2015-2016 ACRP University Design Competition

SimpleQ - An Innovative Security Queue Management System

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Number of Undergraduates: 4
Number of Graduates: 0
Advisor: Professor Eirik Hole

Executive Summary

Through our research, we have found that one of the most unpleasant parts of going to the airport for passengers is the security line. Passengers can spend anywhere from a couple minutes to a couple hours waiting in this line, bottlenecking the flow of airport traffic. Our goal is to minimize the time passengers spend in the security screening queue while also improving their overall customer experience and increasing airport revenue with our new queuing system.

The SimpleQ program will accomplish our main goal while also increasing revenue and customer satisfaction at airports. It works incredibly similar to drawing a number at the deli counter or getting a buzzer at a restaurant. Upon entering the airport, you will be entered into the queuing process and receive a number in our system. After that, you will wait for your time to go through security check. During this time, you can use our app or text message based system to do a variety of things including: checking where you are in the queue, postponing when you want to be called, and receiving alerts for when it is your time to go to security check.

Due to its innovative design, we have very few competitors. This allows us to create a new market for us to thrive. The one-time software purchase by airports will be recuperated over time with the increased revenue generated for the airport after its implementation. Revenue for the airport is created through higher rents charged to restaurants or stores in the airport because higher foot traffic is guaranteed.

In theory, this would be able to be purchased by airports everywhere due to the fact that the airport could gain significant amounts of profit through multiple new revenue streams. Additionally, more passengers would be drawn to airports with this software for the higher customer satisfaction they would experience.

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1 - Problem Statement & Background

The topic the team addressed is how much time is wasted by by passengers waiting in the queue for security check-in. The scope of the project encompasses analyzing and improving the process at the point after passenger/luggage check-in to the point right before passengers complete the actual TSA check. On a normal day, waiting on line for the security check makes up a lot of the time the passengers spend at the airport, besides waiting to board the plane or for it to take off. By improving the pre-security screening process, the overall experience of the passenger will also be improved. Better customer experiences will encourage passengers to continue to come back and cause an increase in airport and airline business.

We spoke to people who often visit airports and asked them what they thought the biggest problems in airports were, and possible solutions for those problems. They told us that they often thought the most difficult part of being in an airport was having to wait in the line for security clearance, and that this process often took much longer than necessary, wasting much of their valuable time. Through extensive research and eliminating other brainstormed ideas, we decided to specifically address improving this queueing management problem. We believe that by improving this aspect of the airport, we will be able to help the flow of the entire airport for our clients, both the employees and passengers, and help prevent delays in everyday processes. Our team believes that through this project we can fix this problem by making the system faster and more efficient through a new and better queuing management system.

The current processes for security queueing are incredibly inefficient. It takes an excessive amount of time for passengers to get through the queue. Our goal was to work to make these processes faster and make it possible for more people to get through security faster and

with less idle waiting time. Less idle waiting time leads to improved customer satisfaction, which will greatly improve passengers' overall experience when taking a trip to the airport.

We started out by looking at different designs to decrease the amount of idle waiting time. We thought of many different things but settled on the following two alternative concepts:

The first is called SimpleQ. This is an app which will assign different group numbers to individuals and parties. Similar to getting a number at a deli, passengers will be called to the queue by group number only when it is their turn in the system. This app will be free to users and will allow for advertisement and deals by shops and restaurants inside the security system. This app will also address issues such as people traveling together, missing allotted time, and postponing time to be called. This will also promote more revenue before the security check and give opportunity to those that are not flying to spend money.

Our second design was extending the conveyor belt and seeing how this affects the security system flow. Before going through the security check, passengers spend a lot of idle time waiting for the passengers ahead of them to lay out their belongings properly to run through the scanner on the conveyor belt. With a longer conveyor belt, more people would be able to get prepared for the security check, which in turn would decrease their idle waiting time in line. If there are more people ready, it can be assumed that the process will be smoother and there will be less of a bottleneck effect.

We sought to Anylogic for our numbers and simulations of the alternative designs to solve our chosen problem. Anylogic is a commonly used simulation and modeling program that allows us to simulate the current queuing system for security in Newark International Airport (EWR), Terminal C. We chose this as our environment to model because it is close to our school, allowing us to go and observe at our convenience for necessary data to run the model. Also,

EWR has great ratings so we have gone ahead and assumed that their security kiosks and scanners are working most efficiently. This helps us remove factors that can effect our data rendered from our model and simulation.

The biggest design challenge we experienced was programming system itself, after a winning design was chosen from simulating the alternatives. We have made a theoretical app and program to represent SimpleQ. Considering our team does not have extensive software and/or application programming experience, prototyping was the most difficult challenge we faced. We relied on the simulations to prove that our solution would be a viable one in real life.

2 - Literature Review

When we first read over the prompt for the competition, we started with a couple basic questions. “What is the biggest problem with airports?” “What makes people unhappy about how airports are run?” “What are things that make the airport less effective in its goals?” With these questions in mind we started thinking. We first started with “airport employee management”. We thought if we could manage the employees more effectively, then the entire airport would run more effectively. Eventually we decided that that idea might be a little broad, and we decided upon a slightly more specific idea of managing the airport security line. From there we started doing background research on what about the security line made passengers so upset. And we decided to look more in depth on the queueing of people into the security check.

When our team finally decided upon a topic we pulled from every resource we could find. We reached out to multiple professors, an alumnus who currently works for the airline industry, and found all of the literature we could get our hands on. We used notes from a previous class, Modeling and Simulation, and used the text from that class “Introduction to

Management Science" by Bernard W. Taylor III, Eleventh Edition. From this text and the notes we found a lot of general knowledge on queuing theory, and a number of different approaches we could take. It introduced us and refreshed us on queueing theory principles such as "the calling population", "arrival rate", "service rate",etc. Next we used a variety of websites including, ifly.com, the TSA's website, and the Port Authority of New York & New Jersey's website. This gave use data on Newark Liberty Airport and wait times for their security lines. These helped us create a base model from which we could refer to. We also took time to go to Newark Airport and gather data by watching people go through the security lines and timing them.

3 - Problem Solving Approach

In order to solve the problem, we reviewed the overall acceptance criteria and measure of effectiveness. What's more, we identified the stakeholder requirements, constraints, and regulations. After that, we started our multiple alternative designs. Finally we narrowed down all alternative designs into one final design based on their overall efficiency, cost, etc.

Evaluation

Acceptance Criteria

1. Provide clean and simple integration software which will generate a queueing number for passengers using boarding tickets at check in.
2. Identify different revenue generating opportunities for the airport.
3. Provide a simple text, app, and website interface for travelers to use to stay up to date with security line information.

4. Organize a security check method to minimize time standing in line to get scanned.

Measures of Effectiveness

1. Time spent standing in security line before being able to put items in basket.
2. Money the airport can generate with new system and external investors in the airport.
3. Sum of internal and external orders equal to the total usage.
4. Maintain the same security level (not to interfere with TSA).

Stakeholder Requirements

- The system shall compute estimated queue times for passengers.
- The system shall update the passenger of the time remaining before being called to the queue.
- The system shall allow the passenger to input personal information.
- The system shall allow the passenger to stay in queue for the security check without waiting in line.
- The system shall not affect TSA security or safety check procedures.
- The system shall not give priority to passengers arriving late.

Technical System Requirements

- The system shall be able to collect data and store data.
- The system shall be able to calculate the queue time real time.
- The system shall be able to interact with customers.

Constraints

We have a few constraints within the project. First, we can only assume that the data for the time each step taken at the airport, each process, from the samples we have taken is the average of the population. Our second constraint is that we have to assume that the Newark International Airport, Terminal C's security line base set-up is the same at other international airport terminals. We also have the constraint right now of getting real data from an airport. We have reached out to Newark International Airport many times, however there has been no permission granted to go into the terminal and observe actual data. Another constraint is that we have to assume that the TSA security check time is the same for every traveler except for some exceptions who might have to be double checked. We have to assume that there is a certain ratio for this. Any data we have collected so far is by self simulations and estimations. Another constraint we have is we are assuming that the time and day we chose to have the model represent is representing every normal, non-holiday rush day at the airport. We will be reusing the conveyer belt and the employees at the beginning of the security queue line. We have to assume that the employee is doing his/her job with full effort and following all protocols and standards. If we plan to create an app, we will need to hire different developers that can create something that will help us meet our success criteria. We will be using AnyLogic for simulation and modeling and basing all our calculations on it.

Our priority is to keep the budget low, keep the same amount of employees, and have a very effective queueing method by developing an accurate model.

Design & Optimization

In order to approach solving the problem, we created a base model of Newark Airport Terminal C and ran the simulation for preliminary results. We then created alternative models, ran the simulations, and chose a winning design based on the resulting data discussed below.

Alternatives Considered & Modeled

As mentioned in Section 1, there were two alternative designs we modeled in an attempt to come up with a winning queue management solution. The first was assigning group numbers to passengers to be called when the system is ready for them. The second was extending the conveyor belt for their belongings. It was anticipated for Alternative 1 to be the winning design due to the drastic decrease in the amount people allowed in the queue at once, as demonstrated in the models below.

Base Model (EWR):

As seen below, this is a standard airport terminal set-up with multiple check-in stations and only a few winding lines with a lot of people waiting to go through only a few security lanes.

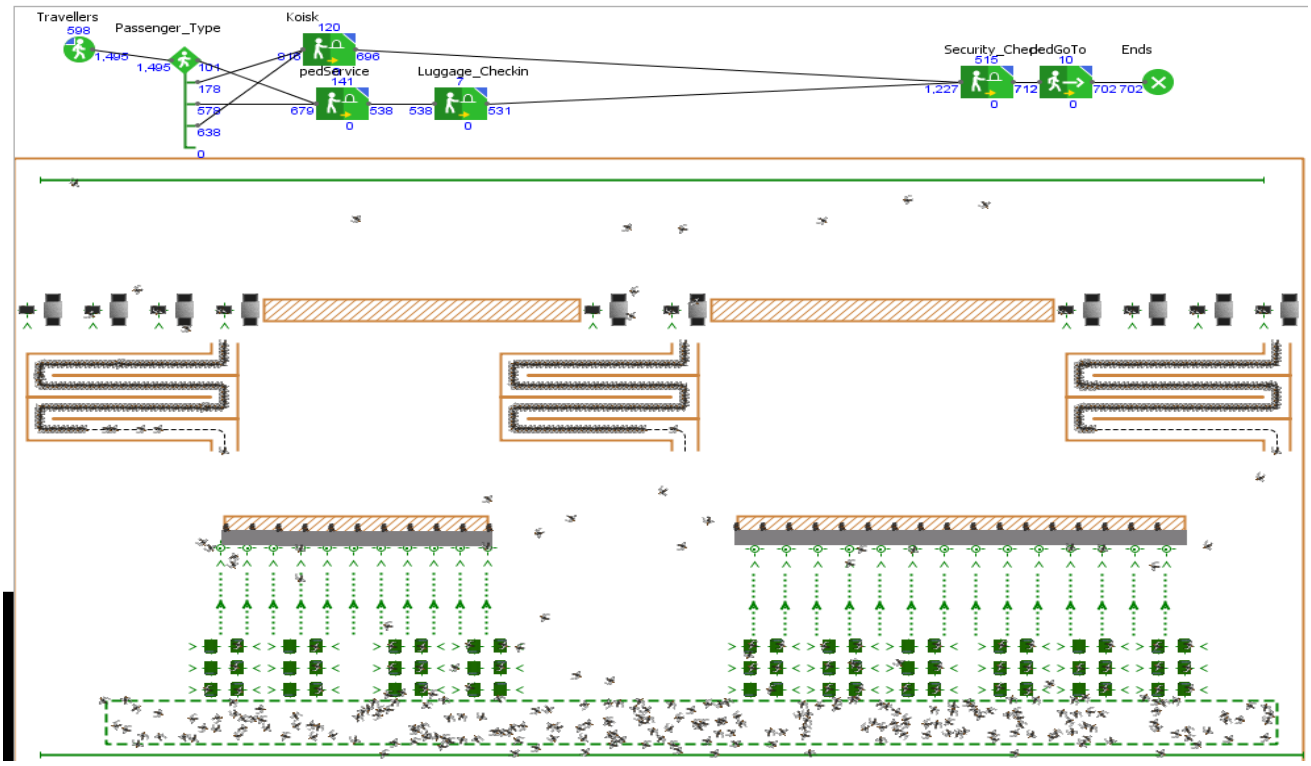


Figure 3.1: AnyLogic Base Model of EWR Terminal C

Alternative 1:

