VCU College of Engineering

CS 25-341 Cyber Intrusion Detection and Visualization
Project Proposal

Prepared for

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Executive Summary

Problem Statement - Section A

This project plans to provide a solution identifying a Radio Frequency Identification (RFID) attack. This can be very difficult. RFID attacks leave almost no trace and have no way to identify that one was carried out until damage has been done. We wish to change this by developing a way to visually identify an attack.

Engineering Design Requirements - Section B

The requirements for this assignment are very loose which allows us to have a lot of freedom in the design of our visualizer but there are a few points that need to be made. This project needs to focus on anomaly detection and must be a visualizer. This design should stay below $1,000 in cost however if needed more can be acquired.

Scope of Work - Section C

The scope of our project is to develop visualization software that can detect and alert a user to anomalies found using tools like Raspberry Pi and Proxmox 3 This will all be done without our project's timeline using iterative development. This project will not cover attack mitigation past the detection of an anomaly on an RFID system.

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Section A. Problem Statement

This project plans to provide a solution to identifying a Radio Frequency Identification (RFID) attack. RFID attacks can be very difficult to detect since attacks usually leave no trace. We want to change this by developing a way that visually alerts victims to an attack on their RFID system and helps them easily reach a solution to protect their systems. This project also plans on testing how the visualization benefits an operator's ability to detect and react to an attack in real-time.

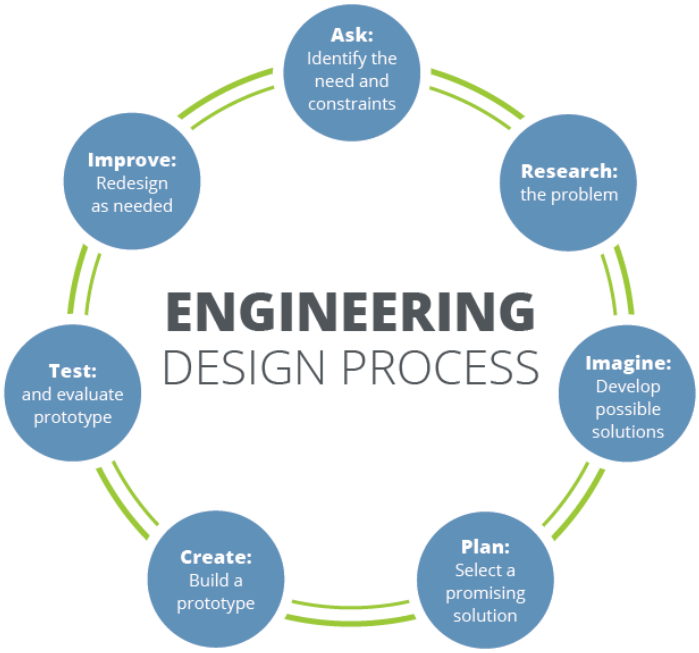


Figure 1. The iterative nature of the engineering design process [2].

Section B. Engineering Design Requirements

The requirements for this assignment are very loose which allows us to have a lot of freedom in the design of our visualizer but there are a few points that need to be made. This project needs to focus on anomaly detection and must be a visualizer that is easy to read so that almost anyone can understand the situation. This design should stay below $1,000 in cost however if needed more can be acquired. For testing, we need to make a testbed and develop attacks and attack our testbed to see if our visualizer works. We have a few options for which types of attacks we could carry out varying from car keyfobs to RFID badges.

B.1 Project Goals (i.e. Client Needs)

The goal of this project is to enhance cyber attack detection and response, particularly for RFID systems and networks, by developing an intuitive way to visualize and alert users of a potential threat. Specifically, the aim is:

- To create a user-friendly interface to represent network anomalies.
- To minimize the time between an onset attack and its detection.
- To better prepare systems for cyber-physical attacks and improve situational awareness for its administrators for a real-time response.

B.2 Design Objectives

The design will be able to identify anomalies, categorize them into three distinct threat levels, and suggest a course of action to respond to them.

- The design will include a user-friendly interface that is easy to understand and interact with with minimal training.
- The design will create a comprehensive report of network activity every 24 hours.
- The design will be able to handle high amounts of traffic data without degradation of performance.
- The test bed for the design must reflect a real-world environment for attacks.

