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Digital Hallpass Monitoring System to Improve Emergency Evacuation Procedures in Secondary Schools

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1. Introduction

This paper will describe a senior capstone project to create a digital hallpass system for Lima Senior High School to replace their current paper-based system. There are a number of motivations for implementing this new system, with many of them centered around safety and security. Most importantly, this digital system will allow school faculty to have an accurate, up-to-date list of all students that are not currently in their scheduled class rooms. This could be very beneficial in the event of an emergency, so that school administrators can account for these students, whether the situation is an evacuation or a lock-down. It will also allow school faculty or administrators to quickly verify if a student has a valid hall pass when they are seen outside of their classrooms. Additionally, switching to a digital system from a physical, paper-based system is a way to further reduce contact between people during the COVID-19 pandemic.

This system will have a number of convenient features for teachers and administrators to use. It will allow access to data for faculty to observe student patterns such as who goes where, how often, and at what times. It will also allow the viewing of all currently active hallpasses, which can be extremely important for the safety of students in cases of emergency such as a fire or lockdown.

Aside from the team's solution there are other digital alternatives to hallpass monitoring currently on the market. The most notable are e-Hallpass [1] and SmartPass [2]. These systems provide mobile device specific applications to allow a student to request a hallpass that can be approved by a teacher through a web-page. These existing solutions would not allow Lima Senior to utilize student identification cards. Along with the high cost of these alternatives, another down-side is that they require students to utilize their mobile devices, typically cell-phones, during school hours. Lima Senior is reluctant to implement a digital hallpass solution that would encourage the use of cell-phones in the classroom.

The team is on track with creating an easy to use hallpass system for the client. The client has laid out their vision for the dream product that they want to use in the future. The full paper will present a detailed overview of the problem, existing solutions on the market along with their drawbacks and limitations, and the overview of the solution to create the digital hallpass monitoring system to improve emergency evacuation procedures in secondary schools.

The rest of this paper is organized to give the audience a better understanding of the current software solutions already available for hall monitoring and the software that is being developed for Lima Senior. In Section 2, the problem definition is explained including constraints and evaluation metrics. Section 3 includes a comparison of the currently existing solutions that are available for hall pass monitoring. Section 4 outlines the proposed solution for Lima Senior High School catering to their needs and preferences. Section 5 goes over the implementation of the software explaining what languages and frameworks will be used. Finally, Section 6 concludes this paper by giving a quick overview of what was discussed throughout.

2. Problem Definition

The team's goal is to create a digital hall pass system for Lima Senior High School to replace their current paper-based system. This new digital hall pass system will allow teachers to create hall passes for their students, which school administration will then have access to in real-time. These hall passes will record the student the pass is assigned to, the teacher that created the pass, the locations the student is leaving from and going to, and the times they left and returned. The hall pass data will be stored for the course of the entire school year. There are a number of helpful convenience features that are also requested. Some examples are the ability for school administrators to view all currently active hall passes, and the ability to view reports of the school year's data. Potential other customers would be other school systems, particularly larger ones.

The team has a number of constraints for the project that were developed through meetings and discussions with the client about their requirements and visions for the hallpass system. They are separated into capability and numeric constraints, depending on whether they were quantifiable or not. The team also developed a number of evaluation metrics.

The capability constraints are shown in Table 1. Many of the capability constraints revolve around the access to the program, such as requiring the use of Google's G-Suite single sign on, limiting the administrator component to only authorized administrators, and limiting the teacher component to only authorized school faculty. Other constraints concern the basic functionality of the system, such as the teacher component needing to allow the checking in and out of students, check in and check out being completable with the student's ID, and the administrator component must be able to show all currently active passes.

Table 1: Capability Constraints

Capability Constraints
Teacher component must allow checking in/out of students
Teacher component must be usable by any authorized school faculty
Teacher component must not be usable by any non-school personnel
Student check-in/check-out must be completable using the student's ID
Administrator component must not be usable by any non-administrators
Administrator component must be able to show all students with active hall passes
Database must at least store Student ID, check-out time, check-in time, initial location, and destination location
Database must not lose any records
Must use existing G-Suite single sign on for authentication

The numeric constraints are shown in Table 2. The two most important numeric constraints are about the time for experienced or inexperienced users to check students in and out. This is important since the time to use the system must be at least as fast as the current paper-based system, otherwise teachers will not want to switch to using the new system. The other constraints are to ensure that the system can handle the amount of students and teachers that the school requires.