As seen in the below model, the large winding lines have been removed because of the decreased amount of people allowed in the queue at one time. The waiting area in the center, indicated by the rectangle made of the green dotted line, is where shops and restaurants would be placed so passengers would not be idly waiting in line.

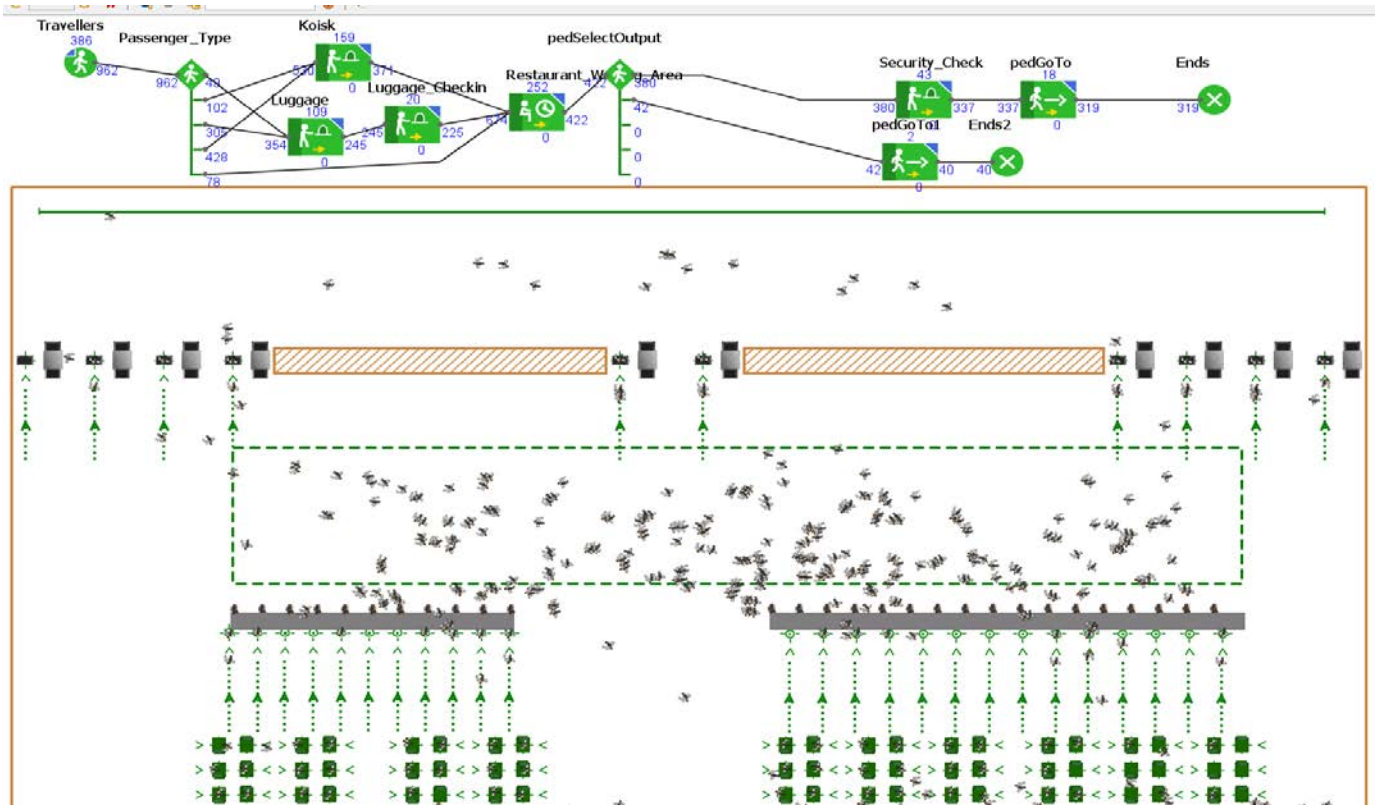


Figure 3.2: Alternative 1 AnyLogic Model (SimpleQ)

Alternative 2:

The second alternative looks the same as the base model, but numbers on the backend of the simulation were changed to account for the increased length of the conveyor belt.

Winning Alternative

Based on the results of the simulations in the table below, Alternative 1 proved to be the solution that would decrease the most idle time on average.

Model	**Avertime Time for Check-in**	**Average Idle Waiting Time in Security Check Line**	**Time Saved**
Base	2.29 mins	12.5 mins	N/A

Alternative 1	3.07 mins	2.45 mins	9.27 mins
Alternative 2	2.29 mins	8.45 mins	4.05 mins

Figure 3.3: Simulation Results

The check-in time for Alternative 1 is on average a little longer because of the additional information passengers may need to provide upon check in to be entered into the system. Despite the additional time at check-in, the idle waiting was still drastically decreased and was the result the team was expecting. After the winning design was chosen, we named it SimpleQ and proceeded to fully outline in detail how the system would work. We also stayed on track with outlining the details of the system's operations by following the acceptance criteria and measures of effectiveness we created as a team.

4 - Safety Risk Assessment

In considering designs for our idea, safety was considered as one of the top priorities. According to the FAA Safety Management Manual (2014), it is the primary concern of the Federal Aviation Administration "to provide the safest, most efficient aerospace system in the world" (p. 1). Because the design was based off of efficiency, we also wanted to ensure safety remained a top concern as well. It was decided to address the queueing process before the actual security check as not to interfere with the procedures and safety standards of the Transportation Security Administration (TSA). This was done to ensure passengers can remain just as safe, if not more, with SimpleQ implemented in airports.

Although our design does not pose a high threat of risk to passenger safety with only addressing the amount of people in the queue, we followed the Safety Risk Management (SRM) approach as mentioned in the FAA Advisory Circular 150/5200-37 to ensure that a proper

assessment could be made. The SRM approach consists of five phases: 1) Describe the system; 2) Identify the hazards; 3) Determine the risk; 4) Assess and analyze the risk; and 5) Treat the risk. Below is our resulting assessment of SimpleQ:

Phase 1 - Describe the System:

SimpleQ is an electronic/web based system that will interact with both passengers and airport employees, relaying relevant information back and forth in order to move passengers through the system safely and efficiently.

Phase 2 - Identify the Hazards:

Hackers/Viruses - One main hazard involves hackers getting into the system or the airport database(s) in order to interfere with passenger information or crash/harm the system.

Emergency Situations - In the event of any kind of emergency (i.e. - security threats to passenger safety, possible disease outbreaks, etc.), more people outside of the queue could change how the responses to these emergencies are handled.

Phase 3 - Determine the Risk:

Hackers/Viruses -

- Theft of passenger/employee information
- Theft of confidential airline/airport information
- System crashes/failures
- System and/or flight delays

Emergency Situations -

- Lack of organization in evacuations
- General passenger safety jeopardized (depending on the situation)

Phase 4 - Assess and Analyze the Risk:

Using the risk matrix provided in the FAA AC 150/5200-37, pictured below, each risk was given a likelihood (L) and severity (S) level.

Hackers/Viruses -

- Theft of passenger/employee information: Medium Risk (L-Remote, S-Major)
- Theft of confidential airline/airport information: Medium Risk (L-Remote, S-Major)
- System crashes/failures: Low Risk (L-Extremely Remote, S-Major)
- System and/or flight delays: Medium Risk (L-Extremely Remote, S-Hazardous)

Emergency Situations -

- Lack of organization in evacuations: High Risk (L-Extremely Remote, S-Catastrophic)
- General passenger safety jeopardized: Medium Risk (L-Extremely Remote, S-Hazardous)

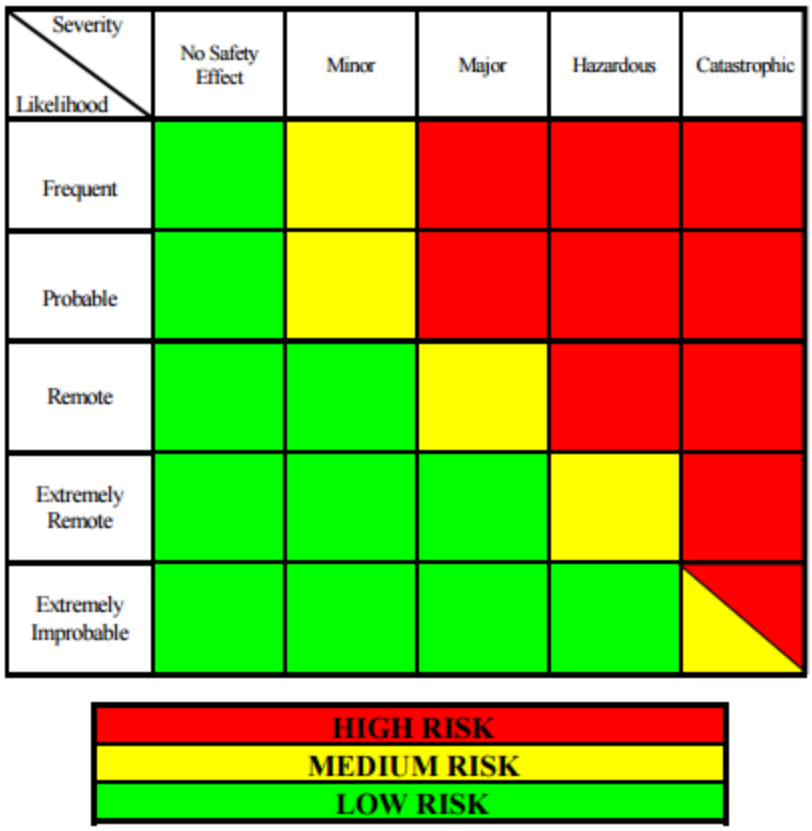


Figure 4.1: Risk Matrix (FAA AC 150/5200-37)

Phase 5 - Treat the Risk:

Hackers/Viruses - The best way to prevent cyber attacks on the system is to ensure the latest security algorithms and/or software used for SimpleQ is well-maintained and up to date. This will provide the most protection for the system and allow operators to be proactive in keeping information secure and preventing any interference that could ultimately lead to system/flight delays.

