SDMAY24-20 - Mohamed Selim

PAWR Program

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

Faculty Design Review

Camron Corcoran	Brendon Droege	Bryan Pope	Susanna Noble	Corey Lieu	Leha Dutta
Client Liaison	Informational Manager #1	Technical Lead	Informational Manager #2	Secretary	Project Manager

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Project Vision

The Challenge:

On August 1, 2023, GENI (Global Environment for Network Innovation), a virtual lab environment used for simulation of networking and systems for research and education, **shut down** its servers and began transitioning to FABRIC.

No current good replacement.

Iowa State has used GENI for networking classes in the past, such as CprE 431.

The Solution:

The goal of this project is to research and analyze a variety of platforms that educators can use to replace GENI within their curriculum.

Our efforts are to be a **resource** for educators and students to look at and determine the best alternative or solution to finding a network infrastructure to create and simulate networking and cybersecurity courses.

Future or current professors from around the country would read our paper and sample our test lab experiments, and determine if it would make a good fit for their class.

Presenter: Camron C.

Introduction to PAWR

What is PAWR?

The Platforms for Advanced Wireless Research (PAWR) program plays a pivotal role in:

- facilitating experimental exploration within the domain of wireless technologies
- encompassing novel wireless devices
- network infrastructures and system architectures

Goal:

- reshape the landscape of wireless communication, ensuring dominance in the field.

PAWR has received roughly around **40-50 million dollars in funding** since the creation and just received a recent 2.8 million dollar check from the NSF.

Presenter: Camron C.

ARA

A wireless living lab here at Iowa State University that uses TV white space that focuses on precision agriculture in both crop and livestock farms.

AERPAW

AERPAW is a 5G wireless testbed based in NC State and the surrounding city of Cary. Primarily focuses on drone communications using fixed and portable radio nodes.

COSMOS

COSMOS is centralized in New York that focuses on traffic related data with three types of nodes: small and portable, medium and tangible, and large and fixed.

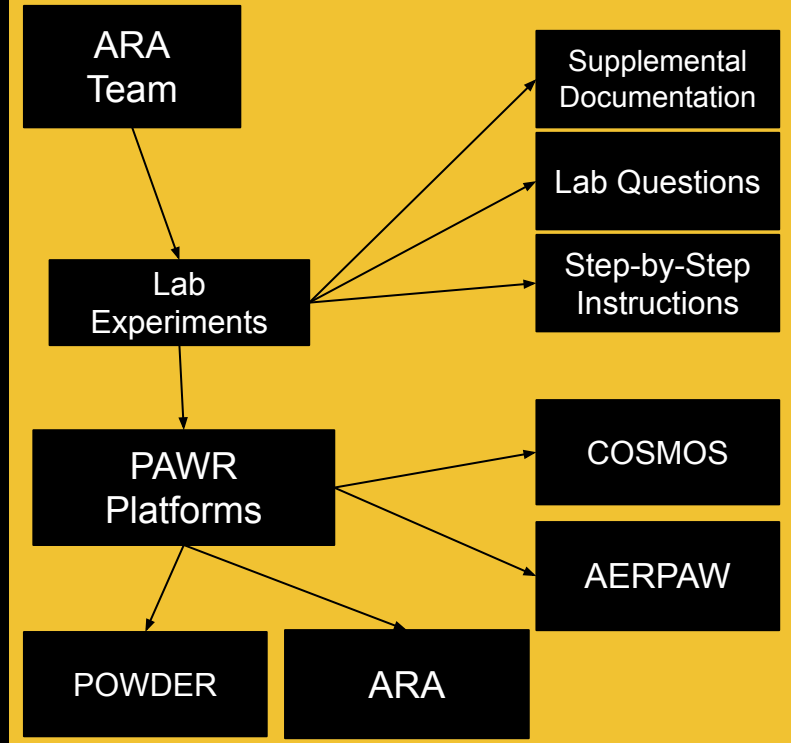
POWDER

POWDER is a city-scale wireless testbed in Salt Lake City, UT. Nodes, both mobile and static are in urban, suburban, and campus environments.