B.3 Design Specifications and Constraints

- All aspects of the project must fit within the $1000 budget.
- The system must operate on a Raspberry Pi 4 with at least 4GB RAM, ensuring real-time processing capability within the hardware constraints.

- The design will provide a real-time visual representation of system activity, updating once every second.
- The interface must be easily understood by users who have no prior cybersecurity experience, within 10 minutes of interaction.
- The system must generate reports and log detected anomalies within 24 hours, and using no more than 500MB of storage space per session.
- The system must be able to handle at least three common RFID protocols.
- The simulated training environment must include at least 5 pre-programmed attacks without disrupting system performance.
- All data processed and stored by the system must be encrypted using AES-256 encryption
- The design must easily integrate into an existing network within 24 hours.

B.4 Codes and Standards

1. **NIST SP 800-53** - Security and Privacy Controls of Information Systems:
    - Offers guidelines for implementing security controls and safeguards in IT systems, critical for the Project's development on intrusion detection.
    - Provides a framework to ensure that the RFID system aligns with best practices in securing data against unauthorized access.
2. **FCC Part 15 -** Radio Frequency Devices:
    - This relates to the Proxmark3's usage as it involves radio frequency (RF) communication with RFID systems.
    - Ensures that the RF signals used for testing and analysis are within acceptable limits and do not interfere with other electronic devices or systems.
3. **ISO/IEC 27001** - Information Security Management Standards:
    - Relevant for ensuring the proper security management of data during RFID interactions and transmissions.
    - Helps define the requirements to secure data handling, encryption protocols, and risk management during the analysis and detention processes.
4. **IEEE 802.11 Standards** - Wireless LAN Standard:
    - Governs the wireless communication aspects of the project, particularly for devices like the Raspberry Pi that may connect wirelessly to during the testing phases.
    - Ensures interoperability and secure communication channels in scenarios where the project relies on wireless data transmission.
5. **OSHA 1910.147 -** Control of Hazardous Energy (Lockout / Tagout):
    - While primarily for physical safety, it is essential when working with hardware components like the Raspberry Pi and Proxmark3 to ensure safe handling during the testing and implementation phases.

Section C. Scope of Work

The scope of this project is to develop a robust system for detecting and visualizing cyber intrusions, specifically focusing on vulnerabilities and attacks targeting RFID systems. The primary objectives include analyzing RFID communication protocols, detecting unauthorized access or attacks using tools like Raspberry Pi and Proxmark3, are visualizing potential security breaches in a user-friendly interface.

- **Project Timeline**: The project will be conducted within a certain time frame, with milestones set for the completion of system design, hardware integration, intrusion detection programming, testing, and final report generation.
- **Methodology**: The team will use the part of Agile methodology for the approach, allowing for iteration testing and improvement based on the reviews and feedback from our representatives.
- **Responsibilities:** The team will be responsible for developing the intrusion detection system, testing with various RFID tags and frequencies, and creating a visualization dashboard. Tasks such as the setup of test environments, coding of detection algorithms and presentation materials will be managed by the team.
- **Exclusions:** The project will not cover comprehensive attack mitigation beyond detection nor focus on physical security aspects of RFID systems.
- **Verification and Approval:** Our weekly meetings and progress reports will be used for continuous feedback and validation of the project's progress.

C.1 Deliverables

- **Technical Deliverables:**
    - Implementation of RFID-based based intrusion detection system using Raspberry Pi and Proxmark3
    - Source code for detection algorithms and scripts for RFID analysis.
    - Functional dashboard for visualizing detected intrusions and potential attack vectors
    - Documentation covering the setup, operation, and testing procedures of the system.
    - Detailed reports on testing outcomes and analysis of RFID vulnerabilities.
- **Academic Deliverables:**
    - Team contract and project proposal submission.
    - Preliminary design report and project timeline.

    - Fall presentation and poster detailing project progress.
    - Final Design Report and Project timeline.
    - Final design report summarizing the entire project, including methodologies, results, and future recommendations.
    - Capstone EXPO poster and final presentation to show the project results.
- **Risk Mitigation:**
    - Access to the campus is required for hardware testing and final presentation setups.
    - Most coding and report writing can be completed remotely, utilizing shared drives and version control platforms like GitHub.
    - Hardware components have already been acquired to mitigate potential supply chain delays but any replacements or additional parts will be ordered well in advance.

