National Research Platform Meeting
August 7-8, 2017

Large Synoptic Survey Telescope (LSST) Scaling Issues and Network Needs

Heidi Morgan, Ph.D.
University of Southern California

Jeronimo Bezerra
Florida International University

AmLight ExP
Americas Lightpaths Express & Protect

Outline

- What is LSST?
- LSST Data Management Facilities
- LSST Network Requirements
- LSST End-to-End Path
- LSST Deployment Calendar
- LSST Network Topology
- SLA requirements for networking
- Initial Draft for the LSST 2018 network
- Network Monitoring & Performance
- Challenges & Ongoing Efforts

Telescope Construction June 13, 2017

Large Synoptic Survey Telescope

- This telescope will produce the deepest, widest, image of the Universe:
  - Expecting 10 million alerts, 15-30 Terabytes of data... every night!
  - First motion picture of our universe
  - This 10 year survey of the sky will catalog 37 billion objects (20B galaxies, 17B stars)
  - Each image is the size of 40 full moons
  - 3200 megapixels camera with 2-second readout
  - 8.4-m mirror, the width of a single tennis court

Webcam: Cerro Pachón Summit 2015-2017 (https://gallery.lsst.org/bp/#/)

Large Synoptic Survey Telescope(2)

WIDE:

- World's Widest Digital Camera

FAST:

- Rapidly scan the sky
- Charting - exploding supernovae to potentially hazardous near-Earth asteroids

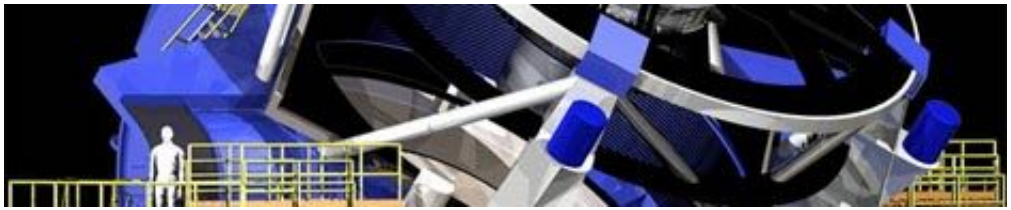
DEEP:

- Trace billions of remote galaxies
- Probes of the mysterious dark matter and dark energy

Site (http://www.lsst.org/lsst/gallery/site)

Mirror Casting (http://www.lsst.org/lsst/gallery/mirror-casting)

Telescope (http://www.lsst.org/lsst/gallery/telescope)

