

# FABRIC

(an NSF Midscale CyberInfrastructure Project)

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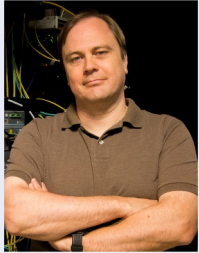
# FABRIC

an NSF Mid-scale Research Infrastructure, empowers researchers to **securely prototype** and **validate disruptive designs** in wide-area networks.

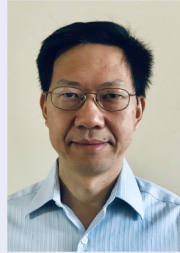
With its inclusion of advanced hardware uncommon in routers and switches, FABRIC facilitates experiments that **closely emulate real-world production** environments. By prioritizing connectivity with existing research and compute facilities, FABRIC enhances its usability and relevance.



Ilya Baldin  
(RENCI)



Zongming Fei  
(UKY)



Jim Griffioen  
(UKY)



Tom Lehman  
(Virnao)



Inder Monga  
(ESnet)



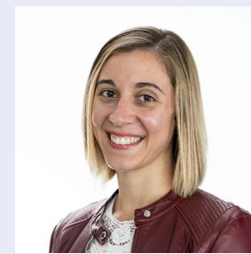
Anita Nikolich  
(UIUC)



Paul Ruth  
(RENCI)



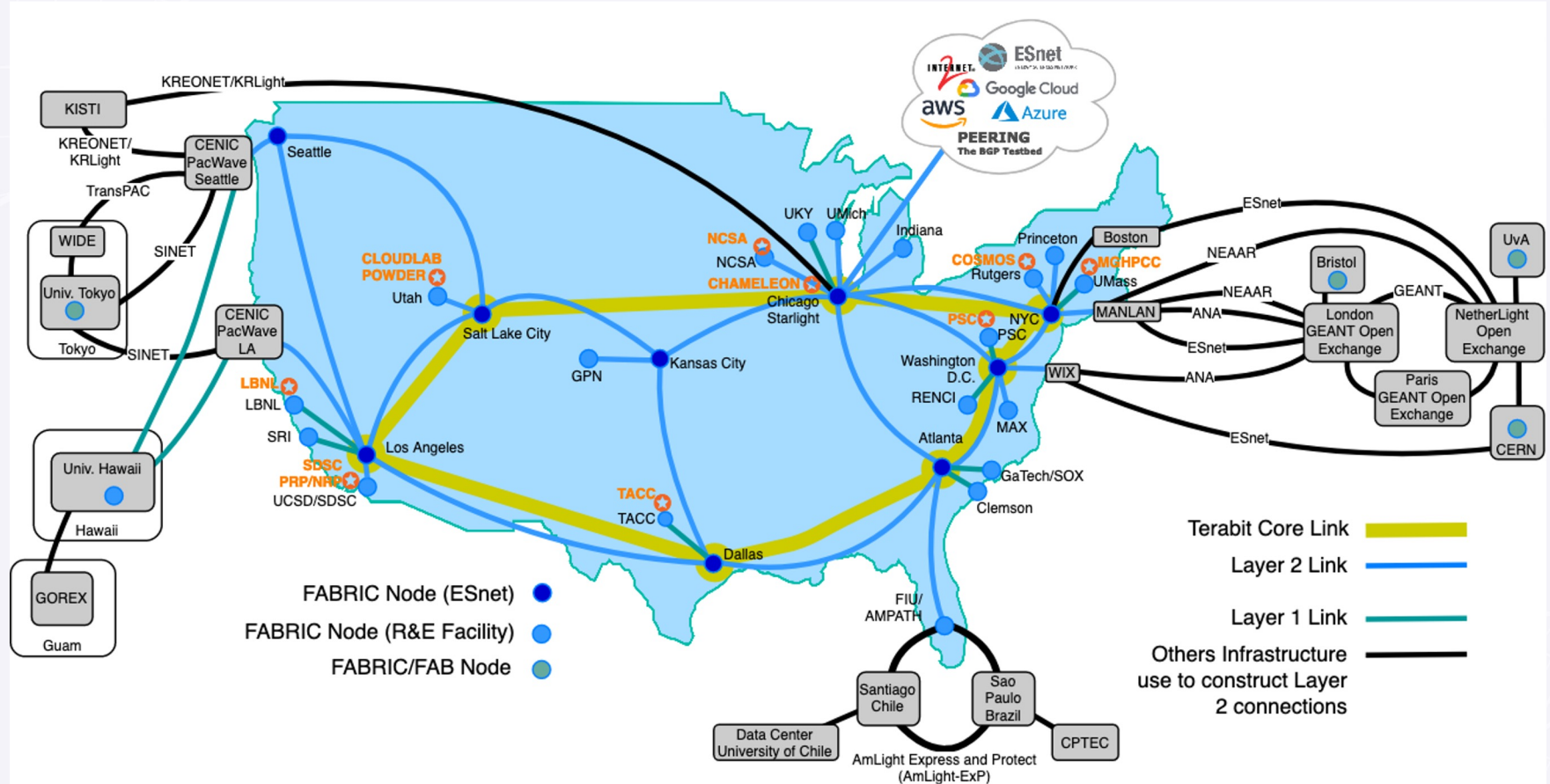
Bryttany Todd  
(RENCI)



