Weather and Climate HPC on AWS

Cloud Modeling Workgroup – 21st July 2022

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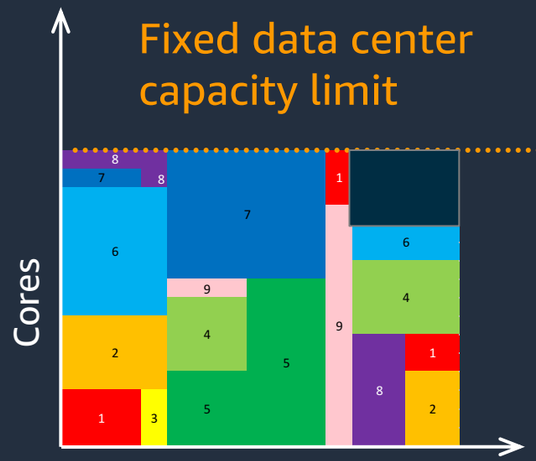
Agenda

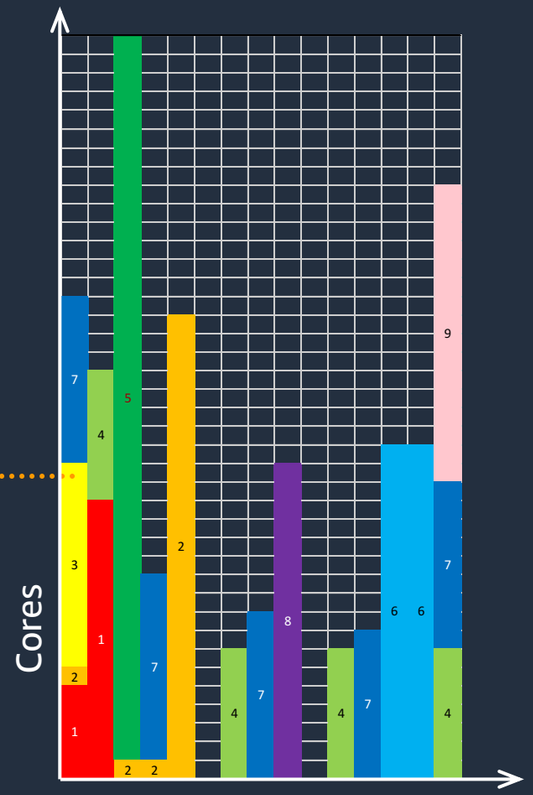
1. AWS HPC Overview
2. Weather and Climate HPC on AWS
3. Application Performance Results

Why HPC on AWS

Rethink the problem – focus on innovation not operational issues



Finite capacity, usually with long queues to wait in



Massive capacity when needed to speed up time to results, and agile environment when additional hardware and software experimentation is needed

Virtually unlimited infrastructure enabling scaling and agility

Instant access to latest technologies with no lengthy procurement cycles or big capital investments

Flexible configuration options quickly iterate resource selection and ensure cost optimization

On premises infrastructure can limit innovation

Lost productivity & longer time to results

72.8% of organizations that use HPC reported delayed or cancelled HPC jobs*

Lost innovation

Questions are left unasked, experiments are left undone, and potential revenue left on the table.

Outdated technology

Almost 20% of the useful life of new technology/ hardware lost in the procurement process.

Technical debt

Adapting newer algorithms to meet the requirements of an existing infrastructure = delays, and below-par performance.

* Source: Hyperion Research, 2018

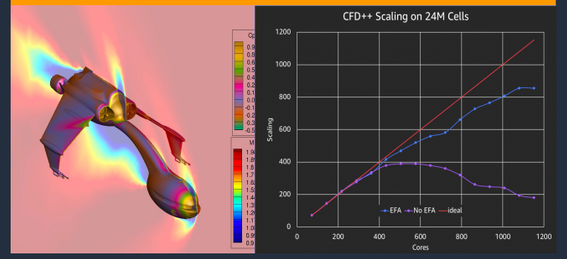
Summary of AWS HPC Benefits for Researchers

- Faster Innovation: more agile, virtual design process – larger more complex models for increased accuracy
- On-demand scalability: You can spin up 10s of thousands of cores and 100’s of TB HPC systems in a manner of minutes and change their configuration
- Simultaneous dynamic workloads: parallel product development and elastic infrastructure
- HPC+ other methods: AI/ML, Big Data, IoT, and Digital Twins, etc.
- Open Science: AWS hosts a variety of public datasets to lower the cost and improve the speed of research.
- Best Practices: Integrate HPC+PLM create a cloud native end to end process.

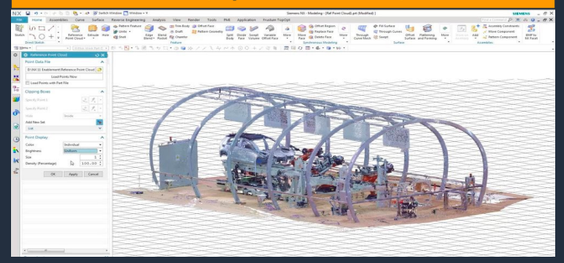
Flexible compute options and purchase models optimize price performance

Flexible compute to maximize performance

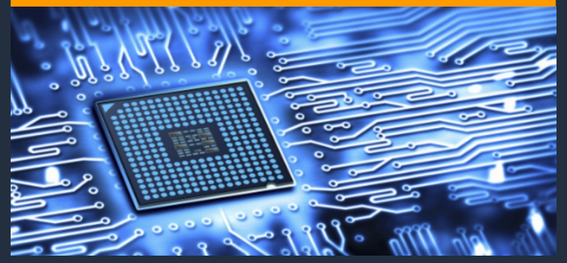
Memory & compute optimized
2.5-3.5Ghz, 2-16GB/core, 100Gbps, EFA



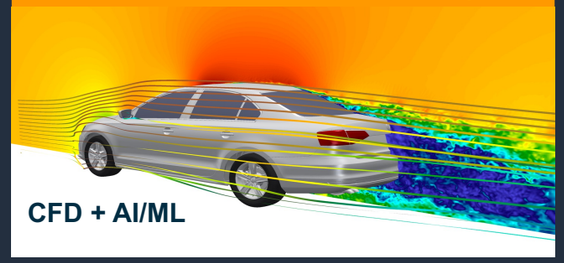
Graphics and rendering
1-8 GPUs, up to 384GB RAM, SSD



High clock speed
4.5Ghz, 192GB RAM, 100Gbps, EFA



Accelerated computing
8 A100 GPUs, 1.1TB RAM, SSD, 400Gbps

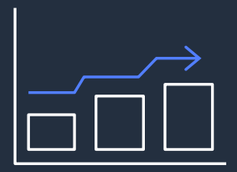


Flexible pricing models to optimize cost

On-Demand

Pay for compute capacity by the second with no long-term commitments.

