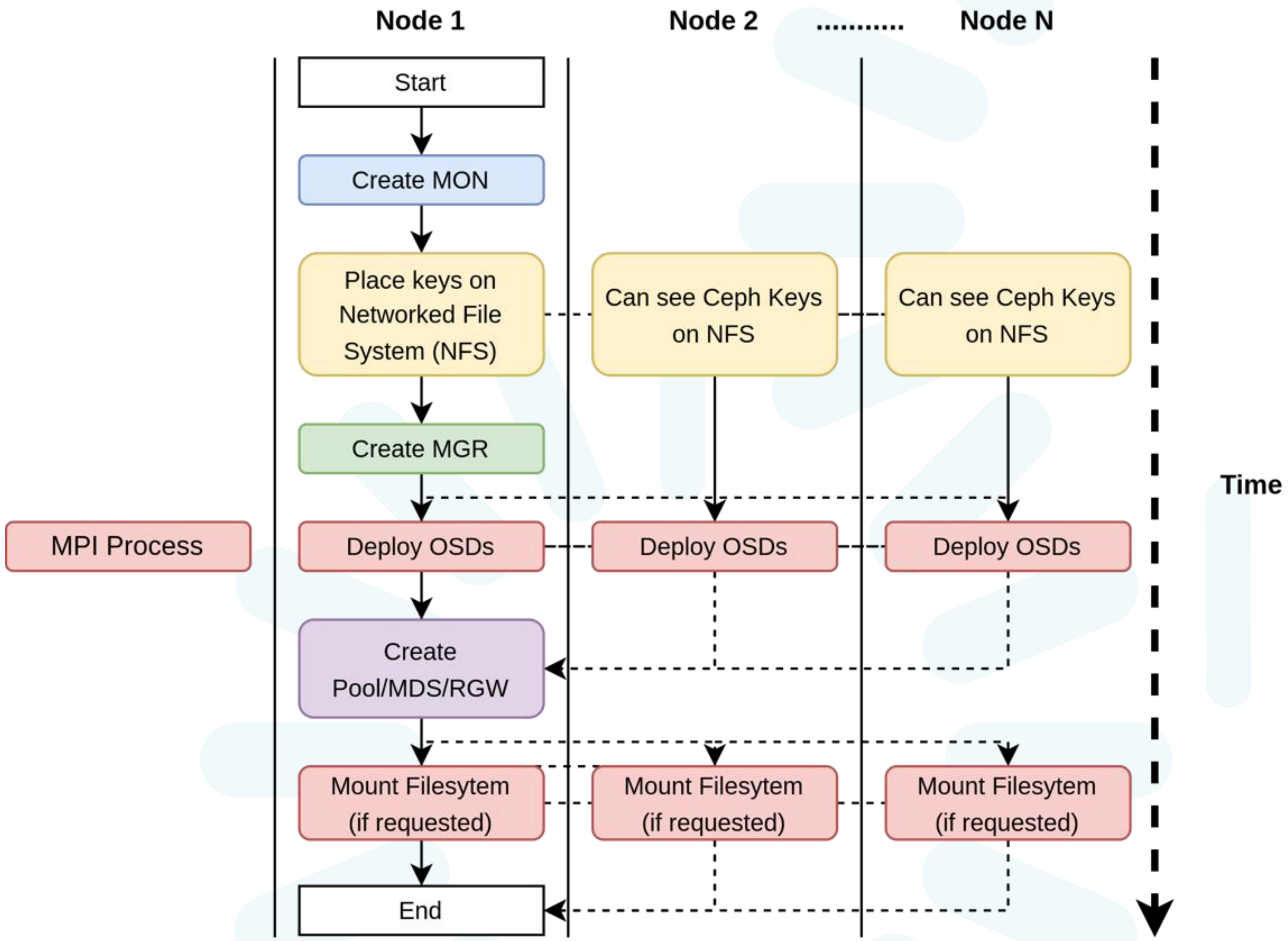
Current Deployment tools

- Designed to build long-lasting maintainable clusters
  - Lots of safety checks
  - Slow to deploy and remove clusters
- Sequential
- Require passwordless SSH

