EXPERIENTIAL LEARNING USING VIRTUAL LABORATORIES

Jorge Crichigno

Integrated Information Technology Department

College of Engineering and Computing

EdTech SHOWCASE – UofSC

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Agenda

- Introduction to and motivation for hands-on teaching / training
- Laboratory challenges
- A scalable virtual platform
- University of South Carolina pods
- Impact of the proposed platform
- Concluding remarks

Introduction

- During the last years, South Carolina (SC) has experienced increased demand for Information Technology (IT) labor

- Employment statistics in SC saw a 24.3% jump in the number of job postings related to IT

- The average IT industry wage is $79,480 compared to the state's average private sector annual wage of $43,660

- Companies have been relocating offices to the Carolinas. E.g., Lenovo, IBM, Capgemini, etc.

South Carolina Press Release, CompTIA, March 2018.
Online: https://www.comptia.org/aboutus/newsroom/press-releases/2018/03/27/south-carolina-technology-industry-added-more-than-2-500-jobs-in-2017-tech-contributes-nearly-$11-billion-in-economic-impact-to-state

Introduction

- In Cybersecurity alone (an area of IT), the current number of job openings is 3,380

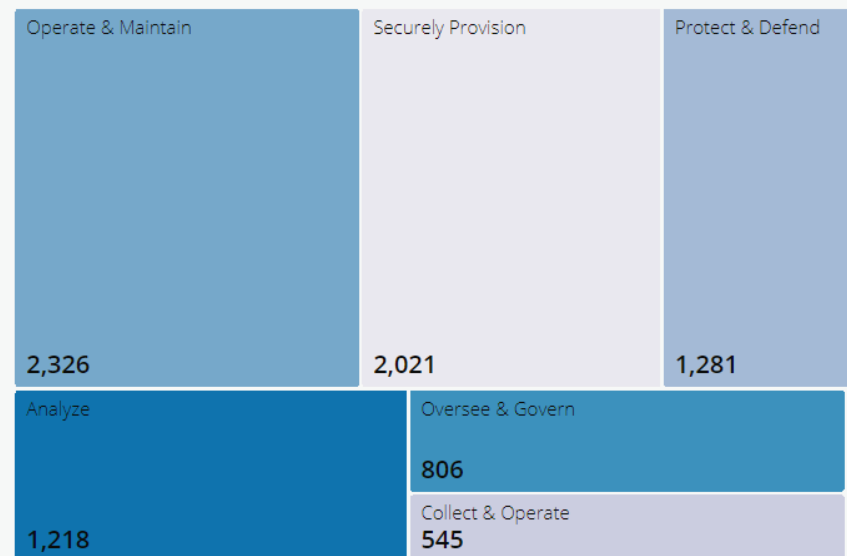**South Carolina**

TOTAL CYBERSECURITY JOB OPENINGS
3,380

TOTAL EMPLOYED CYBERSECURITY WORKFORCE ⓘ
8,374

TOP CYBERSECURITY JOB TITLES
- Cyber Security Engineer
- Cyber Security Analyst
- Network Engineer / Architect
- Systems Engineer
- Cyber Security Manager / Administrator
- Systems Administrator
- Cyber Security Specialist / Technician
- Software Developer / Engineer
- Cyber Security Architect

JOB OPENINGS BY NICE CYBERSECURITY WORKFORCE FRAMEWORK CATEGORY

Operate & Maintain	Securely Provision	Protect & Defend
2,326	2,021	1,281

Analyze	Oversee & Govern
	806
	Collect & Operate
1,218	545

https://www.cyberseek.org

Challenges

- The Department of Integrated Information Technology (IIT) is hosted in the College of Engineering and Computing (CEC)

