

SDMAY24-20 - Mohamed Selim

PAWR Program

Utilizing a PAWR Program to Develop Advanced Hands-on Labs for Networking & Cybersecurity Courses

IRP Presentation - Senior Design II, Spring 2024

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Project Challenge

The Challenge:

- Iowa State University utilized GENI in several labs for classes like CprE 431 and CprE 489.
 - GENI is a large scale experiment infrastructure. Provide a platform for networking & distributed systems research and education.
- However, GENI had started to decommission and transition away from to a new infrastructure starting in August of 2023.

Presenter: Brendon D.

What is going to replace GENI?

How can researchers and educators continue to learn and inspire?

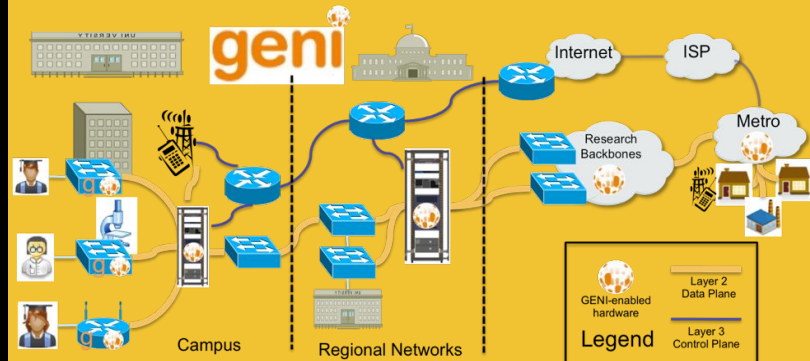


Image:
GENI Architecture | GENI

Project Solution

The Platforms for Advanced Wireless Research (PAWR) Program Announces Fourth Wireless Research Platform in Central Iowa to Drive Innovation in Rural Broadband Connectivity

Iowa State University will lead development of the new testbed with funding from the U.S. National Science Foundation, a consortium of industry partners, and the U.S. Department of Agriculture's National Institute of Food and Agriculture



<https://arawireless.org>

Presenter: Brendon D.

Our Solution:

- Research and use a PAWR Platform (ARA) to replace GENI's purpose.
- Adapt and create labs to showcase the infrastructure to educators and students.
- Fill the void GENI left for educators by empowering them with new relevant labs on this new platform.

Our ARA Approach

Research & Motivation

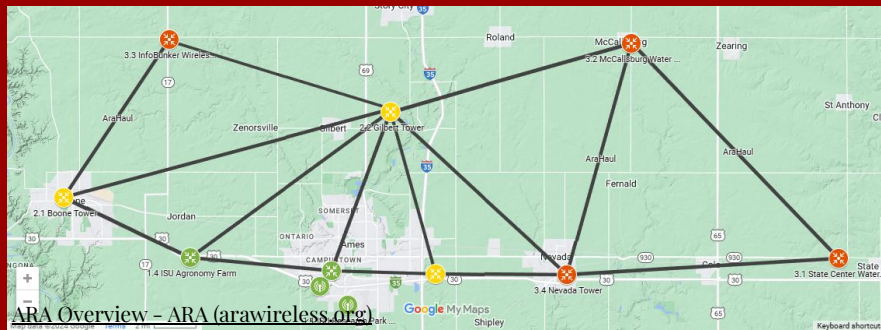
- PAWR (Platforms for Advanced Wireless Research) received 40-50 million dollars in funding since the creation.
- ARA, backed by PAWR, is a wireless living lab right here at Iowa State University and Story County.
- The infancy and closeness ensures an active technical and support team to quickly meet demands.

[ARA Overview - ARA \(arawireless.org\)](http://arawireless.org)



Presenter: Corey L.

Project Impact



ARA Deployment Plan

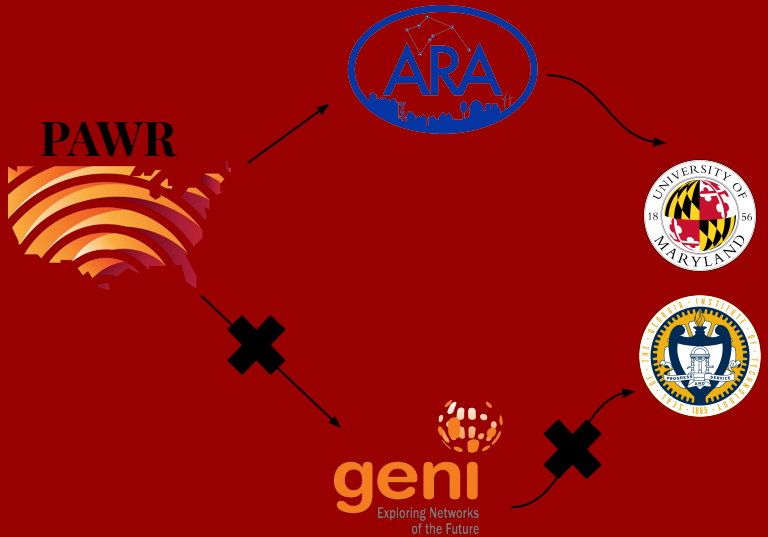
- ARA has plans to stay within Story County to assist the Agricultural and Rural Areas, but with our labs and exposure to the system and infrastructure, we've been able to aid and assist in the development of the platform.

