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ENERGY SCIENCES NETWORK

Janus: Lightweight Container Orchestration for High-performance Data Sharing

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SNTA'22
June 30th 2022

U.S. DEPARTMENT OF ENERGY
Office of Science

BERKELEY LAB

Overview and motivation

- Develop a managed data movement service capability
  - Support a pool of transfer software images that “just work”
  - Reduce reliance on varying levels of network/system expertise for deployments
  - Enable automated operations on Data Transfer Nodes (DTNs)
- Make use of containerization supported by lightweight orchestration
- Target high-speed data transfer deployments with dual-stack and multi-homed networking requirements
- Evaluate container networking with data transfer tools used in R&E nets

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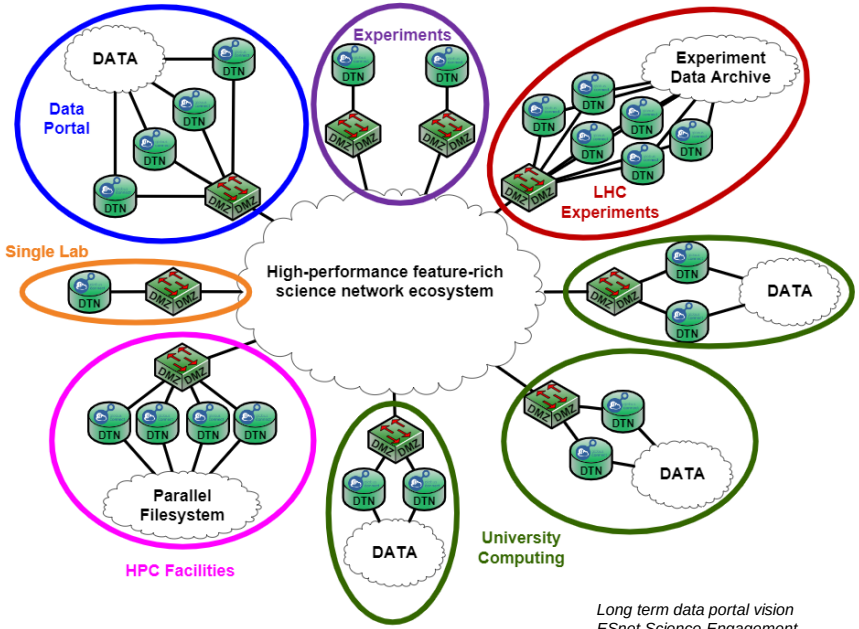
Data Transfer Nodes

- DTNs fulfil a key role in enabling high-performance data movement
- Deployment models well-understood
  - There exists a wealth of knowledge in building, tuning, troubleshooting and maintaining DTN hardware and software
- Goal: expand availability, explore new usage models, and meet future demands → DTN-as-a-Service



Long term data portal vision
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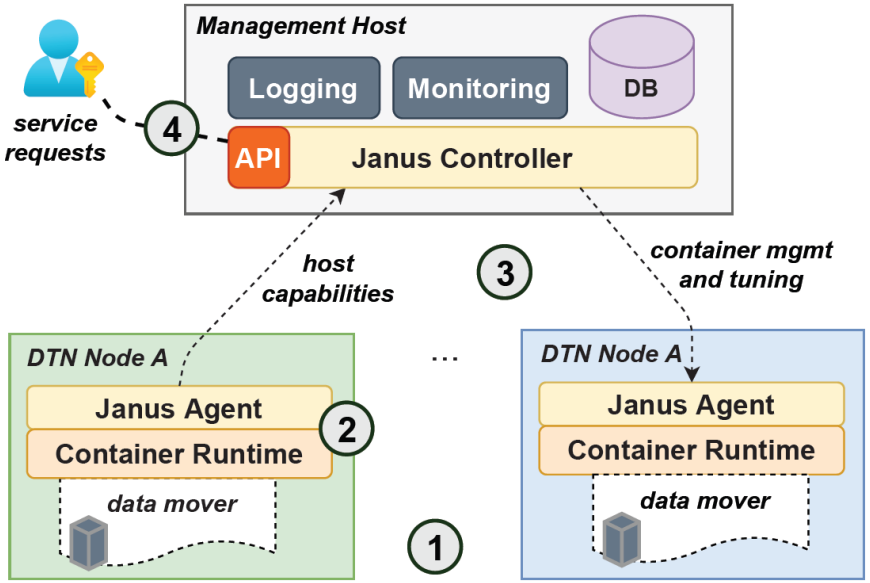
Janus concept

