



## **Rensselaer Cybersecurity Collaboratory (RCC)**

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## Section 1: Executive Summary

The Rensselaer Cybersecurity Collaboratory (RCC) is a group comprised of students at Rensselaer Polytechnic Institute (RPI). The students are presented with Capture the Flag (CTF) write-ups, a digital problem consisting of names, descriptions, videos, images, and instructions. From there, the students are meant to compete with one another by attempting to solve the problem as fast as possible. Honing and practicing their coding skills, the RCC provides developers with the opportunity to practice and learn new skills.

The RCC faced challenges without an online presence and a dedicated CTF system. The absence of limited outreach, hindered donor connections and impeded growth. It also impacted the immersive learning experience for CTF challenges, hindering knowledge sharing and collaborative learning. The lack of a front-end interface further affected user engagement. These shortcomings underscore the importance of a digital presence and a structured CTF system for achieving organizational goals. With that, a group of Rensselaer Polytechnic Institute students worked with Dr. Brian Callahan, the current director of the RCC and the project team's client, to discuss the requirements for the successful development of these sites.

A group of students, Ben Manicke, Peter Krumpholz, Meena Mall, and Raphael Chung approached their client, Dr. Brian Callahan, and offered their skills and abilities upon hearing he had some concerns for the RCC and its outreach. After agreeing to work together on this project, both the client and team would meet every Tuesday to discuss progress reports, ensure work was meeting client standards, and ask any questions that may have arisen. Once permitted to begin working, Dr. Brian Callahan addressed three issues with the RCC, each of which was expected to be completed in sequential order. Firstly, the RCC had no digital presence. They had no public-facing website which hindered their outreach, ability to attract potential donors, and showcase their successes with others. Secondly, the RCC needed a database management system for their CTF write-ups. That way, students can upload, edit, and retrieve CTF write-ups for practice from this system. Lastly, the RCC needed a comprehensive platform that would allow users to engage with Capture the Flag challenges efficiently. This platform would provide users with a curated list of diverse CTF challenges. Users could select a specific challenge from the list, solve it within the site's interface, and seamlessly transition to other CTF challenges.

The team's list of solutions first began by tackling the public-facing website. The team decided to work with the MERN stack due to each of the member's great amount of experience with it and they determined it would be the most effective to complete their goals. The MERN stack is a tech stack made up of MongoDB, Express.js, React.js, and Node. The team wanted to ensure that while looking appealing, the site is functional and meets all accessibility standards. The team performed several tests using screen readers and Wave, a tool used to accessibility test websites. Once finalizing this solution, the team quickly moved on to the next problem. The team decided to continue using the MERN stack when building the database system. This system has input features accessible by Dr. Brian Callahan and students that allow for CTF uploading, editing, and

retrieval. That way there is a place where students can upload and retrieve these write-ups for practice. Finally, the team implemented a site that allows students to access a wide range of CTF challenges. Within the site itself, students can solve problems using the site's built-in digital compiler. High-level challenges included balancing aesthetics with functionality, ensuring accessibility, and designing a versatile database system. Advantages encompass streamlined collaboration, efficient challenge management, and enhanced user engagement.

Knowing the financial statistics behind such a list of requirements is extremely important. Such statistics would allow the team to adapt and change their course of action based on the financial return to ensure success. Getting this data was achieved by performing a cost-benefit analysis (CBA). The analysis determined a Net Present Value (NPV) of \$1,795 using a 10% interest rate and an Internal Rate of Return (IRR) of 42%. These figures underscore the project's economic viability, reflecting a positive financial outlook. The NPV signifies the projected profitability, indicating a positive return on investment. Simultaneously, the IRR of 42% further reinforces the project's worthiness, indicating a robust rate of return. Retrieving these numbers allowed the team to see that this product would be viable as it would be profitable and worth their time, providing a solid foundation for decision-making throughout the project development process.

Throughout the project, Ganttter was consistently used for project planning. The team began production on September 5 and finished development on November 28. Over this period, the project plan was broken into 6 sections, planning, analysis, design, development, testing, and wrap-up. The team understood that out of the 3 variables, time, financials, and scope, the team only had control over scope. The team was determined to align with the original scope of the project so they decided factors like time must be closely monitored as much as possible using the respective tools so changes can be made if necessary. Additionally, the team followed a scrum approach. Every Monday at 10:00 A.M. the team would meet to discuss their weekly progress report. This allowed the team to assess the current situation they were in and allowed them to set goals for the upcoming week. The team would also regularly meet with Callahan on alternating Tuesdays at 4:00 P.M. to report progress and ensure that their vision is aligned.

Regarding communication, the team heavily relied on a discord server they created at the beginning of the semester. This server had several channels that allowed the team to ask questions, post updates, plan future meetings, and much more. The team shared many of their files through Google Drive for its easy-to-use synchronous editing capabilities. Additionally, a GitHub repository was made to share the code among group members. Using GitHub and utilizing new branches allowed for very few merging conflicts and a synchronous workflow among team members. Each of these sources of communication was shared with the client, providing transparency into the team's collaborative efforts and fostering a sense of accountability. The use of a Discord server, in particular, proved invaluable for real-time discussions, quick issue resolution, and maintaining an open channel for executive input, ensuring that the client could actively participate in decision-making processes and stay well-

informed about the project's progress. This approach not only facilitated efficient communication within the team but also contributed to the success of delivering a high-quality product.

The RCC's challenges were successfully addressed within the project timeline and scope. Dr. Callahan and the RCC community are pleased with the outcomes—gaining a digital presence and a structured CTF system for storing and practicing challenges. The project's positive impact is evident in enhanced knowledge sharing and engagement. As the team hands over the completed product, stakeholders recognize the transformative nature of the initiative, positioning the RCC for continued success in cybersecurity education and community involvement.

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## Section 2: Introduction

Led by Dr. Brian Callahan's leadership, the Rensselaer Cybersecurity Collaboratory at Rensselaer Polytechnic Institute is undertaking three transformative projects this term. These include crafting an impactful public-facing website to attract donors, developing a comprehensive Capture the Flag management system that will allow users to access various CTF writeups and challenges, and creating a prototype of front-end interface designs used for the Capture the Flag management system to ensure each user is receiving that immersive challenge-solving experience. Together, these initiatives aim to propel the RCC to new heights in cybersecurity innovation and community engagement by the term's end.

## **Section 3: Client Organization and Description**

At Rensselaer Polytechnic Institute, the Rensselaer Cybersecurity Collaboratory stands as the foremost cybersecurity-focused research laboratory on campus. Comprising a dynamic team primarily composed of Information Technology & Web Science students under the guidance of the director, the RCC not only serves as a hub for cybersecurity research but also distinguishes itself as a premier participant in 'Capture the Flag' challenges and tournaments. The organization's size, bolstered by the enthusiastic involvement of ITWS students, contributes to its multifaceted nature. The RCC's significance is further underscored by its active participation in diverse research projects, ranging from exploring blockchain security and sustainability to developing innovative AI/ML models for Intrusion Detection Systems and Intrusion Prevention Systems as well as implementing compiler-based mitigations for binary exploitation techniques. In addition, the RCC consistently demonstrates practical skills and competitiveness through active engagement in various 'Capture the Flag' events and competitions, including the National Cybersecurity League (NCL). In these competitions, participants, often referred to as ethical hackers, engage in a series of puzzles, vulnerabilities, and tasks designed to test their skills in cryptography, reverse engineering, web exploitation, and other facets of cybersecurity. These events serve as dynamic and engaging platforms for cybersecurity enthusiasts to apply their knowledge and problem-solving abilities. This active involvement not only showcases the RCC's practical skills but also reinforces its commitment to hands-on learning. By combining cutting-edge research with direct participation, the RCC strengthens Rensselaer's position in cybersecurity while nurturing an environment that encourages continual growth and exploration in the field. This approach not only benefits the institution but also fosters a community dedicated to advancing cybersecurity amongst students and researchers alike.

The organization is actively working on expanding its outreach and is in the process of collecting donations to increase funding. Dr. Callahan's extensive cybersecurity expertise, supported by a range of certifications, seamlessly complements the RCC's diverse research efforts. The topic of his research covers a wide range of concepts, including technical aspects of system security as well as societal and business ramifications. Dr. Callahan's commitment to education is demonstrated through his oversight of both undergraduate and graduate concentrations in Information Security and Science and Technology Studies, nurturing the development of future

cybersecurity professionals. Publications such as 'Culturally Situated Design Tools: Generative justice as a basis for STEM diversity,' highlight Dr. Callahan's work and the RCC's commitment to promoting inclusivity and diversity in cybersecurity and STEM.

The team only coordinated with Dr. Brian Callahan, the Director of the RCC. Dr Callahan's best means of contact is his email which can be reached at [callab5@rpi.edu](mailto:callab5@rpi.edu). The team mostly engaged with Dr. Brian Callahan during client meetings and over Discord.

## **Section 4: Project Team**

The dedicated team entrusted with navigating the intricate landscape of the Rensselaer Cybersecurity Collaboratory's diverse initiatives comprises four students from Rensselaer Polytechnic Institute. They represent a well-balanced blend of diverse skills and expertise, bringing a wealth of knowledge, innovation, and unwavering dedication to the table. The team is prepared to address the multifaceted challenges posed by the RCC's projects and guide them to successful completion.

Meena Mall is the Project Manager and Project Designer. She is a senior majoring in Information Technology & Web Science at Rensselaer Polytechnic Institute. She has actively contributed to organizations like Helping Hands, Hidaya Soup Kitchen Project, and has previously held a prominent Information Specialist position at Al-Hidaya Organization. These roles provided her with valuable experience in leading and coordinating large teams and obtaining various organizational goals. Meena's role as Project Manager involves comprehending client requirements, overseeing the project team, and ensuring the project's successful progression. Her role as a Project Designer allows her to infuse creativity and incorporate client feedback to guide the project toward a triumphant conclusion.

Ben Manicke is the Lead Frontend Developer and Lead Writer. He is a junior pursuing a double major in Information Technology & Web Science and Computer Science at Rensselaer Polytechnic Institute. From his working experience at NEPA, he has gained knowledge in crafting user-facing elements that guarantee an engaging and interactive user experience as well as worked on countless web applications such as Taplen, Fiture, and Project Greenfoot. This provided him with a solid foundation, making him the ideal Lead Frontend Developer to ensure each user gets an immersive experience. Moreover, as a Lead Writer, Ben's proficiency extends to written content creation, ensuring that the project's written materials are not only informative but also captivating.