Conceptual / Visual

Our Design Element, with abstraction

- IEEE Standard Research Paper to compare and analyze the different infrastructures of PAWR (ARA, AERPAW, COSMOS, and POWDER).
- Targeted to professors and educators around the country to read, understand, and gain insight on these various platforms to see if it could benefit their class.
- Strive for longevity and a living team to update and facilitate documentation



Requirements

Functional Requirements:

Looking at the specific features and functionalities that the project/paper must have to fulfill its intended purpose:

- Building & Designing labs dedicated to Network and Security on various PAWR platforms like GENI
- Develop relevant lab documents to accompany various activities and programs (around 4-10 full scale labs).
- Create supplemental learning materials with supported research and documentation (meant to further expand on our created labs).
- Our labs will be **no cost**, **easily usable**, **scalable**, and **repeatable**.

Non-Functional Requirements:

Let's look at the quality and attributes that the project/paper must have that are not directly related to the specific behaviors or functionality:

- Our Research Paper should be written in clear and concise language (usability)
- Our Research Paper will follow IEEE Standards
  - Looks at ethical considerations
  - Looks at accuracy and quality of work
- Our Research Paper + Associated Test Labs are to be completed before May 2024
- Fairly compare the platforms to **not have a bias**

Presenter: Brendon D.

Conceptual Final Design

Conceptual Design and Product

- IEEE Research Paper
  - Introduce networking platforms and their use cases
  - Displaying functionality for each platform when running labs
  - cover the platforms in an educational situation
- Develop labs to assess individual capabilities of the platforms
  - Currently preparing to consult ARA team to pursue this goal

The end result of this goal is to have quantifiable results to compare between platforms and give us the ability to judge their best use cases.

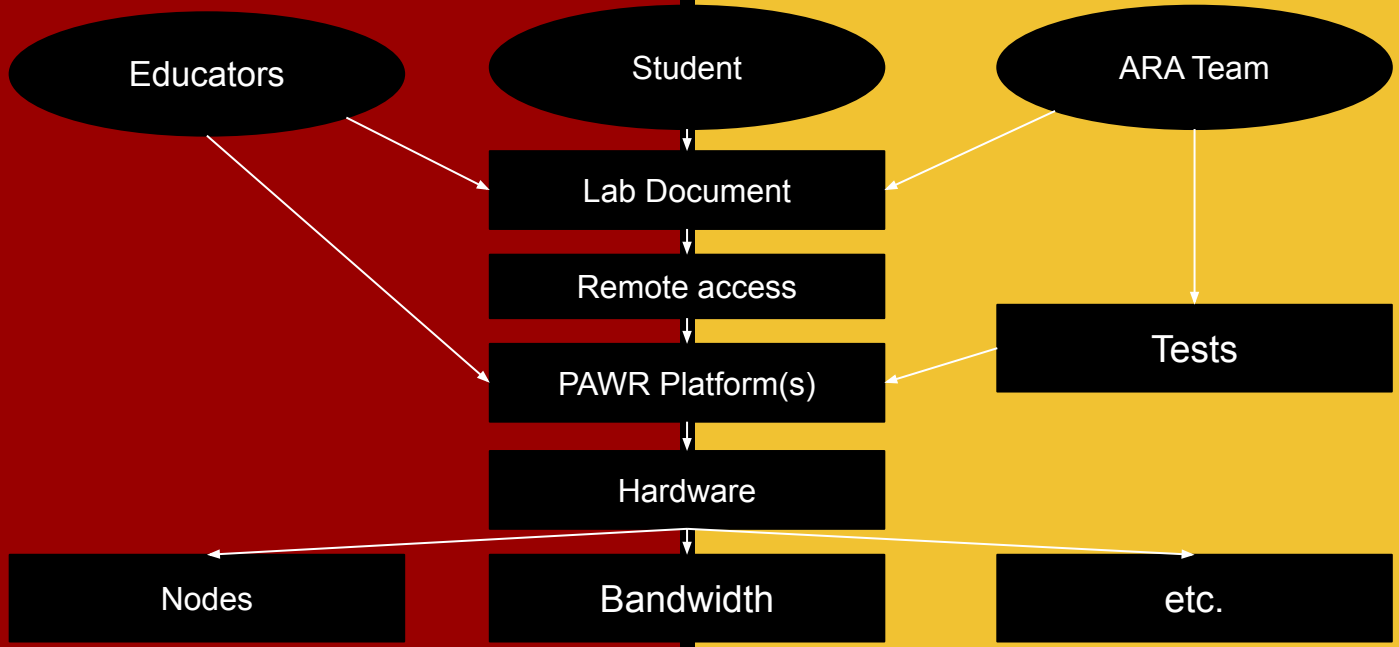
Lab Concepts and Vision

We aim to complete 4-8 custom introductory networking and cyber security related labs. The labs will house the following bits of information:

- Lab Document with Step-By-Step Instructions
- Lab Questions to engage the students
- Lab Justifications to spark thought and reasoning behind the lab decisions.

Presenter: Susanna N.

Conceptual Final Design



Conceptual Final Design

Potential Lab Experiments

Lab 01: This lab would ask the student to perform multiple general tests of the ARARAN using tools such as iperf, and ping. The student would then perform the same tests over the LAN environment of the lab.

Lab 02: Testing latency of packets at rest (normal state) and under various types of load conditions (lots of other traffic between the same machines/ lots of machines clogging up the same frequency range) and determine how different conditions affect packet delivery.

Lab 03: Tracking network statistics with various network configurations i.e. two UEs close to BS, one close one far, both very far. Track states from all three machines UE1, UE2, BS

Lab 04: Testing how different frequency configurations of MIMO, Aviat network, and USRP affect network fidelity.

Lab 05: simulate regular network traffic and collect general statistics, and show an understanding of what they mean

Presenter: Susanna N.

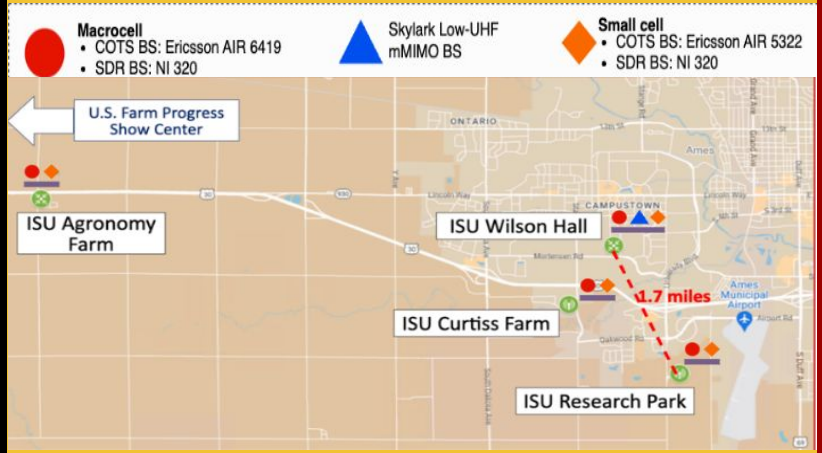
System Design

ARA Available Hardware

AraRAN - Ara Rural Area Network
- SDR and COTS Radio Equipment
- USRP (Universal Software Radio Peripheral)
  - N320
  - X410
  - B210
- Ericsson AIR 6419
- Ericsson AIR 5322

AraHaul - The Ara Backhaul Network
- Aviat Networks WTM 4800
- Free Space Optical Communication link (FSOC)
  - Undergoing installation and testing

AraRAN has two major components:
- SDR Base Stations - For experiments
  - Uses USRP N320 and USRP B210
  - Deployed at Wilson Hall, Curtiss Farm, Agronomy Farm, and Research Park
- Skylark Base Station - For data collection
  - Deployed at Wilson Hall



Presenter: Bryan P.

System Design

Hardware across other PAWR platforms

AERPAW
- Deploys fixed and portable nodes
- Fixed nodes
  - USRP N310, X310, B205 mini
  - Dell 5820 with Intel Xeon
  - Keysight RF sensors
  - Facebook Terragraph Radios
- Portable nodes
  - Two USRP B205minis
  - Intel NUC-10

Cosmos
- Small, Medium, and Large Nodes
- USRP 2974, N310 (Universal Software Radio Peripheral)
- Sub 6GHz Radio Freq. Sector
- Optical S320 320 fiber pairs Switch
- 320 wavelength filtered add/drop fiber pairs

Powder
- Variety of static and moving nodes
- SDR Radios
- 4G and 5G networking
- mMIMO

Presenter: Bryan P.