KC Wang  
(Clemson)



# FABRIC: Experiments at Scale



## Campus Cyberinfrastructure

- Edge computing with the cloud
- Campus instruments, compute centers, and facilities
- Campus Science DMZs

## Data Staging & Transfer

- Access to data repositories/instrument streams
- Dissemination of results
- Inter-domain data transfers (cloud, compute centers, campus)

## Remote Device Control

- Microscopes, telescopes, medical devices, etc.



# Scientific Computing: Across Networks

## Facilities

- HPC Compute Centers
- Public/Private Clouds
- Campuses
- Data Repositories
- Large Instruments (microscopes, etc.)

## Infrastructure

- Internet2, ESnet, regional RENS
- Data Transfer Nodes (DTNs)
- Science DMZs

## Tools & Features

- Workload Managers (SLURM, etc.)
- Data Transfer tools (Globus)
- Workflow Managers (Pegasus, etc.)



# Scientific Computing: Resources and Tools

## Applications are Limited to Running at the *Edge*

- Limited by edge-to-edge protocols
- Growing emphasis in Edge-Core-Cloud paradigm

## End-to-end Performance

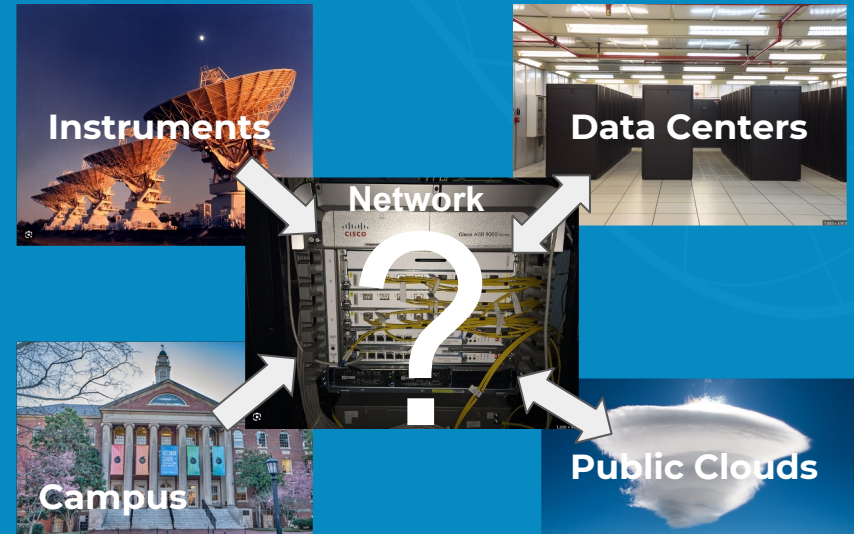
- Network performance between data repos, instruments, campuses and compute centers
- Requires Internet2 AL2S, optimized DTNs and/or Science DMZs

## Multi-facility Computation

- Distributed workflows
- Edge-core-cloud paradigm



# Realities & Trends



# FABRIC: Smart Programmable Cyberinfrastructure

"If I had asked people what they wanted, they would have said faster horses."

– Henry Ford, (maybe)





# FABRIC: Smart Programmable Cyberinfrastructure

Networks

"If I had asked people what they wanted, they would have said faster ~~horses~~."

