Cyberinfrastructure Lab
University of South Carolina

http://ce.sc.edu/cyberinfra/

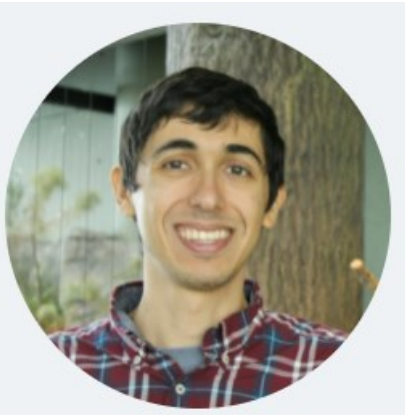
Department of Integrated Information Technology (IIT)
College of Engineering and Computing (CEC)

Jorge Crichigno, Elie Kfoury
Monday June 13, 2022 – IIT Conference Room

Members

Dr. Jorge Crichigno
Faculty Member, IIT

Elie Kfoury
PhD Student



Jose Gomez
PhD Student

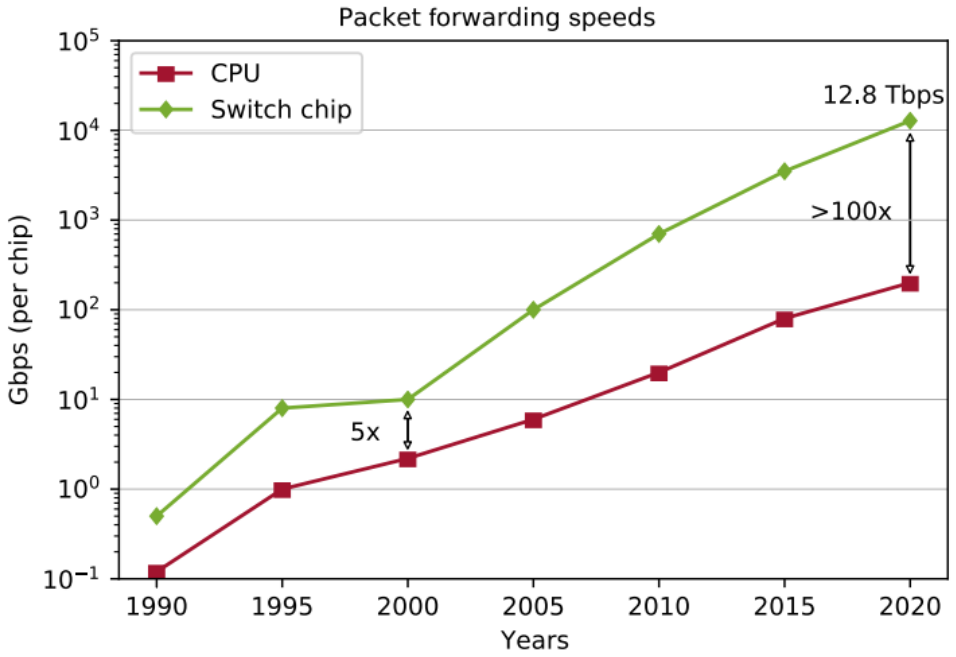
Ali AlSabeh
PhD Student

Ali Mazloum
PhD Student

Christian Vega
PhD Student

Project 1 – P4 Programmable Data Planes

- NSF funded project, 2021-2025. URL: https://tinyurl.com/2ew277rs
- It supports training and research on P4 programmable data planes –hardware-level network appliances–, recently developed by Intel
- USC is developing applications on networking and cybersecurity that exploit the performance advantages of programmable data planes (agreement with Intel)



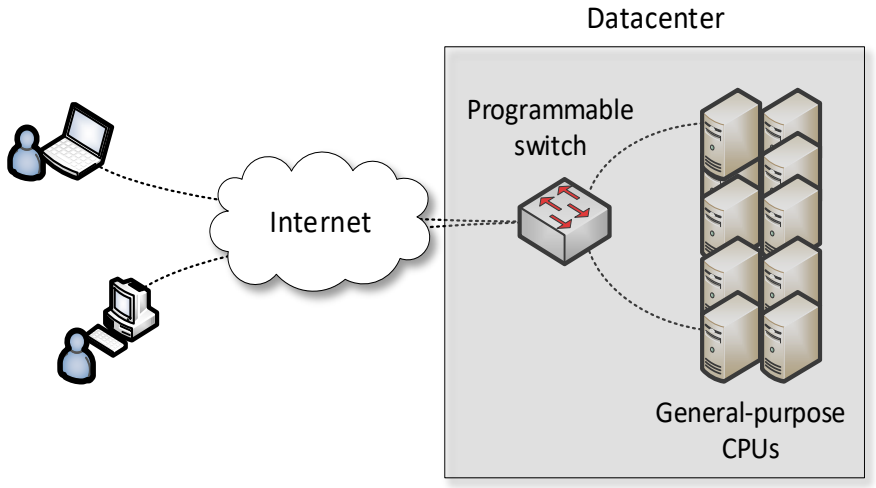
Project 1 – P4 Programmable Data Planes

- Analogy, networks (programmable data planes) and other computing domains

Domain	Year	Processing Unit	Main Language/s
General computing	1971	Central Processing Unit (CPU)	C, Java, Phyton, etc.
Signal processing	1979	Digital Signal Processor (DSP)	Matlab
Graphics	1994	Graphics Processing Unit (GPU)	Open Computing Language
Machine learning	2015	Tensor Processing Unit (TPU)	Tensor Flow
Computer networks	**2017**	**Protocol Independent Switch Architecture (PISA) (programmable data plane)**	**P4**