Emergency Situations - Some emergency procedures may need to be re-evaluated in order to accommodate more people being outside of the queue and more spread out across open area. This varies case by case, but it is not anticipated to create major changes in emergency preparedness procedures.

5 - Description of Technical Aspects

Below outlines the processes the team came up with for the design of SimpleQ to meet all necessary operational requirements.

Check-in Processes of SimpleQ

In-Person Check-in

Below outlines the "in-person check-in" process:

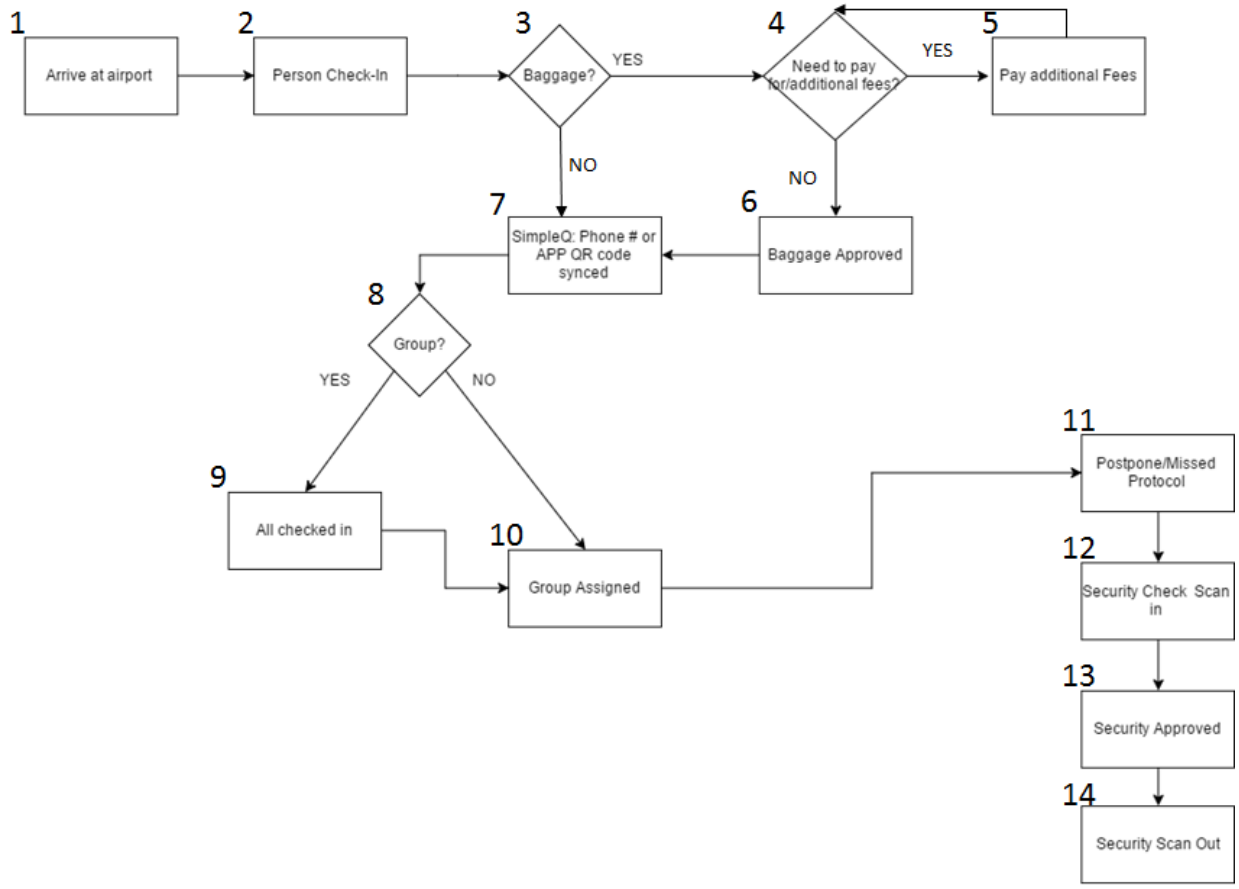


Figure 5.1: In-Person Check-in Process Flowchart

"In-person check-in" is defined as passengers check-in in the airport with airport staffs' assistance. Detail defined in the following with matching number.

1. Passengers will arrive at the airport.
2. Passengers go to meet the check-in staff.

3. Passengers’ decision to check-in luggage or not.
4. Whether passengers need to pay for luggage check-in.
5. Pay for luggage check-in.
6. Luggage checked-in.
7. Check-in staff will enter passengers’ phone numbers or SimpleQ app user id for passengers’ to mark passengers’ arrival and put them in the waiting line in SimpleQ system.
8. Whether the passenger has a group to travel with and all checked-in.
9. Add the passenger's group.
10. SimpleQ system will assign the passenger or the passenger’s group a security check number.
11. Passenger/group postpone the security check, which is a process will be explained in Postpone Flowchart.
12. Passenger/group’s security check number called, passenger/group scan boarding pass to start waiting in security check line. SimpleQ system will mark them as waiting for security check.
13. Security checked.
14. Passenger/group scan boarding pass to walk out of the security check station after security check. SimpleQ system will mark them as finished security check.

Kiosk Check-in

Below outlines the “kiosk check-in” process:

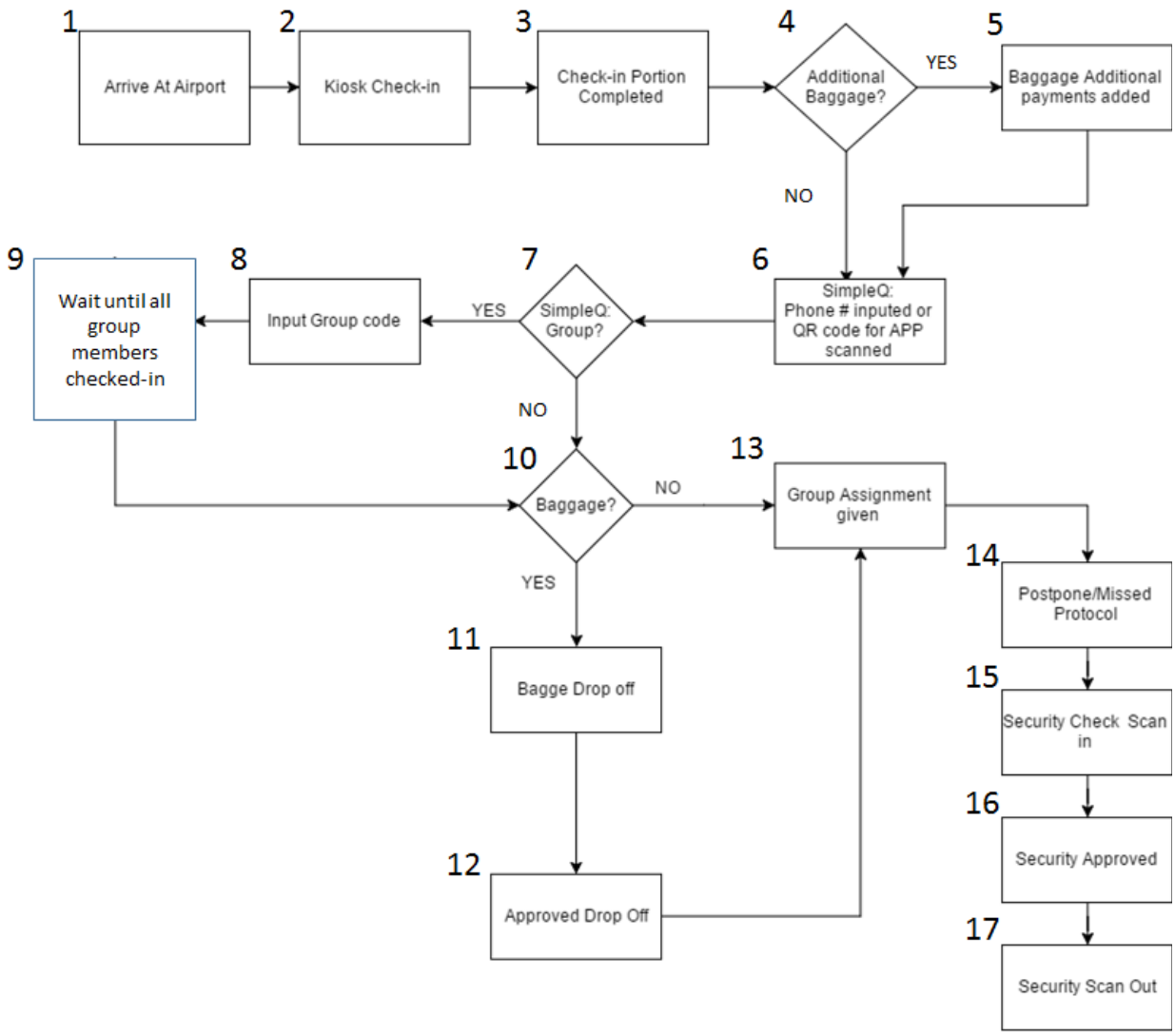


Figure 5.2: Kiosk Check-In Process Flowchart

Kiosk check-in is defined as passengers check-in in the airport by themselves on kiosks.

Detail defined in the following with matching number.

1. Passengers will arrive at the airport.
2. Passengers go to self-service kiosks.
3. Passengers finish general check-in process on kiosks.
4. Whether passengers need to check-in for luggage.
5. Pay for luggage check-in.

6. Enter passengers' phone number or SimpleQ app user ID.
7. Whether the passenger has a group to travel with and all checked-in.
8. If the passenger travel with a group, a group code will be assigned to them, when they enter the group code on the kiosk, SimpleQ system will recognize their group.
9. Wait until all group members checked-in.
10. If they have luggage to check-in, kiosks will print the label.
11. The passenger/group will need to hand the luggage to airport staff.
12. The airport staff approve their luggage check-in.
13. SimpleQ system will assign the passenger/group a security check number.
14. Passenger/group postpone the security check, which is a process will be explained in Postpone Flowchart.
15. Passenger/group's security check number called, passenger/group scan boarding pass to start waiting in security check line. SimpleQ system will mark them as waiting for security check.
16. Security checked.
17. Passenger/group scan boarding pass to walk out of the security check station after security check. SimpleQ system will mark them as finished security check.