1. Data mover software in containers
2. Network and storage performance optimization
3. Configuration and tuning flexibility
4. Lightweight service orchestration



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Extensible profiles

- Provide common configuration sets for service containers
- Helpful for consistency and re-use for larger deployments
- Specify capabilities once, then apply often

```
ID : Status              | Nodes/Services           | Image                                                | Profile
3  : STOPPED             | lbl-dev-dtn [None]       | wharf.es.net/dtnaas/opensciencegrid/cms-xcache:fresh | macvlan2x
5  : STARTED             | chic-cache1 [None]       | wharf.es.net/dtnaas/opensciencegrid/cms-xcache:fresh | chic-cms-xcache01
6  : STARTED             | bost-cache1 [None]       | wharf.es.net/dtnaas/opensciencegrid/cms-xcache:fresh | bost-cms-xcache01
janus>
janus> session create lbnl-tbn-1 image dtnaas/ofed profile lbnl-400g-1
```

```
features:
  rdmacap:
    devices:
      - devprefix: "/dev/infiniband"
        names:
          - rdma_cm
          - uverbs
    caps:
      - IPC_LOCK
      - NET_ADMIN
    limits:
      - Name: memlock
        Soft: -1
        Hard: -1

profiles:
  lbnl-400g-1:
    cpu: 4
    affinity: network
    mgmt_net: bridge
    data_net:
      name: net3001_eth200
      ipv4_addr:
        - 10.33.1.20
      ipv6_addr:
        - 2001:400:2202:2191::3
    features:
      - rdmacap
    privileged: false

  lbnl-400g-2:
    cpu: 8
    affinity: network
    mgmt_net: bridge
    data_net:
      name: net3002_eth200
      ipv4_addr:
        - 10.33.2.20
        - 10.33.2.21
    features:
      - rdmacap
    privileged: false
    volumes:
      - data
```

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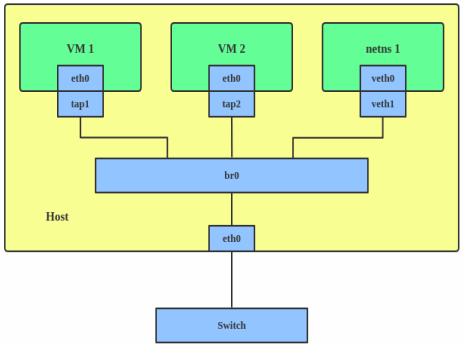
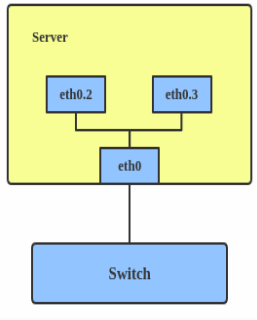
Linux virtual networking and containers

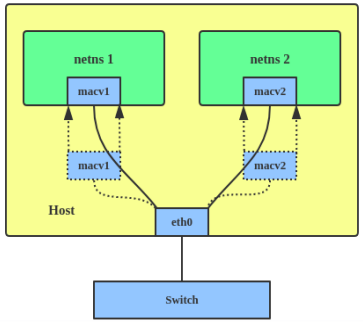
bridge[1]



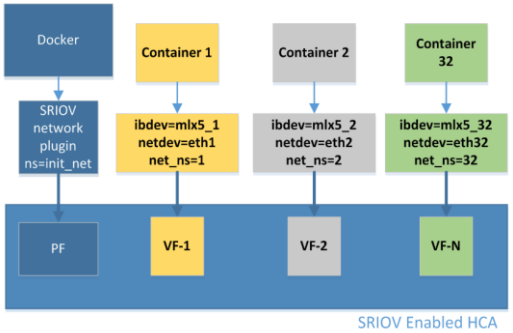
vlan[1]



macvlan[1]



sriov[2]



...and ipvlan, bonds, teams, etc.