We need something quick and efficient

- Compute should be used for compute not setting up storage

DisTRaC Deployment



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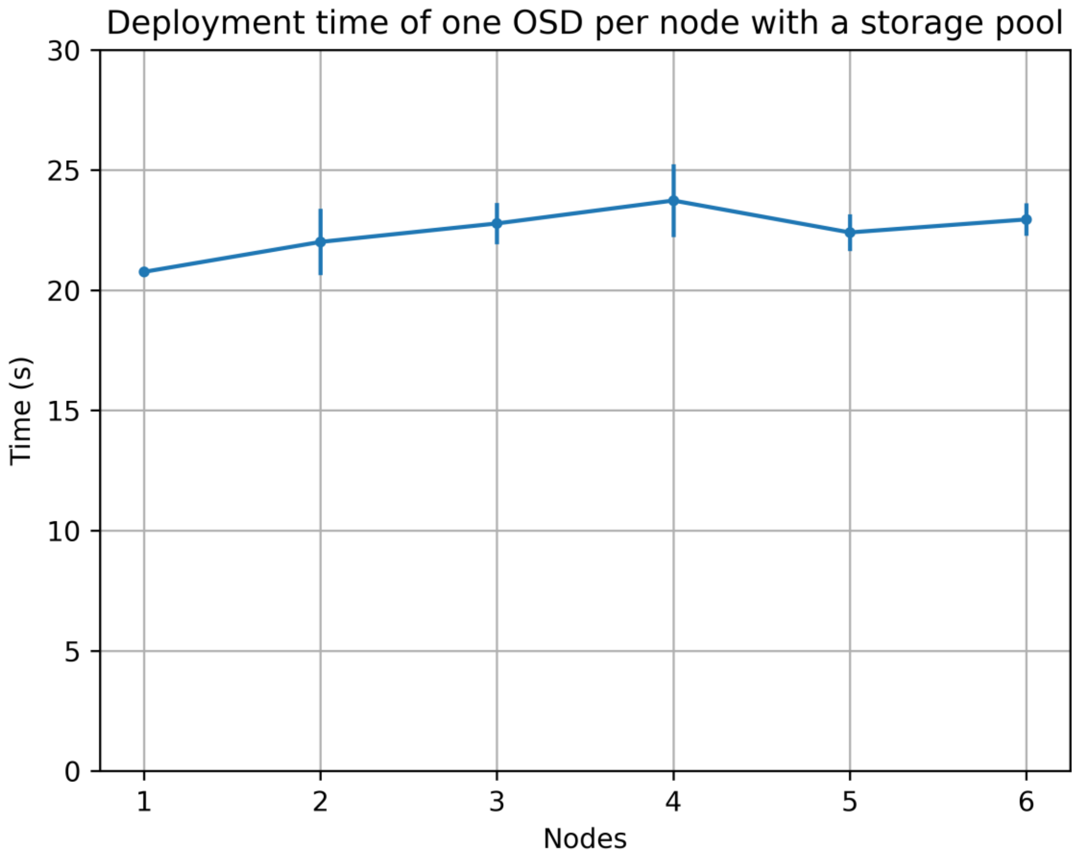
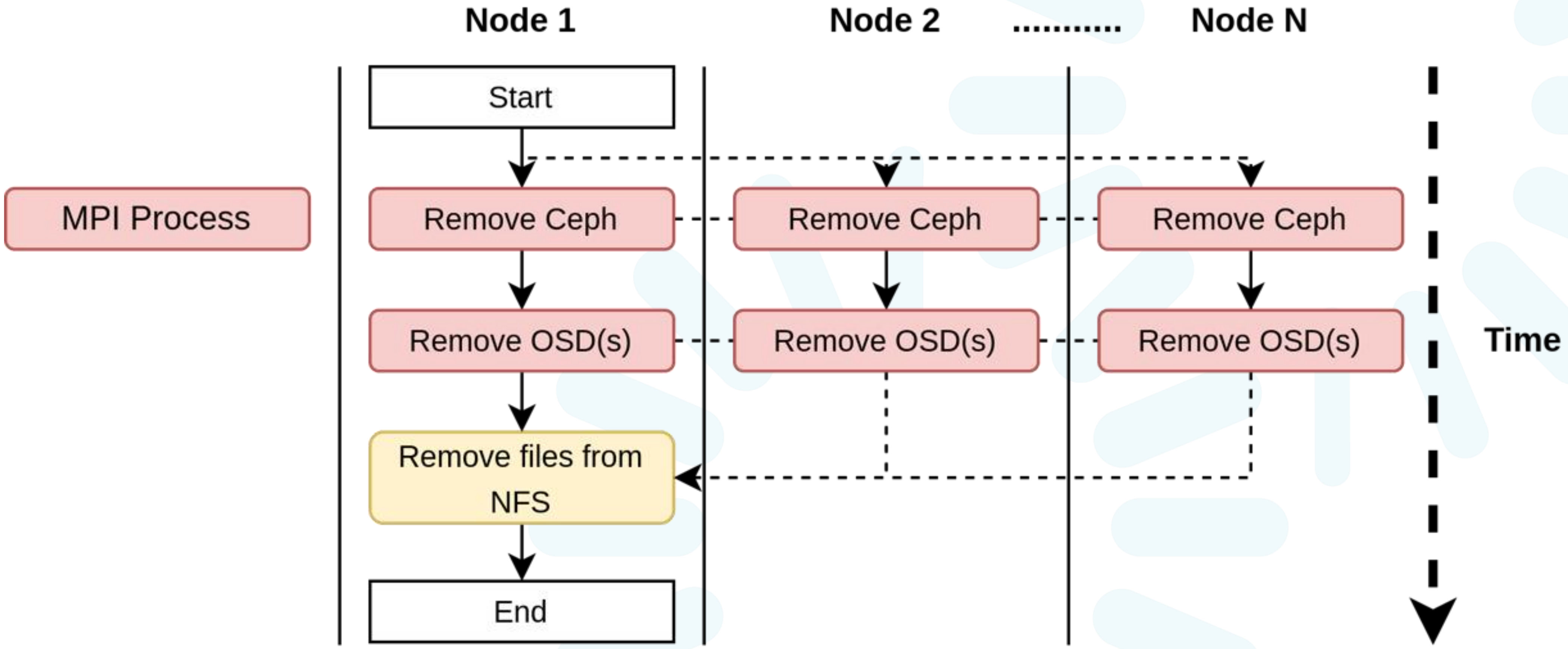
Deployment Time



