Resilient Distributed Processing

Naval Research Laboratory
Center for Computational Science
SC21 Demonstrations

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NRL aims to demonstrate:
• Dynamic arrangement and re-arrangement of widely distributed processing of large volumes of data across a set of compute and network resources organized in response to resource availability and changing application demands
• Real-time video processing pipeline will be demonstrated from SC21 to compute and storage assets in Washington, DC; McLean, VA; Chicago, IL; and Berkeley, CA

Specific goals:
1. Fast fault detection and location using an active probe.
2. Dynamic shifting of processing and network resources from one location/path/system to another (in response to demand and availability).
3. Leverage RDMA/distance performance for timely Terabyte bulk data transfers (goal < 1 min Tbyte transfer on 400G network).

The Data to Decision Challenge:
- Global Data Acquisition
- Resilient Distributed Processing
- Immediate Global Data Access

Terabyte Data Movement

<table>
<thead>
<tr>
<th>Bitrate</th>
<th>Timely Mission Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gigabit/sec</td>
<td>Largest imagery</td>
</tr>
<tr>
<td>10 Gig/sec</td>
<td>3D additive manufacturing</td>
</tr>
<tr>
<td>100 Gig/sec</td>
<td>Medical imaging</td>
</tr>
<tr>
<td>400 Gig/sec</td>
<td>Terabyte Data Transfer (Seconds)</td>
</tr>
</tbody>
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Terabyte Data Transfer (Seconds)

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Interconnected and interlocking problems demand a resilient distributed DoD, high performance, low latency data sharing infrastructure.
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- **Resilient** Distributed Processing
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“Interconnected and interlocking problems” demand a high performance dynamic distributed data centric infrastructure.
400G SC21 Stand-up
Mission Oriented Reconfigurable Networking (MORN) System View

- MORN provides resilient service delivery using failure detection to trigger prioritized restoration
- MORN maps applications to available network resources based on mission policy and priorities
- MORN leverages industry traffic engineering and SDN

MORN is our approach to optimizing the allocation of resources to meet mission requirements.
Fast Fault Detection

• Synchronized monitoring detects rectilinear location of two-way faults
  – Limited by *time synchronization and network delay variation*
• Knowledge of the path allows mapping of rectilinear location to geographic location
  – Limited by accuracy of *detailed path knowledge*
Fault Location Accuracy

- Expected operating range: 2-200 km location accuracy
- Rectilinear location accuracy: 1000 km
- Minimum network traffic:
  - 50 Mbps
  - 5 Mbps
  - 500 kbps
  - 50 kbps

- Time Delta (Accuracy/Precision):
  - 10 µsec to 10 m sec

- Minimum network traffic:
  - 50 kbps
  - 500 kbps
  - 5 Mbps

Note that geolocation accuracy is a function of the rectilinear location accuracy and the network path geolocation uncertainty.
MORN Architecture Components

Mission Applications

Network Coordinator
- MORN Network Orchestration
- Manages/controls delivery of MORN services end to end
  -- Includes cross-domain information/coordination

Resource Controller
- Local Resource Control
- Manages/control resources for a single controller
- Provides sensors for Fast Failure Detection

Network Resource(s)
- Links and Networks

Network Management Services

- MORN Policy
- MORN SS

- Mission service requirements from policy
- SDN Orchestration Based on FRRouting
- Cross and multi-domain support

- Tailored network sensor for Fast Failure Detection

- CDS friendly YANG interfaces
- Policy
- Service Status telemetry

- Optional

- Inter Domain Coordination
- Detailed domain-specific information and control
- Network specific information and control

- Cross Domain Interface
- Encryptor
Black = Mgmt plane
Red = Control plane
Green = Data plane

DISTRIBUTION A: Approved for Public Release; Distribution Unlimited
Terabyte Data Movement

Timely mission results:
- Largest imagery
- 3D additive manufacturing
- Medical imaging

100 Gigabyte = ~3 hours of high quality 4K video (H.265),
the best Blu-ray disc, 9 hours of Netflix 4K video
BW vs RTT
(for 1 MB Message Size)
Most Relevant to Lustre Performance