Online Check-in

Below outlines the "online check-in" process:

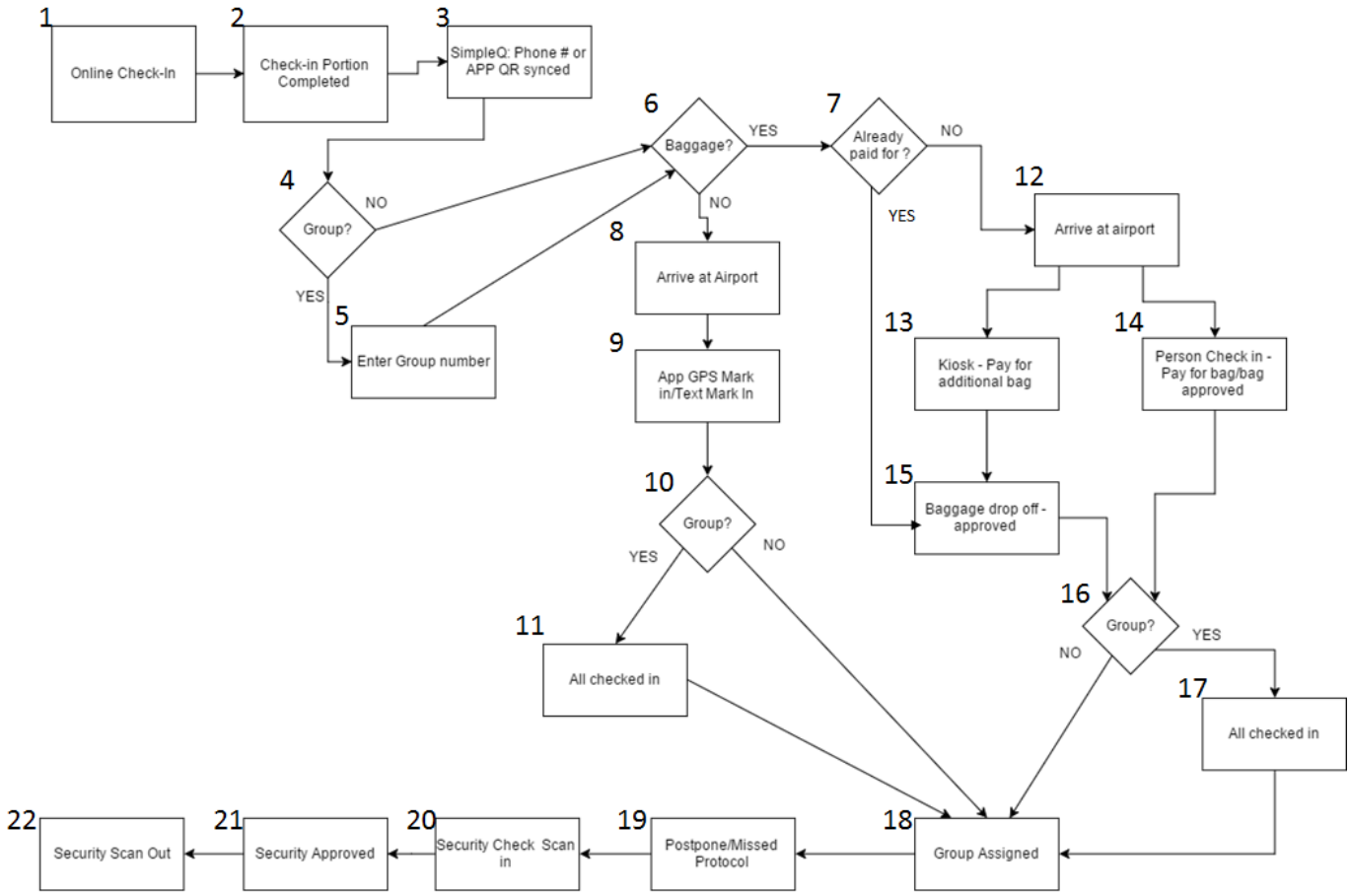


Figure 5.3: Online Check-in Process Flowchart

Detail defined in the following with matching number:

1. Passenger check-in online.
2. Regular online check-in finished.
3. Enter/register phone number or SimpleQ app user ID.
4. Whether the passenger has a group to travel with.
5. Enter group code.
6. Passengers choose to check-in luggage.
7. Passengers pay for luggage.
8. Passengers arrive at airport.
9. SimpleQ system mark passenger as arrived at airport.

10. Whether passenger travel with group.
11. Wait for all group member to be checked-in.
12. Passengers arrive at airport.
13. Passengers pay for luggage check-in at kiosk.
14. Luggage approved and dropped off.
15. Passenger pay for luggage check-in with staff approval.
16. Whether passenger travel with group.
17. Wait for all group member to be checked-in.
18. SimpleQ system will assign the passenger/group a security check number.
19. Passenger/group postpone the security check, which is a process will be explained in Postpone Flowchart.
20. Passenger/group's security check number called, passenger/group scan boarding pass to start waiting in security check line. SimpleQ system will mark them as waiting for security check.
21. Security checked.
22. Passenger/group scan boarding pass to walk out of the security check station after security check. SimpleQ system will mark them as finished security check.

Postpone Process

Below outlines the postpone process functionality SimpleQ will have:

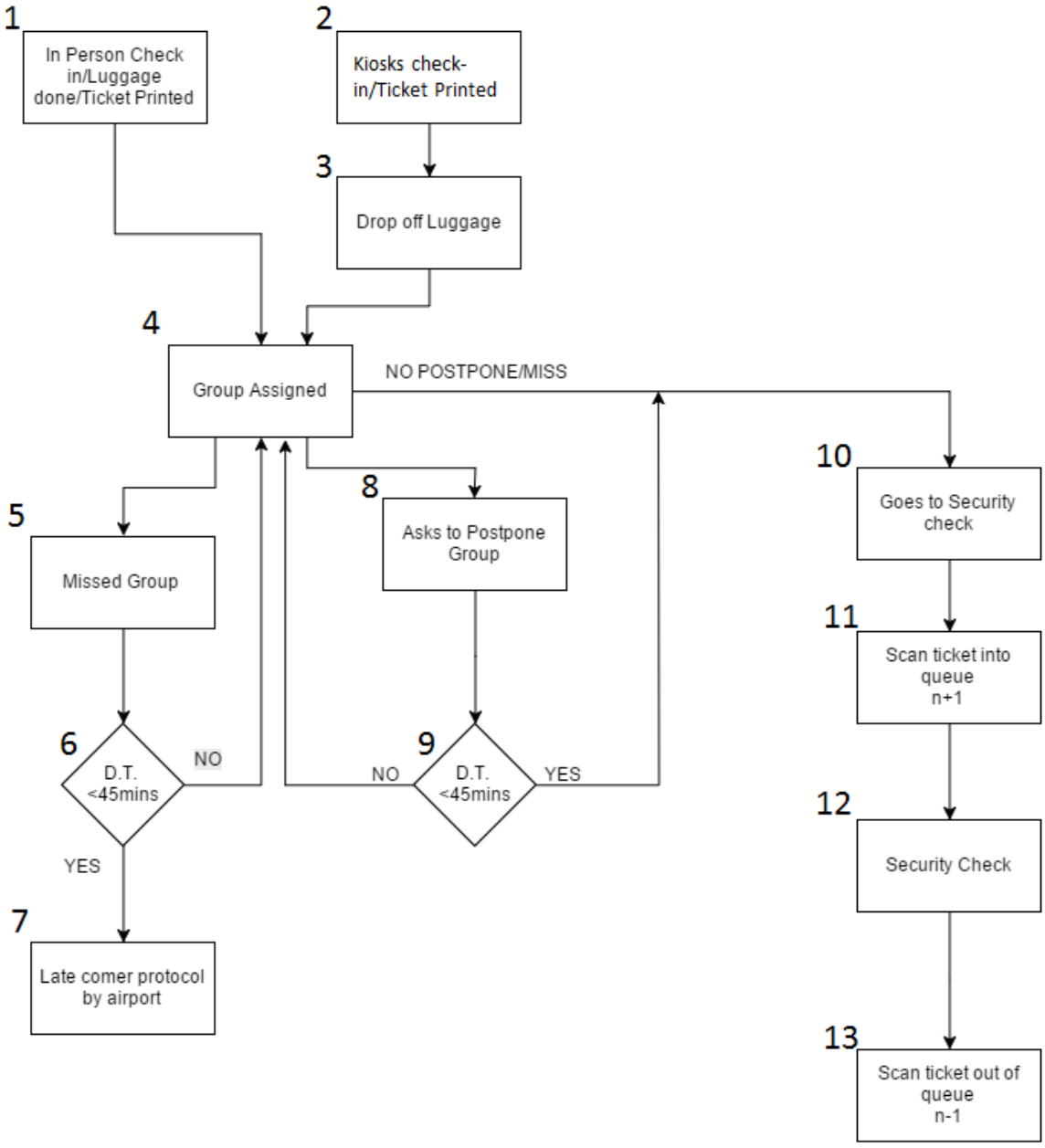


Figure 5.4: Passenger Postponing Attempt Process

There are different cases that passengers actually need to postpone their security check, for reasons like finishing up the drink and saying goodbye with friends and families. So the postpone process will allow the passenger to postpone the security check while not being late for their flights. Detail defined in the following with matching number:

1. Airport staff check-in with luggage dropped off.

2. Kiosks check-in.
3. Passenger drop off luggage if passenger have luggage.
4. SimpleQ system will assign the passenger/group a security check number.

5-6-7. If passenger doesn't go to security in 5 minutes after their number is called, the system will check if their D.T.(Departure Time) is within 45 minutes. If it's more than 45 minutes, the system will put them to next security check group. However, if it's less than 45 minutes, they system will notify airport staffs to assist the passenger.

8-9. If passenger choose to postpone security check after their number is called, the system will check if their D.T.(Departure Time) is within 45 minutes. If it's more than 45 minutes, the system will put them to next security check group. However, if it's less than 45 minutes, won't have the option to postpone.

11. Passenger/group's security check number called, passenger/group scan boarding pass to start waiting in security check line. SimpleQ system will mark them as waiting for security check.
12. Security checked.
13. Passenger/group scan boarding pass to walk out of the security check station after security check. SimpleQ system will mark them as finished security check.

System Diagram

The following system diagram shows how the SimpleQ interact with each components in the system.