Version 1 of DisTRaC, Ceph Luminous

DisTRaC Removal



Node 1

Node 2

....

Node N

MPI Process

Start

Remove Ceph

Remove OSD(s)

Remove files from NFS

End

Remove Ceph

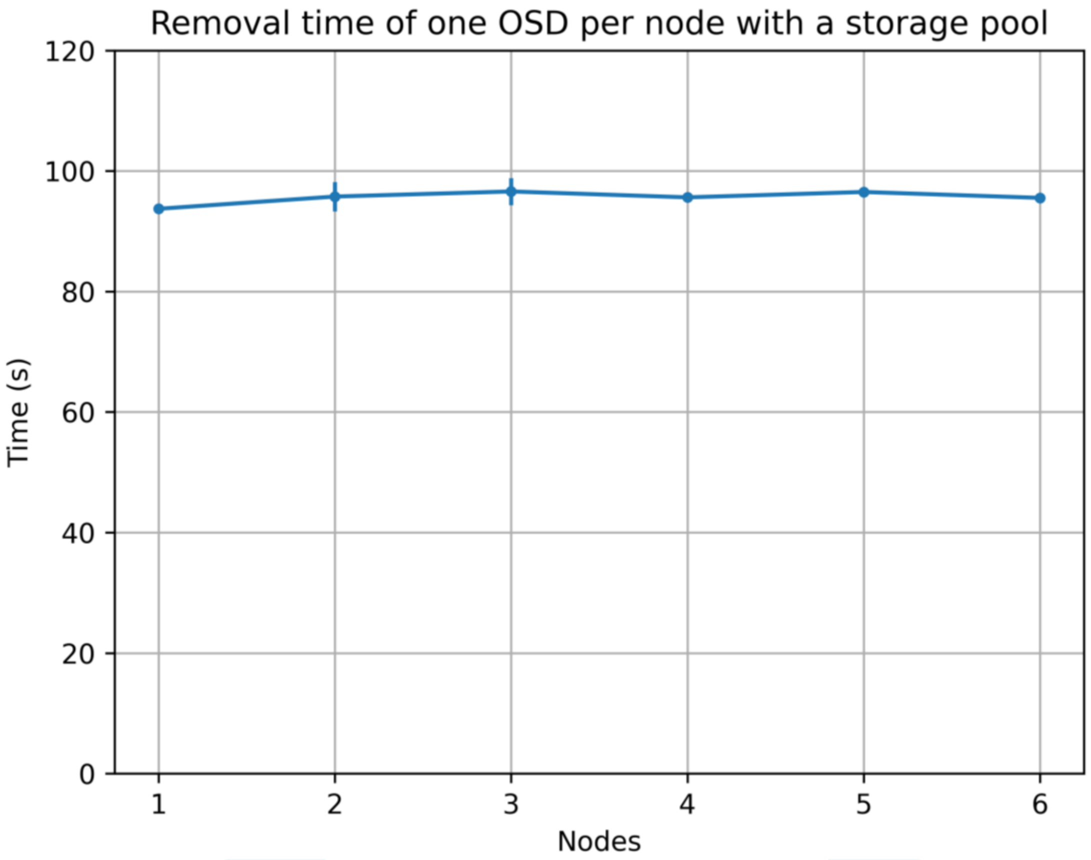
Remove OSD(s)

Remove Ceph

Remove OSD(s)