Excellent Performance out to 12,000 km or ~7 time zones

- August 2020: “Fix” is in Mellanox GA firmware
- Desirable to confirm performance vs distance over real test networks - hoping to do this over SC21 WAN path options
- Would like to extend this result to 200G with available CX6 on PCI Gen 4 - hoping to do this over SC21 400G WAN path options!
- Would *really* like to extend this result to 400G with NDR/400G on PCI Gen 5 over 400+G waves?
RDMA/Distance Reference Data Set

BW Performance
(Tx Depth 1024, 20,000 iterations)

BW Performance
(Tx Depth 4096, 20,000 iterations)
Traffic Flow Security (TFS)

• Full period (bulk) encryption historically used to deliver Traffic Flow Security (TFS) in fixed/wired networks, Network encryption is replacing link encryption in wireline communication systems

• Work underway to update standards
  – IEEE MACsec 802.1 Aedk
    Publication approval process underway
    https://1.ieee802.org/security/802-1aedk/
  – IETF IPsecME WG TFS
    Core protocol accepted, working through process
    Publication approval process requested
# Terabyte Data Movement

<table>
<thead>
<tr>
<th>Network Type</th>
<th>Network: Systems: Storage: TB Transfers:</th>
<th>Now</th>
<th>Next</th>
<th>Soon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Network</td>
<td>2 x 100 Gbps PCIe Gen 4 Memory 75 seconds</td>
<td>400 Gbps 2 x PCIe Gen 4 NVMe 30 seconds</td>
<td>Tbps (3 x 400G?) 3 x PCIe Gen 5 NVMe &lt;10 seconds</td>
<td></td>
</tr>
<tr>
<td>Pilot Network</td>
<td>2 x 100 Gbps 2 x PCIe Gen 3 HD/NVMe 150 seconds</td>
<td>2 x 100 Gbps 4 x PCIe Gen 3 HD/NVMe 55 seconds</td>
<td>400 Gbps 2 x PCIe Gen 4 NVMe 30 seconds</td>
<td></td>
</tr>
<tr>
<td>Operational Network</td>
<td>2 x 100 Gbps 4 x PCIe Gen 3 HD/NVMe 60 seconds</td>
<td>4 x 100 Gbps PCIe Gen 4 HD?/NVMe 40 seconds</td>
<td></td>
<td></td>
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This demonstration will build on our previous demonstrations. We aim to show dynamic arrangement and re-arrangement of widely distributed processing of large volumes of data across a set of compute and network resources organized in response to resource availability and changing application demands. A real-time video processing pipeline will be demonstrated from SC21 to the Naval Research Laboratory assets in Washington, DC, McLean, VA, Chicago, IL, Berkeley, CA and back to SC21. High volume bulk data will be transferred concurrently across the same data paths. A software-controlled network will be assembled using a number of switches and multiple SCinet 100G/400G connections. We plan to show rapid deployment and redeployment, real-time monitoring and QOS management of these application data flows with very different network demands. Technologies we intend to leverage include SDN, RDMA, RoCE, NVMe, GPU acceleration and others.

NRL will have two major thrusts for our SC21 demo/tests: Mission Oriented Reconfigurable Networking (MORN) and rapid terabyte data movement. We have 5 sites (NRL/Washington, DC; McLean, VA; StarLight/Chicago, IL; NERSC/Berkeley CA; SC21/St. Louis, MO) in the 100G network monitored and controlled by MORN and 4 of those sites have 400G wide area network connections supporting fast delivery of critical data sets and massive distributed computing problems.

Specific Goals:

• Fast fault detection and location using an active probe.
• Dynamic shifting of processing and network resources from one location/path/system to another (in response to demand and availability).
• Leverage improved (restored) RDMA/distance performance for timely Terabyte bulk data transfers (goal < 1 min Tbyte transfer on 400G network).
• Network data flows protected by IP and Ethernet Traffic Flow Security
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The Networking and Information Technology Research and Development (NITRD) Program

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