C.2 Milestones

Project Proposal Tasks

1. Work on the proposal (09/26 - 10/11)
   This period involves the development of the overall project proposal. During this phase, we will be drafting the initial structure, and outlining project goals, design requirements, milestones, and things we'll need to work on the project throughout the semester.
2. Break down proposal (09/26)
   A one-day task where the team divvies up the project proposal into smaller, more manageable components for each team member to complete.
3. Finalize project idea (10/02)
   This milestone marks the point at which the core project idea was finalized. All key decisions and directions for the project should have been determined by this date.
4. Present idea to our advisor (10/03)
   The project idea was formally presented to our advisor in our weekly meeting for feedback and approval. This step ensures alignment with academic requirements and expectations, as well as ensuring everyone is on the same page for where the project is headed.
5. Review proposal (10/10)
   A final review of the project proposal is planned before submission or further progress. It's a chance for our advisor and company sponsor to refine, revise, and ensure everything is in order.

Fall Design Poster Tasks

1. Work on poster (10/12 - 11/15)
   This phase involves creating the design poster, which will visually communicate our project idea, design choices, and intended outcomes.
2. Break down poster (10/17)
   The poster content will be divided into key components to ensure a logical and organized layout, making the complex project information easily digestible. We will also be able to create a more detailed timeline and set of milestones for this section of the project.
3. Review poster (11/14)
   A review day is dedicated to checking the poster for accuracy, design quality, and overall clarity with the advisor before it is finalized.

Preliminary Design Report Tasks

1. Work on report (11/16 - 12/09)
   The preliminary design report will outline our project's theoretical framework, design decisions, and early results or projections. This phase is about drafting the document.
2. Break down report (11/21)
   A focused task to divide the report into structured sections, ensuring the content flows logically and covers all necessary details. We will also be able to create a more detailed timeline and set of milestones for this section of the project.
3. Review report (12/05)
   This milestone is for reviewing the full report draft, refining sections, addressing feedback, and ensuring it meets all the required criteria before submission.

Other Tasks

1. Order needed supplies (10/03 - 10/17)
   During this time, we'll be procuring any essential hardware, software, and other possible items for the project's technical setup.
2. Set up Raspberry Pi servers (After 10/17 for 1 week)
   Once supplies are ordered, this milestone involves setting up the Raspberry Pi servers, a key component of the project's infrastructure.
3. Set up Zeek on the server (After Raspberry Pi setup for 1 week)
   After the server is configured, Zeek (the Network Security Monitor) will be installed and set up for network monitoring purposes.
4. Run attacks on the server (After Zeek setup for 2 weeks)
   Following the Zeek setup, cyber-attacks will be simulated on the server to test the system's detection capabilities and gather data for analysis.
5. Design visual of attacks (After attacks for 2 weeks)
   Once all attacks have been run and detected, we'll create a visual representation of the

cyber-attacks to effectively communicate what our project entailed to those not well versed in cyber security.

C.3 Resources

3 Raspberry Pi Boards
The Raspberry Pi boards will act as small, versatile servers to simulate a network environment where we'll install Zeek and run cyber-attacks. These boards are ideal for lightweight network setups and can handle the necessary traffic monitoring and attack detection tasks. These will serve as the backbone of our project's cyber network infrastructure. We will use one Raspberry Pi to host the RFID server and the other run the attacks against the server.

2 Proxmark 3s
The Proxmark 3 devices will emulate and interact with RFID tags and NFC systems. These tools are essential for testing the security of physical access control systems and conducting various RFID-based attacks. Using the Proxmark 3s, we can simulate cloning, intercepting, and modifying RFID communications. This will allow us to evaluate the resilience of our system against unauthorized access attempts. The Proxmark 3s will also provide a hands-on approach to exploring how different RFID protocols can be exploited, giving us valuable insight into potential vulnerabilities and defense mechanisms.