- The Department offers a Bachelor of Science in IIT

- Experiential learning

  - Hands-on courses

  - Real client capstone project course

  - Internship experience

Challenges

- Hands-on experiences are essential in IT
- Goals
  - Teach IT core concepts combined with *authentic practice*
  - Provide a learning experience using *professional tools and platforms*
  - Ease the transition from academia to the workplace (access to *computing technologies in the work environment*)
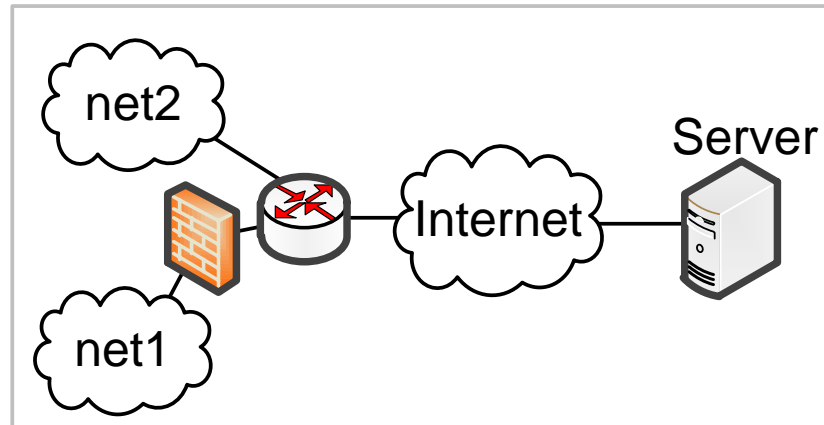
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How to include authentic practice, professional tools and platforms, access to computing technology in the work environment in a **scalable way**?

Challenges

- Teaching, training, and research on IT topics (networks, cybersecurity) require realistic scenarios
- A *pod* per student
  - A pod is a set of equipment required to complete a hands-on experience (authentic, professional tools / platforms, work environment emulation)

Challenges

- Physical labs are not scalable
- Require maintenance
- Time consuming to setup the experimental environment
- Costly in labor (technician), equipment, and space
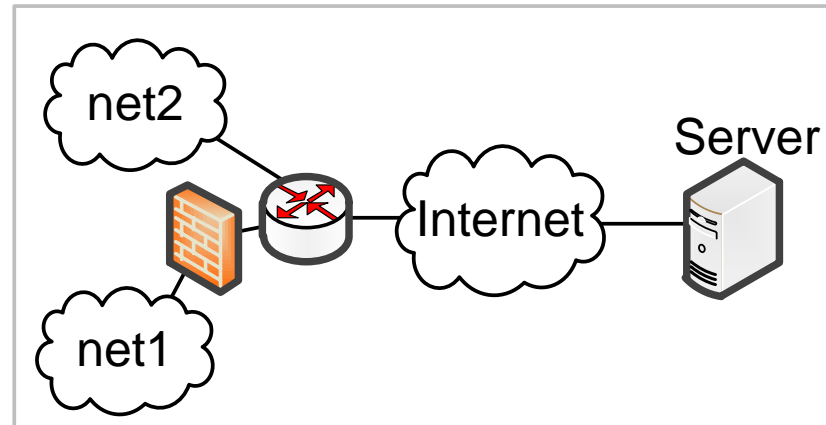
Virtual Platform

- Virtual platform based on virtual machine (VM) technology
- Pod elements (computer, firewall, router, equipment) are VMs rather than physical devices
- Pods launched on demand on an server hosted in IIT
- Access to the virtual platform via web interface