Peter Krumpholz is the Lead Backend Developer. He is a junior pursuing a major in Information Technology & Web Science with a minor in Management Information Systems at Rensselaer Polytechnic Institute. Through working for his fraternity, Pi Lambda Phi, he gained both backend and frontend development from developing the Pi Lambda Phi Website as well as getting practical hands-on experience gained from projects such as Fiture, where he focused on

organizing databases and handling database queries. His role as the Lead Backend Developer involves ensuring the optimization of the databases and high-quality performance optimization.

Raphael Chung is the Full Stack Developer and Assistant Writer. He is pursuing a major in Information Technology and Web Science at Rensselaer Polytechnic Institute. He has work experience at AML designing the Information Security Management System which provided him with a comprehensive understanding of both backend and frontend development. Raphael's role as a Full stack Developer involves collaborating with both backend and frontend developers. His role as an Assistant Writer involves supporting the Lead Writer in creating various written materials, including reports.

## **Section 5: Problem Statement**

The Rensselaer Cybersecurity Collaboratory community faces several critical challenges that hinder its growth, outreach, and knowledge-sharing capabilities. First off, the RCC currently lacks a centralized digital platform to effectively showcase its achievements, profiles, events, and alumni engagement, making it challenging to attract potential donors and sponsors. This absence of a public-facing website to highlight the RCC's accomplishments and its essential components, such as faculty and student profiles, events calendar, and an engaging alumni engagement portal, poses a significant hurdle to expanding the RCC's outreach and securing vital support for its activities.

The RCC community also currently faces an obstacle in knowledge sharing and collaborative learning, primarily due to the absence of a streamlined system for members to access, upload, and search through Capture the Flag writeups which are comprehensive documents that outline the solutions and techniques used to solve challenges in Capture the Flag competitions, helping participants learn and improve their cybersecurity skills. This challenge hampers the community's ability to effectively utilize and contribute to this invaluable resource, which necessitates the development of a knowledge management system that enables members to learn easily and efficiently more about CTF writeups.

In the realm of Capture the Flag challenges, the RCC possesses a robust backend but lacks an intuitive frontend interface that provides users with an interactive and immersive challenge-solving experience. This fragmented user experience hinders the full realization of the potential for learning and engagement within the RCC community. To bridge this gap, the development of a user-friendly frontend is required, offering interactive modules that mirror the functionality of the open-source project Ghidra, fostering enhanced user participation and learning.

## **Section 6: IS/IT Solution**



The RCC project establishes a comprehensive and interconnected digital ecosystem tailored specifically for the RCC community. As its inaugural phase 1, the solution is to amalgamate the showcasing prowess of a public-facing website with the functional utility of a knowledge management system. The website showcases RCC's milestones, achievements, and events, while also serving as a dynamic platform for faculty, student, and alumni profiles. Its interactive features not only foster community engagement but also enhance the RCC's appeal to potential donors and sponsors.

Complementing the website, the knowledge management system is a pivotal component that facilitates the seamless archival, search, and retrieval of CTF writeups. The development of this system will act as phase 2, which will be a knowledge hub, streamlining the process of uploading diverse content types, from text and images to videos and binaries. It is crafted to provide a user-friendly interface for efficient content management.

Moreover, the team endeavors ambitiously to develop a frontend that seamlessly interfaces with an existing CTF backend, constituting the pivotal phase 3 of the project. Drawing inspiration from the Ghida project, this component aspires to provide users with an immersive experience, allowing them to explore challenge binaries and achieve triumphant flag captures. Together, these elements converge to create a solution that not only celebrates the accomplishments of the RCC community but also empowers its members with tools for ongoing learning and effective challenge-solving.

## **Section 7: Methodology**

The project team was presented with the option to select their client and project to complete or pursue the project presented to them by Dr. Callahan. Upon choosing the latter option, the team began planning out and dissecting the requirements of the proposed project to prepare for development. Considering the project involved creating a website with both a functioning front and back end, the project team immediately divided up roles to play off their strengths to complete the implementation of the web app. The client, being a member of the RPI community, was easily able to meet and communicate with the project team to discuss the overall functional and non-functional requirements. Upon discussing the requirements, the team completed and presented a project proposal to the client and, after it was approved, the team began developing the proposed IT solution.

Alongside the project proposal, the team adeptly employed the waterfall method in creating a comprehensive project plan using Ganttter. This method involves a sequential progression through distinct phases, starting from defining requirements, progressing to design, implementation, testing, and concluding with maintenance. The use of Ganttter facilitated a structured and step-by-step approach, allowing the team to navigate the semester-long development process with clarity and precision. In addition to the project plan, the team conducted a Cost-Benefit Analysis to assess the economic viability of the project. The analysis

affirmed that the project would not only be economically feasible but also profitable for both the client and the RCC. Throughout the development, effective communication was maintained through various channels, including Discord and in-person meetings. The team's commitment to routine check-ins ensured continuous progress monitoring of the IT solution. This approach, aligned with the waterfall method, allowed the team to adhere to a predetermined vision and maintain a clear roadmap for the creation of their solution.

To facilitate their IT solution, the project team effectively utilized GitHub as a centralized platform to consolidate all code and project documents. GitHub played a crucial role in project management, assigning specific roles (such as Lead Frontend, Lead Backend, Full Stack Developer) to each team member. This approach allowed individuals to focus on their designated section of development while still ensuring an overall management tool to keep every member aligned with the established project plan.

The project's primary focus was the design and development of a public website compliant with RPI guidelines. This encompassed showcasing RCC's successes, faculty and student profiles, events, and alumni engagement. The team successfully deployed these elements onto the team GitHub repository, maintaining a streamlined and organized development process. Concurrently, the team established a secure knowledge management system, providing authenticated access to a database of CTF writeups. This system facilitated seamless uploads and searches, further contributing to the project's overall success. The entire knowledge management system was also deployed to the GitHub repository, ensuring efficient collaboration and version control among team members.

## **Section 8: IS/IT Requirements**

Below are the project requirements meticulously categorized into functional and non-functional components, representing the diverse array of specifications. These comprehensive requisites were diligently assembled and refined through collaborative discussions held during multiple client meetings with the client, Dr. Brian Callahan.

### **Functional Requirements**

#### ***People:***

- Users should experience seamless and intuitive navigation of the public-facing website across both desktop and mobile devices.
- Administrators must possess the capability to modify various content elements, including updating faculty profiles, student profiles, events, and alumni engagement sections on the website.

- Users should encounter an intuitive and user-friendly interface for the creation, editing, and searching of CTF write-ups.
- Administrators should be empowered to manage permissions effectively, enabling specific users to perform tasks such as creating, deleting, editing, and searching for CTF write-ups based on their designated roles.
- The front-end conceptual design should harmonize with the overall project theme and branding, providing an initial visual representation of the envisioned user experience.

### ***Process:***

- The public-facing website will encompass Home, Faculty Profiles, Student Profiles, Events, Alumni Engagement, Donation, and Contact pages.
- Secure account creation and login functionality will be provided for users.
- Users will have access to their profiles, allowing them to track achievements, events attended, and engagement within the alumni community.
- The website will enable users to make secure donations, contributing to the financial sustainability of the RCC.
- The front end of the CTF management system will offer users a conceptual interface for interacting with challenges and CTF content.
- Data for the CTF management system will be retrieved from MongoDB, ensuring its display on the front end.

### ***User Interface:***

- The public-facing website's user interface must align with the current RPI branding and theming, ensuring compliance with accessibility guidelines.
- The interface should promote effortless navigation and interaction, minimizing the clicks necessary to access information or complete actions.
- Users should enjoy a visually captivating and responsive design that enhances their overall browsing experience.
- The system must ensure secure authentication, allowing access and contributions to the CTF knowledge base only for authorized users.

### ***Software:***

- To ensure web accessibility, the public-facing website will be hosted using Node.js on a live server.
- The site's front end will be crafted using Express.js and React, guaranteeing dynamic and responsive page rendering.

- Integration with MongoDB is vital for the knowledge management system, facilitating efficient storage and retrieval of CTF write-ups.
- CTF data will be parsed into a JSON file and transferred from that file to the MongoDB database for accessibility on the front end.
- The website's backend will implement robust security measures to safeguard user data and ensure a secure browsing experience.

## **Non-Functional Requirements**

### ***Software:***

- The public-facing website must maintain accessibility across diverse devices, encompassing both desktop and mobile screens.
- Compatibility with widely used web browsers is imperative to deliver a uniform user experience.
- The website ought to incorporate accessibility features, aligning with pertinent guidelines to foster an inclusive user experience.

### ***Scalability:***

- In line with RCC's objective to broaden outreach, the public-facing website and related systems must possess scalability to handle heightened user traffic and content expansion.

### ***Aesthetics:***

- The design of the public-facing website's user interface must stay in harmony with RPI's branding guidelines, upholding a unified and professional look.
- Prioritizing a modern and visually captivating design, the website's aesthetics should enhance a positive and engaging user experience.

### ***Usage:***

- Ensuring the optimal performance of the public-facing website, CTF management system and any supplementary components is imperative.
- Admins must possess the capability to modify existing features or introduce new ones as necessary.

### ***Security:***

- Ensuring the utmost security, user data, especially within the secure login system, must be handled to maintain confidentiality and privacy.
- The public-facing website and associated systems should incorporate robust security measures to safeguard against potential threats.
- Authentication and authorization protocols within the systems must adhere to industry standards, guaranteeing a secure user experience.

Based on the proposed IS/IT solution and requirements, several technologies will be required to achieve the finalized product. Considering the project team's use of the MERN stack, the primary requirement for the public-facing website is that it must be served with Node on a live server so that it can be accessed by anyone on the web. The front end of the site must be in line with current RPI branding and theming as well as following all RPI's accessibility guidelines.

Express JS & React will be used to build all the pages dynamically alongside Node. Besides developing the custom frontend, the project team is also required to create a backend that contains a knowledge management system for the existing Capture the Flag write-ups using MongoDB, as well as all of the JavaScript and other necessary code to allow users to create, delete, edit, and search for any CTF write-ups they have permission to access.