Savings Plan & Reserved Instances



Make a commitment and to save up to 72% off compute.

Spot Instances

Spare EC2 capacity at savings of up to 90% off On-Demand prices.

AWS ParallelCluster

intel select solution

One-stop shop to set up your HPC cluster

Integrated with AWS services you need

Amazon FSx for Lustre

Amazon EC2 instances

EFA

NICE DCV

AWS Batch

Weather and Climate HPC Use Cases on AWS

Weather

- Operational Weather Forecasting
- Extreme Weather Modeling
- High Resolution Rapid Refresh (HRRR) Weather Modeling
- Datacenter Disaster Recovery

Climate

- Downscaled Climate Risk Modeling
- Flood/Fire Resiliency and Adaptation
- Sustainability Initiatives Planning
- Strategic Infrastructure Investment Planning

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Worldwide Collaboration on Weather and Climate HPC

Global Weather & Climate Model Cloud Enablement

- WRF
- FV3-GFS
- MPAS
- Harmonie
- ICON
- Unified Model
- CESM, E3SM

NCAR | National Center for Atmospheric Research

JCSDA

Public Sector and Commercial Deployments

MAXAR

DTN

LADCO

Danmarks Meteorologiske Institut

Research and Open Data Pipelines

NOAA

NASA

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Amazon EC2 Hpc6a Instances

Designed to deliver the best price performance for compute-intensive, high performance computing workloads in Amazon EC2

NEW!

AMD 3rd Gen EPYC Milan processors, 96 cores, up to 3.6GHz frequency, and 384GB of RAM

Up to 65% better price performance over comparable Amazon EC2 x-86 based, compute-intensive instances

Elastic Fabric Adapter enabled by default for 100 Gbps networking for inter-instance communications

AWS Regions at launch: US East (Ohio) and GovCloud US West

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Amazon EC2 C6i Instances

Offering up to 15% better price performance over comparable C5 instances

NEW!

- Compute optimized instances powered by third-generation Intel Xeon Scalable processors
- Up to 50 Gbps networking bandwidth (2x compared to C5), EFA supported on C6i.32xlarge
- Up to 40 Gbps Amazon EBS throughput (2x compared to C5)
- Flexibility and choice – 9 instance sizes
- AWS Regions at launch – US East (N. Virginia, Ohio), US West (Oregon), and EU (Ireland)

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TOP500: AWS #40 June 2021

Geo Spatial Data Analysis

9.95 PetaFlops ~ 172,692 Cores

Mike has worked for decades to prove to the world that mass-produced, commodity hardware and software can be used to build a supercomputer, and the results more than speak for themselves.”

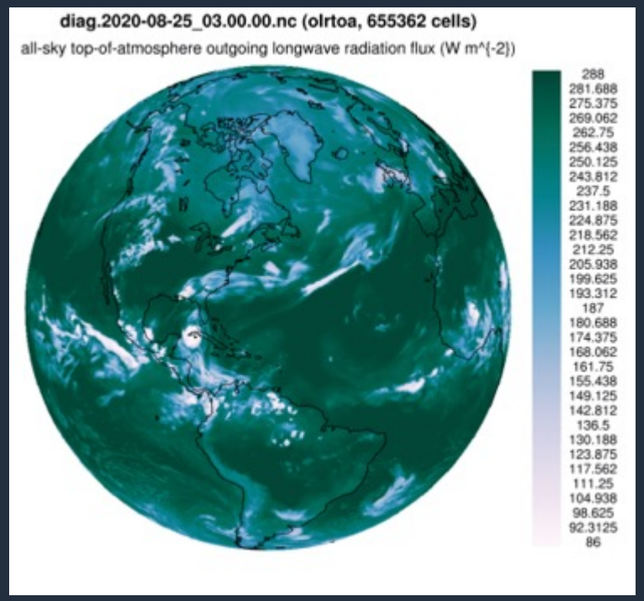
Jeff Barr, VP & Chief Evangelist, AWS

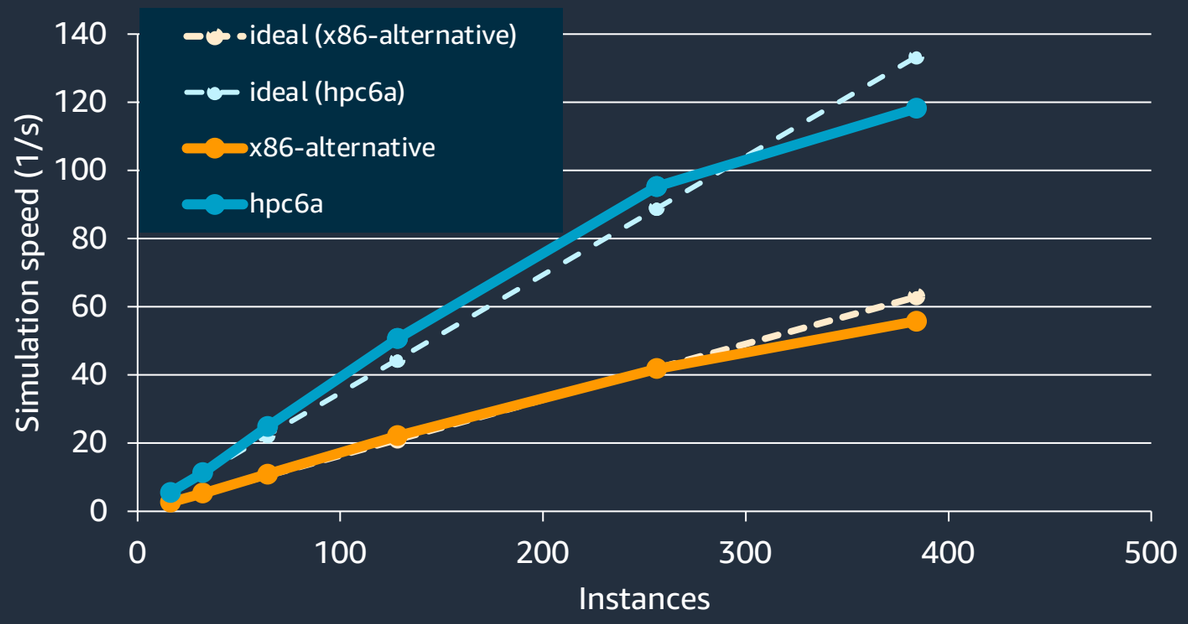
https://blog.descarteslabs.com/achieves-number-41-in-top500-cloud-based-supercomputing