Table 2: Numeric Constraints

Numeric Constraint	Target
Time for an experienced user to check in/out a student	< 45 seconds
Time for an inexperienced user to check in/out a student	< 180 seconds
Supported number of teachers	> 100
Supported number of administrators	> 10
Supported number of students	> 1100

The Evaluation Metrics are seen in Table 3. There are a couple of basic cost metrics, which are best to minimize. There are evaluation metrics related to the usability of the system, such as the time for an (in)experienced user to check in and out a student, and the number of button presses necessary to do so. These are best to be minimized to maximize the ease of use of the system. There are also some evaluation metrics related to the maintainability of the project, such as the percentage of lines of code covered by unit tests, and the number of undocumented methods/blocks of code. Maximizing the maintainability of the project is a major concern for the project, since a less maintainable system will have higher recurring maintenance costs, and is more likely to fall into a state of disrepair.

Table 3: Evaluation Metrics

What to Measure	Unit	Target
Up-front costs	$	Lower is better
Recurring costs	$/yr	Lower is better
Time for an experienced user to check in/out a student	seconds	Lower is better
Time for an inexperienced user to check in/out a student	seconds	Lower is better
Number of buttons pressed to check in/out a student	# of presses	Lower is better
Lines of code covered by unit testing	%	Higher is better
Supported number of teachers	# of teachers	Higher is better
Supported number of administrators	# of admin.	Higher is better
Supported number of students	# of students	Higher is better
Time to load teacher component	seconds	Lower is better
Time to load administrator component	seconds	Lower is better
Number of undocumented methods/blocks of code	number	Lower is better

Stakeholders

The team has identified six main groups of stakeholders for the project:

- Students
- Teachers
- School Administrators
- School IT staff
- The Capstone team
- Ohio Northern University

Obviously, the different evaluation metrics will be more/less important to each group. Students will value the speed and ease of use of the teachers' component of the project, along with the security of their data. If the teacher's component was slow and hard to use, the students would get frustrated while waiting for their teacher to fill out their hall pass. This will be especially true if it is slower than the do-nothing alternative of the existing paper-based solution.

Teachers will primarily be concerned with the speed and ease of use of the interfaces they will be working with. They would also feel frustration if their interface to the project was slow or difficult to use, and they would see the system as a waste of time if it slows them down compared to their existing paper-based solution.

School administrators will be concerned about the speed of the component they will be working with, particularly viewing all active passes. In an emergency situation, the faster they can get that data the better. Additionally, administrators will be concerned about the speed, costs, and security of the project. For them, a slow teacher component would mean wasting the time of both the teachers and the students.

School IT will be most concerned with the security and maintainability of the project. They do not want to be handed a project that will break immediately and will take many hours of work to keep working every school year.

The capstone team and Ohio Northern University are concerned with all of the different metrics, as their reputations are on the line if the project fails to meet expectations. Especially important are the security concerns, as a breach of security/privacy would reflect poorly on the groups, and an especially egregious breach could have more tangible consequences.

3. Existing Hallpass System Options

There are a few competing products on the market that could be used as a substitute for the project. The largest competition is the hallpass monitoring system that is already in place. The other competition to the project is digital forms of hallpass monitoring that is done through a google form or through a web page and application.

There are two different hallpass monitoring systems used widely throughout schools. The first system uses classroom-specific, physical objects that are passed from student to student as they would like to leave a teacher's classroom. This object prevents more than one student from leaving the classroom at a time and cannot notify the administrators of the students who are not in the classrooms in the event of an emergency. The other system, which is currently in place, uses sheets of paper that the teacher fills out with the location that a student is traveling to and the time that they left. After the teacher signs the paper the student is free to leave for their destination. This system is also unable to report to administration the students that are not in the classroom during an emergency, although it does allow some amount of historical data tracking if the slips of paper are saved.

The digital alternative to hallpass monitoring allows administration to be notified of students that are not in a classroom during an emergency. A google form can be used to create a digital hallpass system however this system makes it very difficult to analyze data later. A google form hallpass system is typically implemented using a form specific to the teacher that is scanned on a

phone by the student to request a hallpass and the teacher then approves before the student leaves.