– Henry Ford, (maybe)





## Run Applications Everywhere

- Edge, cloud, or routers in between
- Real facilities
- In-network compute, storage, and accelerators

## Sandboxed Experimentation

- Minimize security exposure
- Rapid test-fix-test cycles

## Production Scale

- Geographic and performance

## Tools & Apps

- Refine and invent novel tools and applications required for using programmable hardware in the network



# Impact on Cyberinfrastructure



## Science Unbound

- Applications natively running across platforms and domains
- Smart in-network processing, caching, and data collection/distribution

## Full Scale Prototypes

- Production scale
- Connected to real facilities
- Measured validation of expensive/risky systems
- Path for transition to production deployments

## Educating the Next Generation

- Hands-on learning
- Experiment in the network core with minimal impact

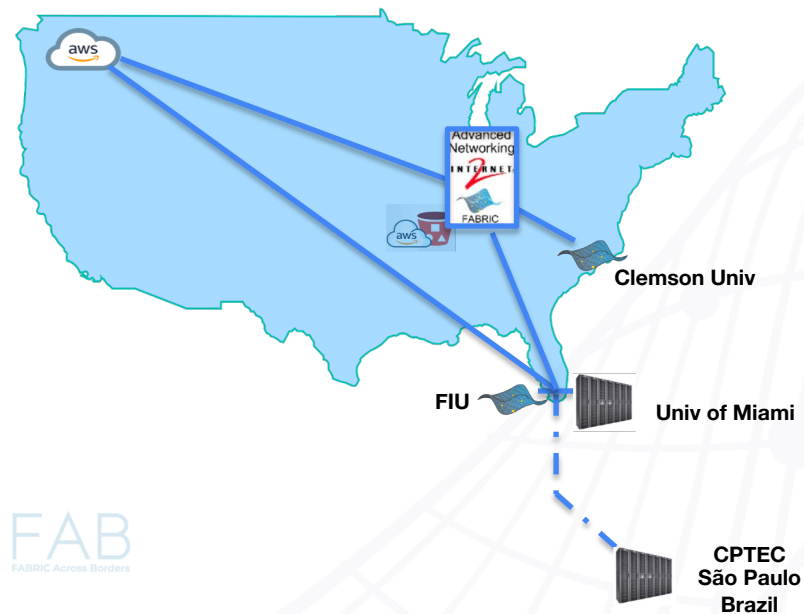
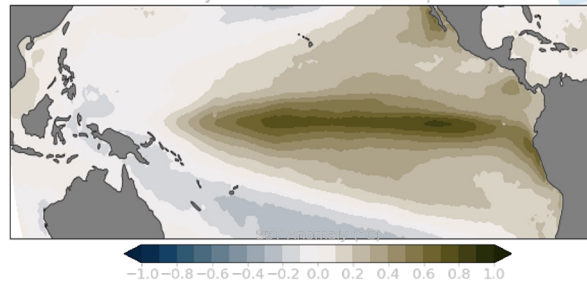
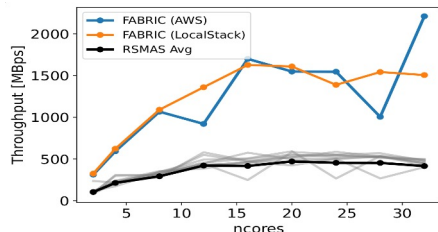
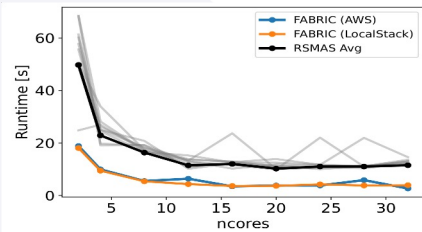
# FABRIC Does Climate: El Niño Forecasting

Existing El Niño forecasts use Global Climate Models issuing forecasts by modeling the physics of the atmosphere and ocean