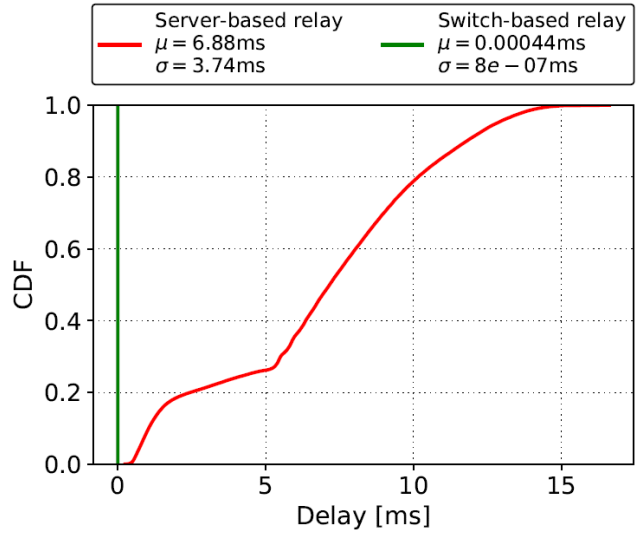
Project 1 – P4 Programmable Data Planes

- E.g., Offloading media relay tasks to switch's data plane
  - Orders of magnitude faster than general-purpose CPU
  - Limited instruction set (e.g., no multiplication, no division, simple operations)



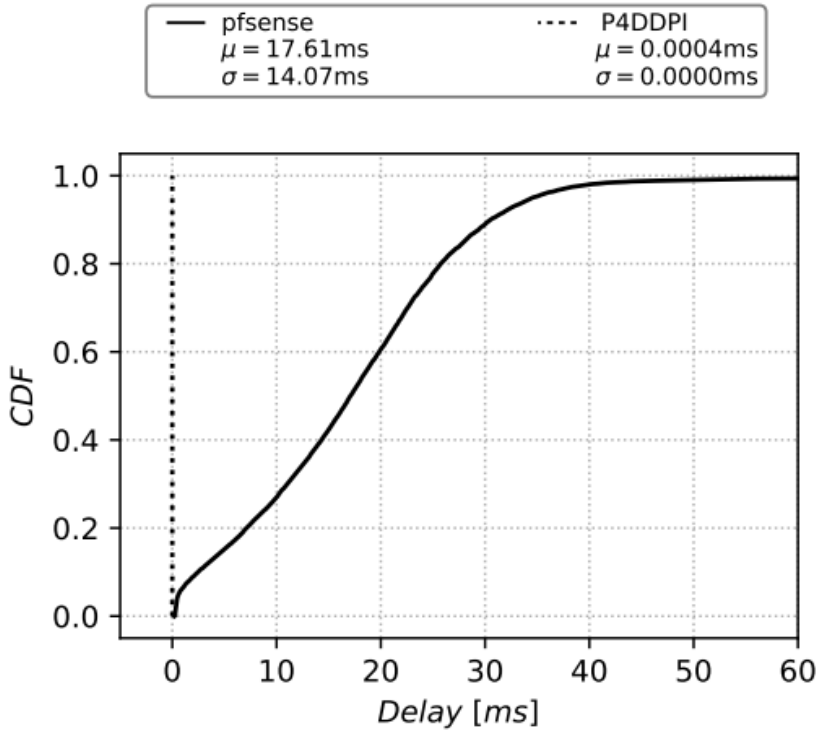
Application example: media (voice) relay server

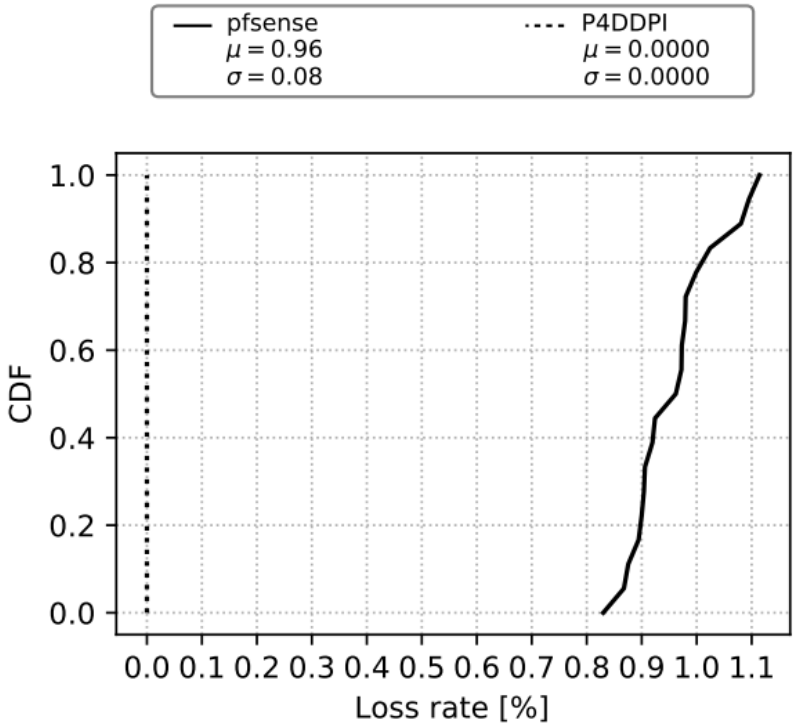
	Programmable Switch	General-purpose CPU
Cost	$6,000	$ 10,000 - 25,000
Capacity	~35,000,000 connections/switch	~500 connections/core
Latency	400 nanoseconds	Tens-hundreds of msec