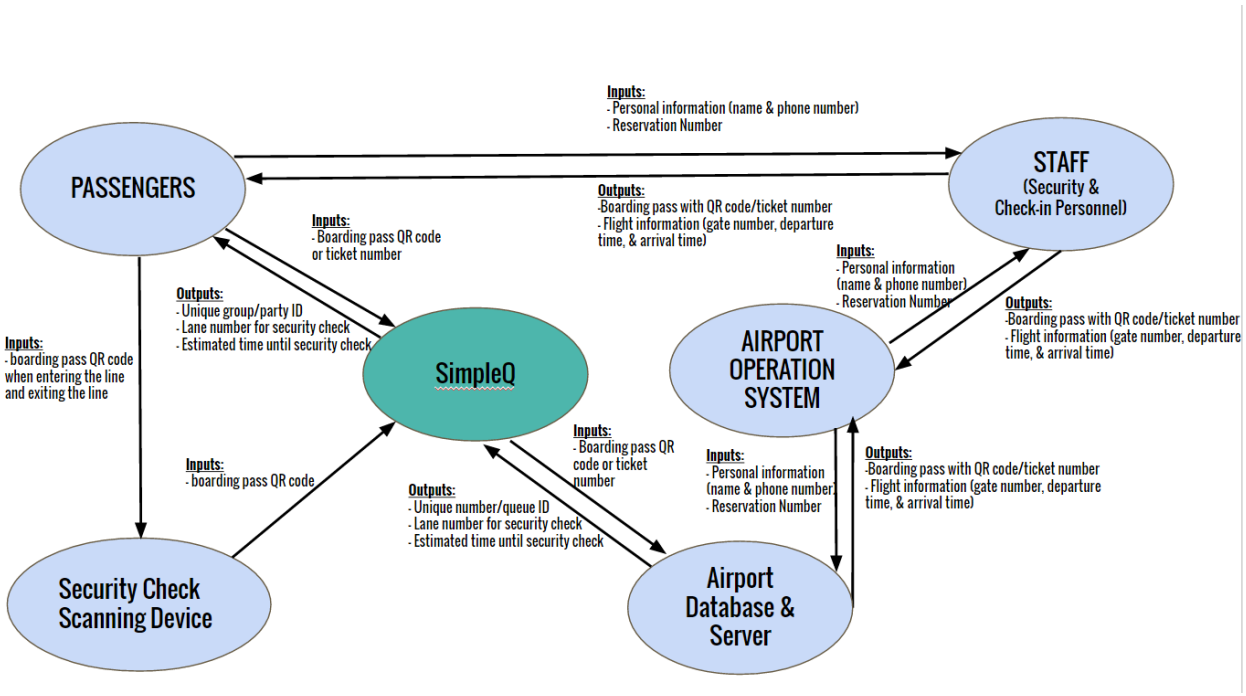


Figure 5.5: Component Interactions with SimpleQ System

SimpleQ App Interface Design

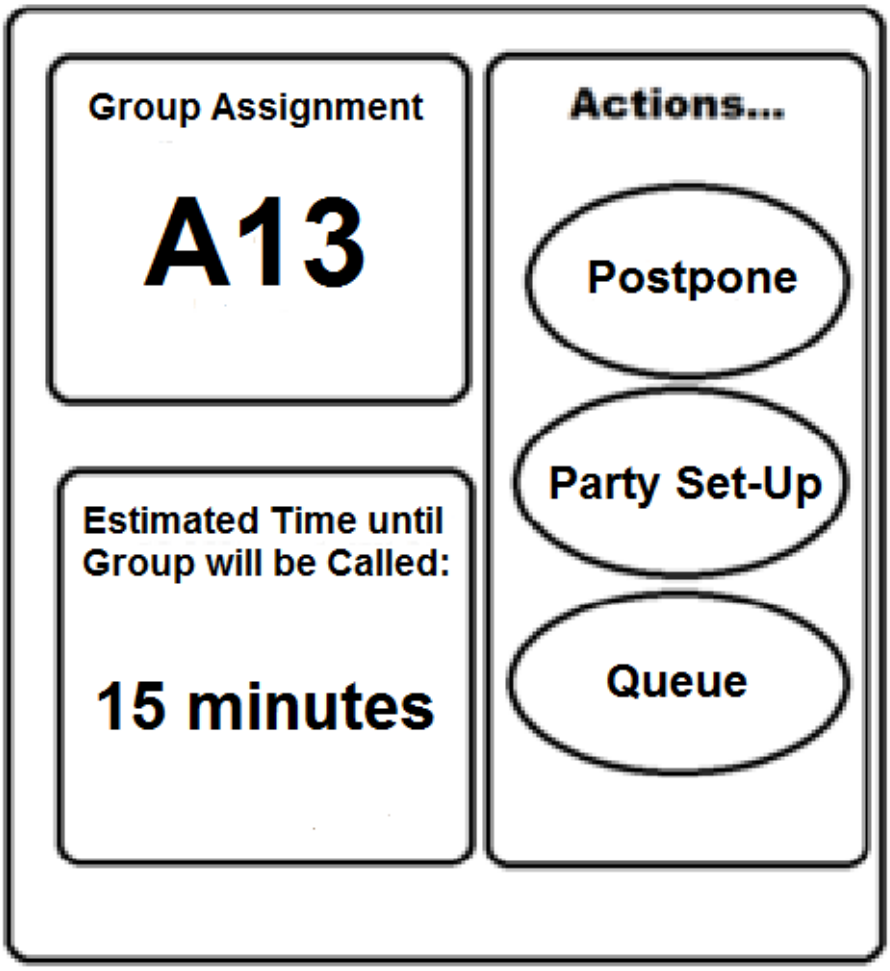


Figure 5.6: SimpleQ App User Interface

This is the main interface of the SimpleQ app, which advises users about their group number and estimated time for being called to the security queue. Also, it allows passengers to postpone their security check time, set up a party, and monitor the number of people in the queue.

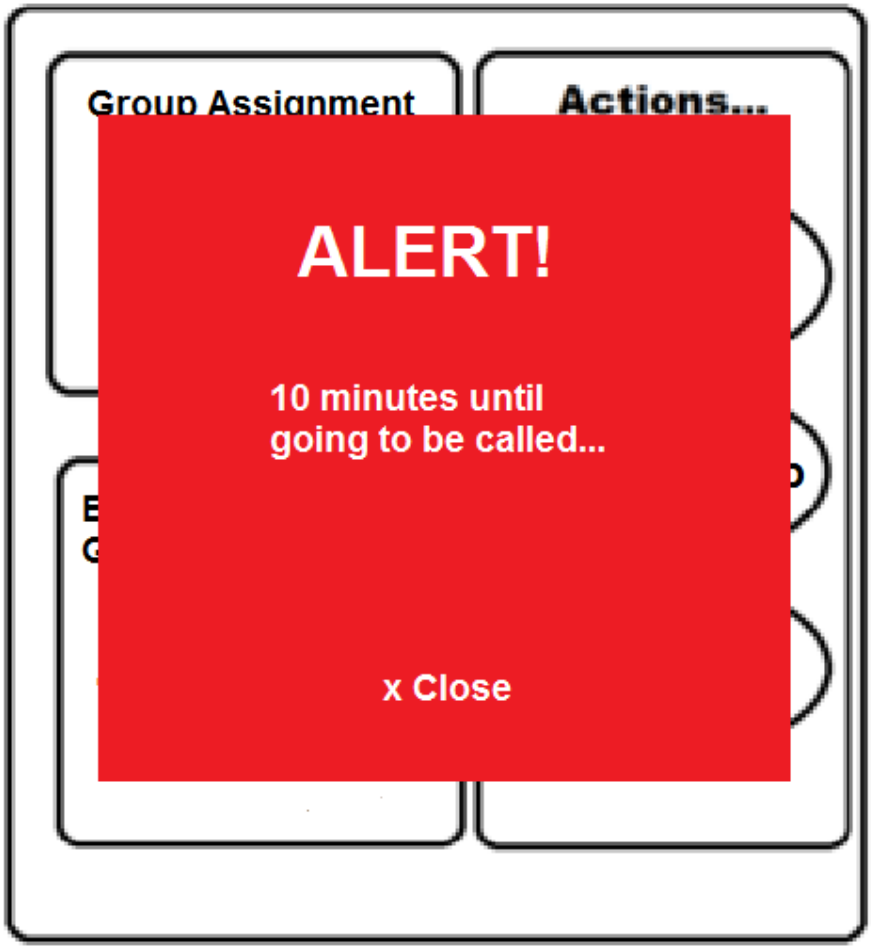


Figure 5.7: Sample Alert on SimpleQ User Interface

The app will notify passengers when security check time is approaching, so that the uncertainty of passengers that miss the security check time can be lowered, since they will know when they will be called for security check and they can get prepared.

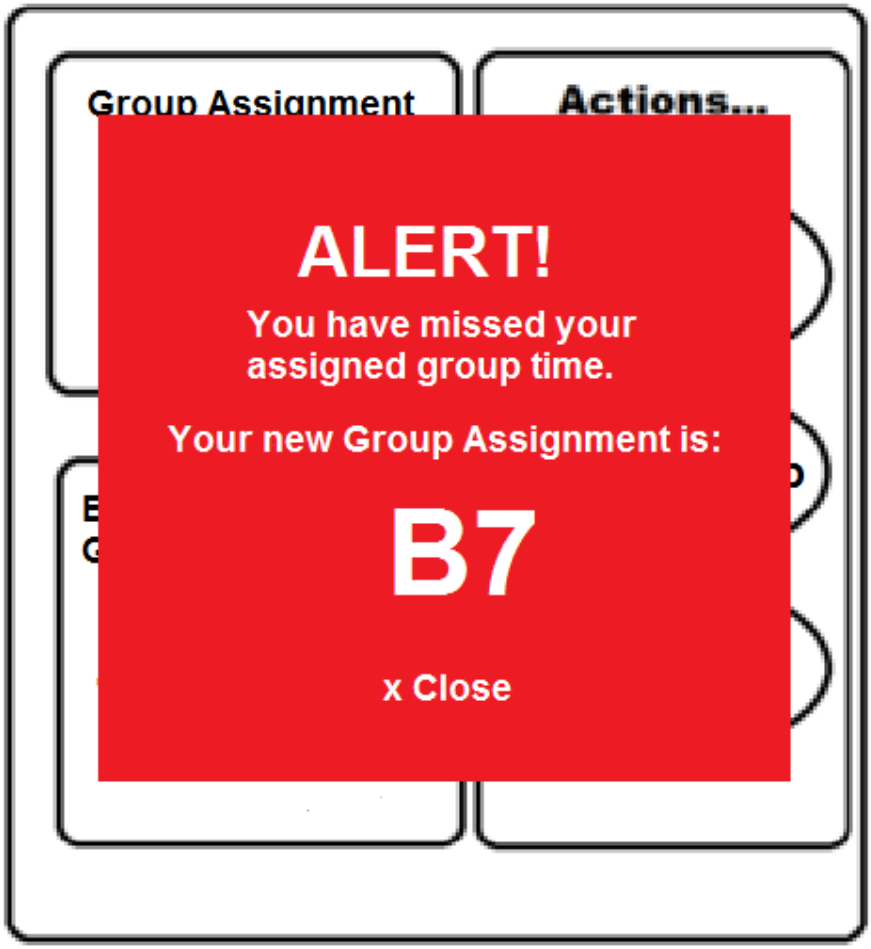


Figure 5.8: Sample "Missed Group" Alert on SimpleQ User Interface

When people miss the security check time, they will be assigned to the next available security check group, if their departure time is more than 45 minutes.