Sources:
[1] https://developers.redhat.com/blog/2018/10/22/introduction-to-linux-interfaces-for-virtual-networking/
[2] https://community.mellanox.com/s/article/Docker-RDMA-SRIOV-Networking-with-ConnectX4-ConnectX5-ConnectX6

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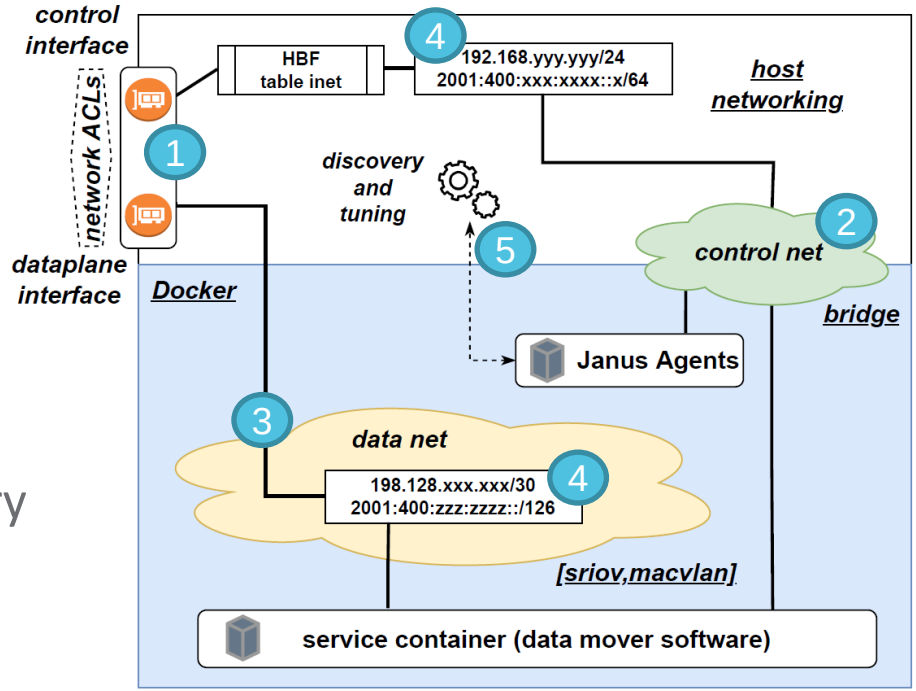
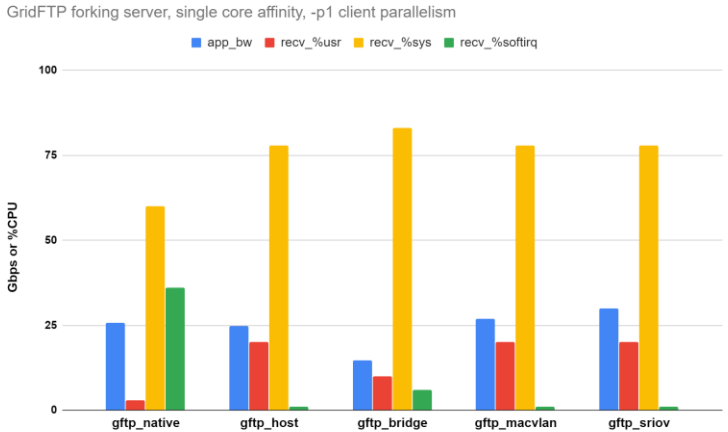
Example data transfer node configuration

1. Multi-homed physical nodes
2. Slow path control
3. Fast path data plane
4. Dual-stack IP networking
5. Local agents for resource discovery and customized tuning