Project 2 – DNS and Internet-scale IoT Security

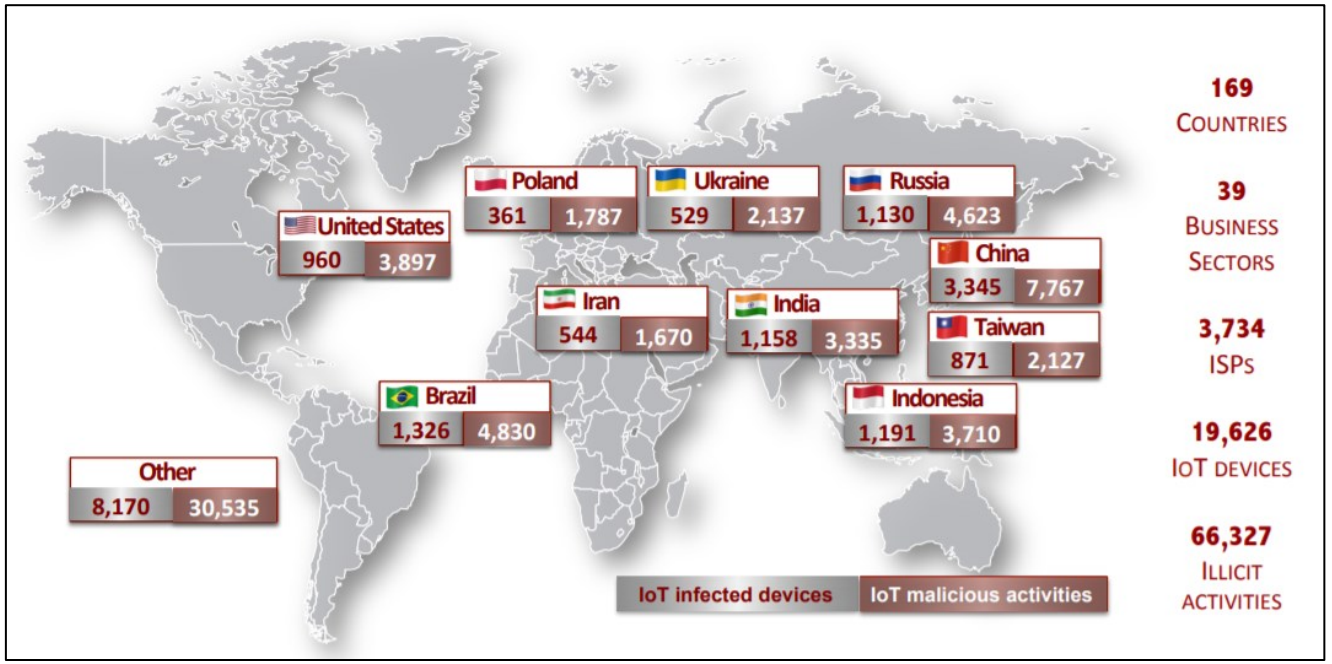
- NSF funded project, 2019-2023. URL: https://tinyurl.com/3a48wvtu
- Remove the software-based 'bottlenecks' by offloading functionality to switch ASIC
  - Parse and analyze DNS traffic solely in the data plane
  - Extract domain names and apply filtering rules



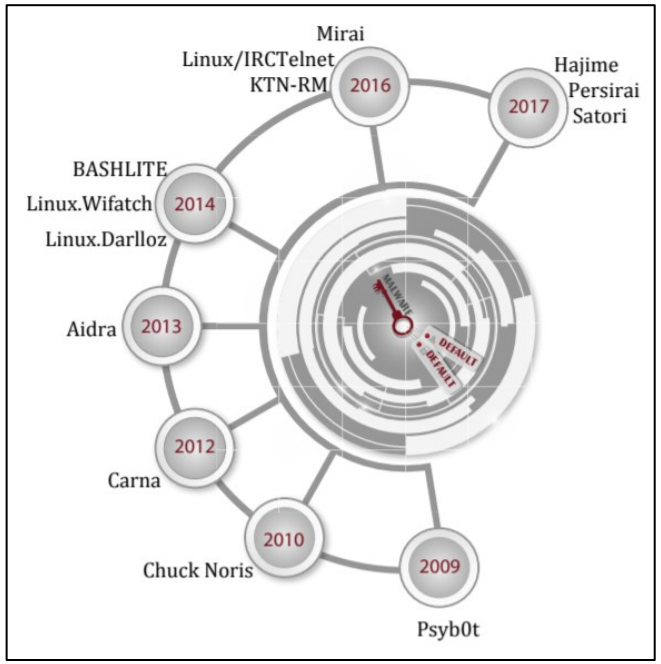


Project 2 – DNS and Internet-scale IoT Security

- NSF funded project, 2019-2023. URL: https://tinyurl.com/3a48wvtu
- Analyze IoT data worldwide from the Darknet; E.g.,
  - Global distribution of exploited IoT devices
  - Malware behavior