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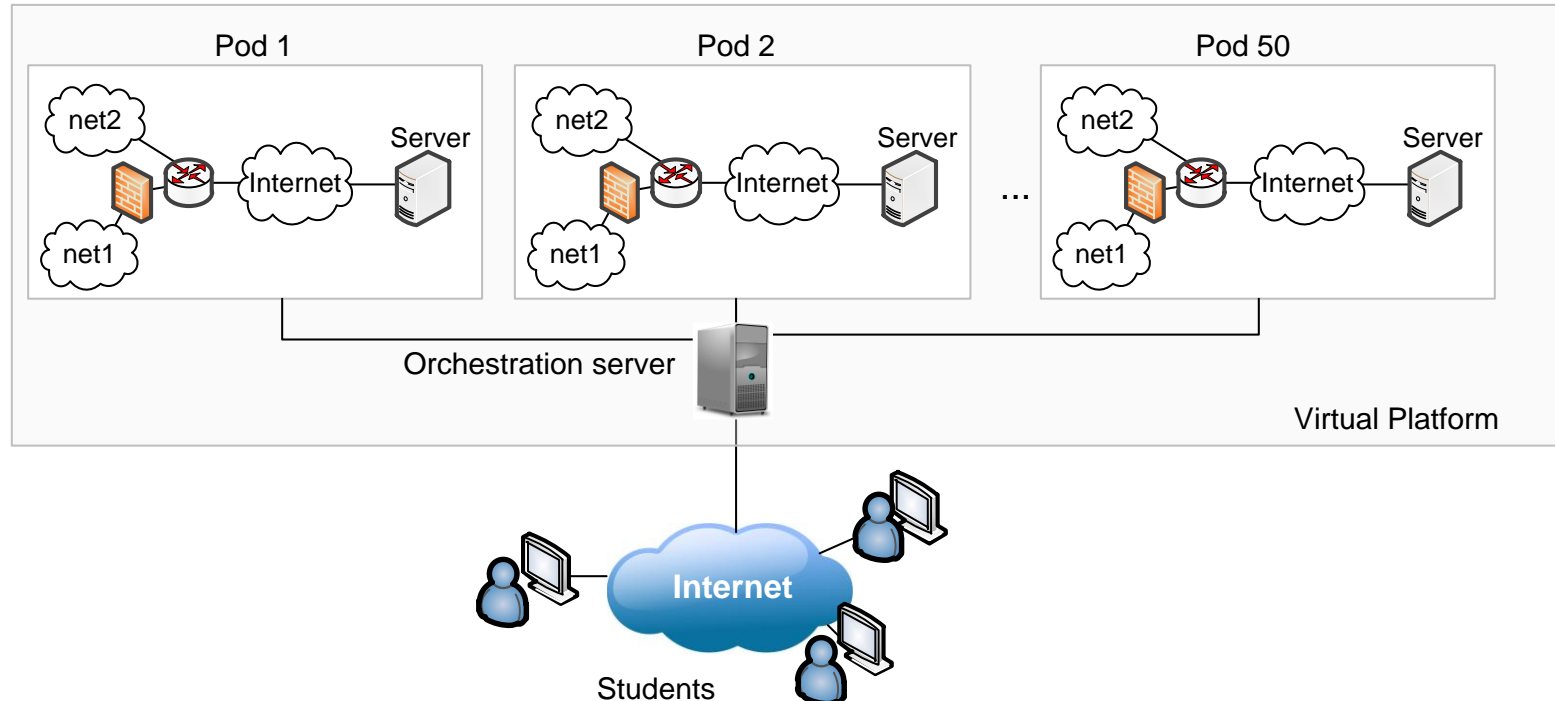
# Pod Examples – Introduction to Cryptography

- Symmetric-key encryption
- Generation of public keys
- Public-key encryption
- Certificate authorities
- Digital signatures
- Digital envelopes
- Web of trusts
- Encryption protocols
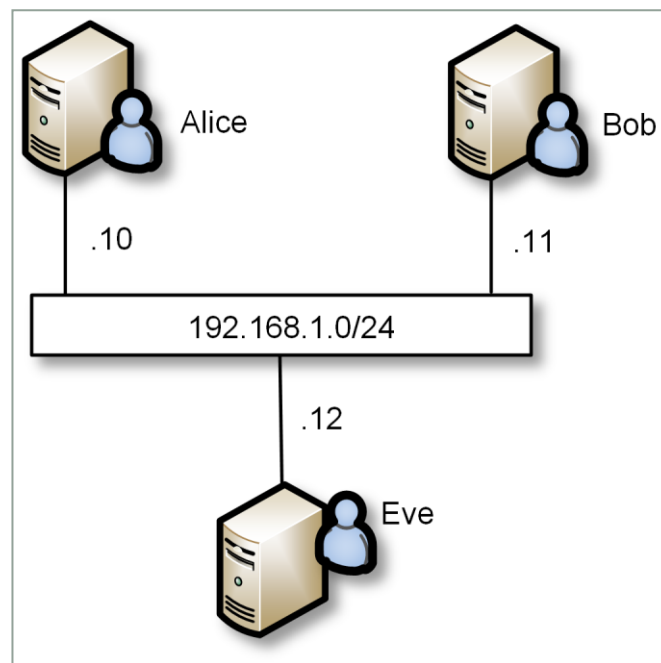
Course: ITEC 493 (Security)