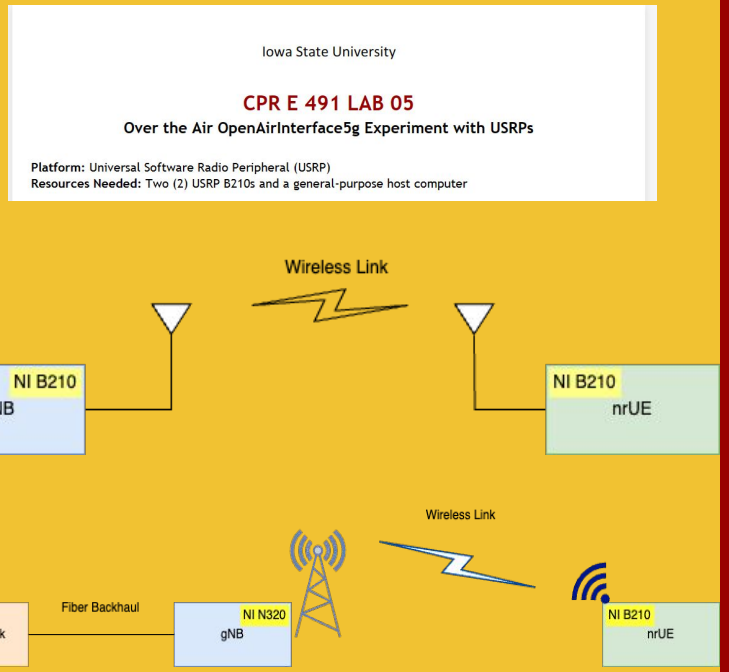
Prototype Implementation

In a sense,

For the prototype implementation our client asked us to convert experiments developed by graduated students for the ARA platform.

The goal of this prototype is to attest the feasibility of taking experiments that cover mid to low level topics and formatting them to suit a class lab curriculum.

This helps us explore where the **boundaries of the labs** our team designs and implements should **fall in complexity** and skill that should be asked of the lab user.



Presenter: Brendon D.

Design Complexity

Challenges we Face

Initial access for us and educators to the PAWR Platforms may be a time consuming and restricting process.

We have no physical access to the hardware or any physical components.

Overall capabilities of the infrastructures causing potential limits and bounds.

Converting complex and technical instructions to student-friendly verbiage.