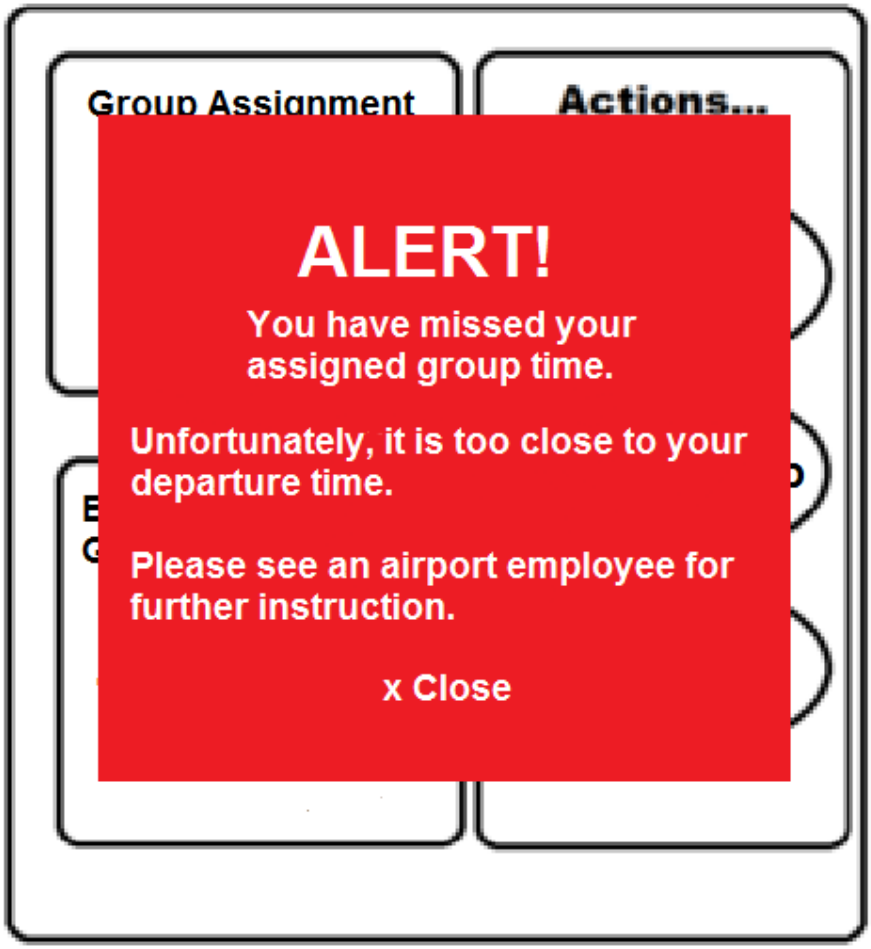


Figure 5.9: Sample "Final Warning" Alert on SimpleQ User Interface

If the passenger's departure time is within 45 minutes and they miss the security check time, an airport employee will be able to help them.

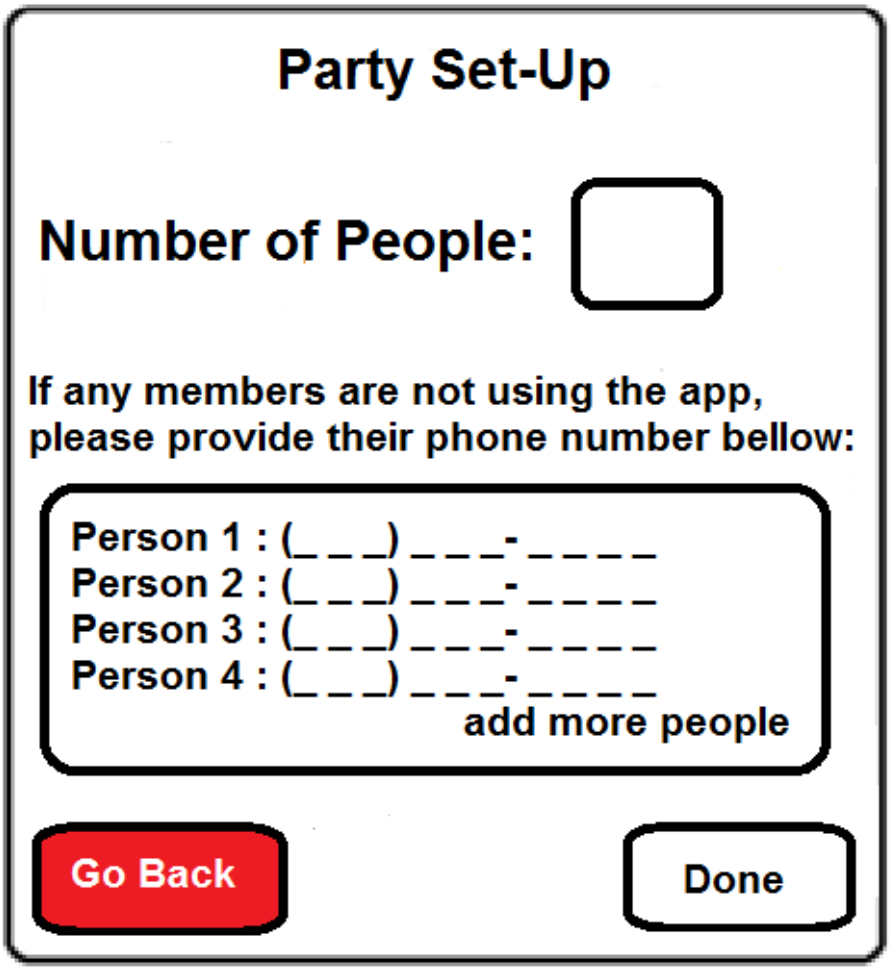


Figure 5.10: "Party Set-Up" Sample Interface for Group Travel

This is the interface to set up party if the passenger travel with group.

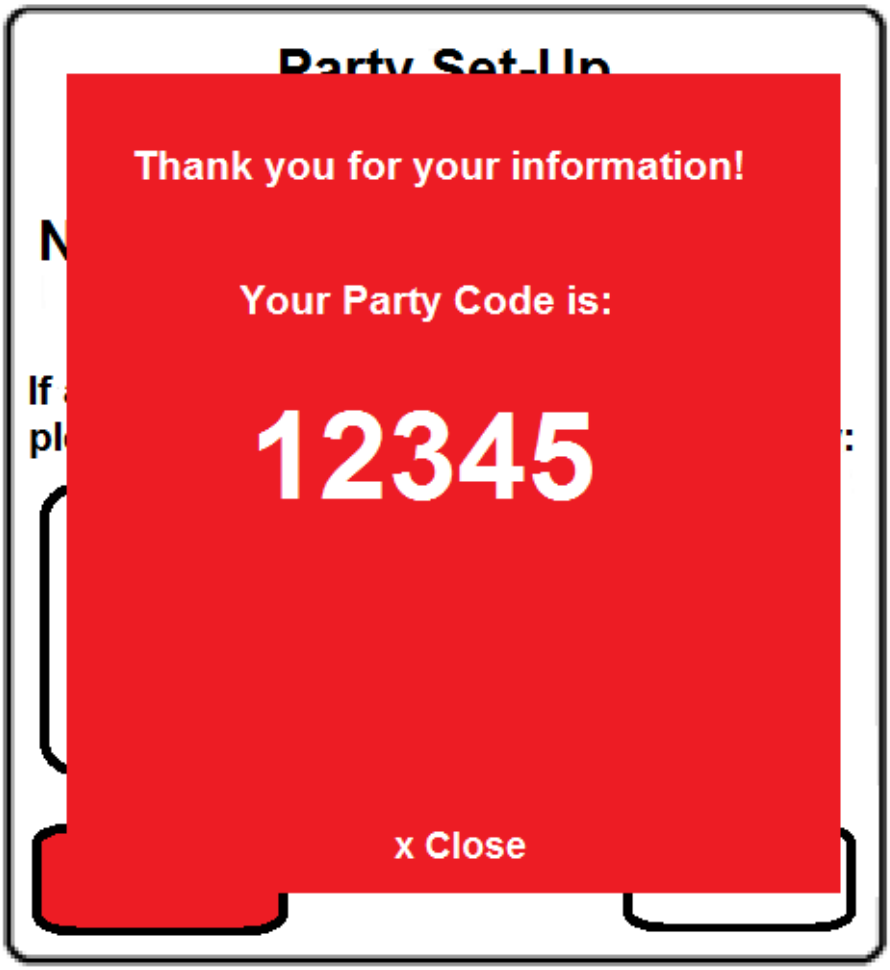


Figure 5.11: Sample Party Confirmation Code User Interface for Group Travel

Once the passenger is done setting up the group, his or her group will be assigned to a party code.

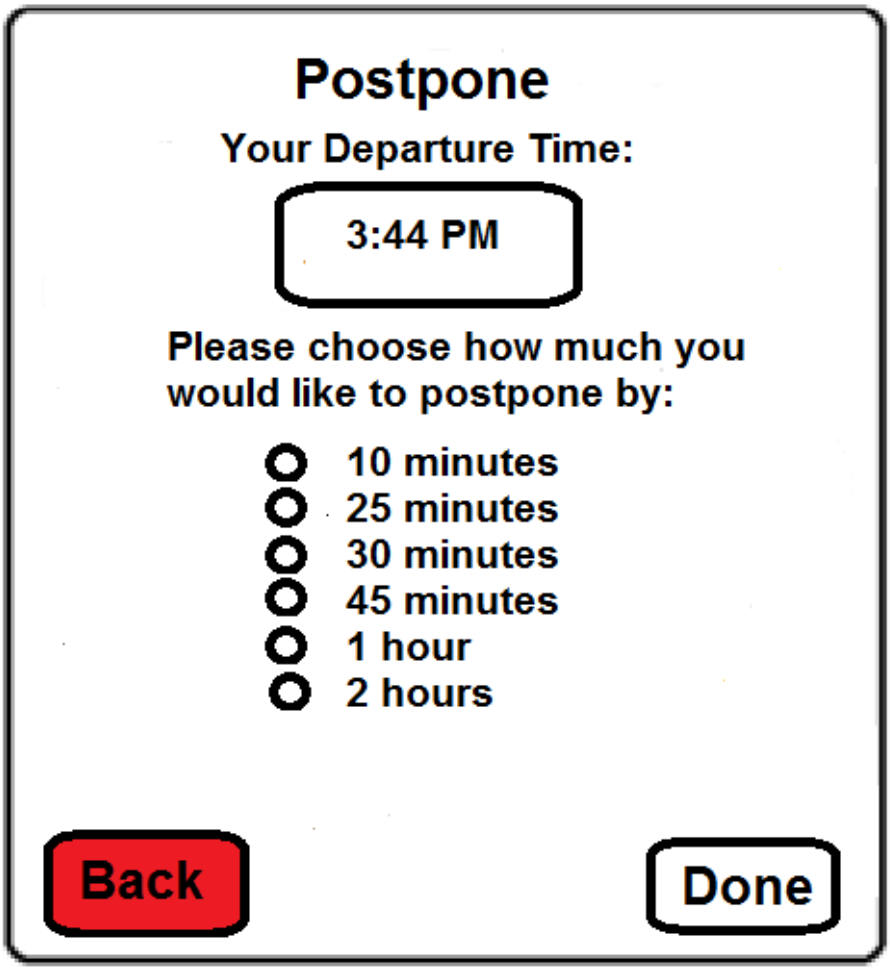


Figure 5.12: Sample Postpone Page User Interface

When passengers need to postpone their security check time, the postpone function will be able to help them if allowed to.