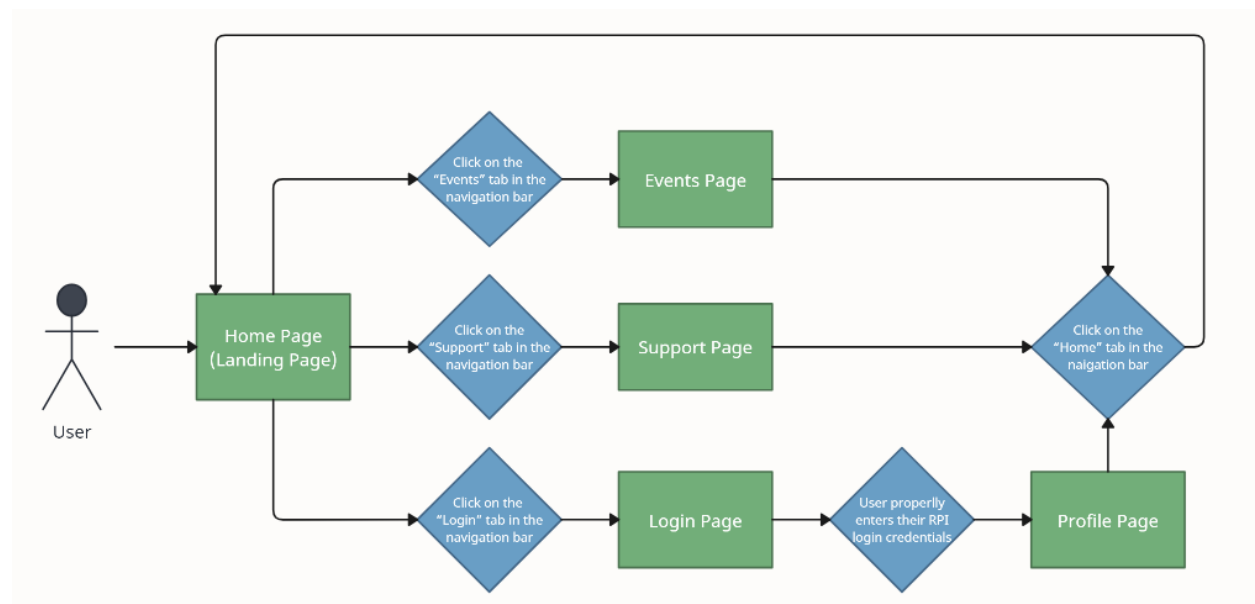
The project team must implement a secure login system for users who want to access more than just the public-facing website. This login system will authenticate users via RPI's CAS system, pending client and organization approval, and will require all user input data to remain private and secure. As an aspirational component, the project will explore crafting a front end to interface with a pre-existing CTF backend, presenting users with interactive modules for challenge-solving. However, the full delivery of this third component is recognized as a reach goal and may not be fully realized within the project's timeframe. The primary focus is ensuring the completion of components one and two while completing these in sequential order. The first component's website will be designed using Bootstrap and React while the logo will be developed using tools from Adobe Creative Cloud. Next, the knowledge management system will be implemented using MongoDB and Node.js, while the third phase will utilize the complete MERN stack which is a powerful combination of technologies used to build web applications, with each component handling a specific part of the development process. This phase additionally includes the use of Express.js and React, for a well-designed and cohesive final product.

The outlined requirements for the project are structured into functional components, covering essential product features and user requirements, as well as non-functional components, specifying the product properties necessary to achieve functional features and align with user expectations. These requirements have been synthesized through consultations with the Rensselaer Cybersecurity Collaboratory.

## Section 9: IS/IT Design

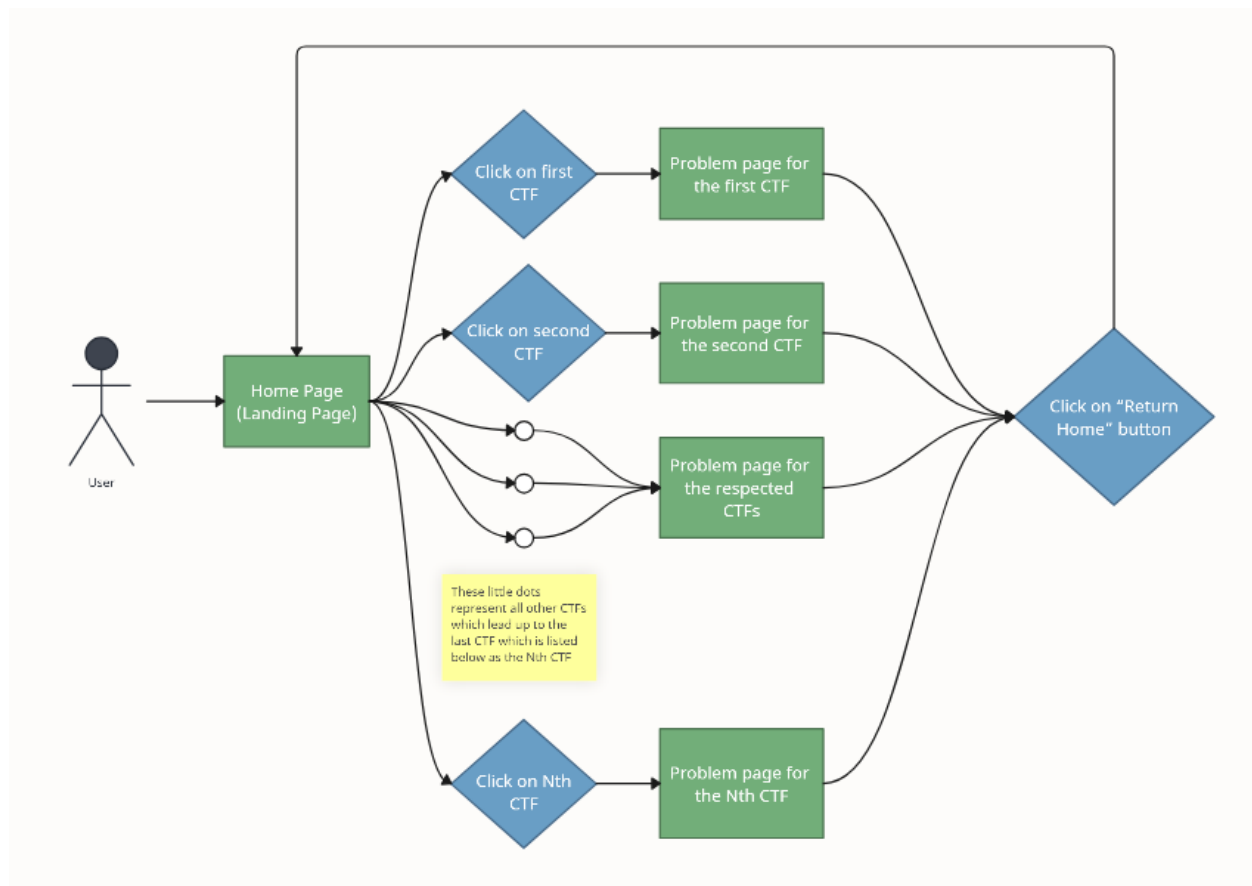
### Site Map Diagram

The websites are composed of several pages that cohesively mesh for one efficient and easy-to-use experience. To illustrate the maneuverability of the site, the team built a site map to show which features and pages the site is made up of. The first diagram, Figure 9.1, displays the site map built for the public-facing website. This illustrates that the user can view the home, events, support, and login, and if properly enter their RPI credentials, they can also view a profile page.



**Figure 9.1:** Public facing website site map diagram

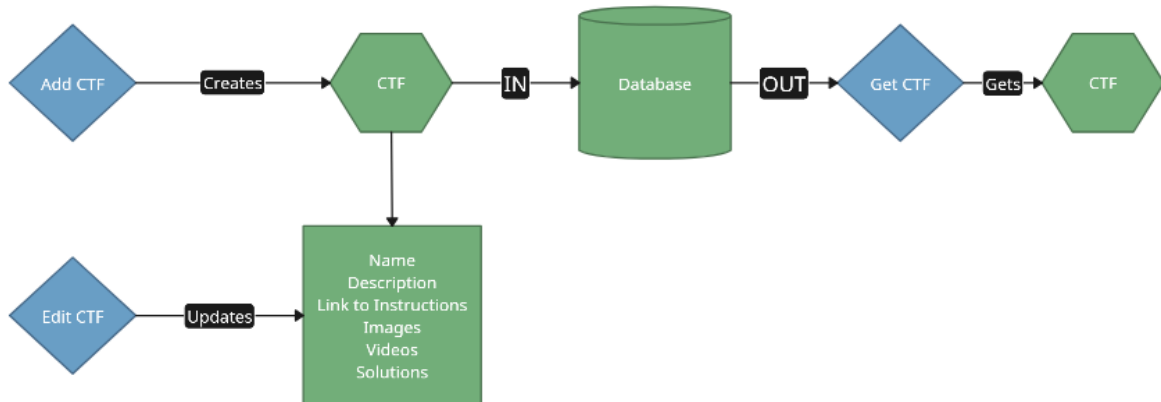
Figure 9.2 illustrates the site's structure as a dedicated CTF coding playground for RCC students. This platform offers a diverse range of cybersecurity challenges, enhancing practical skills through an interactive interface and a built-in compiler for coding exercises. The diagram effectively presents the logical layout, ensuring easy navigation and a smooth learning experience for users within the RCC community.



**Figure 9.2:** CTF coding playground site map diagram

## Data Flow Diagram

Figure 9.3 offers a comprehensive data flow diagram elucidating the intricate solution devised to tackle the second problem concerning the database system. This strategic visualization provides an in-depth exploration of the various functionalities incorporated to optimize user experience. Some of these functionalities are data storage and data retrieval. Furthermore, the diagram illuminates the seamless management of Capture the Flag writeups, emphasizing efficiency and accessibility for the RCC community.