Presenter: Brendon D.

Outreach & Impact

- ARA's Mission: revolutionize the agriculture and rural areas
 - Our labs are capable of expanding ARA's impact and name nationwide!
- ARA was designed and developed for research use, our project is the **FIRST** educational and application based exposure.
 - We are building the stepping stones

Project Roadmap



Iowa State University
CprE 431



North Carolina State University
CSC 575 Introduction to Wireless Networking

Missouri S&T
COMP ENG 5430 Wireless Networks



University of Central Florida
GNT 4403 Network Security & Privacy

Georgia Institute of Technology
CS 4251 Computer Networks II



Grinnell College
CSC 214 Computer & Network Security

Iowa State University
CprE 489

University of Maryland
CMSC 414 Computer Networks

Ethics & Responsibilities

ARA's Capabilities & Bounds

- We were in close contact with the ARA team to ensure we stayed within our bounds as guest users.
 - disrupting services
 - hogging resources
 - crashing systems

Responsibilities

- We remained respectful of their resources and devices
- We made sure to utilize on their resources and not the general public or any private sector
- Everything was done and facilitated in a controlled, safe, and inexpensive environment

Project Results

Final Deliverables

- Met our advisors mission by developing six (6) hands-on labs related to Networking & Cybersecurity Courses.
- Extended our impact to other universities across the nation by reaching out and sharing our research and products.
- Developed and engineered custom labs on the ARA platform for these specific courses.

4G LTE Network Emulation and Throughput Testing Utilizing ARA

Senior Design sdmay24-20 Experimental Lab

Transmitting, Receiving, and Visualizing Waveforms using UHD and GNURadio

Senior Design sdmay24-20 Experimental Lab

Outdoor 5G Channel Measurement using COTS UEs

Senior Design sdmay24-20 Experimental Lab

Presenter: Camron C.

Lab Details



Lab Report
Key

Lab Report
Template

Lab
Walkthrough

Goal

- Empower educators to have options when distributing the lab documents as well as a justification for doing so.

Presenter: Susanna N.

Lab Reach

- Our adapted and custom labs were engineered by adapting basic Wireless Networking and Cybersecurity concepts and morphing them into the new ARA Platform and Infrastructure.
- With labs like:
 - 4G Throughput
 - Measuring 5G Channel using COTS UE
 - Visualizing Waveforms
 - 4G Packet Structure & Analysis
 - Network Jamming and Snuffing
 - Monitoring AraMIMO Link Behavior with CLI

In-Depth Lab Look

```
root@ue:~# iperf -C 172.16.0.1 -u -i 1 -D 25M -l 10
-----
Client connecting to 172.16.0.1, UDP port 5001
Sending 1470 byte datagrams, IPG target: 448.61 us (kernel)
DP buffer size: 208 KByte (default)
-----
[ 3] local 172.16.0.3 port 53006 connected with 172.16.0.1
ID] Interval      Transfer      Bandwidth
[ 3]  0.0- 1.0 sec  3.13 MBytes  26.2 Mbits/sec
[ 3]  1.0- 2.0 sec  3.12 MBytes  26.2 Mbits/sec
[ 3]  2.0- 3.0 sec  3.12 MBytes  26.2 Mbits/sec
[ 3]  3.0- 4.0 sec  3.12 MBytes  26.2 Mbits/sec
[ 3]  4.0- 5.0 sec  3.12 MBytes  26.2 Mbits/sec
[ 3]  5.0- 6.0 sec  3.12 MBytes  26.2 Mbits/sec
[ 3]  6.0- 7.0 sec  3.12 MBytes  26.2 Mbits/sec
[ 3]  7.0- 8.0 sec  3.12 MBytes  26.2 Mbits/sec
[ 3]  8.0- 9.0 sec  3.12 MBytes  26.2 Mbits/sec
[ 3]  0.0-10.0 sec 31.3 MBytes  26.2 Mbits/sec
[ 3] Sent 22292 datagrams
[ 3] Server Report:
[ 3]  0.0-10.3 sec 10.8 MBytes  8.81 Mbits/sec  0.7
```



4G LTE Network Emulation & Throughput Testing Utilizing ARA

Objectives:

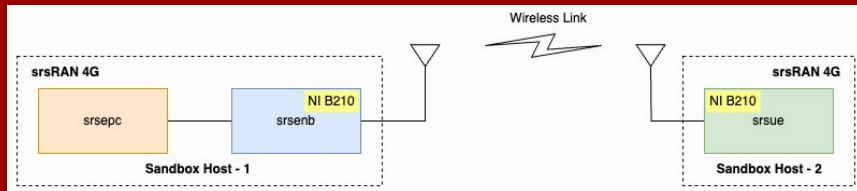
- Set up an emulated 4G Network
- Simulate data traffic between UE and EPC
- Conduct a throughput test to analyze performance

Learning Objectives:

- Gain knowledge of 4G Networks & interact with it
- Define metrics that can affect the throughput of 4G
- Understand the purpose of SDRs in a practical uses

Lab Questions:

- Example: “Define the options used by the UEContainer *iperf* command. Reference the man pages.