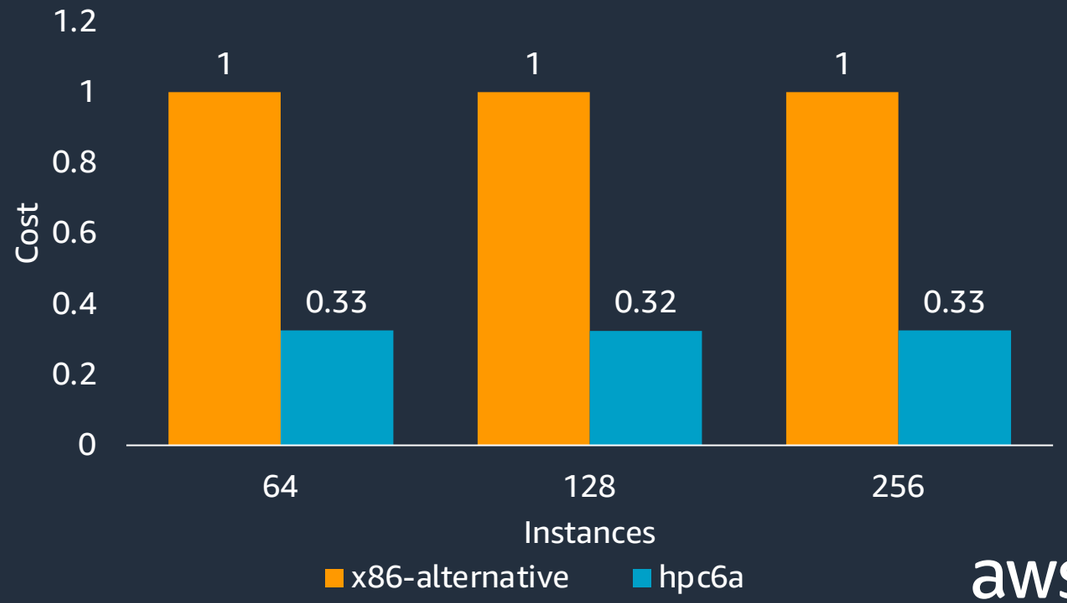
DTN: Enabling High-resolution Weather Modeling

"Our collaboration with AWS allows us to better serve our customers with high-resolution weather prediction systems that feed analytics engines. ***We're very excited to see the price/performance of Hpc6a and we expect this to be our go-to Amazon EC2 instance choice for HPC workloads going forward."***

- Lars Ewe, Chief Technology Officer, DTN



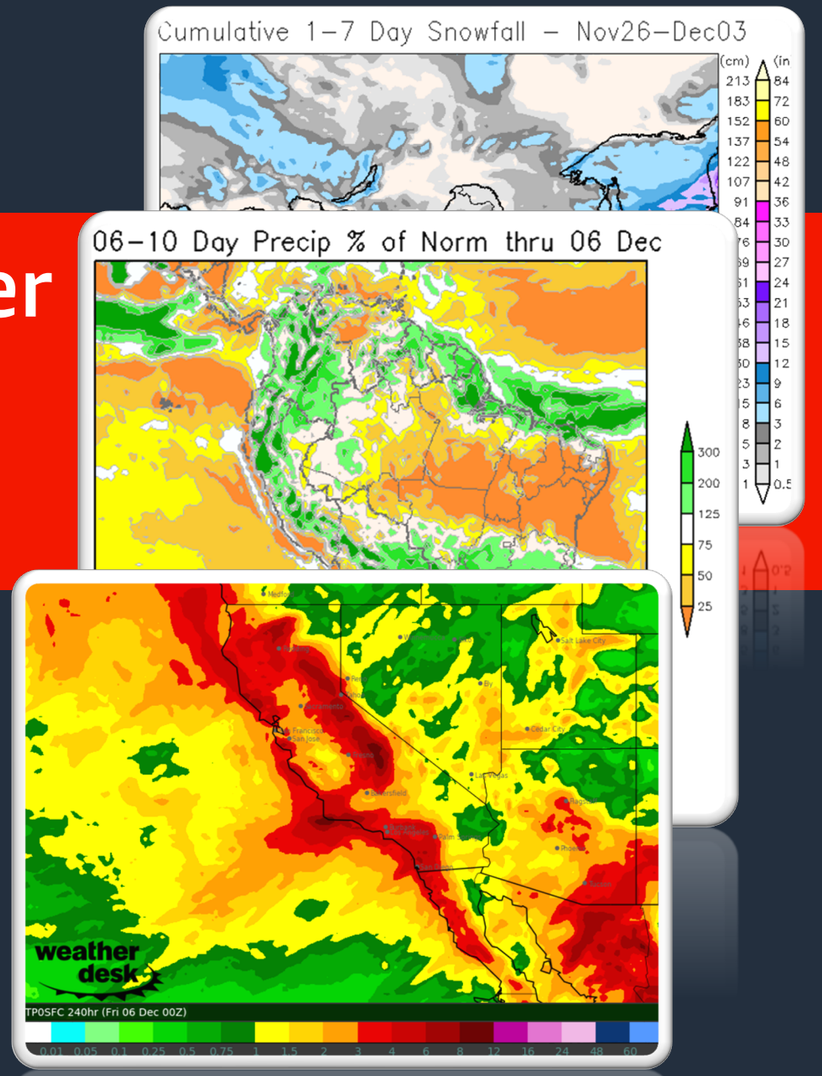




Accelerating Weather forecasts Numerical Weather Prediction

MAXAR

58% Faster than NOAA Supercomputer
45% Lower Compute Cost
~ 5600 Cores



"Prior to using AWS, no one thought any cloud environment was capable of outperforming an on-premises supercomputer in generating numerical weather predictions. But with the fast networking speed provided by AWS, we accomplished what many IT experts considered impossible."