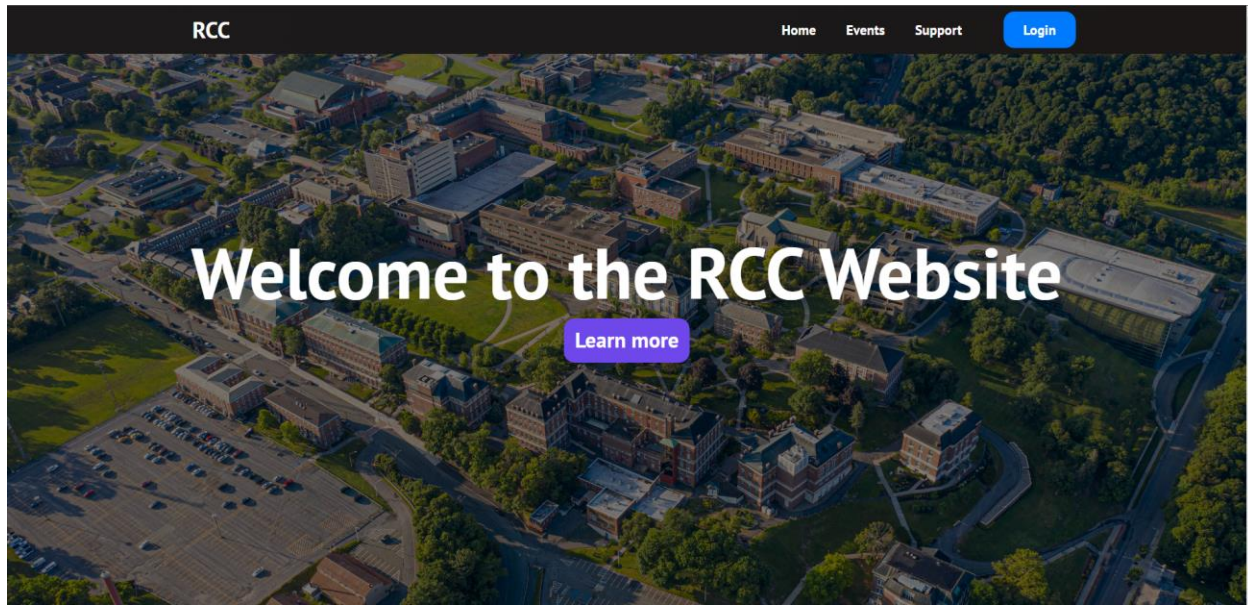
**Figure 9.3:** Database system data flow diagram

## Frontend Design

Ensuring a balance between formality and a welcoming atmosphere was a top priority for the team during the website's development. While dedicating ample time to meticulous planning and crafting an intuitive layout, the team remained steadfast in adhering to the project's initial scope. Recognizing the potential for diversion with the inclusion of excessive features and niche designs, the team prioritized comprehensive accessibility testing. The public-facing website is showcased in Figures 9.4 to 9.11 offering a visual representation of the team's commitment to a thoughtful and inclusive design.

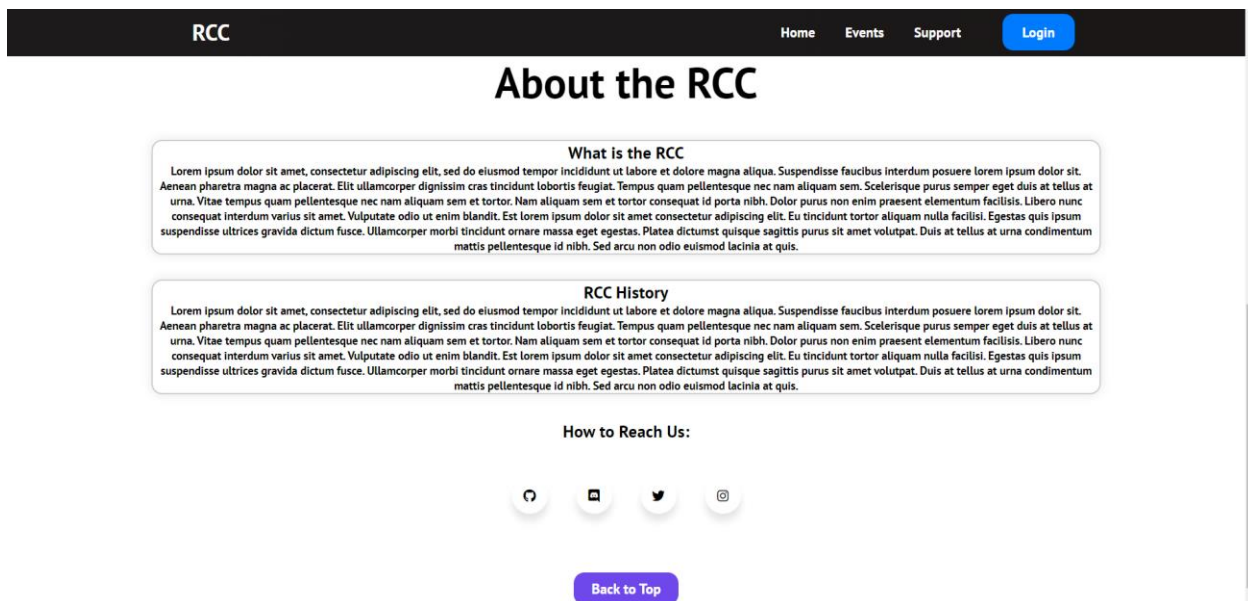
Displayed in Figure 9.4 is the homepage of the public-facing website for the RCC. Users have the ability to access other pages, such as Events, Support, and Login, by selecting the corresponding links located at the top right of the screen. Additionally, users can acquire more detailed information about the RCC by clicking on the "Learn more" option.





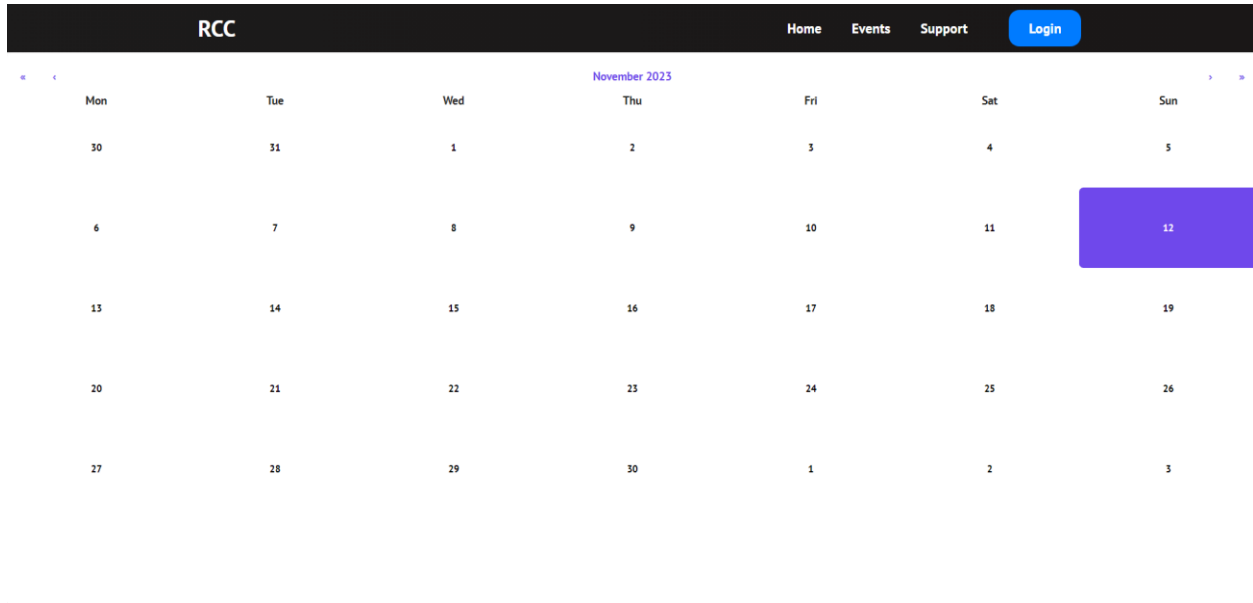
**Figure 9.4:** Home page (landing page)

Illustrated in Figure 9.5, users can navigate to this section by scrolling down on the page or selecting the "Learn more" button from the initial landing page. Upon doing so, users gain access to detailed information about the RCC, including its history and an overview. Additionally, users can discover methods to connect with the RCC and utilize the "Back to Top" button for easy navigation back to the initial landing page.



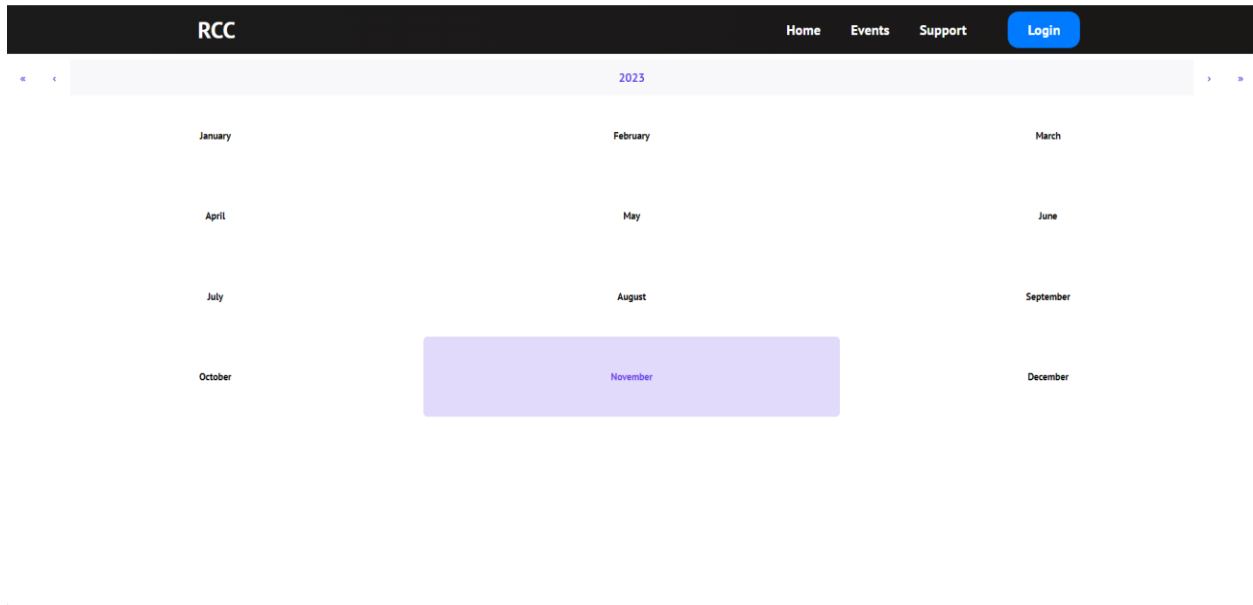
**Figure 9.5:** Home page (About us section)

Within Figure 9.6, users find themselves on the events page of the public-facing site. Here, a standard calendar is presented, encompassing all past and upcoming events hosted by the RCC, ranging from tournaments and lectures to meetings. Users are afforded the capability to navigate to future or past months by utilizing the right and left buttons situated above the calendar. Should a user click on the current month, November 2023 in this instance, they will be directed to the corresponding page for the current month, as depicted in Figure 9.7.