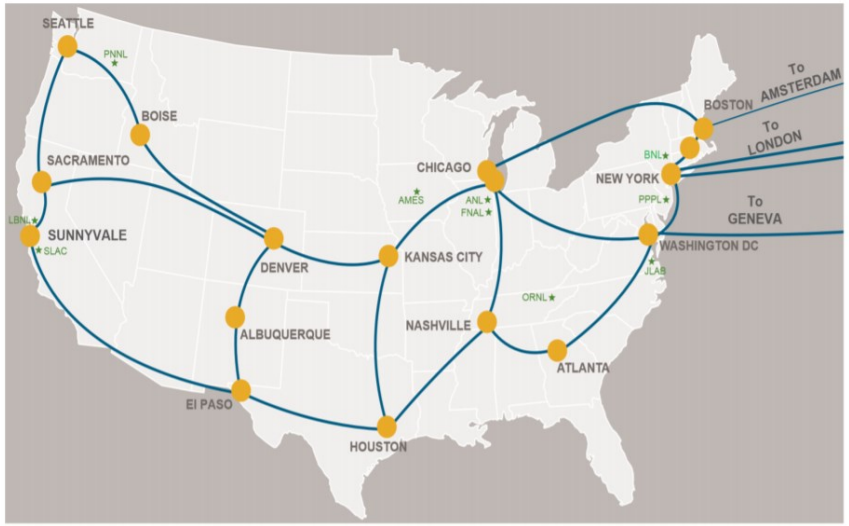
Global distribution of exploited IoT devices



Malware exploiting default credentials

Project 3 – Cybertraining High-Speed Networks

- NSF funded project, 2019-2023. URL: https://tinyurl.com/mw6dv8ma
  - Online training platform for high-speed networks and cybersecurity
  - Cooperation with LBNL, Internet2, Research and Education Networks (RENs) (TX's LEARN, NY's NYSERNET, CO's Front Range GigaPop, GA's SOX, Midwest's Great Plain Network, etc.)
  - Training approximately between 500-1,000 IT professionals per year –engineers, system admins, PhD students –nationwide



Platform enables ESnet-type network in the cloud

Project 3 – Cybertraining High-Speed Networks

- NSF funded project, 2019-2023. URL: https://tinyurl.com/mw6dv8ma
  - Established internships related to IT and cybersecurity with SRNL

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Job details

Job 1 of 1

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Auto req ID	4471BR
Job Abbreviation Title	SRNL Industrial Control Systems Security Intern
Job Description	Savannah River National Laboratory (SRNL) is a multi-program laboratory applying state of the art science and practical, high- Department of Energy's (DOE) Savannah River Site (SRS), the laboratory develops and deploys innovative technologies to ad Intern will participate in the development of a virtual network which simulates known environments to research vulnerabilities o through scanning and patching industrial controllers and generating documentation to ensure each system meets SRS cyber s environments and robotics systems.
Major	Computer Science Other
Other Major	Cyber Security, Industrial Systems, Virtual Reality, Industrial Controls/Robotics
Basic Qualifications (Quantifiable; e.g. Three Years Experience, Bachelors Degree)	Junior or Senior Knowledge and skill in basic computer applications and coding. Pursuing degree in Computer Science, Cyber Security, Industrial Systems, Virtual Reality, Industrial Controls/Robotics or relate Minimum overall GPA of 2.5 on a 4.0 GPA scale
Preferred Qualifications (e.g. Masters Degree)	Preferred courses: Introduction to Computer Networks Advanced Computer Networks IT Security
Removal Date	22-May-2019

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Steve Tibrea, former CIO, SRNL; interns; Jorge Crichigno

Project 3 – Cybertraining High-Speed Networks

- NSF funded project, 2019-2023. URL: https://tinyurl.com/mw6dv8ma
  - Approximately 100 internships per year