2 Flipper Zeros
The Flipper Zeros will serve as versatile, portable hacking devices, capable of interacting with RFID systems, IoT devices, and wireless protocols like NFC and Wi-Fi. These multifunctional gadgets will allow us to simulate a variety of physical and wireless-based cyber-attacks in a real-world context. Their ability to interface with hardware like RFID tags, access control systems, and various IoT devices makes them crucial for exploring both the offensive and defensive aspects of cybersecurity. The Flipper Zeros will be used to test how well our network and security infrastructure hold up against different forms of wireless attacks and will help us assess how such attacks can be detected and mitigated by Zeek and our visualization system.

Breadboard and Wires
The breadboard and wires will connect the RFID scanner or other hardware-based security features to the Raspberry Pi server. This hardware is essential for prototyping any additional physical components (e.g., sensors or scanners) and integrating them into the network. It helps with experimenting with IoT security aspects, complementing the cyber-attack simulations in the network.

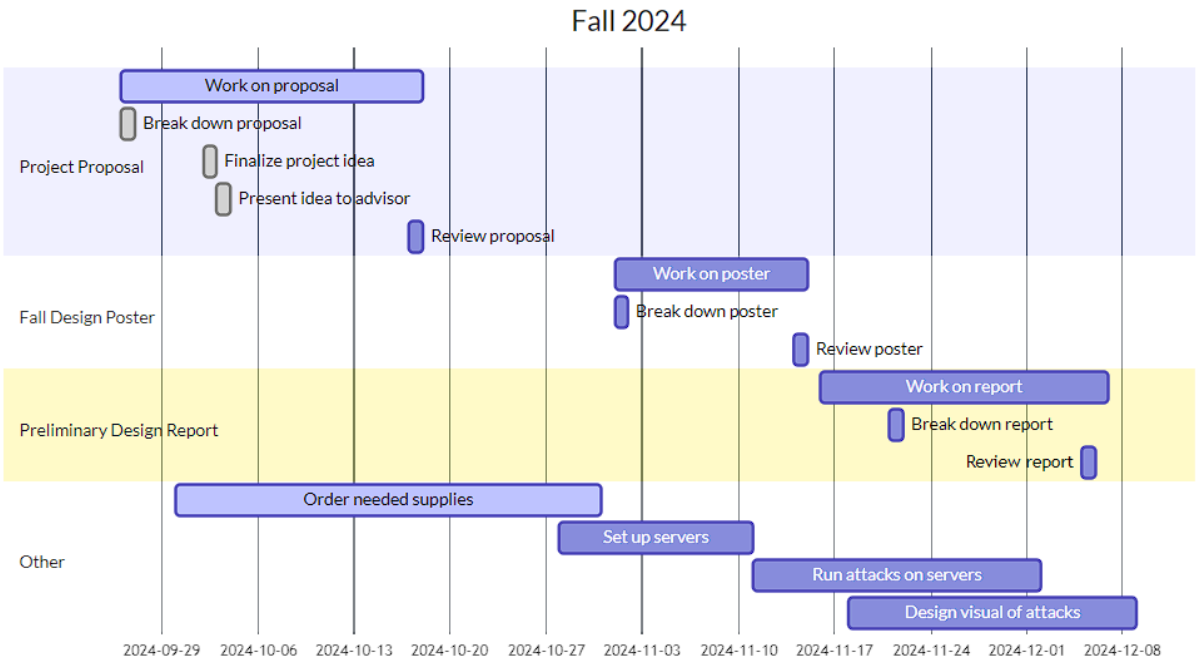
Cyber-attack Simulation Tools (e.g., Metasploit, Scapy)
These tools will be used to simulate cyber-attacks on our Raspberry Pi network, allowing us to test Zeek's detection capabilities and gather data for our visualization system. Simulating attacks is crucial for validating our project. Tools like Metasploit and Scapy provide a realistic environment to test various attack types and monitor how Zeek responds.

Zeek
Zeek is an open-source network monitoring tool that will be installed on one of our Raspberry Pi servers. It will analyze traffic, detect network anomalies, and log cyber-attacks or suspicious behavior. Zeek is crucial to our project's goal of detecting and visualizing cyber-attacks. It will generate the network data that forms the foundation of our project's attack detection and situational awareness system.