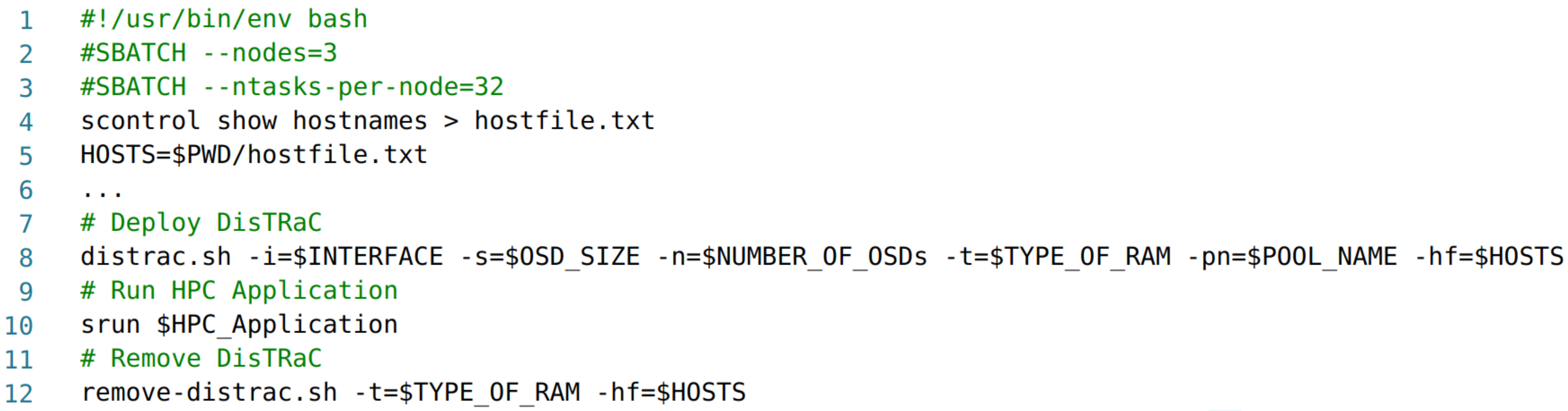
Time

Removal Time



Version 1 of DisTRaC, Ceph Luminous

Example Deployment Script



```
#!/usr/bin/env bash
#SBATCH --nodes=3
#SBATCH --ntasks-per-node=32
scontrol show hostnames > hostfile.txt
HOSTS=$PWD/hostfile.txt
...
# Deploy DisTRaC
distrac.sh -i=$INTERFACE -s=$OSD_SIZE -n=$NUMBER_OF_OSDs -t=$TYPE_OF_RAM -pn=$POOL_NAME -hf=$HOSTS
# Run HPC Application
srun $HPC_Application
# Remove DisTRaC
remove-distrac.sh -t=$TYPE_OF_RAM -hf=$HOSTS
```

DisTRaC deploy and remove

Recap

- We can create a Ceph cluster in fast and scalable way
- We can use DisTRaC deployment and removal within a job submission script
- But how does this solve the problem?

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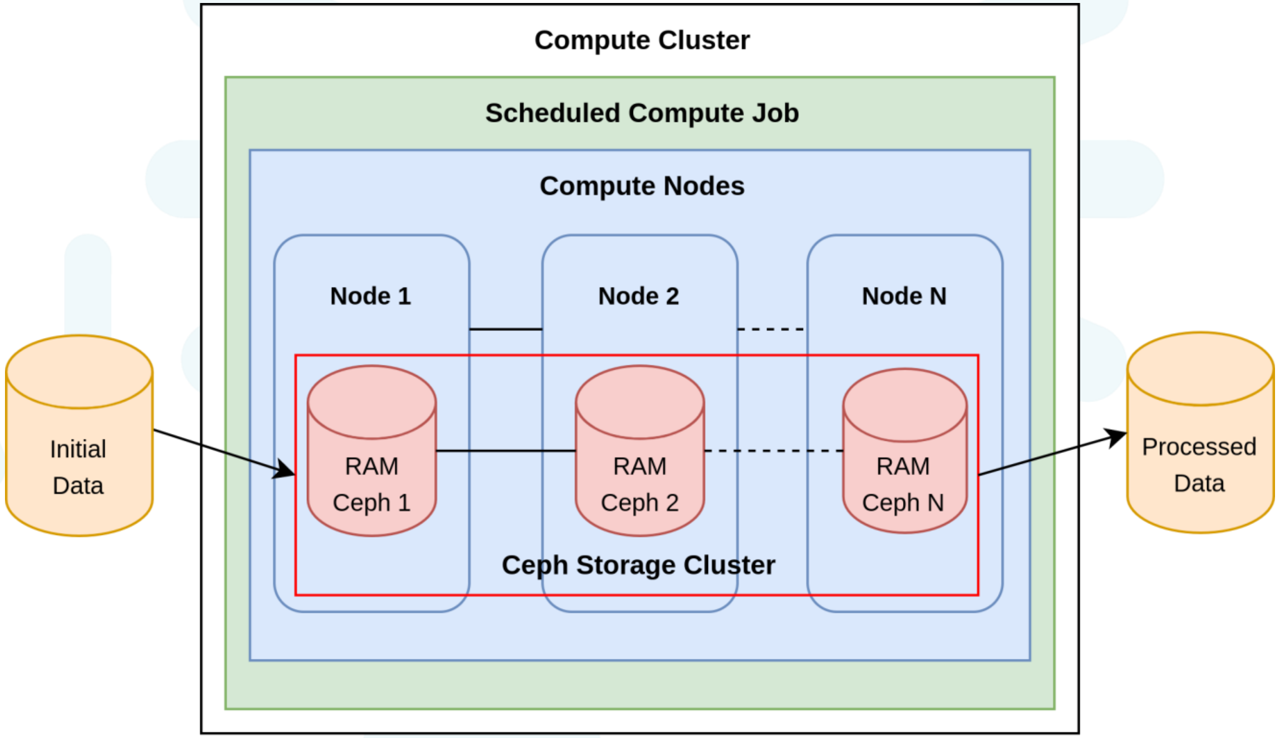
How DisTRaC solves the problem