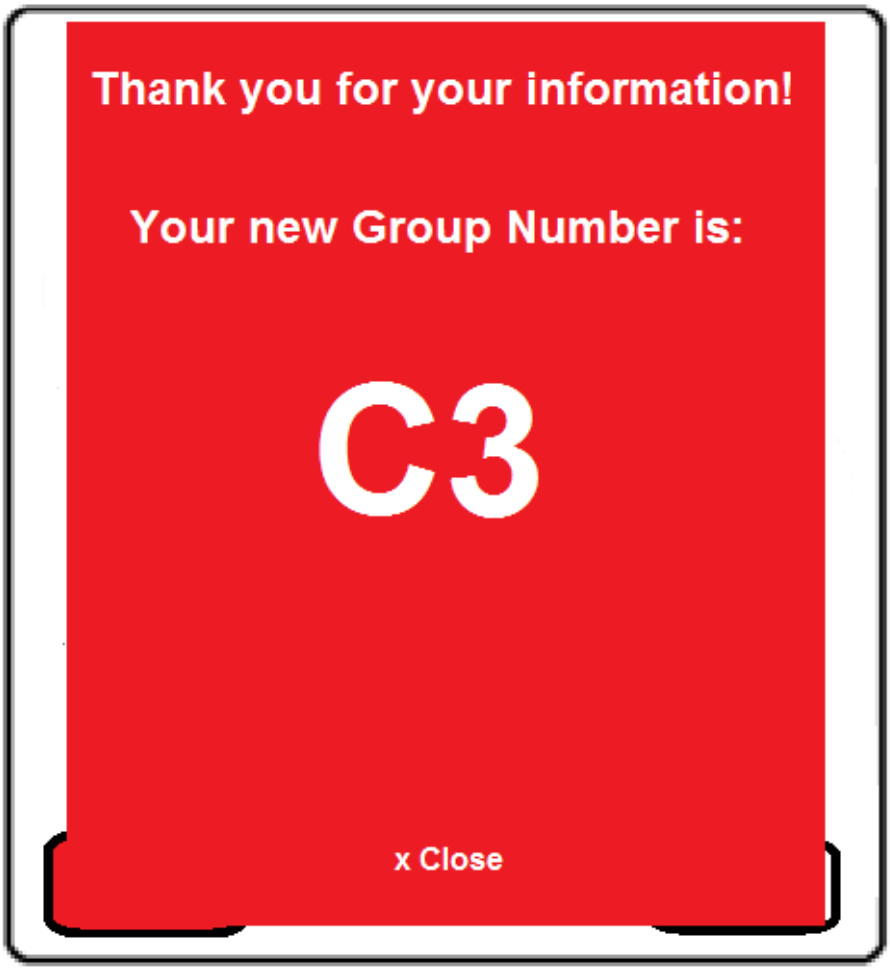


Figure 5.13: Sample User Interface for New Group Number Confirmation

After passengers choose the time they'd like to postpone, they will be assigned to a new group number based on how much time they want to postpone.

Check-in Kiosk Interface Design

Figure 5.14: New Interface Design for Kiosk Check-In

After the passenger checked in, they can choose to scan the barcode using their SimpleQ app, or just enter their cell phone number if they do not have the app.

Figure 5.15: Sample Interface for Party Check-In for an Individual

Passengers have the option to enter their party code if they travel together but arrive separately.

Use Case Model

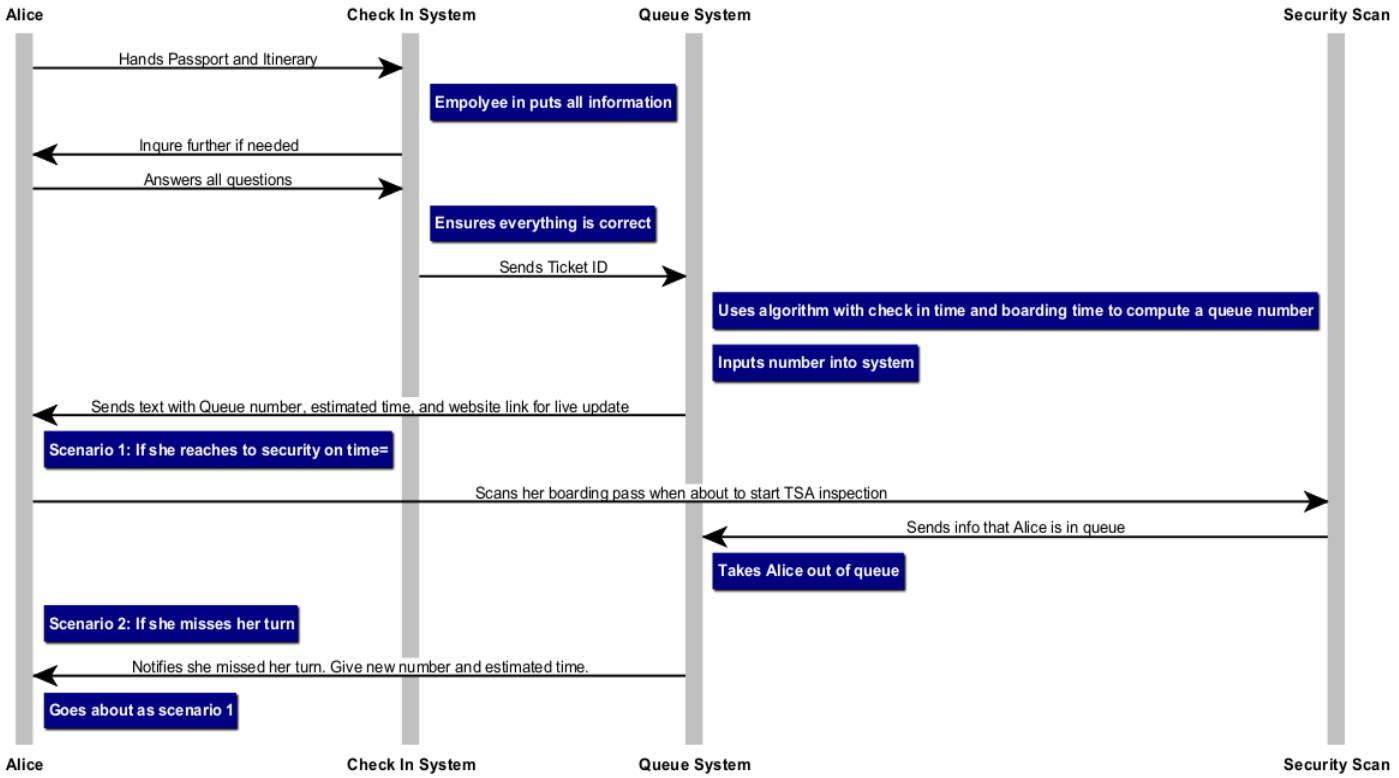
Use Case	**Description**
SimpleQ check in input	This is where the check in employee can add the phone number or app id for the queue number option
Text message option	Check in employee can input the travelers phone number for the option for text message notification, when checking the customer in.
App notification option	Check in employee can input the travelers unique app id for the app to update with queue number and delay options.
Compute Queue Number	The software will compute a number which is within the sequence of numbers up for security check soon. The number will take into account the time of check in.

Attach number and boarding pass	The software will attach the boarding pass number and the queue number in the system so that when the boarding pass is scanned at the end, the number will be taken out of the system
Text message notification	Text will be sent to the traveler notifying them of the queue number, estimated time til being called, and the website for real-time update of queue numbers being called
Website	This website will show the real time updates of the numbers up for security check
App Download	User can download the SimpleQ app in the apple or google play store
App notification	App will tell the traveler their queue number and estimated time in a pop up and within the app
App real time update	App will display the first 15 numbers up next for security check. Will update constantly with communication with SimpleQ
App Delay Button	Option in app which allows traveler to delay when they are being called. Can be done in 15, 25, and 35 increments.
Lounge/Restaurant	Used for travelers to charge their phone, relax, and talk to family or even eat or drink something.
Scanner	At the beginning of the security scanner line, there will be a scanner for travelers to scan their boarding pass at so they will be removed from the SimpleQ system.
LED Board	this will display the different numbers up for security check
Software Team	Maintain the system to ensure that everything is operating correctly

Notification Sequence Diagram

App Notification Sequence

Text Notification Sequence



6 - Descriptions of Interactions Within the Industry

When the idea of focusing on security queueing was finalized, the team referred to the list of expert industry advisors found on the competition website's resource page. Because security queueing was not explicitly listed in the guidelines under a specific category, the team felt it best fit under the "Airport Operations and Maintenance" topic and decided to reach out to advisors listed for this category. One team member reached out to Alex Gertsen, President of Aviation Fury, LLC. Another reached out to Frank Farmer, an Aeronautics Manager at the Alabama Department of Transportation Aeronautics Bureau. A third member reached out to Richmond Nettey, Associate Dean of the College of Applied Engineering, Sustainability and Technology at Kent State University.

Of the three advisors the team reached out to, Dr. Nettey responded to the correspondence. He had a conference call with one of our team members and was able to provide his feedback on the problem the team chose to address and alternative design solutions the team was coming up with. With the input from the advisor who responded, the team used the feedback to help guide our approach to completing the project. Besides reaching out to expert advisors, the team tried reaching out to other contacts through Stevens and by directly reaching out to Newark International Airport. We only had success in hearing back from a Stevens alumnus who participated in the FAA Design Competition a few years ago, and who also currently works in the industry.

7 - Description of Projected Impact

Currently passengers wait through a single line to then have their papers checked, then from there have to go through the whole security check process. There is a lot of idle waiting time wasted. In our project, idle time refers to time spent not doing anything but standing and waiting. In terms of the security line, it is the point where you enter the line to the point where you are able to get a bin at the conveyer belt. Many people come to the airport early and then go through the security process and spend the time before boarding duty-free shopping or at a restaurant. Many people come with family and friends to get dropped off at the airport, and end up having the spend this time eating alone. We see an opportunity to lower the idle time and generate revenue by creating more opportunities for those who have not passed security yet.

We see the 10 - 30 minute time spent in the security line as an opportunity for revenue and higher customer satisfaction. If we give flyers less time spent in the security line and less anxiety from missing their flight from long lines, we can have these flyers and their family members who come drop them off spend money on restaurants outside of the security line.

The SimpleQ app allows for revenue to be generated before the security line and gives the opportunity to more than those who are flying. This also generates revenue with the parking lot system as more people will park to spend time in the airport with the people they have come to drop off.

Airports' main commercial use is the ratings and advertising. Any store would be able to advertise on the app and the airport who owns the app license can charge the stores for the marketing. This new queueing management system will accomplish our main goal while also increasing revenue and customer satisfaction at airports. The one-time software purchase by airports will be recuperated over time with the increased revenue generated after its implementation. Revenue for the airport is created through higher rents charged to restaurants or stores in the airport because higher foot traffic that can be guaranteed. Aside from profits made through software purchases, our group would generate additional revenue from company advertisements that could be included in the application interface of the software.

This system can be purchased by airports everywhere, due to the fact that the airport could gain significant amounts of profit through multiple new revenue streams. Although this is a theoretical system, the cost can be profited back very quickly with marketing efforts and new shops and restaurants before security. More passengers would be drawn to airports with this software for the higher customer satisfaction they would experience. With more passengers comes more business, leading to increased revenue for both airports and their tenants.

	Base	SimpleQ
Average Check-in Time	2.29 min	3.07 min
Average Idle Waiting Time	12.5 min	2.45 min
Time Saved	n/a	9.27 min
Sales Generated Per Hour (Pre-Security)	$0	$8,910*

*Sales projections based off of EWR2015 sales results and data.