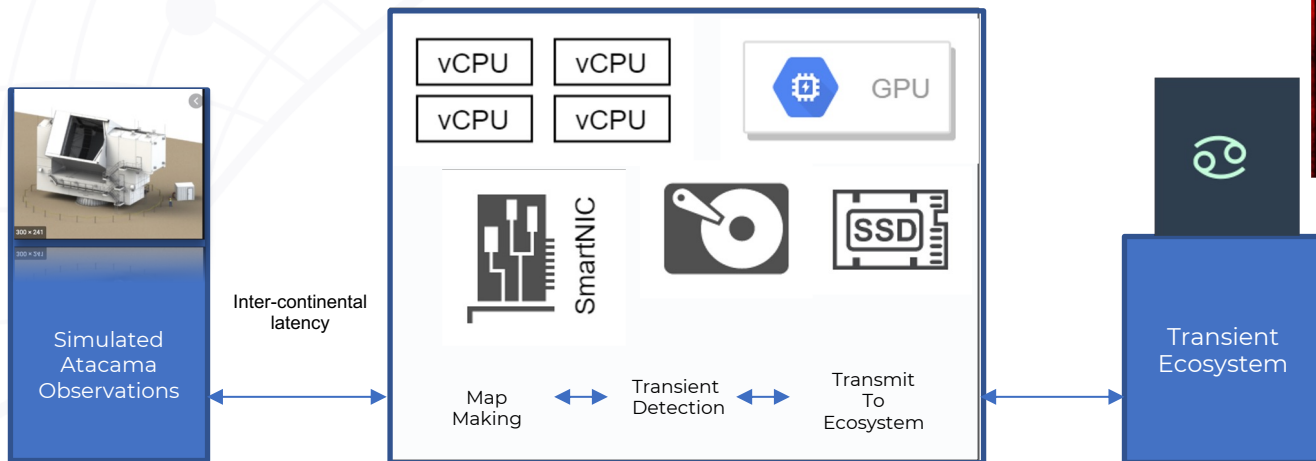
**Goal: Combine data from satellite observations with a pool of six Climate model forecasts (North American Multi-Model Ensemble) and CPTC (Brazil) using machine learning to issue better El-Niño forecasts**

Convolutional Neural Network to forecast El-Niño on FABRIC nodes

- Dr. Ben Kirtman (U of Miami)
- Dr. Leo San Pedro Siqueria (U of Miami)
- Dr. Kuang-Ching (KC) Wang (Clemson)



# FABRIC Does Astronomy: CMB-S4



With 12 telescopes at the South Pole and in the Chilean Atacama desert surveying the sky with 500,000 cryogenically-cooled superconducting detectors for 7-10 years, CMB-S4 will deliver transformative discoveries in fundamental physics, cosmology, astrophysics, and astronomy.

- Don Petravick, Gregory Daues (UIUC/NCSA)
- Designed/deployed CMB-S4 experiment(s) on FABRIC
- Simulated observatory source at FIU (projected actual path)
- In-network data processing
- Implemented a shell on top of FABlib to control their experiment

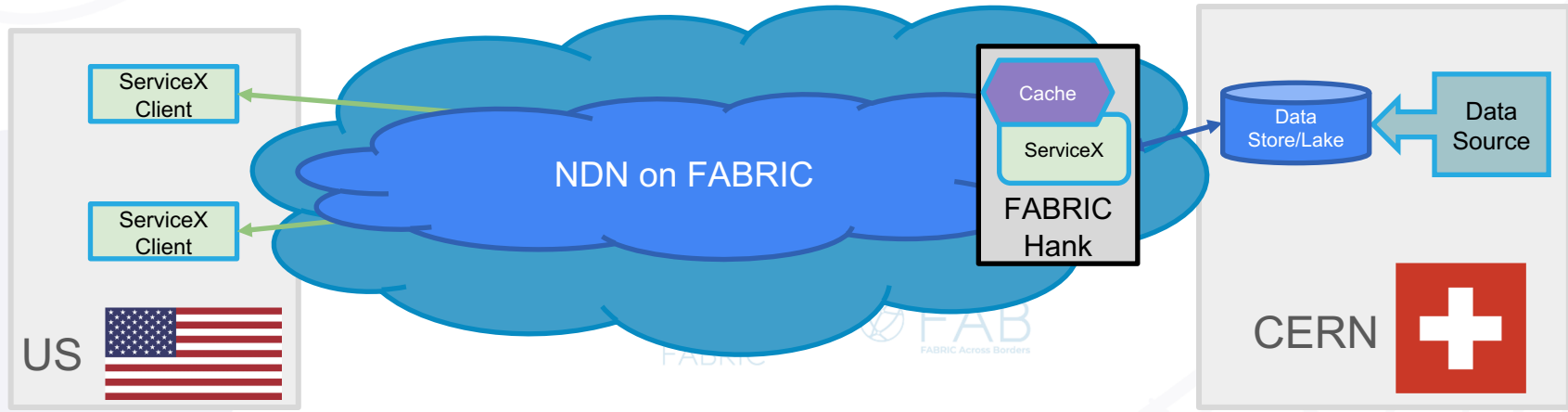
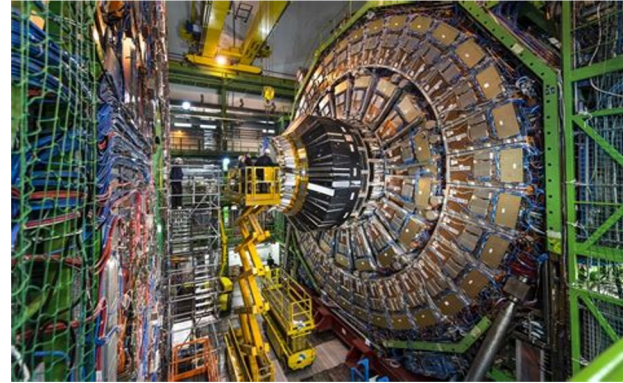