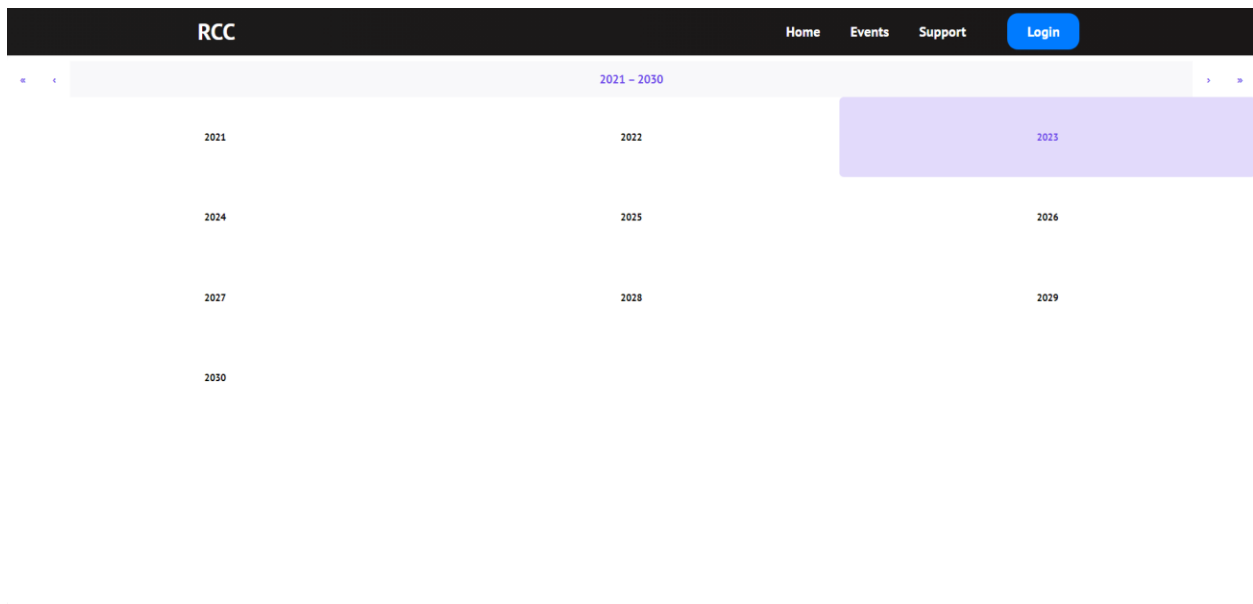
**Figure 9.6: Current Day Events page**

Illustrated in Figure 9.7, users have the option to select a specific month, thereby accessing the 'current month' page. This selection aids in navigating the user to the present day, clearly highlighted in Figure 9.6 above. Users can utilize the arrows on either side of the current year (2023 in this instance) to increment or decrease the year. In the event the user clicks on the current year, they will be directed to the page for the current year, as depicted in Figure 9.8 below.



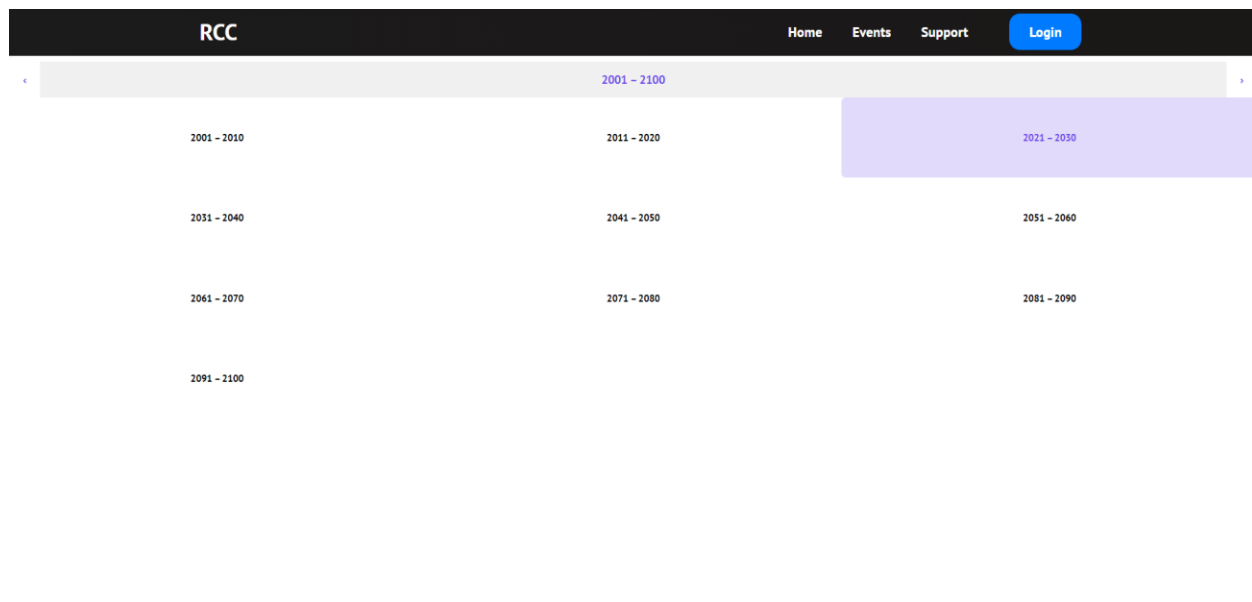
**Figure 9.7: Current Month Events page**

Presented in Figure 9.8, users have the ability to choose a specific year within the past decade (spanning from 2021 to 2023 in this instance). The selection of a particular year seamlessly navigates the user to the corresponding 'current month' page, as showcased in Figure 9.7 above. Users can dynamically adjust the range of years by employing the arrows situated to the left and right of the current decade (2021 to 2023). In the event that the user clicks on the current decade, they will be directed to the page representing the current decade, as illustrated in Figure 9.9 below.



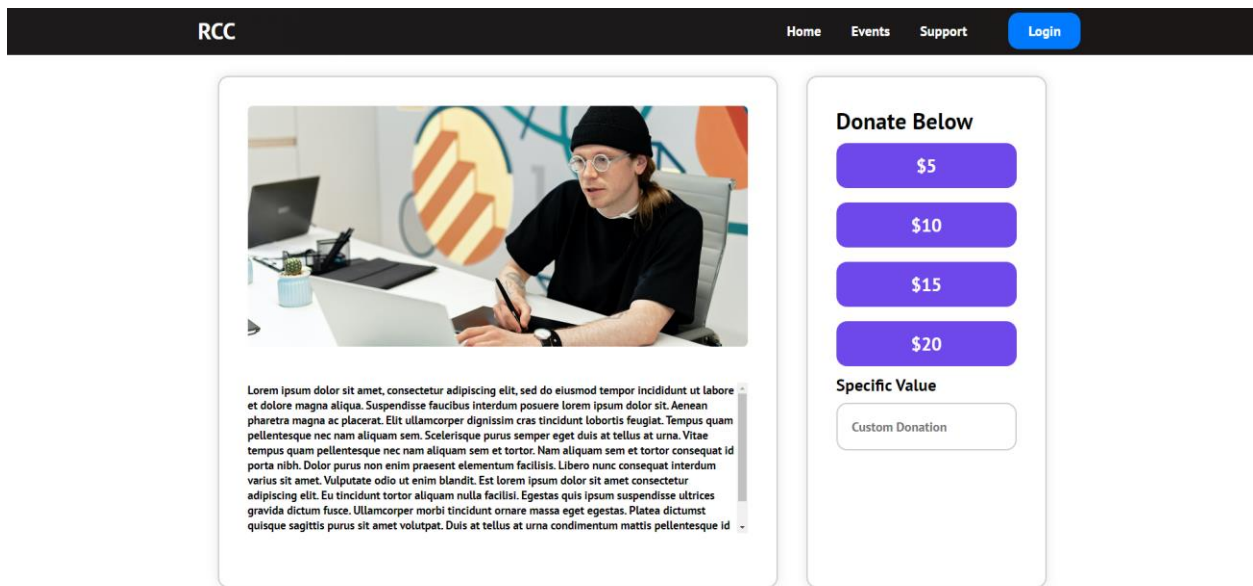
**Figure 9.8: Current Year Events page**

Depicted in Figure 9.9, users find themselves on the current decade page. Within this interface, users can meticulously select a particular decade to explore within the current century, spanning from 2001 to 2100 in this context. The incorporated arrows allow users to effortlessly navigate between future and past centuries, providing insights into events that transpired during those periods. Upon choosing a specific decade, users will be seamlessly redirected to the corresponding 'current year' page, as exemplified in Figure 9.8 above.



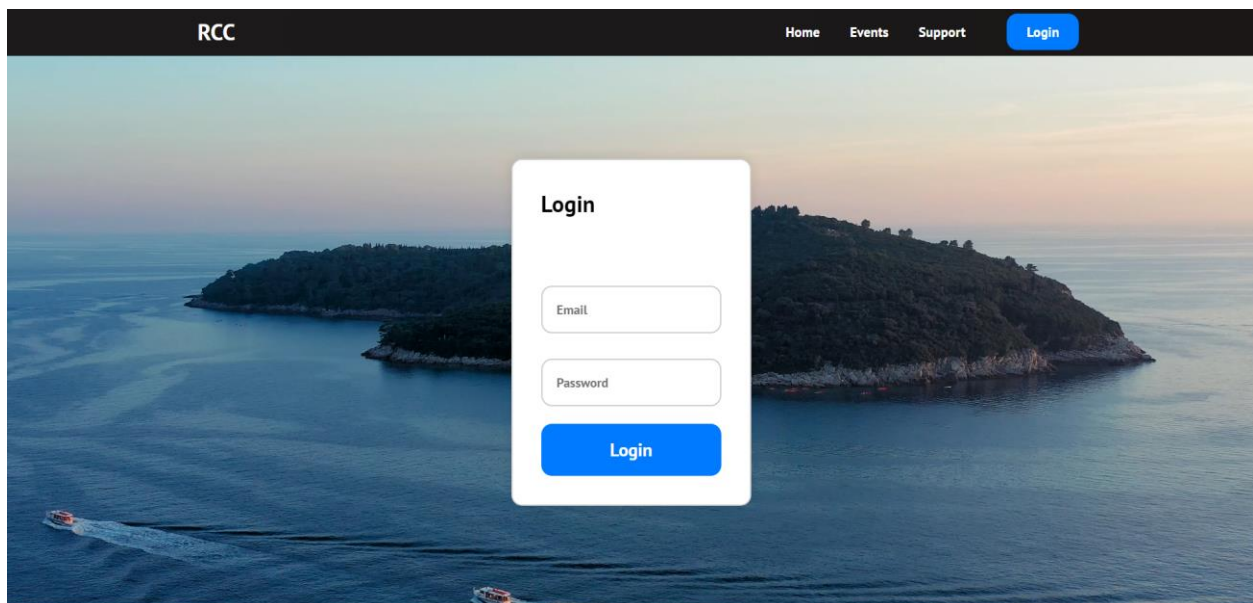
**Figure 9.9:** *Current Decade Events page*

In Figure 9.10, users access the Support page of the RCC's public-facing website, where they can gain insights into the organization's current goals and initiatives. Upon reviewing this information, users are presented with the option to contribute by either selecting one of the four designated buttons on the right or entering a custom donation value. The user-friendly interface facilitates seamless navigation back to other pages of the site through the four links listed at the top of the page.