Linux Distribution to Run on Servers
A lightweight Linux distribution, such as Raspbian or Ubuntu, will run on our Raspberry Pi boards to serve as the operating system for setting up the network environment and Zeek. Linux is ideal for running servers due to its flexibility, security, and low resource consumption. It provides a stable platform for hosting Zeek and other necessary network services, allowing us to simulate realistic cyber network conditions.

Database
The database will store the logs and traffic data collected by Zeek, allowing us to manage and query large datasets of network activity and attack information. This will make it easier to visualize patterns and anomalies. Having a robust database system (e.g., MySQL or PostgreSQL) is essential for efficiently storing and analyzing network traffic data. This is especially important for building the visualization component of our project, as it allows for complex queries and meaningful insights to be drawn from the data.

Appendix 1: Project Timeline



Appendix 2: Team Contract (i.e. Team Organization)

Step 1: Get to Know One Another. Gather Basic Information.

Task: This initial time together is important to form a strong team dynamic and get to know each other more as people outside of class time. Consider ways to develop positive working relationships with others, while remaining open and personal. Learn each other's strengths and discuss good/bad team experiences. This is also a good opportunity to start to better understand each other's communication and working styles.

Team Member Name	***Strengths each member brings to the group***	***Other Info***	***Contact Info***
Jaspreet Singh	Cyber Security Experience and a handful of knowledge	I enjoy being a part of the Cyber security team.	Singhj21@vcu.edu
Christopher Malatesta	Jave experience and a little bit of C	Hoping to learn about CyberSec as we progress through the project	malatestacn@vcu.edu
Keith Tran	Cloud Experience	Not a cyber focus, software, but can learn quick	trand15@vcu.edu
Calvin Hurlbert	Java, C, Operating Systems, and Algorithms	I don't have any cybersecurity experience but I'm very excited to learn.	hurlbertc@vcu.edu

Other Stakeholders	***Notes***	***Contact Info***
Milos Manic	Faculty Advisor	mmanic@vcu.edu
Bjorn Vaagensmth	Project Sponsor	bjorn.vaagensmith@inl.gov

Step 2: Team Culture. Clarify the Group's Purpose and Culture Goals.

Task: Discuss how each team member wants to be treated to encourage them to make valuable contributions to the group and how each team member would like to feel recognized for their efforts. Discuss how the team will foster an environment where each team member feels they are accountable for their actions and the way they contribute to the project. These are your Culture Goals (left column). How do the students demonstrate these cultural goals? These are your Actions (middle column). Finally, how do students deviate from the team's cultural goals? What are ways that other team members can notice when that culture goal is no longer being honored in team dynamics? These are your Warning Signs (right column).

Resources: More information and an example of Team Culture can be found on the Biodesign Student Guide "Intentional Teamwork" page (webpage | PDF)

Culture Goals	***Actions***	***Warning Signs***
Being on time for every meeting	- Set up meetings in Discord - Send a reminder Discord message in day before the meeting.	- Student misses first meeting, warning is granted. - Student misses meetings afterward – the issue is brought up with the faculty advisor
Informing the group of any delays in completing assignments	- Stay up to date with each other's project responsibilities. - Set reasonable deadlines and note when an extension is needed	- Student shows up for weekly meeting with no considerable work done

Step 3: Time Commitments, Meeting Structure, and Communication

Task: Discuss the anticipated time commitments for the group project. Consider the following questions (don't answer these questions in the box below):

- What are reasonable time commitments for everyone to invest in this project?
- What other activities and commitments do group members have in their lives?
- How will we communicate with each other?
- When will we meet as a team? Where will we meet? How Often?
- Who will run the meetings? Will there be an assigned team leader or scribe? Does that position rotate or will the same person take on that role for the duration of the project?

Required: How often you will meet with your faculty advisor, where you will meet, and how the meetings will be conducted. Who arranges these meetings?
See examples below.