There are digital alternatives to hallpass monitoring on the market now. The most notable are SmartPass and e-Hallpass. Both of these systems provide mobile device specific applications to allow a student to request a hallpass. A teacher can approve the hallpass on a web page or through a teacher specific application on mobile devices. These products allow the teacher to review who has been leaving class more frequently, administration to put limits on individual students, and track the exact location of a student while they are not in the classroom. SmartPass is priced as $2.45 per student annually plus an additional $200 base fee and e-Hallpass costs $2.00 per student annually. To support the number of students that the client has requested SmartPass would cost $2,895.00 annually and e-Hallpass would cost $2,200.00 [1], [2].

The largest distinction between SmartPass or e-Hallpass with the team's solution is that the team will be utilizing each student's identification cards to create hallpasses so that a student is not required to use a mobile device. The team's solution will also allow for Lima Senior to utilize their Google Single Sign On for teachers to access the web page. This will allow Lima Senior faculty to use their existing log-in credentials to access the digital hallpass system, similar to how they access all other school affiliated services.

Table 4 provides a brief comparison between the different competing solutions.

Table 4: Competing Solutions

Features	**e-Hallpass [1]**	**SmartPass [2]**	**Existing System**	**The Team's Solution**
Emergency Reporting	✓	✓	X	✓
Historical Data Tracking	✓	✓	X	✓
Low Cost	X	X	✓	✓
Utilize ID Cards for Pass Creation	X	X	X	✓
Google Single Sign On	X	X	X	✓

4. Proposed Solution

The team's proposed solution includes the following components from the potential solutions: barcode scanners and a feature to use web cameras to scan the student ID card, a web application that uses Laravel as a PHP framework for teachers to interact with the program and for administrators to gather reports, and lastly using mySQL as the database management system.

A specific barcode scanner has yet to be decided by the client as they are still evaluating the options that were presented to them. The specific type will not be as important for now as all scanners will follow a similar implementation procedure in the program. The team will be beginning with developing a working system for their cameras to scan the ID cards. This is a crucial feature for the system as the client may decide to not do the barcode scanning but is still important to have barcode accessibility in case they ever want to use it instead. The user interface will have an option to manually enter the student ID number as a fail safe for any failure with scanning, or if a user finds manual entry easier.

On the front end of this system will be the user interface being displayed through a web based application. To access this, staff will need to go to the web URL and login using their GSuite sign in. The user interface for the teachers will have a "My Passes" section as the homepage. In this section they can create new or future scheduled passes as well as see their active and scheduled passes (Figure 1) (Note: All names in Figures 1, 2, and 3 are examples, and are not based off of real people).