**Figure 9.10: Donation page**

Figure 9.11 represents the Login page for the RCC website. Within this interface, users can securely access the RCC site by logging in using their individual RPI credentials, which are entered into the provided text fields. Upon inputting the required information, clicking the “Login” button seamlessly navigates the user to the RCC home page, as illustrated in Figure 9.4. Additionally, users retain the ability to explore other pages by utilizing the four links listed in the navigation bar located at the top right of the screen.



**Figure 9.11: Login Page**

## Backend Design

The backend functionality of the website plays a pivotal role in ensuring its seamless operation, comprising two essential components. The first component involves the implementation of a secure account creation and login system. Utilizing the Central Authentication Service (CAS) authentication, the system has been meticulously designed with an emphasis on simplicity while providing robust functionality for users to effortlessly create accounts and securely log in. CAS authentication, a trusted and secure system, serves as the linchpin for secure user authentication, ensuring the protection of RPI credentials during login processes. The team collaborated closely with DotCio, led by Dale Tuttle, engaging in a detailed consultation process to seamlessly integrate and implement the CAS authentication mechanism. This involved a comprehensive assessment of security protocols and custom configurations tailored to the project's requirements. The careful collaboration with DotCio not only bolstered the system's security but also facilitated a user-friendly and seamless authentication experience. Users can confidently utilize the system to upload Capture the Flag challenges or access CTF data, appreciating the combined efforts to ensure the highest standards of authentication and data protection.

The second component focuses on the CTF data management system. The information associated with each CTF challenge is securely stored in a MongoDB database, ensuring robust data management. The project team employs web scraping techniques to gather the required information from the web, which is then organized into a JSON file. This file acts as an intermediary, facilitating the smooth transfer of data into its designated location within the MongoDB database. The schema for this database details each CTF writeup as its own object, each with a unique ID generated by MongoDB. Within these objects the data is organized as such: unique ID, title of the CTF, problem description, connection string, CTF solution, any links related to the writeup, and finally, the answer. Each CTF contains these fields even if one is left blank (for example, several CTFs come without a link) and can all be deleted, modified, or newly created by any user with access to the database. On the frontend, users can effortlessly view, search for, and interact with CTF challenges, seamlessly bridging the gap between the front-end and backend functionalities of the website.

## Test Plan and Test Results

The team implemented a comprehensive test plan to validate the functionality of the solutions, ensuring they aligned with the specified requirements and met the high standards set by the client. One crucial aspect of the testing process involved conducting extensive cross-browser compatibility checks. The team rigorously tested the site on popular browsers, including Chrome, Firefox, and Edge, under various settings. This approach ensured a consistent and appealing user experience across diverse browsing environments. The results of those tests were highly satisfactory for the team, providing valuable insights into the site's performance under different conditions. This thorough testing not only affirmed the robust functionality of the

solutions but also offered significant learning opportunities for the team. Analyzing the results allowed the team to gain a deeper understanding of the intricacies of the site's behavior, enabling them to make informed refinements and enhancements. This iterative process not only contributed to the overall success of the project but also served as a valuable learning experience, further refining the teams' skills and ensuring the delivery of an optimized and reliable solution for the client.

In addition to browser compatibility, the team prioritized accessibility testing to guarantee an inclusive user experience. To achieve this, the team integrated tools such as Wave and screen readers into their testing process. These tools played a pivotal role in evaluating the site's accessibility standards, ensuring that users with different needs and preferences could navigate and interact with the site effortlessly. The comprehensive test plan and meticulous testing procedures contributed to the delivery of a robust and user-friendly solution that adhered to both functional and accessibility requirements. The results of this focused accessibility testing were exceptionally positive. The team adeptly utilized the tools to identify and address potential accessibility barriers, enhancing the site's usability for a diverse user base. The collaboration with accessibility tools not only demonstrated the team's commitment to creating an inclusive digital environment but also showcased their proficiency in working seamlessly with these tools. This positive outcome underscored the effectiveness of their accessibility testing strategy and reinforced the team's dedication to delivering a solution that caters to a broad range of user needs.

## **Section 10: Cost-Benefit Analysis**

Through a comprehensive financial evaluation, including a thorough risk management assessment, the team analyzed the cost-benefit factors. The risk management process involved identifying and evaluating potential risks associated with the project. These identified risks were then quantified and integrated into the Cost-Benefit Analysis to ensure a holistic financial perspective. By incorporating risk analysis into the CBA, the team derived more accurate and nuanced values, providing a robust foundation for concluding that the project is financially viable and poised for substantial returns and comprehensive advantages.

### **Risk Analysis**

The team utilized a risk management spreadsheet and a risk analysis spreadsheet to analyze the foreseeable risks based on probability and impact. The various potential risks that could impact the team were put into four categories: technological, security, organizational, and implementation. Technological risks included failure to implement technologies to establish the front end and back end, inability to manage and upload CTF challenges to the backend, or configuration of the site being misaligned and not working in its parameters. Security risks include data being mislabeled when auto-sorted or cybersecurity threats from outside.



Organizational risks include compliance with RPI guidelines, Lack of user acceptance from RCC users, change in requirements by the client if needing to switch goals or team members being unavailable to work on the project due to any emergencies/other classes. Implementation risks include the website not working correctly with CAS.

Each risk was calculated using a probability and an impact as a dollar amount. The impacts were decided by estimating the probability of the risk and how much the risk would cost should it happen. The weight of risk is calculated using the total risk amount caused by all risks and dividing the individual risk by the total risk. Each risk was assigned a probability\*impact score to determine the priority of risk mitigation. The team then inserted the weights of each risk and their respective scores into the risk analysis spreadsheet and came out with a risk index that corresponded to a discount rate of 35%. The discount rate was later used to find the project's net present value.

Most risks within the project were generally low; however, a few had higher priority due to their elevated probability and potential impact. Notably, the team grappled with cybersecurity threats originating both externally and internally. Internal threats involved the risk of users, such as students, attempting to hack the website and compromise security. To address this, the team implemented robust security measures, recognizing the importance of outsmarting potential hackers. External cybersecurity threats, including Distributed Denial of Service attacks, Malware, Phishing, Social Engineering, and Brute Force attempts, required proactive risk mitigation. The team implemented various security measures, such as firewalls, intrusion detection/prevention systems, antivirus software, and robust authentication methods, to safeguard against these potential threats.

Additionally, misclassification of data and misalignment of configuration emerged as high-probability risks. Correctly classifying data was essential to ensure proper display and prevent unauthorized access to sensitive information. Proper configuration was crucial to prevent performance issues, security vulnerabilities, and compliance violations. While these risks intersected with organizational and security concerns, they primarily fell within the realm of technological risk.

During implementation, the team faced a significant risk concerning the seamless integration of the website with CAS, the login system used by RPI students. This represented a high-probability risk, potentially impacting the website's functionality. The team's goal was to streamline the login process for RPI students by incorporating CAS. However, uncertainties loomed regarding approval from the Division of the Chief Information Officer (DotCIO). Fortunately, DotCIO approved, successfully mitigating the risk. Despite the risk being considered high probability, the team remained vigilant, ensuring ongoing accuracy and reliability in the login system.

## **Cost-Benefit Analysis**



The Cost-Benefit Analysis offers a detailed financial examination of the RCC project spanning five years. It dissects recurring costs like database hosting and fixed costs such as software hosting. Projected benefits include increasing profits, reduced training and IT costs, and sustained reputation improvements. The CBA concludes with a positive financial outlook, showcasing a rising Net Present Value and a robust Internal Rate of Return of 42%. This analysis serves as a vital tool in determining the project's economic feasibility and profitability.

When developing the CBA, it was recognized that there will be plenty of year 0 costs that end up recurring every year. One of these happens to be the highest cost listed on the CBA which is the “Database Hosting” cost (\$684). To calculate such a value, the team recognized they were using MongoDB and navigated to MongoDB’s pricing page. From there, they were able to calculate the amount of traffic the site would be undergoing and plan a yearly database hosting cost. While the site’s user count could expand or streamline to nothing making this cost susceptible to change, the team only can assume the site will receive a regular amount of traffic having the price remain consistent for coming years. Database hosting will have a resulting total cost of \$3,420. Another notable cost is software hosting. While extensively searching for an inexpensive and reliable resource, they managed to find a deal where the year 0 cost reached as low as \$12. Following this, it would be a fixed cost of \$144 to host the software each year. While there is potential that the team may one day find a better hosting platform, they intend to stick with this one, bringing them to a total cost of \$588 over the 5 years.

Moving on to the benefits, such values were estimated on the impact the provided solutions would end up having. The CBA reveals increasing gross profits of \$0, \$400, \$1200, \$2250, and \$3150. Correspondingly, there are decreasing trends in training costs, starting at \$0 and incrementally reducing to \$200, and consistently low IT costs at \$0, \$20, \$20, \$20, \$20, \$20. Additionally, an enhanced reputation is maintained throughout the period, contributing positively with values of \$40 each year. Overall, the CBA demonstrates a favorable financial outlook with rising profits, reduced training and IT costs, and sustained improvements in reputation over the analyzed five-year span.

Lastly, the team weighed these values to determine a net present value and internal rate of return which would provide insight as to whether this is a financially viable project or not. After determining the costs and benefits over the next 4 years, the team was able to calculate an NPV of \$1,795 using a 10% discount rate. Additionally, the team calculated the IRR to be 42%. The positive NPV and return number for an IRR represent a profitable and worthy project which allowed the team to know they had a project worth doing.