– Stefan Cecelski, Data Scientist, Maxar Technologies

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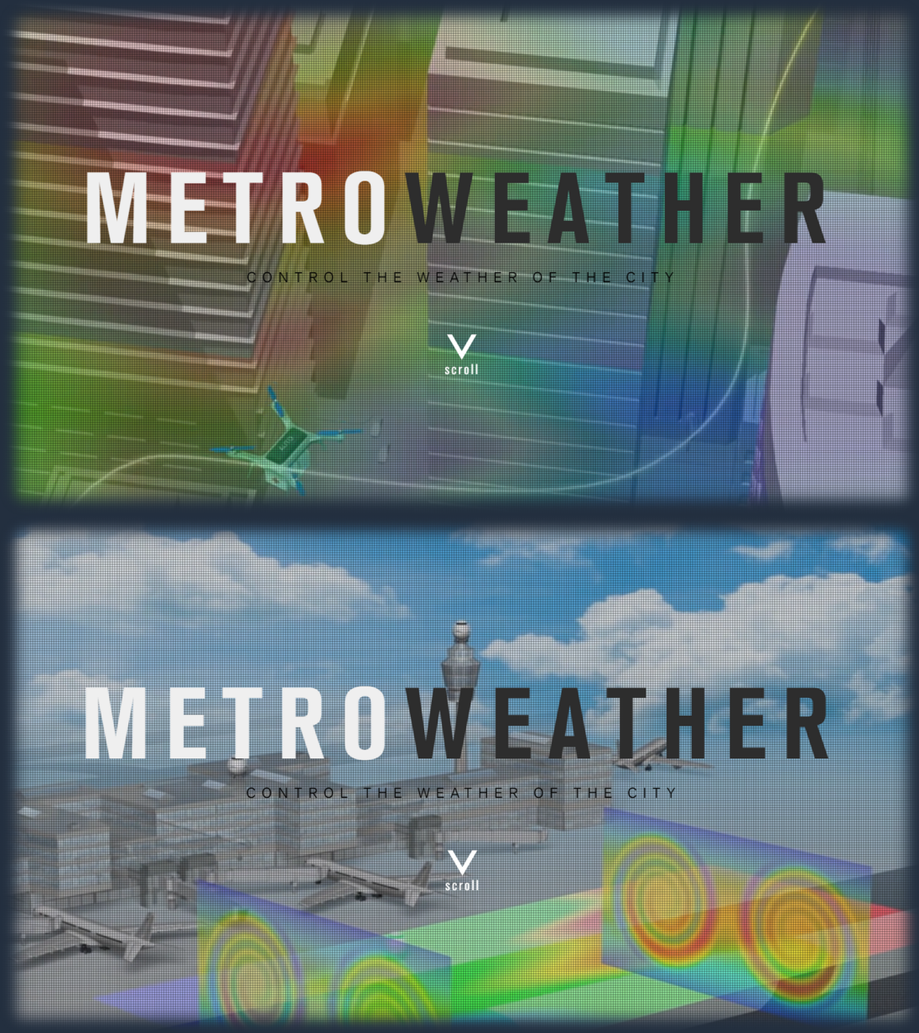
Metro Weather: Enabling Wind Forecasting

*"**With Amazon EC2 Hpc6a instances, Metro Weather is able to achieve up to a 43% performance improvement over C5n instances for its wind forecasting workloads.** Additionally, this performance boost over C5n instances required 50% less compute instances and reduced compute costs by as much as 75%. Hpc6a's impressive price/performance benefits make it an ideal choice to power Metro Weather's wind forecasting HPC platform."*