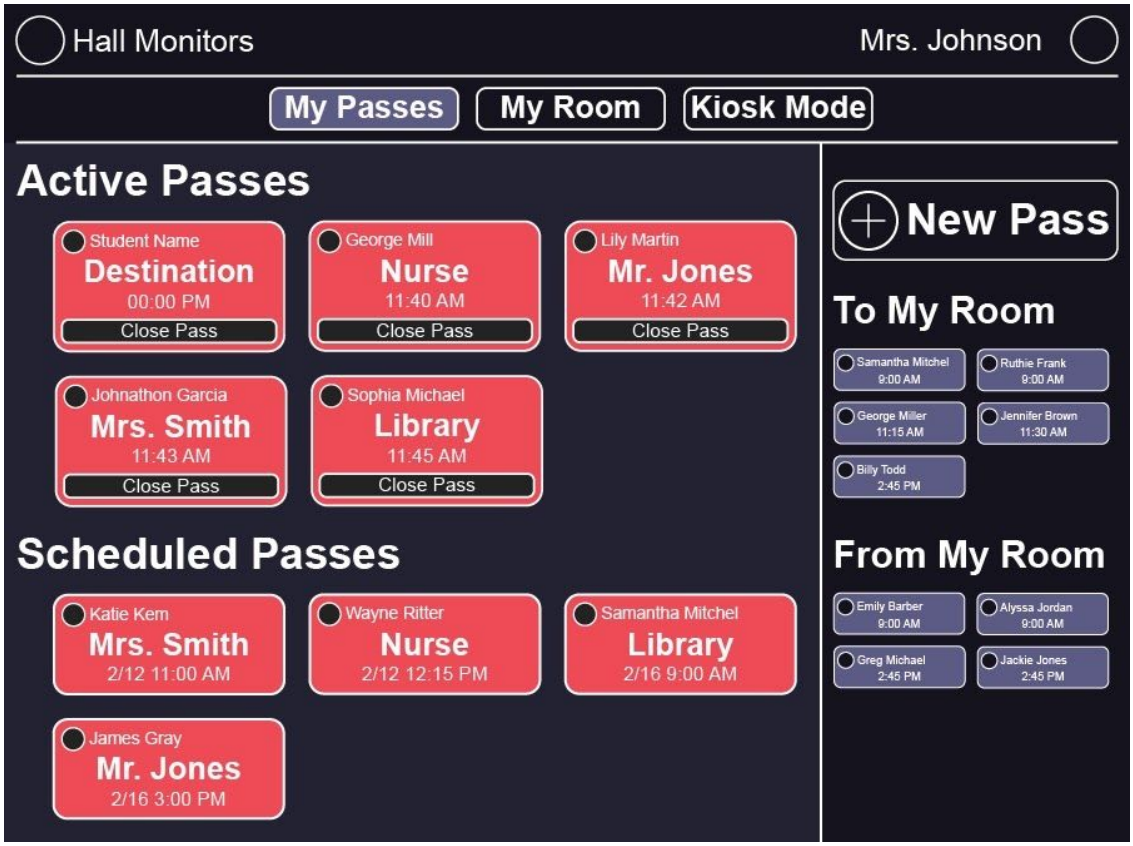

Figure 1: My Passes View

When they click on an option to create a pass, a popup will be displayed and from there they can then scan the barcode or enter the ID manually. Once the ID is entered, the student's name will appear. This information is being pulled from the school's student database. The pass' "From" category will be automatically filled with the teacher's name based on their GSuite information. The current time will also be auto-filled if it is for a current pass, or will need to be manually entered if it is a future pass. Lastly, the teacher will then have to enter a destination from a dropdown list that is pre-populated with locations.

Once the pass is created, it will be added to their "My Passes" page and will be returned to that screen. From the "My Passes" page, users can also go to a different view which is the "My Room" tab (Figure 2). This tab shows any passes that are being directed to that teacher (ie. a pass that a different teacher created but the student's "To" destination is at the specified teacher's room).