# Pod Examples – Next-generation Firewalls

- Firewalls
- Malware analysis
- Application identification
- User identification
- URL filtering
- Virtual Private Networks
- Monitoring and reporting
- Modern techniques for malware identification
- Palo Alto Firewalls provided VMs at no cost
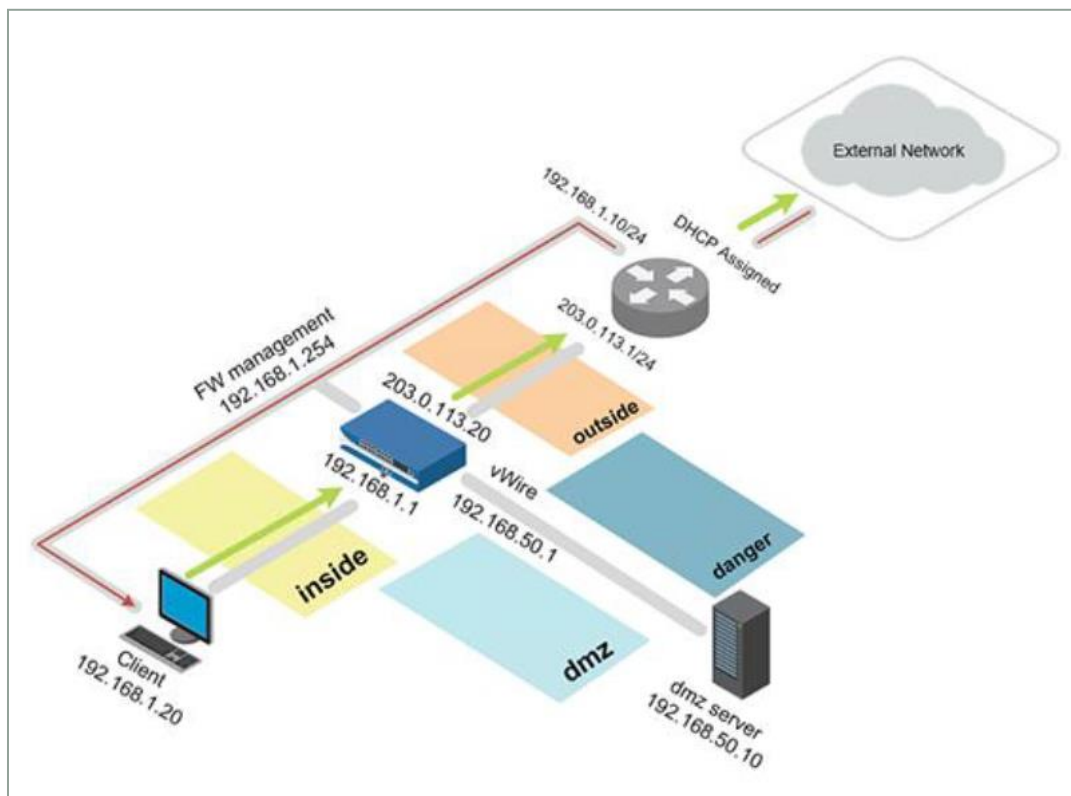
Course: ITEC 493 (Security)