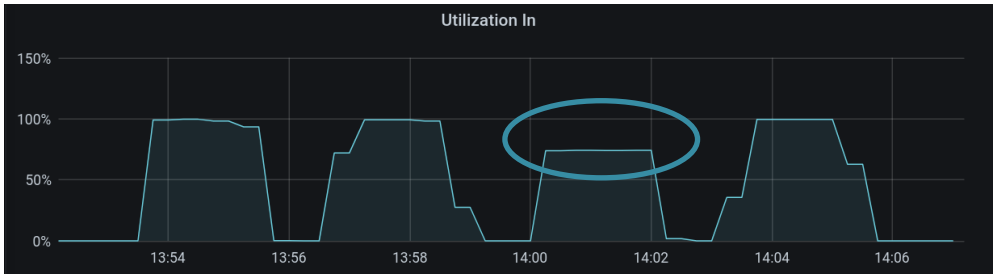
Container networking performance

- A number of container network attachments are supported and available
  - Which works best for high-performance networking in each deployment?
- Relatively easy to achieve matching performance using tuning params
  - E.g., container execution mapped to appropriate NUMA nodes for cores and memory

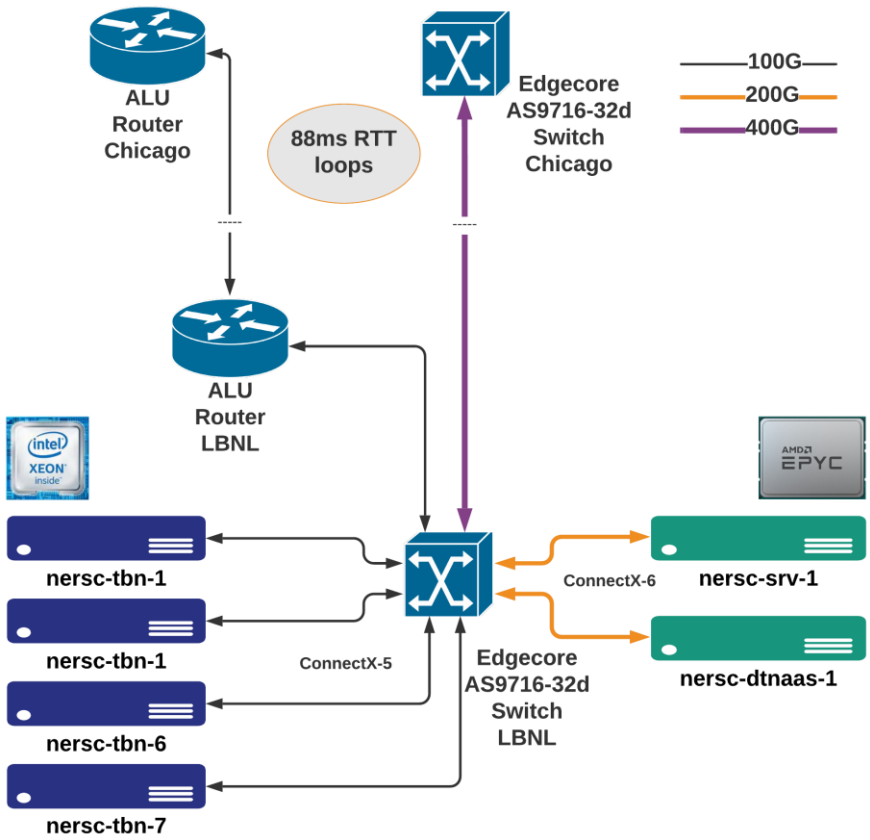


100G links, GridFTP, forking server, 5 clients with -p4 parallelism

native system *container host net* *container bridge net* *container macvlan/sriov net*