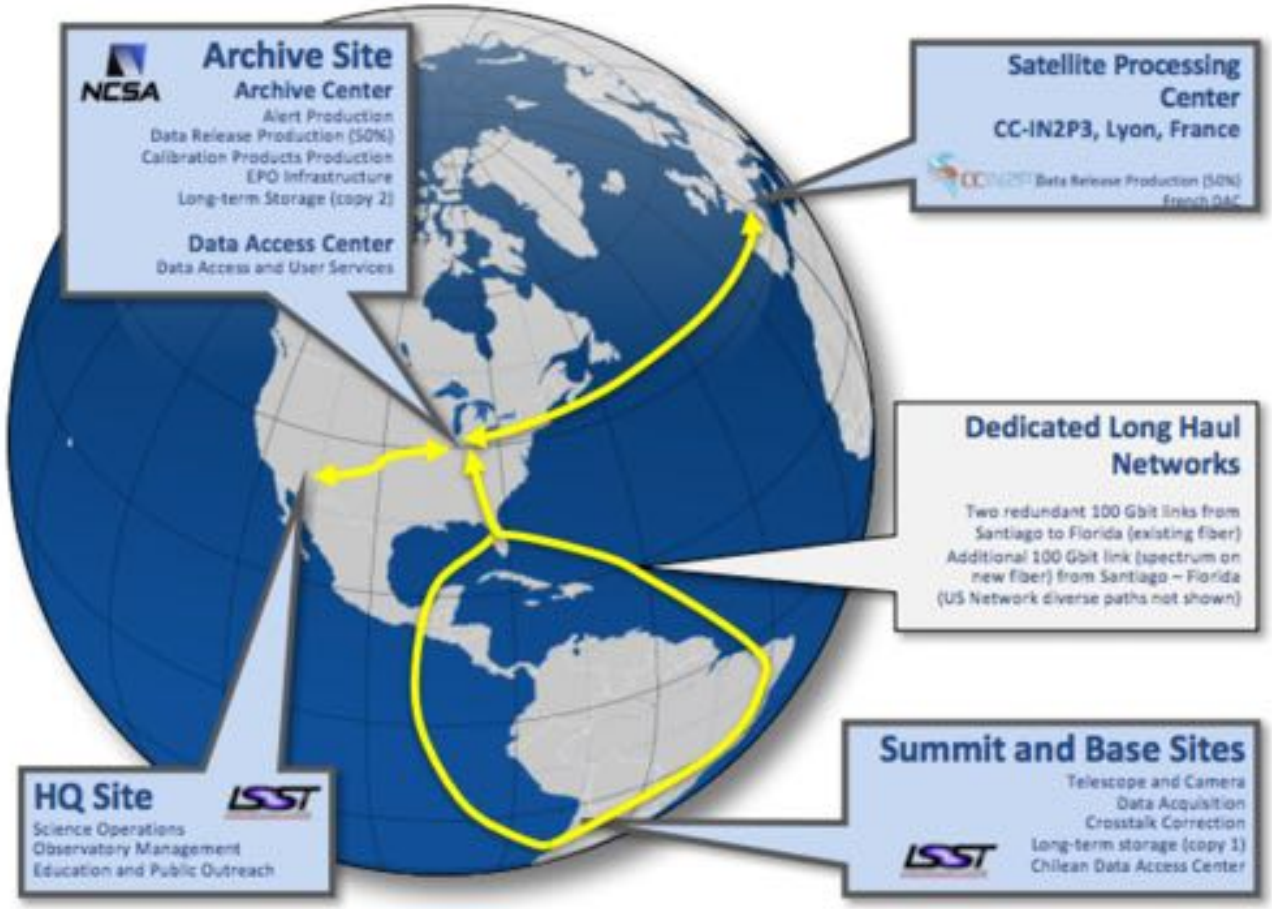


Data (http://www.lsst.org/lsst/gallery/data)

LSST AmLight Trailer (https://youtu.be/T6eRshTuU88)
LSST & AmLight Video (https://youtu.be/c16h1yyS-78)
Seeing the Beginning of Time (https://tinyurl.com/ybk27qm7)

LSST Data Management Facilities

New astronomical scientific instruments that are being designed and deployed are increasing the need for large, real-time data transfers among scientists throughout the world.



LSST Network Requirements

The LSST operation will consist of two main channels:

- Control Channel
  - Remotely operated from Tucson, AZ.
  - Requires low bandwidth, low latency, and high priority,
  - Bandwidth needs are about 2 Mbps
- Data Channels
  - Multiple data streams summing up 90 Gbps:
    - Each 12.7GB data set (6.4GB picture + 6.3GB metadata) must be transmitted to the U.S. in 5 seconds
    - Database synchronization, etc.
- The end-to-end path must provide high resilience, low delay, multiple paths, and an efficient control plane to act in all network status changes

LSST End-to-End Path (1)

- Some R&E networks can accommodate some of the LSST requirements:
  - Multiple paths with multiple 100G links (including AmLight-ExP)
  - Dynamic provisioning, bandwidth reservation

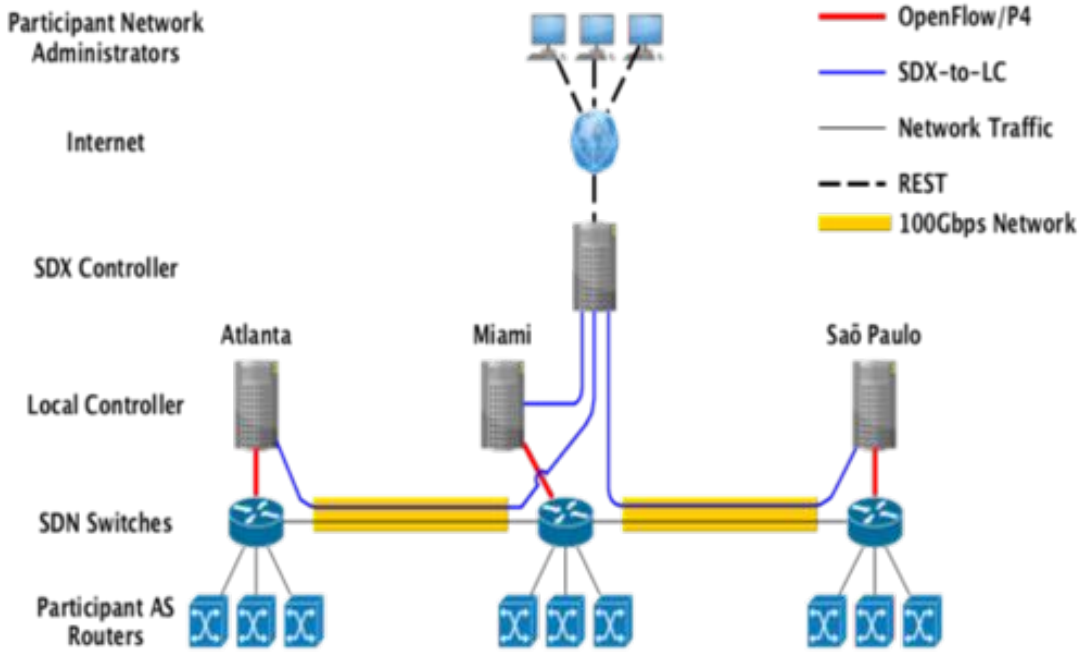
- But R&E networks are interconnected through Academic Exchange Points that have challenges:
  - Heterogeneous configurations and services
  - Almost no support for network programmability (SDN)