A screenshot of the full CBA is shown in Figure 10.1.

| CBA Term Project        |                   |                         |               |               |               |           |  |
|-------------------------|-------------------|-------------------------|---------------|---------------|---------------|-----------|--|
|                         | 2023 (Year 0)     | 2024 (Year 1)           | 2025 (Year 2) | 2026 (Year 3) | 2027 (Year 4) | Total     |  |
| Revenue                 | \$ -              | \$ 1,000                | \$ 3,000      | \$ 5,000      | \$ 7,000      | \$ 16,000 |  |
| Gross Profit Margin     |                   | 40%                     | 40%           | 45%           | 45%           |           |  |
| Gross Profit            | \$ -              | \$ 400                  | \$ 1,200      | \$ 2,250      | \$ 3,150      | \$ 7,000  |  |
| <b>Benefits</b>         |                   |                         |               |               |               |           |  |
| Gross Profit            | \$ -              | \$ 400                  | \$ 1,200      | \$ 2,250      | \$ 3,150      | \$ 7,000  |  |
| Lower Training Costs    | \$ -              | \$ 50                   | \$ 100        | \$ 150        | \$ 200        | \$ 500    |  |
| Lower IT Costs          | \$ -              | \$ 20                   | \$ 20         | \$ 20         | \$ 20         | \$ 80     |  |
| Enhanced Reputation     | \$ -              | \$ 40                   | \$ 40         | \$ 40         | \$ 40         | \$ 160    |  |
| Total Benefits          | \$ -              | \$ 510                  | \$ 1,360      | \$ 2,460      | \$ 3,410      | \$ 7,740  |  |
| <b>Costs</b>            |                   |                         |               |               |               |           |  |
| Software Hosting        | \$ 12             | \$ 144                  | \$ 144        | \$ 144        | \$ 144        | \$ 588    |  |
| Software Development    | \$ 100            | \$ -                    | \$ -          | \$ -          | \$ -          | \$ 100    |  |
| Database Hosting        | \$ 684            | \$ 684                  | \$ 684        | \$ 684        | \$ 684        | \$ 3,420  |  |
| Domain Name Ownership   | \$ 6              | \$ 6                    | \$ 6          | \$ 6          | \$ 6          | \$ 30     |  |
| Operational Disruptions | \$ 250            | \$ 150                  | \$ 100        | \$ 50         | \$ 25         | \$ 575    |  |
| Total Costs             | \$ 1,052          | \$ 984                  | \$ 934        | \$ 884        | \$ 859        | \$ 4,713  |  |
| Cash Flow               | \$ (1,052)        | \$ (474)                | \$ 426        | \$ 1,576      | \$ 2,551      |           |  |
| Cumulative Cash Flow    | \$ (1,052)        | \$ (1,526)              | \$ (1,100)    | \$ 476        | \$ 3,027      |           |  |
| Interest Rate           | Net Present Value | Internal Rate of Return |               |               |               |           |  |
| 10%                     | \$ 1,795.60       | 42.1%                   |               |               |               |           |  |
| 35%                     | \$ 239.21         | 42.1%                   |               |               |               |           |  |

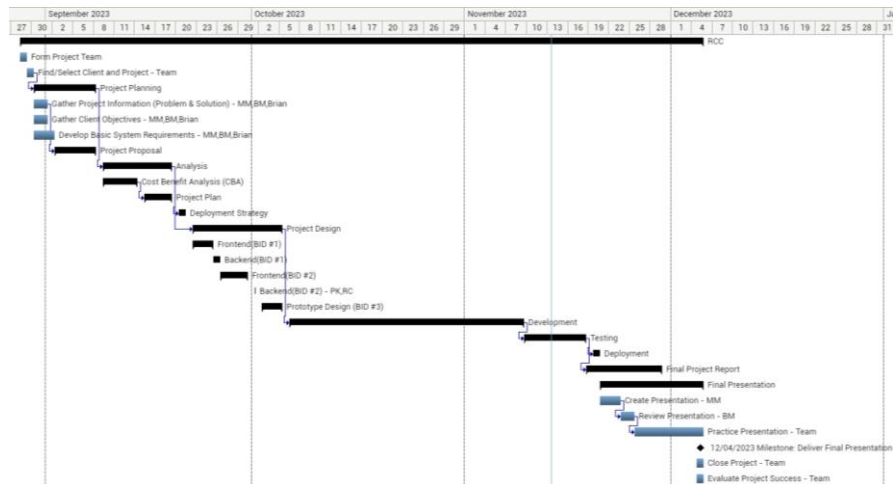
**Figure 10.1. Cost-Benefit Analysis**

## Section 11: Project Management

The project team devised a comprehensive strategy plan, utilizing a dynamic Gantt chart to ensure a well-organized and efficient distribution of the project timeline. This detailed plan outlines seven key phases, each signifying a crucial juncture in the project's progression: planning, analysis, design, development, testing, final report, and final presentation. Figures 11.1 and 11.2 showcase the complete plan in two detailed images.

|     | ① | Name  | Duration | Work       | Cost        | Start      | Finish     | Predecessors | Resources   |
|-----|---|---|----------|------------|-------------|------------|------------|--------------|-------------|
| 1   |   | ☐ RCC   | 99days   | 8143.65hrs | \$527260.46 | 08/28/2023 | 12/05/2023 |              |             |
| 2   |   | Form Project Team                               | 1day     | 0hr        | \$0         | 08/28/2023 | 08/29/2023 |              |             |
| 3   |   | Find/Select Client and Project                  | 1day     | 24hrs      | \$4392      | 08/29/2023 | 08/30/2023 |              | Team        |
| 4   |   | ☐ Project Planning                              | 9days    | 1104hrs    | \$51120     | 08/30/2023 | 09/08/2023 | 3            |             |
| 5   |   | Gather Project Information (Problem & Solution) | 2days    | 144hrs     | \$4464      | 08/30/2023 | 09/01/2023 |              | MM,BM,Brian |
| 6   |   | Gather Client Objectives                        | 2days    | 144hrs     | \$4464      | 08/30/2023 | 09/01/2023 |              | MM,BM,Brian |
| 7   |   | Develop Basic System Requirements               | 3days    | 216hrs     | \$6696      | 08/30/2023 | 09/02/2023 |              | MM,BM,Brian |
| 8   |   | ☐ Project Proposal                              | 6days    | 600hrs     | \$35496     | 09/02/2023 | 09/08/2023 | 5            |             |
| 15  |   | ☐ Analysis                                      | 10days   | 384hrs     | \$22296     | 09/09/2023 | 09/19/2023 | 4            |             |
| 16  |   | ☐ Cost Benefit Analysis (CBA)                   | 5days    | 216hrs     | \$11208     | 09/09/2023 | 09/14/2023 |              |             |
| 21  |   | ☐ Project Plan                                  | 4days    | 168hrs     | \$11088     | 09/15/2023 | 09/19/2023 | 16           |             |
| 25  |   | ☐ Deployment Strategy                           | 1day     | 24hrs      | \$4392      | 09/20/2023 | 09/21/2023 | 15           |             |
| 27  |   | ☐ Project Design                                | 13days   | 791.97hrs  | \$63353.9   | 09/22/2023 | 10/05/2023 | 15           |             |
| 28  |   | ☐ Frontend(BID #1)                              | 3days    | 407.98hrs  | \$25244.95  | 09/22/2023 | 09/25/2023 |              |             |
| 39  |   | ☐ Backend(BID #1)                               | 1day     | 24hrs      | \$4392      | 09/25/2023 | 09/26/2023 | 30           |             |
| 41  |   | ☐ Frontend(BID #2)                              | 4days    | 287.98hrs  | \$20540.95  | 09/26/2023 | 09/30/2023 |              |             |
| 51  |   | ☐ Backend(BID #2)                               | 0day     | 0hr        | \$0         | 10/01/2023 | 10/01/2023 |              | PK,RC       |
| 53  |   | ☐ Prototype Design (BID #3)                     | 3days    | 72hrs      | \$13176     | 10/02/2023 | 10/05/2023 |              |             |
| 55  |   | ☐ Development                                   | 34days   | 2791.68hrs | \$152494.56 | 10/06/2023 | 11/09/2023 | 27           |             |
| 102 |   | ☐ Testing                                       | 9days    | 864hrs     | \$82524     | 11/09/2023 | 11/18/2023 | 55           |             |
| 109 |   | ☐ Deployment                                    | 1day     | 72hrs      | \$3672      | 11/19/2023 | 11/20/2023 | 102          |             |
| 111 |   | ☐ Final Project Report                          | 11days   | 1680hrs    | \$84672     | 11/18/2023 | 11/28/2023 | 108,102      |             |
| 127 |   | ☐ Final Presentation                            | 15days   | 360hrs     | \$49560     | 11/20/2023 | 12/05/2023 | 126          |             |
| 128 |   | Create Presentation                             | 3days    | 72hrs      | \$3528      | 11/20/2023 | 11/23/2023 |              | MM          |
| 129 |   | Review Presentation                             | 2days    | 48hrs      | \$2112      | 11/23/2023 | 11/25/2023 | 128          | BM          |
| 130 |   | Practice Presentation                           | 10days   | 240hrs     | \$43920     | 11/25/2023 | 12/05/2023 | 129          | Team        |
| 131 |   | Milestone: Deliver Final Presentation           | 0day     | 0hr        | \$0         | 12/04/2023 | 12/04/2023 |              |             |
| 132 |   | Close Project                                   | 1day     | 24hrs      | \$4392      | 12/04/2023 | 12/05/2023 |              | Team        |
| 133 |   | Evaluate Project Success                        | 1day     | 24hrs      | \$4392      | 12/04/2023 | 12/05/2023 |              | Team        |

**Figure 11.1. Initial Timeline at Project Definition**



**Figure 11.2. Initial Timeline at Project Definition**

## **Planning**

After the formation of project teams and establishing collaboration with the client, the Project Planning phase commenced on August 30th, extending through September 8th. This phase primarily involved extensive information gathering, project proposal refinement, and diverse analyses. Engaging with the client, Dr. Callahan, a comprehensive discussion took place to determine the requirements for each project and to articulate the expectations of the client. Subsequently, the team established a structured schedule for regular meetings with the client to provide updates on each project's progress and to address any questions or challenges encountered by the team. With this foundational information in place, the team defined the project scope and meticulously crafted a project plan, inclusive of the Project Planning phase, to facilitate effective project management and ensure adherence to specified deadlines.

## **Analysis**

During the analysis phase, spanning from September 9th to September 19th, the project team, spearheaded by the project manager and lead writer, embarked on the critical task of formulating a comprehensive Cost-Benefit Analysis and project plan for the upcoming RCC projects. The lead writer, in coordination with team members, took charge of determining the necessary information for the CBA. This involved a thorough process of data gathering, considering diverse cost factors, and potential benefits, and evaluating the overall project feasibility. The joint effort led to the development of a detailed Cost-Benefit Analysis, subject to a rigorous review process that culminated in its final approval. This CBA now stands as a guiding financial framework for the upcoming phases of the project.

