International Networking in support of Extremely Large Astronomical Data-centric Operations

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Outline

• A bit of history: international networks in South America to support astronomical operations
• A bit of future: the Large Synoptic Survey Telescope
• Key Challenges for Inter-Domain provisioning to support extremely large astronomical data-centric operations
• LSST Network Engineering Team Goals
• Conclusion
A bit of past: networking needs

Back in the 90s, *high-bandwidth* connections (256kbps) were used for basic communication and coordination:

- Satellite connections for point-to-point connection
- Data was *shipped* via Fedex

In the 2000+, *high-bandwidth* links (45 – <1Gbps) were used for data transfer in a very limited fashion:

- In 2011, Chile was home to 42% of the world's astronomical infrastructure
- It was still not unusual to have data *shipped* via Fedex
- In South America, projects such as AURA, GEMINI, ALMA, NOAO and others started *demanding* more network capacity
- Many projects and partnerships were created to deal with this demand for networking capacity, for example, the Americas Lightpaths (AmLight) project, that connects South America to the U.S.

- In 2013, at AmLight, 20+ Gbps of total capacity was available in Chile to support data transfers.
A bit of future: Large Synoptic Survey Telescope

Composed of **multiple** Data Management facilities

Multiple data streams summing up 90 Gbps:
- Every 30 seconds during observing, a 12.7GB data set must be transmitted from La Serena to the U.S. in 5 seconds!

The path created from the Base Site to Archive Site is composed of multiple academic networks with multiple high bandwidth links

*The end-to-end path must provide high resilience, low delay, and an efficient control plane to act in all network status changes!!*
Challenges...
Inter-Domain Coordination

Leveraging multiple academic network operators has many advantages:

• Academic networks are usually more flexible for complex requirements
• Shared costs help lower the total cost per Mbps

However, it has challenges:

• Each academic network might have a completely different technology, configuration or vendor making interoperability complex
• Most academic networks rely on static provisioning and multi-domain provisioning can easily take weeks to be completed
Inter-Domain Coordination [2]

The LSST network is being created with multiple 100G links involving many academic networks:

- REUNA
- AmLight
- CLARA
- ANSP
- RNP
- FLR
- Internet2
- ESNet
- StarLight
- NCSA
High Delay*Bandwidth Product

- The "distance" (delay) from La Serena to Champaign, Illinois varies from 140ms (primary path) to 280ms (backup path).

- Most Layer 4 Transport protocols (including TCP) were not made to operate with such long delay.

- 0.001% of packet loss with this delay is enough to kill a data transfer:

- Performance Measurement is key in this kind of environment.

![Expected TCP Performance using Mathis Equation](image)
Performance Measurement

perfSonar framework is the primary solution for performance measurement in the academic community

- More than 2000 installations

To measure end-to-end performance, each domain has its own nodes sending results to a centralized measurement archive:

- Maddash
Even with no errors, our job as network engineers is not done: Best Effort & Bursts are always testing us!

The LSST network requirements specifies different traffic types with minimum bandwidth reservation when using shared infrastructure:

- A complex inter-domain QoS framework is being evaluated

An "almost deterministic" network is the main goal.
Next Steps...
Centralized Network Monitoring System will track all domains and network layers (optical and packet)

Performance Measurement: multiple perfSonar nodes at 100G!

Network Automation as much as possible for future provisioning activities

Better interfaces for researchers: Software-Defined Exchanges
Deploying an international network to support data-centric operations is challenging but possible!

LSST Network Engineering Team includes network engineers and operators from domains in the path

Meetings every month

A lot of coordination in the present to automate the future!
Acknowledgement

This material is based upon work supported in part by the National Science Foundation through Cooperative Agreement 1258333 managed by the Association of Universities for Research in Astronomy (AURA), and the Department of Energy under Contract No. DE-AC02-76SF00515 with the SLAC National Accelerator Laboratory. Additional LSST funding comes from private donations, grants to universities, and in-kind support from LSSTC Institutional Members.
Thank you!
Questions?

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