- The IO bottleneck is now the node interconnect
- Isolated resources
- Takes pressure off HP storage
- Can remove the need for HP storage
- Reduces HPC cluster costs, especially in the cloud.
- Helps HPC facilities move towards Net-Zero



DisTRaC Deployed High Performance Compute Cluster Setup

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Case Studies

- RELION [2]
- SAVU [3]

Case Study: RELION

- RELION: A cryo-microscopy structure determination program used at The Rosalind Franklin Insitute
- Compute Bound Application
- Runs using whole node cluster allocation
- Produces small intermediate files.
- Can negatively impact other users' jobs

RELION: Benchmark Setup

- Dataset provided by Cambridge[4]
- Baseline: 2xg4dn8xlarge nodes utilizing the EBS file system provided by AWS
- DisTRaC: 2xg4dn8xlarge nodes utilizing 96 Gib of RAM split into 6-16 Gib OSDS 3 on each host

RELION: Results

- Reduction of processing time: **5.51%**
- Total time reduction: **4.37%**
- Reduction in IO overhead: **100%**
- Removed the cost and need for running of running HP file system in the cloud
- More efficient usage of existing hardware
- Helping towards Net-Zero Goals

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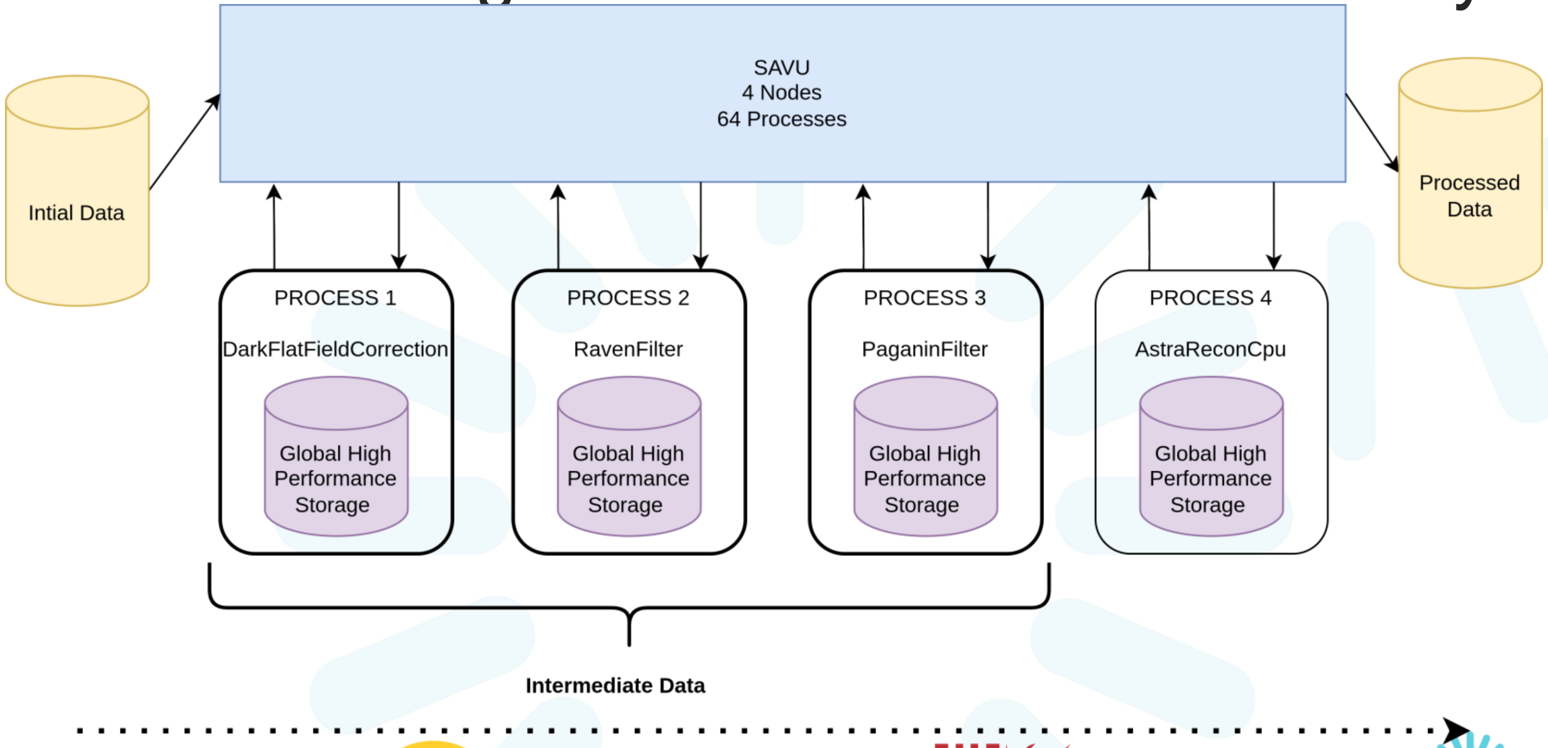
Case Study: SAVU