~ Jun-ichi Furumoto, CEO, Metro Weather Co., Ltd

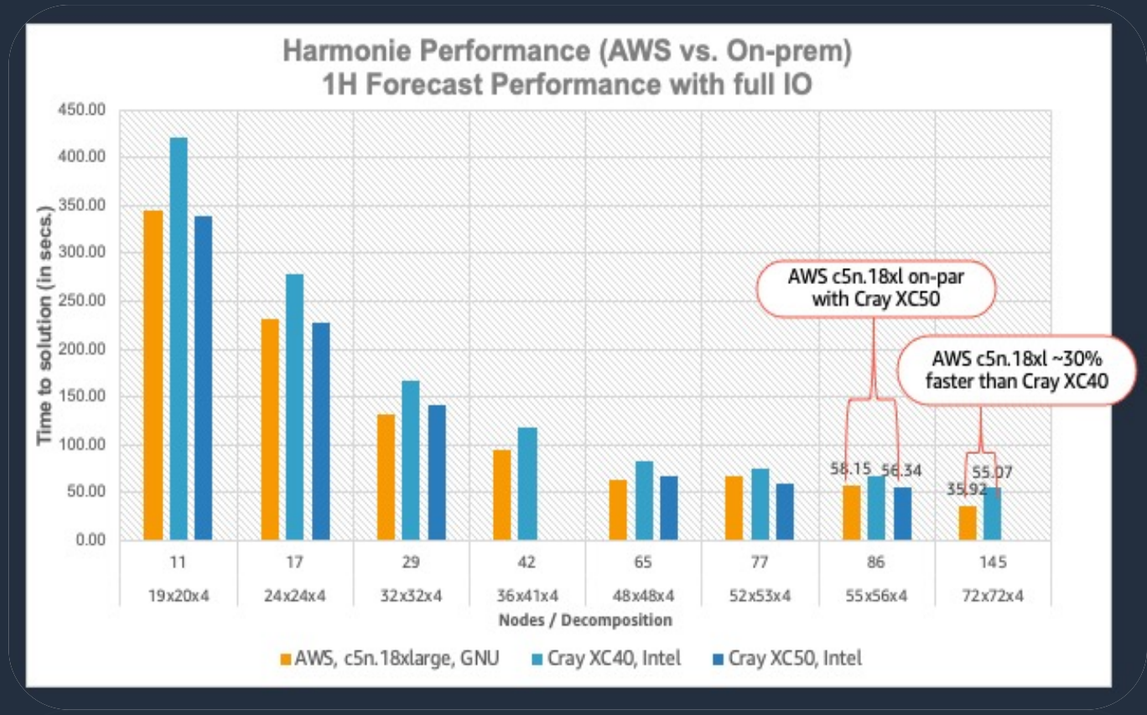


DMI: Building Disaster Recovery Pipelines

Danmarks Meteorologiske Institut

In collaboration with Danish Meteorological Institute (DMI), AWS HPC has successfully demonstrated scaling of Harmonie- a key NWP model in the Nordics, achieving:

- **30% Better Performance over Cray XC40**
- **73% Parallel Efficiency with EFA ~ 5220 cores**



2021 AWS HPC Blog on Harmonie [link]

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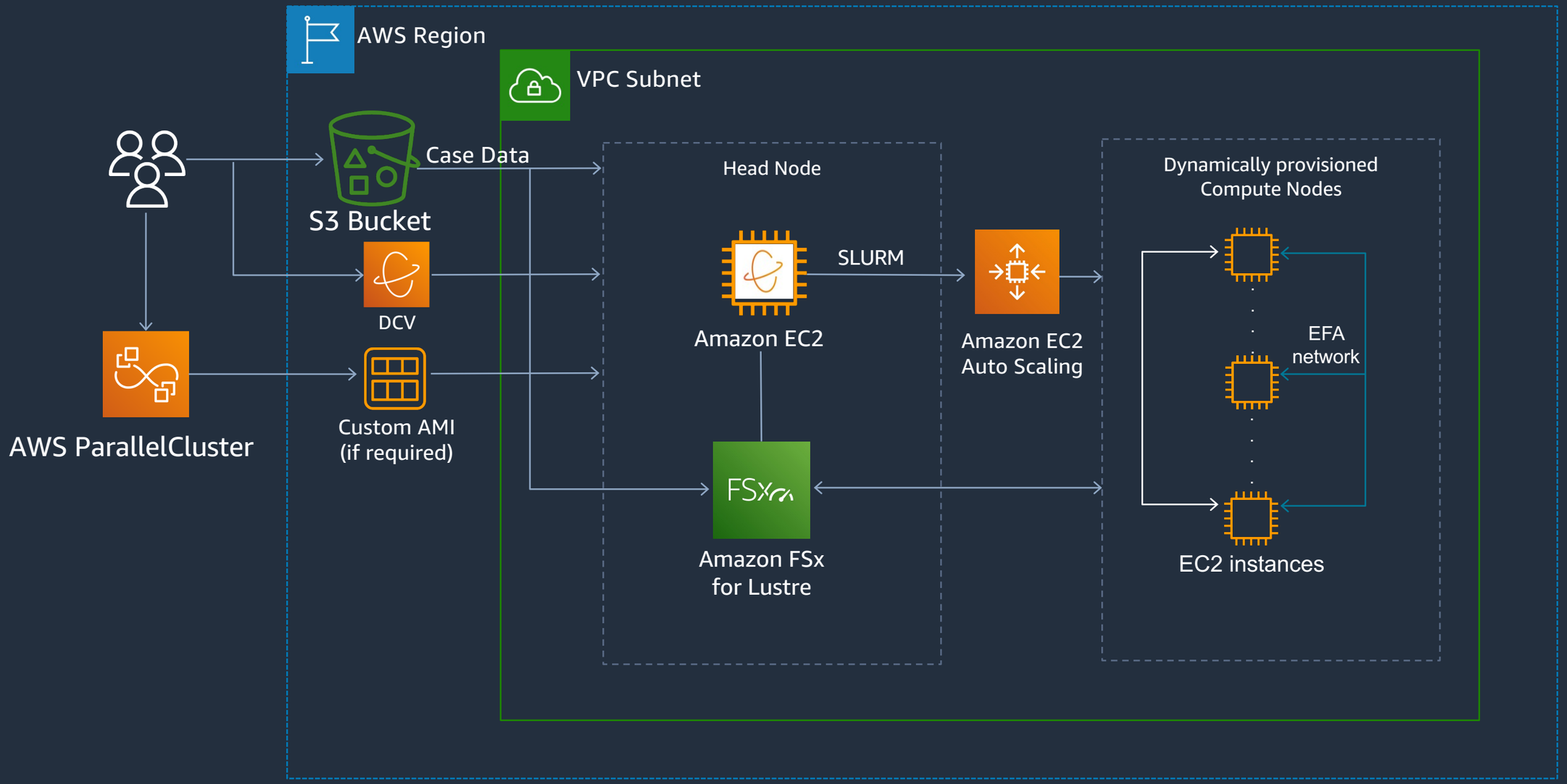
Running NWP on AWS: Reference Architecture



For more, visit the self-service NWP on AWS Workshop- https://weather.hpcworkshops.com/

FSx for Lustre and S3

Lustre

- Parallel filesystem with an HSM backed by S3
- Scales to petabyte size file systems
- Daily backups

S3

- 99.999999999% durability
- 99.99% availability
- ACL policies (IAM, Cognito)
- pre-signed URLs

https://docs.aws.amazon.com/AmazonS3/latest/userguide/DataDurability.html

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Amazon Open Data Sponsorship Program

Benefits

- Open Data Program (ODP) covers the cost of storage for publicly available high-value cloud-optimized datasets
- Egress data waiver for the ODP S3 bucket
- Democratize access to data by making it available for analysis on AWS
- Develop new cloud-native techniques, formats, and tools that lower the cost of working with data
- Encourage the development of communities that benefit from access to shared datasets

URL- Open Data Sponsorship Program homepage

Snapshot of ODP Participants

- NOAA- GOES, GEFS, HRRR
- ECMWF- ERA5
- UK Met Office- UKV
- FMI- HIRLAM, Weather Radar