Concurrently, the project manager orchestrated the development of an extensive project plan. The team collaboratively compiled a detailed list of project tasks and sub-tasks during this phase, addressing various project facets such as development, testing, client feedback cycles, and documentation. Individual team members assumed responsibility for specific tasks, diligently working on them throughout the period. Regular team reviews ensured ongoing progress assessment, issue resolution, and alignment with project objectives. This cooperative approach resulted in a comprehensive and adaptable project plan, providing a roadmap for the team's coordinated efforts and successful project execution.

## **Design**

Following the project analysis, the Project Design phase commenced, spanning from September 22nd to October 5th. During this phase, the team initiated the process by crafting both frontend and backend wireframes utilizing tools such as Balsamiq and Figma. Upon the completion of each wireframe, a dedicated client meeting was convened to present and discuss the layout updates for all projects. Subsequently, these layouts received client approval, signifying the green light to proceed. Notably, the Project Design phase unfolded smoothly without

encountering any notable barriers or challenges. The clarity of client requirements and expectations rendered this phase explicit and well-defined.

## **Development**

In the development phase, spanning from October 6th to November 9th, the team focused on the coding aspects and semi-prototype of three distinctive projects.

For the development phase of the RCC website, the approach was evident throughout. The front-end and full-stack developers collaborated to craft a sophisticated platform that not only met but surpassed the outlined requirements. Noteworthy features, including an events calendar and a donation page, were seamlessly integrated to enhance user experience. On the front-end development front, the developers didn't just stop at coding; they went the extra mile with thorough code validation, extensive page reviews, and engaging with the client through every step. The process was agile. This dynamic development strategy ensured not only the fulfillment of basic requirements but also the creation of a website that excelled in functionality and user appeal.

For the development of the CTF Management System, the approach was meticulous, mirroring the detailed process applied to its system. The development activities went beyond the basics, encompassing precise code validation, comprehensive page reviews, and responsive adaptation to client feedback. The developers implemented CRUD functionalities, a crucial aspect of the system's functionality. CRUD, which stands for Create, Read, Update, and Delete, provided a robust framework for managing data. The Create functionality enabled the seamless addition of new information, Read allows efficient retrieval and display, Update facilitated dynamic modifications, and Delete ensures the removal of outdated or irrelevant data. This comprehensive set of functionalities enhanced the system's adaptability and usability, catering to the specific needs of the RCC community and its diverse cybersecurity challenges.

As for the CTF's Frontend idea, a semi-prototype was developed. This prototype underwent a comprehensive validation process, accompanied by valuable feedback. The iterative development approach facilitated ongoing refinement and improvement, ensuring that the ultimate Frontend CTF System not only met but surpassed client expectations. This systematic approach streamlined the transition from development to client approval, aligning the system precisely with the envisioned goals.

## **Testing**

Upon concluding the Development phase, the planned Testing phase, originally scheduled from November 9th to November 18th, underwent an adjustment, beginning on November 17th following the approval of the DotCIO. Within this phase, a comprehensive team meeting was convened to conduct a thorough evaluation of each project's completion status, ensuring alignment with the established standards of the client and the RCC community. The team

diligently verified the functionality of the systems, ensuring seamless operation. After this verification, a client meeting took place, during which requested changes were documented and seamlessly accommodated, culminating in the finalization of the Usability Testing phase.

## **Final Report**

The project timeline for the Final Report phase was from November 18 to November 28. This was dedicated to refining the Report Paper comprehensively covering the project's inception to completion. In this phase, the lead writer and assistant writer collaborated on meticulous editing and augmentation of the final report. Strategic assignments were delegated to each team member, ensuring a comprehensive and polished outcome. Following the paper's completion, a joint meeting between the lead writer and assistant writer facilitated a thorough review and finalization. While adjustments were necessary, they were promptly addressed, ensuring the timeline held up well during this phase and the Final Project Report was successfully concluded promptly.

## **Final Presentation**

Following the completion of the Final Report, the Final Presentation phase was from November 20 to December 4. A comprehensive team meeting was convened to outline the presentation's requirements and identify the key elements to be incorporated. Sections were distributed among team members, aligning with their contributions to the project. The team remained engaged through Discord, collaborating on their respective section slides and rehearsing for the presentation. After this collaborative effort, the lead writer undertook a thorough revision of the presentation. The final presentation took place on November 30 in class, with Dr. Brian Callahan, the client, in attendance. The Final Presentation followed the predetermined timeline, ensuring a seamless and timely conclusion to this phase.

## **Section 12: Post-Turnover Plan**

The post-turnover plan involves providing all three project phases, including the code, to the client, pre/post-launch meetings, project automation, and offering ongoing support to ensure a seamless transition and sustained success in the management and utilization of the implemented solutions.

In terms of providing all project phases, the team handed over all the resources and materials that they had used when working with Dr. Brian Callahan. After the final submission of the completed IS/IT solution, the project team will serve the custom website to the web via Node, React, and Express.js so that it can be accessed by the public. After a pre-launch meeting, Dr. Brian Callahan will be launching the RCC Website through his available resources. Several days to weeks after the website is published, the project team will have a post-launch meeting with the

client to discuss any possible improvements/pain points that need to be remedied as well as discuss how to continue to innovate and update the website well into the future.

In regards to the project automation, another improvement that will have to be made will be the automation of maintenance across the website and easy control over the configuration of the website. Automation of the website will include regular data backups, performance checks, and behavioral monitoring to prevent zero-day exploit attacks. An administrator panel will also be available to administrators that will allow them to monitor the website and check for any problems regarding the website's configuration and panels. It will also make it easier for administrators to change information on the website when it is needed, albeit with restrictions to prevent situations where one admin can change whatever they want on the website.

In terms of ongoing support, the project team is committed to maintaining the excellence of the RCC projects post-launch. They will promptly address user inquiries, provide timely updates, and conduct regular maintenance checks to ensure optimal functionality and security of the websites. The goal is to foster a lasting partnership, offering continuous support to adapt and enhance the projects as needed, ensuring their sustained success within the RCC community.

## **Section 13: Results and Client Feedback**

Dr. Brian Callahan expressed satisfaction with the successful completion of each project phase, highlighting the fulfillment of all project scope requirements and client specifications. Subsequently, the entire deliverable was formally handed over to the client in preparation for launch. The team remains dedicated to maintaining a collaborative partnership with the client and RCC, focusing on ongoing innovation. Recognizing the time constraints during the project's execution, the team anticipates the possibility of incorporating additional features. This strategic approach aligns with the post-turnover plan, ensuring continuous support and adaptability. Overall, feedback from the client was positive, with any minor adjustments identified expected to be promptly addressed in the near future.

The main source of feedback revolved around the Capture the Flags and their content, as well as the user experience of completing them. Specific functionalities such as CTF upload, CTF searching, and CRUD operations (create, read, update, and delete) facilitated the collection of this feedback. While the data included in the CTFs was typically very in-depth, the process of completing the CTFs in the site's coding playground was described as very basic. Users suggested that it could be reworked to include more challenging CTFs or simply expand the variety of CTFs available. The inclusion of CRUD functionalities also provided valuable insights into how users interacted with and managed the CTFs on the site. This feedback mechanism allowed for a comprehensive assessment of the user experience, ensuring that the site's coding playground aligns more closely with user expectations and preferences.

In addition, the site is currently a huge step up from the RCC's past online presence (which was nearly nonexistent) and the client was thrilled to have a frontend that could be viewed by anyone on the internet. With this, however, the client would like to see the site scale to reach a larger audience and hold more data in the future, while maintaining current functionality, or better yet, increasing functionality alongside its scale. This could be done in a multitude of ways with some options that the client offered being, more CTFs, different challenges in the coding playground besides just CTFs, a possible way to test the security of the actual site (most likely in an emulator as to not expose the website to possible malicious attacks), etc. Beyond these suggestions, the project team has also begun to think about more possible changes to both the front end and backend of the site as it continues to be used in the future.

A final piece of feedback from the client was that being a member of the RPI community and a professor in the ITWS department, the client would like to make edits to the site, alongside the development team, to further increase the overall effectiveness and functionality of the web application. These edits would not only be made initially after the project solution was presented but would continue to be altered well into the future to match the evolving needs of the client and where the client wants the web app to be functional and aesthetics-wise.

## **Section 14: Conclusions**

In reflection, the project with the Rensselaer Cybersecurity Collaboratory has been an unequivocal success, fostering a positive and enriching experience for both the team and the client. Throughout the collaboration, the team encountered numerous learning opportunities that facilitated individual and collective growth. The collaborative spirit and continuous discussions with the client allowed them to navigate project updates seamlessly, leading to minimal challenges and a smooth communication flow.

Amidst the overall positive experience, the journey with the RCC project wasn't without its share of hurdles. The intricacies of time management posed a substantial challenge, with the three project phases extending beyond initial estimates. This resulted in not only extended work hours but also unforeseen delays that impacted on the project timeline. There was also the approval waiting process from DotCIO, a critical checkpoint in the project plan that took nearly two weeks, causing a ripple effect of disruptions in the detailed timeline. Furthermore, the backend development for phase 2 encountered unanticipated intricacies, particularly in web scraping, leading to an extended timeline for completion. These challenges, while demanding, became valuable lessons in navigating the unpredictable landscape of project execution.

To combat the time-related challenges, the team strategically leveraged communication tools such as Discord, utilizing both text channels for ongoing discussions and voice channels for more immediate exchanges. This comprehensive approach, along with the establishment of due dates and alarms, played a crucial role in maintaining alignment among team members. While a few deadlines were surpassed, the collaborative team effort emerged as a dynamic force,



effectively compensating for any delays, and ensuring a cohesive workflow. The delay in DotCIO approval prompted the team to take proactive measures, emboldening them to move assertively into subsequent phases. This showcased the team's adaptability in navigating unforeseen obstacles and maintaining momentum in the face of challenges. As the team neared the project's conclusion, recognizing the importance of consistent and direct communication, they heightened the frequency of meetings with the client.

Despite these challenges, the project's success was evident. The client expressed satisfaction, and the team, having faced unexpected hurdles head-on, emerged triumphant. The experience taught valuable lessons, emphasizing the importance of starting early and adapting to unforeseen challenges. The team is proud of its collaboration with the RCC and Dr. Callahan, gaining first-hand experience in overcoming obstacles and delivering a successful project.