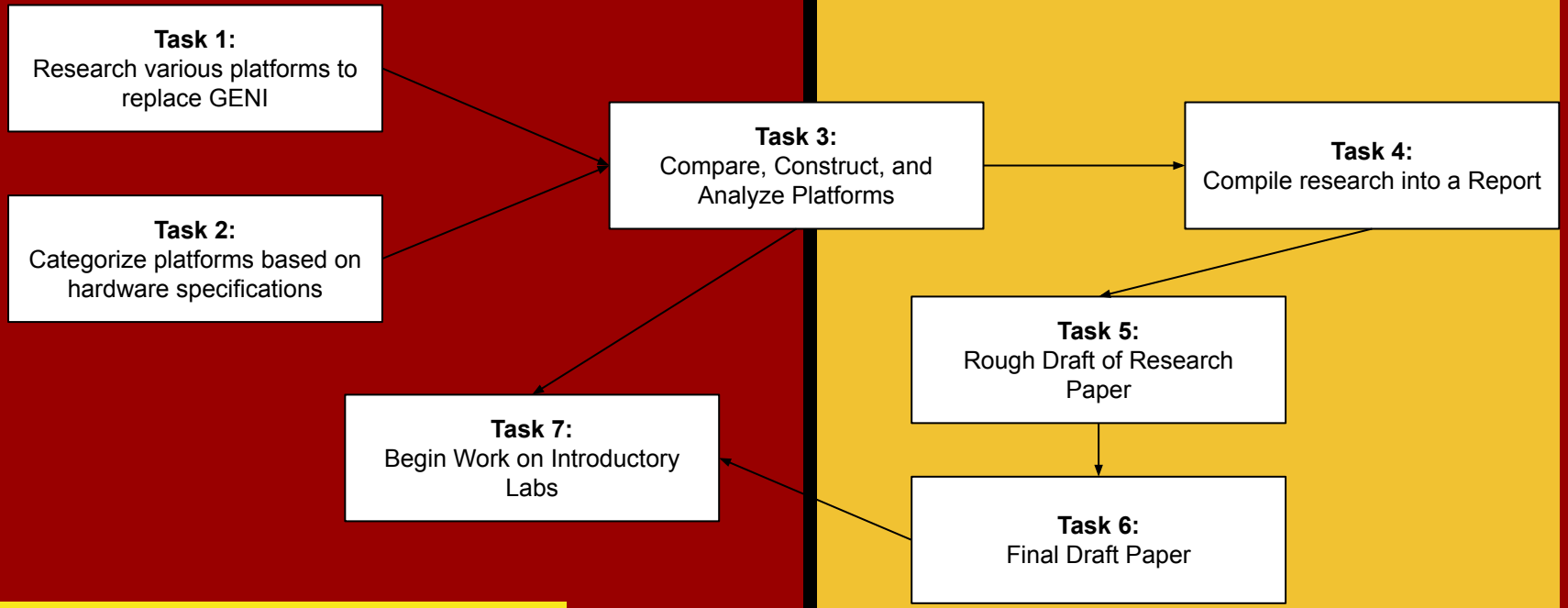
How we plan to overcome

While the hardware applications and configurations being out of our control and realm of this project, we are working diligently to use the resources provided to create introductory labs and simulations to fully test the capabilities of each PAWR infrastructure.

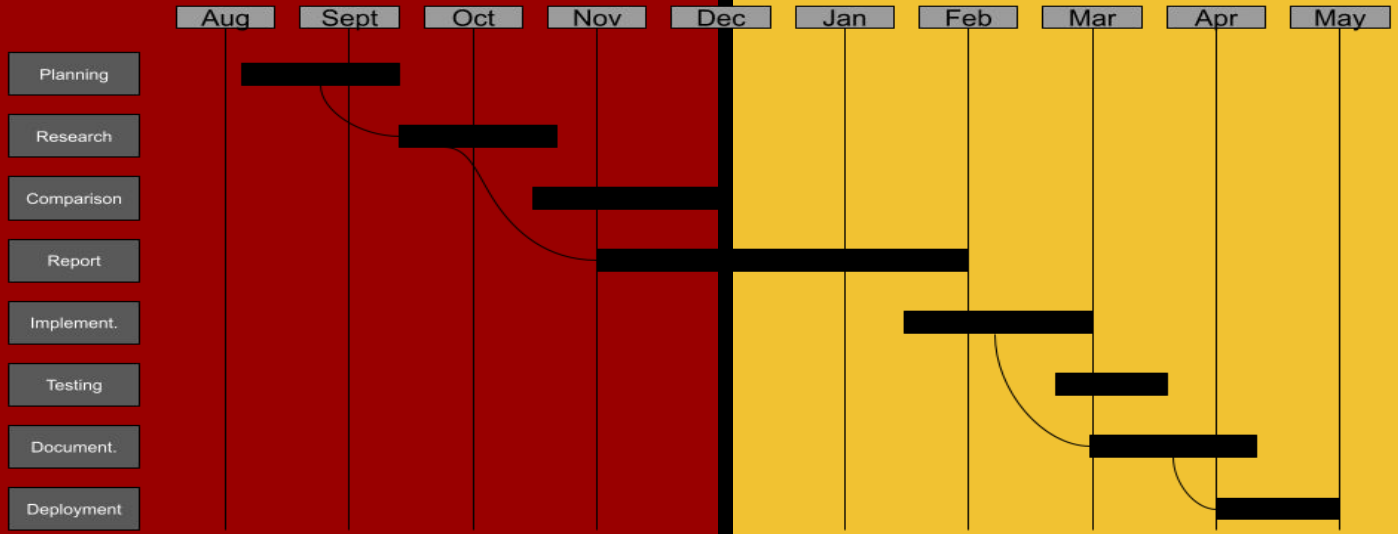
Our design iterations have changed to accommodate these restrictions by simplifying our approach and capabilities.

Presenter: Leha D.