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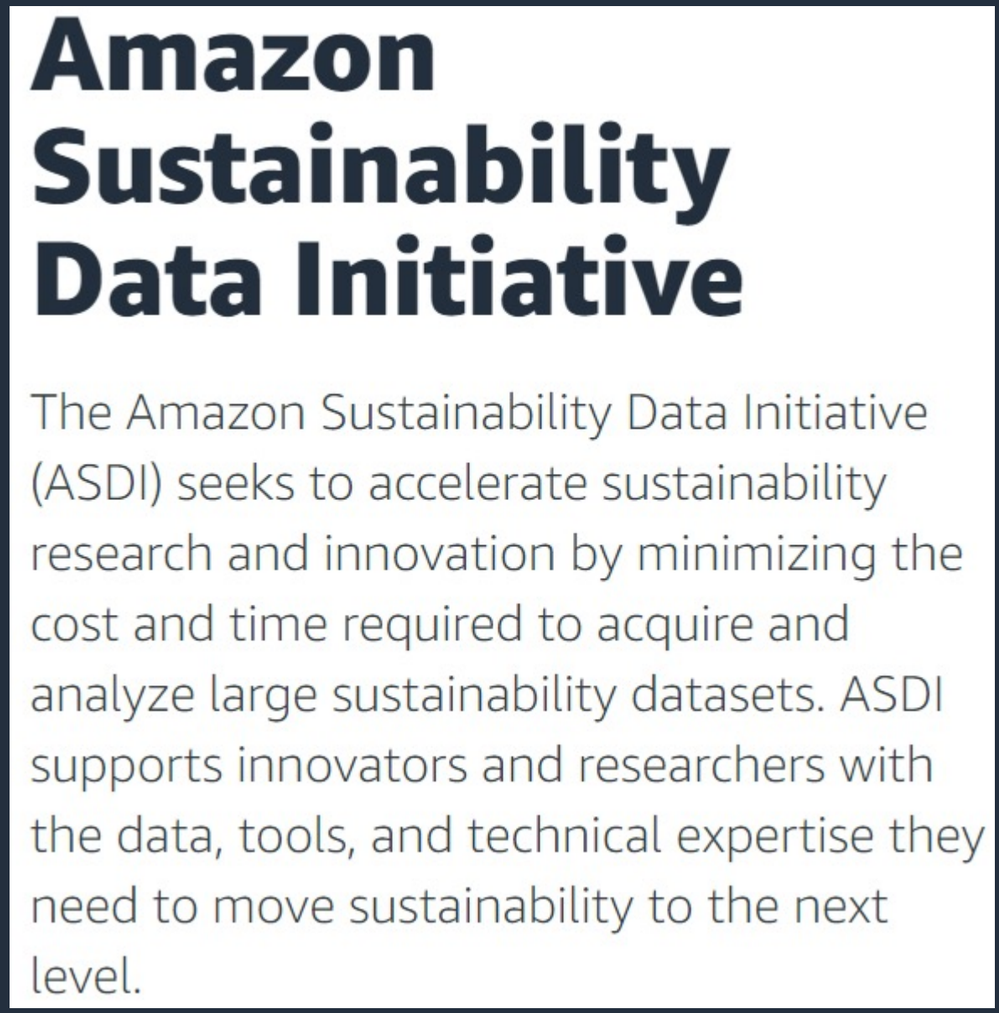
Amazon Sustainability Data Initiative (ASDI)

- Enabling critical weather and climate research around the world
    - Open data from NOAA, FMI, and IDEAM weather radars to support extreme weather modeling (blog)
    - Ocean-related datasets from NOAA, Farallon Institute to support climate change research (blog)
- AWS Promotional Credits to offset the cost of cloud-based experimentation