Pod Examples – High-speed Networks

- Tools and metrics
   for high-speed monitoring
- Regular network testing
- Scheduling performance tests
- Multi-domain monitoring
- Throughput and latency
   networks in multi-domain env.
- Security of monitoring systems
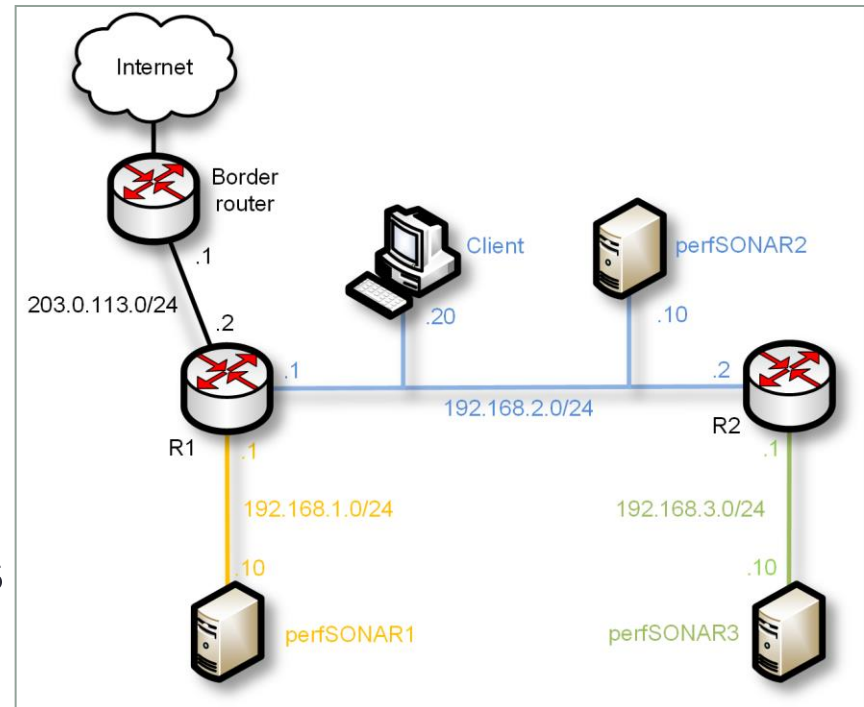
Course: ITEC 445 (networks), research

Pod Examples – High-speed Networks

- High-performance tools
- Big data transfers
- Access-control lists
- Traffic routing for high speeds
- Intrusion detection systems
- Passive network monitoring
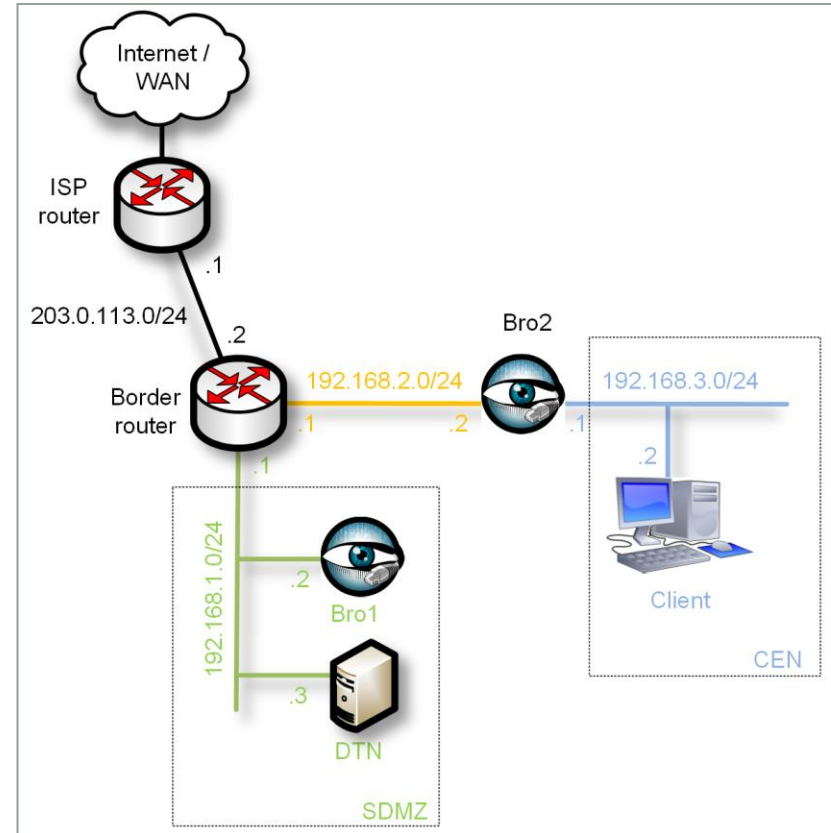
Course: ITEC 445 (networks), research