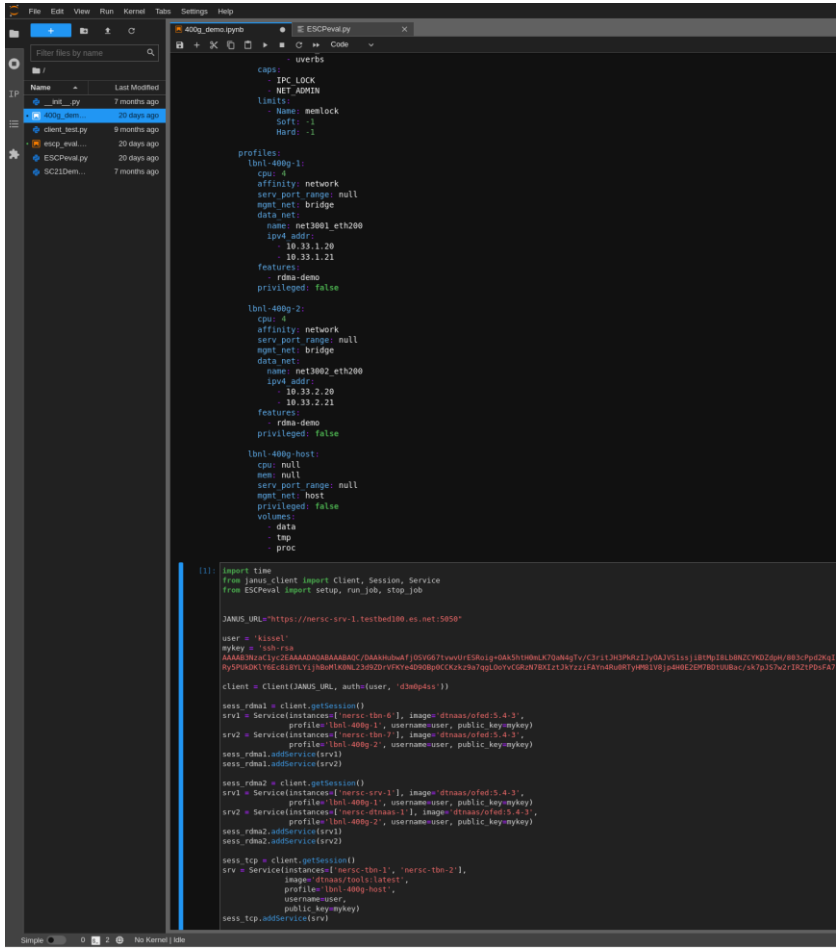


Evaluation topology (ESnet testbed)

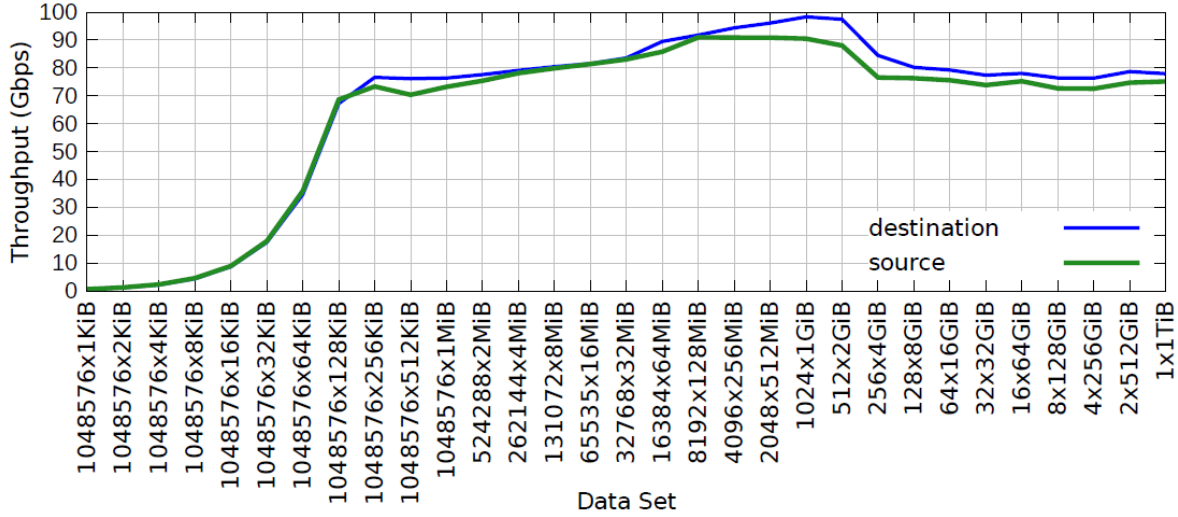


Evaluation environment

- Performant data movers: EScp, GridFTP, mdtmFTP, Zettar zx
- Janus Python client and CLI
  - Programmatic execution
  - Jupyter Notebook scripting
- Standard 100G host and network interface tuning