Constraints & Limitations

Constraints & Impacts

- ARA's newness resulted in frequent technical disruptions, challenges, and bugs.
- Halted progress, affected reliability, and led us astray on some lab experiments.

Solutions?

- Set up our own USRP!
 - Respected their compliance and bounds within ARA and created our own controlled environment

Presenter: Camron C.

The screenshot shows the ARA Public Launch Program interface. At the top, there are navigation tabs: Overview, Program, Venue & Travel, Registration & Travel Grant, and Event Sponsors. The main content area displays the program title "ARA Public Launch Program" for September 6-8, 2023, at Iowa State University. Below this, there is a section for "Selected talks & demos" with a link to "ARA Overview and Call for Participation [video]".

Below the main content, there are two error messages in a light red box:

- Error: An error occurred while creating this lease: ERROR: Not enough hosts available. Details
- Error: Unable to create lease.

At the bottom of the error messages, there is a "Host Calendar" icon and a "+ create Lease" button.

* ARA is still in **Phase 2** of the launch. Issues are expected and not abnormal.

Below the error messages, there is a search bar with the text "Click here for filters or full text search." and a table displaying 2 items:

Name	Image	Status
bdpope_cont_NUE	arawirelesshub/srsran/srsenb	Error
bdpope_cont_UE	arawirelesshub/srsran/srsenb	Error

The "Status" column in the table is circled in red.

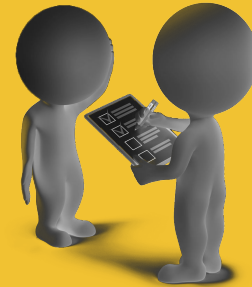
Testing Practices

Testing Practice

- We deployed our labs to volunteers and collected around a small classroom size portion.
- Collected quantitative data that could show trends and average feedback.
- Recorded qualitative feedback to help gauge and respond appropriately to weak areas.

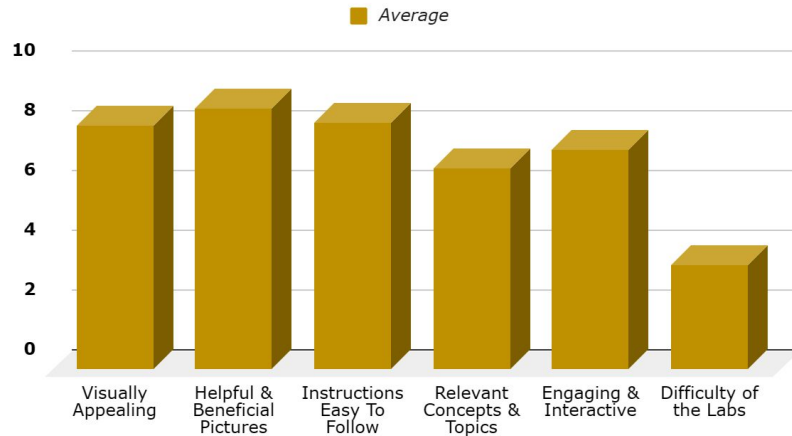
Volunteers: Engineering Students from ISU, Non-Engineering Students, and students from other universities.

Our team makes up the **alpha** testers, these volunteers are the **beta** testers!



Testing & Analysis

Quantitative Data on Lab Aspects



Average results from the survey responses **after** they had completed the labs.

Presenter: Leha D.

Survey Results

- The template/themes were uniformed throughout the lab reports, so the scores could remain universal across all labs

“From having no engineering experience, these labs were pretty simple and straightforward. No real issues with following the instructions and pictures”

“I felt like the labs were straight to the point and helpful. It was neat to see some of the scripts and tools in action”

“Pictures were good, but I feel like they were misplaced a bit”

Conclusion

The Challenge,

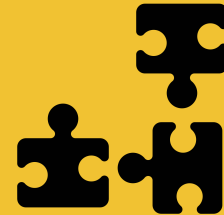
- Universities, Iowa State University included, were left empty handed on educational material when GENI decommissioned it's assets.

Our Solution,

- With ARA, we made it an educational stepping stone by engineering Wireless Networking and Cybersecurity Labs to fill that demand.

Our Work,

- Created six (6) advanced hands-on labs on the relevant topics within Wireless Networking & Cybersecurity
- Pioneered the research and application based work in an educational setting for ARA.



PAWR Program

Thank you!
Questions?

Camron Corcoran, Bryan Pope, Corey Lieu, Brendon Droege, Susanna Noble, Leha Dutta

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