Demo

- Virtual platform is accessible via a web portal
  - https://netlab.cec.sc.edu
  - https://10.173.78.50

Impact

- Spring 2019: ~50 students
- Hours attended: 1,399.25
- Hours per user: 27.9
- Hours per user / week: 2.5

Admin > Usage > Community Usage > List

📈 Community Usage

Search

ID	Name	Reservations Made	Labs Attended	Hours Reserved	Hours Attended
1	default	835	794	2457.50	1399.25
	Page Total:	835	794	2457.50	1399.25
	Table Total:	835	794	2457.50	1399.25

Showing **1** to **1** of **1** items

Impact

- Focus group on Nov. 29, 2018, by Dr. Janet Gordon, Ed. D.
- 10 students from ITEC 493 (Security), 60 minutes

Impact

- *I'm a visual learner and so doing the labs, where I can create something and see it, helped! I had to physically make it myself which I thought helped me understand…*

- *It's different when you're doing it, than just reading it. I mean, reading it in a book, you can read it and you might understand it, but you won't know until you actually apply that…*

- *Before, without seeing the lab, it probably would have just gone over my head and I would have understood the definition and the word, but not what it was…*

- *[The vLabs] kept me in check … and [helped me] learn everything more gradually and more fully… I can picture myself doing it and now it comes so much easier…*

- *My manager was really stressing to me the importance of [security] rules. The vLab had taught him how to create rules and that he could now successfully determine the outcome of a security network*

Impact

- *We only have one [security] class. So, I would love to see them offer security courses or even a security pathway…*

- *I really wished I'd had more experience with the GPG part of it, like encrypting emails and the different methods you can do, because that to me was part of the crash course in crypto email. I'd never seen it before and if we would have learned that at a lower level it would have been good…*

- *If there was an intro to cybersecurity back when I was a sophomore, I could've developed it, and actually started applying for cyber-security jobs*

- *Pathway [to cybersecurity] is not that clear…*

Related Activities

- Workshop on Developing Virtual Laboratories
  - Date: July 30-31, 2018
  - Place: University of South Carolina
  - Attendance: 61 instructors from 25 states

Survey result, pilot training workshop on development virtual labs and industry certificates (July 2018).

Workshop rate	Instructor rate	Pedagogic material	I would attend other workshops
4.3	4.7	4.4	4.7

5: Extremely satisfied; 4: very satisfied; 3: moderately satisfied; 2: Slightly satisfied; 1: poor.

Related Activities

- Paid internship opportunities at Savannah River National Laboratory
  - Start date: May 20, 2019
  - Hours: 400
  - Requirements: hands-on skills on networks and cybersecurity

Provide support to Savannah River National Laboratory (SRNL) Research and Development Engineering Department as a Student Intern on the Savannah River Site (SRS), a US Department of Energy (DOE) facility in western South Carolina. The rising senior who is an American citizen may participate in the development of a ***virtual network*** which simulate know environments to research vulnerabilities of Industrial Control Systems. The intern may assist R&DE personnel in the validation of field systems through scanning and patching industrial controllers and generating documentation to ensure each systems meets SRS cyber security requirements. Additionally the intern may participate in the development of Virtual Reality training environments and robotics systems.

Conclusion

- IIT is adopting and developing hands-on virtual laboratories and companion material for essential IT domains

- They permit to teach IT concepts combined with authentic practice using professional tools and platforms

- During the first two semesters, students attended lab hours for ~2 hours / week, without supervision or technician needs

- A workshop on vLabs-based IT training is scheduled for July 2019, co-organized with DOE and other institutions

- A paper has been accepted to the 2019 Annual Conference of the American Society for Engineering Education

- Future work
  - Full implementation of virtual laboratories in multiple courses
  - Disseminating nationwide of the **UofSC model**