Storage baseline



elbencho storage sweep, sequential write benchmark

https://github.com/breuner/elbencho/tree/master/contrib/storage_sweep

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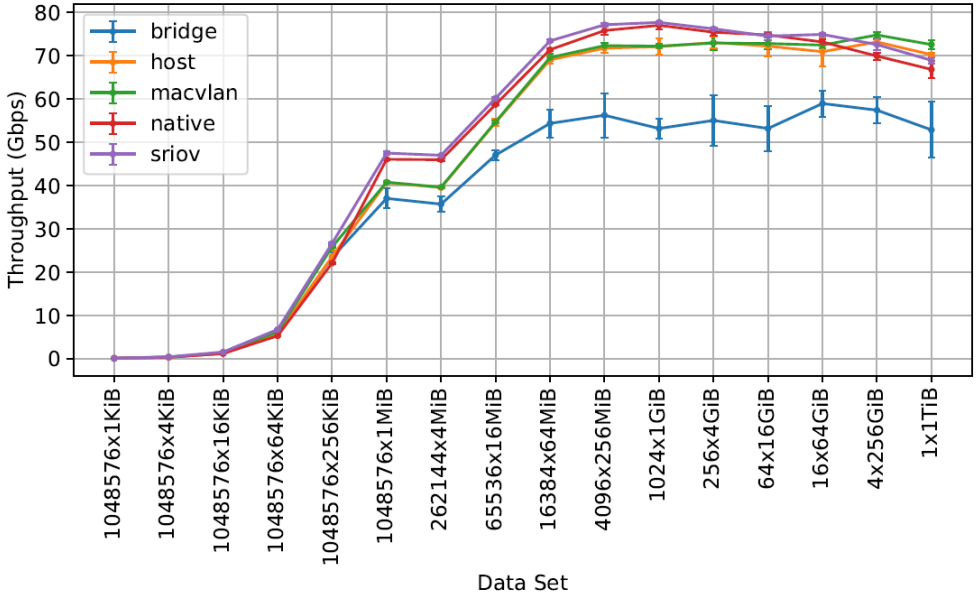
Container network comparison (LAN)



Each src/dst container instance launched by Janus with specified net profile

SR-IOV provides best performance compared to native

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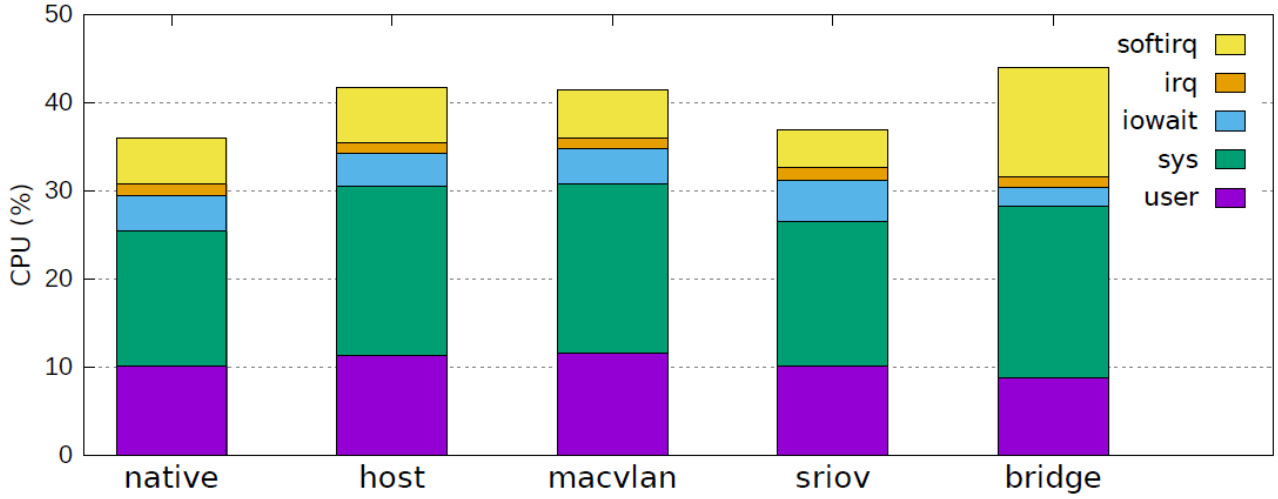
CPU usage comparison