Figure 7.1: Benefits of SimpleQ

Appendix A - Contact Information

Table A.1 - Team Member Contact Information

Name	Permanent E-mail
Shuyuan Jin	justonjin@gmail.com
Ashely Oliver	ashely.oliver.93@gmail.com
Samantha Scarpone-Jones	sami.ecs.jones@gmail.com
Harleen Vohra	harleenvohra23@gmail.com

Table A.2 - Advisor Contact Information

Name	Permanent E-mail
Eirik Hole	ehole@stevens.edu

Appendix B - University Description

Stevens Institute of Technology is a premier, private research university situated in Hoboken, New Jersey. Founded in 1870 by America's First Family of Inventors - who patented steam ferries and the modern form of railroad track, among many other inventions - technological innovation has remained the hallmark of Stevens' education and research programs. Today within the university more than 6,800 undergraduate and graduate students collaborate with more than 380 faculty members in an interdisciplinary, student-centric, entrepreneurial environment to advance the frontiers of science and leverage technology to confront global challenges. Stevens' alumni network, more than 40,000 strong, also continues to make national and global impacts while contributing energy, ideas and support to the continued growth and momentum of the university.

Stevens has a unique curriculum blending technical training, teamwork, design projects, internships and cooperative education opportunities. Stevens graduates are consistently in high demand by industry leaders and agencies seeking highly prepared, solutions-oriented employees and team members. Almost all Stevens students secure jobs or graduate school enrollment within six months of graduation. Stevens graduates also enjoy starting mid-career salaries that outpace those of graduates of nearly all other U.S. high educational institutions. This allows Stevens to educate leaders, who create, apply and manage innovative technologies while maintaining a deep regard for human values.

Stevens has established its reputation as a premier institute for secondary education, being named a National Center of Excellence in Systems Engineering Research by the US Department of Defense and in Information Assurance Research and Education by the National Security Agency.

Appendix C - Non-University Partners

We did not have any non-university partners involved in this project. We relied on the help of our advisor, our teaching assistant, and other faculty who donated their time to work with us to successfully complete the project.

Appendix D - Advisor Sign Off

Please see final page attached with our advisor's signature.

Appendix E - Evaluations

Student Evaluation Responses

Shuyuan Jin -

1. Did the Airport Cooperative Research Program (ACRP) University Design Competition for Addressing Airports Needs provide a meaningful learning experience for you? Why or why not?

   I think working on this project is indeed a meaningful learning experience. It turned 4 students, who didn't know much about airport, security check, into experts in the field. What's more, the project aroused our interest in airport design and planning.

2. What challenges did you and/or your team encounter in undertaking the competition? How did you overcome them?

   While working on the project, we had a hard time getting ideas for solution because we don't have much knowledge about check-in process in airports. However, after we went to airport a few times for observation and data collecting, it was more comfortable to come up with innovative ideas.

3. Describe the process you or your team used for developing your hypothesis.

   At the beginning, we defined all the criterias and collected all the possible solutions. Then, based on different criterias, requirements, we started brainstorming, analyzing, and developing new ideas. The next step was collecting data in airport and building the model with Anylogic to support our design, which does indicate the effectiveness of our design.

4. Was participation by industry in the project appropriate, meaningful and useful? Why or why not?

It is absolutely meaningful, because what we learned is not just from researched and textbook, but also from the real world. Moreover, comparing to other projects we did for college, this project is more useful and realistic, because it can potentially change the process of checking-in in airport and save passengers' time.

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?
   I believe the most useful thing I learned is building real world models with Anylogic, because a real world simulation can be applied to almost everything on the world.

Ashely Oliver -

1. Did the Airport Cooperative Research Program (ACRP) University Design Competition for Addressing Airports Needs provide a meaningful learning experience for you? Why or why not?
   I think taking on this project/competition was definitely a meaningful learning experience for me. I liked the freedom we had in choosing an issue to address, which really helped us in enhancing skills to be utilized in the real-world after college, such as critical thinking and team decision-making.
2. What challenges did you and/or your team encounter in undertaking the competition? How did you overcome them?
   With the freedom in choosing any kind of problem to address, we struggled at first coming up with a consensus on what problem was worth fixing as well as which seemed like the most interesting/unique to approach as a team. We overcame this by

brainstorming with each other, as well as our advisor, until we had a clear vision of what we wanted to move forward with.

3. Describe the process you or your team used for developing your hypothesis.

   As previously mentioned, it took a lot of brainstorming to finally end up with a problem we wanted to solve. Before coming up with a solution, we asked others and ourselves what could be improved and tried to hypothesize the best solution that would address all of the desired improvements.

4. Was participation by industry in the project appropriate, meaningful and useful? Why or why not?

   It was meaningful for me because we got to utilize a lot of the skills and knowledge learned over the course of our education at Stevens to solve a real world problem. The impact as a result of this project could really bring about change, as opposed to theoretical solutions to theoretical problems created/used in classwork and other assignments.

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?

   This absolutely helped with preparation for successful entry into the workforce. It was an open-ended long-term project for our team, which is a type of project that will most definitely be encountered as we advance and move forward in our career and education paths.

Samantha Scarpone-Jones -

1. Did the Airport Cooperative Research Program (ACRP) University Design Competition for Addressing Airports Needs provide a meaningful learning experience for you? Why or why not?

   Yes, I believe that the ACRP Design Competition provided a meaningful learning experience for me. Not only did it allow me to expand upon my previous knowledge of queuing and any logic, but I learned valuable knowledge in teamwork and time management. I believe that both of these experiences will be useful for when I graduate and go out into the industry.

2. What challenges did you and/or your team encounter in undertaking the competition? How did you overcome them?

   With such a broad prompt, one of the major problems we incurred early on was indecision on which part of the airport we should work to improve. We overcame this by trial and error, testing and researching each of our brainstormed ideas until we found the one with the most potential. Additionally, throughout the project we struggled continuously with team communication and time management. We worked to overcome this with bi-weekly team meetings to get a chance to meet face to face to discuss progress.

3. Describe the process you or your team used for developing your hypothesis.

   When we first got the prompt we brainstormed a whole bunch of different ideas of things we could improve in the airport, from there we did research on different idea. Eventually we found one idea, the security line queue, that had enough data and was a big enough problem in the airport that it stuck. From there we gathered information and created a

variety of different simulations to how we could fix the queue in the most efficient manner. The SimpleQ process was the most effective.

4. Was participation by industry in the project appropriate, meaningful and useful? Why or why not?

   Yes and no, some of the people we talked to at Newark Airport were not incredibly helpful or forthcoming, but I can understand why. They were gracious enough to let us go to the airport and take notes on times and the process of which people checked in and went through the security line. This research allowed us to appropriately model the base and prove accurately how much our new system would change the industry.

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?

   I believe, above all else, that this project helped me to learn more about teamwork, and the different skills needed to work with a team such as compromise and professionalism. Working with others is an incredibly valuable skill that one needs to possess entering the workforce. You don't always work with people you like, and sometimes there are a whole bunch of problems happening that each team member wants to approach differently. However, a lot more can be accomplished by four people than one, and you have to learn to compromise your team members and present yourself in a professional manner.

Harleen Vohra -

1. Did the Airport Cooperative Research Program (ACRP) University Design Competition for Addressing Airports Needs provide a meaningful learning experience for you? Why or why not?

Yes! I learned a lot about the different processes of security system and check in system and how everything is becoming more modern yet taking the same amount of time. The competition showed me that there is always room for improvement in all the different areas of an airport.

2. What challenges did you and/or your team encounter in undertaking the competition? How did you overcome them?

   Our biggest challenge was losing the group of computer and electrical engineers in the beginning of the semester. If we had these students then maybe our projected wouldn't have been heavily based on speculation and educational observations and conclusions. We would have been able to actually create a program and app and be able to simulate the impacts of this technology.

3. Describe the process you or your team used for developing your hypothesis.

   We wanted to work on something that really aggravated us when we went to the airport. We thought about the check in system and luggage but it seemed that many different airports and airlines have already invested a lot of money into creating a more mature system and a more versatile, modern method. That is where we got to research security lines and saw that it has mostly been the same except for TSA pre check and other pre check like systems which still force you to go through a queue of some sorts.

4. Was participation by industry in the project appropriate, meaningful and useful? Why or why not?

   It was meaningful because a big part of Engineering Management has been quality management, queueing systems, modeling and simulation and even supply chain.

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?

   The security line is a big part of the whole airport experience so any sort of delay or disruption in that has a huge impact of the passenger boarding the flight and making it to their destination. These are all things we have learned as engineering management students, the impact of the bottleneck and domino effect. The black-swans of the supply chain. So it was great to be able to create a method that could, theoretically, solve the idle wasted time at an airport. Yes this project helped me with many skills and gave me much knowledge about queuing systems.

Faculty Advisor Evaluation Response

Professor Eirik Hole -

1. Describe the value of the educational experience for your student(s) participating in this competition submission.

   This student competition provides a very nice context and goal for our 2 semester capstone design course. It provides real problems for real organizations, which is both a motivational factor as well providing a "real-world" setting.

2. Was the learning experience appropriate to the course level or context in which the competition was undertaken?

   Yes. The nice thing about this competition is that there is flexibility in defining both scope and depth of the research and design to be done to fit the needs of the course.

3. What challenges did the students face and overcome?

The biggest challenge I think the students encountered was to get in touch with subject matter experts that could guide them and provide information. They partly overcame this by doing their own research. But it did put a limit on how well they could understand the problem they were trying to solve as well as getting competent feedback on their various design options.

4. Would you use this competition as an educational vehicle in the future? Why or why not?

   This competition is always a part of my "portfolio" of potential projects, and I encourage interested students to participate.

5. Are there changes to the competition that you would suggest for future years?

   I think there is room for better facilitation of communication between student participants and subject matter experts to make sure that the team gets started on the right path.

Appendix F - References

Ifly.com. (n.d.). Newark Liberty Airport (EWR) Security Wait times. Retrieved December 1, 2015, from http://www.ifly.com/newark-libery-internationa/wait-times

My TSA- View Security Wait Times. Retrieved December 10, 2015, from http://apps.tsa.dhs.gov/mytsa/wait_times_detail.aspx

Port Authority of NY & NJ. Newark Liberty International Airport. Retrieved December 1,2015, from http://www.panynj.gov/airports/newark-liberty.html

Safety Management System Manual Version 4.0: Air Traffic Organization 2014. (2014). Washington, D.C.: Federal Aviation Administration Air Traffic Organization Retrieved from

http://vsgc.odu.edu/ACRPDesignCompetition/2015/Resources%20for%20Design%20Competion%20Website/FAA%20Safety%20Management%20System%20Manual.pdf

Taylor, B.W. (1999). *Introduction to Management Science.* Upper Saddle River, NJ: Prentice Hall.

U.S. Department of Transportation, & Federal Aviation Administration. (2007). Advisory Circular. Retrieved from http://www.faa.gov/documentLibrary/media/advisory_circular/150-5200-37/150_5200_37.pdf