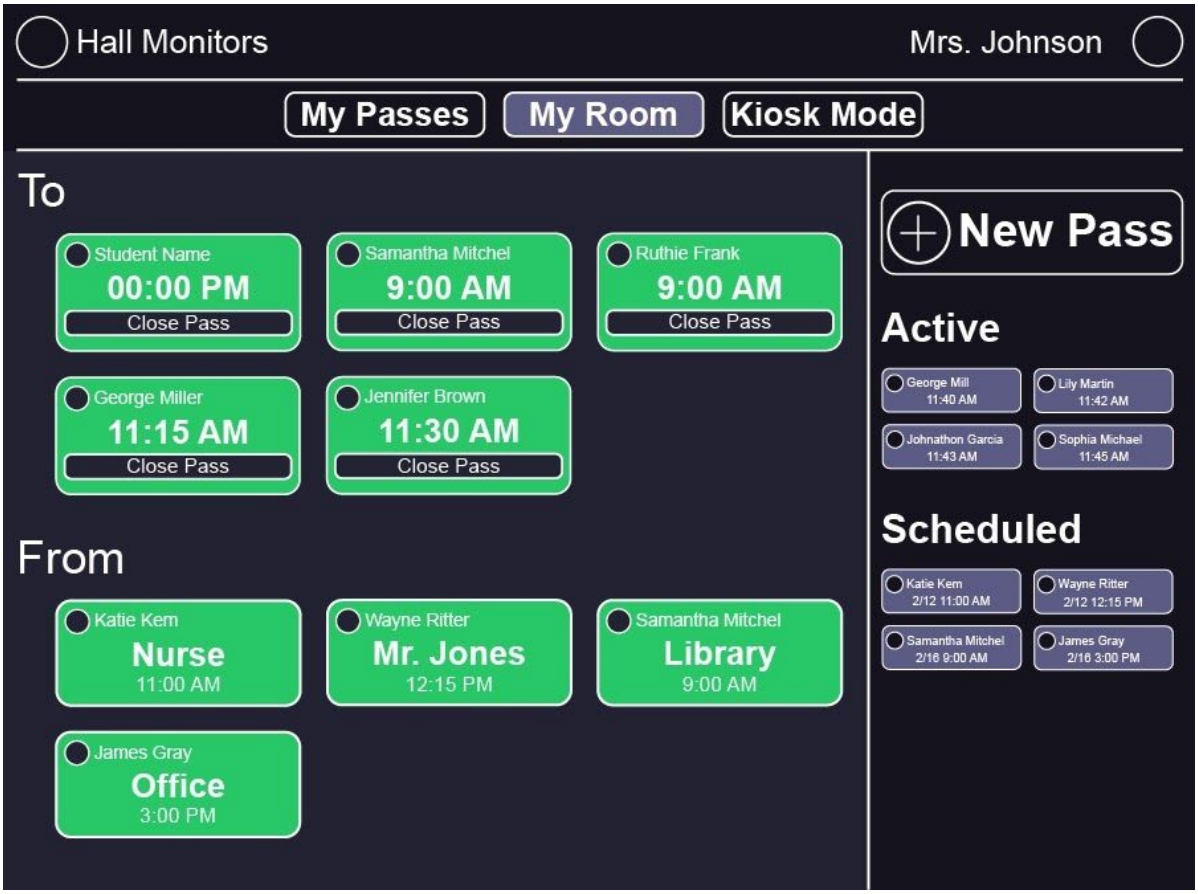

Figure 2: My Room View

Lastly, users can navigate to a “Kiosk Mode” which will be for creating multiple passes (Figure 3). This page will be stuck on the pass creation page and allows teachers to create many passes at once without having to start the pass creation process from the beginning each time.

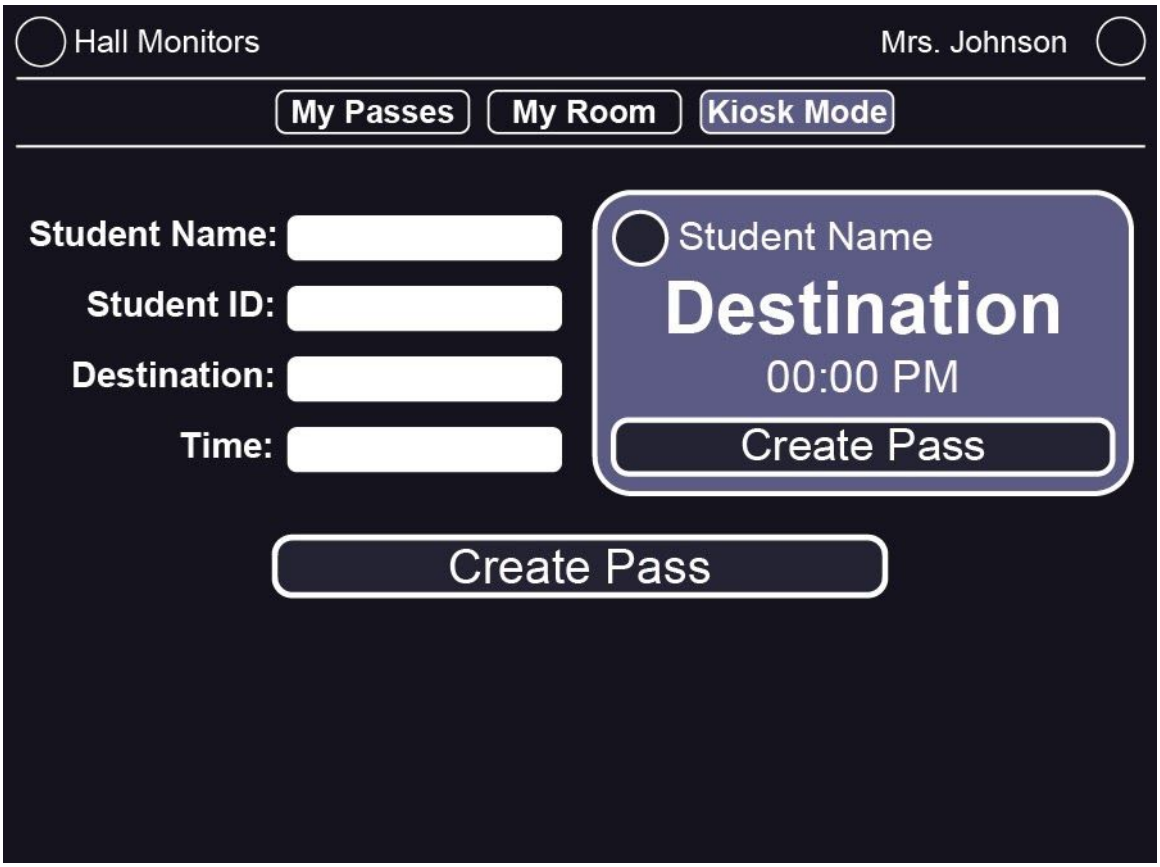

Figure 3: Kiosk Mode View

The administrator interface will be almost identical. The difference is that instead of the “My Passes” section they will have “All Passes” and can view every pass that is currently active as well as all scheduled future passes. Where they should find the “My Room” page, they will instead see a page for the analytical data. The client is still working on creating specific data that they would like to see on this given page, but once specified, the team will have templates created for displaying this information.