- SAVU: Tomography Reconstruction and Processing Pipeline used at Diamond Light Source and The Rosalind Franklin Insitute.
- Runs using whole node cluster allocation
- Can run at network rate
- Produces intermediate files.
- Capable of saturating access to a parallel file system
- Can negatively impact other users' jobs

SAVU: Setup At Diamond Light Source

- Dataset: Diamond Light Source Visit NT23252 Dataset [5]
- Baseline: 4 nodes utilizing the GPFS Central HP File system



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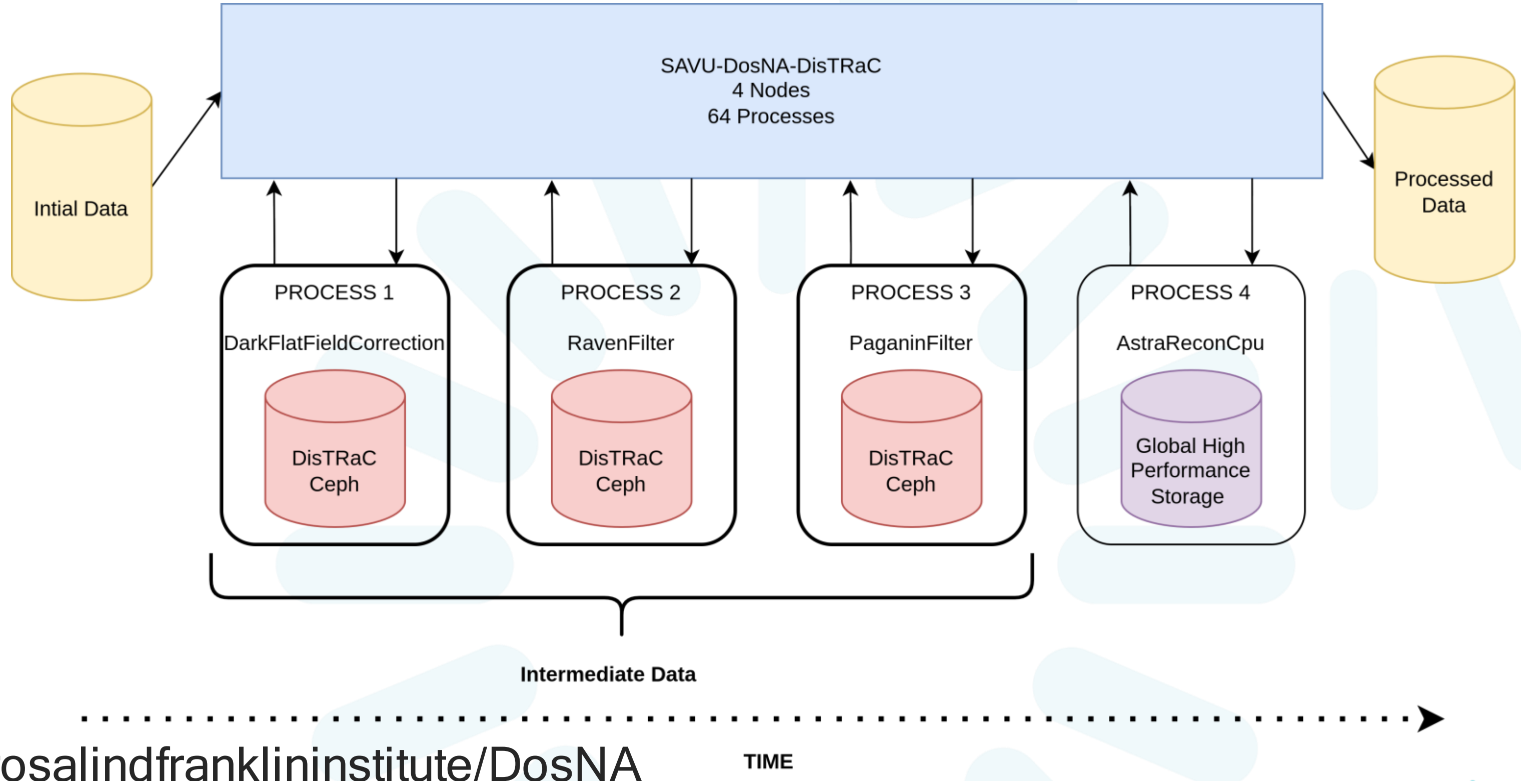
SAVU: Setup At Diamond Light Source