URL- ASDI homepage



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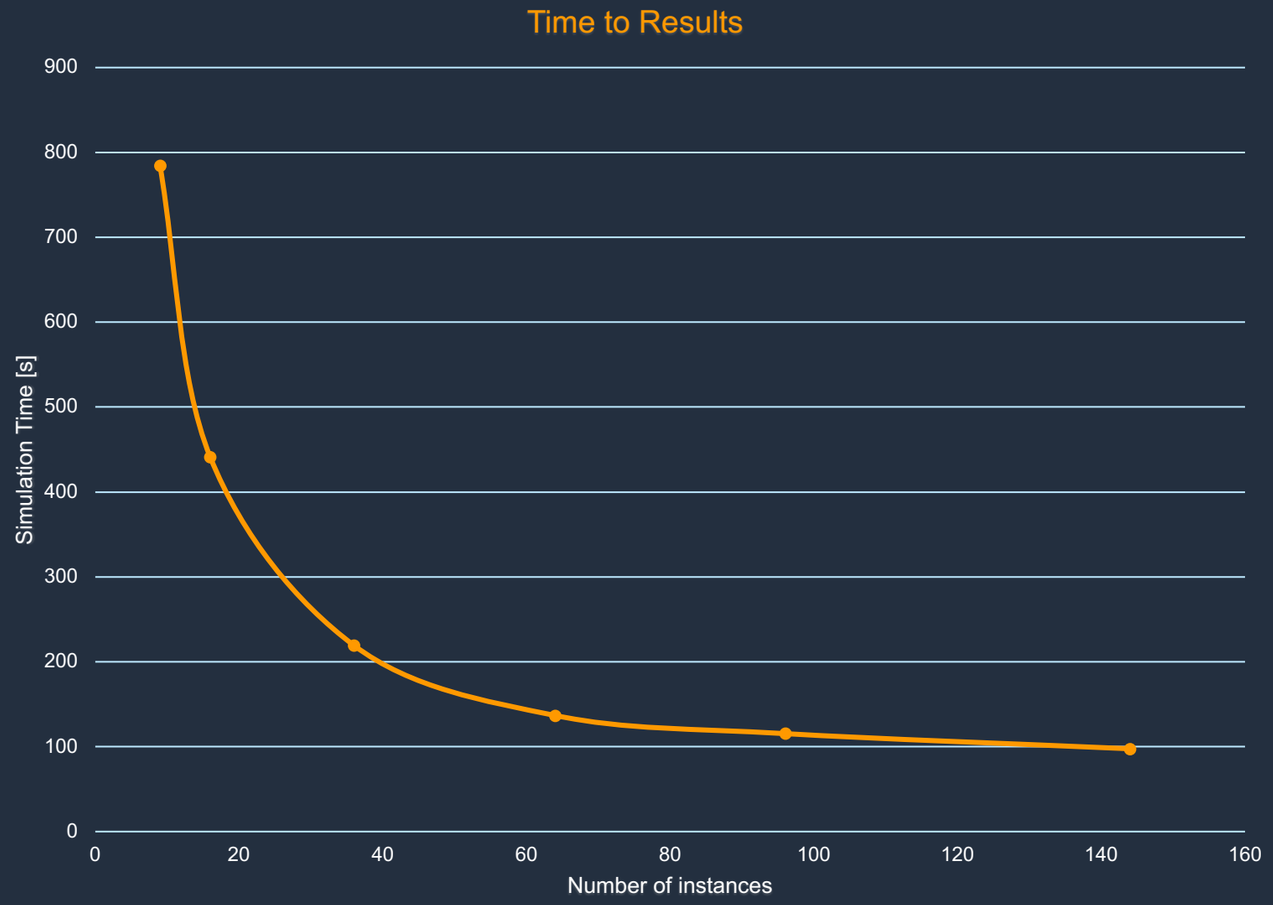
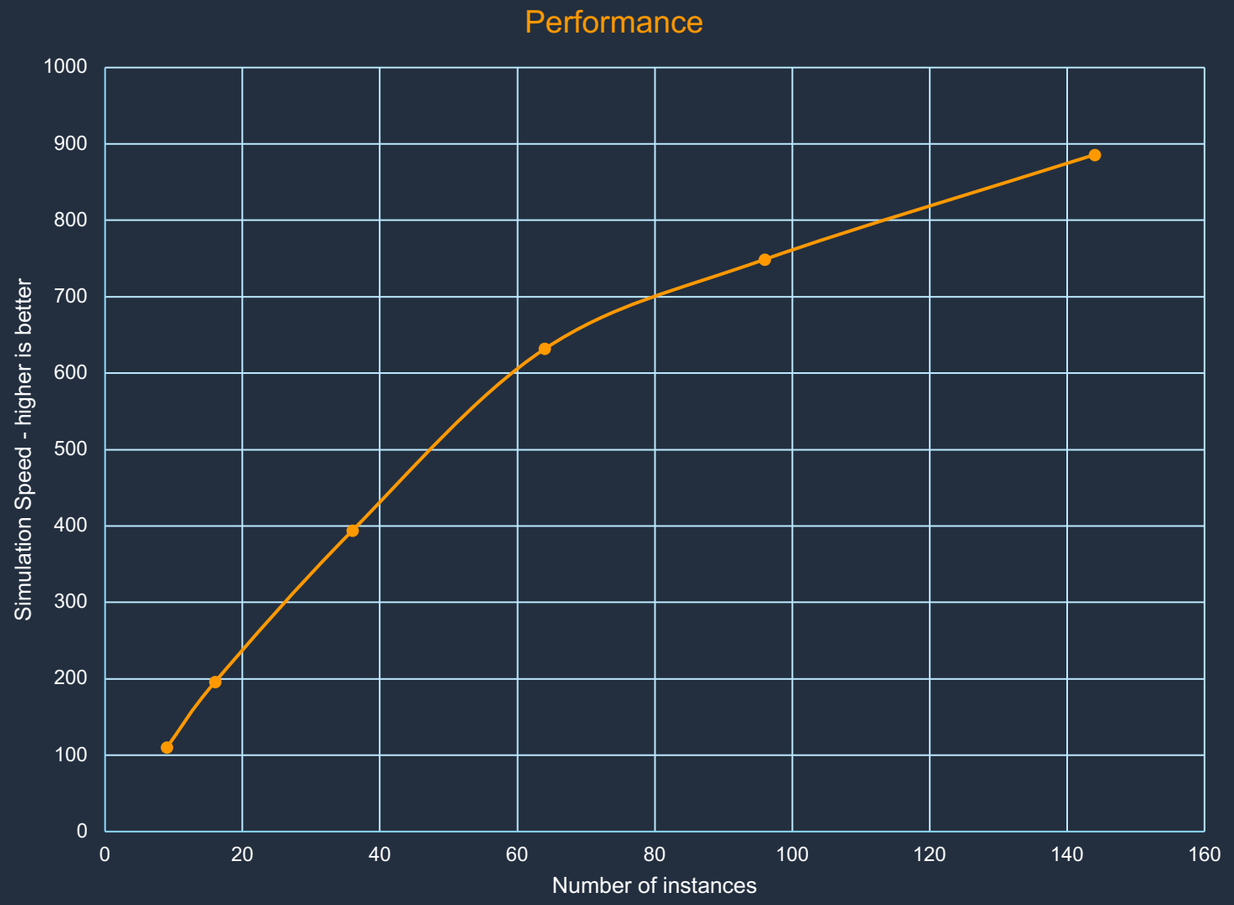
Unified Forecast System

- Version 2.0.0
- C768 (~13km)