Based on the team’s previous evaluation of PHP frameworks in potential solutions, the team decided to go with Laravel. The amount of documentation provided for Laravel over Symfony was the biggest deciding factor [6]. The IT team at the school mentioned that any PHP framework will work with their current servers, and with all the resources that Laravel provides, integration will be easier to do. Laravel uses a database configuration file to make connecting to a database simple [4]. It also includes the Eloquent ORM, which provides a simple, object-oriented method of interacting with the database, instead of building raw SQL queries [7]. This can make the flow of data easier to understand, and can help prevent SQL injection attacks on the system. It also follows the model-view-controller (MVC) architectural pattern for developing the user interface. This makes the development process more efficient and easier to

follow for future maintenance. Laravel also includes a template engine called Blade [5]. Blade makes working with data and logic inside views easier than regular PHP. The team will be using Blade a lot when it is required to display data from the database for the administrator views as well as any hallpasses for the teacher views.

The school currently uses mySQL as their database management system. The team will need to query their existing database in order to retrieve information about students, specifically to retrieve their names and grade levels. The system will also be using mySQL as its own database and will hold all the relevant information needed by the system that is not already stored on their current database. This will primarily be the Passes table, which will hold all of the information related to passes. The final schema is not yet determined but it will at minimum contain the information specifically requested by the client: student ID number, location leaving, location returning, time left, and time returned. There will likely be additional tables, such as a Locations table, which would store all of the pre-filled location options when creating passes. Other tables may be added as they are found to be necessary while going through development and meeting with the client.

This design checks off all of the given capability constraints. Its user interface allows teachers to check students in and out as well as completing this by using the IDs. The GSuite sign on capability allows only teachers and administrators to use it and also restricts them to only view their given roles. Both of their pages have the required functionality. Lastly, the database records all of the needed information and stores it in an easily usable way. This design also creates value when compared to the traditional hallpass system. It becomes a more efficient process in terms of speed and accuracy, and it also allows reports to be generated from recorded data. There currently is not a method of recording any sort of hallpass data so this is a huge improvement over the traditional system.

5. System Implementation

Development of the database and web application are well underway as of the writing of this paper. The team currently has working prototypes of both components, and the basic use-case of creating and closing hall passes is functional. We aim to complete the rest of development soon, so that there is ample time for integration and integration testing.

The team expects integration to take a significant amount of time for this project, as they are aiming to integrate the project into Lima Senior's existing systems in a way to make it as easy to use for teachers, students, and administrators as possible, and in order to minimize costs. The team will need to get the project's database running on the client's existing database server hardware, and to get any necessary connections to their existing databases setup and secured. The team will need to get the project's web application running on the client's existing server hardware, and also set up secure database connections for the web application. The team will be needing assistance from Lima Senior's IT staff in order to set these different components up, although how the work will be divided is currently unknown. It is possible that the team will do the majority of the work, with just some help from their staff. The opposite could also happen, with their staff doing the majority of the integration work.

Another important aspect of integration will be integrating with Lima Senior's existing Google single-sign-on for the application's authentication. One exchange the team had with the school's

IT staff made it appear that this shouldn't be a difficult task, and the IT staff may already have a script that will perform the necessary authentication. This will have to be more thoroughly discussed and tested as the team gets further into implementation and integration.

During and after integration, the team will have to perform various kinds of integration testing. This will involve testing all of the different connections between different components of the project, along with end-to-end testing once all components are finished. To assist in this phase the team will be performing a beta test with a small group of faculty from Lima Senior. This small release will allow the team to have a final test before deploying the system.

After the team has completed the project and handed it off to the school's IT staff, all maintenance will be handled by the IT staff. This means that the team needs to make the project as maintainable as possible, in order to reduce the effective cost of maintaining the project. The team has already made some decisions to make maintaining the project as easy as possible, such as deciding to use the same web server and database systems as the ones they use currently. The team also has a couple of maintainability-focused evaluation metrics to help us make the project as maintainable as possible.