**CMB-S4**  
Next Generation CMB Experiment

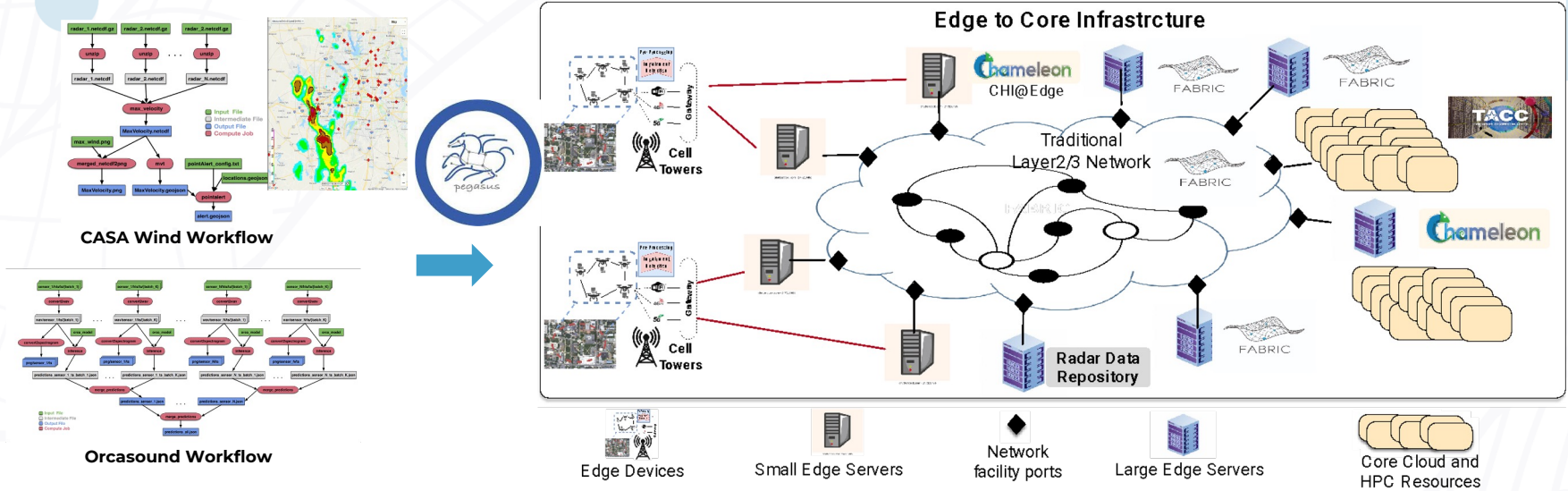
# FABRIC Does HEP: ServiceX for LHC Atlas

## ServiceX over NDN on FABRIC

- Incorporates in-network caching
- Extend the FABRIC ServiceX deployment by replacing TCP/IP flows with NDN data transfers that cache results at every hop in the network
- University of Chicago, University of Michigan



# FABRIC Does Edge Computing: FlyNet



Scientific workflows deployed by the Pegasus workflow management system in the edge-to-cloud continuum leveraging the FlyNet architecture; Using resources from Chameleon and/or FABRIC and utilizing the FABRIC network to move data

M. Zink (UMass Amherst), E. Deelman (USC/ISI), A. Mandal (RENCI/UNC), P.Calyam (U of Missouri), G.Papadimitriou (USC), A. Esquivel (U of Missouri), Cong Wang (RENCI/UNC), Komal Thareja (RENCI/UNC)