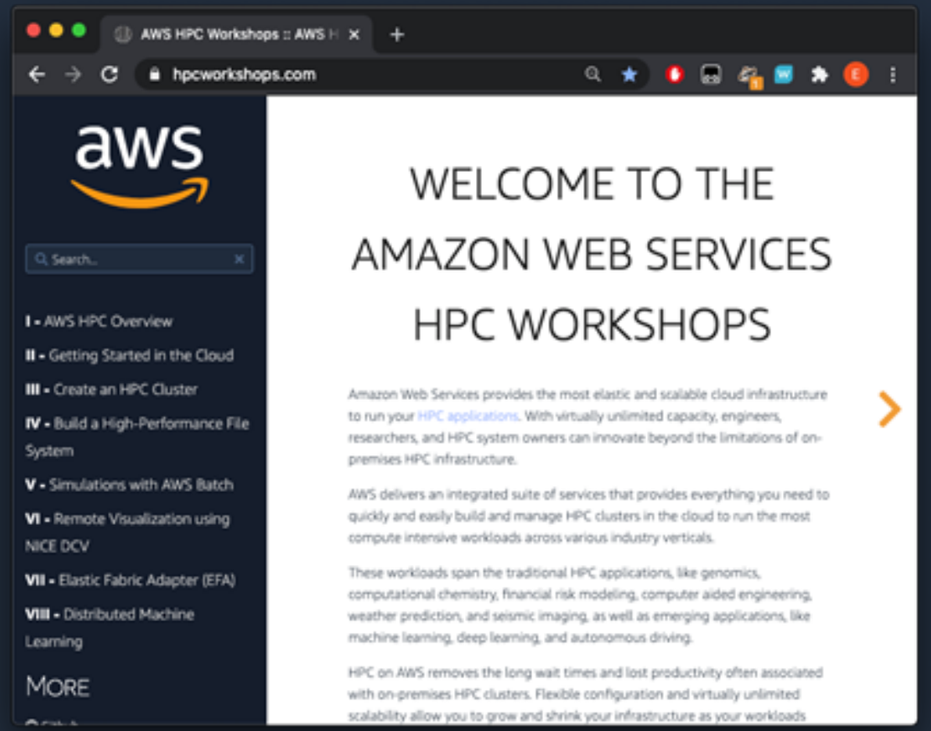


Training and Education

- Weather workshop, online, self paced https://weather.hpcworkshops.com/
- HPC workshops https://www.hpcworkshops.com/
- Github samples https://github.com/aws-samples/
- AWS Documentation https://docs.aws.amazon.com/index.html
- Conferences - SC, re:Invent, AWS Summits
- Dedicated on-site workshops

Other Resources

- AWS Getting Started Resource Center- https://aws.amazon.com/getting-started/
- AWS HPC- https://aws.amazon.com/hpc/
- The Well-Architected HPC Lens Whitepaper- https://d1.awsstatic.com/whitepapers/architecture/AWS-HPC-Lens.pdf
- HPC Blog- https://aws.amazon.com/blogs/hpc/
- AWS Professional Services- https://aws.amazon.com/professional-services/
- AWS Training & Certification- Training and certification link



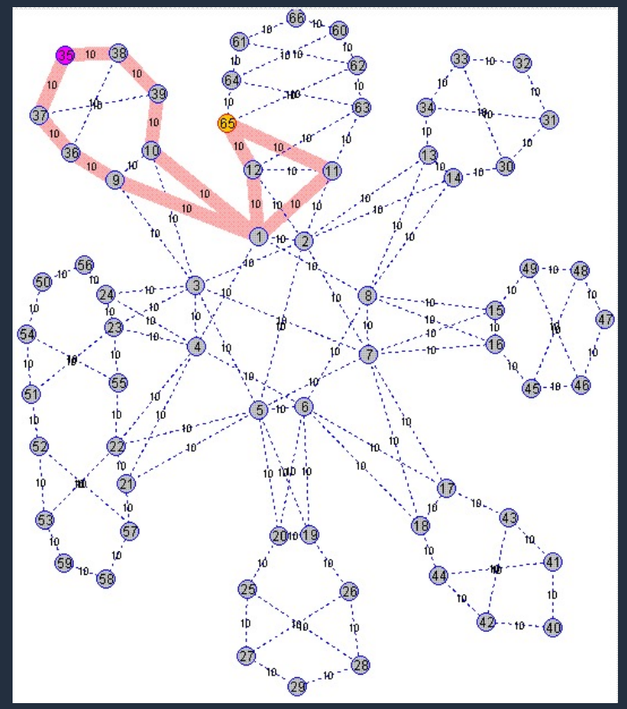
Thank you

Appendix

Elastic Fabric Adapter – Networks built to scale

Up to 400 Gbps networking bandwidth

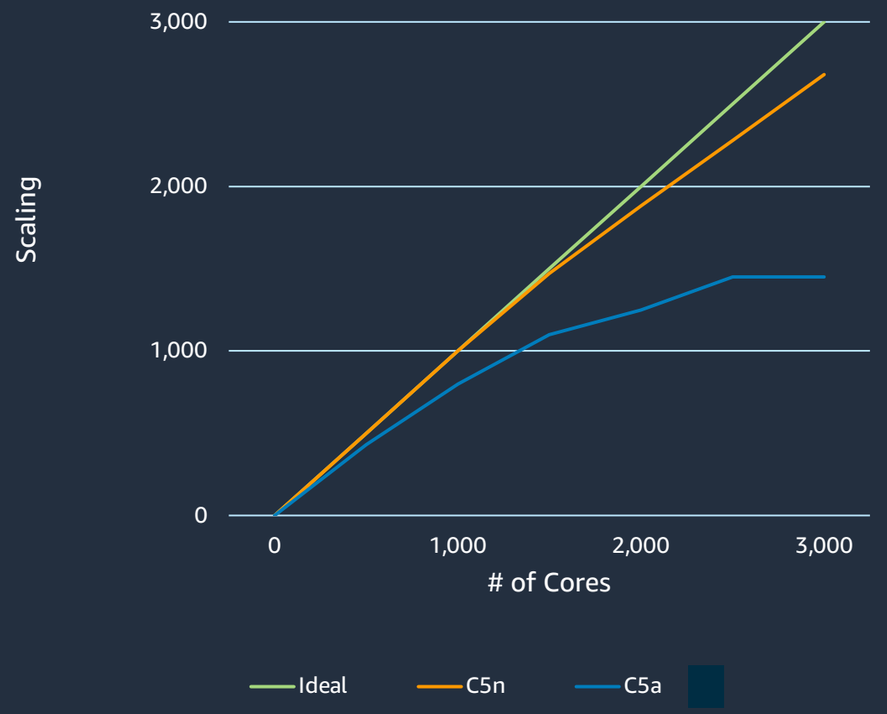
- ✓ OS bypass
- ✓ GPUdirect RDMA
- ✓ Libfabric core supports wide array of MPIs and NCCL



ECMP-enabled packet spraying and cloud-scale congestion control

ANSYS Fluent

External flow over F1 race car (140M cell mesh)



At ~3,000 cores (~83 nodes), C5n+EFA shows ~89% scaling efficiency vs ~48% using C5 w/o EFA