Due to the project storing information of students the team will be required to follow all of the FERPA requirements in regards to who has access to each student's information. In accordance with FERPA all of the data that is stored is the possession of the student if they are over the age of eighteen unless they are claimed as a dependent on their parent or guardian's most recent taxes. If the student is claimed as a dependent then the stored information is the possession of the parent or guardian.

The team will also be following the Web Content Accessibility Guidelines (WCAG) in the implementation of the project. These guidelines are used to create software that is accessible to people with disabilities. This is essential to the project due to the implementation of the software in a school environment. If the software is not accessible to students with disabilities the school will not implement the solution [4].

In addition to FERPA and WCAG there are some standards and codes that are directly related to software engineering. Many of the standards and codes created for software apply at a hardware or programming language level and the team will not need to implement the code or standard. Below are some standards and codes directly relating to software that the team will be following while creating the project.

The ISO/IEC/IEEE 29119-3:2013 software and systems engineering software testing standard is defined to create standards for software testing that can be used when testing software performance. This set of codes and standards will be used in this project to determine how the team will test the software in the implementation testing phase of the project [3].

The ISO/IEC TR 24766:2009 information technology standard is used to guide a team in the development of desirable engineering tools and provides evaluation criteria for the created tools. The team will use the criteria in this code to determine that the project has a long life cycle and decreases the amount of maintenance costs [3].

In the implementation of this project the team will also be required to implement many application programming interfaces (API). Many of these APIs have standards regarding how

they are used in a software application. At the present time the team is unable to identify all of the APIs that will be needed to implement the project.

6. Conclusions

The primary goal is to create a digital hall pass system for a high school to replace their current paper-based system. The client is a local high school with about 1,100 students and they have a set dream product in mind with many constraints that has guided the team on a clear path to a preferred solution. The team wants to create a faster and more effective hall pass system than the one the client currently has that is also more hands-free in the COVID-19 environment. Since students all have their own personal identification cards with a barcode and number, the client would like them to be used as a data entry for a hall pass system. Whether it be scanning of the card via barcode scanners or iPads or just a manual entry of the number, the student will be logged in a database with the time and location. There are a number of helpful convenience features that are requested to pull analytical data on students regarding their time being out of a classroom. These same features are used to determine who is not in a classroom during the case of an emergency.

Since the client has very specific constraints for the project, it makes it more difficult for further sales of this product. It is still possible to use the project at other high schools, bigger or smaller, but the further the team gets into the customer requirements, the more integrated the project gets with this particular high school. Each client would have their own constraints for the monitoring system as well as the provided hardware and technology. Modifications that would need to be made in order to make this more versatile would be multiple operating system implementations, become less dependent on current databases and web server hardware, require a specific budget for barcode scanners, and remove any hall pass rules that are specific to the current client. If the team were to do this project again, something that should be done differently is how it is presented to the client in order to make it more versatile. Though the capstone project is for a specific client, at the time the team was not thinking about mass production and possibly selling this product to other school districts. Due to this the team began integrating the project with the client school specifically and allowed them to completely define the layout of the application and user interface.

References

[1] Eduspire Solutions. 2020. *Online Digital Hall Pass | E-Hallpass | Eduspire Solutions*. [online] Available at: <https://www.eduspiresolutions.org/e-hallpass/> [Accessed 16 September 2020].

[2] Smartpass.app. 2020. *Smartpass Digital Hall Pass*. [online] Available at: <https://www.smartpass.app> [Accessed 16 September 2020].

[3] ISO. 2020. *Standards*. [online] Available at: <https://www.iso.org/standards.html> [Accessed 10 September 2020].

[4] "Installation," *Laravel*. [Online]. Available: https://laravel.com/docs/8.x. [Accessed: 29-Oct-2020].

[5] "Blade Templates," *Laravel*. [Online]. Available: https://laravel.com/docs/8.x/blade. [Accessed: 29-Oct-2020].

[6] "Documentation," *Symfony*. [Online]. Available: https://symfony.com/doc/current/index.html. [Accessed: 27-Jan-2020].

[7] "Eloquent ORM," *Laravel*. [Online]. Available: https://laravel.com/docs/5.0/eloquent. [Accessed: 27-Jan-2020].