- DisTRaC: 4 nodes utilizing Ceph via DosNA[1]



[1] https://github.com/rosalindfranklininstitute/DosNA

SAVU: Results

- Total time reduction: **8.32%**
- Reduction in IO overhead: **81.04%**
- Reduce impact of SAVU on other users
- Prevented storing of intermediate data.
- More efficient usage of existing hardware
- Helping towards Net-Zero Goals

SAVU: Benchmark Setup At AWS

- Dataset: Diamond Light Source Visit NT23252 Dataset
- Baseline: 4 nodes utilizing the EBS AWS File system
- DisTRaC: 4 nodes utilizing Ceph Via DosNA

SAVU: Results

- Total time reduction: **67.53%**
- Reduction in IO overhead: **81.04%**
- Reduce costs of AWS
- Makes the cloud more viable for HPC
- Helping towards Net-Zero Goals

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Ongoing work

- DisTRaC – Intergration into Cluster-In-The-Cloud[1]
- Adding support for Heterogenous Clusters
- Adding support for NVME deployment
- DisTRaX- removing the Ceph requirement making it extensible to other storage mechanisms.

[1] https://cluster-in-the-cloud.readthedocs.io/en/latest/

Conclusion

- DisTRaC is a Ceph deployment tool that creates a hyper-converged HPC cluster for the duration of the job by utilising the RAM of the Compute Nodes.
- DisTRaC reduces the I/O overhead of the networked filesystem and offers a potential data processing performance increase.
- Helps better utilise existing hardware to improve the performance of HPC applications
- Moves us closer to sustainable and net-zero HPC

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Thank you

This project has spanned many years and has had many people involved:

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- Mark Basham

STFC Ceph User Group:

- Tom Byrne

Rosalind Franklin Institute Artificial Intelligence theme:

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- Laura Shemilt
- Joss Whittle

University of Bristol:

- Matthew Williams
- Christopher Woods

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- [3] Wadeson, N. and Basham, M., 2016. Savu: a Python-based, MPI framework for simultaneous processing of multiple, N-dimensional, large tomography datasets. *arXiv preprint arXiv:1610.08015*.
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Thank you for listening

Questions?

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