Brad Wilson, IT student

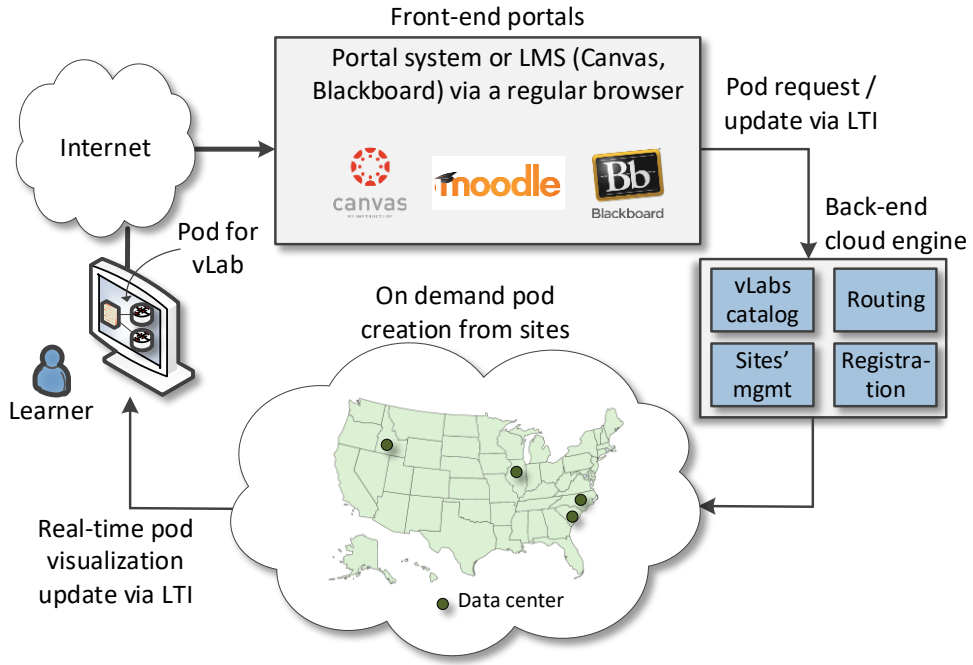
"I learned vital cybersecurity skills, such as creating policies with Application Identification rules, generating traffic to ensure security policies are operating appropriately, and reading logs to understand where traffic is traversing the network. The **skills I learned during my ONR project were very similar to those skills needed to become part of the Networking/Perimeter team at Savanna River National Laboratory (SRNL)**… as a result of my experience and previous internship at SRNL **I was offered a full-time position contingent upon my graduation in May 2022"**.

Internship examples

Name	Position
Ty Love-Baker	2nd Lt. at United States Marine Corps, DC
Dakota McDaniel	Information Security Analyst at Lowe's
Lauren Waddell	IT Specialist, SC Department of Insurance
Josue Hernandez	Technical Solution Specialist at IBM
Kyle Radzak	IT Specialist at Lowe's Companies
Nathan Bohmer	Project Coordinator at Black Box Networks
Brad Wilson	IT Intern Savannah River National Lab
Zach Fowler	IT Intern at Blue Cross Blue Shield
Nathan Long	Technology Analyst at AIG

Project 4 – Advanced Tech Education

- NSF funded project, 2019-2023. URL: https://tinyurl.com/4f9wfbuc
  - Develop a multi-state distributed cloud to support teaching, research, and training
  - 2+2+2 program (HS + College + University)
  - The distributed cloud seamlessly pools resources from four data centers: University of South Carolina (SC), Network Development Group (IL), Stanly Community College (NC), Idaho National Lab (ID)
  - The platform supports hundreds of organizations



Project 4 – Advanced Tech Education

- NSF funded project, 2019-2023. URL: https://tinyurl.com/4f9wfbuc
  - A platform tailored for research and education

Feature	Comments
Allocation of resources	Pod granularity
Custom pods	Easy to create custom pods
Cost	Cost-effective when used extensively
Presentation layer	Topology is graphically presented to the learner using a regular browser
Time sharing	We control who can access resources; easy to implement time-sharing policies
IP addresses	Pods (and learners) can have the same topology and IP addresses (overlapping)
Functional realism	Virtual labs have the same functionality as hardware and execute the same code
Traffic realism	Devices generate/receive real, interactive network traffic to/from the Internet

Project 5 – Workforce Development Cybersecurity

- ONR funded project, 2020-2022 (potential extension to 2026)
  1. Develop a cybersecurity concentration

Cybersecurity Operations, Minor

Degree Requirements (18 Hours)

Course	Title	Credits
Select one of the following:		3
ITEC 101	Thriving in the Tech Age	
ITEC 204	Program Design and Development	
ITEC 552	Linux Programming and Administration	
ITEC 233	Introduction to Computer Hardware and Software	3
ITEC 245	Introduction to Networking	3
ITEC 293	Cybersecurity Operations	3
ITEC 445	Advanced Networking	3
ITEC 493	Information Technology Security for Managers	3
Total Credit Hours		**18**

https://tinyurl.com/4mbj3z4k

Project 5 – Workforce Development Cybersecurity

- ONR funded project, 2020-2022 (potential extension to 2026)
  2. Establish an Undergraduate Research Program in Applied Cybersecurity

     Participants include ROTC cadets (Navy, Army, Air Force), Veterans, and students from CS, IT, IS, Cyber Intelligence

Name	Project Examples
Christian S	Application ID
Brendan C	Protection against Bruteforce Attacks with NGFW
Jack S	Mitigating Routing Hijacking Attacks
Matthew D	Mitigating Routing Hijacking Attacks
Chris N	Protection against Reconnaissance and Scan Attacks
Jack S	Policy-based Forwarding
Matthew D	Policy-based Forwarding
Keegan S	An open-source library for computer networks and cybersecurity
Dakota M	Distributed Denial of Service (DDoS) Protection
Lauren W	Protection against Bruteforce Attacks with NGFW
Josue H	Site to site VPN with NGFWs
Brian N	Distributed Denial of Service (DDoS) Protection