Project Plan



Estimated Schedule



Presenter: Susanna N.

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Milestones / Progress

Milestones

1) Fully research 10 various platforms to allow the team member to have 80% knowledge of public website and infrastructure.
2) Categorize the platforms and aim for a scalability of 75% rating
3) Categorize the platforms and aim for a usability of 60% rating
4) Categorize the platforms and aim for a capability rating of 80%
5) Select the best platform(s) that score the highest in our rating criteria based on our arbitrary metrics
6) Create lab assignments that have a rating of 60% or higher for usability

Measuring Success & Progress

Due to our project being heavily reliant on research and data collection of various platforms and architectures, our metric of progress is rather abstract and arbitrary.

Some metrics with our goals are as follows:

- The Scale of the Network
- Coverage and size it's capable of supporting
- The Ease of Use
- How easy it is to use for an introductory lab
- Capabilities and Abilities
- How advanced and how many tools are in our arsenal

Presenter: Camron C.

Test Plan

Unit Tests

The unit tests of our project are the individual labs we are creating.

We will be developing and testing any of the network protocols and security algorithms on an individual platform.

Integration Testing:

Deploying and observing the behavior of a lab(s) from an initial sandbox environment to the different PAWR platforms will constitute our integration testing.

System Testing:

Testing a lab as a whole in an individual PAWR platform as an end-user and simulating a student working through the lab, considering different avenues of error or implementation, **before** integrating it into different platforms, then **after** integration is complete.

Regression Testing:

We'll abide by their policies and guidelines to ensure our labs do not cause harm or conflict with their current system. We must also ensure every component is working correctly when we port labs over to different platforms during integration testing.

Presenter: Corey L.

Test Plan (Cont.)

Acceptance Testing

Our acceptance testing won't be focused on acceptability, but rather **usability** from students and professors as well as applicality.

We'll look at students' success and their ease of access with our introductory labs on different PAWR Platforms.

Results

The results will take two forms, one being the data analytic return from each individual PAWR Platform (scalability, modifiability, performance, capability), and the other in conjunction with the acceptance testing: usability.

Limitations

Because we are using third-party platforms to develop, test, and deploy labs, we won't have access or the responsibility to interact or configure the hardware for each platform as that is out of the scope of our mission.

Any limitations of the testing environments themselves is also out of our control.

Presenter: Corey L.

Conclusion

What we've done this semester:

We have focused primarily on researching and gathering information about the individual platforms making up the PAWR project, and are currently in the process of completing and finalizing the first draft of our research paper, according to IEEE formatting standards.

In addition to this, we have also started to gather example labs from some of the PAWR platforms in order to facilitate development of our own labs and experiments, geared towards students and education. Two full lab documents and experiments have been completed and awaiting deployment.

What we'll do next semester:

Once we obtain formal access to each of the PAWR platforms, we will begin development and experimentation of our own labs. Our goal is to be able to development at least one universal lab that operates seamlessly across all four PAWR platforms (ARA, AERPAW, COSMOS, POWDER), as well as additional labs for each individual platform.

With our testing results, we will also begin revising and writing a final draft of our paper that includes these findings as well as platform comparisons to be published along with finished implementations of our labs.

Presenter: Bryan P.

Contributions

Name	Overall Summary of Duties Performed throughout the Semester	Role
Brendon Droege	Developed the deliverables for the project. Contributed to the Research Paper and developed one of the unit test labs. Kept the website and all information up-to-date and accurate.	Informational Manager
Susanna Noble	Contributed to the Research Paper with the platforms EduceLab and Chameleon and helped with the deliverables for the project.	Informational Manager
Bryan Pope	Researched POWDER and CloudLab and contributed greatly to the Research Project	Technical Lead
Camron Corcoran	Spearheaded research and contribution on the Research Paper and acted as a mediator between the group and the client.	Client Liaisons
Leha Dutta	Completed the Weekly Reports and kept the project flowing and inline with the schedule. Research and contributed to the overall Research Paper.	Project Manager
Corey Leiu	Contributed to the research of ARA and AERPAW and wrote segments of the Research Paper. Acted as our secretary with keeping track of meeting notes.	Project Secretary

Presenter: Camron C.

PAWR Program

Thank you!
Questions?

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

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