LSST End-to-End Path (2)

- High demand end-to-end applications like LSST require that all networks in the path support QoS and Programmability
  - Including the Academic Exchange Points
  - Software Defined Exchanges (SDX) within the exchange point are a possible solution
  - AtlanticWave SDX is aiming to overcome those limitations that exchange points have
  - LSST is a primary use case for Awave-SDX, a collaboration between FIU, Gatech, and SouthernLight in Sao Paulo to be extended to AndesLight in Santiago, Chile this October

LSST End-to-End Path (3)

AtlanticWave-SDX



- Initially, three locations to cover
- Thousands of KM of fiber between each location
- Split controller design
  - Central controller for interacting with users
  - Local controllers at each location

LSST Deployment Calendar

- From 2017 to 2020, the LSST network will be installed and fine-tuned (mainly for evaluations and simulations)
- Engineering ”first light” anticipated in 2019
- Science ”first light” in 2021
- Full operations for a ten-year survey commences in Q4 2022
- The LSST Network Engineering Team must guarantee all network requirements by 2021
  - Bandwidth guaranteed and resilience
  - Effective and efficient operation

AmLight ExP
Americas Lightpaths Express & Protect

LSST Network Topology

- AmLight-Express (spectrum) is the primary
- AmLight-Protect 100G ring is the backup

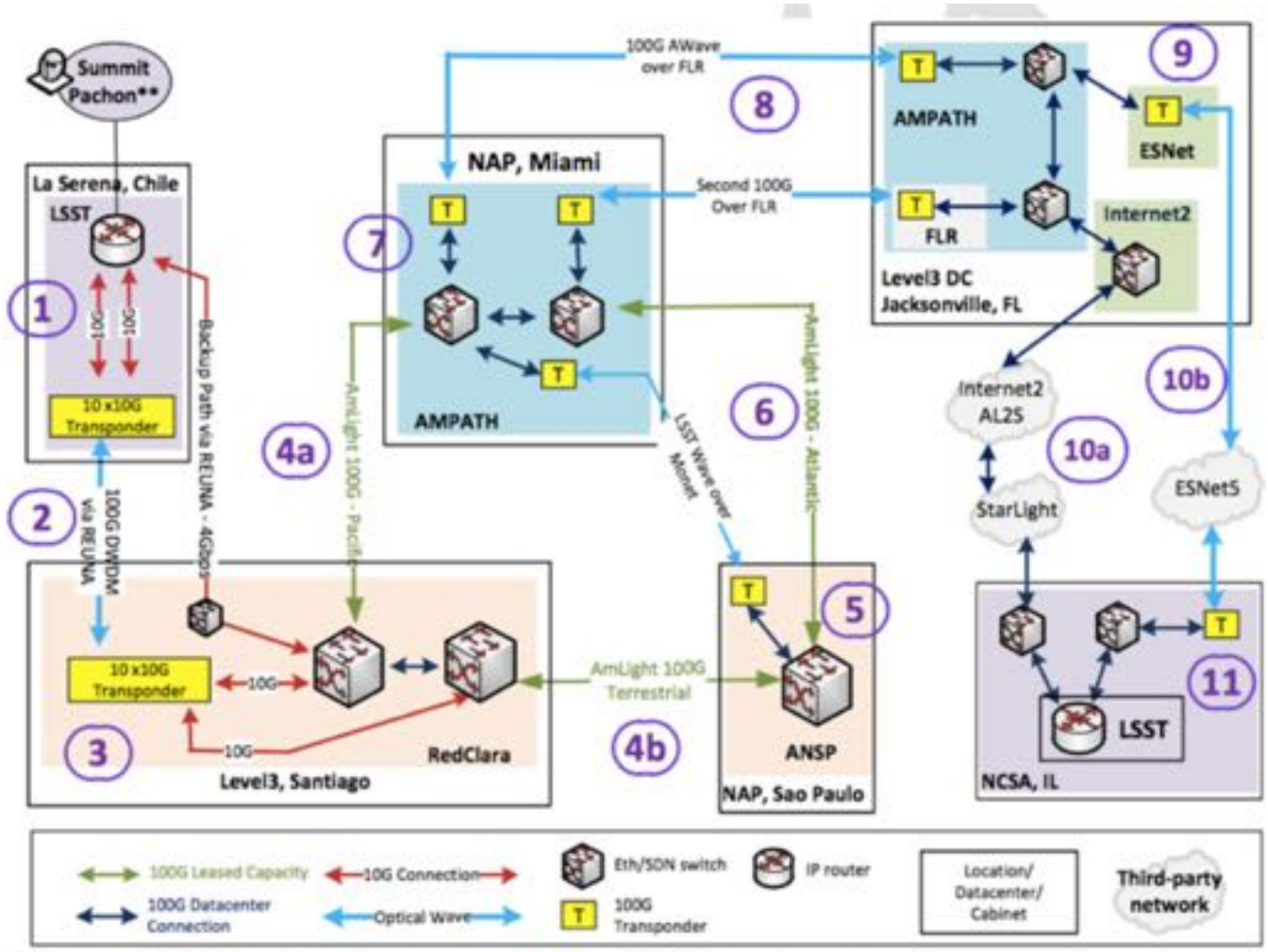
AmLight ExP
Americas Lightpaths Express & Protect