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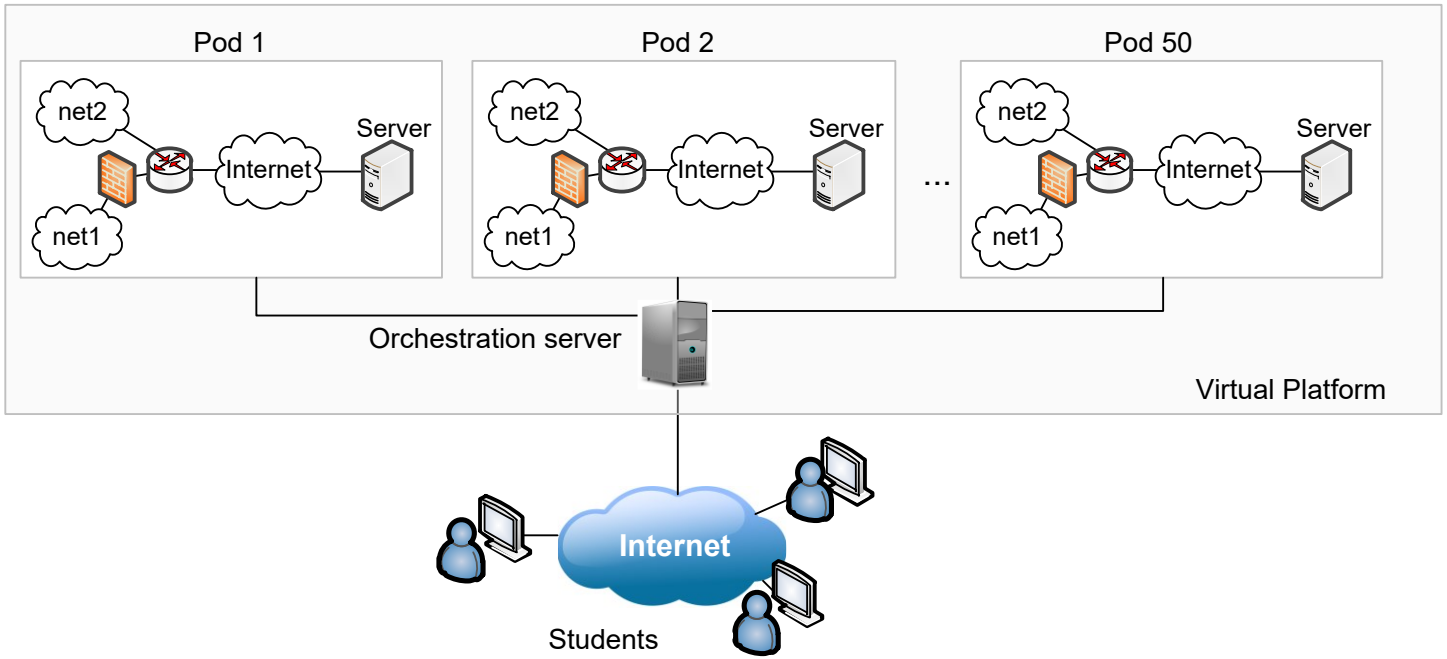
Project 5 – Workforce Development Cybersecurity

- ONR funded project, 2020-2022 (potential extension to 2026)
  3. Deploy virtual equipment pods on a virtual platform

  - Lawrence Berkeley National Lab
  - SANS institute (“girlsgocyber”)
  - Multiple higher-ed institutions
  - International Networks at Indiana
  - Fort Gordon
  - Texas’ Lonestart REN
  - Great Plains Network REN
  - New York State REN
  - U.S. Army Cyber Center of Excellence (CCoE) (Signal School)