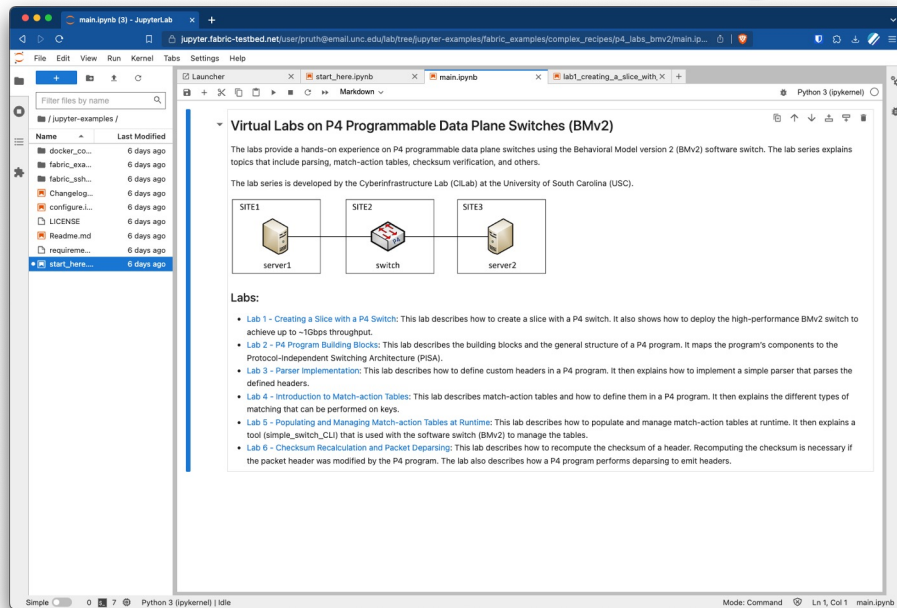
# FABRIC Does Education: P4 Labs

## Educational Laboratory

- Cyberinfrastructure Lab (CILab) at U of SC
- Prof. Crichigno and his team created a set of P4 Tutorials/Labs for FABRIC
- Available in FABRIC's JupyterHub

## P4 Experiments on FABRIC

- Deploy software P4 BMv2 on FABRIC
- Learn match action tables
- Deploy across real distributed infrastructure
- Tofino P4 Switches (coming soon)



The screenshot shows a JupyterLab environment with a notebook open. The notebook title is "Virtual Labs on P4 Programmable Data Plane Switches (BMv2)". The content includes a diagram of a network topology with three sites (SITE1, SITE2, SITE3) connected to a central switch, and a list of six labs describing various P4 experiments.

**Virtual Labs on P4 Programmable Data Plane Switches (BMv2)**

The labs provide a hands-on experience on P4 programmable data plane switches using the Behavioral Model version 2 (BMv2) software switch. The lab series explains topics that include parsing, match-action tables, checksum verification, and others.

The lab series is developed by the Cyberinfrastructure Lab (CILab) at the University of South Carolina (USC).

**Labs:**

- **Lab 1 - Creating a Slice with a P4 Switch:** This lab describes how to create a slice with a P4 switch. It also shows how to deploy the high-performance BMv2 switch to achieve up to ~1Gbps throughput.
- **Lab 2 - P4 Program Building Blocks:** This lab describes the building blocks and the general structure of a P4 program. It maps the program's components to the Protocol-Independent Switching Architecture (PISA).
- **Lab 3 - Parser Implementation:** This lab describes how to define custom headers in a P4 program. It then explains how to implement a simple parser that parses the defined headers.
- **Lab 4 - Introduction to Match-action Tables:** This lab describes match-action tables and how to define them in a P4 program. It then explains the different types of matching that can be performed on keys.
- **Lab 5 - Populating and Managing Match-action Tables at Runtime:** This lab describes how to populate and manage match-action tables at runtime. It then explains a tool (simple\_switch\_CLI) that is used with the software switch (BMv2) to manage the tables.
- **Lab 6 - Checksum Recalculation and Packet Deparsing:** This lab describes how to recompute the checksum of a header. Recomputing the checksum is necessary if the packet header was modified by the P4 program. The lab also describes how a P4 program performs deparsing to emit headers.



# Join the Community!



## FABRIC Account

<https://portal.fabric-testbed.net/>

## FABRIC + You

- Collaborate with FABRIC
- Add FABRIC hardware
- Conduct experiments

# Thank You!

## Questions?

Visit <https://whatisfabric.net>

## Newsletter Signup

[bit.ly/FABRICnewsletter](https://bit.ly/FABRICnewsletter)



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