SLA requirements for networking

- General SLA:
  - Mean Time Between Failures (MTBF) - **180 days**
  - Mean time To Repair (MTTR) - **48 Hours**
  - Different QoS profiles for different network conditions (chart below)
- Bandwidth Required:
  - Summit (Cerro Pachon) to Base(La Serena, Chile): 200Gbps
  - Base (La Serena, Chile) to Archive (NSCA Champagne, Illinois, USA): 200Gbps
  - Archive to Data Archive Centers - DACs (ex. DAC Lyon, France): 10Gbps

	Chile to Miami		Miami to Illinois	
	Full Connectivity	Minimal Connectivity	Full Connectivity	Minimal Connectivity
Traffic Types	Bandwidth Available 300G	Bandwidth Available 100G	Bandwidth Available 200G	Bandwidth Available 100G
Science & Data Backbone Transport	90	70	90	70
Other Behavior Aggregates	45	10	45	10
Chilean Academic Usage	Best Effort	Best Effort	Best Effort	Best Effort
Bandwidth Reservation for LSST	45%	80%	68%	80%

Initial Draft for the LSST 2018 Network design



** - The network configuration of the segment La Serena to Pachon is outside of the scope of this document.

1. Colina El Pino/La Serena, Chile
2. La Serena to Santiago
3. Santiago, Chile
4. Santiago to Miami and Sao Paulo
5. Sao Paulo, Brazil
6. Sao Paulo to Miami
7. Miami AMPATH
8. Miami to Jacksonville/Florida FLR
9. Jacksonville/Florida
10. Jacksonville to Chicago
11. Chicago to Champaign/Illinois
12. Champaign/Illinois

AmLight ExP
Americas Lightpaths Express & Protect

Network Monitoring/Performance

- The *LSST Management Plan* defined a centralized Network Management System (NMS) for easy monitoring
  - To be used by LSST NOC and LSST Engineering teams
  - A single NMS will see all links, devices, CPUs, power supplies, etc. of all networks in the path

- perfSonar instrumenting the path: currently each site has two 10G ports dedicated for monitoring and performance evaluation; 100G nodes are planned for the future.

- End-to-end Performance Metrics: Latency, Packet Loss, Jitter, Maximum Payload Throughput

Challenges & Ongoing Efforts

- Complexity of multiple NOC teams
- Bi-annual South American Astronomy Coordination Committee (SAACC) meetings focus on networking needs for science & technology
- Bi-weekly LSST Network Engineering Team (NET) calls and NET meetings at the SAACC
- Bandwidth Calendaring: Different network utilization profiles for night and day are being discussed
- Security and Applications are being handled by separate Association of Universities for Research in Astronomy (AURA) Data Management Teams

THANK YOU!

Heidi Morgan, Ph.D.
hlmorgan@isi.edu

Infrastructure, science application support, education, outreach and community building efforts are made possible by funding and / or support from:

- National Science Foundation (NSF) awards: LSST #ACI-1202910, AmLight ExP #ACI-1451018, AtlanticWave SDX #ACI-1451024
- FAPESP, ANSP – grant no. 2008/52885-8
- Rede Nacional de Ensino e Pesquisa (RNP)
- RedCLARA
- Association of Universities for Research in Astronomy (AURA)
- Florida International University
- Internet2 and GRNOC
- ESnet
- Florida LambdaRail (FLR)
- National Center for Supercomputing Applications (NCSA)
- Latin American Research and Education community
- The many national and international collaborators who support our efforts