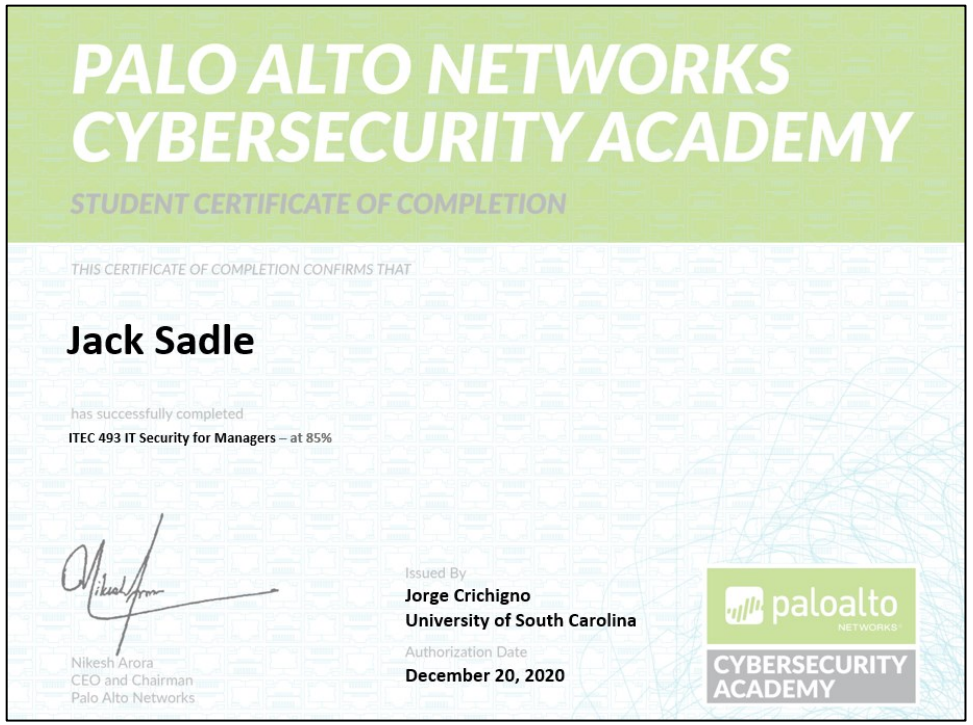


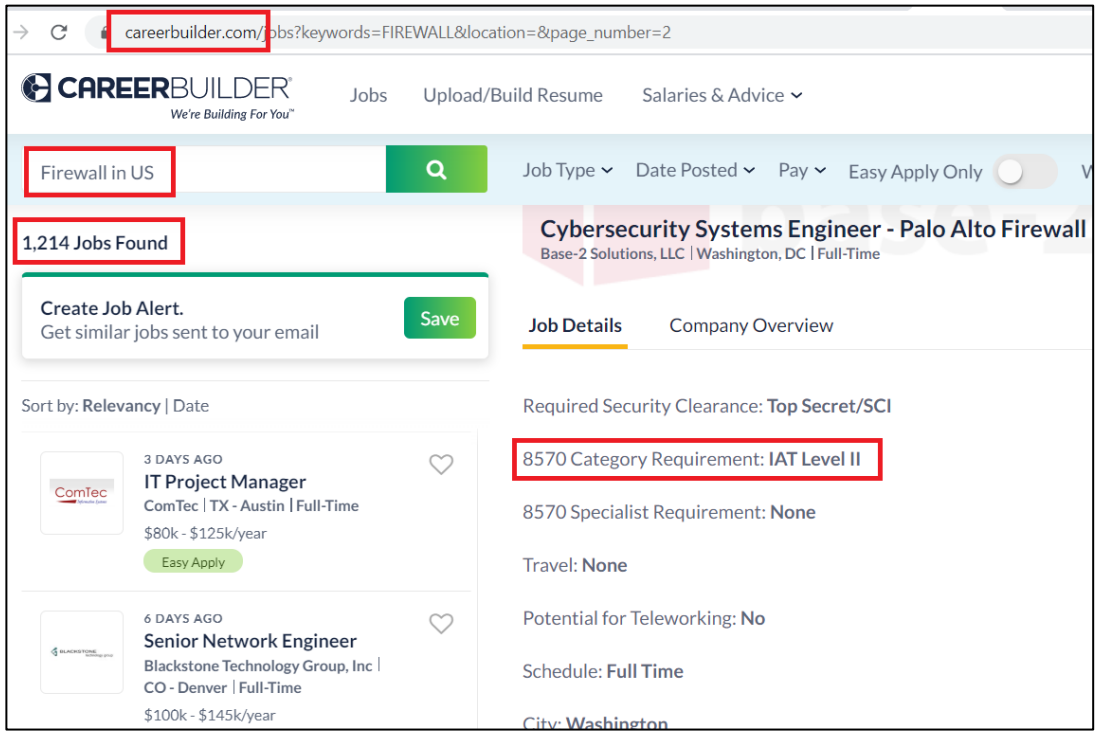
Project 5 – Workforce Development Cybersecurity

- ONR funded project, 2020-2022 (potential extension to 2026)

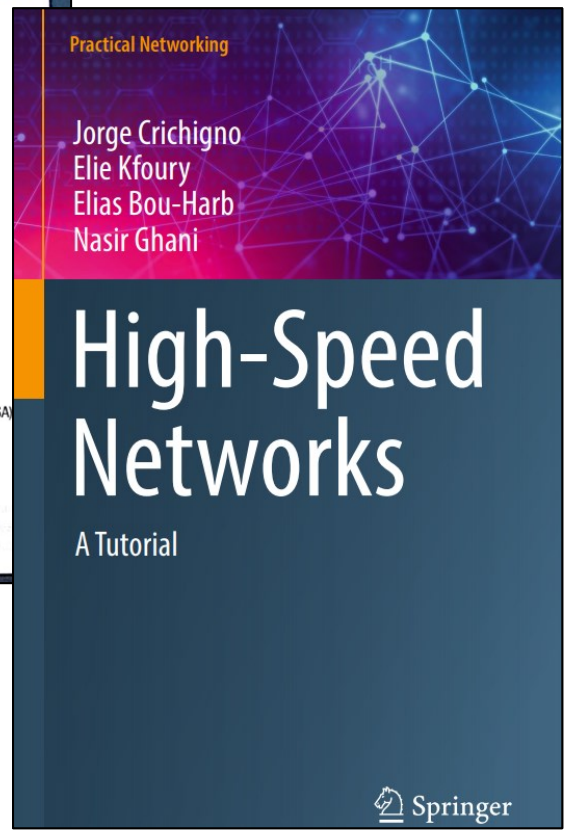
4. Develop cooperation among industry, government, higher-ed institutions

Internships, research experience, certs, professional platforms and tools: Palo Alto Networks, Cisco Systems, VMware, Intel, SRNL, LBNL, and others