Meeting Participants	***Frequency*** ***Dates and Times / Locations***	***Meeting Goals*** ***Responsible Party***
Students Only	Every Thursday at 06:00 PM on Discord	Update the group on day-to-day challenges and accomplishments. Completing anything that needs to be done as a group.
Students Only	As needed	Actively work on projects. Finalizing deliverables if needed.
Students + Faculty advisor	Every Thursday at 10:00 AM through Zoom	Update the faculty advisor and get answers to our questions.
Project Sponsor	Every Thursday at 10:00 AM through Zoom	Update the project sponsor and make sure we are on the right track

Step 4: Determine Individual Roles and Responsibilities

Task: As part of the Capstone Team experience, each member will take on a leadership role, ***in addition to*** contributing to the overall weekly action items for the project. Some common leadership roles for Capstone projects are listed below. Other roles may be assigned with the approval of your faculty advisor as deemed fit for the project. For the entirety of the project, you should communicate progress to your advisor specifically about your role.

- **Before meeting with your team**, take some time to ask yourself: what is my "natural" role in this group (strengths)? How can I use this experience to help me grow and develop more?
- **As a group,** discuss the various tasks needed for the project and role preferences. Then assign roles in the table on the next page. Try to create a team dynamic that is fair and equitable, while promoting the strengths of each member.

Communication Leaders

Suggested: Assign a team member to be the primary contact for the client/sponsor. This person will schedule meetings, send updates, and ensure deliverables are met.

Suggested: Assign a team member to be the primary contact for the faculty advisor. This person will schedule meetings, send updates, and ensure deliverables are met.

Common Leadership Roles for Capstone

1. **Project Manager:** Manages all tasks; develops an overall schedule for the project; writes agendas and runs meetings; reviews and monitors individual action items; creates an environment where team members are respected, take risks, and feel safe expressing their ideas.
   Required: On Edusourced, under the Team tab, make sure that this student is assigned the Project Manager role. This is required so that Capstone program staff can easily identify a single contact person, especially for items like Purchasing and Receiving project supplies.
2. **Logistics Manager:** coordinates all internal and external interactions; leads in establishing contact within and outside of the organization, following up on communication of commitments, obtaining information for the team; documents meeting minutes; manages facility and resource usage.

3. **Financial Manager:** researches/benchmarks technical purchases and acquisitions; conducts pricing analysis and budget justifications on proposed purchases; carries out team purchase requests; monitors team budget.
4. **Systems Engineer:** Analyzes client initial design specification and leads establishment of product specifications; monitors, coordinates, and manages the integration of sub-systems in the prototype; develops and recommends system architecture and manages product interfaces.
5. **Test Engineer:** oversees experimental design, test plan, procedures, and data analysis; acquires data acquisition equipment and any necessary software; establishes test protocols and schedules; oversees statistical analysis of results; leads presentation of experimental findings and resulting recommendations.
6. **Manufacturing Engineer:** coordinates all fabrication required to meet final prototype requirements; oversees that all engineering drawings meet the requirements of machine shop or vendor; reviews designs to ensure design for manufacturing; determines realistic timing for fabrication and quality; develops schedule for all manufacturing.

Team Member	***Role(s)***	***Responsibilities***
Chris Malatesta	Project Manager	Manages the project as a whole and keeps a schedule for the project. Runs meetings and ensures everybody completes their tasks.
Keith Tran	Financial Advisor	In charge of budgeting for the group and keeping track of purchases. Carries out purchases on behalf of the team after discussion with the group.
Calvin Hurlbert	Logistics Manager	Tasked with staying up to date with all communication with the faculty advisor and the project sponsor. Keeps the team updated with all communication and reviews during team meetings.
Jaspreet Singh	Systems Engineer	Summarizes the client's design specification and breaks down tasks for everyone to complete. Make sure the GitHub is up to date and all branches are merged properly.

Step 5: Agree to the above team contract

Team Member:	*Signature: Christopher Malatesta*
Team Member:	*Signature: Jaspreet Singh*
Team Member:	*Signature: Keith Tran*
Team Member:	*Signature: Calvin Hurlbert*

References

Provide a numbered list of all references in order of appearance using APA citation format. The reference page should begin on a new page as shown here.

[1] VCU Writing Center. (2021, September 8). *APA Citation: A guide to formatting in APA style.* Retrieved September 2, 2024. https://writing.vcu.edu/student-resources/apa-citations/

[2] Teach Engineering. *Engineering Design Process*. TeachEngineering.org. Retreived September 2, 2024. https://www.teachengineering.org/populartopics/designprocess