CPU overheads are a non-trivial factor, destination usage shown

Bridge networking incurs the highest overheads

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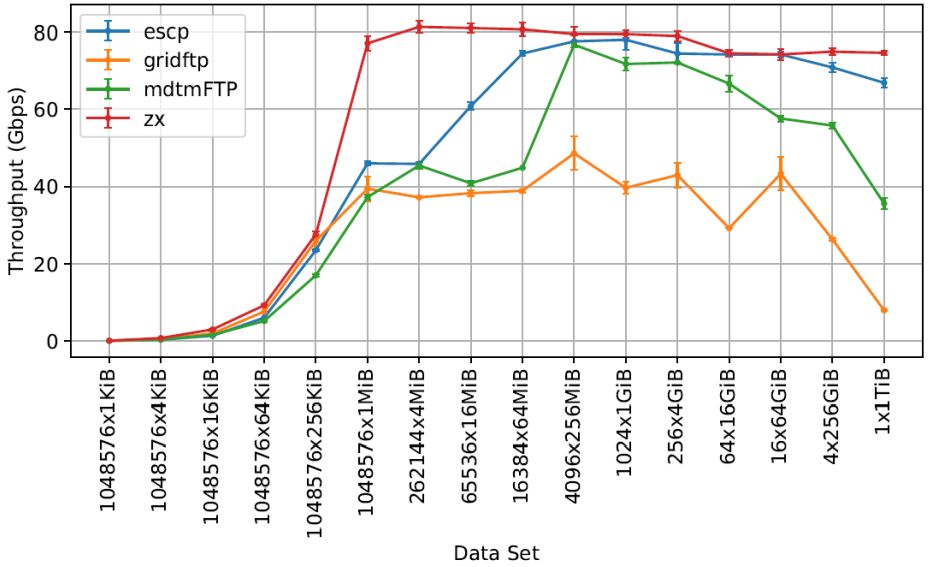
Data mover comparison over WAN



Performance of various transfer software over 88ms WAN link

Transfer parallelism approach has a large impact across file size distributions

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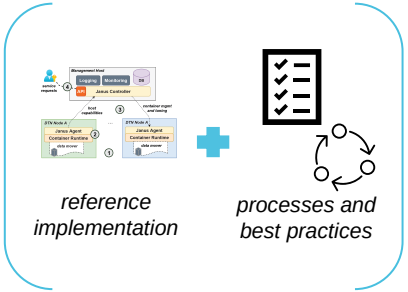
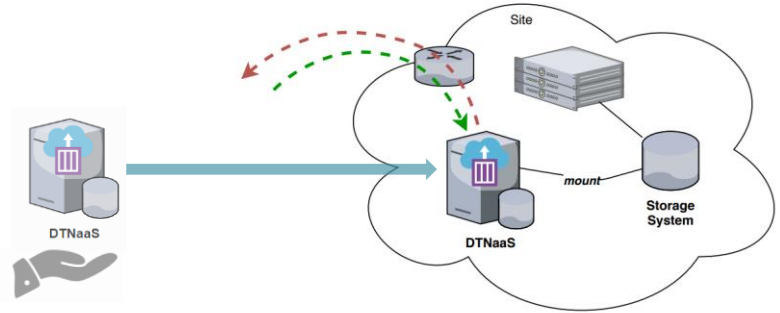
Conclusion and Future work

- Containers for high performance data movement is a viable approach
- 200G/400G evaluation
- Extend tuning automation
- Provide guidance for best practice and common concerns
  - Performance, security, network orchestration, measurement and monitoring





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Thank you

Questions?

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