Cyberinfrastructure Lab - Impact



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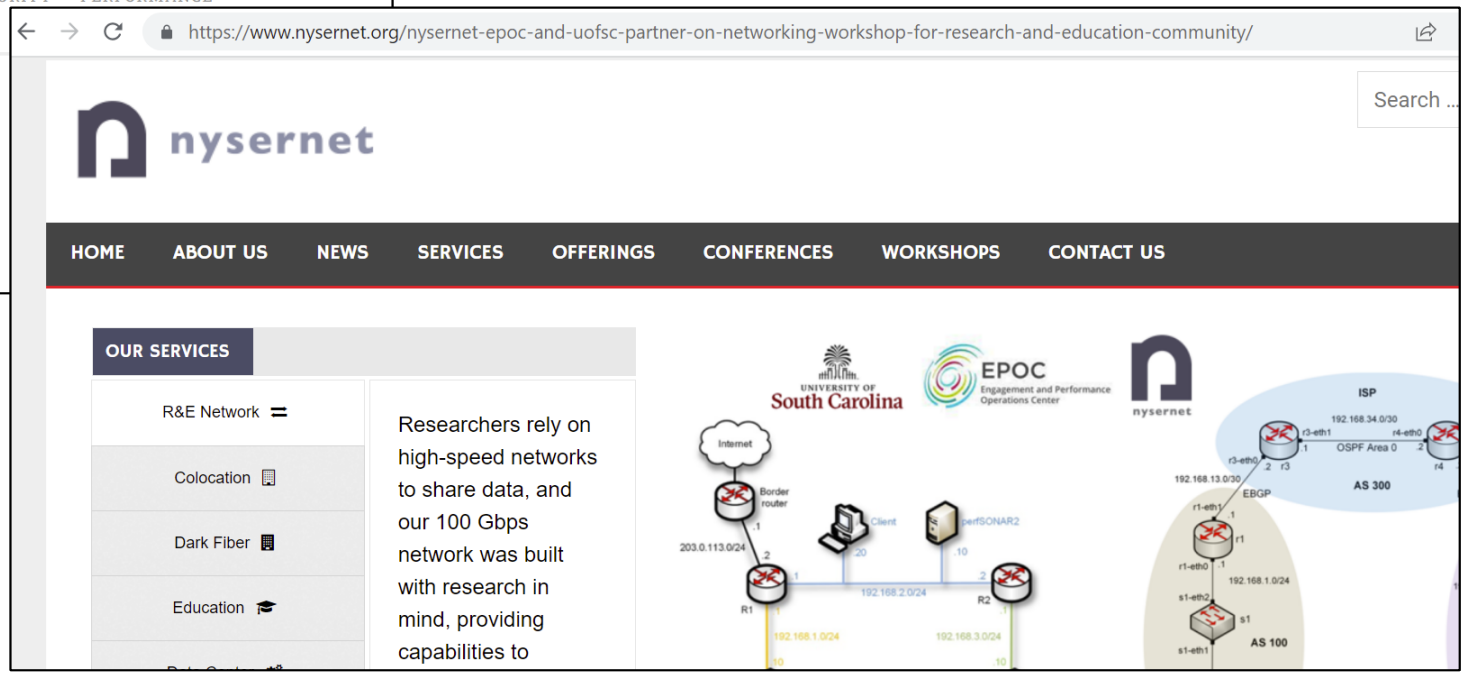

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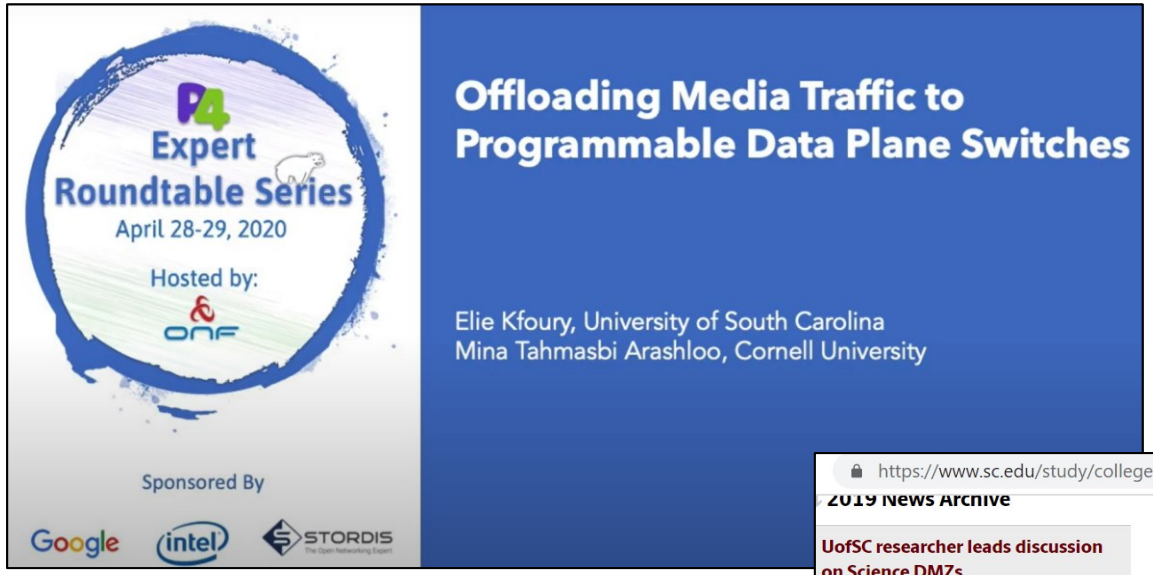

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